

Agassiz, Garman, *Albatross*, and the Collection of Deep-sea Fishes

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Introduction

The U.S. Fish Commission Steamer *Albatross* was sent forth on many, often pioneering, missions of basic and applied science. Principally, this ship was engaged in defining and discovering new fishing grounds and exploitable species. The impact of these expeditions on the development of various fisheries is evident in several of the papers in this special issue of the *Marine Fisheries Review*. However, the long-term legacy, and indeed the immortality of the *Albatross* rests to a great extent on the purely scientific findings that arose from both the applied ventures and the few voyages which were entirely devoted to oceanography and organismic biology.

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ABSTRACT—*The first of Alexander Agassiz' voyages on the U.S. Fish Commission steamer Albatross in 1891 yielded significant scientific results. This paper reviews the background of the voyage, including the career path that led Agassiz to the back deck of the Albatross. We also give a brief account of the life and work of Samuel Garman. Garman wrote up the ichthyological material from this Albatross voyage in a magnificent book on deep-sea fishes published in 1899. This book was exceptional in its coverage, anatomical detail, and recognition of phylogenetically important morphology.*

Among these expeditions was a rare trip, under nongovernment funding, from which the specimens were deposited and described at the Museum of Comparative Zoology (MCZ) at Harvard University. This particular voyage left an impressive legacy due primarily to the disparate talents of two participants—the noted invertebrate embryologist Alexander Agassiz and the irascible ichthyologist Samuel Garman.

We are concerned with a single voyage, in 1891, of only 2 months duration, during which the *Albatross* conducted deep-water trawls and sampled the eastern Pacific off Panama and Ecuador. Alexander Agassiz (Fig. 1), the director of the Museum of Comparative Zoology, was in charge of the expedition. He also funded the running costs and provided part of the scientific party. The collections from this expedition were worked up over the years by many authorities, both at the MCZ and at other institutions, but perhaps one of the finest scientific legacies is the volume of deep-sea fishes authored by Samuel Garman (1899) (Fig. 2).

This voyage was the outcome of the persistence and drive that characterized Alexander Agassiz (Agassiz, 1913). Born in Switzerland in 1835 to the impecunious but brilliant zoologist Louis Agassiz, Alexander was destined to become a biologist. During Alexander's early childhood, his father parlayed a prestigious speaking engagement in the United States into the founding of the Museum of Comparative Zoology. Thus, young Alexander was immersed both in the science of that museum and its precarious finances from a very young age. He graduated from Harvard in 1855, and was awarded two baccalaureate degrees, the first in 1857 and the second in 1862 from the

Lawrence Scientific School (his father's domain), where he studied zoology, geology, chemistry, and engineering. His father then convinced him to sign on as an assistant in the Museum, despite the fact that he wanted to become a railroad engineer, and he took charge of the work and business of the institution (Agassiz, 1913).

Determined not to follow in his father's footsteps in all ways, in 1868 the young Agassiz decided to accept an offer from his brother-in-law, Quincy Shaw, to assume managerial control over the failing Calumet and Hecla copper mines in Michigan. According to Eliot (1910), this decision was based on his desire to make money, because he considered that a successful career as a naturalist in the United States required independent personal funds. As it turned out this decision was to prove especially appropriate for Alexander. His opinion was no doubt largely due to the financial difficulties, both institutional and personal, into which his father continually plunged the MCZ as well as his family.

Though Alexander Agassiz had many setbacks, the Calumet and Hecla copper mining companies in Michigan were eventually able to supply his personal needs as well as those of the museum. Moreover, it was entirely due to his personal fortune, accrued by his skill in managing the copper mines, that subsequently enabled him to undertake his remarkable 30 years of worldwide oceanographic explorations (Zinn, 1980).

In 1873 Louis Agassiz died and the directorship of the MCZ passed to Alexander, a position he held actively until 1904. Under doctor's orders to stay away from the Cambridge winters, Agassiz began a series of winter field trips. The first was to Lake Titicaca,



Figure 1.—Alexander Agassiz (1835–1910), director of the Museum of Comparative Zoology and chief zoologist in charge of the collecting expedition of the *Albatross* in the winter of 1891. Reproduced with permission of the MCZ archives.



Figure 2.—A middle-aged Samuel Garman (1843–1927), western explorer turned curator of fishes, amphibians, and reptiles at the Museum of Comparative Zoology. Reproduced with permission of the MCZ archives.

between Bolivia and Peru, where he prospected in a hired steamer. Later explorations of the Caribbean were made from J. H. Forbes yacht, the *Wild Duck*, and the U.S. Coastal Survey Steamer *Blake*.

During three cruises from 1877 to 1880 Alexander used the *Blake* to gather zoological evidence for his theories of biogeography and oceanography (Agassiz, 1888). His passion was echinoderms, with many of his publications detailing the variation within and among species of sea urchins. With typical European feeling for his patrimony, Agassiz also devoted considerable time and expense to ichthyology, the field in which his father had made such important contributions. He often took his father's last student, Samuel Garman, on voyages to work up the fish collections.

