

A Century of Copepods: The U.S. Fisheries Steamer *Albatross*

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"You were kind enough to say something very complimentary about the work that has been done upon the collection of parasitic copepods. It does not seem to me as if the work was as worthy of credit as is the collection itself. This collection is the natural outcome of the activities of the Bureau of Fisheries extended over a long period of years. Beginning away back in the sixties of the last century someone has been collecting fish parasites pretty steadily ever since. The result is the present Museum collection . . . which is by far the largest and richest collection in the world."

—C. B. Wilson letter to W. L. Schmitt, 9 March 1922

Introduction

The marine invertebrates of North America received little attention before the arrival of Louis Agassiz in 1846. Agassiz and his students, particularly Addison E. Verrill and Richard Rathbun, and Agassiz's colleague Spencer Fullerton Baird, provided the concept and stimulus for expanded investigations. Baird, through the establishment of the U.S. Commission of Fish and Fisheries in 1871, provided a principal

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means (Hobart, 1995). This fortunate convergence soon created the *Albatross* (1882), a classic vessel at the center of the golden age of oceanography. For length of service, areas explored, and volumes written, the *Albatross* record is likely unsurpassed.

The *Albatross* (Fig. 1) was not the first vessel for the U.S. Fish Commission (Galtsoff, 1962; Nelson, 1971). The *Fish Hawk* (157 feet), built for near-shore investigations, was earlier by 2 years, and she worked longer by 6 years. The *Fish Hawk*, however, did not visit such exotic climes as the *Albatross* (234 feet), nor did she have such an army of distinguished investigators associated with her. The *Albatross* also

reflected the experiences of other predecessors, the Coast Survey's *Bache* (1872) and *Blake* (1874).

The making and equipping of the *Albatross* has been told by others (Tanner, 1885a,b; Hedgpeth, 1945), and will be the stuff of many more fine stories to come. Likewise, *Albatross* journeys and accomplishments in far-flung geographic and academic fields will be reverently spoken of as long as men admire the sea (Agassiz, 1913; Andrews, 1929; Dunn, 1996a,b).

Tanner (1885a) described in incredible detail the equipment of the *Albatross* and how it was used. The men of the *Albatross* were as proud of her then as any of today's engineers would be of a satellite space station. A particularly engaging passage related to the commencement of trawling, in some cases to 1,000 fathoms:

"When the vessel reaches the intended station the officer of the deck stops her with her stern to the wind, has the patent log hauled in, and then takes his station on the grating at the sounding machine, where he superintends the sounding, and maneuvers the vessel to keep the wire vertical during the descent. Having satisfied himself that the specimen cup is properly bent to the stray line, the sinker adjusted, the thermometer and water bottle clamped, the friction rope properly attended by a careful man detailed for the purpose, a man forward of the machine at the brake, one abaft it with the crank shipped, and another on the grating to attend the guide pulley, he will lower away gently until the apparatus is under water, then seize the small lead to the stray line, caution the record keeper to look out, have the pawl thrown back

ABSTRACT—*The marine invertebrates of North America received little attention before the arrival of Louis Agassiz in 1846. Agassiz and his students, particularly Addison E. Verrill and Richard Rathbun, and Agassiz's colleague Spencer F. Baird, provided the concept and stimulus for expanded investigations. Baird's U.S. Commission of Fish and Fisheries (1871) provided a principal means, especially through the U.S. Fisheries Steamer Albatross (1882). Rathbun participated in the first and third Albatross scientific cruises in 1883–84 and published the first accounts of Albatross parasitic copepods.*

The first report of Albatross planktonic copepods was published in 1895 by Wilhelm Giesbrecht of the Naples Zoological Sta-

tion. Other collections were sent to the Norwegian Georg Ossian Sars. The American Charles Branch Wilson eventually added planktonic copepods to his extensive published works on the parasitic copepods from the Albatross. The Albatross copepods from San Francisco Bay were reported upon by Calvin Olin Esterly in 1924.

Henry Bryant Bigelow accompanied the last scientific cruise of the Albatross in 1920. Bigelow incorporated the 1920 copepods into his definitive study of the plankton of the Gulf of Maine. The late Otohiko Tanaka, in 1969, published two reviews of Albatross copepods. Albatross copepods will long be worked and reworked. This great ship and her shipmates were mutually inspiring, and they inspire us still.

and the crank unshipped, and order 'Lower away!'"

With respect to the copepod crustaceans collected by the *Albatross*, it is essential to recognize the two principal, although artificial, copepod groups. These groups, the free-living and the parasitic copepods, are generally caught with different methods. On the *Albatross*, the parasitic copepods were mostly taken from fish, although copepods could be parasitic on most any marine animal, even whales. The free-living copepods were taken primarily by plankton nets, which would catch pelagic as well as occasional bottom-dwelling copepods. In some plankton samples, free-swimming stages of parasitic copepods were encountered.

I am pleased to record that copepod investigators were present on the first and the last *Albatross* cruises, and that considerable and praiseworthy attention was given to copepods throughout and beyond the active life of this famous oceanographic ship. Most of the promising young men who sailed with the *Albatross* had brilliant careers. This great ship and her shipmates were mutually inspiring, and they inspire us still.

A. E. Verrill and S. I. Smith

The *Albatross* was launched in an undercurrent of anticipation of an immense harvest of little-known marine life. Those who would go down to the sea for invertebrates were not the prime movers of the *Albatross*, for its essential task was always toward vertebrate fisheries research. However, persons of influence recognized direct and indirect links between fish and invertebrates, such as the copepod crustaceans, and their study was encouraged in those early days. The Fish Commission had no staff for this work, so it was obliged to accept outside help.

Indeed, the very first annual report of the Commissioner of Fisheries summarized the essential knowledge of American marine invertebrates to that time (Verrill and Smith, 1873). There had been nothing approaching this in the generation since Gould's 1841 pioneer report on the invertebrates of Massachusetts. Verrill and Smith's large volume

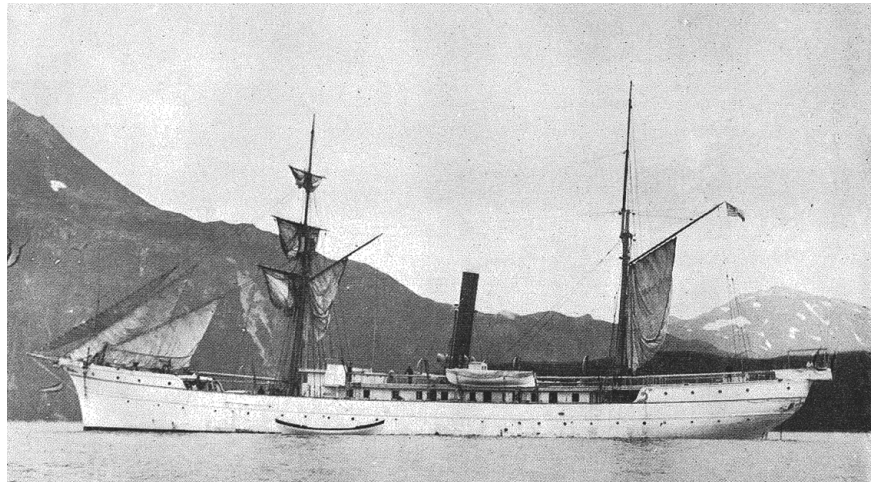


Figure 1.—U.S. Fisheries Steamer *Albatross* under partial sail in Alaska (from Townsend, 1901).

was a major advance in ecology of our seas. Although there was considerable new information on many invertebrate groups, especially mollusks (Verrill) and large crustaceans (Smith), one found little on copepods:

"The . . . minute Copeopoda [sic] of our coast have not yet been sufficiently studied by any one for us to attempt to enumerate even the more common species" (Verrill and Smith, 1873).

Only 20 copepod species were included, and all but one of these were parasitic. This was the basis on which the *Albatross* copepod collections began. [In Verrill and Smith's taxonomy, the old lower-crustacean group Entomostraca included the "Copeopoda" (apparently only the planktonic species, and here only *Sapphirina* sp.) and the Siphonostoma, the parasitic species (19 listed, all from fishes). In early references, the advanced parasitic forms were sometimes also referred to as "lernaeids."]

