

this book makes to the history of a science which has been, and still is, very difficult to assess in its entirety. Certainly the author is to be warmly congratulated on a splendid achievement.

J. B. Tait
"Macbieknowe",
West Linton, Peeblesshire,
Scotland

Michael Culley: The Pilchard. Biology and Exploitation. Pergamon Press Ltd., Oxford, 1971. International monographs on pure and applied biology, zoology division, 48: 241 pp., £ 8.00.

The publishers write on the book jacket that 'The work will be of interest to food and fisheries scientists and to all students of applied biology and zoology. It will also be a useful supplementary text for students on degree courses in marine biology'.

The author has divided the book into five parts. Part 1 comprises 22 pages and the author discusses in three chapters *The Importance of Pelagic Fisheries*, *The Geographical Distribution of Sardines*, and *Factors of Production in the Sea*. In the first chapter he introduces the concepts of fisheries management and population dynamics of fish. Surprisingly no references are made to Beverton and Holt or Gulland in connection with either of these subjects. Indeed, there is no citation to these authors in the book's bibliography – a somewhat remarkable feature in a book of 241 pages.

Part 2, consisting of some 118 pages, comprises 12 chapters on *The Pilchard Industry of England*. The basic biology of the pilchard is covered in two chapters, and consists of a summary of a number of papers mainly by English authors, the latest reference citation being 1963. There are no references to the more recent French investigations on the pilchards of the Bay of Biscay and Brittany. Historical information of some interest is presented concerning the economics of the pilchard fishery, the methods of fishing employed up to 1964, processing techniques, seasonal changes in fat content, and sales outlets for processed products.

Details of monthly catch statistics for 1947 to 1965 inclusive are discussed and the change in catch pattern of the fishery in the 1950's is noted. It is a pity that the author did not continue his enquiry beyond 1965 since a further 5 years of official statistics must have been available prior to publication date. In these more recent years some further changes of interest have taken place.

From remarks on the problem of forecasting changes in pilchard abundance one would gain the impression that no basic biological data have been collected in recent years. Since 1947, with the exception of five years, pilchard samples for age analysis have been taken from the fishery in the south-west by the Fisheries Laboratory at Lowestoft. The level of sampling has not been high but commensurate with the low level of annual catches which are of the order of 3000 tons per annum.

Part 3 in 35 pages provides a useful summary of the history of the Californian sardine industry. It brings together the conclusions of a great number of papers. The author strongly supports the view that the decline was due to overfishing.

Part 4 gives a summary of literature on the South and South-west African pilchard industry. This section of 36 pages covers the fisheries up to 1967. Again, as in the case with the English pilchard, the developments of the fisheries since that date are of considerable interest and it is a pity that the author did not up-date his manuscript.

Part 5 is a statistical appendix which gives data summaries of world sardine and pilchard industries taken from the FAO Yearbooks of Fishery Statistics.

Mr Culley's book is clearly written and beautifully illustrated. However, there are rather many unsubstantiated asides such as: 'It is now thought that complex biological changes were the cause of the failure of the East Anglian herring fishery' – a statement which hardly reflects the real situation. It is a disappointing book to me as the major part on the UK pilchard fishery is an uncritical summary of pieces of information of varying scientific 'quality'. As a student's guide it would be of limited value, particularly as the reference citations do not provide the introductions that one might expect into wider fishery fields.

A. C. Burd
Fisheries Laboratory,
Lowestoft, Suffolk,
England

A. E. Maxwell (Ed.): The Sea. Volume 4. New concepts of Sea Floor Evolution. Part 1 General Observations. John Wiley and Sons Ltd., Chichester, Sussex, 1971, 791 pp., £ 15.25.