Pacific Interest

With an already extensive knowledge of the Atlantic and Caribbean fauna, Agassiz was extremely interested in collections from the Pacific. On several occasions he inquired about the possibility of using the *Albatross* to do a survey of the eastern Pacific's deep waters. He was particularly interested in two questions: 1) is there life in the intermediate depths, and 2) is the fauna of the Pacific in any way related to the creatures he collected from the Caribbean abyss?

Finally, in 1890, when Agassiz was 55 years old, Colonel Marshall MacDonald, Commissioner of the U.S. Fish Commission, asked him to take charge of a deep-sea survey with the *Albatross* (Fig. 3). The conditions of this voyage

were quite similar to those of the *Blake*; Agassiz would pay for coal and assist in equipping the boat in return for the first series of specimens. Many of the techniques for sampling the abyssal depths had been designed, tested, and refined on the *Blake* by Count Louis François de Portalès, including the "Blake trawl," and this outfitting was important for the success of the collecting trip (Agassiz, 1888). Moreover, the captain of the *Albatross*, Zera L. Tanner, had designed and fabricated a variety of ingenious nets (the designs of some are still used today) to sample the pelagic fauna (Fig. 4). The trip was certainly quite expensive for Agassiz: he spent \$12,000 on coal alone, which would be over \$180,000 today. Agassiz clearly felt that the information to be gained from this field trip was extremely important.



Figure 3.—The *Albatross* seen from the Galapagos Islands during the 1891 voyage. Reproduced with permission of the MCZ archives.

Agassiz' (1892) general sketch of the expedition, published soon after his return from the voyage, discusses in depth the intermediate fauna. The question, simply put, sought the bathymetrical range of the pelagic fauna: "Having always been more or less interested in pelagic fauna, having paid considerable attention to its vertical distribution during my earlier cruises on the *Blake*, I was naturally anxious to reconcile the conflicting statements and expressions of the naturalists of the *Challenger* and *Gazelle* on one side, and my own observations on the other" (Agassiz, 1892). Agassiz argued that the nets used for collection in earlier attempts to study the midwater fauna, (including those of John Murray during the *Challenger* cruises, the *Prince of Monaco* off the yacht *Hirondelle*, Carl Chun in the deep waters around the Canary Islands, and Hensen during the expedition of the *National*) were questionable because the depth at which the animals were netted could not be accurately determined. He hoped that with the use of Tanner's newly designed closing net, he would finally put the questions to rest.

The tows with this net were not entirely successful during the 1891 *Albatross* expedition. They did establish the presence of the pelagic fauna down to 300 fathoms, but the mid waters below this depth appeared to Agassiz to be devoid of plankton. Unfortunately, the waters he sampled during both the *Blake* expeditions and the 1891 *Albatross* expedition were not representative of intermediate oceanic depths. We now know that these regions are plankton-poor because of certain oceanographic features. So Agassiz eventually failed in the first of his objectives in boarding the *Albatross* in 1891, but only because of an unfortunate combination of circumstances. A superb treatment of this phase of Agassiz' career is given by Mills (1980).

Alexander Agassiz made three more voyages on the *Albatross*, extending his surveys into the middle and western Pacific. Voyages after 1891 primarily used dredges, plankton nets, and coring drills rather than fish-sampling gear. His main goal on these trips was to prove his theory of coral reef formation. The competing theory, of Charles Darwin (1874), ultimately prevailed, and much

of the theoretical underpinning of Alexander Agassiz' biology now has little application. In contrast, the descriptions of the fishes collected on his first *Albatross* voyage remain an important part of the ichthyological literature. This is largely due to the efforts of Samuel Walton Garman and the two artists whom he supervised.

Samuel Garman

Garman remains one of the most colorful and enigmatic figures in ichthyology. He was born in Pennsylvania of Quaker parents in 1843. He attended the Normal College in Illinois and participated in an early expedition to explore the west. On this trip, in 1868, under the direction of Major John Wesley Powell, he traveled through Colorado and Wyoming. He was briefly a field assistant for Edward Drinker Cope in 1872, and he certainly knew the western fossil localities reasonably well. It was perhaps this knowledge that eventually earned him a place at the Museum of Comparative Zoology.

In 1870 Louis Agassiz was returning from the *Hassler* expedition, a cir-

cumnavigation of South America. At the final destination, San Francisco, he met Garman and was so impressed with him that he asked him to return to Cambridge and immediately take up a position at the museum. For many years the elder Agassiz had been hoping to get a good paleontologist at the museum. He had pursued Othneil C. Marsh but failed to lure the emerging fossil expert away from Yale, and he had even considered going on collecting expeditions himself (Agassiz, 1886; Lurie, 1988). So, it is likely that Garman's field experience in the western fossil fields appealed to Louis Agassiz, especially given the paucity of North American fossils in the MCZ. Garman did in fact make several trips to collect fossils in the Dakotas and Wyoming in the 1880's under the aegis of the MCZ (Summers and Koob, 1997).