Addison Emery Verrill (1839–1926) had been a student of and assistant to Louis Agassiz at Harvard's Museum of Comparative Zoology. In 1864, Agassiz recommended Verrill to Yale, where he remained for 43 years as Professor of Zoology. Verrill continued his studies of invertebrates along the northeast coast. Responding to Baird's desire to

investigate the environment of the commercial fishes, Verrill began comprehensive surveys for the Fish Commission in 1871 (Coe, 1930).

Verrill was at the center of America's major growth in zoology from Agassiz's prime through the experimental era of the first quarter of the 20th century. Verrill participated in the general trend of zoological fashion from taxonomy, to evolutionary adaptations, to embryology, and to experimental physiology and genetics. However, taking a long look back at his work, the single item that probably still brings the greatest recognition is the 1873 report on the northeastern invertebrates.

In this monumental study, Verrill was ably assisted by his brother-in-law Sydney Irving Smith (1843–1926). Smith (Fig. 2) had followed Verrill to Yale as a student; in the following year, Verrill married Smith's sister. In 1867, Smith became Verrill's assistant, co-worker, and eventually coauthor on the Fish Commission's invertebrate report (Coe, 1929). In 1875, Smith was appointed Professor of Comparative Anatomy at Yale. He was also one of the founders of the Marine Biological Laboratory at Woods Hole.

R. Rathbun

Richard Rathbun (1852–1918) (Fig. 3) was linked to the *Albatross* even before it was afloat. That he became the first



Figure 2.—Sydney Irving Smith (1843–1926) (USNM photograph).

scientist to report on the enormous numbers of copepods collected from this celebrated ship gives him a prominent part in the present narrative. He was born in Buffalo, N.Y., and at age 15 began a 4-year apprenticeship as a clerk for his father's contracting and stone business. At this early age, Rathbun had a fascination with fossils of western New York, finding the first in his father's own quarries (Rathbun, 1969). His collections and studies of these, and his obvious knowledge and enthusiasm, led him even then to the honorary post of curator of paleontology at the museum of the Buffalo Society of Natural History. At the urging of Charles F. Hartt (an Agassiz pupil and Professor of Geology at Cornell), Rathbun began science studies at Cornell University in 1871 (Benjamin, 1918; Coe, 1918).

Rathbun's first publications, on fossils, began at this time. His research soon brought him to Cambridge, Mass., where he took classes from Louis Agassiz at the Museum of Comparative Zoology in 1872–73, Agassiz's last years. In September 1873, Rathbun was on the *Bache*, dredging invertebrates off the coast of Maine with A. S. Packard, at that time an Agassiz



Figure 3.—Richard Rathbun (1852–1918) (from Benjamin, 1918).

assistant. Rathbun remained at Cambridge until 1875. During his summers there, he began his long association with Spencer Baird, at first as a volunteer scientific assistant.

In 1875, Rathbun joined Hartt's staff, in Brazil, where Hartt was conducting a geological survey. Rathbun's interests were particularly in coral reefs and fossils. When Hartt died of yellow fever in March 1878, Baird offered Rathbun a position as a paid Scientific Assistant in his new U.S. Fish Commission. Rathbun was detailed to Verrill at Yale where, although Verrill was in charge of the work, Rathbun had day-to-day responsibility, making many invertebrate collections over the following 2 years. Rathbun, although based at various offices, retained this formal position with the Fish Commission through 1896 (Benjamin, 1918).

Rathbun was therefore a protégé of both Agassiz and Baird. Through Baird, Rathbun also spanned both the Fish Commission and the growing U.S. National Museum (USNM), and continued the close relations between the two institutions. In 1880, with a new National Museum building, Rathbun transferred to Washington, D.C., and was assigned as Curator of the Department of Marine Invertebrates. Rathbun thus joined an eager community of biologists in the Nation's capital, in time to be one of ten founders of the Biological Society of Washington, for which he was sec-

retary until 1888. In 1880 and 1882, Rathbun was on the *Fish Hawk*, surveying fishery resources out to the Gulf Stream:

“At each dredging station, collections were made with the towing net [Fig. 4], which is designed to scoop in the free-swimming forms, living at the surface and at intermediate depths. . . . The animals obtained [included] copepods, the latter frequently occurring in countless numbers. They serve as food for the surface-swimming fish, such as menhaden and mackerel” (Tanner, 1884).

As both the USNM and the Fish Commission grew, Baird relied more and more on Rathbun for administrative duties, until Baird's death in 1887. This turned Rathbun into an administrator of remarkable ability.

One of the essential housekeeping chores was the review and recording of the earliest lists of stations and activities of the Fish Commission, copublished by Rathbun (Smith and Rathbun, 1882). This was followed by a number of summaries of North Atlantic fisheries, including accounts of the natural history of crustaceans, worms, echinoderms, and sponges, comprising altogether more than 500 pages (Coe, 1918). This was his best zoological

work, and it established Rathbun as an authority on the investigation and economics of marine zoology.

Rathbun's first obvious connection with the *Albatross* was his role in the preparation of the extensive catalog accompanying the U.S. exhibit at the "Great International Fisheries Exhibition" in London in 1883. Rathbun authored a section on the economic crustaceans, worms, echinoderms, and sponges. In a second section, he reviewed the "apparatus of scientific research" (Rathbun, 1883). The U.S. exhibit outlined fisheries work by American scientists, particularly from U.S. Coast Survey and Fish Commission vessels, but the *Albatross*, her equipment, and expected scientific harvest, was the main feature of the presentation.

Baird had planned to move Rathbun wholly into the USNM, but after his death, George Brown Goode (1857–1896), the interim Commissioner of Fisheries, persuaded Rathbun to retain his Fish Commission position. During this time, Rathbun assisted the international fur seal commission and thereby continued with the results of *Albatross* investigations through 1896. In 1892, he was the U.S. representative for fisheries on the Boundary Commission and visited both coasts and the Great Lakes, from the Gulf of St. Lawrence to Cape Flattery. Rathbun's extensive reviews of the Nation's fisheries (e.g. Rathbun, 1884, 1899) are classics of their kind. Altogether, Rathbun published about 100 papers. In 1894, Rathbun was given an Honorary Doctorate by Bowdoin College, and he included among his many affiliations, membership in the American Fisheries Society.

Rathbun did not leave the Fish Commission until after Goode's successor, Marshall McDonald, died in 1895. Rathbun began working solely for the USNM on New Year's Day 1897. His previous work there ensured an extraordinarily rapid rise. Within a month, Rathbun was Assistant Secretary of the Smithsonian Institution, the parent organization of the USNM, in which, as an old habit, he retained his other official title. In mid 1898, he was named Director of the USNM. He held this position until 1914, and the Smithsonian's until his death in 1918:

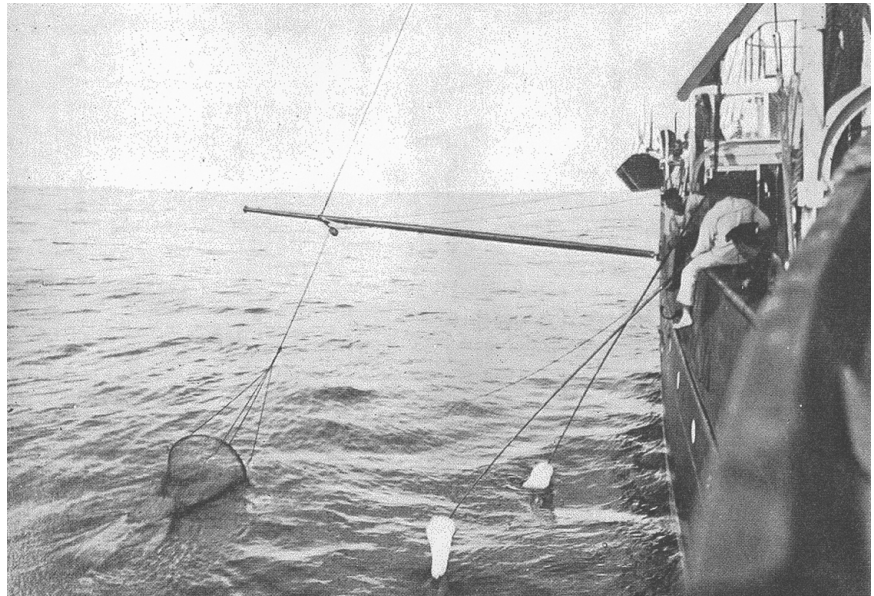


Figure 4.—Surface net and dip nets in use on the *Albatross* (from Townsend, 1901).

