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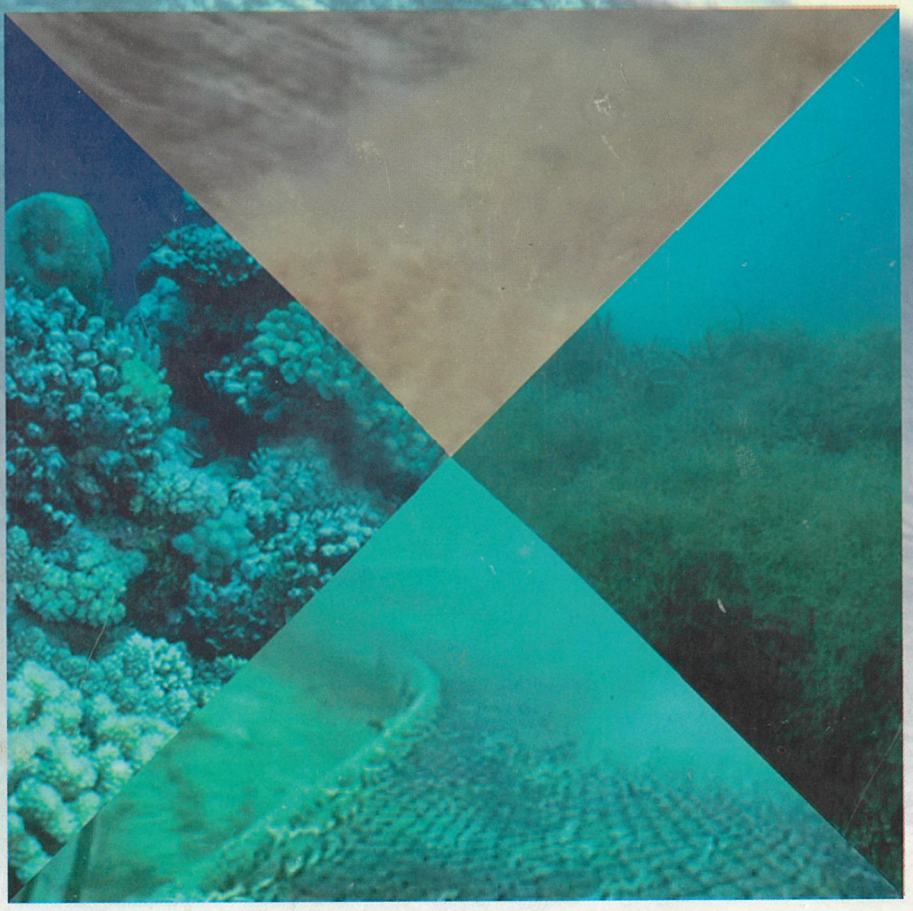
OCEANOGRAPHIC PROCESSES OF CORAL REEFS

Physical and Biological Links in the Great Barrier Reef



Eric Wolanski

OCEANOGRAPHIC PROCESSES OF CORAL REEFS

Physical and Biological Links in the Great Barrier Reef

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Physical and Biological Links in the Great Barrier Reef

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Foreword

I have maintained an on-going and deep interest in the Great Barrier Reef ever since I was involved in the establishment of the Australian Institute of Marine Science more than 25 years ago. This book contains important chapters dealing with different aspects of the functioning of the ecosystem in relation to the Great Barrier Reef and demonstrates the impact of human activities on the Great Barrier Reef.

While progress is continually being made scientifically with our knowledge of the ecosystem, we should constantly have in mind how important it is to preserve and protect the Great Barrier Reef for future generations. There is a delicate balance, and the impact of variations in climate and pollution from such things as mud, fishing, runoff from clearing catchments, mining, etc. all need to be closely monitored.

The current generation should not take unnecessary risks to satisfy economic imperatives if there is even the smallest chance of spoiling any part of this unique heritage.

I commend this book for its comprehensive coverage of the links between physical and biological processes in the Great Barrier Reef. I hope it will create constructive discussion and awareness of the potential pitfalls and possibilities for the region.

The Right Honourable Malcolm Fraser, A.C., C.H.

Dedication

I dedicate this book to my sons, Philippe and Timothy, born and brought up on the shores of the Great Barrier Reef; I hope that something will remain for them to entrust to their children.