When Sverdrup, Fleming and Johnson completed *The Oceans*, they were able to make a comprehensive statement on oceanography in one volume. Their

work was finished in 1938 as oceanography started changing from an academic field of research to an applied science of great importance to naval commanders. Because of accelerated rate of progress during the 1940's and 50's it became necessary to revise *The Oceans* so that significant new developments could be described. An editorial board under the chairmanship of the late M. N. Hill, F.R.S., brought *The Oceans* up to date in 1963 by the publication of the first three volumes of *The Sea: Ideas and Observations*. But the rapid rate of progress continued so that a new volume was required less than eight years after the publication of the first three. The most significant advances in the intervening period have been in the understanding of the geology of the ocean floor. It is thus appropriate that Volume Four is largely concerned with this subject and that the work is dedicated to the memory of Maurice Hill, one of the pioneers and major contributors to modern oceanography.

Volume Four is a massive production, in three parts, bound in two books. Part One is reviewed here together with some general observations on scientific compendia. Parts Two and Three are discussed in the accompanying review.

Part One runs to 791 pages and has 378 illustrations, almost all of excellent quality. The material is arranged in twenty chapters written by thirty-seven authors who are recognized as authorities in their specialities. Thirty-two of the authors work in the United States so the volume primarily reflects the American point of view. It is generally acknowledged that the United States oceanographic community has made the major contribution to present knowledge; it is regrettable, nevertheless, that contributions could not be secured from a more representative international group.

The various disciplines of marine geology are treated in twenty chapters which range in length from six to sixty-seven pages. Each chapter is self-contained and has its own references. It is noted that identical illustrations appear several times and many references are cited more than once. If the latter were collected in a bibliography section at the end of the book, the bulk could have been reduced by about sixty pages.

The bulk could have been reduced also by more rigorous cutting by editors of sections which represent catalogues of data and observations. There are twenty pages of reproductions of seismic profiler records in Chapter One and other catalogue information is found in chapters on Magnetic Anomalies, Heat Flow, Gravity, Seismic Refraction and Earthquakes and Tectonics. Although these catalogues are as good as might be expected, they do not give enough

detail and are not complete for those who really need this type of information. To others, the catalogue sections will appear as unnecessary contributors to the overall cost. A book which is intended as a long lasting and definitive reference should not contain catalogues of original data since these catalogues are bound to be out of date and incomplete by the time the book is published. In addition to leaving out the data, I would have eliminated also Chapter Fifteen: Continental Radiometric Ages. Admittedly, the subject has relevance to the topic of Continental Drift – but so does all geology.

By comparison with Volume Three, chapters on older marine geophysical techniques (Seismic Reflection and Refraction, Magnetic Anomalies, Gravity and Heat Flow) are somewhat disappointing, since they are limited to discussion of the progress and expansion of work already well developed at the time when Volume Three was published. Although there was much progress to report, one somehow feels that it could have waited until Volume Five so that qualitative as well as quantitative advances could be appreciated. On the other hand, the new emphasis on the study of oceanic rocks is well represented in three chapters (130 pp.). One could wish for more. The next qualitative jump in our understanding of marine geology (and ultimately world geology) is likely to come from greatly expanded studies of rock samples recovered from the ocean floor.

A new topic introduced in Volume Four is the discussion of Electro-Magnetic Induction in the Oceans (two chapters, almost one hundred pages). The observational techniques are very difficult and the theoretical treatment introduces too many simplifying assumptions so that only approximate results could be obtained to date. As the bigger and more powerful computers become available it will be possible to describe the solid boundary more precisely and to treat more complicated mathematical expressions. Then it might be possible to describe the structure of the Earth's outer layers with greater precision. Another new topic is the discussion of "The Benthic Boundary Layer", the part of the ocean which is in direct contact with the ocean floor. The treatment is approximate and the results preliminary, but the significance of the chapter is in emphasizing the unity of oceanography: the heat flow from the Earth modifies the boundary conditions of the water masses while the mathematical expressions show analogy with the atmospheric boundary layer (except for the scale of parameters).