Garman settled into the MCZ fish department and was immediately drawn to the cartilaginous fishes, an interest that lasted his entire life. He assisted Agassiz at the short-lived "Lawrence School," a summer school for teachers of natural history on Penikese Island, Mass., and later became a jack-of-all-trades around the museum. Just 18 months after Garman arrived at the MCZ, Louis Agassiz died, but fortunately Alexander Agassiz was determined that his father's work continue. This meant several field trips for Garman to the American west as well as to Peru and the Caribbean. He demonstrated his zoological skills on the trips and in the publications that ensued from them (Garman, 1875; 1881). His duties embraced all aspects of museum work, including preparator, exhibit designer, collector, collections manager, curator, and public spokesman. The press of these duties kept him from participating in any of the field collections after 1888, though there was a commensurate upturn in his output of papers (Summers, 1997).

Garman stayed at the museum during the *Albatross* expeditions to look after the collections and continue his writing. This was not a particular hardship since the fishes collected would be brought back to him eventually; also, Andreas Westergren, an MCZ artist, was on the trip to record colors from life (Fig. 5). It



Figure 4.—The back deck of the *Albatross* just after a trawl has been emptied. The well-dressed man is Alexander Agassiz. Several of the crew, in naval whites, are looking on. Reproduced with permission of the MCZ archives.

took 7 years to complete the *Albatross* fishes, and in 1899 the volume was finally published (Garman, 1899). After this, Garman seems to have become more reclusive. He was much affected by the alleged subterfuge, political infighting, and eventual adverse public-

ity attached to the so called "dinosaur wars" between E. D. Cope and O. C. Marsh (Plate, 1964, provides details on the controversy). He became increasingly private about his work, even going so far as to cover work in progress with newspapers when the rare vis-



Figure 5.—Andreas Magnus Westergren (1844–?) was one of two principal artists for the deep-sea fishes book (Garman, 1899). He recorded the colors of animals fresh from the deep.

itor arrived and was grudgingly admitted to his office in the fish department.

It was this Garman that the young Thomas Barbour knew when the latter started working in the MCZ herpetology collection. This antisocial tendency worsened with age. After eventually succeeding to the directorship of the museum, Barbour lampooned the unfortunate Garman in his various memoirs (Barbour, 1943; 1946). Though Garman continued to work at the museum until his death at age 84, he was not productive after 1913 when his monumental monograph on the cartilaginous fishes appeared (Garman, 1913).

The 1891 Expedition

Agassiz, Westergren, and the rest of the MCZ party arrived in Panama at the end of February 1891. They boarded

the ship for the first leg of the voyage, which took them out into Panama Bay, to the Cocos Islands, and back. The second leg of the trip went to the Galapagos Islands and then back to the mainland at Acapulco, Mex., and the third and final leg ended in Guaymas, Mex., in the Gulf of California where they boarded a train back to Boston (Fig. 6).

This voyage was exceptional in that it concentrated on an investigation of the relatively unexplored deep sea. In total, 75 trawl hauls were made, of which more than half were at depths greater than 1,000 m and a quarter were below 2,000 m. Previous *Albatross* collections in the Pacific between Chile and Alaska fished below 1,000 m only 3% of the time. This is hardly surprising since the fishes at these great depths would have

been difficult to exploit commercially. The collection work was supervised by Alexander Agassiz, with the help of Charles Townsend, whom Agassiz called “the most obliging and hard-working man imaginable” (Agassiz, 1913). Townsend would later become director of the Aquarium of the New York Zoological Society, and he also published extensively on natural history.

In 1891 *Albatross* specimens were preserved in several washes of ethanol and then wrapped in gauze. This expedition just predates the wide use of formalin, which is a mixed blessing. Many of the specimens are now so soft and friable that they are not very useful for anatomical work. However, ethanol preservation does not irreparably destroy DNA, so this material may prove quite useful for future studies. It is not well known in the molecular biological community that many early, extensive faunal collections have never been fixed in formalin and thus represent an untapped source of historical DNA.

When the specimens were returned to the MCZ, the real work began. Working from color sketches made on the deck, Andreas Magnus Westergren produced 20 color plates for the deep-sea fishes volume (Garman, 1899) (Fig. 7). It is interesting to note that many of these plates are of brown or very dark fish, with just a flash of bright color, bioluminescence, or reflective material. Westergren and John Henry Blake, both born in 1844, shared the illustration duties. Both were gifted illustrators with many other works to their credit. Westergren worked on crinoid and echinoid plates for Alexander Agassiz (1892; 1906; 1908), as well as Faxon’s famous work on stalk-eyed crustaceans (Faxon, 1914). He specialized in color work, but, as evidenced in the deep-sea fishes book, he was adept in monochrome as well.