Eric Wolanski

About the Editor

Dr. Eric Wolanski received his B.Sc. in civil engineering in 1969 from the Catholic University of Louvain, his M.Sc. in civil and geological engineering in 1970 from Princeton University, and his Ph.D. in environmental engineering in 1972 from The Johns Hopkins University. He is a Fellow of the Australian Academy of Technological Sciences and Engineering and a Corresponding Member of the Académie Royale Belge des Sciences d'Outre-Mer. He is a member of the Sigma Xi Research Society of North America and the Australian Institution of Engineers. He is an editor of the scientific journal *Estuarine, Coastal and Shelf Science;* a member of the editorial advisory board of the scientific journals *Continental Shelf Research, Journal of Coastal Research, Wetlands Ecology and Management, Journal of Marine Systems,* and *Oceanographic Literature Review;* and a Theme Editor of UNESCO's *Encyclopedia of Life Supporting Systems.* He has published more than 200 research papers. For the last 22 years at the Australian Institute of Marine Science, where he is a Senior Principal Research Scientist, he has been studying tropical coastal oceanography and its biological implications for mangroves and coral reefs.

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Introduction

OCEANOGRAPHIC PROCESSES OF CORAL REEFS

Biologists are aware that the variety of genes within species, species diversity within ecosystems, and the kinds of ecosystems on the planet—all of which are referred to as biodiversity—are the basis of life's resilience and productivity. Human beings, like all other species, depend on the output of that web of living things for our most elemental needs—clean air, water, soil, and energy. As we tear at that skin of life with our activity by clear-cut logging, dams, urban development, agriculture, and toxic emissions, the capacity of nature to cleanse, replenish, and renew itself is diminished.

Humankind's spectacular "progress" in the past century resulted from the conjunction of a number of factors including population growth, technological innovation, consumption, and globalization of the economy. As a result, collectively, we have become a super-species, the first species able to alter the biological, chemical, and physical features of the planet on a geological scale.

But over and over, we discover through our interaction with the earth, patterns of interconnectedness that we simply never knew. DDT use revealed the phenomenon of biomagnification, CFCs liberated free radicals that destroyed ozone, and excessive use of antibiotics led to the discovery of multiple drug resistance. I remember that for years, plankton was the basis of all our models of the marine food chain until picoplankton, ten times smaller than plankton, were discovered and completely upset the models. In North America, we've long known that salmon need the forest because when watersheds are clear-cut, fish populations plummet or even disappear. Now we are learning that the forest needs the salmon which provide the single largest pulse of nitrogen to the trees during the year.

Scientists are very good at description. They are constantly making discoveries because our knowledge about the world is so limited. But the limited knowledge base makes their ability to prescribe solutions to problems very restricted.

If the world were a clockwork mechanism as Newton suggested, then perhaps we might be able to figure out how the world works by examining its parts. Then one might begin to "manage" it. But taking a much simpler system, let's say a shoe factory, we would need at least two things to manage it properly: (1) an inventory of everything in the factory and (2) a blueprint that explains how everything interacts. How well would we do with the natural world? Biologists tell us we have identified (meaning someone has given a dead specimen a name) about 1.5 million species, while the estimated number that exists is thought to be between 10 and 15 million. So we may have an inventory representing 15% of Earth's species biodiversity. But of those identified, the number for whom we have more detailed knowledge of life cycle, numbers, distribution, reproductive habits, and interaction with other species is a fraction of 1% (E. O. Wilson, personal communication). So we have nothing like

of years, the modern GBR evolved to distinctive types of coral assemblages, depending on the seafloor depth and slope below and on the distance from the mainland.

Certainly the GBR is not one class of coral reef, and its diversity of form and function has contributed to both its biological diversity and its aesthetic appeal. Significantly, from the point of view of wise human management of this natural wonder, the complex interactions and interdependencies of physical, chemical, and biological processes that established, nurtured, and continue to protect and sustain the GBR are not yet fully understood. But we do believe there is sufficient evidence to indicate that human management is necessary to counter adverse impacts, which seem to be at a level not consistent with the maintenance of the past vitality of this 2000-km length of coral assemblages and associated plant and animal life.

We must ask ourselves, "What has changed?" and "What are the impacts of those changes?" "If we can identify those changes and their impacts, are there actions we can take — particularly to remove, or to reduce dramatically, any adverse impacts from those changes?"

Because our coral reef ecosystem knowledge is imperfect, our first attempts to correlate "possible changes" with "observed adverse impacts" may not always be correct, but if long-term systematic monitoring is maintained, and associated interdisciplinary research facilitated, we will progressively improve the knowledge base on which secure management practices can be developed, substantiated, and implemented.