"Absorbed in the details of his various activities, all of which had to do with the institution to which he gave his life, he had but little time for other interests" (Benjamin, 1918).

One of Rathbun's great accomplishments, from 1913, was the present Natural History Museum building, where I was employed for several years, and where Rathbun was still remembered with fondness. (Rathbun's attention to every detail of the planning and construction of this building ensured him the repetitive duty with respect to the building of the National Gallery of Art.) Waldo L. Schmitt (1887–1977), who had been Naturalist on the *Albatross*, was the protégé of Rathbun's sister, Mary Jane Rathbun (1860–1943), crustacean specialist at the USNM. Through their close relationship, Richard Rathbun extended every courtesy to Schmitt, who spoke of him often and with great respect. I was privileged to consider Schmitt a friend in the last decade of his life; I was that close to the *Albatross*.

The *Albatross* was taken on a preliminary cruise in March 1883, when much of the equipment was tested. Baird's orders, dated 10 April 1883, for the

first *Albatross* scientific cruise concluded thus:

"You will give to the naturalist of the expedition all possible facilities for collecting and preserving such specimens as you may meet during the cruise.

"P. S.—The operations of dredging and trawling should be carried on as frequently as opportunity offers. . . ." (Tanner, 1885b).

The *Albatross* then put to sea on 24 April, and the first "official" sampling was with a beam trawl at Station 2007 on 27 April between Washington and Norfolk, Va.

The earlier parts of Tanner's (1885b) report of the first *Albatross* year spoke mainly of fish, but soon the response to Baird's orders "to determine . . . the biological peculiarities" of the New England seas became evident as detailed observations and the concurrent excitement of Verrill's crew reached the Commander. With "the naturalists finding no difficulty in picking over the contents of the trawl," log-book entries indicated the examination of the surface and gills of fish for parasites. By May, with "many new and interesting forms

having been brought up,” Commander Z. L. Tanner (1835–1906) was making familiar entries of salps, foraminifera, globigerina, large red crabs, starfish, squid, “coral growth,” barnacles, and lobsters, reflecting the growing interest of all in that portion of the harvest. Some of these notes mentioned genera; “minute crustaceans” sometimes made their way into the ship’s logs. “A number of naturalists” (July) became “a large party of naturalists” (September), and produced “many valuable specimens.” In October, “all the fish taken were carefully examined for parasites.”

In spite of the careful handling of ship and equipment, “the trawl was lost” was an all-too-common entry in the early reports. In one case, the Commander stated that

“. . . the accident was the result of kinking and the fault rests between myself and the dredge rope. I have not yet been able to judge satisfactorily which is responsible for the frequent losses during our present trip” (Tanner, 1885b).

One mystery for which the *Albatross* was charged was to determine what Atlantic menhaden, *Brevoortia tyrannus*, eat. The skipper of a fishing boat met at sea in August said that “their food is a very small marine insect, which appears under the microscope to be a species of crab” (Tanner, 1885b). This is not a bad description of copepods, which, of course, make up a large part of the food of the filter-feeding menhaden. Therefore, it soon was apparent that menhaden, unlike Atlantic cod, *Gadus morhua*, were not “ground grubbers,” which was commonly held, nor did menhaden eat mud. Another old fisherman, speaking of the food of mackerel, *Scomber* spp., said that it “consists in part of what is known among fishermen as ‘cayenne,’ only seen when the water is very smooth. It then appears to skip out of the water.” This is an early American reference to the surface swarming of the copepod *Calanus* (and others), a phenomenon by then well known to Scandinavian biologists (Gunnerus, 1770).

Copepods also surfaced briefly in the report of the *Albatross*’s first Natural-

ist, James E. Benedict (Tanner, 1885b). Underwater lights were often used, typically just beneath the surface, aiding in the capture of several surprising forms. Among these were “early stages of various Copepods,” passed to Professor Sydney Smith.

Richard Rathbun participated on various legs of the first scientific cruise of the *Albatross*, in 1883, dredging and trawling from Woods Hole to the Gulf Stream until 14 November, when the *Albatross* tied up in the Washington Navy Yard. Among the invertebrates which attracted Rathbun most were parasitic copepods found on fish. Rathbun also was on the third *Albatross* cruise, in the same area, in 1884, and from 1885 to 1887 he published the first three accounts of *Albatross* copepods (Rathbun, 1885, 1886, 1887).

Rathbun published pre-*Albatross* lists of invertebrates from the collections of the USNM (Rathbun, 1882a, b); these mentioned copepods, but only from the *Fish Hawk* or from the Commission’s work along the northeast coast. The first *Albatross* copepods, parasites of fish, were listed and described by Rathbun in 1885. At that date, in the museum collections, there were 22 identified species of copepods (not counting 4 species of argulids, then classified as copepods), of which 9 were from *Albatross* Cruises 1 and 3 off the northeastern United States. The various legs of these first two Atlantic cruises were under Verrill’s direction, but Verrill himself apparently never shipped on the *Albatross*.

Rathbun (1886) followed soon with a second publication on parasitic copepods. This included figures for three new species of *Chondracanthus* taken during the *Albatross* first cruise, in 1883, as well as a second *Albatross* record (1885) for a previously reported species.

In a third and final report, Rathbun (1887) described three new species of parasitic copepods from *Albatross* collections, taken from sharks, menhaden, and bluefish, *Pomatomus saltatrix*, in Vineyard Sound or off Florida.

Before leaving Rathbun’s direct participation, it must be noted that Verrill (1885) published a large report on general invertebrates collected by the *Al-*

batross during 1883. Verrill acknowledged that “very interesting additions to our collections were made in nearly every class.” His particular interest was in the mollusks. Smith studied the crustaceans, principally the decapods, while Rathbun dealt with the copepods. The only copepod specifically mentioned by Verrill was found on a red sea anemone, of unpleasant if not dangerous stinging abilities, common below 150 fathoms:

“A very singular, large, soft, pinkish Lernean crustacean (*Antheacheres duebenii* [Michael] Sars, fig. 167–8) lives parasitically in the stomach of this Actinian, with which it agrees in color. It is not uncommon” (Verrill, 1885).

In another section, it was acknowledged that

“. . . the Copepoda . . . are very abundant, both in the lots obtained in the trawl-wings and in the surface collections. Very many fine species were noticed, but they have not yet been reported upon by Mr. Rathbun, who has charge of [this group]. He has studied a number of interesting and novel forms of Lerneans found parasitic on several of the deep-sea fishes” (Verrill, 1885).

The trawl wings (Fig. 5) were muslin nets attached so as to be just above the bottom at the ends of the trawl frame. These were first used by Verrill on the *Fish Hawk*. Verrill noted that many pelagic species which were not caught at the surface were collected in the trawl wings, but that the precise depth of collection could, of course, not be determined.

For the Gulf Stream,

“Copepod crustaceans are usually the most abundant forms of small surface animals, occurring in great quantities and of many genera and species. Various species of the genus *Calanus* are the most common. Several species of the genus *Sapphirina* were taken, some of them very brilliant in colors” (Verrill, 1885).

Verrill's report only hinted at what were to become overwhelming numbers of pelagic copepods in the *Albatross* collections.

The second, the longest, and the most important period of the *Albatross* began at the end of 1887 (Hedgpeth, 1945;

Nelson, 1971). In describing the departure of the *Albatross* for the Pacific Ocean on 20 November, Commander Tanner wrote that

"It is seldom the fortune of men to start on a long voyage under more

favorable auspices. The ship was well equipped and thoroughly seaworthy in every respect. She had on board an efficient corps of officers and scientists, and her crew could not be excelled" (Tanner, 1891).

The *Albatross* sampled around South America, via the Strait of Magellan, and reached San Francisco 11 May 1888, 4 days ahead of schedule.

W. Giesbrecht

The *Albatross* collected vast numbers of planktonic copepods, especially in the Pacific Ocean. The first report of these was published in 1895 by Wilhelm Giesbrecht (1854–1913), the virtuoso German copepodologist on the staff of the Naples Zoological Station (Damkaer, 1995b).