Henry Blake started illustrating works for the MCZ in 1866 at age 22 and became the favored illustrator of Garman (i.e. Garman, 1904). His work can often be distinguished from that of Westergren by artistic touches such as the symmetrical curves in the eels in plates 41 and 43 (Fig. 8). Blake remained at the MCZ for many years after the deep-sea

fishes (Garman, 1899) was published and was the artist for Garman's *Plagiostomia* (1913).

One of the most revolutionary aspects of these illustrations is the amount of anatomical detail. The usual illustrations of external anatomy are accompanied by wonderful renditions of internal detail, the result of Garman's extraordinary dissecting ability. These anatomical drawings include skeletal elements and soft anatomy. This is marked contrast to the far better known work "Oceanic Ichthyology" by George Brown Goode and Tarleton Bean (1895). Of the 123 plates in Goode and Bean (1895), there is but a single skeleton, that of an anglerfish (plate CXX). In general, Garman's anatomical illustrations reflect his careful and skilled dissection of the anatomical details that have proved to be important distinguishing features of the taxa (Fig. 9); however, in some cases the artistic license of the illustrator actually serves to detract from the usefulness of the drawings. For example the gill arch structures of the roughy in plate XI (Fig. 10) have a lovely, sweeping line that fails to show where the finer elements are joined.

The text of the deep-sea fishes book (Garman, 1899) is in five parts. The first part describes the collection of the specimens and also contains Garman's musings on speciation, divergence, and general morphology of deep-sea forms. The second section consists of descriptions of the fishes, which are often in themselves far too brief to be particularly useful today. In many cases there is little attempt to compare species, and instead each is described as if the others do not exist. Part of the difficulty is that there was little comparative material at the museum. Garman did borrow some specimens from the U.S. National Museum, but for the most part he relied on the collection at hand. Were it not for the excellent detail of the plates, these descriptions would be far less valuable.

The third section of the book deals with the variation in the lateral line system of deep-sea fishes. Garman dissected, traced, and described the lateralis enervation, no mean feat in the days before nerve stains and tissue clearing.

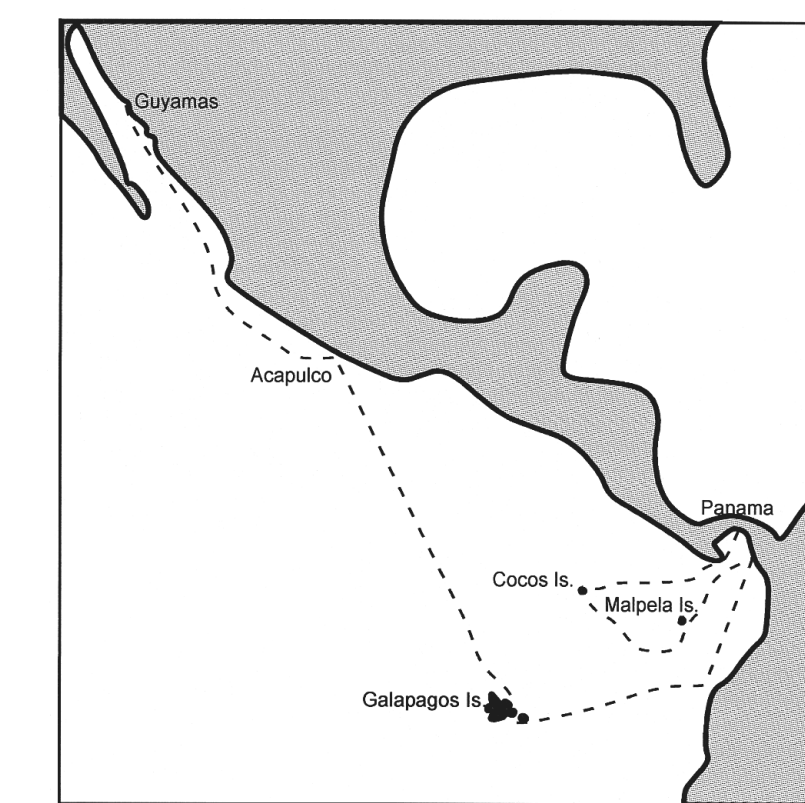


Figure 6.—The 1891 voyage of the *Albatross*.

He also prepared diagrammatic representations of the lateral line canals of 27 species. This is one of the very early works on the anatomy of the lateral line system and one of the most extensive examinations of the differences in morphology across taxa. He even makes some speculative comments about the arrangement of "glandular disks" (free neuromasts) and lateral line canals in fishes with reduced eyes living in low-light environments.

The fourth section of the book addresses one of Agassiz' prime questions in organizing the trip: the relationship between fauna on either side of the Panamanian isthmus. In comparing the fauna from the *Blake* expeditions to that of the *Albatross*, Garman concluded that the uniform environment of the abyssal depths makes it easy for fish to move around the capes of the southern ocean, and so they are not the best organisms to examine for evidence of a Central American connection. His conclusion about the relations of the fish

fauna contrasts with Agassiz' initial conclusion based on the echini that "the Caribbean was probably a bay of the Pacific" (Agassiz, 1892). However, Garman went on to list 42 taxa that might provide evidence of the existence of a channel. The final section of the book gives evidence of Garman's bibliographic skills and interests. He lists 1,047 species of fishes, all of the deep-sea fishes for which he could find references.

