History of a Systematics Odyssey: The Marine Flora and Fauna of the Eastern United States

MELBOURNE R. CARRIKER

On an early fall day in September 1962 I sat quietly, thoughtfully, at my large desk in a newly renovated corner office in the old Crane wing of the Lillie Building, Marine Biological Laboratory (MBL), Woods Hole, Massachusetts. Looking out through high, ancient windows, I could see the busy main street of Woods Hole in the foreground, Martha's Vineyard beyond, behind me the MBL Stone Candle House, across the street the Woods Hole Oceanographic Institution (WHOI) and to the far right, the Biological Laboratory of the Bureau of Commercial Fisheries (BCF)[1] (Fig. 1). Down the inner hall from my office stretched renovated quarters for the fledgling, ongoing, year-round MBL Systematics-Ecology Program (SEP), which I had been invited to direct.

Melbourne R. Carriker, now with the College of Marine Studies, University of Delaware, Lewes, DE 19958, was the founding editor of the Marine Flora and Fauna publication series and continues in that capacity.

[1]The BCF was then a part of the Interior Department's U.S. Fish and Wildlife Service. Since 1971, it has been the National Marine Fisheries Service under the Commerce Department's National Oceanic and Atmospheric Administration.

Where to begin? My desk top was empty. No one else had yet been recruited to the promising adventure: still only a plan on paper. There were objectives needing further focus, personnel to recruit, field and laboratory facilities (beyond those of the MBL) to establish, and contacts with neighboring New England universities to institute. It was, in truth, a lonely, but exhilarating moment! Thus began the fast-paced, demanding SEP directorship.

I was informed of the opening of the SEP directorship by Philip B. Armstrong, Director of MBL, who wrote me on October 23, 1961:

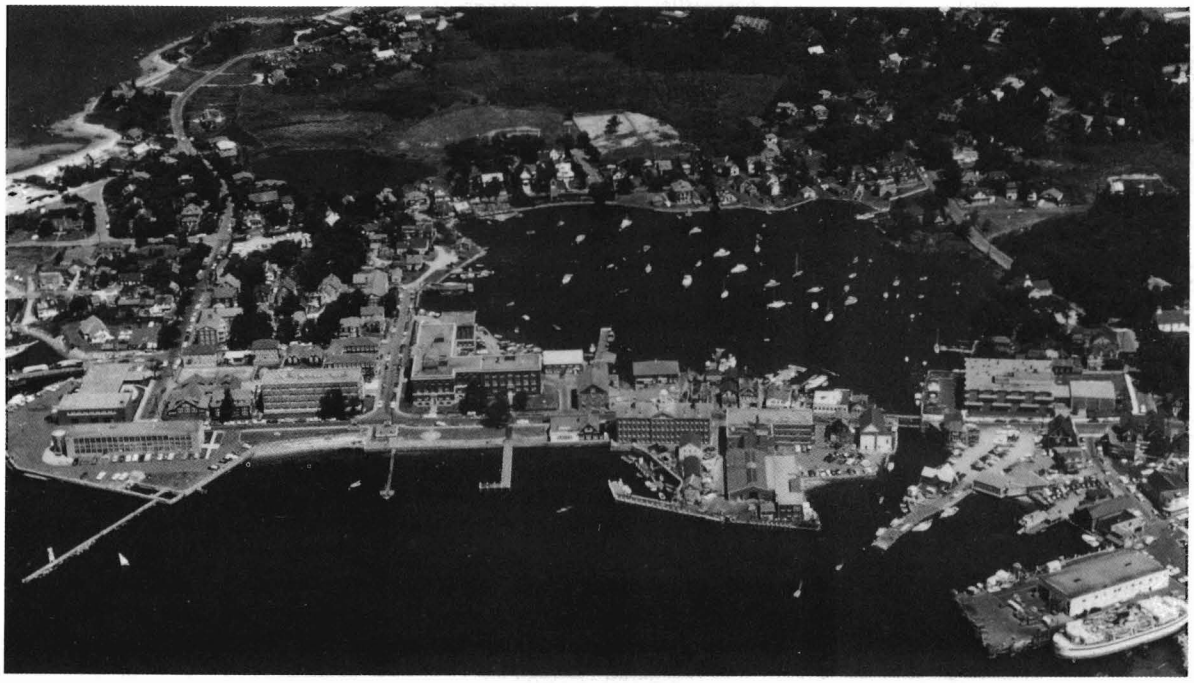


Figure 1.—Aerial view of the Woods Hole scientific community, ca. 1966. Today the Woods Hole Oceanographic Institution campus is extended some 2 km northeast to the Quissett Campus off Woods Hole road. Photograph by M. R. Carriker.

"The Marine Biological Laboratory, which is primarily a summer operation, is planning to embark on a year-round activity in marine systematics and ecology. The systematics segment of this program will be financed by a grant [$75,000] which the Laboratory has been awarded by the Ford Foundation. Would you by chance be interested in exploring this possibility with us?"

At the time I was serving as Chief of the Shellfish Mortality Program of the Biological Laboratory, Bureau of Commercial Fisheries, at Oxford, Md. Armstrong's letter came at a propitious moment. I was discouraged by the unresponsiveness of the Bureau to my requests to increase the personnel and enhance the research facilities of the Shellfish Mortality Program. Both were urgently needed to combat such bivalve diseases as MSX in the waters of the Chesapeake Bay. These circumstances, the proposed SEP, the allure of Woods Hole, and my desire for a professional change, tentatively framed my response.

There followed a meeting with Armstrong and Arthur K. Parpart (Vice President, later President of the MBL Corporation) at Princeton University, to discuss the proposed program; and shortly thereafter, a brief visit to Woods Hole and Falmouth, Massachusetts, with my wife, Meriel ("Scottie") and four sons, Eric, Bruce, Neal, and Robert, to explore at firsthand the new MBL position and living conditions on Cape Cod. Needless to say, I was impressed with the opportunity offered me, and expressed an interest in exploring it.

On March 28, 1962 Parpart wrote me:

"At a meeting of the Executive Committee of the Marine Biological Laboratory held on March 16, 1962 it was voted to appoint you to serve as Director of the Systematics-Ecology Program at the Laboratory. We sincerely hope that you will accept this position and the responsibility that goes with it. The appointment will become effective on September 1, 1962 at an annual salary of $12,500."

Four days later, enthusiastically but with some trepidation, I accepted Parpart's invitation. However, as the future course of events demonstrated, I need not have been disquieted. Begun as a long-range experiment, SEP in many ways was a highly successful one. A major, and the most enduring project of SEP, which continues to this day, is the "Marine Flora and Fauna" series of scientific reports issued by the National Marine Fisheries Service (NMFS) Scientific Publications Office (SPO) as a subseries of that agency's peer-reviewed Technical Reports series (Fig. 2, 3). Closure of SEP, after 10 full, crowded years, came about, not for want of merit, but because of dwindling foundational support, especially for systematics.

Although eager to start my new job, particularly in the stimulating intellec-

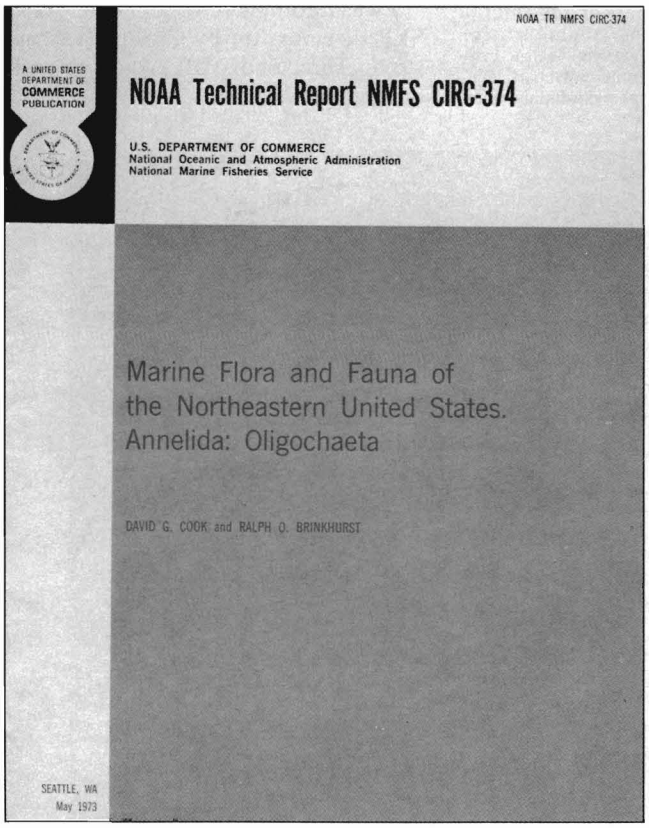


Figure 2.—Cover page of the first MFF manual to appear in print as a NOAA Technical Report NMFS Circular, 1973.

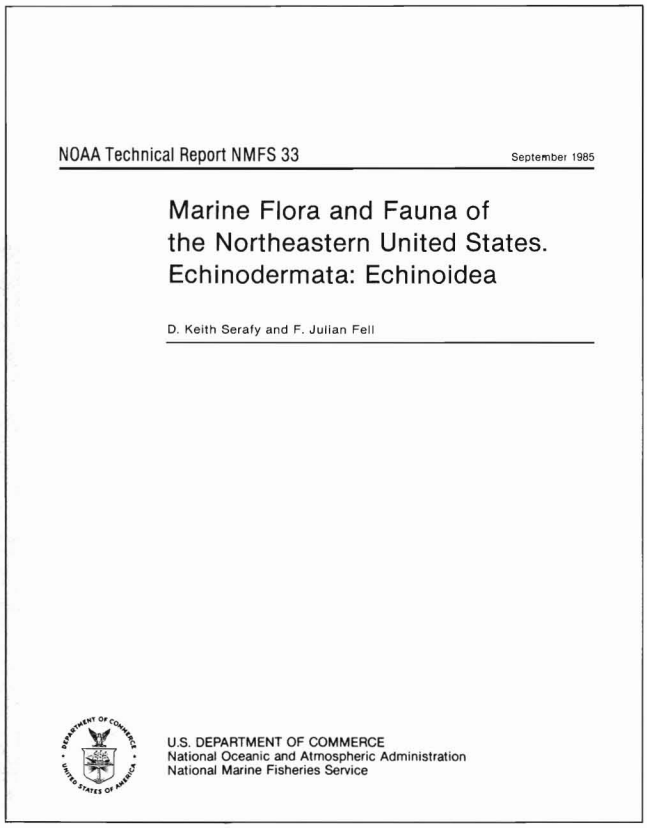


Figure 3.—Cover page of the first MFF manual to appear in print as a NOAA Technical Report NMFS, in 1985.

tual environment of the Woods Hole scientific community in the summer, I had some concerns. I was troubled by the potential impermanence of the proposed grant-financed SEP operation, the competition for space at MBL during the congested three summer months when most visiting scientists and their students were present, the low salaries of MBL personnel, and (as I soon learned) the often disparaging attitude toward whole-organism biology, especially biosystematics, by many of the visiting biochemical-molecular-cellular oriented biologists. I was also concerned about the mainly empty laboratories during the winter months. During SEP's first year or two from September to May, the Program was the principal, though minuscule, scientific activity at MBL. Essentially, we had the run of the physical facilities, library, chemistry stockroom, machine shop, biological supply services, and conference rooms pretty much to ourselves. On the whole, but for SEP, the MBL was an inactive, quiet place during the period October through April. We felt as though we were rattling around in an over-sized building. In time, however, to our advantage and stimulation, the MBL became increasingly active as the administration seriously promoted the use of its nonsummer facilities and services for research and training by independent investigators and groups of researchers. The Boston University Marine Program was one of the latter. Unquestionably, the year-round research and training in SEP benefitted the promotion. In the interim, our SEP isolation was warmly compensated by the full, year-round professional activities of the nearby WHOI and BCF.

For several years prior to the establishment of SEP, the MBL administration had been considering the need to assess further the local marine plant and animal resources of the Cape Cod area, the region from whence these organisms were collected for investigators and teachers at the laboratory. Early monitoring efforts in the 1950's involved Donald J. Zinn and John S. Rankin, Jr., who served consecutively as resident biologists. This was at a time when populations of the common purple sea urchin, *Arbacia punctulata*, popular especially for embryological research at MBL, were heavily harvested and dangerously depleted. It goes without saying that the willing efforts of the two resident biologists were only minimally successful. Obviously, the enormity of the task far exceeded their energy and resources. Ironically, some years later—in the late 1960's—the populations of *A. punctulata* returned, perhaps simply a peak in a population fluctuation?

This was the backdrop that led to the establishment of SEP. In brief, the task before us was to conduct a long-range, year-round, broad-based inventory of the estuarine-marine flora and fauna of the Cape Cod region (Fig. 4), and on this biosystematic foundation to superimpose basic investigations and foster advanced training in biosystematics and ecology.