Giesbrecht (Fig. 6) was born in Danzig and earned a doctorate at the University of Kiel. An appointment as guest researcher at Naples in 1881 resulted in a lifetime position. Giesbrecht's major effort was the unexcelled 1892 monograph on pelagic copepods. Giesbrecht was the first to clearly show that parasitism arose independently at several phases of copepod evolution, and through consideration of morphological development, he removed the prevailing distinctions between free-living and parasitic copepods. Through his writing and artistic skills, he was a respected editor at Naples and for other publishers.

The Giesbrecht (1895) copepod collection was from the 1891 *Albatross* cruise through the warm Pacific from California to the Galapagos. This was the first of three cruises under the direction and patronage of Alexander Agassiz, esteemed son and student of Louis Agassiz. Ironically, this exotic region had been traversed by the U.S. Exploring Expedition (1838–1842), the *Challenger* (Great Britain, 1872–1876), and the *Vettor Pisani* (Italy, 1882–1885), with the copepods incorporated into classic publications. Giesbrecht himself published several reports on copepods from the latter cruise, and he summarized these in his well-known 1892 monograph.

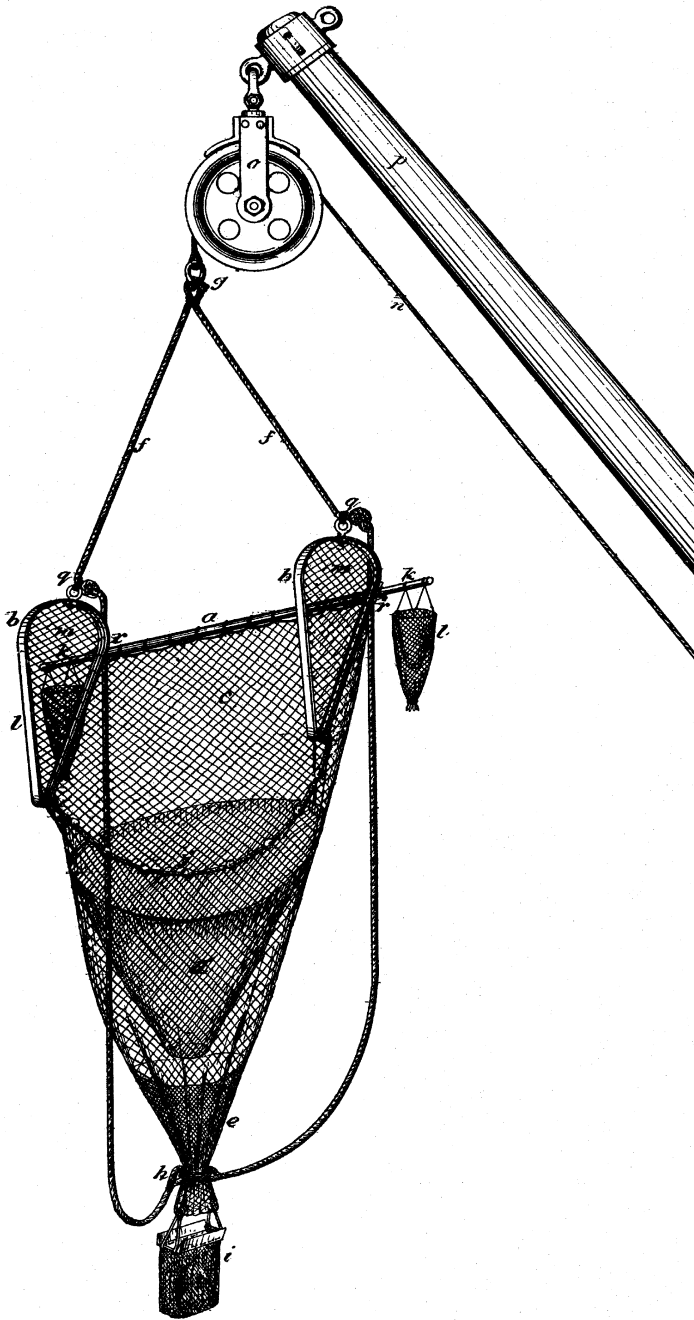


Figure 5.—The improved beam trawl, with trawl wings, as used on the *Albatross* (from Tanner, 1885a).

Although the number of individual copepods was small, this *Albatross* collection, only 32 samples, contained a large number of species; this now well-known feature of tropical waters was not so obvious in the early days. As a supplement to earlier work, Giesbrecht had a keen interest in the collection. Most samples were from the surface, but there were some reaching 200 to 600 m, and one to 3,000 m. Three samples had been obtained with a closing net (Fig. 7). From the deep-sea samples, Giesbrecht suggested that some surface forms from cold-water regions were living at depth in the warm-water regions. This is another notion that has firmed with time. Giesbrecht also found special interest in the species which were common to both the Atlantic and Pacific. Giesbrecht discussed 48 *Albatross* copepod species, describing and illustrating 10 new species and 3 new genera.

Giesbrecht honored both Alexander Agassiz and Lt. Commander Z. L. Tanner through the new copepods *Pontella agassizi* and *Heterochaeta tanneri*.

G. O. Sars

Other *Albatross* collections of pelagic copepods were sent to the Norwegian Georg Ossian Sars (1837–1927), who died with his report less than half completed. The material comprised seven distinct collections: 1) around South America and through the eastern Pacific (1887–88), 2) across the tropical Pacific to Japan and Kamchatka (1899–1901), 3) Hawaiian Islands (1902), 4) California and south (1904), 5) Alaskan salmon (1903, 1905), 6) Northwest Pacific (1906), and 7) the 3-year cruise to the Philippines (1907–10), with the most specimens. Sars sorted and labeled about 40% of the copepods (those collected before 1905) in this large assortment, and he made drawings of new species, at which time he felt an obligation to an earlier study on the copepods collected by the Prince of Monaco. Sars devoted the rest of his life to finishing that exquisite monograph and never looked at the *Albatross* copepods again.

Sars (Fig. 8) was the son of Michael Sars, a priest turned world-class zool-



Figure 6.—
Wilhelm
Giesbrecht
(1854–1913)
(Naples
Zoological
Station
photograph).

ogist. Ossian Sars's international fame was based on his revelation that most of the commercial fishes had planktonic eggs and larval stages. His interests then moved toward the lower crustaceans, and during the next 60 years, his production of definitive and well-illustrated monographs made him the best-known Norwegian zoologist. He became a professor at the University of Christiania. He was a planner, participant, and reporter for the Norwegian North Atlantic Expedition (1876–78). Another acclaimed publication was Sars's account of the copepods collected by his brother-in-law, Fridtjof Nansen, during the Norwegian North Polar Expedition (1893–96). Sars, as many of his efforts proved, was not averse to field work. Indeed, his ingenious applications are still appreciated by those who would again collect material revealed by him. However, the enormous numbers of specimens sent to Sars from all over the world ensured that he would remain near his laboratory (Damkaer, 1993).

After Sars's death, the *Albatross* collection, with Sars's notes and drawings, was returned to the USNM, and the work was taken up by C. B. Wilson, who added the plankton copepods to

his already extensive published works on the parasitic copepods from the *Albatross*. A measure of the task may be suggested by the fact that Wilson, too, died with the work far from complete.

