Uiblein, F., Ott, J., Stachowitsch, M. (Eds), 1996: Deep-sea and extreme shallow-water habitats: affinities and adaptations. - Biosystematics and Ecology Series 11: 1-27.

The Austro-Hungarian Deep-Sea Expeditions

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A b s t r a c t: When, in the second half of the 19th century, oceanography emerged as a scientific discipline of its own, most of the seafaring nations of the time sent out expeditions to oceanographically investigate the sea. The Austro-Hungarian Monarchy did likewise, but instead of organizing another circumnavigation to collect various data from various oceans, the systematic investigation of a defined region of the oceans was chosen as the appropriate approach. On 11 April 1889 the zoologist Franz STEINDACHNER, the geologist Franz Ritter von HAUER, and the meteorologist Julius HANN submitted a proposal for expeditions to the Eastern Mediterranean to the Viennese Academy of Sciences, and the Academy set up the "Commission for the Exploration of the Eastern Mediterranean", later "Commission for Oceanographic Research"; members of this so-called "Deep-Sea Commission" included the zoologist Carl CLAUS and the geologist Eduard SUEß. The Academy of Sciences provided the scientific programme and equipment for these deep-sea expeditions, the navy, under its scientifically minded commander-in-chief, Admiral STERNECK, supplied the ship and crew, and the Museum of Natural History delegated scientists from its staff and took care of the large collections. The navy transport vessel "Pola" was outfitted with the latest oceanographic equipment using the expertise of Prince Albert of Monaco, Alexander AGASSIZ, and the Stazione Zoologica di Napoli. Among the scientists on board on various occasions were the zoologists Karl GROBBEN, Emil von MARENZELLER, Franz STEINDACHNER, and Berthold HATSCHEK, the chemist Konrad NATTERER, and the marine physicist Josef LUKSCH. In the years 1890 to 1894 several oceanographic cruises led to the Eastern Mediterranean - from the Ionic Sea to the Egyptian coast - along with special missions to the Adriatic Sea and to the Sea of Marmara. The success of these cruises led to the extension of the investigations to the Red Sea: in 1895/96 the northern, in 1897/98 the southern part was explored. As a consequence of these expeditions the Eastern Mediterranean and the Red Sea were among the oceanographically best-studied areas of the oceans. The scientific results were published in 14 series by the Academy of Sciences, and the collections kept specialists busy for decades.

Introduction

The Vienna Deep-Sea Symposium was organized to commemorate the 100th anniversary of the Austro-Hungarian naval vessel "Pola" having set out for the first Austro-Hungarian deep-sea expedition to the Red Sea. To the author it seems to be a charming circumstance that it was organized by three institutions which, or the predecessors of which, also played an important role in organizing the Austro-Hungarian deep-sea expeditions themselves and working up their scientific results:

The Imperial Academy of Sciences, predecessor of the Austrian Academy of Sciences, initiated the Austro-Hungarian deep-sea expeditions, provided the scientific programmes and equipment, appointed the members of the scientific staffs, and published most of the scientific results in a separate series of its Proceedings.

The Imperial Court Museum of Natural History, predecessor of the Natural History Museum Vienna, delegated scientists from its staff to the scientific staff of the expeditions and took care of their large collections, which today continue to form a part of the various special collections of the museum and are still accessible for further research.

The University of Vienna, more specifically the Institutes of Zoology and Chemistry of the University of Vienna, delegated scientists to the staff of the expeditions and participated in evaluating their scientific results, too.

Only that institution of the Austro-Hungarian Monarchy which made the Austro-Hungarian deep-sea expeditions possible by supplying the ship and crew and giving logistic support, the Austro-Hungarian Imperial and Royal Navy, no longer exists and has no direct successor; nevertheless, its merits for doing and supporting scientific research are still recognized today and have been acknowledged by the history of science (HAMANN 1980).

The following contribution, based on a more comprehensive study by the author (SCHEFBECK 1991), intends to give a short survey of the Austro-Hungarian deep-sea expeditions in their scientific historical context.

The Context

The Early History of Oceanography

Oceanography in our sense of the word, as "the application of all science to the phenomena of the sea" (ROSS 1982, p. 5) including the physical, chemical, geological, and biological approach and integrating them into an overall view of these phenomena, is a relatively young science. Its birthday has been quoted as 3 January 1873, the day of the beginning of the deep-sea work of the "Challenger" expedition (IDYLL 1969, p. V). Although this is a somewhat pointed view, it was indeed in the early 1870s when oceanography arose as an integrative science in the above-mentioned sense, when the infrastructure necessary for doing oceanographic research work came into being, when the first great oceanographic ship expeditions were sent out and the first marine biological stations founded.

There are several reasons for this development: The findings of single scientists such as Matthew Fontaine MAURY in the fields of hydrography and marine meteorology or Edward FORBES in the field of marine biology had provided the basic knowledge upon which the new integrative approach to the phenomena of the sea could build. Practical purposes of seafaring (the need to improve the knowledge of the hydrodynamic and the marine meteorological conditions) and fishery (especially questions connected with the habits, the reproductive behaviour) and the development of food fish - but also purposes of laying submarine cables were conducive to raising funds for scientifically dealing with the phenomena of the sea.

Charles DARWIN's Theory of Evolution contributed to directing the attention of the public to the sea in general and to the deep sea in particular: Scientists like Thomas Henry HUXLEY, for example, well known as "Darwin's Bulldog", assumed the existence of "living fossils" that might play the role of "missing links" (which were sought to confirm DARWIN's theory) in the deep sea. Charles Wyville THOMSON's first ship expeditions on board H.M.S. "Lightning" and "Porcupine", that had preceded the circumnavigation of H.M.S. "Challenger", had also mainly served the purpose of searching for "living fossils" by dredging in greater depths.

Beyond this, the Theory of Evolution had turned wide-ranging interest to the ontogeny and phylogeny of marine invertebrates, from whose comparative anatomy biologists tried to infer biogenetic relationships. One of those biologists inspired by DARWIN's "Origin of Species" was the German Anton DOHRN. A collecting journey to the Mediterranean had shown him the necessity of having a point of support for biological collecting and research work directly on the coast - a station offering the biologists on site laboratories, aquariums, and libraries, a station where at least the littoral aquatic fauna of a defined region could be systematically catalogued. This led Anton DOHRN to found the first marine biological station, the famous Stazione Zoologica di Napoli, which was officially opened in February 1874.

Soon DOHRN's example was imitated, and various coastal states such as France, Great Britain, Germany, Russia, and the USA set up similar stations; one of the earliest among them was the Austro-Hungarian zoological station at Triest/Trieste founded by Carl CLAUS and Franz Eilhard SCHULZE, professors of zoology at the Universities of Vienna and Graz, respectively, in 1875. Some of these stations remained marine biological stations; others developed into oceanographic stations in the full sense of the word, the most famous today being the Woods Hole Oceanographic Institution at Woods Hole, MA, and the Scripps Institution at La Jolla, CA.

The other "pillar" of oceanography, besides the coastal stations, were and continue to be the ships used for research expeditions - ships that in the first decades of the history of oceanography had to be provided by the navies of the seafaring nations, since constructing special research vessels was virtually unheard of until the early 20th century; the first ship specifically designed and built for purposes of marine research (only in 1882) was the sailing steamer "Albatross" of the U.S. Fish Commission.