As I paused in my new office in the Lillie Building on that September day in 1962, I began more seriously to appreciate the enormity of the work ahead. The only collection of local organisms, the George M. Gray Museum in Candle House, was small and in poor condition. Principal knowledge of local organisms lay unrecorded in the mental computers of MBL Collector Milton Gray and the Manager of the MBL Supply Department, John J. Valois. Other than a few mimeographed keys for local taxa, prepared for teaching purposes by the MBL marine ecology course staff, no identification manuals, catalogs, or lists of published systematic works existed. Among scientists in the neighboring WHOI and the BCF Woods Hole Laboratory (WHL), there were a few systematically oriented, established investigators, including Howard Sanders of WHOI and Roland Wigley of the BCF Laboratory. They, however, were busy with their own biological research programs generally away from Woods Hole.

Because the title "Systematics-Ecology Program" included "systematics" as well as "ecology," we understandably gave careful thought to the role of systematics in SEP, the marine biological sciences, and marine fisheries. As I reviewed the biosystematic literature in the large, comprehensive MBL Library, it became abundantly clear that biosystematics (the study of the diversity of organisms) and taxonomy (the theory and practice of classifying) continue to be of pivotal importance in much of both fundamental and applied biology (Mayr, 1969). For one thing, the immensity of the diversity of organisms in the living world is staggering, a complexity impossible to deal with, if not ordered and classified (Mayr, 1969). For another, identification of organisms gives access to stored systems of biological information (all published knowledge on organisms is cataloged and assembled under the scientific names of species in the world scientific literature). Indisputably, accurate retrieval of this information can only be as reliable as the precision exercised in the original identification and classification. It follows undeniably that increasing refinement and quantification of the results of biological investigation will require comparable exactness in identification of the organisms involved. This applies to both basic and applied research. Imprecision in taxonomy will neutralize whatever rigor was applied in the research; if identifications are in error, reports and published works on them will be nonreplicable and correspondingly unreliable (Carriker, 1976b).

Nonspecialists are usually able to identify and classify species only after these species have been described, named, and properly reported in the technical literature. Owing to the difficulty of use of this literature by nonspecialists, systematists often synthesize the original literature into a form that is more readily applied. Manuals in the "Marine Flora and Fauna" subseries (Fig. 2, 3) are of this form. In this context, Mayr (1968) noted:

"Taxomists supply a desperately needed identification service for taxa of ecological significance . . . In all areas of applied biology good taxonomy is indispensable . . . Much work in conservation, wildlife management, and the study of renewable natural resources of all kinds depends for its effectiveness on the soundness of taxonomic research. The faunas, floras, handbooks, and manuals prepared by taxonomists are indispensable in many branches of

biology and also widely used by the general public."

Serious problems arise from inaccurate identification of biological species. This is evidenced by an excess of examples in the scientific literature. Especially troublesome are marine species similar in external appearance, but dissimilar physiologically or ecologically. Not uncommonly, this results in both basic and applied research being repeated unnecessarily, because identifications of organisms in the original investigation were in error, or because the researcher did not consult the systematic literature or museum collections with sufficient thoroughness.

A case in point is that of wood-boring bivalves found in the warm-water discharge canal of a nuclear generating station in New Jersey. An investigator, identifying them only to generic level, concluded they were indigenous. Ruth Turner, Museum of Comparative Zoology, Harvard University, was later requested to check the identification, and

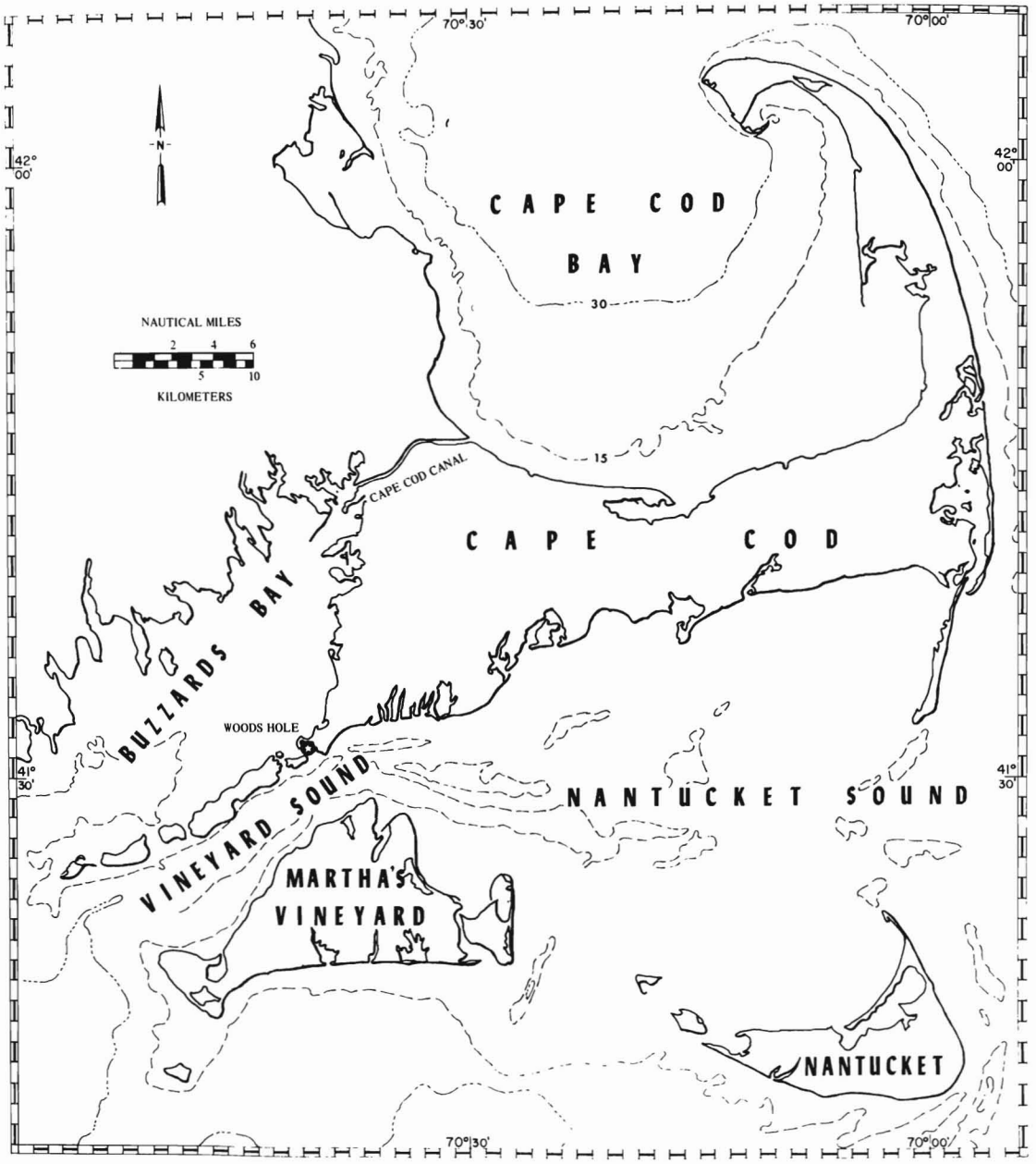


Figure 4.—The Cape Cod region, area of operation of the MBL Systematics-Ecology Program.

to her surprise discovered that the bivalves were an introduced tropical species (personal commun.)!

A second example concerns certain species of marine planktonic dinoflagellates that in massive concentrations sometimes produce "red tides" in coastal waters. These species, in such genera as *Gonyaulax* and *Gymnodinium*, produce toxins in some species of bivalves living in the red tide seawater that are fatally toxic to man (Dale and Yentsch, 1978); other species of dinoflagellates do not.

Libraries, unavoidably, retain many examples of results of expensive research discredited because of faulty or incomplete identification of the species utilized. Michener et al. (1970) stressed that underlying all important biological work is knowledge of the identity of the species and its position in the ecosystem, and that without this basic information it is doubtful that any major advances could have been made in biology. According to Blackwelder (1967) systematics must precede all other forms of biological investigation and necessarily furnishes the foundation and frame upon which the results of researches on all the natural sciences can be built.

In addition to the pivotal significance of theoretical systematics to biology, I soon rediscovered in my review that systematics contributes significantly to the solution of practical fisheries problems. The much admired systematist, Waldo L. Schmitt (1967), Smithsonian Institution, related two such examples. In the first, a specialist on sipunculid worms was asked for copies of his publications by an Alaskan cod fisherman. This man had observed that wherever these worms occurred, he always made good hauls of finfish. He therefore planned to plot the distribution of the worms in order to extend his fishing operation. In a second example, a fisherman sought information on the habits, distribution, and abundance of a certain species of crustacean that he had captured during recreational fishing. A specialist identified the species as a stomatopod, a favorite food of desirable panfish caught by fishermen in the Chesapeake Bay area.

On a broader organizational fisheries level, Collette and Vecchione (1995), while emphasizing the need for practical identification manuals for use by fishery scientists in the field, underscored the importance of increased interaction between systematists and fishery scientists. Such cooperation, they explained, would permit systematists to obtain biological specimens for study and concurrently help fishery scientists resolve systematic problems of practical importance—such as, for example, the accurate identification of seafood species for the seafood industry. They suggest that existing fishery sampling programs could aid systematists in monitoring and understanding biological diversity by expanding collecting efforts at relatively little additional cost. The resulting vouchered specimens would record the distribution of these species and could be used in critical baseline studies of heavy metal, pesticide, and parasite levels in the ecosystems of their origin.

Although the field of ecology was generally accepted by many summer biologists at MBL as an "emerging science" (but yet far down the pecking order), the majority delegated biosystematics to the bottom rung of the hierarchy. This attitude surprised most of us in SEP in view of the important pioneering field studies carried out many decades earlier by Verrill et al. (1873) and Sumner et al. (1913) in southern New England coastal waters—the veritable "backyard" of Woods Hole! In spite of this disinterested prevailing opinion, we determined to consider biosystematics on a par with ecology, giving equal emphasis to both fields. The theoretical and practical significance of biosystematics, the increasing national awareness of the growing number of known endangered biological species, and the accelerating destruction of habitats around the world (Carriker, 1967b) led us to this decision. The Cape Cod region would not escape the pressure: popular with summer visitors and growing rapidly, it would undoubtedly experience pillaged habitats in the future. By the early 1960's we had reached the conclusion, so eloquently phrased much later by Peter Raven (1990), that the crisis of biodiversity has become a cardinal concern, and description and documentation of "the grand pattern of life on earth," while still possible to accomplish on a broad scale, is supremely important. First field studies by SEP investigators soon demonstrated clearly that a knowledge of the kinds and groupings of organisms (biosytematics) is of fundamental importance in the accurate interpretation of the biotic patterns evolving in the Cape Cod marine ecosystem and in deciphering the levels of ecological integration of populations in the region.

And so the work of getting SEP underway began. In the beginning, I and my new secretary San Lineaweaver, running seawater troughs, and much empty laboratory space, occupied principally the second floor of a wing of the Crane building with partially remodeled Candle House next door as an annex. First to join me shortly after I arrived were Victor A. Zullo, postdoctoral fellow; Henry D. Russell, curator; Dennis J. Crisp, visiting investigator from the University College of North Wales; and José Squadroni, s.j., visiting investigator from Montevideo, Uruguay. Growth of the SEP group was rapid. By the end of the first year, the number of full- and part-time personnel reached 24. About half of these were involved in biosystematics.

Traditionally, MBL services had been geared primarily to support laboratory research and teaching, organisms being collected in the Cape Cod region and brought to MBL investigators by collectors in the MBL Supply Department. As SEP developed—because systematics-ecological research generally requires investigators to enter the field to collect, observe, and experiment with plants and animals in their native environment—we added special facilities and personnel beyond those available to us through MBL. These included the 65-foot R/V *A. E. Verrill* (Fig. 5), small boats and vehicles, scuba facilities, biotic reference collections in the Gray Museum, aerial and underwater biophotography, sampling and monitoring gear, crew for boats, and a technologist to work with investigators and students in the field. These were all funded by grants and contracts to SEP.

Figure 5.—The R/V *A. E. Verrill* was launched formally late in 1966 and became the workhorse of the Systematics-Ecology Program. Funded by the Ford Foundation and constructed for the Program, the ship is 64 feet 11 inches long. It has a large main research laboratory with running fresh and seawater for processing samples, and an over-the-stern facility for collection of samples by means of a moveable gantry.

During our first year, we retrieved and incorporated the deteriorating remnants of the original Gray biotic collections in the new SEP Gray Museum in Candle House. In February 1970, SEP and the Gray Museum were moved to spacious new quarters in the new MBL Loeb building across the street from Lillie (Fig. 1). The Museum collections were located in a large space on the lower floor of Loeb[2]. Computer facilities and electron microscopes were available at WHOI, where personnel were cordial and generously cooperative.