C. B. Wilson

Charles Branch Wilson (1861–1941) probably never looked seriously at a copepod until he was 35 years old, when he became a professor, and later head of the science department, at the State Normal School in Westfield, Mass. Before that time, he had experimented with embryonic development of amphibians. Opportunities for field work in Jamaica and in California in 1897 and 1899, respectively, turned most of his energy toward parasitic marine copepods. In fact, by expressing a solid interest, Wilson received the mantle from Rathbun and became his protégé:

“I am pleased to know that some one has again taken up the subject of parasitic crustaceans in this country, and trust that you may be able to make good progress in the work. Some years ago I made quite a collection in that line at Woods Hole and elsewhere along the coast, but lack of opportunity

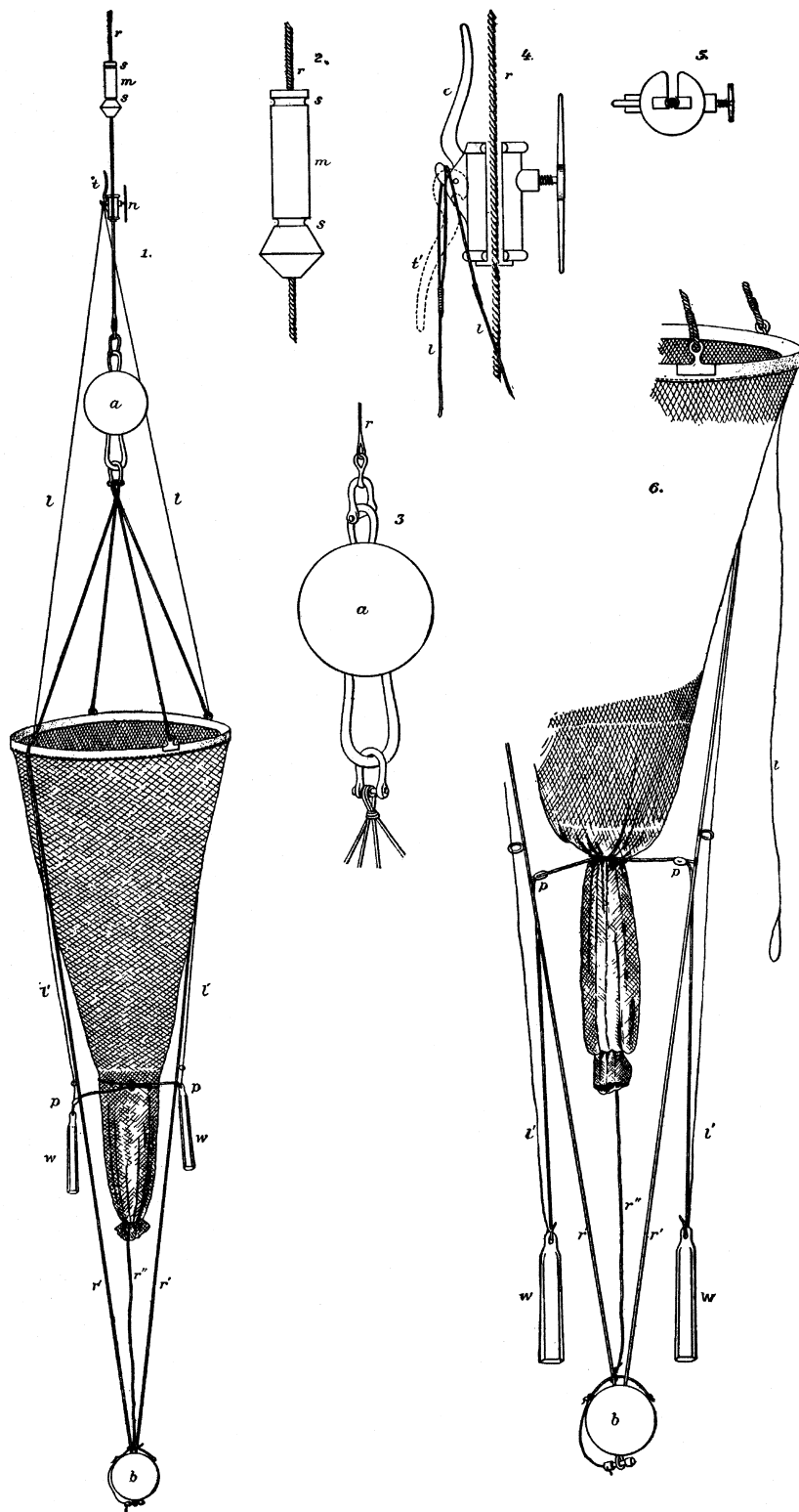


Figure 7.—Tanner's first closing net, as used on the *Albatross* (from Tanner, 1893).

to work them up accounts for the little I have published. The specimens are now here in the National Museum in good condition. Would you care to study and report upon them to the Museum? As I recall it, there are still several undescribed species and much else of interest in the material. I shall be glad to hear from you on the subject at your convenience. Yours very truly, Richard Rathbun, Assistant Secretary" (24 September 1900).

Wilson (Fig. 9) joined the circle of independent Fish Commission researchers in 1901 by spending the first of many summers at the Woods Hole Laboratory. He took up the parasitic copepods with a vengeance, and for a generation no one in this country, and few abroad, came even close to his output and quality (Damkaer, 1995a). Like Sars, Wilson was the recipient of many specimens from around the world, as his long list of publications clearly shows.

Most of Wilson's copepod papers were published by the USNM. Wilson's papers can be grouped somewhat arbitrarily as systematic reviews (source not stressed) or as summaries of geographically limited collections. Not surprisingly, the collections available to him included many specimens from the *Albatross*.

In the first category are eight reports describing *Albatross* copepods. The first, Wilson (1905), was based mainly on Fish Commission collections off the U.S. east coast. Rathbun had turned over to Wilson all of his lists and notes from preliminary work on this collection. Although some *Albatross* copepods were mentioned, including some taken on the trip around South America and in the Pacific, the source was not given for all specimens; USNM records would have to be revisited to determine the exact number of *Albatross* copepods from this study. The emphasis in the report was on hosts, descriptions, and redescrptions of species. Recall that many "good" parasitic copepods had been described from hosts obtained at markets, and that the precise location was less important in those days than a

description of the species. Among the accounts of 36 caligids were 10 from the *Albatross*, including a new genus and 6 new species, one of which had been attracted by the electric light. Typical for Wilson's papers, there was an excellent review of the literature.

The next two papers, Wilson (1907 a,b), reported three *Albatross* species, one of which, from 1887–88, was new, and from various Atlantic and Pacific localities, about 20 species from the *Albatross*, one of which was new.

A large and well-known monograph covering marine and freshwater parasitic copepods of Wilson's (1915) *Lernaeopodidae* included ten *Albatross* species, seven of which were new. One of the latter was *Brachiella nitida*, found in the mouth of the fish *Albatrossia pectoralis* from a 1906 North Pacific locality. A companion report on the *Lernaeidae* (Wilson, 1917) described 13 Atlantic and Pacific *Albatross* species, of which 9 were new species. Three new lernaeid genera from the *Albatross* collections were introduced. A following report (Wilson, 1919) dealt with four Atlantic and Pacific *Albatross* species, three of which were new. A new genus was described from *Albatross* collections off New Jersey in 1883. Wilson (1924) reported two *Albatross* copepods, one from British Columbia and one from the Strait of Magellan. The date of the latter collection, stated as 1908, cannot be correct; conversely, perhaps the locality is incorrect.

The final paper in this group of systematic reports is Wilson (1944), completed only a few weeks before he died. Therefore, this was the last paper of Wilson's own doing. Only one copepod species was clearly from *Albatross* collections, and this represented a new genus and species from the New Jersey coast.

In Wilson's papers based on geographically limited collections are six with *Albatross* material. The first is Wilson (1908) on parasitic copepods found on fishes of the Pacific coast, with descriptions of new genera and species; "some of them are the result of work done upon different expeditions of the steamer *Albatross*." Except for two lots sent directly to Wilson (one from



Figure 8.—
Georg Ossian Sars
(1837–1927)
(photograph
ca. 1925 by
Hjalmar Broch,
University of Oslo),

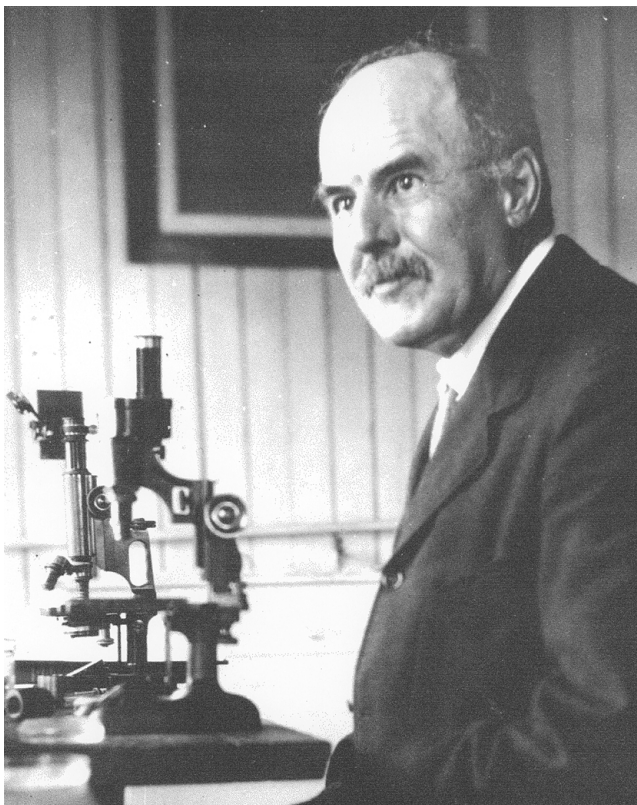


Figure 9.—
Charles
Branch Wilson
(1861–1941)
(photograph
ca. 1925 by
Marine Biological
Laboratory,
Woods Hole).