Garman treated 196 taxa of deep-sea fishes in the *Albatross* report. He described and figured 174 new species, of which about 80% are valid today. Most of the species that he dealt with are benthic, bathypelagic, or mesopelagic, and many of the species are still represented by only the type series. He described 20 species of ophidiiformes, or deep-sea cusk-eels, of which 17 are still considered valid. Of the 13 zoarcids, or eel-pouts, 11 were described as new and nine remain valid. Nine of the 12 ogocephalids, or batfishes, are still considered valid species, and there

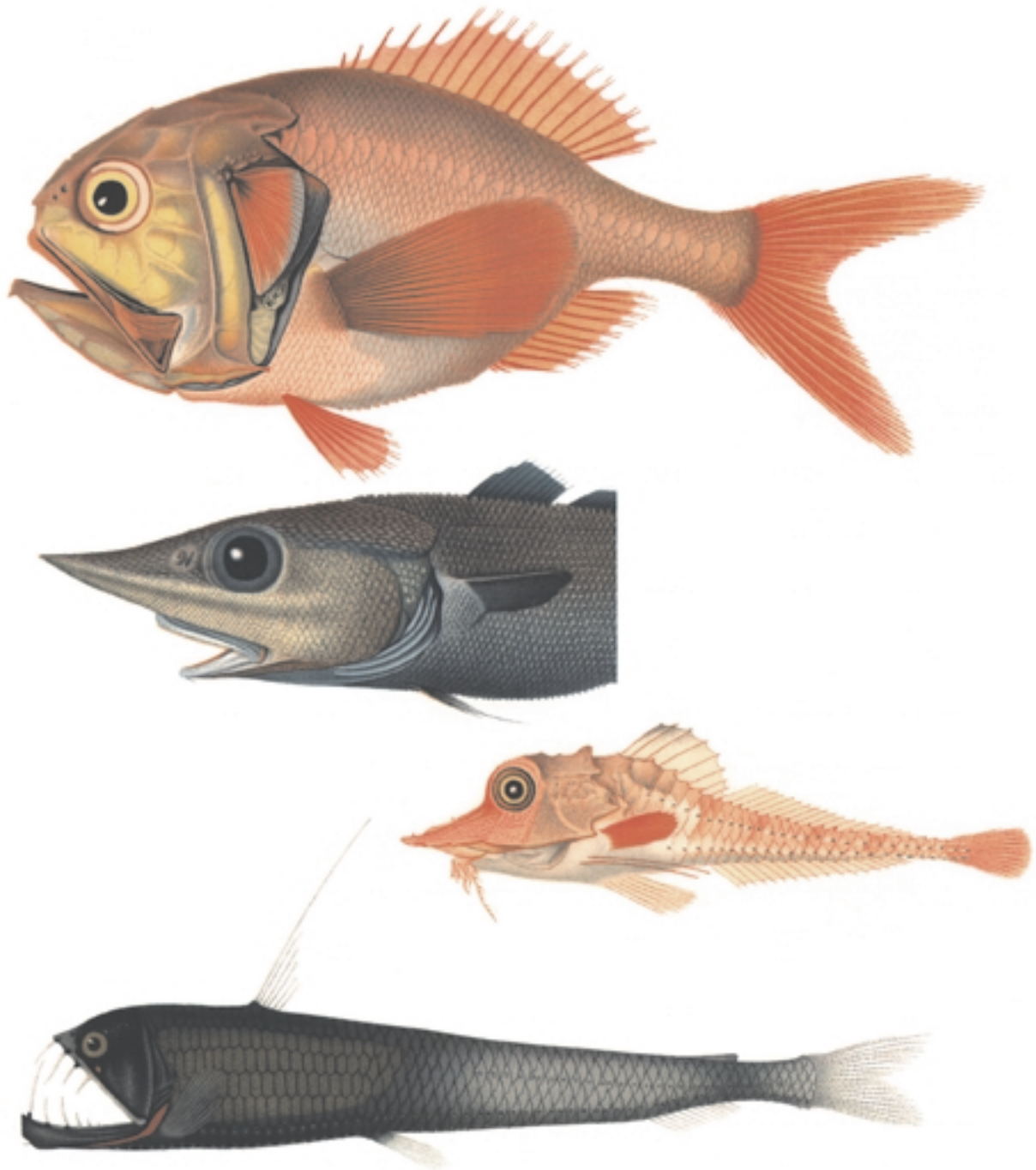


Figure 7.—Illustrations of fishes in color. From top to bottom: a roughy, *Hoplostethus pacificus* Garman (Trachichthyidae), a deep-water beryciform. A macrourid, *Trachyrhynchus helolepis* (Gilbert). An armored searobin, *Peristedion crustosum* Garman, a triglid in the family Peristediidae (armored gurnards). A viperfish, *Chauliodus barbatus* Garman, a stomiid in the family Stomiidae (viperfish). Drawn by A. M. Westergren (from Garman, 1899).