However, even though the young science of oceanography was dependent on navies supplying ships for sea expeditions until the end of the 19th century, this could still be considered significant progress: Before the 1870s the navies of the various seafaring nations indeed had already used to send out vessels for transoceanic missions pursuing either a rather colonial or a rather scientific objective, but even in the latter case the scientific tasks of these expeditions, such as the circumnavigation of the Austrian frigate "Novara" in the years 1857-1859, had been mainly geographic ones; their primary task had been to take natural scientists to overseas coasts and unexplored countries, and marine investigations had been only by-products.

This fundamentally changed when Great Britain sent out the Royal Navy corvette "Challenger" on her three and a half year circumnavigation, whose scientific object was the sea itself. The enormous success of this expedition - in its scientific results as well as in its impact on public opinion - made marine research a question of national prestige. Thus, nearly all important seafaring nations found themselves compelled to organize similar expeditions, including Germany with its circumnavigation by the "Gazelle", later on in the 1880s Italy, the USA, and Russia with similar voyages by the "Vettor Pisani", "Enterprise", and "Vitiaz", respectively.

The "Challenger" expedition had already been an oceanographic one in the full sense of the word. Its instructions had read like a programme of the young integrative science of oceanography; its initiators, foremost Charles Wyville THOMSON had recognized that the phenomena of the sea demanded an interdisciplinary scientific approach, and the situation on board a research ship such as the "Challenger" or her successors had turned out to promote such an approach: the narrowness of space, the close quarters, tended to bring proponents of the various scientific disciplines dealing with the phenomena of the sea together and force them into an interdisciplinary dialogue.

This interdisciplinary dialogue as well as the new science of oceanography itself - both being mutually conditional, if not identical - were based on theoretical and methodological fundamentals laid by the "Challenger" expedition, as well: The monumental "Report on the Scientific Results of the

Voyage of H.M.S. 'Challenger'", published in 50 quarto volumes until 1895, became the "standard work" on oceanography. It included the classical study on the components of sea water by William DITTMAR, the classification of pelagic sediments by John MURRAY and Alphonse RENARD, which in principle has remained valid up to now, and, in 40 volumes, descriptions of all groups of marine animals found by the expedition; within the scope of the "Challenger" work, zoologists such as Ernst HAECKEL, H. B. BRADY, and Alexander AGASSIZ wrote the "standard works" on radiolaria, foraminifera, and sea urchins, respectively. Two Austrian zoologists, Ludwig von GRAFF and Robert LENDLMAYR von LENDENFELD, as well, contributed to the "Results" of the "Challenger" expedition.

Thus, the history of oceanography - or its earliest phase - had begun with this expedition. This first phases (...of altogether four phases) of the history of oceanography has been called the "era of exploration" (WÜST 1964). WÜST dates this phase 1873-1914 and characterizes it as a period of collecting data by carrying out spot checks. According to his study, after the interruption caused by the First World War this earliest phase was followed by the "era of national systematic and dynamic ocean surveys", this having been introduced by the "Meteor" expedition to the South Atlantic Ocean, in which WÜST himself had participated; this second era lasted until the beginning of the Second World War, after the end of which an intermediate "period of new marine geological, geophysical, biological, and physical methods" began that in 1957, the "International Geophysical Year", was replaced by the "era of international research cooperation". In the meantime another phase in the history of oceanography has begun; it is marked by the use of continuously working measuring networks (ROLL 1976, p. 11).

Clearly, the history of oceanography was determined on the one hand by the progressive improvement of measuring instruments and techniques, on the other hand by the development of the methodological and organizational approaches of research: from spot checks to systematic surveys, from national projects to international research cooperation.

However, even the methodological and organizational aspects had already received an early impetus in the first historical phase, the "era of exploration": Although the measuring instruments of the time allowed little more than carrying out spot checks, it made quite a difference if the samples taken were representative ones or not; and whereas the expeditions such as the great circumnavigations in the first two decades of oceanography tried to do as many spot checks as possible in as many different parts of the sea as possible, to collect various data from various oceans without paying much attention to the representativity of the samples taken, from the 1890s on increasingly

oceanographers tried to take representative samples; this meant that they had to reduce their fields of research - in the spatial sense - to smaller parts of the ocean.

At the outset of this development stood the Austro-Hungarian deep-sea expeditions: When, in 1889, their initiators at the Imperial Academy of Sciences discussed their objective, they chose the systematic investigation of a defined region of the ocean instead of organizing another circumnavigation.

As the region to be investigated the Eastern Mediterranean was selected. Its different parts were to be systematically explored in the course of a series of oceanographic expeditions; later, the same methodological approach was applied to the Red Sea. This approach enabled the physical, chemical, geological, and biological conditions of these two regions to become better known within a few years than those of most other seas, but with the important reservation that in the case of the Eastern Mediterranean only the summer conditions, in the case of the Red Sea only the winter conditions were investigated.

In order to also investigate the seasonal variability of these conditions, in the early 1890s the Swedish marine chemists Otto PETTERSSON and Gustav EKMAN developed the methodological approach of the so-called "periodic cruises": Accordingly, fixed routes in a defined region of the sea were visited four times a year, once each season, to observe seasonal changes. This, of course, was a quite costly approach, since serving several routes at the same time required several ships to be available four times a year, each time for at least some weeks. Thus, this methodological approach promoted international cooperation: As early as 1894 the littoral states of the North and Baltic Seas started the systematic investigation of these regions of the sea, and from 1901 on they continued their investigations within the framework of the newly founded "International Council of Marine Research"

In 1910 the "Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranée" was established. The only part of the Mediterranean, however, that was investigated by "periodic cruises" before the First World War cut short these initial steps of international marine research cooperation was the Adriatic Sea, where the Austro-Hungarian Monarchy and Italy in the years 1911-1914 carried out a cooperative research programme. Thus, the Austro-Hungarian marine research activities, the Austro-Hungarian deep-sea expeditions of 1890-1898, and the Austro-Hungarian/Italian Adriatic investigations of 1911-1914, opened and closed the second part of the first phase of the history of oceanography, the time when oceanographers began to systematically investigate the sea.

Early Austrian Marine Research Activities

Although the Austro-Hungarian Monarchy conducted oceanographic research in the full sense of the word only from 1890 on (when it sent out the Austro-Hungarian deep-sea expeditions), at that time it could already look back on a remarkable tradition in marine research - remarkable at least for a country with a relatively short coastline (SCHEFBECK 1994).

Since the late 14th century the Hapsburg Monarchy had had access to the Adriatic Sea. However, only after the Peace of Campo Formido, 1797, as the heir of the Venetians, did it become the most influential power on the Adriatic. From this time on, the military presence on this sea as well as the responsibility for promoting the interests of seafaring and fishery naturally also focused scientific interest on this part of the Mediterranean.

