BOOK REVIEW[1]

Tropical Marine Pollution. Edited by E. J. Ferguson Wood and R. E. Johannes. Elsevier Oceanography Series, 12. Elsevier Scientific Publishing Company, New York. 192 p. $26.95.—There have been numerous compilations and reviews of oil pollution studies from work carried out in temperate regions since the wreck of the Torrey Canyon in 1967. Until recently, the data and conclusions of work on pollution in tropical marine systems was widely scattered through the literature, often available only in difficult-to-locate impact studies and technical reports. A very thorough, well organized, concise and clearly presented summary of our present understanding of tropical marine pollution is now available in a book planned by the late E. J. Ferguson Wood and edited and completed by R. E. Johannes.

The six chapters that make up this book fall into three categories. The introductory chapter is a heuristic summary of basic physical and biological differences between tropical marine systems and temperate marine systems and how these differences in characteristics would predict different behaviors of pollutants and biotic responses to pollution. The next four chapters are reviews of our states of knowledge concerning the effects of pollution on coral reefs, mangrove forests, sea grass beds and tropical-type estuaries. The final chapter is not actually a review but is a good research report, perhaps included to serve as a model impact study with a useful evaluation of the efficiency of the methods that were used.

The book appears to have been written with the intention of expressing two main points. First, an understanding of marine pollution in the tropics and effective diagnoses and treatments cannot always be based on extrapolation from our knowledge of marine pollution in temperate regions because some differences in the biology of the organisms from the different regions are qualitative as well as quantitative. Second, measurements and indices routinely taken as a standard method for evaluating pollution can be misleading if the investigator does not have an adequate understanding of the ecology and natural history of the system under study.

The introductory chapter by R. E. Johannes and Susan B. Betzer is a comparison of the differences in tropical versus temperate marine systems in terms of the physical and chemical characteristics of the water, the biological functions and life history characteristics of the species, and community structures. Comparisons are presented in a table of 46 differences in characteristics accompanied by a total of 106 literature citations upon which the comparisons were based. In the text, these comparisons are organized into some reasonable generalizations that allow us to make predictions about the responses of tropical organisms and marine communities to pollution and about the relative efficiency of water treatment systems in the tropics. The concepts and generalizations are not particularly new as separate parcels, but they have been organized with respect to other concepts and with their supporting literature in a manner that makes it clear what is based on logical extrapolation and what is based on evidence. For instance, several generalizations are based on the assumption that metabolic rates of marine organisms increase with a rise in temperature; therefore, as the water temperature rises, the critical oxygen concentrations increase while the solubility of oxygen in water decreases. Johannes and Betzer point out that most of the data on the effects of temperature on critical oxygen levels for marine animals are from temperate and cold water species. They suggest that tropical marine animals are closer to their oxygen limits while acknowledging the need for investigation of possible physiological and behavioral mechanisms in tropical animals that allow them to survive the normal fluctuations in dissolved oxygen concentrations. In other words, we have a logical basis for predict-

[1] Contribution No. 84, The Marine Laboratory, University of Guam.

Micronesica 12(2): 335-338. 1976 (December).

ing that tropical organisms are potentially nearer to their critical oxygen limits but we are not sure that they do not have their own adaptations to get around this problem. Perhaps the main purpose of the introductory chapter is to stimulate investigation and to organize our generalizations in a way that suggests which information and data are most needed.

Similar to the mistake of failing to consider the possible existence of special adaptations of organisms to particular problems in tropical regions is the potential mistake of assuming that organisms from temperate and tropical regions are adapted to an equivalent range of variation from the usual conditions in their particular habitats. As an example, we would be inclined to assume that shallow tropical reef species would be able to adjust to thermal effluents more effectively than would temperate species because they are adapted to living at higher temperatures. Although this assumption is quite logical, it is often false. Six studies are cited in Chapter II from the literature about corals and over a dozen studies are cited in Chapter V from the literature for algae, crustaceans, or marine animals in general. When taken together, these studies support the generalization presented in Chapter I that many tropical species live closer to their upper lethal temperatures than do their temperate and polar counterparts. A 5°C increase in ambient water temperature from the input of thermal effluents may be more harmful to tropical marine communities than to temperate marine communities. Although tropical marine organisms are adapted to warmer water temperatures than are temperate marine organisms, this does not necessarily imply that they can withstand an increase in temperature of the same magnitude.