Concurrently, we must encourage decision-makers to invoke the Precautionary Principle and ensure that scientists and technologists integrate continuously with decision-makers and managers.

The current knowledge base is certainly adequate to identify those parts of coastal Queensland where certain types of activity should or should not be permitted, and to suggest ways that any adverse impacts of existing permitted activities can be minimised.

THE NEED TO MANAGE THE GBR

Recognition of the need to wisely manage the GBR is not new, nor is it isolated from the time of greatest awareness of the need to nationally coordinate the wise management of Australia's natural resources.

The 1970s stand out in this regard. The Seas and Submerged Lands Act of 1973 and the Great Barrier Reef Marine Park Act of 1975 are but two pieces of Federal legislation, which characterise this national concern. They are, however, the most relevant of the several acts with respect to the protection and wise use of the GBR, through the establishment and development of the multiple-use Great Barrier Reef Marine Park (GBRMP) and the creation of a management body, the Great Barrier Reef Marine Park Authority (GBRMPA).

In 1976 the three-person GBRMPA met for the first time, with one representative of the Federal Government, one representative of the Queensland Government,

and one "independent person." This Authority was advised by the Great Barrier Reef Consultative Committee (GBRCC), which comprised members from all the major "user groups" of the GBR, and was supported by a dedicated and highly committed staff. The GBRCC could also directly advise the Federal Minister responsible for the GBR.

In recognition of the overlapping Federal and Queensland powers in the region from mainland to reefs, and from islands to reefs, a GBR Ministerial Council was established to exercise the necessary balance of political direction, with two ministers from the Federal Government and two ministers from the Queensland Government.

Subsequently, the GBRMPA has been slightly enlarged in membership, and it continues to operate, with the added awareness of recognition of the international significance of the GBR, subsequent to its inscription on the World Heritage List in 1981.

The national and international pressure for wise management of the GBR has grown with the years since the GBRMPA was established, and government objectives to ensure that the various uses permitted within the multiple-use GBRMP are in fact sustainable have been particularly obvious in the years since 1997.

A secure interdisciplinary knowledge base is essential for such multiple use and for sustainable protection of the GBR.

BROADENING THE SCIENTIFIC BASE

The scientific study of the GBR, and of the interactions and interdependencies that distinguish this remarkable ecosystem, has become much more sophisticated since the first establishment in 1961 of a university presence within the area adjacent to the GBR.

In 1961 the University of Queensland established a University College in Townsville, which is roughly midway along the length of the GBR. Prior to that, most GBR research was conducted from southern universities and museums, notably the University of Queensland (UQ), the University of Sydney, the Australian Museum, and the Queensland Museum, often through the Island Research Stations at the southern end of the GBR (Heron Island and One Tree Island).

It is not unfair to say that, prior to 1960, research on the GBR was concentrated in the hands of a very few people, many of whom resented the introduction of any new or competitive effort into the area.

The establishment, in 1961, of the Townsville-based University College (which grew to become James Cook University of North Queensland in 1970) heralded the arrival of a new group of Barrier Reef researchers, and a new spirit of scientific collaboration.

Dramatic improvement through the 1960s in a technology, now very much taken for granted, also expanded our ability to directly observe and record marine processes. That was SCUBA diving.

THE EMERGENCE OF PUBLIC CONCERN FOR THE HEALTH OF THE GBR — AND ITS CONSEQUENCES

In the latter half of the 1960s, there emerged a strong case for an increased commitment to tropical studies, both in marine and terrestrial systems. Tropical agriculture, tropical veterinary science, tropical medicine, and tropical marine science were all considered as possible areas of emphasis for the expanding University College of Townsville. Senior state and federal politicians visited the Douglas site of the developing James Cook University of North Queensland to evaluate the different options.

Two factors may well have influenced the immediate emphasis on marine and "reef" issues, compared with the other competitive tropical issues.

Public awareness of the occurrence of the crown-of-thorns starfish, and of its adverse impact on hard corals of the GBR, grew dramatically in the late 1960s and early 1970s. The then Premier of Queensland and other politicians entered into newspaper debate with prominent scientists on the extent of damage by the crown-of-thorns starfish to the GBR. It became a state and federal item of concern.

The GBR also became a focal point for discussion on the prospects of oil drilling on the GBR, and conservationists heightened their demands for protection of the GBR and for the complete exclusion of drilling for oil, or mining, for commercial purposes.

