dence on which the conjecture was based.

Although the pages of *The Rise and Fall of the Fifth Force* contain interesting and useful lessons for all scientists, this is very much a book about physics written for physicists. Those at the postgraduate level will probably get the most out of it, but the extensive footnotes and thorough referencing make it accessible to those with less knowledge of the field.

Voltaire has provided us with sound advice that seems self-evident. Franklin has shown by specific example, however, that scientific confirmation is a phenomenon that is context-dependent and deserving of careful thought.

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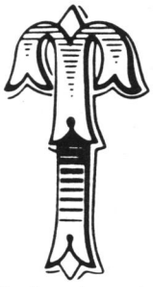
Southernmost Fauna

Antarctic Fish Biology. Evolution in a Unique Environment. JOSEPH T. EASTMAN. Illustrations and graphics by Danette Pratt. Photographs by William Winn. Academic Press, San Diego, CA, 1993. xiv, 322 pp., illus. $74.95 or £57.

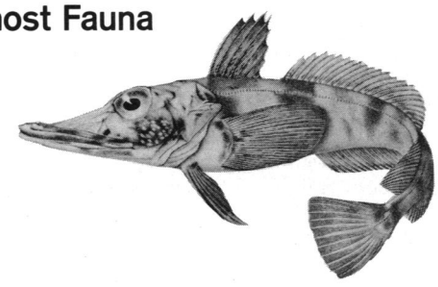
Antarctic Fish and Fisheries. KARL-HERMANN KOCK. Cambridge University Press, New York, 1992. xvi, 359 pp., illus. $110 or £60. Studies in Polar Research.

History and Atlas of the Fishes of the Antarctic Ocean. RICHARD GORDON MILLER. With contributions by Philip A. Hastings and Josette Gourley. Foresta Institute of Ocean and Mountain Studies, Tucson, AZ, 1993. xx, 792 pp., illus. $95; laminated cover, $78.



The Antarctic Ocean is a cold and difficult place. The water temperature is as low as −1.86°C even in summer; there is no intertidal ecosystem because ice covers and scours the shoreline and coastal waters to depths of 30 meters or more; the winter night lasts for months at the higher latitudes, just as the summer day does; and the narrow southernmost tip of the closest major landmass (South America) is about 1000 miles from the narrow northernmost tip of the Antarctic Peninsula. Yet for people who love fishes and the polar regions—there are some—studying antarctic ichthyology is a dream come true. These three comprehensive books take three quite different approaches to describing that dream, focusing to varying degrees on evolution, physiology, ecology, history, morphology, and fisheries.

Antarctica's marine fish fauna (there are no freshwater species, because there is no permanent liquid water on the continent) comprises approximately 275 species, 95 of which belong to the perciform suborder Notothenioidei. This one group of largely antarctic fishes has received a great deal of attention, for its species have a variety of unusual adaptations. Some of them have glycoprotein antifreezes in their blood, some have no hemoglobin, some have so small a temperature tolerance that they die at temperatures above 4°C, some are neutrally buoyant despite lacking swimbladders, and some live as deep as 2950 meters. The suborder has no known fossils, largely because no bony feature—indeed, no single character of any sort—can be used to define it. How did these animals arrive there, what are their ancestors, how do they make a living in such an environment, and can they support commercial harvests?

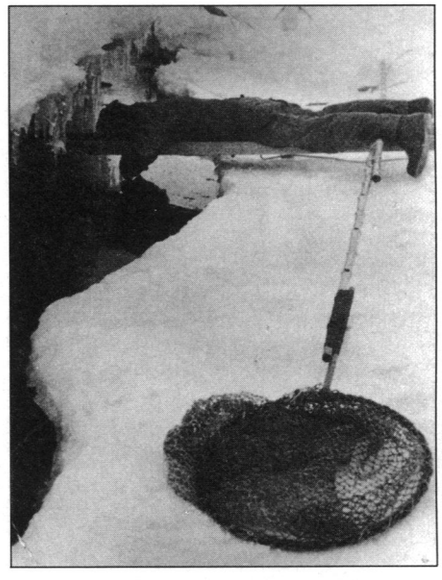


A representative notothenioid fish from Antarctic waters, *Chaenocephalus aceratus*. [From *Antarctic Fish Biology*]