Another qualitative difference between temperate and tropical regions under stress from thermal effluent is that in temperate regions, the flora and fauna eliminated by the change in conditions may be replaced by a comparable association of different species from warmer regions which was originally kept out of the area by the competitive superiority of the residents. In regions of the tropics where the normal ambient water temperatures are near the highest, there are relatively few species available to replace those killed off by an increase in water temperature by thermal effluents. Sometimes the replacement association is not of comparable complexity to the system eliminated, but is a simpler system of a few species capable of tolerating even more extreme temperatures, an example being blue-green algae.

Johannes and Betzer also point out that the pollutants themselves can act at different rates and in different manners under the chemical and physical conditions of sea water in the tropics when compared to their behaviors in the cooler temperate waters. As was found to be the case when farming methods which were highly successful in the Great Plains were brought to the tropics, the differences in the ecology of temperate and tropical regions cannot be ignored.

A number of the comparisons presented in Table I of Chapter I could be effective catalysts for discussion sessions or seminar topics. Is the impression noted in Table I that colonial life forms are favored more in the tropics due to the emphasis on hermatypic anthozoan and hydrozoan corals which deposit aragonite more easily at warmer temperatures ? Colonial tunicates, bryozoans and sea pens are examples of colonial species that determine the life form of extensive subtidal communities in the northeastern Pacific. Colonialism per se may not be directly favored by tropical conditions. What is the implication of the observation stated in Table I that tropical species of marine invertebrates and fish tend to be smaller than their temperate counterparts? Even though tropical species have a general tendency to be small, the largest species of anemones, octocorals, stony corals, gastropods, bivalves, sharks and fishes are all tropical. It may be that there are simply more co-occurring species in the tropics and additional species tend to be smaller. Could the tendency for small size of tropical species be directly related to the greater number of species and only indirectly related to the tropical characteristics of the environment per se? The statements in Table I about higher rates of evolution, greater biological control of community structure, higher incidence of asexual reproduction, slower larval development in the tropics and other such conclusions are a summary from comparisons based on inconclusive data and are likely to stimulate debate and, hopefully, research.

The review of our state of knowledge on pollution and degradation of coral reefs in Chapter II by R. E. Johannes is very thorough, covering the problems of dredging, oil spills, bad land management, sewage, and other issues usually discussed along with other problems not often discussed in previous reviews because they are not major problems in temperate regions, e. g., fishing with poisons and explosives, commercial collecting of aquarium fishes, ciguatera, and other topics. The use of explosives by local fishermen is a major problem in Micronesia and a descriptive list of anatomical disarrangements is provided so that fish collected by this method could be identified in the market.

Several examples were given in Chapter II to show how standard measurements and indices routinely taken can be misleading if the investigator does not have an understanding of the ecology and natural history of the community under study. For instance, when large numbers of small coral colonies begin to recolonize an area following a catastrophic kill-off, the species diversity may be greater than the species diversity of the community before the catastrophe when space may have been occupied by larger, but fewer colonies. Small colonies may together occupy a large amount of the substratum because of their numbers and encrusting species may have survived the catastrophe better than the tall arborescent forms. High readings for surface cover and species diversity may not be a good measure of the recovery of the community because the difference in life form and size distributions of the corals may not be reflected in a measure of substratum covered or in species diversity of the coral community. Tall arborescent corals may not occupy as much of the primary substratum as encrusting forms, but they are more important as shelter for fishes and invertebrates.

Low oxygen levels have been associated with organic and nutrient enrichment and have therefore been used as a measurement of the state of the system. However, in natural conditions in reef communities, the amount of oxygen produced by photosynthesis during the day might nearly be matched by oxygen uptake by respiration at night. Johannes points out that "In enriched waters, rapid photosynthesis may produce abnormally low nighttime levels. Thus, measurements limited to daylight hours can lead to false confidence in the state of the system."