Ultimately, the maximal size of the SEP staff was that which could be accommodated year-round in the facilities set aside for SEP by the MBL administration; this size, in turn, was limited by the space requirements of the growing visiting summer population of scientists and students. Because SEP funding was primarily from grants and contracts (over the decade from the Ford Foundation, the Grass Foundation, the Federal Water Pollution Control Administration, the National Science Foundation, the National Institutes of Health, Office of Naval Research, and Whitehall Foundation, among others), frequent changes occurred in SEP personnel, especially among the resident staff, who sooner or later obtained "permanent" positions elsewhere. During the SEP decade (1962–72), a total of 256 persons were associated with the Program: 20 resident investigators, 24 postdoctoral fellows and research associates, 23 graduate research trainees, and 42 visiting investigators; the remainder were support staff.

In addition to advancing knowledge of the marine organismic biology of the Cape Cod region by a resident research and support staff, SEP biologists served as a nucleus to 1) attract faculty and advanced students, primarily from New England colleges and universities, to conduct studies in association with the resident staff and 2) foster research training, communications, and experience in biosystematics, ecology, and related organismic disciplines. This milieu provided the impetus and an invaluable resource for the inception and early development of the "Marine Flora and Fauna" program and publications.

A major impediment to organismic studies in the Cape Cod region was the abysmal lack of adequate identification literature and reference collections. As the work of SEP investigators and students progressed, the coastal plant and animal reference collections in the Gray Museum grew apace. With the valued collaboration of visiting investigators, mainly from New England colleges and universities, our resident staff identified and classified an increasingly large number of specimens. This was a colossal task and a complex organizational problem for the curator of the Gray Museum, as well as for scientists and students undertaking regional biotic inventories. These were the major source of biological specimens.

These censuses included the intensive, quantitative analysis of the Cape Cod Bay ecosystem from the R/V *A. E. Verrill*; and investigations of smaller scale in Barnstable Harbor, Buzzards Bay, Hadley Harbor, Quicks Hole, Vineyard Sound, the intertidal zones and shallow water of the lower Cape and the nearby islands (Fig. 4). A total of 42 major algal, plant, and animal groups were examined during the SEP decade. Several new species were described, and the range of many more was extended. The majority of studies was on free-living benthic algae and animals, primarily macroalgae and invertebrates; a few were on parasites and commensals. A large part of SEP biosystematic research was necessarily descriptive, at the alpha level, owing to the plethora of gaps in the knowledge of the holistic biology of the Cape Cod region (Carriker, 1962–72).

Our earliest effort to fill the critical need for, and void in the identification literature of the Cape Cod region was enthusiastically and energetically spearheaded by Ralph I. Smith in 1963. He

[2]In 1993 the Gray Museum collections were awarded, through competitive proposals, to the Peabody Museum, Yale University, and were incorporated in the Peabody Museum collections. There they retain their identity in computerized records, and can be searched electronically on the World Wide Web Site (personal commun., Eric A. Lazo-Wasem, Collections Manager).

persuasively marshalled the collaboration of some 25 biologists at MBL (and some from elsewhere) who possessed systematic expertise. With their help he coordinated the preparation of and edited the valuable and still much used (but out of print) "Keys to Marine Invertebrates of the Woods Hole region" (Smith, 1964). With intensity but with good humor, Smith kept our faithful secretaries, Hazel Santos, San Lineaweaver, and Virginia Smith, busy and sometimes bewildered, as he organized and reorganized (no computers then) the contributions of collaborating systematists. [Secretary Eva Montiero, who remained with SEP until its close, did not join us until 1965.] In his "Editor's Preface", Smith (1964) noted "Relatively few present-day biologists realize the difficulties involved in identifying with certainty the myriad species of marine invertebrates. . . . Keys are useful mainly in the identification of common and obvious animals . . . something out of the ordinary should be referred to a specialist."

After publication of those "Keys," there followed the SEP works: "Marine and Estuarine Environments, Organisms and Geology of the Cape Cod Region, an Indexed Bibliography, 1665–1965" by Anne Yentsch et al. (1966); and publications of broad scope by SEP visiting investigators from other institutions: "The Triumph of the Darwinian Method" by Michael Ghiselin (1969), "Shallow-water Gammaridean Amphipoda of New England" by E. L. Bousfield (1973) with beautiful illustrations (Fig. 6) by Ruth von Arx [now deceased], and the "Ascidiacea of the Atlantic Continental Shelf of the United States" by Harold Plough (1978).

Starting in early 1966, the hiatus in identification literature for the Cape Cod region, importantly though only partially, filled by Smith's "Keys," had prompted serious discussions among senior SEP investigators (primarily Ruth D. Turner, Robert T. Wilce, Victor A. Zullo, and I) on the need for a more comprehensive volume. It would be one, we hypothesized, that would include brief, illustrated, artificial couplet keys and related biological information on the estuarine and coastal marine plants and invertebrates of the New England area. These keys would complement existing as well as planned systematic monographs and handbooks, and be directed to undergraduate and graduate biology students and nonsystematic biologists.

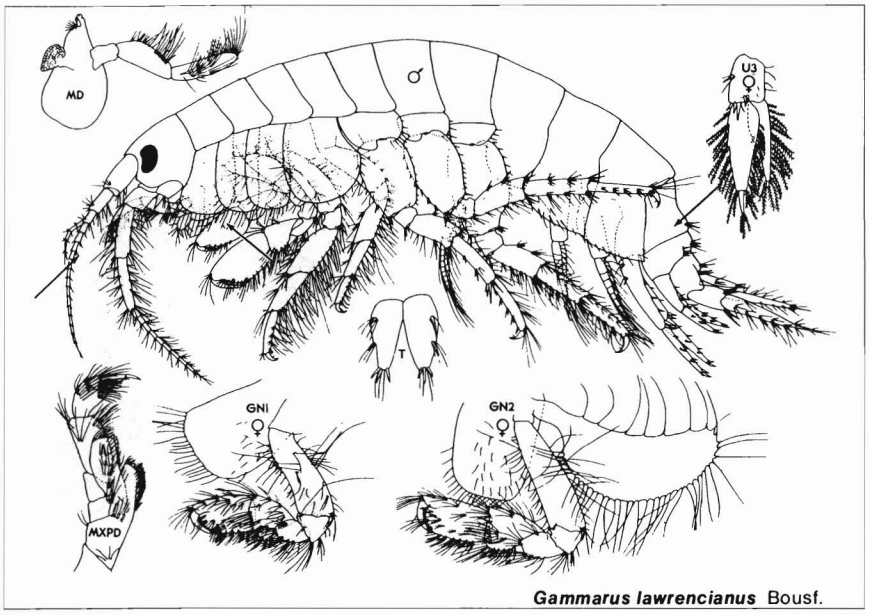


Figure 6.—A gammarid amphipod crustacean drawn by Ruth von Arx, Figure 2, p. 214, for Bousfield (1973).

By this time (1965), Smith's popular "Keys" was in need of updating with additional taxa. We were confident that the impressive recent contributions in marine biosystematics by biologists of the long established New England institutions and the substantial research accomplished by SEP investigators, with the support of the Gray Museum collections and continuing inventories in the Cape Cod region, would provide a significant systematic resource for the preparation of the proposed volume. Furthermore, the opportunity for visiting investigators to use SEP field facilities in cooperation with SEP staff and the services of the Gray Museum, would materially facilitate the research of collaborating systematists. Also possible, was collecting in cooperation with biologists in other New England institutions, such as, for example, the new marine station of Northeastern University at Nahant in Massachusetts Bay.

By early 1967, we had completed preliminary discussions and began serious planning of the systematic volume. I prepared a draft manuscript on a representative local taxon, and distributed it to several interested persons in SEP and in the Boston area. It soon became painfully clear, however, that a single volume accommodating all the ideas that were emerging would not be practical. For one thing, the proposed volume would include many systematic specialists, each probably completing his/her contribution at a different time, putting final publication years or decades away. For another, updating of sections of different taxa would not be possible without republication of the entire volume.

Realistically, then, the concept of a single volume had to be abandoned, and in its place a plan evolved for a series of manuals, each for a major taxon, appearing periodically as manuscripts were completed. The proposed series was initially named the "Marine Flora and Invertebrate Fauna of New England." This was subsequently shortened to the "Marine Flora and Fauna of New England" (MFF).

As planning of the MFF proceeded, there arose the sensitive questions as to the official address and institutional sponsorship (if any) of the series. A

potentially vexing problem was revealed earlier by E. L. Bousfield, visiting investigator in SEP and senior scientist, Museum of Natural Sciences, Ottawa, Canada, who commented casually one day that Ruth D. Turner, Museum of Comparative Zoology, Harvard University, and visiting investigator in SEP, and Nathan W. Riser, director, Marine Laboratory, Northeastern University, also had been thinking about preparing illustrated taxonomic keys to the marine organisms of the New England area.

To open the matter for discussion, I telephoned Turner. We agreed to call several meetings, alternating between Boston and Woods Hole, to talk over our suggested format and direction for the MFF and the Turner-Riser plan for keys. Those attending generally included Turner; Robert T. Wilce, Botany Department, University of Massachusetts and visiting investigator in SEP; Riser; I. MacKenzie Lamb, Director, Harvard University Farlow Reference Library and Herbarium of Cryptogamic Botany; William Randolph Taylor, Department of Botany, University of Michigan; Victor A. Zullo, resident systematist in SEP; and me. At the onset, we concurred that the official address of the MFF should be either the Harvard Museum of Comparative Zoology, or SEP-MBL, Woods Hole. Turner and the Boston Malacological Club strongly

Figure 7.—Photograph of Ruth Turner, 1957.

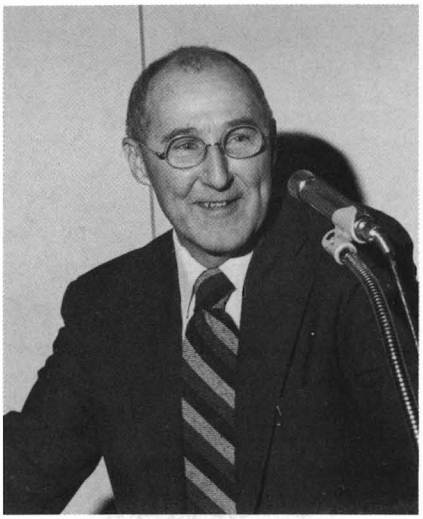


Figure 8.—Photograph of Robert T. Wilce, 1985.

favored the Boston address, and Wilce, the SEP staff, and I equally strongly leaned toward the Woods Hole address. The strong systematic emphasis of the SEP Program, proximity and access to the Cape Cod marine-estuarine habitats, attractions of the Woods Hole scientific community, and the strong cooperative support we in SEP could provide, swung the decision in favor of Woods Hole. The weight of these arguments prevailed, and SEP was eventually chosen good-naturedly.

This matter peacefully resolved, we turned next to detailed planning on the MFF. An editorial board, consisting of Turner (Fig. 7), Wilce (Fig. 8), and me (Fig. 9), was formed. I consented to serve as coordinating editor. We concurred that this administrative board would function as an independent, nonprofit operation, responsible for the format, organization, financing, and publication of the MFF series.

Next, we developed a tentative format for a sample manual in the series that would be applicable generally to most taxa with minimal variation from taxon to taxon. Such a format, we reasoned, would make the manuals "user friendly." We defined the "Marine Flora and Fauna" as a series of original, illustrated manuals on the identification, classification, and general biology of coastal marine plants and animals, ranging from the headwaters of estuaries seaward to about the 200 m depth on the continental shelf; geographic distribution would vary with each major taxon treated and interests of authors. Each manual was to be based primarily on recent research and a fresh examination of organisms, where this was possible, and would be completed without a deadline, and published after due review by referees. Each manual would represent a major taxon and contain an introduction, illustrated glossary, uniform originally illustrated keys, annotated checklist with information when available on habitat, life history, distribution, and related biology, references to major literature of the group, a systematic index, and coordinating editor's comments. Manuals were intended for use by biology students, biologists, biological oceanographers, informed lay persons, and others wishing to identify coastal organisms in the region, and to serve as a guide to additional information about the species in the taxon. A version of this description appears in the "Foreword" to each of the published manuals.

These plans were well received by biologists. The format and plans for financing and publishing of the MFF were presented to and, following discussion of several questions on the fi-

Figure 9.—Photograph of Melbourne R. Carriker, 1968.

nancial aspects, approved by H. Burr Steinback, Director, MBL.