Eastman's book—the most technically demanding of the three—focuses on the evolution and physiology of the notothenioids. It provides a thorough review of the geologic history of Antarctica, tracing its development from the time it finally broke away from the other tectonic elements of Gondwana about 25 million years ago. The icy climate probably had developed by that time, although there were milder periods; "the latest expansion of the ice sheet [probably] commenced 2.5 [million years ago] during a period of gradual marine and terrestrial cooling, and the present Antarctic climate is as severe as it has ever been." Antarctica's ocean is effectively separated from other world oceans by the circumpolar Antarctic Convergence, so it appears that a substantial part of the fish fauna became isolated there from relatives in warmer seas and underwent an adaptive radiation somewhat reminiscent of that of the cichlid fishes in Africa's Great Lakes. In this respect, Antarctica differs from the Arctic: the arctic fish fauna consists mainly of species found also in adjacent subarctic waters.

Having set the stage, Eastman describes the fish fauna, with an emphasis on the six families of notothenioids. Not an illustrated key, this section nonetheless provides some idea of the morphological diversity of these fishes: that diversity is not great, and the external morphology of most of the species would not cause surprise in a bottom-trawl off the U.S. west coast. The obvious exceptions are the enormous toothfish (*Dissostichus mawsoni*), which can reach nearly 2 meters and more than 70 kilograms; and the hemoglobinless icefishes (family Channichthydae), whose creamy-white gills, pale blood, and yellow muscles would surely draw attention anywhere. Eastman then discusses the group's evolutionary history, pointing out that "the radiation of whales, seals, and penguins, like that of fishes, is roughly coincident with the Miocene events producing [oceanic] features similar to those of the modern Southern Ocean." Despite this long period of isolation in the cold seas, notothenioid ancestry is still uncertain. Eastman's analyses and literature review of these topics are detailed and scholarly (despite his misspelling of "plesiomorphic"), and he grounds them in clear questions about how things came to be as they are today.

The second half of Eastman's book, focusing on what must be his first love, physiology, would be hard going without advanced study; examples include passages about "aglomerularism [being] apomorphic in notothenioids" and the "drag-based labriform swimming cycle of notothenioids." Indeed, much of the sec-



"Observer at 'Bergy Bit' fishing hole at tidal Cape Hallett, 1959. Antarctic ichthyologists use ladders horizontally." [From *History and Atlas of the Fishes of the Antarctic Ocean*]

"*Pagetopsis macropterus*, photographed at 39 m depth in McMurdo Sound." [From *History and Atlas of the Fishes of the Antarctic Ocean*; G. A. Robilliard photo, from Robilliard and Dayton, 1969]

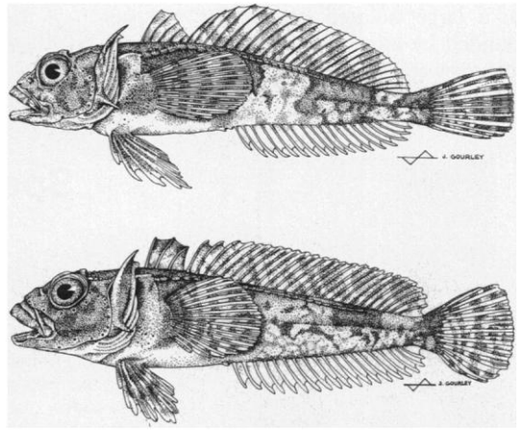
tion amounts to a detailed, scholarly review of the surprisingly large literature (36 pages of references) on the evolution and physiology of antarctic fishes, sometimes with the conclusion that there is no large or surprising difference from the condition in temperate fishes. Yet although this part is technically difficult, its very detail is absorbing and it deals with interesting (if sometimes teleological) questions. How is icefishes' lack of hemoglobin related to their physiology and ecology? How and why are so many antarctic fishes neutrally buoyant, although they lack swimbladders? How is cellular physiology different at very low temperatures? How and why did the glycoprotein antifreezes evolve? (A related book is *Biology of Antarctic Fish*, proceedings of a symposium, edited by G. di Prisco, B. Maresca, and B. Tota, published by Springer-Verlag in 1991 at $129. Although that volume is less comprehensive than Eastman's treatise, some of the individual papers provide interesting counterpoint to it.)