About 1820 and again from 1859 to 1870 the Adriatic coasts were surveyed by the Austrian Navy, which had to bear the brunt of Austria's marine research activities. When the Hydrographic Office of the Navy was founded at Triest/Trieste in 1860 (and moved to the Navy's newly established central port, the Istrian harbour of Pola/Pula, in 1871), it became the center of the Austrian hydrographic data system, where sea charts and sailing handbooks were produced. The Naval Academy, established 1866 at Fiume/Rijeka and drawing on a tradition going back to the Naval College founded 1822 in Venice, offered an excellent training in both nautic and hydrographic fields. Besides, among the books produced for teaching in this institution was the first textbook of oceanography in the German language, the "Lehrbuch der Oceanographie" by August JILEK, published in 1857 (obviously the earliest use of the term in German!).

In direct connection with the Adriatic survey of 1859-1870 and in order to expand the scientific investigation of the Adriatic Sea beyond the fields of cartography and hydrography, around which the activities of the Navy centred, in 1867 the Imperial Academy of Sciences in Vienna set up a "Commission for the Investigation of the Physical Properties of the Adriatic Sea", abbreviated "Adriatic Commission". This commission, that existed until 1880, initiated pioneering work in marine physics, especially of coastal Adriatic waters, and published the results in a five-volume series of the Proceedings of the Academy; marine biology was not included in the research programme of the commission due to financial reasons. Beyond the work of the commission, the physical features of the open Adriatic were investigated in a series of expeditions carried out by professors Emil STAHLBERGER (who initiated the expeditions but died soon thereafter), Josef LUKSCH, and Julius WOLF from

the Naval Academy between 1874 and 1880. Where the "Adriatic Commission" on the one hand and LUKSCH and WOLF on the other hand left off, the Austro-Hungarian deep-sea expeditions could later carry on - at least with regard to physical oceanography.

As far as marine biology was concerned, the appropriate point of contact was the Zoological Station at Triest/Trieste. After its establishment in 1875, Carl CLAUS acted as the director, but the person in charge of running the laboratory was Eduard GRAEFFE, who immediately embarked on the task of creating a reference collection and an inventory of the fauna of the Gulf of Triest/Trieste. GRAEFFE also supplied living and preserved animals for the Universities of Vienna and Graz, and he had to look after and support the biologists using the facility, among them eminent scientists such as Richard and Oscar HERTWIG, Eduard van BENEDEN, Ilia I. MECNIKOV, and Alexander O. KOVALEVSKI; the young Sigmund FREUD, as well, spent some time there as a student investigating the gonads of the eel. Nearly all important Austrian biologists of the time used the facility to acquaint themselves with the methods of marine biological research; and the zoologists participating in the Austro-Hungarian deep-sea expeditions such as Franz STEINDACHNER and Berthold HATSCHEK also updated their knowledge of these methods here when preparing for the expeditions.

Thus, basic research work on which the Austro-Hungarian deep-sea expeditions could build had been done in the physical as well as in the biological branch of oceanography. However, at this point it should be mentioned that in the early 1860s, a full decade before the era of oceanography started, there had already been an Austrian oceanographer in the full sense of the word. This pioneer of oceanography suffered one of these so-called "Austrian fates", i.e., he did not receive the acclaim he deserved because neither Austria nor the scientific community were ready for his achievements: Josef Roman LORENZ (later: von LIBURNAU) was a grammar school teacher at Fiume/Rijeka and later an official in the Ministries of Trade and of Agriculture. During his time at the Adriatic coast he studied the Quarnero/Kvarner, the gulf on which Fiume/Rijeka is situated. In a book on "The Physical Conditions and the Distribution of Organisms in the Quarneric Gulf", published in 1863, he introduced a division of the marine littoral into depth zones which was exemplary for its time. This concept modified earlier attempts of FORBES and ØRSTED and dealt with the distribution of communities rather than single species - both animal and plant - to characterize "regions". Having recognized that a rigid depth zonation as advocated by FORBES cannot describe the distribution of communities and organisms, he used the term "facies", borrowed and modified from geology, to account for the horizontal variations of

substrate and organisms along gradients of hydrographic and edaphic parameters. In using factors such as light, temperature, water movement, and substrate to substantiate and explain his classification scheme, he introduced ecological concepts into marine biology at a time when systematics and comparative anatomy still prevailed, and at the same time an interdisciplinary and therefore oceanographic approach into marine science - an approach that only hundred years later became fully acknowledged (RIEDL 1964).

The Austro-Hungarian Deep-Sea Expeditions

The Preparatory Phase

On 11 April 1889, three of the most eminent members of the Imperial Academy of Sciences, the zoologist Franz STEINDACHNER, the geologist Franz Ritter von HAUER, and the meteorologist Julius HANN, submitted a proposal for oceanographic expeditions to the Eastern Mediterranean to the Mathematical Scientific Section of the Academy. The author of the motion was Franz STEINDACHNER, then Director of the Zoological Department of the Imperial Court Museum of Natural History, later the Director General of said museum, and one of the most famous ichthyologists of the world, who had enormously increased the fish collection of his museum not only through purchases but also by his own expeditions, which had led him to Western Africa, to North and South America, and to nearly all parts of Europe.

As the financial situation of the Academy, which more than ten years earlier had forced the "Adriatic Commission" to stop its research work in the Adriatic Sea, had significantly improved in the years since 1887, the time had come to initiate a major scientific project again. And it was STEINDACHNER who seized the opportunity and turned the attention as well as the financial resources of the Academy towards marine science again, but along with two important modifications to the approach chosen by the "Adriatic Commission": First, this time marine biology was also to be included in the research programme so that the approach was an oceanographic one in the full sense of the word; secondly, the investigations were not to be focused on coastal waters but on the open sea, a circumstance which made the project much more expensive than the research programme of the "Adriatic Commission" (STEINDACHNER himself was especially interested in deep-sea research, not least because he hoped to gain some interesting new deep-sea fishes for his collection).

However, instead of another circumnavigation such as those of the other seafaring nations quoted in STEINDACHNER's motion to present marine

research as a question of national prestige, instead of carrying out unsystematic investigations all over the oceans, the systematic investigation of a defined region of the sea was proposed as the appropriate approach; as to the field of this research (in the topographic sense) STEINDACHNER proposed to systematically investigate the Eastern Mediterranean by a series of cruises, so that the chosen field of research was to border on that of the "Adriatic Commission" (and of LUKSCH and WOLF).

In reaction to the motion the Mathematical Scientific Section of the Viennese Academy immediately set up a commission to deliberate on the matter. This "Commission for the Exploration of the Eastern Mediterranean", later on "Commission for Oceanographic Research", abbreviated "Deep-sea Commission", consisted of the three movers, STEINDACHNER, HAUER, and HANN, of the zoologist Carl CLAUS, and of the famous geologist Eduard SUEß, who was then Secretary of the Section, later on Secretary General, Vice President, and from 1898 to 1911 President of the Academy. Due to the interdisciplinary character of the matter to be deliberated on, soon the chemist Adolf LIEBEN and the physicist Josef STEFAN became members of the Commission; in later years, the physicist Viktor Edler von LANG, the zoologist Karl GROBBEN, the physicist Franz S. EXNER, the mineralogist Friedrich BECKE, the geographer Eduard BRÜCKNER, and the meteorologist Felix M. EXNER EWARTEN were among its members.