Following this, we prepared a sample manual on a well known taxon to send to potential collaborators in the "Marine Flora and Fauna." By 1969, Turner and Johanna Reinhart, Curator of the Gray Museum, had completed a draft manual consisting of an introduction to the Mollusca, an illustrated key to the classes of the Mollusca, and a partial illustrated key to shelled benthic gastropods, the detailed figures drawn by artist Ruth von Arx of Woods Hole. This draft was distributed to potential collaborators, systematists visiting SEP, and others in the New England region and elsewhere, with an invitation to consider preparing a manual of their choice. By this time (1969), some 4,725 copies of the Smith's (1964) "Woods Hole Keys" had been sold by the MBL Supply Department. This encouraged us, indicating something of the interest in, and need for this kind of systematic literature.

Response to our invitation was gratifying. By 1970, 45 collaborators had agreed to prepare manuals. That year, also, the first manual "Higher Plants of the Marine Fringe of Southern New England" by E. T. Moul (1973: Table 1, Fig. 10) appeared in preprint form, and preliminary drafts of manuals on the Tardigrada by L. W. Pollock (1976: Fig. 11), Oligochaeta by D. G. Cook and R. O. Brinkhurst (1973: Fig. 12), Ciliata by A. C. Borror (1973), and Kinorhyncha by R. P. Higgins were completed. [The Higgins draft has not yet been published]. Several other manuals were in various stages of preparation. That same year (1970), the National Science Foundation granted SEP-MBL $25,000 for 2 years of support specifically for preparation of manuals by collaborators. Additional support for the "Marine Flora and Fauna" had been available through SEP grants from the Ford Foundation and the National Science Foundation. In addition, some collaborators from other institutions provided partial support from their own grants.

At this time we also enlarged the Editorial Board of the MFF by inviting Marie B. Abbott, curator, Gray Museum (Fig. 13); Arthur G. Humes, Director, Boston University Marine Program at MBL (BUMP) (Fig. 14); Wesley N. Tiffney, Boston University Graduate School (Fig. 15); and Roland L. Wigley, Supervisory Fishery Biologist (Research), Woods Hole Laboratory, NMFS Northeast Fisheries Center (Fig. 16). These additions were made to more broadly represent the diverse categories of taxa being considered for inclusion in the MFF. Humes became associated with SEP in 1970 and later accepted the directorship of BUMP in cooperation with SEP. Manuscripts were reviewed by members of the Editorial Board of SEP and by outside referees. Revisions in those days were time consuming and a chore, as desktop computers, so common today, were not yet available.

By 1971, 75 systematic specialists were collaborating in the writing of manuals, and those by Borror, Cook and Brinkhurst, Moul, and McCloskey (Table 1) were essentially ready for final editing and publication. In December 1970, I sent courtesy copies of those manuals to Steinback in recognition of his kindness in helping us to initiate the MFF series. He kindly responded in a hand-written note: "Dear Mel: Many thanks for showing these to me. I'll come and borrow copies if I need them. Congratulations on the operation!"

In 1967, the Editorial Board had begun exploring possible commercial publication outlets for the "Marine Flora and Fauna." The first was through

Table 1.—List of taxa and authors of Marine Flora and Fauna manuals published and in press in the NOAA Technical Report NMFS series, 1973–1996. The NTIS[1] accession no. is given in parentheses ( ).

Marine Flora and Fauna of the Northeastern United States

Annelida: Oligochaeta. David G. Cook and Ralph O. Brinkhurst. 1973. NOAA Tech. Rep. NMFS CIRC-374, 23 p., 82 figs. (COM 73 50670).
Protozoa: Ciliophora. Arthur C. Borror. 1973. NOAA Tech. Rep. NMFS CIRC-378, 62 p., 193 figs. (COM 73 50888).
Higher plants of the marine fringe. Edwin T. Moul. 1973. NOAA Tech. Rep. NMFS CIRC-384, 60 p., 108 figs. (COM 74 50019).
Pycnogonida. Lawrence R. McCloskey. 1973. NOAA Tech. Rep. NMFS CIRC-386, 12 p., 39 figs. (COM 74 50014).
Crustacea: Stomatopoda. Raymond B. Manning. 1974. NOAA Tech. Rep. NMFS CIRC-387, 6 p., 10 figs. (COMS 74 50487).
Crustacea: Decapoda. Austin B. Williams. 1974. NOAA Tech. Rep. NMFS CIRC-389, 50 p., 111 figs. (COM 74 51194).
Tardigrada. Leland W. Pollock. 1976. NOAA Tech. Rep. NMFS CIRC-394, 25 p., 71 figs. (PB 257 987).
Cnidaria: Scyphozoa. Ronald J. Larson. 1976. NOAA Tech. Rep. NMFS CIRC-397, 18 p., 28 figs. (PB 261 839).
Higher Fungi: Ascomycetes, Deuteromycetes, and Basidiomycetes. A. Ralph Cavaliere. 1977. NOAA Tech. Rep. NMFS CIRC-398, 49 p., 125 figs. (PB 268 036).
Copepoda: Harpacticoida. Bruce C. Coull. 1977. NOAA Tech. Rep. NMFS CIRC-399, 48 p., 100 figs. ((PB 268 714).
Sipuncula. Edward B. Cutler. 1977. NOAA Tech. Rep. NMFS CIRC-403, 7 p., 6 figs. (PB 273 062).
Echinodermata: Holothuroidea. David L. Pawson. 1977. NOAA Tech. Rep. NMFS CIRC-405, 15 p., 55 figs. (PB 274 999).
Copepoda: Lernaeopodidae and Sphyriidae. Ju-Shey Ho. 1977. NOAA Tech. Rep. NMFS CIRC-406, 14 p., 16 figs. (PB 280 040).
Copepoda: Cyclopoids Parasitic on Fishes. Ju-Shey Ho. 1978. NOAA Tech. Rep. NMFS CIRC-409, 12 p., 17 figs. (PB 281 969).
Crustacea: Branchiura. Roger F. Cressey. 1978. NOAA Tech. Rep. NMFS CIRC-413, 10 p., 15 figs. (PB 222 923).
Protozoa: Sarcodina: Amoebae. Eugene C. Bovee and Thomas K. Sawyer. 1979. NOAA Tech. Rep. NMFS CIRC-419, 56 p., 77 figs. (PB 285 538).
Crustacea: Cumacea. Les Watling. 1979. NOAA Tech. Rep. NMFS CIRC-423, 23 p., 35 figs. (PB 296 460).
Arthropoda: Cirripedia. Victor A. Zullo. 1979. NOAA Tech. Rep. NMFS CIRC-425, 29 p., 40 figs. (PB 297 676).
Cnidaria: Scleractinia. Stephen D. Cairns. 1981. NOAA Tech. Rep. NMFS CIRC-438, 15 p., 16 figs., 2 tables (PB 124 520).
Protozoa: Sarcodina: Benthic Foraminifera. Ruth Todd and Doris Low. 1981. NOAA Tech. Rep. NMFS CIRC-439, 51 p., 324 figs. (PB 225 053).
Turbellaria: Acoela and Nemertodermatida. Louise F. Bush. 1981. NOAA Tech. Rep. NMFS CIRC-440, 71 p., 184 figs. (PB 219 387).
Lichens (Ascomycetes) of the Intertidal Region. Ronald M. Taylor. 1982. NOAA Tech. Rep. NMFS CIRC-446, 26 p., 43 figs. (PB 124 735).
Echinodermata: Echinoidea. D. Keith Serafy and F. Julian Fell. 1985. NOAA Tech. Rep. NMFS 33, 27 p., 42 figs. (PC A03/MF A01).
Echinodermata: Crinoidea. Charles G. Messing and John H. Dearborn. 1990. NOAA Tech. Rep. NMFS 91, 30 p., 18 figs. (PB 86 156 395).
Erect Bryozoa. John S. Ryland and Peter J. Hayward. 1991. NOAA Tech. Rep. NMFS 99, 48 p., 69 figs.

Marine Flora and Fauna of the Eastern United States

Cephalopoda. Micheal Vecchione, Clyde F. E. Roper and Michael J. Sweeney. 1989. NOAA Tech. Rep. NMFS 73, 23 p., 29 figs. (PB 89 189 583).
Copepoda, Cyclopoida: Archinotodelphyidae, Notodelphyidae, and Ascidicolidae. Patricia L. Dudley and Paul L. Illg. 1991. NOAA Tech. Rep. NMFS 96, 40 p., 47 figs., 2 tables.
Dicyemida. Robert B. Short. 1991. NOAA Tech. Rep. NMFS 100, 16 p., 39 figs.
Anthozoa: Actiniaria, Zoanthidea, Corallimorpharia and Ceriantharia. Kenneth P. Sebens. In press.
Platyhelminthes: Monogenea. Sherman S. Hendrix. In press.
Acanthocephala. Omar M. Amin. In press.

[1] National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. NTIS sells copies of the manuals in either microfiche or hard (xerographic) copy form.

Juncus balticus

Erect herbs with slender cylindrical stems; basal leaves reduced to bladeless sheaths; rhizomes firm, extensively forked; along brackish shores and margins of tidal marshes.

Figure 107.—(a) Habit sketch; (b) sheathing basal leaves × 1/10.

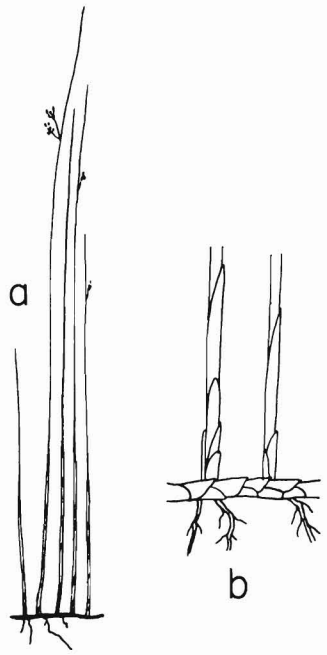


Figure 10.—A marsh juncus, Figure 107, p. 43, from Moul (1973), Ruth von Arx illustrator.

39 (38) Caudal ala deeply sculptured and nearly divided; lateral alae divided ..... *Florarctus heimi*

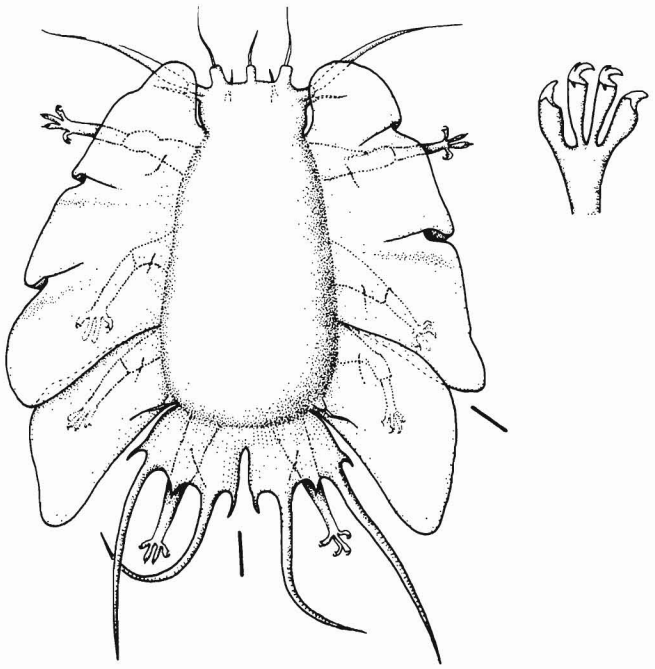


Figure 11.—A tardigrade metazoan, at couplet 39(38), p. 18, from Pollock (1973).