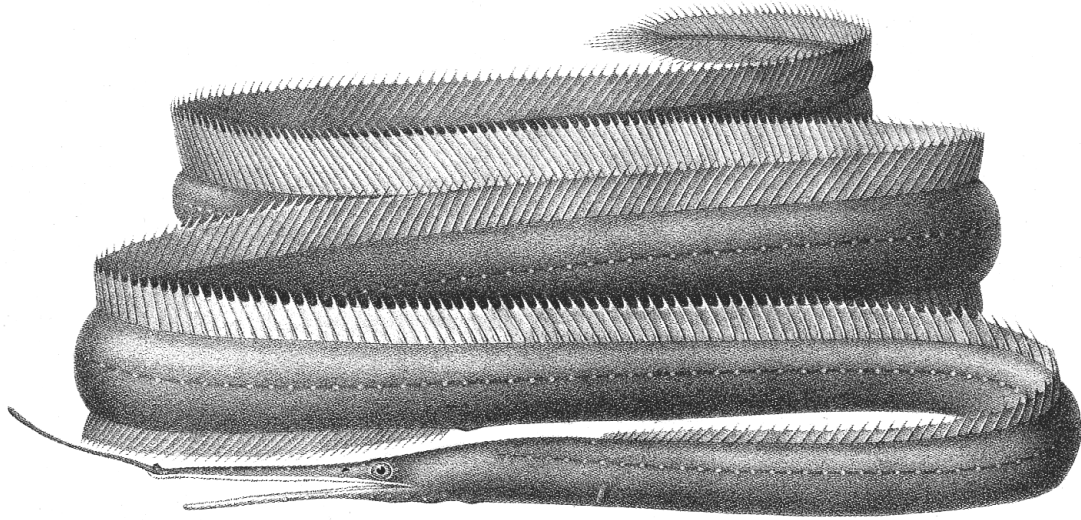


Figure 8.—This pike-conger shows J. H. Blake's fine artistic style. The fish is *Venefica ocella* Garman, a nettastomatid eel, one of 25 new species described by Garman in his deep-sea fishes book (Garman, 1899:pl. LXI).