As Franz STEINDACHNER had already stated in his motion, carrying out the project was impossible without the support of the Imperial and Royal Navy: Only the Navy had ships available, and without a suitable ship and crew no one could think of going ahead with oceanographic expeditions. Fortunately, the commander in chief of the Navy, Admiral Maximilian Baron STERNECK, was personally deeply interested in natural science in general and marine biology in particular (at an early age, as a young naval officer, he had collected conchylia and algae); so he promised Eduard SUEß, who called upon him on behalf of the Academy, to place a ship at the Academy's disposal for the expeditions in question. Having this in prospect, the Mathematical Scientific Section of the Academy on 9 May 1889 carried the motion submitted by STEINDACHNER, HAUER, and HANN, and on 28 May the entire Academy gave its consent. The Navy's official assent followed on 18 June 1889.

As making the preparations for an oceanographic expedition would take at least a full year, the summer of 1890 was chosen for the first expedition that was to lead to the Ionian Sea, the westernmost part of the survey area; the following cruises were to lead to the more eastern parts of the Eastern Mediterranean.

Just as the field of research (topographically, again) was divided between several expeditions, the responsibilities for preparing them and evaluating their scientific results were divided between several institutions: The Navy supplied the ship and the crew; as the expedition ship, the transport vessel "Pola" - a sailing steamer of 920 tons that had already brought the Austro-Hungarian scientific expedition to Yan Mayen in 1882 - was chosen. The ship's commander was to be Captain Wilhelm MÖRTH.

Supplying the oceanographic equipment that the "Pola" was to be outfitted with fell within the responsibility of the Academy, which had to spend considerable amounts of money for the latest instruments such as thermometers, hydrometers, water ladles, dredges, fishing nets, and a deep-sea sounding apparatus. In order to provide the expedition with truly up-to-date instruments, some of the most eminent oceanographers such as Alexander AGASSIZ, John MURRAY, Henrik MOHN, and Prince Albert of Monaco were consulted; of course, the experiences gained at the zoological stations at Naples and Triest/Trieste were also taken into consideration.

Moreover, the Academy was responsible for the scientific programme of the expeditions (worked out in detail by the "Deep-sea Commission"), for appointing the members of the scientific staff, and finally for publishing the scientific results. Most of the publications were to be prepared at two other scientific institutions that also took part in the preparation of the expeditions themselves: the University of Vienna and the Imperial Court Museum of Natural History, that according to STEINDACHNER's and the "Deep-sea Commission"'s intentions was also to take care of the collections gathered by the expeditions.

The latter institutions also delegated most of the members of the scientific staff of the deep-sea expeditions (who were formally appointed by the "Deep-sea Commission"): The scientific staff of the first expedition in 1890 consisted of two zoologists, Karl GROBBEN, a student of Carl CLAUS and associate professor at the University of Vienna, and Emil von MARENZELLER, curator at the Natural History Museum and recognized specialist for certain invertebrate groups such as echinoderms and corals, as well as a chemist, Konrad NATTERER, LIEBEN's assistant at the University of Vienna, and a marine physicist, Josef LUKSCH, professor of history and geography at the Naval Academy, veteran of the Adriatic investigations of the 1870s.

NATTERER and LUKSCH remained staff members until the end of the series of the Austro-Hungarian deep-sea expeditions. An important change took place in 1891, when Franz STEINDACHNER himself took charge of the scientific staff. In that year, STEINDACHNER and Berthold HATSCHEK, pro-

fessor of zoology at the German University of Prague (later at the University of Vienna), acted as the zoologists of the expedition instead of GROBBEN and MARENZELLER; in 1892 and 1893 STEINDACHNER was the only zoologist, and from 1894 on he was accompanied by his assistant at the Natural History Museum, the herpetologist Friedrich SIEBENROCK. Thus, Franz STEINDACHNER was not only the initiator of the Austro-Hungarian deep-sea expeditions, but, as head of the scientific staff and zoologist, also personally responsible for the scientific results of most of them.

In the summer of 1890, STEINDACHNER and HAUER came to Pola/Pula for another reason: as representatives of the "Deep-sea Commission" they had to see off the first deep-sea expedition. Another personage who took part in seeing it off was no less than Prince Albert of Monaco, who on board his private yacht had done oceanographic research in the Western Mediterranean and presented his equipment and results at the world exposition in Paris the year before, where Emil von MARENZELLER had had the opportunity to meet him.

The "Pola" had been adapted for the purposes of the expedition; thus, e.g., a biological and a chemical laboratory had been installed in the hatchway of the ship, and a stud lined with lead had been established in the ship's hold to store the alcohol required for preserving the animals caught (as well as the spirit preparations after they were made). On deck the deep-sea sounding apparatus as well as a steam winch and the cable drums carrying the steel wire needed for dredging operations were installed (MÖRTH 1892).

A test cruise on 9 August 1890 provided an opportunity to put the machines and instruments to a final test; then, ship, crew, and scientific staff were ready to set out for the first Austro-Hungarian deep-sea expedition.

The Expeditions

The First Expedition to the Eastern Mediterranean (1890)

The "Pola" left the central port of Pola/Pula on 10 August 1890. After having left the Adriatic and reached the Ionian Sea, the deep-sea research work began in the waters of the Ionian Islands; from the southernmost of these islands, Cerigo/Kithira, the "Pola" headed southwards for the Libyan coast, that was reached near Ras al Hilal and followed until Benghazi, from where the open Ionian Sea was traversed northwards. On 16 September the ship returned to its home port.

Whereas the soundings, the physical observations, and the chemical analyses after some slight initial difficulties were rather successful in the course of

the first deep-sea expedition, the same could not be said of the biological deep-sea work: On the one hand going about with the dredge proved difficult, on the other hand it turned out to be extremely time consuming; a dredging operation in a depth of about 3000 m took 3-4 hours. This was why the ship's officers and crew - much in the same way as those of the "Challenger" (from which the original quotation is testified) and of other research vessels - called dredging their "bête noire" and tried to cut down the number of dredging operations as far as possible. In the course of the first Austro-Hungarian deep-sea expedition the dredge was used only 14 times, and fewer than half of these operations were successful.

This put a great strain on the relations between the zoologists of the scientific staff and the ship's commander; especially Emil von MARENZELLER - diplomacy was not one of his strengths - got into an open confrontation with MÖRTH, who did not hesitate to complain about him to Admiral STERNECK. Therefore in order not to cast a shadow over the relationship between the Academy and the Navy, the membership of the scientific staff for the next expedition had to be changed. To ensure the success of the biological investigations, STEINDACHNER himself took over the function of the head of the scientific staff; in fact, by combining the authority of a member of the Academy of Sciences and a high ranking civil servant with tactfulness in the contact with the ship's commander, he managed to increase the biological results, for example to double the number of dredging operations performed during the second versus the first deep-sea expedition. (The price he had to pay was to bear MÖRTH's lamentations during lengthier operations of this kind.)

The Second Expedition to the Eastern Mediterranean (1891)

The "Pola", having been given a major overhaul in the months before, set out from the central port on 22 July 1891. The first discovery made by the expedition, already on 28 July, gave it an as yet unknown publicity: About 50 naut. mi. southwest of Cape Matapan/Tenaro a depth of 4404 m was sounded - the greatest depth ever found in the Mediterranean! As we know today, the "Pola" expedition in fact found the deepest region of the Mediterranean, the so-called Hellenic Trench with depths of more than 5000 m; the name "'Pola' Depth" proposed by LUKSCH and the Viennese Academy did not gain acceptance with the scientific community.