Ritter collected in 1904 and another from Kofoid), all *Albatross* specimens were sent to Wilson via the USNM. Of 13 *Albatross* species, 4 were new; Wilson also described one new genus.

Two new copepods, one from an echinoderm in Japan and the other from a Hawaiian mollusk, were reported from *Albatross* collections in Wilson (1921). Wilson (1923) described a new genus and species of parasitic copepod from a Lower Californian annelid dredged by the *Albatross* in 1911.

Wilson's (1932) "Copepods of the Woods Hole region Massachusetts" is likely the most-used American publication on copepods—the copepod "bible" for a generation, and still a ready companion for those working in the North Atlantic. Wilson defined this region as ca. 200 miles wide and 150 miles long:

"Any reduction of the area would of necessity eliminate some of the excellent material gathered during the earliest cruises of the . . . *Albatross*. As these were all included in the notes and drawings made by Dr. Richard Rathbun, it has been deemed best to keep the collection intact."

Rathbun spent his summers and early autumns during 1880–85 at Woods Hole, and his investigations formed the basis of this classic work. He made copious notes regarding living forms and their colors. For marine copepods in this area, northern and southern faunas overlap, so diversity is high, and a

" . . . remarkable feature of the present collection is the large number of species that have never before been reported from the Woods Hole region . . . [or] anywhere along the Atlantic shores of North America. . . . How does it happen that so many species escaped the attention of those investigators . . . already mentioned? The first answer is suggested by a perusal of the notes and records made by Doctor Rathbun and his associates. They were exceptionally thorough in their search, and their task was accomplished long before the intro-

duction of any agitation in reference to an 8-hour working-day. . . . Evidently in the interests of science a 17-hour day was not deemed impossible by those enthusiasts.

"If all this wealth of material be considered in connection with the several papers that Doctor Rathbun published, it can easily be seen that he would have become one of the foremost authorities upon copepods, had not his executive duties compelled him to give up research work. It is, therefore, eminently appropriate that the present paper, which embodies so much of his work, be dedicated to his memory" (Wilson, 1932).

The *Albatross* was in the Atlantic for only a relatively short time, although virtually all marine copepods reported in Wilson (1932) could have been collected from that ship. Most of the copepod species were from *Grampus* collections, which may have had a higher priority. Noted from the *Albatross* were 57 calanoid species and 11 species from other groups, including a new genus and species. This represents 18% of the 373 copepods reported and described in this monograph. Many of the other copepods were from fresh water or brackish ponds and beaches. Wilson included a key to all the known copepod genera, worldwide, ensuring the broad and lasting value of this work.

Wilson's (1935) report on parasitic copepods from the Pacific coast supplemented Wilson (1908) by adding three species from the *Albatross*, one of which was new and named for Ed Ricketts of "Cannery Row" fame (Hedgpeth, 1978a, b). Other specimens came from Stanford University and University of California collections.

In Wilson's publications covering *Albatross* copepods, only the last, Wilson (1950), dealt exclusively with this collection. Wilson died in 1941, and his colleagues at the USNM, especially Waldo L. Schmitt, completed the references, edited the records, and brought this report to publication.

The *Albatross* Atlantic forms were addressed in "Copepods of Woods Hole"—the remainder, from tow nets

and dredging in the Pacific Ocean (i.e. plankton copepods), essentially the same samples that had been sent to Sars, was covered in Wilson (1950). This collection comprised thousands of mostly surface samples; in amount and coverage of plankton, these compared with the greatest collections to that time: U.S. Exploring Expedition, *Challenger*, Prince of Monaco cruises (1885–1914), *Siboga* (1899–1900), and the *Carnegie* (Wilson, 1942). Altogether, from the *Albatross*, there were 473 copepod species (including one larval *Pennella*, a parasitic copepod), of which 29 were new. Males of pelagic copepods are frequently scarce, and this collection provided previously unknown males for 26 species. From similar areas traversed by other expeditions, 93 species were found only by the *Albatross* (including, of course, the 29 new species); only 12 species were on all of the lists.

The methods employed on the *Albatross* were not quantitative, and there were few comparisons of numbers. The nets were 1) surface ring nets, 12 in to 5½ ft; an electric light added to numbers of copepods captured; 2) paired ring nets for horizontal and vertical tows, sizes to 10-ft diameter; 3) ca. 3-ft diameter closing nets at intermediate depths:

"A good start has been made toward a knowledge of the surface plankton, but it is only a start, and a broad field is still left for future investigation and discovery. Many species have been obtained in vertical hauls from considerable depths, but we have absolutely no definitive knowledge as to where they entered the net" (Wilson, 1950).

Each species was described, and many were illustrated. Each station is listed separately (location, depth, date) with the species found there. Wilson was lavish in his praise for Sars and the preliminary work on this collection; if not for the rules of nomenclature, Sars would have been credited with many new species. Wilson (and his colleagues) included an exceptionally good

literature list, which has been my constant companion for 40 years.

Therefore, the *Albatross* copepods reported by Wilson in 14 publications comprised 623 pelagic and parasitic species, including 66 new species and 9 new genera. The numbers would be larger if the *Albatross* argulids, no longer held as copepods, were included.

Wilson retired in 1932 but retained his laboratory at Westfield, Mass., and returned in summers to Woods Hole. Toward the end of his life, through the urgings of Schmitt, Wilson was persuaded to take on the planktonic copepods from the *Albatross*. Schmitt had more than one regret over this; first, because he felt that the task contributed to Wilson's death, and second, that Wilson was never able to give the planktonic copepods the deliberation that he might have as a younger man. The day before Wilson's death, Schmitt visited him at Westfield, where Wilson went over the *Albatross* records and showed Schmitt some of the recent additions to his

“ . . . incomparable library of copepod literature that he had built up in the course of a busy lifetime. . . . [Wilson was] one of the most valued scientific collaborators on the rolls of the Museum. He bequeathed to the Museum his library of copepod literature, which is perhaps the most complete of its kind in the world” (Schmitt, 1941).

Wilson's library has been kept up to date as a distinct world-class resource.

Many of Wilson's classic papers on parasitic copepods, systematically dealing with groups worldwide, included annotated literature reviews that have never been surpassed. In contrast, his papers on planktonic copepods from the *Albatross* (Wilson, 1950) and the *Carnegie* (Wilson, 1942) were essentially limited to the specific collections, no doubt due to the necessities of posthumous editing:

“Dr. Charles Branch Wilson, the last of that outstanding group of great monographers of the marine copepods which included Brady, Dana,

Giesbrecht, Sars, and Thomas and Andrew Scott, died August 18, 1941” (J. A. Fleming of the Carnegie Institution in Wilson, 1942).

C. O. Esterly

In 1912 and 1913, the *Albatross* surveyed the biology and hydrography of San Francisco Bay in a cooperative effort by the U.S. Bureau of Fisheries (the U.S. Fish Commission was renamed in 1903) and the University of California. Francis B. Sumner (1874–1945) was Naturalist for the Bureau, and Charles A. Kofoid (1865–1947) represented the University. Waldo Schmitt was a Scientific Assistant.

Nearly 200 stations were occupied throughout San Francisco Bay, from January 1912 until July 1913. Plankton samples were collected approximately every 2 months; often there were multiple plankton samples at a particular station. Although he did not participate in the *Albatross* cruises, the separated copepods from these samples were sent to C. O. Esterly (Fig. 10) for his identifications and report.