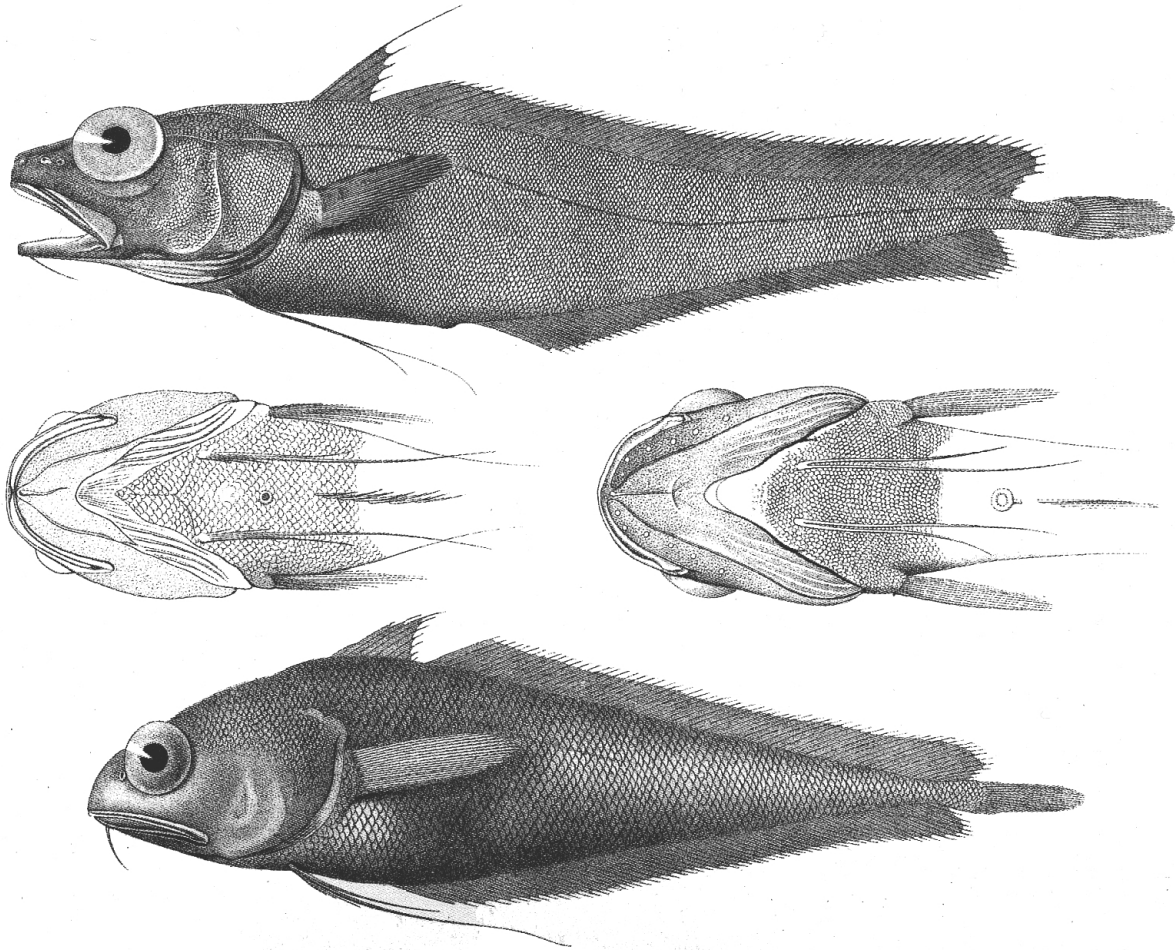


Figure 9.—Morid codfish (Moridae): Top, *Laemonema gracillipes* Garman; middle left, underside of the head of *L. gracillipes*; middle right, underside of the head of *Physiculus nematopus*; bottom, *Physiculus nematopus* Gilbert. Drawn by A. M. Westergren (from Garman, 1899: pl. XLII).

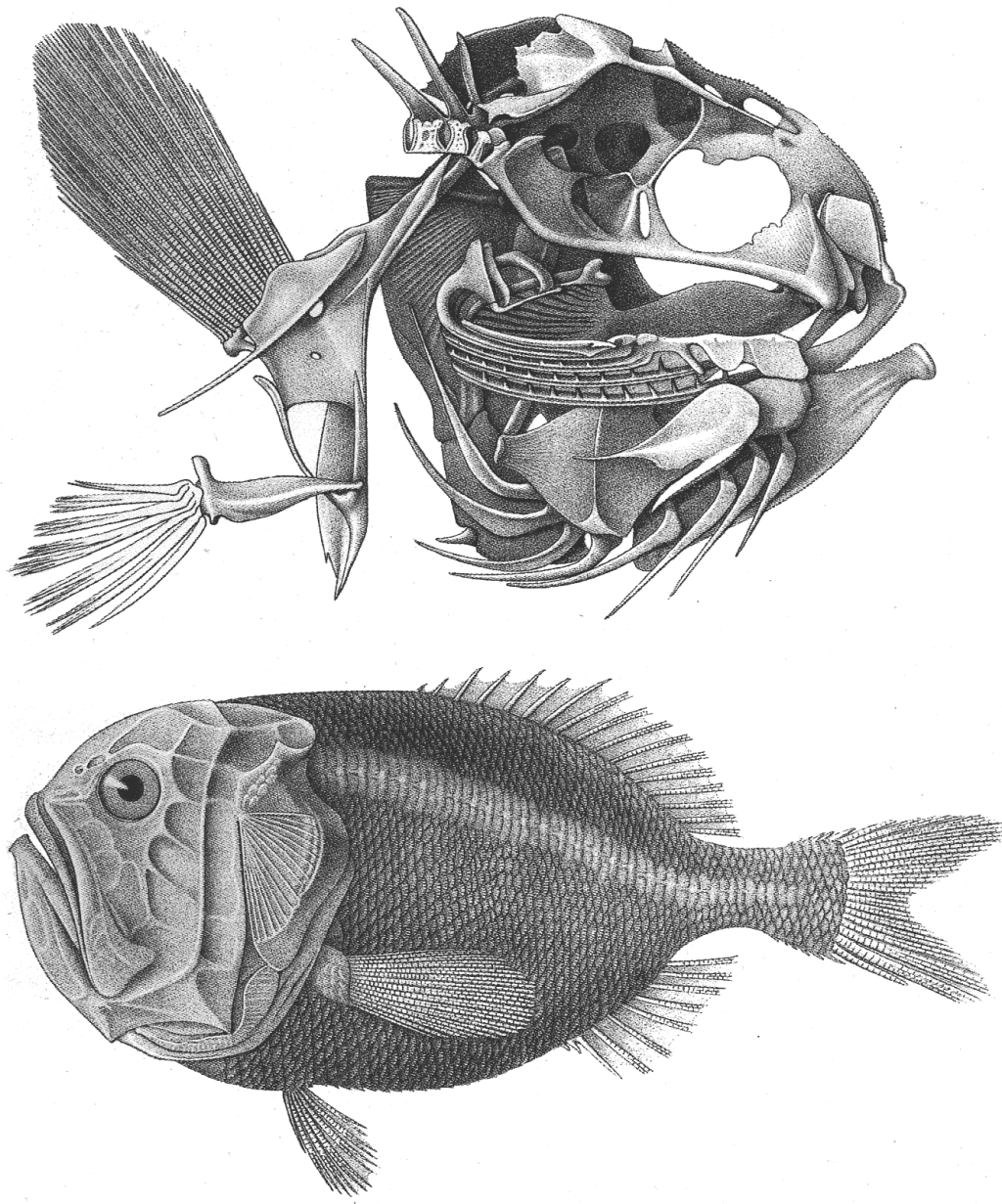


Figure 10.—Internal and external anatomy of the roughy. Top, the skeleton of *Hoplostethus pacificus* (Trachichthyidae). Though the skeleton is well rendered in most respects, the detail of the neurocranium and branchial arches is glossed over. The external anatomy of this fish is seen in Figure 7. Bottom, *Hoplostethus mento* (Garman), another roughy which Garman has assigned to the genus *Trachichthyes*. Drawn by A. M. Westergren (from Garman, 1899:pl. XI).