The GBR and marine science had become matters of public concern. The knowledge base for management of marine regions was revealed as dreadfully inadequate. Debate began on the need for a separate research institute or centre to concentrate on marine scientific studies.

After a period of intensive debate and competitive bids from Brisbane, Mackay, Cairns, and Townsville, the Federal Government announced that the Australian Institute of Marine Science (AIMS) would be established on a 500-acre site, within a National Park, some 50 km from central Townsville. From 1973, AIMS progressively emerged as a world leader in tropical marine research, with an emphasis on coastal and reef oceanography, corals and coral reefs, mangroves, and coastal processes and resources. Meanwhile James Cook University was continuing to increase the depth and breadth of its commitment to tropical marine studies and to marine park management.

When the GBRMPA was established in Townsville in the latter half of the 1970s, Townsville was beginning to establish the intellectual infrastructure to become a world leader in tropical marine science, technology, and multiple-use marine park management.

The latter years of the 1970s and the 1980s will be recalled as the period when national attention was directed to the value of Australia's marine resources, with considerable emphasis in the tropical regions. The Australian Marine Science and Technology Advisory Committee (AMSTAC) was established to advise the Minister for Science on priorities for marine research; special funds were allocated for marine research, and competitive bids were assessed through the Marine Research Allocations Advisory Committee (MRAAC) for the Marine Sciences and Technologies (MST) Grants Scheme. In the early years of the MST Scheme,

the greatest percentage of available funds was allocated — deliberately — to GBR projects.

THE RELEVANCE OF SCIENTIFIC RESEARCH TO THE MANAGEMENT OF THE GBR

In the introductory words, I referred to the presentations in this publication as "a fascinating collection." They are equally a collection directly relevant to management needs. They could well be significant in changing public, development, management, and political opinion of the condition of the GBR, and of the pressures that may be adversely affecting that condition. But will they be read and understood by those groups? I suspect not — unless we mount a concerted effort to use this volume as a basis for effective communication outside of the scientific community. There is a need for that extension of communication.

The past four decades have witnessed a vast increase in human impact on the GBR. This impact is not only due to increased numbers of people visiting the reefs, but perhaps more to the technological opportunities that have been adopted on land and on water, without adequate consideration of their long-term adverse impacts on natural habitats, populations, and interactive systems.

Environmental Impact Assessments have been seen as necessary only after clear examples have been shown of adverse impacts of related activities. We have not used our knowledge adequately to forecast impacts of new technologies before they are in use.

The Precautionary Principle has not been as strong as the Economic Rationalism, which is so contrary to the principles of Ecologically Sustainable Development, and we have not yet learned to assess economic benefits and costs alongside, rather than in front of, social, ecological, cultural, and aesthetic benefits and costs.

A classic example of this is the way in which proposals for major coastal developments have been considered in the majority of coastal areas adjacent to the GBR. Awareness by the public, and by scientists, of such proposed development is generally long after some money has been committed by a proposed developer for feasibility studies. When public and scientific concerns have been raised, the claim is made that the development proposal must go ahead because of the amount of money already expended — and perhaps because some preliminary site works have already commenced. This type of process is ecologically unsustainable.

Two acts of Parliament of the Queensland Government have the potential to completely remove such practices. One is the Coastal Planning and Management Act (1995), and the other is the Integrated Planning Act (1997). But legislation itself is not the solution. It is essential that a partnership for sustainable development be established and maintained, between decision-makers, developers, and scientists. The Cooperative Research Centre (CRC) concept facilitates such partnerships, and the CRC-Reef could fulfil that role.

There has been a tendency for us scientists and technologists to lay the blame for poor development decisions at the hands of the Economic Rationalists. But my

experience is that we, as scientists and technologists, have been ineffective in translating our knowledge into a form that is easy to understand by the decision-makers. There have been exceptions, but not enough! And, of course, it is not difficult to find the scientist willing to negate the claims of another, so that the media and the decision-makers are left in doubt as to the security of the information they are receiving. Yet we do have a more secure information base than do the majority of the economic planners. That anomaly must be corrected.

The papers in this volume relate to a wide range of topics which demonstrate how improved scientific and computer techniques can be used to better explain and demonstrate how ecosystems function, and how relatively minor changes may have significant impacts on biological species and their interactions. Many of the papers reveal the value of interdisciplinary studies, and of the way in which physical, biological, and chemical features are so closely interrelated and interdependent.

This could well be a publication to be used to better plan for developments on and adjacent to the GBR region. Its readers should be people concerned for and involved in wise management of the GBR — and of all coral reef systems.