It may seem surprising that in a volume on the ocean floor only one bottom photograph is to be found amongst 378 illustrations. The great excite-

ment with bottom photography has generated perhaps some hundreds of thousands of negatives now neatly (or often not so neatly!) filed in laboratories around the world. They have helped us form an impression of different ocean floor provinces, but the scientific contributions have been minimal. Photography will therefore remain an auxiliary tool, primarily to be used to monitor operations of other equipment. As a detailed mapping technique, the near bottom side-looking echo-sounder technique of Spiess and Mudie is more promising (Chapter Seven: Small Scale Topographic and Magnetic Features). For this reviewer, Chapter Seven is the best example of the type of material that a review volume like *The Sea* should contain. The "Deep-tow" method is brand new, developed mostly since Volume Three. It is fully developed so that a number of results can be discussed, yet it has not been adequately described elsewhere. The description is important because this tool will expand our understanding if wisely used and if the technical problems can be solved so that multiple installations become feasible.

A few editorial suggestions could be made regarding this volume. Contents of previous volumes and of Parts Two and Three should be given in Volume Four, Part One. The Index is excellent and no obvious faults were found. It could have been expanded, however, in particular by using more "see also" references. Although the book is expensively produced, the binding does not appear to be strong enough: it was broken on a library copy belonging to a small research unit after a month of use. All chapters are dated but it is not clear what this date means. Presumably it is the date of the last revision by authors but if so this should be stated. Discussion of specific instrumentation and "gadgetry" has been resisted and in this way the book represents a departure from older oceanographic literature. In these days of rapidly changing technology the instrumental details have very little permanent value. Nevertheless, the old sea dogs will miss descriptions of ingenious new devices like "pickle-bottle-bung connectors" and "jelly-jar current meters", or sketches of how to rig an over-the-side assembly. There are, however, at least three instrumental developments which deserved a mention in *The Sea*. Satellite navigation has become routine and is already revolutionizing marine research; digital computers are taken to sea on a number of ships and have made automatic data acquisition and processing a reality; and new submersible devices, both manned and unmanned are likely to have a great influence on future technological developments leading to the exploitation of the ocean floor riches. Perhaps an additional chapter on "Marine Research Technology" could have filled a gap.

Appreciating the problems of an editor and bearing in mind the fact that the metrication question has not been resolved, perhaps a reviewer should not harp about the units. Nautical mile and fathom (defined as 1/800 of a second) will be hard to replace in any case. Nevertheless, unless we as scientists can resolve the jungle of units, it will be resolved for us by decree. Proper use of units (like a correct spelling) is largely a question of self-discipline. Future editors will be well advised to state at the outset their policy regarding the units.

Preserving a unity in a compendium like *The Sea* is a gargantuan editorial task, and general editor A. E. Maxwell has done an outstanding job with the text following closely the style and tradition established by M. N. Hill. The unity of the volume is somewhat interrupted however by the variety of styles used in the preparation of illustrations. Different styles exist, not only from chapter to chapter, but also within chapters, since the diagrams were prepared at various times for a variety of purposes. Redrafting three hundred diagrams would have inflated the price beyond all reasonable limits so, regrettable as it may be, we probably have to accept some differences in style. The editors could have insisted, though, that each chapter be consistent and could have again issued firm guidelines to insure some measure of conformity.

With thirty-seven authors there is little possibility of achieving a complete conformity of style, treatment, scope and presentation irrespective of how firm the guidelines may be. That kind of unity can only flow from one pen and we might ask the question whether a compendium like this should not be written by one person. It is immediately obvious that such a person will have an impossible mission, since the majority of scientists would refuse to prepare the background material for someone else to rework into a book and so (presumably) receive the credit. A large part, perhaps as much as three-quarters, of the material in Volume Four, Part One, is not new, but has been published elsewhere. The remaining quarter is the critical review and interpretation of the data by each author, and this could have been done by one person almost as well as by thirty-seven. To be sure, the task is monumental and requires the type of scholarship not often associated with earth sciences. Perhaps someone should try it, though some relevant questions must be answered first: What is the purpose of a scientific compendium like *The Sea*; do we, as a scientific community need such publications; can we afford the resources necessary for this production and, assuming that the publishers will keep trying to publish encyclopaediae as long as they are commercially attractive, should

we support their efforts by a) writing contributions, and b) by paying exorbitant prices for the books?