are some fine anatomical drawings of these peculiar fishes. Garman described seven species of slick-head, or alepocephalids, which remain a poorly known group. Oddly, there were very few lanternfishes in the trawls, but he described seven new species and lumped them all in the genus *Myctophum*, though there

were existing genera available. Today the six valid species are each assigned to a different genus.

Garman was an authority on snailfishes, or liparids, having produced a monograph on them 7 years earlier (Garman, 1892). He described six new species from the *Albatross* material, of

which only one has since been synonymized. Twenty-one of the 22 species of grenadiers were lumped into a single genus, though today they have been split into six genera, and eight of the species have been synonymized. Garman was not particularly receptive to the classification schemes of others,

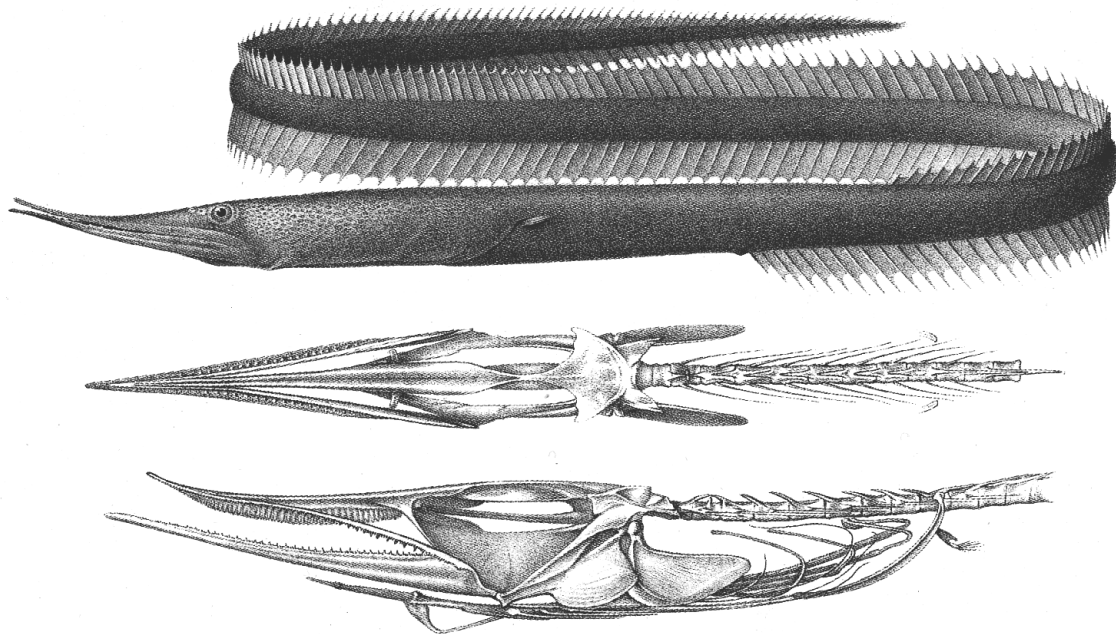


Figure 11.—The anguilliform *Serrivomer sector* Garman. The anatomical drawings are side and ventral views of the head and vertebral column of this sawtoothed eel. Drawn by J. H. Blake (from Garman, 1899: pl. LXIII).

including that of Jordan and Evermann (1896). This, more than anything, has led to the reassignment of many of his species to different genera. Twenty-five species of eels were described of which 15 are still valid. Garman described 14 eels based on adult material (Fig. 11) and 11 based on the leptocephalus larvae. In a practical move, he assigned the larvae to the genus *Atopichthys* since he knew that the genus *Leptocephalus* had been linked specifically to the congrid eels. The eel material is now placed in 6 families in 11 genera.

Summary

It should be clear from the list above that our knowledge of deep-sea fishes was greatly enhanced by the publication of the 1891 *Albatross* material. It is worth noting that MCZ *Albatross* voyages yielded this volume (Garman, 1899), 17 other monographic memoirs, and over 20 shorter bulletins covering both vertebrates and invertebrates. It is hoped that the presentation of the scientific legacy of the *Albatross* in this issue of the *Marine Fisheries Review* will increase the recognition of the value of

collection based science and the vital role of field expeditions. There is currently little governmental support for non fisheries-related collecting expeditions such as those undertaken by the *Blake* and *Albatross*, and it seems clear that there should be.

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