After this sensational discovery the "Pola" headed for the west coast of Crete. Her survey area for the following two weeks was the waters north of Crete; after having rounded the eastern part of Crete, from the south coast of this island the "Pola" took course for Alexandria and traversed the

southeastern part of the Eastern Mediterranean. After a longer stay in the harbour of Alexandria the ship sailed along the Egyptian coast and, upon reaching the Gulf of Sollum, headed for the south coast of Crete again; thus, during this expedition the waters all around this island were investigated. After having touched Cerigo/Kithira and Milo/Milos, the second Austro-Hungarian deep-sea expedition ended in Piraeus on 9 September 1891.

Whereas the "Pola" still had to fulfill two further missions that year, investigating the Northern Aegean coasts for military purposes and surveying the Albanian coast for the revised edition of the Sailing Handbook of the Adriatic, the members of the scientific staff individually returned to Vienna. The untiring STEINDACHNER seized the opportunity to undertake an ichthyological collecting journey to the Macedonian inland lakes; similar private expeditions to the Balkan Peninsula or to the Levant also followed the other deep-sea expeditions in which he participated (except the last one).

The Third Expedition to the Eastern Mediterranean (1892)

After having left Pola/Pula on 16 August 1892, the "Pola" briefly conducted a test dredging operation south of the Straits of Otranto (where she dredged up a telegraph cable - fortunately without damaging it), took some additional soundings to delimit the "'Pola' Depth" discovered the year before, and then took a course that led south of Crete to Alexandria, where that year's research work was to begin in earnest. That year's fields of research were the remaining parts of the open Eastern Mediterranean, the waters off the mouths of the Nile (where the influence of the Nile water on the salinity of the seawater as well as on the richness of organisms could be observed) and off the Palestinian and Syrian coast, the Channel of Cyprus, and the Caramanian Sea, the sea south of Asia Minor; all were investigated by laying transversal sections. The greatest depth yet in this so-called Levant Basin of the Eastern Mediterranean was sounded as 3591 m off the Gulf of Makri/Fethiye. From Rhodes the "Pola" returned to her home port, where she arrived on 22 October 1892.

The Fourth Expedition to the Eastern Mediterranean (1893)

Of the survey area defined in 1889, only the Aegean Sea (with the exception of its southernmost part) and the Sea of Marmara remained uninvestigated. Since the Sublime Porte refused its consent to the "Pola" as a man-of-war passing through the Dardanelles, and since the investigation of the Sea of Marmara was of special importance to analyse the exchange of water between the Black Sea and the Mediterranean, the research had to be done on board another ship: The Austro-Hungarian guardship in Constantinople, the paddle

steamer "Taurus", was chosen for this task; but because the necessary instruments were needed on board the "Pola" that year, the expedition to the Sea of Marmara could only take place the following year. That year's "Pola" expedition was given two main tasks: first, more thorough investigation of the benthic fauna of the waters around Cerigo/Kithira and Cerigotto/Antikithira as well as Milo/Milos, where the dredgings so far had yielded the most interesting results (this, of course, was a special request of STEINDACHNER); secondly, oceanographic exploration of the Aegean Sea.

The "Pola" set out for her last Mediterranean deep-sea expedition on 16 July 1893. Due to stormy weather and time lost to help the crew of a shipwrecked Austrian sailing vessel, the dredging campaign was not as long and as successful as STEINDACHNER had hoped. After having made a short detour to the waters east of Rhodes to carry out supplementary soundings in the region of great depths found the year before (that after Admiral STERNECK's death in 1897 was named "Sterneck Depth" by the Academy), the "Pola" turned to her major task, the Aegean Sea.

She sailed northwards along the west coast of Asia Minor, and from Mytilini/Lesvos traversed the Aegean along a course for the Gulf of Monte Santo/Agion Oros. Then she called at the Dardanelles where, notwithstanding a prohibition by the Ottoman authorities, physical observations were taken (as discreetly as possible). On the way back the western part of the Aegean Sea was to be investigated, but the Greek authorities interrupted the research work by putting the "Pola" in quarantine at the quarantine ward of Delos (cholera had broken out in Constantinople and at Gallipoli/Gelibolu, so that provenances from the Dardanelles were subjected to quarantine). To shorten the quarantine, from Delos the "Pola" directly made for Corfu, where for the first time after three weeks spent on board the crew was allowed to go ashore. On 5 October 1893 she dropped anchor in the central port of Pola/Pula.

During the four deep-sea expeditions to the Eastern Mediterranean the "Pola" in 254 days had covered a total of 12 188 naut. mi. 417 oceanographic stations had been visited. A wealth of physical and chemical data, sediment samples, and collected and preserved animals waited for evaluation.

The Expedition to the Sea of Marmara (1894)

In the years since 1890, the Eastern Mediterranean and the Black Sea had been investigated by the Austro-Hungarian deep-sea expeditions and by some simultaneous but smaller Russian expeditions, respectively; only the intervening Sea of Marmara remained oceanographically unexplored. Its investigation seemed to be of particular interest, as it was called upon to answer the

question whether the water stratification of the Sea of Marmara was similar to that of the Black Sea, where the Russian expeditions had just discovered the deep layer containing hydrogen sulphide instead of oxygen, or to that of the Mediterranean.

Since therefore the main task to be carried out in the course of the expedition on board the paddle steamer "Taurus" in May 1894 was a chemical one, the scientific staff of this expedition consisted only of the chemist Konrad NATTERER. The rest of the research - soundings, fishing operations, etc. - was to be done under supervision of the ship's officers; the ship's commander was Captain Emil HERMANN. The "Taurus" left Constantinople on 22 May 1894 and during the following week layed a series of sections through the Sea of Marmara, whose deep layers turned out to be free of hydrogen sulphide and full of animal life - results that were confirmed by a Russian expedition in autumn 1894. The "Taurus" expedition ended when the ship reached the Dardanelles on 30 May 1894.

The Marine Biological Expedition to the Adriatic Sea (1894)

The Adriatic investigations carried out by the "Adriatic Commission" as well as by LUKSCH and WOLF had left marine biological research aside; thus, the marine biological exploration of the Adriatic Sea still remained a desideratum of oceanography. It stood to reason that the situation upon completion of the deep-sea expeditions to the Eastern Mediterranean offered appropriate conditions to make up for what then had been missed: there was a suitably equipped ship available, there was an experienced crew and scientific staff. The particularly interesting circumstance is that this idea was first forwarded not by the Academy but by the Navy, specifically by Admiral STERNECK ,who in a letter of 11 November 1893 offered the Academy the "Pola" for a marine biological expedition to the Adriatic Sea at the first best opportunity.

The Academy, of course, accepted, and the opportunity came up soon: The following year a naval officer was to be conveyed to the Adriatic islands to take observations of relative gravity (a scientific object that was paid great attention at the time) and to establish a small meteorological observatory on Pelagosa/Palagruža. The "Pola" was charged with this task, and this opportunity was taken to entrust her also with said marine biological expedition, to which the Academy delegated the zoologists Franz STEINDACHNER and Friedrich SIEBENROCK.