Calvin Olin Esterly (1879–1928) had already distinguished himself in this area by publishing the first comprehensive accounts of copepods from the U.S. west coast. The San Francisco Bay report (Esterly, 1924) supplemented Esterly's long series of papers on the systematics and distribution of pelagic copepods from the San Diego region, beginning in 1905. From the San Francisco Bay samples, Esterly described 11 species and their marked seasonal abundances. The bay-wide distribution of four species was related to salinity. Esterly's characteristically practical illustrations make this report useful still.

Esterly was born in Texas and earned a B.A. from the University of California in 1902. His interests turned early toward marine invertebrates, and he came to the notice of William E. Ritter, the first Director of Scripps Institution of Oceanography. Esterly was with Ritter at the institution's beginning, as the San Diego Marine Biological Laboratory, in 1903 (Raitt and Moulton, 1967).

Esterly studied at Harvard under E. L. Mark, obtaining a Ph.D. in 1907, with a



Figure 10.—Calvin Olin Esterly (1879–1928) (photograph ca. 1926, Occidental College, Los Angeles).

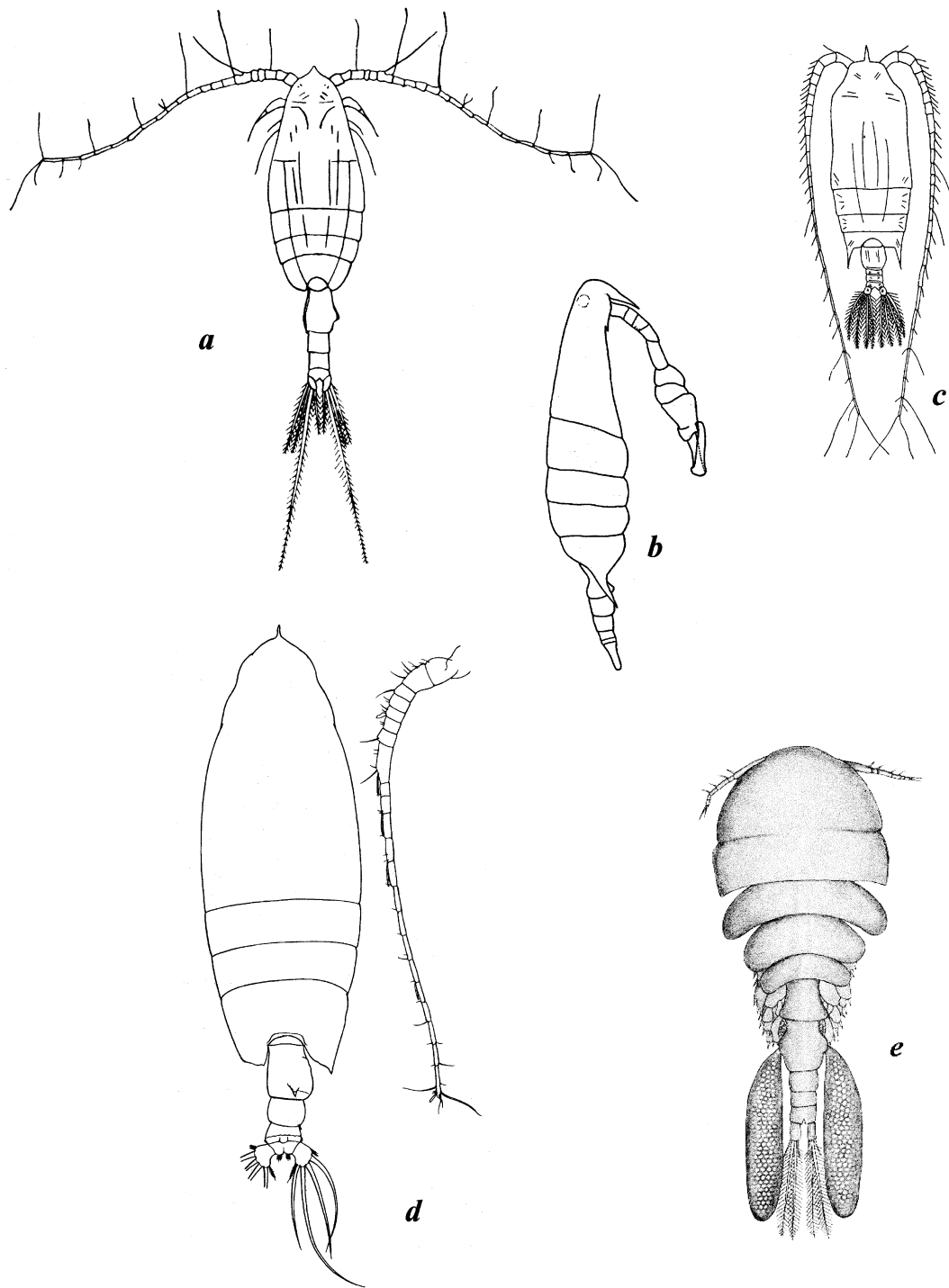
dissertation on copepods. Copepods remained the principal research field

“ . . . to which Esterly set himself, and pursued for more than two decades without a moment of doubt about its worth, of swerving in purpose relative to it, or relaxation in pursuing it. . . . The history of marine biology does not furnish many instances of such a well-balanced combination of field, statistical work and laboratory experimentation as is furnished by the researches of Esterly on the Copepoda of the ‘San Diego area’ of the Pacific” (Ritter, 1928).

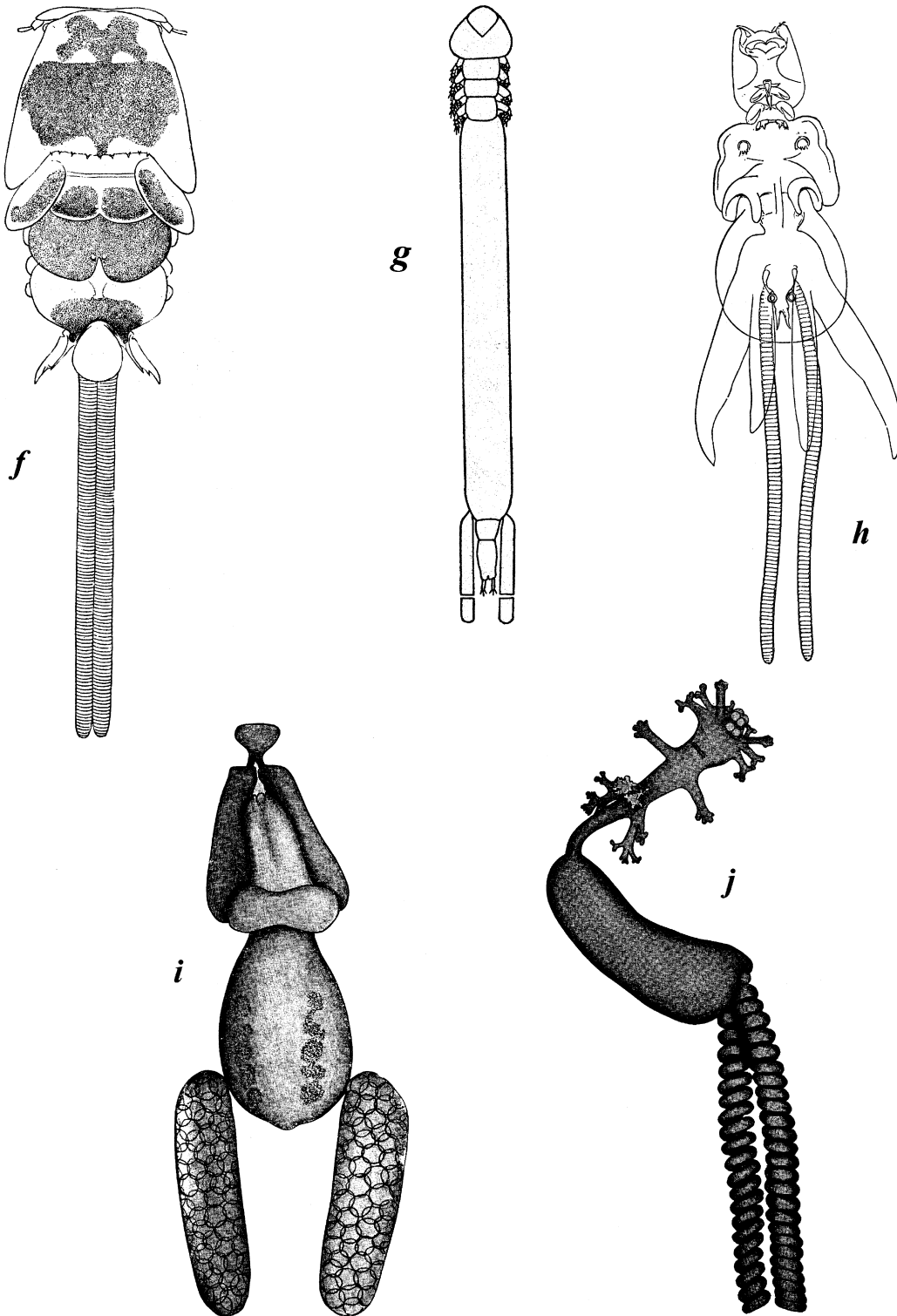
Returning from Harvard, Esterly was appointed Professor of Zoology at Occidental College in Los Angeles, a post he held for the rest of his short life. He was named to the “Non-Resident Staff” of Scripps Institution of Oceanography in 1910. Esterly only worked one full year at Scripps, but he was a virtual volunteer every summer otherwise. He died at La Jolla, Calif., in 1928.