The answer is not a simple one, and depends on the objectives of the compendium. For centuries groups of eminent scientists and thinkers have been attempting to put together a definitive "Book of Knowledge", a compendium of everything that is known on a subject. The eleventh edition of Encyclopaedia Britannica was probably the last successful effort. It is not possible, with the current rate of expansion of knowledge, to make a compilation which is not out of date by the time the work appears in the book stores. Except for a fleeting moment, no review volume can claim to be up to date. Even the established, recognized and accepted means of communication of scientific results through specialized journals is unsatisfactory due to the delay between the completion of research and publication. The delays associated with book production are even longer and thus books are even less satisfactory for publication of original results. Books like *The Sea* as already discussed, should not be used as catalogues of data and should not be used for rehashing already published material.

By elimination, therefore, we conclude that the main purpose of a scientific compendium should be to present an integrated interpretation of the whole field of research. Perhaps this can only be achieved by reworking material already collected in a book like *The Sea*. The interpretative analysis will certainly be easier with *The Sea* at hand. For this we should be grateful to Maxwell, his editorial board, and the galaxy of authors. But as scientists we must remember that there is one more step to be taken.

The editor of an early edition of Encyclopaedia Britannica claimed that their product was "not merely a register but an instrument of research". Modern editors of scientific compendia would be well advised to keep this dictum in mind.

B. D. Loncarevic
Atlantic Geoscience Centre,
Bedford Institute of Oceanography,
Dartmouth, Nova Scotia,
Canada

A. E. Maxwell (Ed.): *The Sea. Volume 4. New Concepts of Sea Floor Evolution. Part 2, Regional Observations. Part 3, Concepts*. John Wiley and Sons Ltd., Chichester, Sussex, 1971, 664 pp., £ 15.50.

J. Tuzo Wilson ends Volume 4 of *The Sea* with a suggestion that perhaps since 1956, but most certainly since the mid-sixties, the science of the earth

has undergone a scientific revolution. Wilson draws upon Thomas Kuhn's (1962) analysis of change in scientific thought to argue that the changes in the thinking of earth scientists in the sixties were not evolutionary or "normal" in nature but rather were revolutionary in nature and were changes "in which the whole frame of reference of a branch of science [was] altered" (p. 642). Wilson of course is speaking of the general acceptance and near proof of the concepts of continental drift and sea-floor spreading that have become such a unifying framework for much of geologic and geophysical thinking in the past decade. Wilson suggests that the scientific revolution, like that of Copernicus, should be named after its first protagonist, Alfred Wegener (1915) – *The Wegenerian Revolution*.

Wilson might have used Kuhn's argument even further as Marwell (1972) has, and noted, in Kuhn's terms, that Wegener was a man with a paradigm – a model "from which spring particular coherent traditions of scientific research." Such paradigms share two defined characteristics; "Their achievement [must be] sufficiently unprecedented to attract an enduring group of adherents away from competing modes of scientific activity. Simultaneously, it [must be] sufficiently open-ended to leave all sorts of problems for the redefined group of practitioners to resolve." (Kuhn, 1962, p. 10). But as Kuhn indicates such new paradigms draw more than just converts; they draw arguments and dispute, scorn and disbelievers, as Wegener has in the work of van Waterschoot van der Gracht (1928), Jeffreys (1959) and Meyerhoff and Meyerhoff (1972). Kuhn states that "Resistance is inevitable and legitimate" (p. 151). Marwell (1972, p. 19) puts it in terms perhaps more familiar, "... new paradigms are sects and cults competing with the established intellectual church. Churches do not suffer such competition gladly". It is perhaps a measure of the intransigence of established earth science, or perhaps a measure of the vision of Wegener that it took over half a century for the *drifters* – the converts – to gain control of the bastions of the Church. The control is now near-complete; the converts and the zealots are respectable. Wilson as a recent convert (contrast Wilson, 1951, with the book under review) is a zealot and one of the revolutions' most outspoken and peripatetic disciples. It is fitting that Volume 4 of *The Sea* should end with Wilson's own work on transform faults admixed with his historical and philosophical overview.

The Sea, Volume 4, Parts 2 and 3 is a book written by the converts for the converts. It deals entirely with the geology and geophysics of the oceans, and the ideas of continental drift and sea-floor spreading