Altogether, the expedition took more than two months, from 31 May to 2 August 1894. As its result, with regard to marine biology the Adriatic Sea and the northern part of the Ionian Sea - after the Gulf of Naples, of course - were

among the most intensively investigated parts of the Mediterranean; some of the most interesting results stem from the pelagic hauls at intermediate depths carried out using the new Tanner net. During the expedition a total of 39 dredging operations, 51 pelagic hauls at intermediate depths, and 76 surface hauls had been carried out; the collections brought in (and for the first time preserved in formaldehyde instead of alcohol) were nearly as large as those of the four Eastern Mediterranean expeditions together.

The First Expedition to the Red Sea (1895-1896)

Even after the Adriatic expedition the series of the Austro-Hungarian deep-sea expeditions had not yet come to its end; on the contrary, it was to culminate in the two expeditions to the Red Sea.

As already had to be seen in the case of the Adriatic expedition, however, the initiative had devolved from the Academy of Sciences upon the Navy. Again it was Admiral STERNECK himself who suggested the new project consisting of two main issues: first, extension of the oceanographic research from the Eastern Mediterranean to the Red Sea, which had been connected with the former by the Suez Canal since 1869 and was therefore readily accessible; secondly, the geophysical and geodetic investigation of the Red Sea basin. This second part of the research programme was to be fundamentally conceived by the Naval Technical Committee and worked out in detail and carried out by the ship's officers; in this way the Navy took an especially large and immediate share in the scientific results of the expeditions to the Red Sea.

The preparations for the expeditions took more than one year: the Navy's proposal was submitted to the Academy on 24 September 1894, and the first expedition began on 6 October 1895. Considering the climate of the Red Sea basin, it had been decided to go ahead with the expeditions in the winter months. The field of research was divided into two parts: the northern part of the Red Sea including the Gulfs of Suez and of Aqaba was to be investigated during the first expedition, the southern part between the parallel of Djedda and the Straits of Bab el Mandab during the second one. The "Pola" was again outfitted with the latest technical equipment to make the enterprise easier, such as a ventilating system, an electric lighting system, a deep-sea anchor, and a "naphtha boat" (a launch driven by a petrol engine). Instead of MÖRTH, Captain Paul Edler von POTT was appointed the ship's commander; the scientific staff consisted of Franz STEINDACHNER as its head, Friedrich SIEBENROCK, Konrad NATTERER, and Josef LUKSCH.

After having left the central port on 6 October 1895, the "Pola" headed straight for Port Said, the starting point for the passage of the Suez Canal. From Suez, the northern base point of the geophysical observation network, she made for Djedda; on the way, small temporary meteorological observatories were established, at the lighthouse on Brothers Islands and at Koseir, a third one at Djedda. From Djedda, the northern part of the Red Sea was investigated in the course of three cruises; a fourth cruise was designed to investigate the Gulf of Suez, a fifth one the Gulf of Aqaba, which was visited by a research ship for the first time ever (whereas the Red Sea proper and the Gulf of Suez had been touched by the oceanographic circumnavigations of the "Vettor Pisani" and the "Vitiaz"). After a second passage of the Suez Canal, the "Pola" returned to her home port on 18 May 1896.

Due to the geodetic and geophysical observations conducted onshore, the Red Sea expeditions were not pure deep-sea expeditions; during these observations there was enough time to also study the littoral fauna, which explains why the zoological collections brought in from the Red Sea were much larger than those from the Eastern Mediterranean. Thus, the zoological collections of the first expedition to the Red Sea alone filled no fewer than 135 crates; these collections included 4000 littoral fish representing about 320 species.

The Second Expedition to the Red Sea (1897-1898)

Only half of the survey area of the second expedition to the Red Sea was appropriate for deep-sea research, the rest was shallow shelf sea interspersed with coral reefs. As STEINDACHNER, who then already acted as Director General of the Natural History Museum, was granted a leave of absence of only four months, the open southern Red Sea (more interesting to him from the standpoint of deep-sea research) was to be the object of the first part of the expedition; from its southern base point, Aden, STEINDACHNER was to return to Vienna. Since Konrad NATTERER was preparing to be appointed associate professor and did not participate in the expedition, the scientific staff during the second leg consisted only of SIEBENROCK and LUKSCH.

The "Pola" set out on 4 September 1897. After having passed through the Suez Canal, from Suez she headed for Raveiya, situated opposite Djedda on the Egyptian coast of the Red Sea, the starting point of the research work. During two cruises whose end points were Sawakin (where a temporary meteorological observatory was established) and Massawa, the open southern Red Sea was investigated. Then the "Pola" made for Perim and Aden, where the message of the death of Admiral STERNECK (meaning the end of the phase of particularly strong support for scientific research by the Navy) was received.

On the way back from Aden the shallow-water regions were investigated; the passages through the coral banks of Dahlak off the Egyptian coast and of Farasan off the Arab coast were navigationally difficult and dangerous. After having defeated a beduin attack at Ras Turfa and touching Sawakin a second time, the "Pola" finally headed for Djedda again, the point of connection to the observation network of the first expedition to the Red Sea. From Suez a dredging cruise in the northern part of the Red Sea was carried out (at the particular request of STEINDACHNER, who was interested in complementing the knowledge of the benthic fauna gained during the first expedition). Afterwards the "Pola" again passed through the Suez Canal and returned to her home port, where she arrived on 24 March 1898. The Austro-Hungarian deep-sea expeditions had come to their end.

In the course of the two expeditions to the Red Sea the "Pola" had covered 16 495 naut. mi. Again, the scientific results were impressive: 349 oceanographic stations had been sampled. Besides the extensive oceanographic research, at 49 observation points ashore the ship's officers had carried out determinations of the constants of terrestrial magnetism and gravity, as well as surveys of the coast including exact astronomical locations and photogrammetric surveys, and finally meteorological observations. The naval officers themselves also worked out the results and published them in the Proceedings of the Viennese Academy of Sciences, which had also assumed the responsibility for publishing the oceanographic results of the Austro-Hungarian deep-sea expeditions.

The Oceanographic Results

Already in 1892 the first series of the reports of the "Deep-sea Commission" had been published in the Proceedings of the Academy of Sciences and were well received by the scientific community. During the next four decades a total of 67 reports, integrated into 14 series, were published.

The physical and chemical results of the Austro-Hungarian deep-sea expeditions were elaborated and published by those scientists who, as members of the scientific staff, had been responsible for taking the data: Josef LUKSCH (as to the results of the Mediterranean expeditions, supported by his colleague at the Naval Academy, Julius WOLF), and Konrad NATTERER. As no geologist had been on board the "Pola", the fields of geological work had been divided between the physicist and the chemist, the former charged with geomorphology, the latter with sedimentology; thus, LUKSCH's physical reports also dealt with bathymetry, NATTERER's chemical reports also with the sediments of the Eastern Mediterranean and the Red Sea. However, whereas LUKSCH as well as NATTERER published single reports on the results

of each of the expeditions, an early death prevented both from summarizing their results and drawing final conclusions.