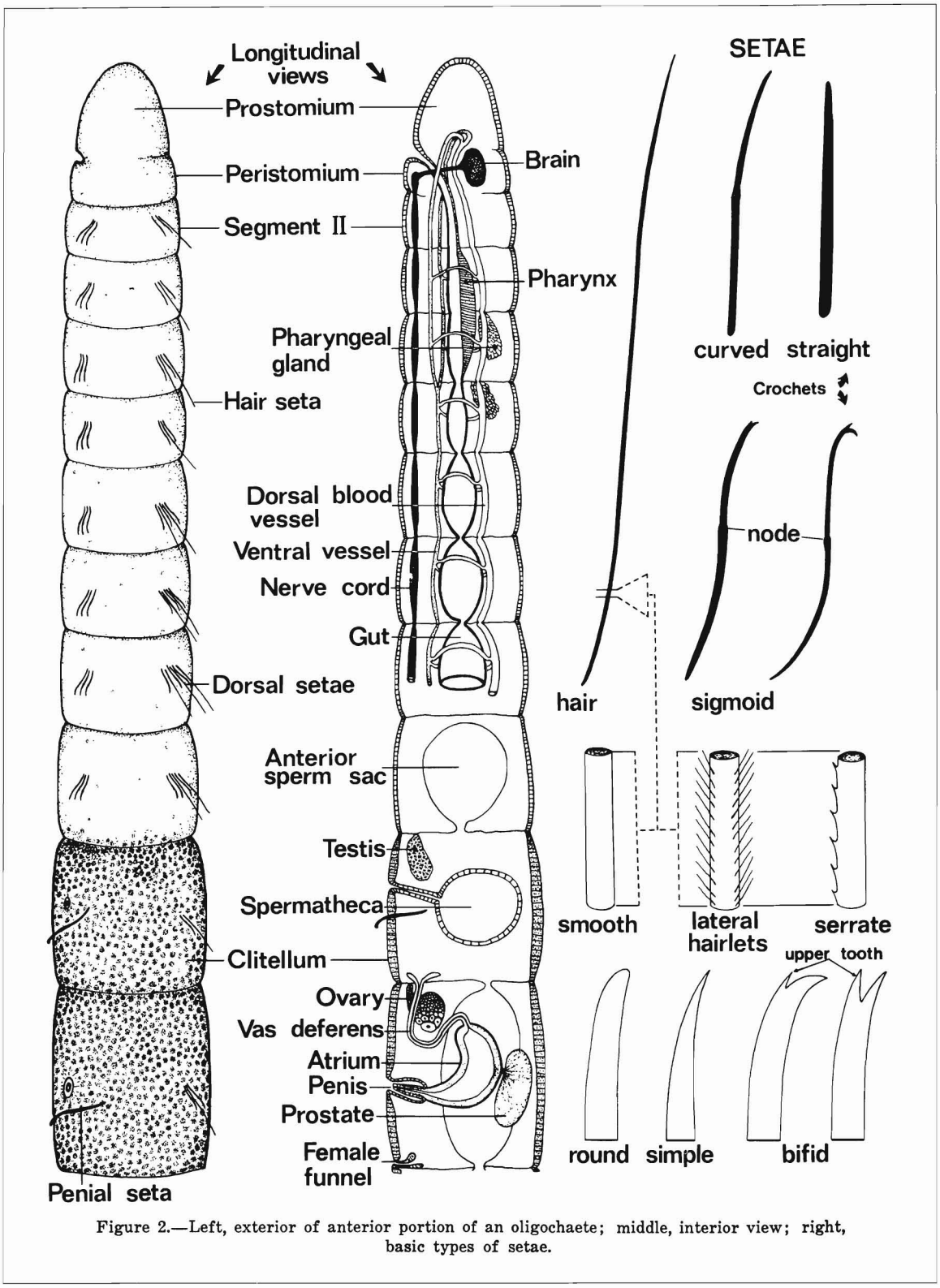


Figure 2.—Left, exterior of anterior portion of an oligochaete; middle, interior view; right, basic types of setae.

Figure 12.—An oligochaete annelid, Figure 2, p. 3, from Cook and Brinkhurst (1973).

Figure 13.—Photograph of Marie B. Abbott, 1977.

a local Cape Cod printer, and with distribution through the MBL Supply Department. This idea was soon abandoned because of the limited distributional facilities of that Department. There followed discussions with a representative of the Harvard University Press in Boston. The options with this Press seemed promising. However, during later negotiations, Wigley suggested yet another approach, publication by the NMFS, which was warmly received by our MFF Editorial Board. This approach coincided with establishment by the NMFS of its Scientific Publications Staff (now Office) in Seattle, Washington, along with the appointment of a new Scientific Editor, Reuben Lasker, for the NMFS publications *Fishery Bulletin*, a quarterly journal, and the Circular and the Technical Report series.

Figure 14.—Photograph of Arthur G. Humes, 1973.

In May 1972, Wigley submitted his suggestion to the Publication Policy Board of NMFS. This Board met, and to our delight, unanimously agreed to undertake publication and distribution of the series. Lasker, the new NMFS Scientific Editor, had met with the Publication Policy Board, and on April 18, 1972, wrote to Wigley:

"The Publication Policy Board of NMFS met in St. Petersburg, Florida last week and discussed the publication of the Marine Flora and Invertebrate Fauna of New England. The unanimous opinion of the Board was that this is a project that NMFS should undertake. We agreed that our Circular series is the most useful vehicle for the MFIFNE because of the wide circulation it gets. . . . These Circulars will be available from the Superintendent of Documents at a cost of about a cent a page . . .".

At Lasker's suggestion, he and Thomas A. Manar, Chief, NMFS Scientific Publication Staff in Seattle, Washington, met with Abbott, Turner, Wigley, and me in my MBL office on 31 August to "get acquainted" and discuss details of format and publication of the individual "Marine Flora and Fauna" manuals. Lasker's enthusiasm for publishing the series was more than matched by ours in finding an excellent publication outlet, with wide circulation to major libraries not only in the United States but worldwide, and at a reasonable cost for reprints for authors and individual purchasers.

Thus I began transmitting manuscripts to the NMFS Scientific Editor, then Lasker. He, as is still the practice today, had them further peer reviewed before acceptance for publication. Serious planning of the "Marine Flora and Fauna" had begun in 1967, and the Cook and Brinkhurst manuscript, the first sent to Lasker 5 years later in 1972, appeared in print in May 1973.

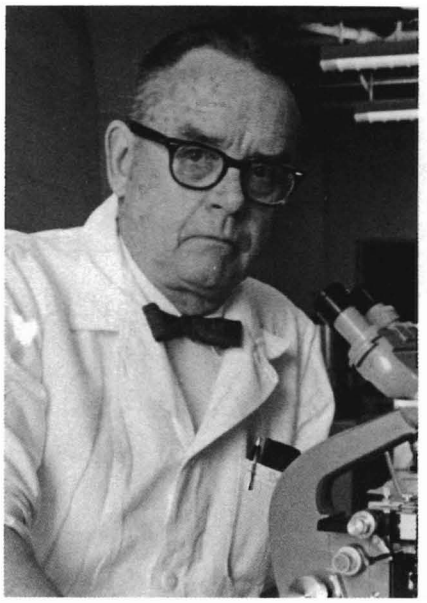


Figure 15.—Photograph of Wesley N. Tiffney, 1970.

Originally, the manuals were published in the NMFS "Circular" series, beginning with the Cook and Brinkhurst's (1973) "Annelida: Oligochaeta," issued officially as NOAA Technical Report NMFS CIRC 374 (Fig. 2). This MFF subseries appeared under that designation until 1984 when the "Circular" series was merged into the overall NOAA Technical Report NMFS series.

Figure 16.—Photograph of Roland L. Wigley, 1981.

The first manual in this series was by Serafy and Fell (1985) on Echinodermata: Echinoidea, issued as NOAA Technical Report NMFS 33 (Fig. 3).

By 1972, funding from agencies and foundations for SEP had become most difficult to obtain. On 31 August of that year, James Ebert, Director of MBL, and I discussed the seriousness of the situation and jointly concluded with goodwill that all things considered it would be prudent to close the Program. Ebert then invited me to remain at MBL for an additional year to advance my research on predatory shell-boring marine gastropods, help my staff find other positions, continue coordination and editing of the "Marine Flora and Fauna," and seek new employment myself. This I did. On 1 September 1973, a year after the closing of SEP, at the invitation of Dean William Gaither and several of my University of Delaware colleagues, I joined the faculty of the College of Marine Studies, University of Delaware, Lewes, Delaware.

Early that September, my wife and I (our sons had by now left home) arrived in Lewes with a large van of scientific supplies and equipment from my MBL research activities, and the complete and carefully guarded files of the "Marine Flora and Fauna"; I was prepared to continue serving as Coordinating Editor. My first task was to promote the series widely through short articles in several scientific journals (Carriker 1973a,b; 1976a).

During this period it was increasingly difficult for individual investigators to obtain financial support for systematic research. I was also keenly aware that systematists collaborating in the preparation of manuals required some financial assistance. Accordingly, I submitted a proposal in 1975 through the University of Delaware on behalf of the MFF Editorial Board to the Environmental Protection Agency in Narragansett, Rhode Island. We received a grant of $18,000. In 1987, I presented a second proposal, this time to the National Science Foundation. For this, we received an award of $12,988. Both grants provided funds for systematists whose manuscripts were well along and who needed funds for illustrations, duplicating manuscripts, and the like.

In more recent years (late 1980's and early 1990's) the squeeze on funding has seriously slowed the preparation of manuscripts, and consequently their transmittal to the NMFS Scientific Editor and the Scientific Publication Office in Seattle, Washington. Despite these straitened circumstances, a few systematists have been able to continue to work, albeit at a snail's pace, on the taxonomy of their favorite organisms. Thus, from time to time an occasional manuscript has reached my office in Lewes, Delaware.

In 1984, Tiffney died and Wigley retired from the Editorial Board of the "Marine Flora and Fauna." They were replaced by A. Ralph Cavaliere, Department of Biology, Gettysburg College, (Fig. 17), and David L. Pawson, curator of Echinoderms, Department of Invertebrate Zoology, Smithsonian Institution (Fig. 18). In 1987, Abbott died, and was succeeded by Kenneth P. Sebens, currently in the Department of Zoology, University of Maryland (Fig. 19), who also serves as Associate Coordinating Editor on the Editorial Board.

Editing and publishing of MFF manuals has been performed in close cooperation with the NMFS Scientific Editors (who serve for 3-year terms) and with the editorial staff of the NMFS Scientific Publications Office in Seattle, Washington. Without exception, communications concerning external review of manuscripts, interaction with authors, and final publication of manuals have been accomplished pleasurably and as expeditiously as NMFS funds and the workload on the NMFS editorial staff permitted. Publication of the more recent manuals has been delayed many months—but through no fault of the

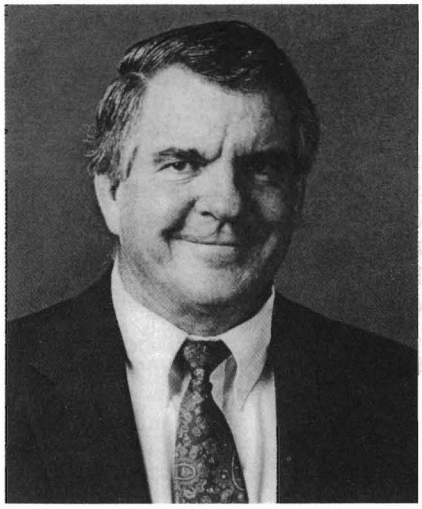


Figure 18.—Photograph of David L. Pawson, 1994.

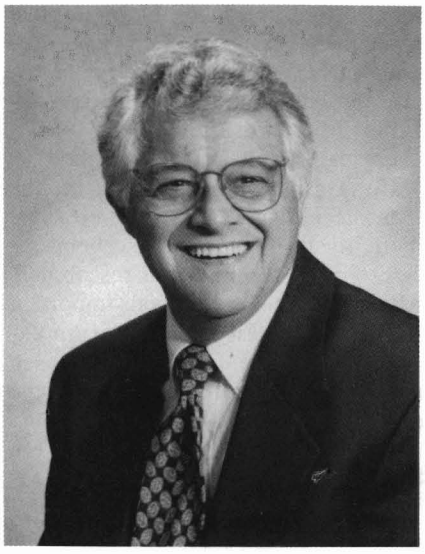


Figure 17.—Photograph of A. Ralph Cavaliere, 1996.

Figure 19.—Photograph of Kenneth P. Sebens, 1994.

NMFS staff—because of the current funding stringencies in the U.S. Government.

Since the inception of the "Marine Flora and Fauna," I have enjoyed my interaction with the editors of the NMFS scientific publications—nine editors in all. This number is rather large because the position of NMFS Scientific Editor has changed every 3 years, rotating from one NMFS Research Center to another. After each triannual change, I have written a lengthy letter with several enclosures to acquaint each new Scientific Editor with the background and organization of the MFF series. The following is a list of these Scientific Editors:

- Reuben Lasker, 1971–74, NMFS Southwest Fisheries Center, La Jolla, Calif.
- Bruce Collette, 1974–77, NMFS National Systematics Laboratory, U.S. National Museum, Smithsonian Institution, Wash., D.C.
- Jay C. Quast, 1977–80, NMFS Northwest and Alaska Fisheries Center, Auke Bay Laboratory, Auke Bay, Alaska.
- Carl J. Sindermann, 1980–83, NMFS Northeast Fisheries Center, Sandy Hook Laboratory, Highlands, N.J.
- William J. Richards, 1983–86, NMFS Southeast Fisheries Center, Miami, Fla.
- Andrew E. Dizon, 1986–89, NMFS Southwest Fisheries Center, La Jolla, Calif.
- Linda Jones, 1989–92, NMFS National Marine Mammal Laboratory, Alaska Fisheries Science Center, Seattle, Wash.
- Ronald W. Hardy, 1992–95, NMFS Northwest Fisheries Science Center, Seattle, Wash.
- John B. Pearce, 1995–98, NMFS Northeast Fisheries Science Center, Woods Hole, Mass.

Occasionally, congratulatory letters have been received from the Scientific Editors. On October 17, 1984, for example, William J. Richards wrote:

"I certainly find this series on the Marine Flora and Fauna of the Northeastern United States to be of outstanding quality and wish that workers in the other three corners of the country would consider doing the same thing."