H. B. Bigelow

It was fitting that copepods would have been collected by the multifaceted Henry Bryant Bigelow (1879–1967)



Some copepods from the *Albatross* collections: *Euchaeta concinna* (a) from Wilson (1950); *Paralabidocera amphitrites* (b) from Esterly (1924); *Gaetanus recticornis* (c) from Wilson (1950); *Scottocalanus infrequens* (d) from Tanaka (1969); *Pseudomolgus hawaiiensis* (e) from Wilson (1921); continued on next page



(Cont. from facing page) *Pandarus cranchi* (f) from Rathbun (1886); *Kroyerina elongata* (g) from Wilson (1944); *Lernanthropus pomatomi* (h) from Rathbun (1887); *Lernaepoda bicauliculata* (i) from Wilson (1908); *Phrixocephalus cincinnatus* (j) from Wilson (1908). Figures a–d are of free-living, planktonic species; the others are of parasitic copepods.

on the last scientific cruise of the *Albatross*, from February into May 1920. The last *Albatross* station was occupied 19 May 1920, and Bigelow was there. No one was more entitled to write about these copepods than Bigelow. A 1906 Harvard Ph.D., he was a protégé of Alexander Agassiz, and had been on Agassiz's third *Albatross* cruise in 1905. Bigelow's earliest publications were on the systematics and distribution of planktonic coelenterates, which quickly gave him an international reputation. He contributed to this field for more than 30 years. To these studies, he soon added fishes, and ichthyology became his major field between 1925 and 1955. Remarkably, Bigelow added a third scientific discipline, that of oceanography and general plankton studies between 1914 and 1940. No one could accuse him of claiming harvests gathered by others; throughout his career, Bigelow was a preeminent field man. Associated with the Museum of Comparative Zoology, he became a principal spokesman for the development of oceanography in the United States, and he was the first director (1931–40) of the Woods Hole Oceanographic Institution (Anonymous, 1955). After that time, Bigelow was a Professor at Harvard until his death.

Bigelow incorporated the 1920 *Albatross* copepods into his definitive study of the plankton of the Gulf of Maine, begun as an "oceanographic and biologic survey" in 1912 (Bigelow, 1926). Most of the plankton for this study was collected from the *Fish Hawk* and the *Grampus* (90 feet), a Fish Commission schooner used from 1886 until 1918. Bigelow's tour de force was a review of a tremendous quantity of data on the horizontal and vertical distribution and seasonal abundance of phyto- and zooplankton, as well as chemistry and hydrography of the region. The plankton study complemented Bigelow's survey of the fishes of the same region.

The copepods were identified and enumerated by C. B. Wilson, and they were so acknowledged in the full title as well as the text. Copepods were the only group counted routinely in the samples from vertical hauls (including some *Albatross* collections). Bigelow discussed

the problems of quantitative investigations for copepods and acknowledged the primary deficiencies in this study. There are better quantitative methods today. In Bigelow's survey, the sampling and the counting were standardized, so that at least relative abundances could be considered.

From the 1920 *Albatross* cruise, there were about 75 vertical and about 50 surface plankton hauls. Data tables showed stations, dates, depths, numbers of each species, and numbers of each species per square meter sea-surface.

Bigelow's (1926) report, "being ecologic and not systematic," included copepods as one of "the more important groups." Indeed, the specific copepod section comprised more than one-fourth of the total. Bigelow's summary on the food of copepods, and copepods as food for other organisms, is a classic in the field. Nearly 100 plankton copepod species are listed, with those from *Albatross* collections being the most diverse. Detailed information is provided for more than 50 species. Figures are given for the distributions and abundances of many 1920 *Albatross* species. There are good photographs of selected plankton samples, including many copepods from the *Albatross* collections.

Bigelow compared his information with what other studies there had been in the North Atlantic, by Canadian and European researchers. All in all, his report filled a large and detailed piece of the emerging picture of the biology of many important groups. For such a large area, this was probably the most detailed study of its kind, stressing repetitive sampling at the same stations, and it remains extremely useful.

After her active use, the *Albatross* was tied to the Bureau of Fisheries dock at Woods Hole until June 1924, when it was sold to a Boston firm (Hedgpeth, 1945). During this period, Paul S. Galtsoff was assigned to the now-dry-land but funded position of "*Albatross* Naturalist." Charles Fish continued the work on the seasonal distributions of Woods Hole copepods under Galtsoff's direction (Galtsoff, 1962). Fish's title was "General Assistant, U.S.F.S. *Albatross*," another now-dry-land assignment. If Fish had sampled from the tied-

up *Albatross*, we would, I suppose, have been required to consider those copepods as a continuation of the *Albatross* tradition. However, the report from this work (Fish, 1925), except for a few new observations in Vineyard Sound, was based on samples collected entirely from the Woods Hole dock. During the *Albatross* years, the complementary reports on copepods by Wheeler (1900) and Sharpe (1911) should also be mentioned here only to record that they did not include *Albatross* material.

O. Tanaka

The copepods from the *Albatross* continued to be worked and reworked. Otohiko Tanaka (1902–1990), in 1969, published two reviews of *Albatross* copepods (Tanaka, 1969; Tanaka and Omori, 1969). Tanaka was a 1928 graduate of the Department of Fisheries of the Imperial University of Tokyo. In 1931, he joined the university as an assistant, already with his life-long interest in copepods. In 1934, Tanaka joined the staff of a private biological laboratory on the coast of the Izu Peninsula, where he began a long series of exceptional papers on the marine copepods of that region. This work was interrupted by World War II, when Tanaka served as an engineer officer in Manchuria.

After the war, Tanaka was appointed to the faculty of Kyushu University, where he renewed his study of the Izu copepods. He retired in 1965, whereupon he joined the Ocean Research Institute of the University of Tokyo. Tanaka (Fig. 11) was widely regarded for his nearly 50 papers on copepods, and kept up a lively correspondence and personal interest until his death (Nishida and Omori, 1991).

In a review of the genus *Euchirella* (Tanaka and Omori, 1969), advantage was taken of the large number of specimens available from Wilson's *Albatross* collections. A new species was described from samples off the west coast of South America, and 13 other species were redescribed. Seven of these had not been reported by Wilson (1950).

In the same year, Tanaka (1969) described or redescribed 13 other interesting copepod species that he had encountered in the review of *Euchirella* species



Figure 11.—
Otohiko Tanaka
(1902–1990)
(photograph 1965,
Kyushu
University).

collected by the *Albatross*. Again, seven of the species had not been reported by Wilson (1950). These included three new species, one of which, *Wilsonidius alaskaensis*, represented a new deep-water genus named for Charles Branch Wilson.

With marine copepods, pelagic or parasitic, whether you are studying new or old genera or species, descriptions, or distributions, sooner or later you will encounter the *Albatross*. About 1,600 virtually untouched *Albatross* samples remain on the shelves of the Smithsonian Institution. As our coastal faunas are inadvertently homogenized and destroyed, these old samples take on new value. The century-old echoes from the *Albatross* have not yet faded away.

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