The collection and removal of small colorful cleaner fish from a reef to sell for aquariums may be concluded to be of trivial concern because they constitute a negligible portion of the biomass of the community of reef fishes. However, the consideration of biomass alone is another example of calculating the expected impact of a process from standard measures without being familiar with the natural history of the species or ecology of the system. The relative importance of species in the determination of community structure may be disproportionate to their relative biomass.

In addition to warning that standard measurements and indices can be misleading without a basic understanding of the system, Johannes also points out other conceptual complications of tropical coral reef systems. Once coral reefs have become established, they may maintain themselves although the environmental conditions have changed in such a way as they are now in a state of environmental conditions that would not have allowed the initial establishment of the reef. If the reef is devasted by pollution, the cleaning of pollution does not guarantee that the community will replace itself since the natural environmental conditions may have changed since time of the original establishment of the reef community. Examples are given from the literature of reefs that have had negligible recovery decades after the catastrophe. Other conceptual complications involve sublethal stress and extrapolation from short-term laboratory experiments. Johannes documents that under conditions of sublethal stress the behavior of organisms can change in such a manner that they could not survive for long in nature although they are able to survive the stress under laboratory conditions. Also, stress factors can act synergistically. This complicates a prediction from a simple additive combination of stress factors.

Like the chapter on coral reef pollution, the chapters on pollution of sea grass beds (by J. C. Zieman), mangrove communities (by W. E. Odum and R. E. Johannes) and tropical-type estuaries (by J. C. Zieman and E. J. Ferguson Wood) present some original considerations. For instance, from our intuition based on terrestrial grasses, we would assume that sea grasses would rapidly reinvade cleared or disturbed areas of sandy substratum which were orginally occupied by sea grasses. This is not always the case. *Thalassia* is highly productive and if only its leaves are removed, by either grazing or storm damage, even as often as three times a year, regrowth is rapid because of energy reserves stored in the rhizomes. However, if its rhizomes are broken up, the rhizome mat will not be replaced, sometimes for as long as 10 years. This is not the case for another genus, *Halodule*, which is less resistant to pollution or anaerobic conditions but will rapidly reinvade an area even if upro- oted.

Mangroves are documented as having remarkable physiological adaptation to both widely fluctuating and extreme environmental conditions. However, they have an Achilles Heel. The aerial roots of mangrove trees which allow them to succeed in anaerobic soils where most plants cannot survive are also their most vulnerable components. Aerial roots are particularly susceptible to clogging and drowning.

In addition to living closer to their upper thermal lethal limits, organisms in tropical estuaries are often in greater hazard than are those in temperate regions because evaporative cooling is depressed by the high local relative humidity.

The final chapter by R. H. Chesher is an impact study concerned with the effect of a large-scale desalination plant on the local marine communities at Key West, Florida. At the end of the chapter, the several methods of biological surveys, investigations, and experimental designs are assessed and evaluated as to their relative efficiencies, merits and shortcomings.

Many (probably most) of the up-to-date findings from tropical marine pollution studies are in hard-to-locate technical reports and impact statements. At the end of this volume is a 29 page bibliography listing 633 references, many of which obviously had to be searched out by personal correspondence.

In summary, TROPICAL MARINE POLLUTION is a fine review and organization of material which was previously widely scattered and in hard-to-locate sources. The presentation was concise, stimulating, and included some concepts new to the field of marine pollution. Some of the conclusions need verification and are open for debate but where further studies are needed is made clear. The discussions are heuristic, not misleading. There are almost no typographical errors. This book is almost indispensable for any student or professional person in the fields of tropical marine biology, ecology, coastal zone management or urban planning in Micronesia. After lavishing this sincere praise, I cannot ignore the problem that students in these fields may be discouraged by the price of this book. Including only a single half-page photograph, this book consists mostly of printed material and costs 14 cents per page. At $26.95, the book is marketed mainly to institutions, libraries and unmarried professors. Since the pages are small enough to fit two to a long sheet, the entire book could be xeroxed for $4.80 at 5 cents per page by those potential buyers excluded from the market by the price, were it not for the copyright laws.

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Printed by the International Academic Printing Co., Ltd.,
8–8, 3-chome, Takadanobaba, Shinjuku-ku
Tokyo 160, Japan