Nevertheless, LUKSCH and NATTERER had laid down the basis of the knowledge of the physics and chemistry of the Eastern Mediterranean and the Red Sea (at least of the summer conditions of the former and the winter conditions of the latter); it took 15 years until new oceanographic research began to broaden this knowledge for the Mediterranean and even 30 years for the Red Sea. The instruments available to Luksch were, of course, of much lower accuracy than those in use already several years later: the thermometers were read to 0.1°C, and the salinity was measured by hydrometers to the nearest 0.1 ‰. Due to the low precision of thermometers, e.g., the effect of adiabatic heating (that was first observed in the Mediterranean by the Danish "Thor" expeditions of 1908-1909 and 1910) escaped LUKSCH's observations.

But at least with regard to surface temperature and salinity, the isotherm and isohaline charts compiled by LUKSCH formed a relatively correct impression of the summer conditions of the Eastern Mediterranean and the winter conditions of the Red Sea; besides, LUKSCH presented horizontal sections for three further levels (10 m, 100 m, and sea bottom), as well as various vertical sections. Neither the fine structure of the depth layers of water nor the depth currents could be revealed using this data, although conclusions on the surface currents were partially valid.

As regards geomorphology, the bathymetric charts LUKSCH drew revealed the most important large-scale formations of the sea bottom of the Eastern Mediterranean and the Red Sea, such as the Hellenic Trench or the Main Trough of the Red Sea. Details of the bathymetry of the oceans, of course, were only clarified after the introduction of sonar; precisely in the Red Sea, however, even the possibilities of echosoundings are limited by the precipitous slopes and the irregular sea bottom.

Only in one field was LUKSCH able to publish his final report before his death in 1901, and his results in this field were acknowledged as pioneering work: namely the optical properties of seawater. LUKSCH had used Secchi disks and photographic plates to observe daylight absorption; for his estimations of sea colour he had even developed an own scale, or modified the Forel scale that was originally designed for inland water. This so-called Forel-Luksch Scale became common property of oceanographers.

With regard to the methods applied, Konrad NATTERER, as well, had done pioneering work, in his case for marine chemistry: He used the latest analytical methods and introduced, for example, the newly developed Winkler method of oxygen determination into chemical oceanography, where it found use for

the next fifty years. Although NATTERER did not determine the oxygen content of water samples of enough different levels, and therefore the existence of an intermediate layer of minimum oxygen escaped his attention, his oxygen determinations were as pioneering as his determinations of nitrogen compounds and of dissolved organic matter in seawater; he proved the low content of nitrogen compounds in the water of the warm seas and for the first time the existence of dissolved organic matter in seawater. NATTERER's determinations of the main components of seawater are among the classical studies of their kind. His death in 1901 (half a year before that of LUKSCH) cut short his studies as well.

As in the case of other oceanographic expeditions, the zoological results of the Austro-Hungarian deep-sea expeditions not only made up the greater part of the scientific results but also took the longest to be worked up. The zoological collections brought in by the expeditions were initially sorted at the Zoological Institute of the University of Vienna; subsequently they were kept in the several departments of the Natural History Museum. In the following years, and in some cases decades, specialists were entrusted with working on the various animal groups and publishing the results, mostly in the reports of the "Deep-sea Commission".

Among these specialists were leading authorities such as Emil Edler von MARENZELLER, who dealt with the echinoderms, worms, and corals, and used the example of the Eastern Mediterranean echinoderms to show that due to its nearly homothermal depth layer - unlike the adjacent Atlantic Ocean - it had no differentiated abyssal fauna; MARENZELLER's colleagues at the Natural History Museum, Rudolf STURANY and Theodor ADENSAMER, confirmed this conclusion when working on the molluscs and decapods, respectively, of the Eastern Mediterranean (MARENZELLER 1895, pp. 128f.; STURANY 1896, pp. 1-3, pp. 32-35; ADENSAMER 1898, pp. 597-599). With regard to the corals from the Red Sea, MARENZELLER showed the enormous variability of their forms and that these forms were correlated with local conditions (MARENZELLER 1907, p. 30).

Among the specialists working on "Pola" material, moreover, was Heinrich BALSS, curator at the Zoological Museum in Munich, who published the decapods and stomatopods of the Red Sea and, with regard to the character of the deep-sea fauna of the Red Sea, came to similar conclusions as MARENZELLER, STURANY, and ADENSAMER for the Mediterranean (BALSS 1931, pp. 26f.). Further investigators, only to give some examples, included Franz STEINDACHNER, who after having determined the fishes published some new species (naming them, e.g., after STERNECK and SUEß), Franz Eilhard SCHULZE, who dealt with the Hexactinellida, Rudolf von Ritter-ZÁHONY,

who worked on the Chaetognatha, Willy KÜKENTHAL, who published a study on the Alcyonaria of the Red Sea, and Wilhelm MICHAELSEN, curator at the Zoological Museum in Hamburg, who worked out a monograph of the Ascidia of the Red Sea.

Most of their studies, of course, were systematical and faunistic, although morphologists such as CLAUS and GROBBEN also chose certain species from the "Pola" collections for studies in comparative anatomy.

Most of the scientific work on the zoological collections of the Austro-Hungarian deep-sea expeditions was done by the specialists of the Viennese Natural History Museum. Even after the "Deep-sea Commission" had ceased to exist, curators such as Otto PESTA, head of the Crustacea collection of the museum, continued working on the "Pola" material. The "Deep-sea Commission" had been dissolved in 1925, the last of its reports being published in 1931; the Republic of Austria, now a landlocked country suffering a hard economic crisis, could no longer afford to deal with matters of oceanography. But the zoological collections of the Austro-Hungarian deep-sea expeditions kept in the Viennese Natural History Museum remained an object of scientific research; and they have retained this status up to the present, being not only a record of Austria's oceanographic past but, with respect to the active marine biological research done by Austrian zoologists since the Second World War, even the symbol of a revived tradition.

References

(Preliminary remark: A complete bibliography is contained in SCHEFBECK 1991, pp. 233-244.)

ADENSAMER, T., 1898: Decapoden, gesammelt auf S.M. Schiff "Pola" in den Jahren 1890-1894. - Denkschr. Kaiserl. Akad. Wiss. Wien, math.-nat. Kl. (Ber. Comm. oceanogr. Forsch.) **65**: 597-628.

BALSS, H., 1931: Decapoden des Roten Meeres IV. Oxyrhyncha und Schlußbetrachtungen. Denkschr. Akad. Wiss. Wien, math.-nat. Kl. (Ber. Comm. oceanogr. Forsch.) **14**: 1-30.

HAMANN, G., 1980: Die österreichische Kriegsmarine im Dienste der Wissenschaften. - In: Österreich zur See, p. 59-90. - Wien: Heeresgeschichtliches Museum.

IDYLL, C. P. (Ed.), 1969: Exploring the Ocean World. A History of Oceanography. - New York: T.C. Crowell.

MARENZELLER, E., 1895: Echinodermen, gesammelt 1893, 1894. - Ber. Comm. Erforsch. östl. Mittelmeeres **4**: 123-148.

MARENZELLER, E., 1907: Riffkorallen. - Denkschr. Akad. Wiss. Wien, math.-nat. Kl. (Ber. Comm. oceanogr. Forsch.) **9**: 27-97.

MÖRTH, W., 1892: Die Ausrüstung S.M. Schiffes "Pola" für Tiefsee Untersuchungen. - Ber. Comm. Erforsch. östl. Mittelmeeres **1**: 1-16.