And on March 3, 1987, Andrew E. Dizon wrote:

"As in the past, NMFS will be pleased to consider for publication manuals in your excellent series 'Marine Flora and Fauna of the Eastern United States' (MFFEUS). Because of the thorough review process through which you put your manuscripts before submission, I anticipate no problems in the acceptance and eventual publishing of the ten manuals listed in your NSF proposal. As Scientific Editor of the 'Fishery Bulletin' and of the 'Technical Reports', I feel that the MFFEUS series is an important scientific contribution and am pleased to contribute to its production."

Since 1972, four different people have served as Chief of the NMFS Scientific Publications Office in Seattle, Wash., and have interacted importantly and cordially with us during processing of manuscripts. In chronological order, these have been: Thomas A. Manar, Joseph D. Harrell, Jack McCormick, and Willis L. Hobart. Equally pleasant have been our relations with the Managing Editors of the NMFS Circulars and Technical Reports in the same office. Again, in chronological order these are: Mary Fukuyama, Lee Thorson, Nancy Peacock, Sharyn Matriotti, and James Orr (currently the Managing Editor position for the NMFS Technical Reports remains unfilled).

Congratulatory comments on the "Marine Flora and Fauna" series and their illustrations have also been received from teachers and researchers who have found the manuals important in their work. Figures 20–28 are examples of representative illustrations in the manuals selected at random in the order of year of publication (Table 1).

J. Frances Allen, Staff Scientist, U.S. Environmental Protection Agency, 1973:

"I am pleased to have your recent letter on the 'Flora and Fauna' and the two manuals on the Ciliophora and on the higher plants of the marine fringe. It is indeed gratifying to see them and to look forward to others as they become available. I am sure you are hearing many fine things about the 'Flora and Fauna'".

Kenneth J. Boss, Museum of Comparative Zoology, Harvard University, 1973:

"We all await the new revised series, one of which arrived this week. Cook and Brinkhurst's [1973] contribution appears to have initiated a high quality group of helpful aides to the study of the marine organisms of the Northeastern United States. Congratulations and thanks again."

Emery F. Swann, Department of Zoology, University of New Hampshire, 1973:

"I have received Cook and Brinkhurst's [1973] report on the Oligochaeta. This is certainly a nice piece of work, and if succeeding manuals of the series are up to its standard, the series will be very valuable indeed."

Lorus J. Milne, Department of Zoology, University of New Hampshire, 1975:

"It has come to my attention that in the series of manuals entitled 'Marine Flora and Fauna of the Northeastern United States', those by Raymond B. Manning on the stomatopod crustaceans and by Austin B. Williams on the decapod crustaceans are presently unavailable, and others are in short supply. I do hope that you will use all the pressure you can exert from your office to have the two out-of-print manuals reprinted and to keep all of them in stock with the Superintendent of Documents. These manuals on identification of marine life are of immense value to students and to the growing number of ecological consultants who must sample coastal organisms toward presentation of environmental-impact statements".

Winifred Dickinson, Beaver Campus, Pennsylvania State University, 1977:

"Thank you for the manuals in the 'Marine Flora and Fauna of the Northeastern United States' series, the Holothuroidea [Pawson, 1977] and higher plants of the marine fringe [Moul, 1973]. We used two of the manuals last year and found them to be most workable".

Joseph E. McCarthy, Biddeford High School, Maine, 1977:

"I am an instructor in Marine Science and Marine Biology at the high school level. . . . Most of the keys for our area are too spotty or overly technical for most of our students. I have seen a single publication from the series you are coordinating relating to the Stomatopoda by Manning [1974]. If the other articles are as well illustrated and written, they will be of great service to students of marine biology".

Mary Hanson Pritchard, Zoology and Museum, University of Nebraska, Lincoln, 1977:

"The manuals are excellent and I commend you and your authors for an important, much needed undertaking. It is most understandable that it is a labor of love—I'm just delighted that the work can be published under the aegis of NOAA. Looking over the list of specialists, I know you will have an impressive set of manuals when the project is completed."

David L. Pawson, Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, 1979:

"Many thanks indeed for sending me copies of the three manuals, all of which appear to be excellent additions to your distinguished series. The response by institutions and individuals, even to the manual on such an unpopular group as the holothurians [Pawson, 1977] has been amazing, and testifies to the value of your project. You can be justly proud that your yeoman efforts have resulted in a series which is exceedingly useful".

Arthur Bedard, Science Coordinator, Canton Public Schools, Massachusetts, ca. 1980:

"I wonder if you would have a minute to send me an updated list of the Marine Flora & Fauna . . . publications. They have been of great value and I fear that I am starting to miss some of the reports".

Douglas J. Barr, National Museum of Natural History, Smithsonian Institution, ca. 1980:

"I am an instructor for a marine biology course offered by the University of Southern Maine (USM). The course is based almost entirely on field research carried out along the coast of Maine, therefore I rely heavily on MFFNEUS manuals."

John B. Pearce, NMFS Northeast Fisheries Science Center, Woods Hole, Massachusetts, 1996:

"From my point of view, much of the ecology and taxonomic research in recent decades in the waters off of New England and the Mid-Atlantic Bight have been accomplished using the Smith [1964] manual, the several MFF manuals [Table 1], and the volume by Bousfield [1973]. Ann Frame, and others working with the perocarids and other arthropods, turn regularly to the Bousfield document, and the other publications are used in a range of courses and researches ongoing in the Woods Hole area. I continue to use the Smith [1964] manual and the other publications in my research on epi-benthic communities and pollution effects".

In 1987 the name of the MFF series was changed to the "Marine Flora and Fauna of the Eastern United States" better to reflect the geographic coverage of many of the manuals. By now, the fall of 1996, 28 manuals have been published in the series; some of these have been superbly illustrated (Fig. 20–28). Three more manuals are in press: Kenneth P. Sebens on the Anthozoa, Sherman S. Hendrix on the monogenean Platyhelminthes, and Omar M. Amin on the Acanthocephala (Table 1). Several more manuscripts are in various stages of preparation.

Contributing to the early and continuing success of the "Marine Flora and Fauna" have been the high quality of the systematic effort put forth by highly supportive collaborating systematists, the early stimulus extended by the pivotal support of the SEP staff, the extensive MBL Library, and the stimulating milieu of the Woods Hole scientific community.

Success of the MFF series has been achieved, especially recently, under penurius circumstances. Research and writing on many of the manuscripts has been done with no or little financial support, carried out "on the side" or as a "labor of love" that is enjoyed, found satisfying, and productive. Although this frugal approach is admirable in a fiscal sense, realistically it sidesteps the greater issue of the niggardly sums generally available for universally needed classification and identification literature (Schmitt, 1967; Mayr, 1969; Michener et al., 1970; Raven, 1990, Simpson and Cracraft, 1995), and overlooks the fundamental importance of taxonomy and systematics as the "primordial biological fabric" (Carriker, 1991).

One might then finally ask, "What specifically is the universal need and importance of a biosystematic series like the "Marine Flora and Fauna?" The answer lies in the certainty that all hierarchical levels (genetic, species, and ecologic) of the biodiversity of the world ocean (Thorne-Miller and Catena, 1991; Norse, 1993) are being increasingly assaulted by a human anthropogenic blitzkrieg. And the only way to monitor the creeping rate of biotic deterioration is by biological inventories of representative areas (Norse, 1993; Systematics Agenda 2000, 1994; Butman and Carlton, 1995; Collette and Vecchione, 1995; Vecchione and Collette, 1996). But biological inventories of all kinds inescapably depend on identification instruments—among them, for example, the MFF—for accurate identification and classification. Some far thinking persons (Norse, 1993) go so far as to recommend that industrialized nations establish national institutes for the environment, which among other functions, should coordinate and fund national marine biodiversity inventories to provide informa-

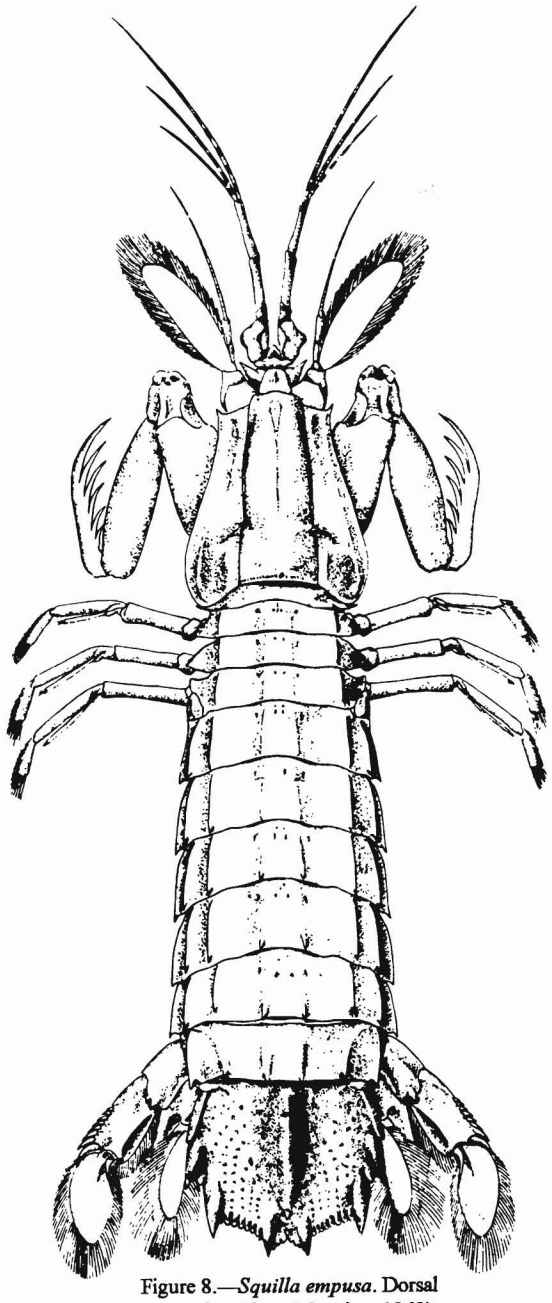


Figure 8.—*Squilla empusa*. Dorsal view (from Manning, 1969).

Figure 20.—A stomatopod crustacean, Figure 8, p. 4, from Manning (1974).

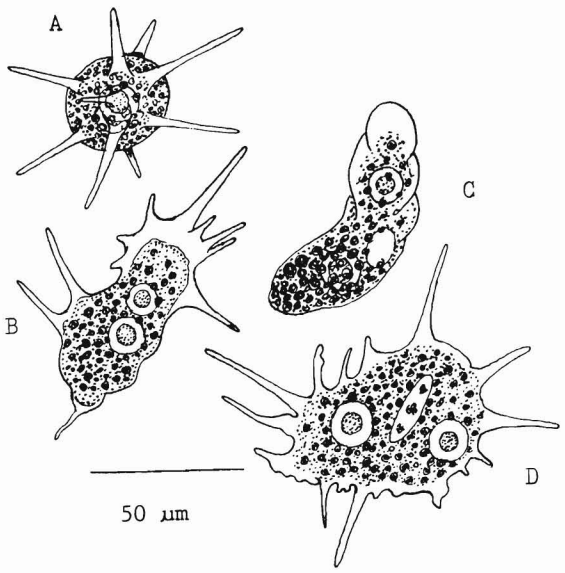


Figure 34.—*Striolatus tardus*: A—radiate, afloat; B—beginning locomotion; C—feeding, active stage; D—slowly locomotive; after Schaeffer (1926).

Figure 21.—Different stages of a sarcodinian amoeba, Figure 34, p. 25, from Bovee and Sawyer (1979).

27(25) **Three filamentary appendages; upper part of peduncle orange in live specimens** ..... *Lepas hilli*

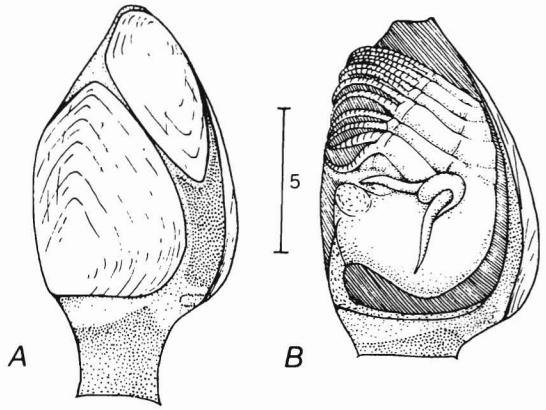


Figure 38.—*Lepas hilli*: A. lateral view of capitulum; B. cutaway of capitulum showing body with three filamentary appendages at base of first thoracic limb. Scale in millimeters.

Figure 22.—A goose barnacle, Figure 38, p. 23, from Zullo (1979), illustrated by Ruth von Arx.