Kock's book also provides a brief overview of the geologic and climatic history of the region and of the fauna—briefer than Eastman's, although enough for a general understanding—but most of it is devoted to ecological questions, such as fecundity, variations in recruitment (astonishingly to someone familiar with temperate and boreal commercial fishes, several antarctic species seem to have little or no interannual variation in recruitment), age and growth, and food habits and to the history and development of the fisheries and their management. Kock's is a modern and thorough treatment, also richly documented (43 pages of references), and provides frequent comparisons with temperate-zone fishes and ecosystems. Kock provides as broad a context as possible, for example pointing out that while fish consume perhaps 20 million metric tons of euphausiids (krill) in the High Antarctic Zone, whales and seals take a total of 175 million, birds take 115 million, and squid take 30 to 50 million tons. (The Russian and Japanese antarctic catch of krill amounted to only about 400,000 tons per year in the late 1980s and early 1990s.) However, some of those predators feed additionally or mainly on fishes, so the ecological significance of those numbers is not clear.

The development of antarctic commercial fisheries is a familiar, sad story of overexploitation. Proclamations of good intentions, the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), and the Antarctic Protocol (which excludes fishes) have all failed to prevent overexploitation of several species, especially the antarctic cod, *Notothenia rossii*. Current harvest of antarctic cod, following a Soviet harvest of 400,000 tons in 1969–1970, is only a few thousand tons per year. Other species show similar, if less dramatic, trends. Kock estimates that, even with good management practices, the sustainable harvest of *all* finfishes from the Antarctic would be only 100,000 metric tons per year (about 0.1% of the world's perhaps unsustainable harvest). The reasons for the overexploitation include most of the familiar ones: lack of enforceable regulations, voluntary participation in treaties, and scientific uncertainties. Two informative appendixes provide the conservation measures of CCAMLR and the fishery laws and regulations of France applying to its territories and surrounding Exclusive Economic Zones in the Southern Ocean. It is unfortunate that apparently nobody has taken the opportunity of studying these newly exploited stocks to see what the genetic effects of fishing are on them. Also, some discussion of the role of whales in the ecosystem—and of how they will affect it if their populations recover—would have been interesting.

Miller's *History and Atlas*—the largest and most lavishly illustrated of the three books—is also the most idiosyncratic. Antarctic fishes and their environment, according to Miller's preface, have "gripped [his] attention for fifty years!" And the book seems to have had a gestation period more typical of the great historical dictionaries than of a fish book—over 35 years. This is a traditional faunal work. Although it discusses the environment and history of Antarctica and its fishes, the history of ichthyology in the Southern Ocean, and the exploitation and conservation of fishes there, most of the book is devoted to an illustrated atlas of the fishes. The book covers all known species from the region, although endemics are treated more fully than those that also occur north of the Antarctic Convergence. Only the endemic species are all illustrated and given distribution maps. The fine illustrations (by Josette Gourley) are either directly from specimens or redrawn from earlier works. This is the only one of the three books that describes the entire fish fauna, from lampreys to sharks to an odd group of flounders that lack pectoral fins.

Miller's book is filled with notes, anecdotes, and photographs, some from his diaries and others from those of earlier workers. My favorite photograph is of John Reseck Jr. sitting on the ice, smoking a pipe, and fishing, to the apparent amusement or consternation of three penguins. A few of the notes from early workers' diaries are intriguing, as are some of Miller's describing historical events. (I would have liked a note explaining how plunderfishes, Artedidraconidae and Harpagiferidae, got their name.) And Miller's is the only book of the three that provides any inkling of what any of these fishes are like to eat (from "most deliciously delicate," of the toothfish, to "one meal was enough," of the antarctic cod). But the buyer of this book must be prepared to accept many typographic errors, an index that does not allow one to find the location of the primary treatment and illustration of each fish, many references cited but missing from the reference list, a difficult-to-follow system of notes, and some very obscure passages. (Somewhat similar in scope, much better edited, but without the personality and occasional pearls in Miller's book, is *Fishes of the Southern Ocean*, by O. Gon and P. C. Heemstra, published in 1990 by the J. L.



Two specimens of *Harpagifer georgianus marionensis* Andriashev, 1976, collected on an Australian expedition to Macquarie Island and characterized by R. J. Slack-Smith (1962) as "abundant in rock pools throughout the year." [From *History and Atlas of the Fishes of the Antarctic Ocean*]

B. Smith Institute of Grahamstown, South Africa, at $105. In this superbly illustrated book, the faunal accounts are written by a variety of specialists in each family.)