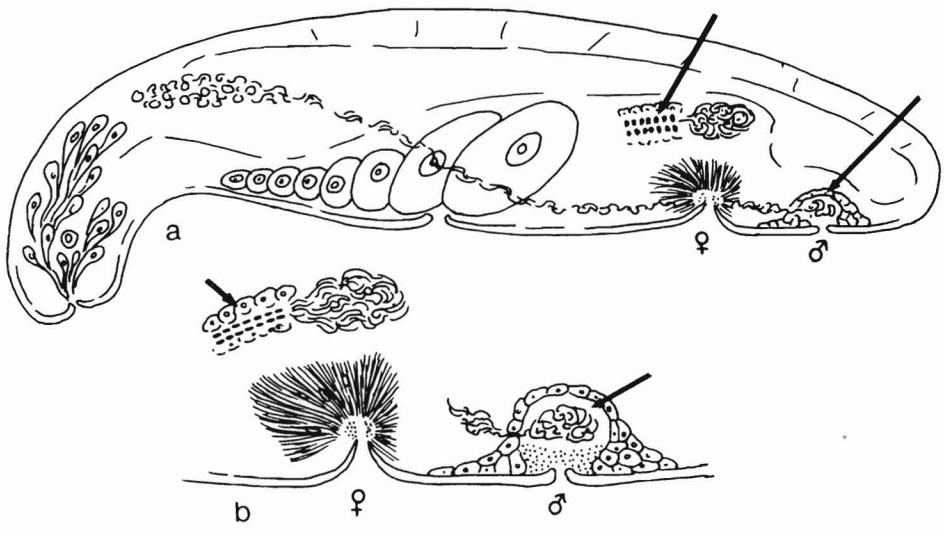


Figure 72.—*Pseudohaplogonaria vacua.*

Figure 23.—A turbellarian flatworm, Figure 72, p. 26, from Bush (1981).

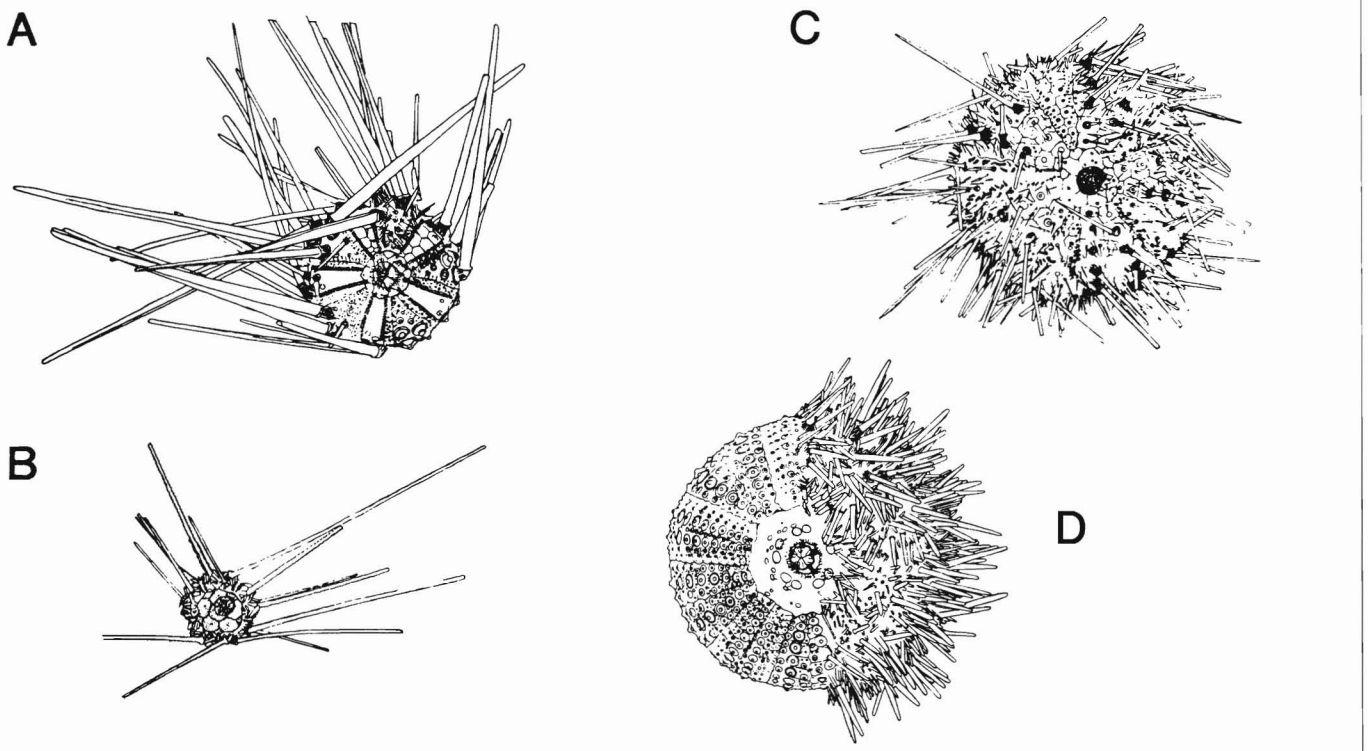


Figure 5.—Examples of regular urchins. A, *Coelopleurus* (aboral aspect); B, *Salenocidaris* (aboral aspect); C, *Echinus* (aboral aspect); D, *Strongylocentrotus* (oral aspect).

Figure 24.—Echinoid echinoderms, examples of sea urchins, Figure 5, p. 6, from Serafy and Fell (1985).

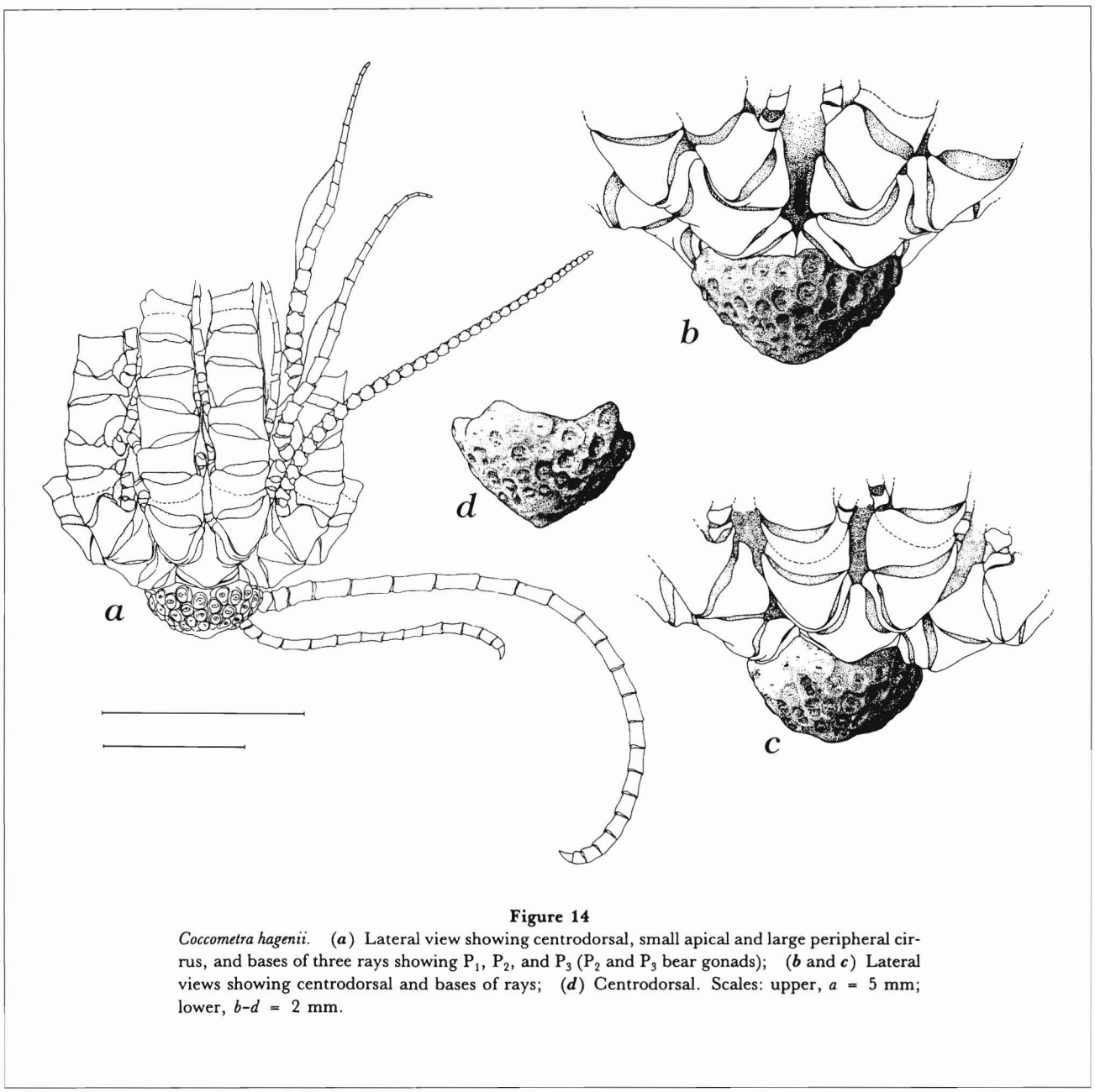


Figure 14

Coccometra hagenii. (***a***) Lateral view showing centrodorsal, small apical and large peripheral cirrus, and bases of three rays showing P_1, P_2, and P_3 (P_2 and P_3 bear gonads); (***b*** and ***c***) Lateral views showing centrodorsal and bases of rays; (***d***) Centrodorsal. Scales: upper, *a* = 5 mm; lower, *b–d* = 2 mm.

Figure 25.—A crinoid echinoderm, a feather star, Figure 14, p. 18, from Messing and Dearborn (1990).

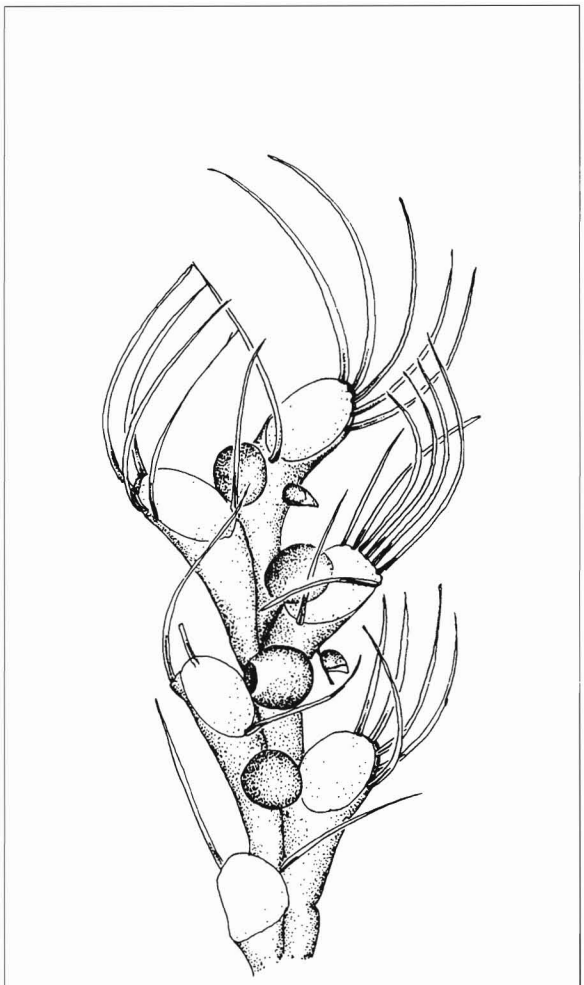


Figure 45
Bicellariella ciliata. Scale: 0.5 mm.

Figure 26.—An erect bryozoan, a moss animal, Figure 45, p. 32, from Ryland and Hayward (1991).

tion to decision makers in health and medical research, biotechnology, agriculture and fisheries, industries, government, conservation and resources, ecotourism, and basic biological sciences. In addition to classical taxonomy, new state-of-the-art techniques, such as the use of DNA analyses, are now available to establish the taxonomic basis for many groups of marine mammals, fishes, and invertebrates, especially of groups of species once thought to be one species (J. B. Pearce, NMFS, NEFSC, personal commun.).

From my perspective it is certain that classical procedures in taxonomy and biosystematics will continue to be the indispensable master keys that swing open the doors to an understanding of the community structure and function (Butman and Carlton, 1995) of our vitiating world-ocean ecosystem. No substitutes appear over the horizon.

Undeniably, the systematic task that we in SEP set before ourselves as we launched the "Marine Flora and Fauna" is far from complete; the substantial voids in the list of taxa of algae and invertebrate animals yet to be addressed are painfully evident in Table 1. But true as this is, beside the significant list of widely circulated useful manuals already in print, a successful prototype has effectively demonstrated that the "Marine Flora and Fauna" can serve as a model in the organization and operation of future flora and fauna programs in representative regions of the world.