These books deal with interesting and important topics in an important and captivating part of our planet. For people who love fishes, biology, the polar regions, and books—there are some—they provide rich food for thought.

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Eocene Revelations

Messel. An Insight into the History of Life and of the Earth. STEPHAN SCHAAL and WILLI ZIEGLER, Eds. Clarendon (Oxford University Press), New York, 1993. vi, 322 pp., illus. $75 or £50. Translated from the German edition (Frankfurt am Main, 1988) by Monika Shaffer-Fehre.

Early in the Middle Eocene, roughly 50 million years ago, a persistent lake developed in what is now west central Europe, on a large isolated island that was surrounded by arms of shallow seas. Anoxic bottom waters preserved, in exquisite detail, all manner of life forms that sank after death onto the central lake's muddy substrate. The resulting deposits show just how good a fossil record can be.

This lavishly illustrated book is an excellent English translation of the 1988 German summary of the flora and fauna of the "Messel pit," near Darmstadt. The book transports readers into the warm forests and volcanically bordered rift valleys of the European Eocene. The wealth of detail presented, including discussion of an astonishing diversity of plants, arthropods, and vertebrates, allows us to experience the stench from this ancient lake and to hear the night-calls of countless animals in the adjacent multistoried forests.

The format is a series of 27 short chapters that successfully bridge the interests of paleobiologists and lay readers. Most of the illustrations are in color, and the photography of specimens is outstanding. Diverse, well-chosen drawings, including scientifically conservative life reconstructions, fill the pages of this handsomely designed volume. The chapters include illustrations of many undescribed species, and the text conveys the excitement of work yet to be done and of discoveries yet to be made at Messel. A species index includes references to pertinent illustrations.

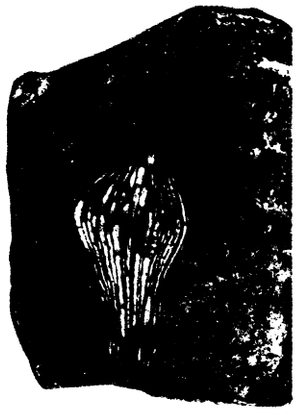
In contrast to most paleontological sites, Messel preserves plants and animals side by side. The ancient bottom waters apparently were hostile to benthic life, and with the exception of predatory fishes and certain of the crocodilians and turtles, most of the fauna exemplified life on the surrounding dry land and in the paratropical forests. Most species are represented by body parts that had floated post mortem by way of streams, apparently from considerable distances, into the lake. The preserved fossils therefore provide insight into a broad geographic area of environmental settings. Lake-bottom sediments remained unburrowed.

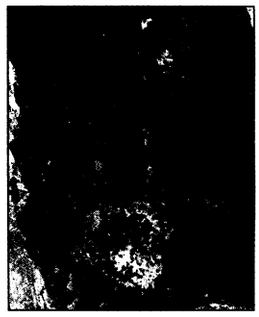
The organic-rich bottom setting also provided a natural laboratory for the comparative study of fossilization of differing biological materials (lignin of wood; siliceous spicules of freshwater sponges; calcium carbonate of molluscan shells and fish otoliths; chitin of insects; keratin, bones, and teeth of vertebrates). Plant and animal soft parts abound. A water-lily flower preserves caddis-fly larval cases. Oil droplets can be seen in leaf mesophyll of ancient relatives of laurels. Original structural colors shimmer in beetle elytra. Frog spawn and tadpoles exist. Gut contents from invertebrate and vertebrate animals provide direct evidence for their dietary abilities, sometimes with surprises. Tiny dawn-horses probably staggered drunkenly after feasting on fermented grapes. Traces of body shapes, internal organs, and even hair patterns are represented by clear outlines, usually formed by the cell walls of

Specimens from Messel

"Leaf beetle (Chrysomelidae) with very well-preserved structural colours. This family is very species-rich today and includes at northern latitudes numerous metallic coloured species."

"Cone scale of the center of the conifer *Doliostrobus* cf. *certus*, probably a member of the Taxodiaceae which was widely distributed in the early Tertiary. 15 mm long."





"*Lutetiobatrachus gracilis*. Only one specimen of this species has been found to date. Head and body length, c. 5 cm."