Acknowledgments

I am pleased to thank the current members of the MFF Editorial Board

3(2) Ink sac present; arms moderately long; suckers large; cirri above eyes small or absent; ligula of hectocotylized right arm III of males very small ..... ***Octopus vulgaris*** **(Fig. 15)**

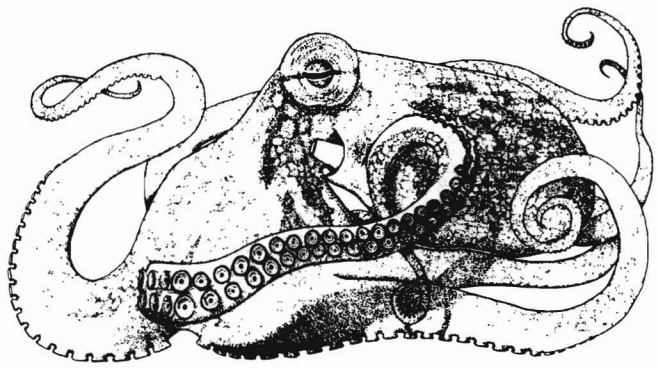


Figure 15
Octopus vulgaris **(lateral aspect).**

Figure 27.—An octopus, Figure 15, p. 7, from Vecchione et al. (1989).

for their comments and suggestions on the manuscript: A. Ralph Cavaliere, Arthur G. Humes, David L. Pawson, Kenneth P. Sebens, Ruth D. Turner, and Robert T. Wilce; as well as John B. Pearce, Willis L. Hobart, and Donald J. Zinn for their helpful suggestions. Thanks go also to Kate Tuttle for a copy of the photograph of Ruth D. Turner, to Judith E. Winston for the photograph of Marie Abbott, and Boston University Photo Services for the photograph of Wesley N. Tiffney. I am grateful to Linda Leidy for preparing the final typescript. And finally, I want to thank Willis L. Hobart for originally offering me the opportunity to prepare this history of a systematics odyssey.

Literature Cited

Blackwelder, R. E. 1967. Taxonomy, a text and reference book. John Wiley & Sons, N.Y., 698 p.

Borror, A. C. 1973. Marine flora and fauna of the northeastern United States. Protozoa: Ciliophora. U.S. Dep. Commer., NOAA Tech. Rep. NMFS CIRC-378, 62 p.

Bousfield, E. L. 1973. Shallow-water gammaridean Amphipoda of New England. Cornell Univ. Press, Ithaca, N.Y., 312 p.

Bovee, E. C., and T. K. Sawyer. 1979. Marine flora and fauna of the northeastern United States. Sarcodina: Amoeba. U.S. Dep. Commer., NOAA Tech. Rep. NMFS CIRC-419, 56 p.

Bush, L. F. 1981. Marine flora and fauna of the Northeastern United States. Turbellaria: Acoela and Nemertodermatida. U.S. Dep. Commer., NOAA Tech. Rep. NMFS CIRC-440, 71 p.

Butman, C. A., and J. T. Carlton (Co-chairs). 1995. The critical role of taxonomy. *In* Understanding marine biodiversity, a research agenda for the nation, p. 46–48. Committ. Biol. Diversity Mar. Syst., Natl. Acad. Press, Wash., D.C.

Carriker, M. R. 1962–72. Systematics-Ecology Program, Marine Biological Laboratory, Annual and Final Reports, 1962–1972. Offset, Mar. Biol. Lab. Libr., 503 p.

_____. 1973a. Marine flora and fauna of the northeastern United States. BioScience 23:607.

_____. 1973b. Marine flora and fauna of the northeastern United States. Chesapeake Sci. 14:306–307.

_____. 1976a. Progress report: Marine flora and fauna. Chesapeake Sci. 17:311.

_____. 1976b. The crucial role of systematics in assessing pollution effects on the biological utilization of estuaries. In Estuaries pollution control and assessment. Proc. Conf., vol. 1, 2, p. 487–506. U.S. Environ. Prot. Agency, Off. Water Plann. Stand., Wash. D.C.

_____. 1991. Systematics, the primordial biological fabric: a regional example. Am. Zool. 31(5):107A (Abst. #536).

Collette, B. B., and M. Vecchione. 1995. Interactions between fisheries and systematics. Fisheries 20:20–25.

Cook, D. G., and R. O. Brinkhurst. 1973. Marine flora and fauna of the northeastern United States. Annelida: Oligochaeta. U.S. Dep. Commer., NOAA Tech Rep. NMFS CIRC-374, 23 p.

Dale, B., and C. M. Yentsch. 1978. Red tide and paralytic shellfish poisoning. Oceanus 21(3):41–49.

Ghiselin, M. T. 1969. The triumph of the Darwinian method. Univ. Calif. Press, Berkeley, 320 p.

Manning, R. B. 1974. Marine flora and fauna of the northeastern United States. Crustacea: Stomatopoda. U.S. Dep. Commer., NOAA Tech. Rep. NMFS CIRC-387, 6 p.

Mayr, E. 1968. The role of systematic biology. Science 159:595–599.

_____. 1969. The role of systematics in biology. *In* C. G. Sibley (Chairman), Systematic biology, proceedings of an international conference, Univ. Mich., Ann Arbor, 1967, p. 4–15. Natl. Acad. Sci., Wash., D.C., Publ. 1692.

Messing, C. G., and J. H. Dearborn. 1990. Echinodermata: Crinoidea. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 91, 30 p.

Michener, C. D., J. O. Corliss, R. S. Cowan, P. H. Raven, C. W. Sabrosky, and G. W. Wharton. 1970. Systematics in support of biological research. Natl. Res. Counc., Div. Biol. Agric., Wash., D.C. Comm. Rep., 25 p.

Moul, E. T. 1973. Marine flora and fauna of the northeastern United States. Higher plants of the marine fringe. U.S. Dep. Commer., NOAA Tech. Rep. NMFS CIRC-384, 60 p.

Norse, E. A. (Editor). 1993. Global marine biological diversity. A strategy for building conservation into decision making. Island Press, Wash., D.C., 383 p.

Pawson, D. L. 1977. Marine flora and fauna of the northeastern United States. Echinodermata: Holothuroidea. U.S. Dep. Commer., NOAA Tech. Rep. NMFS CIRC-405, 15 p.

Plough, H. H. 1978. Sea squirts of the Atlantic Continental Shelf from Maine to Texas. Johns Hopkins Univ. Press, Baltimore, 118 p.

Pollock, L. W. 1976. Marine flora and fauna of the northeastern United States. Tardigrada. U.S. Dep. Commer., NOAA Tech. Rep. NMFS CIRC-394, 25 p.

Raven, P. H. 1990. The politics of preserving biodiversity. BioScience 40:769–774.

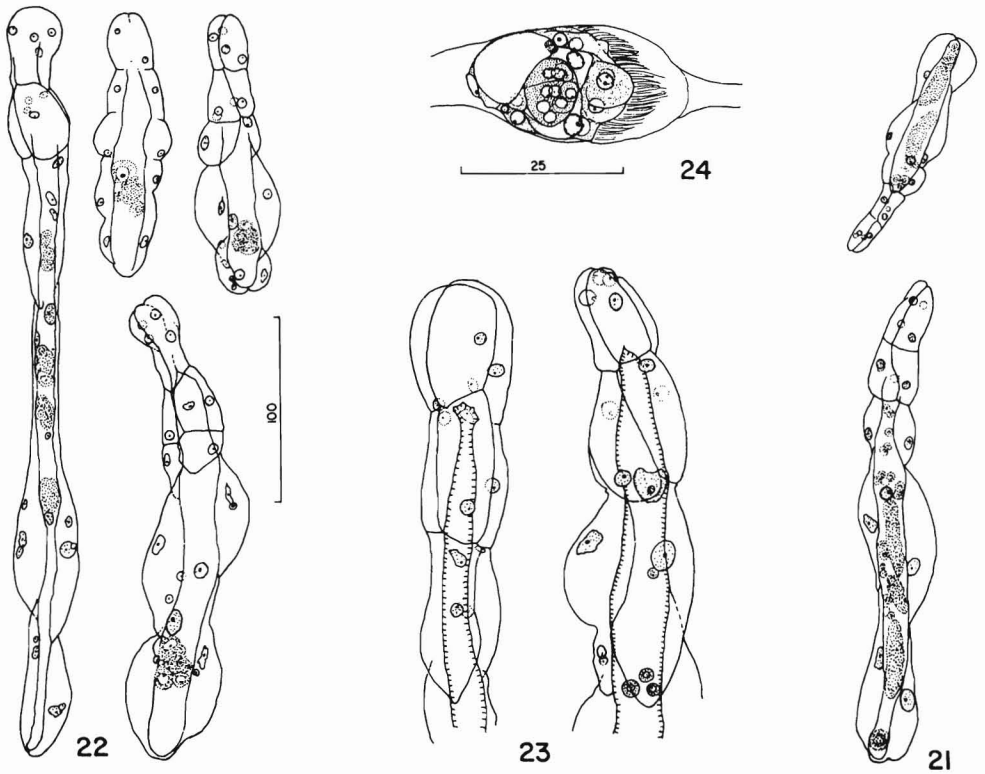
Ryland, J. S., and P. J. Hayward. 1991. Marine flora and fauna of the northeastern United States. Erect Bryozoa. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 99, 48 p.

Schmitt, W. L. 1967. Applied systematics: the usefulness of scientific names of animals and

plants. *In* R. E. Blackwelder, Taxonomy, a text and reference book, p. 24–37. John Wiley & Sons, N.Y. [Quotation of a paper read by Schmitt at the 1953 conference on systematics, Smithson. Inst., Wash. D.C.]
Serafy, D. K., and F. J. Fell. 1985. Marine flora and fauna of the northeastern United States. Echinodermata: Echinoidea. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 33, 27 p.
Short, R. B. 1991. Marine flora and fauna of the eastern United States. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 100, 16 p.
Simpson, B. B., and J. Cracraft. 1995. Systematics: the science of diversity. Use of a systematic perspective is burgeoning, and the need for the field is becoming even greater. BioScience 45:670–672.
Smith, R. I. (Compiler and Editor). 1964. Keys to marine invertebrates of the Woods Hole region. Spauling Co., Bost., 208 p.
Sumner, F. B., R. C. Osborn, L. J. Cole, and B. M. Davis. 1913. A biological survey of the waters of Woods Hole and vicinity. Sect. 1, Physical and Zoological. U.S. Dep. Commer., Bur. Fish., Fish. Bull. 31, 1:11–442.
Systematics Agenda 2000. 1994. Systematics agenda 2000: charting the biosphere. System-

4(3) Lengths of mature nematogens 254 to 264 μm, mature rhombogens 438 to 657 μm. Somatic cell number almost invariably 14. Calotte markedly elongate; in young vermiform individuals often 30 to 50% of total length, in largest vermiforms 14 to 20% of total length. Parapolar cells usually shorter than calotte. Vermiform embryos about 40 to 50 μm long at eclosion. Refringent bodies, in infusoriforms viewed laterally, appearing larger than cluster of urn cells (*see* Fig. 3B) ..... ***D. hypercephalum*** **(Figs. 21–24)**

Host: *Octopus joubini* Robson, 1929



Figures 21–24

Dicyema hypercephalum. (**21**) Nematogens. (**22**) Rhombogens. (**23**) Anterior ends of rhombogens. (**24**) Infusoriform within axial cell of rhombogen, sagittal optical section. All figures from Short (1962). Scales in micrometers. Cilia not shown on vermiform stages.

Figure 28.—A dicyemid mesozoan, Figures 21–24, p. 9, from Short (1991).

atics Agenda 2000 Tech. Rep., 34 p. Am. Mus. Nat. Hist., N.Y.
Thorne-Miller, B., and J. Catena. 1991. The living ocean. Understanding and protecting marine biodiversity. Island Press, Wash., D.C., 180 p.
Vecchione, M., and B. B. Collette. 1996. The central role of systematics in marine biodiversity problems. Oceanography: 9(1):44–45.
_____, C. F. E. Roper, and M. J. Sweeney. 1989. Marine flora and fauna of the eastern United States. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 73, 23 p.
Verrill, A. E., S. I. Smith, and O. Harger. 1873. Catalogue of the marine invertebrate animals of the southern coast of New England and adjacent waters. Rep. U.S. Comm. Fish. 1871–1872:537–778.
Yentsch, A., M. R. Carriker, H. Parker, and V. A. Zullo. 1966. Marine and estuarine environments, organisms and geology of the Cape Cod region. An indexed bibliography, 1665–1965. Mar. Biol. Lab., Woods Hole, and Leyden Press, Plymouth, Mass., 200 p.
Zullo, V. A. 1979. Marine flora and fauna of the northeastern United States. U.S. Dep. Commer., NOAA Tech. Rep. NMFS CIRC-425, 29 p.