RIEDL, R., 1964: 100 Jahre Litoralgliederung seit Josef LORENZ, neue und vergessene Gesichtspunkte. - Int. Rev. Gesamten Hydrobiol. **49**: 281-305.

ROLL, H. U., 1976: Meeresforschung: Aufgabe und Entwicklung. - Schiff und Zeit **4**: 1-11.

ROSS, D. A., 1982: Introduction to Oceanography, 3rd ed. - Englewood Cliffs, N.J.: Prentice Hall.

SCHEFBECK, G., 1991: Die österreichisch ungarischen Tiefsee Expeditionen 1890-1898. - Graz: Weishaupt.

SCHEFBECK, G., 1994: Österreichs Beitrag zur Meeresforschung. Von den Anfängen bis zur Mitte des 20. Jahrhunderts. Ausstellungskatalog. - Wien: "PRO MARE"

STURANY, R., 1896: Zoologische Ergebnisse VII. Mo Musken I (Prosobranchier und Opisthobranchier; Scaphopoden; Lamellibranchier), gesammelt von S.M. Schiff "Pola" 1890-1894. - Ber. Comm. Tiefsee-Fosch. **XVIII**: 1-36.

WÜST, G., 1964: The Major Deep Sea Expeditions and Research Vessels 1873-1960. A Contribution to the History of Oceanography. - Prog. Oceanogr. **2**: 1-52.

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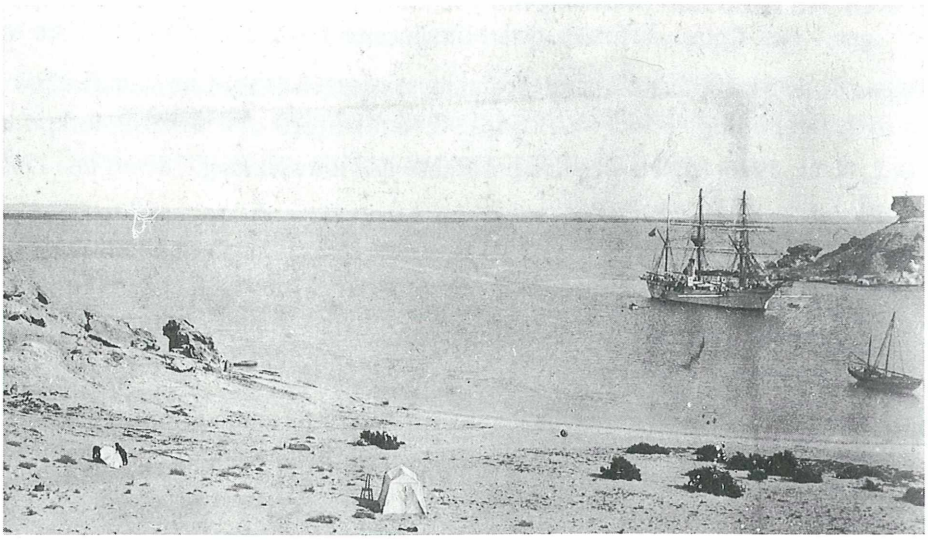
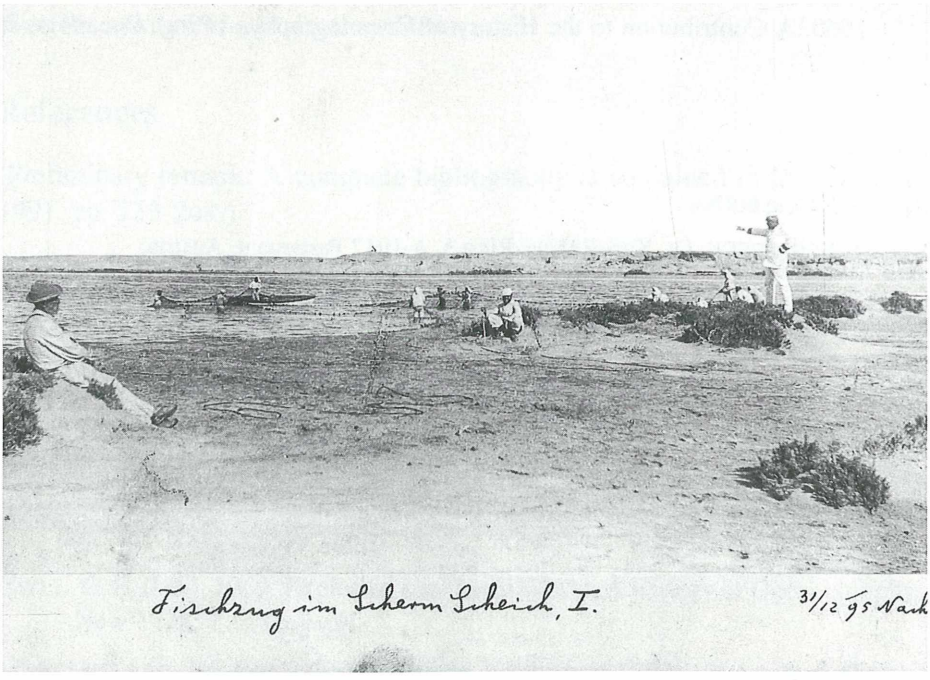
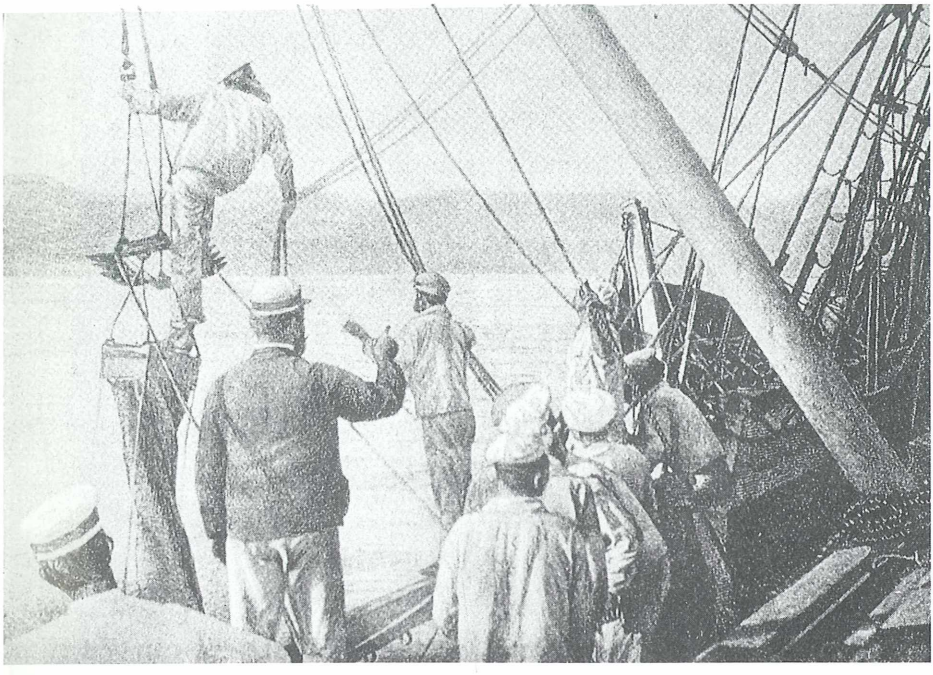
Appendix



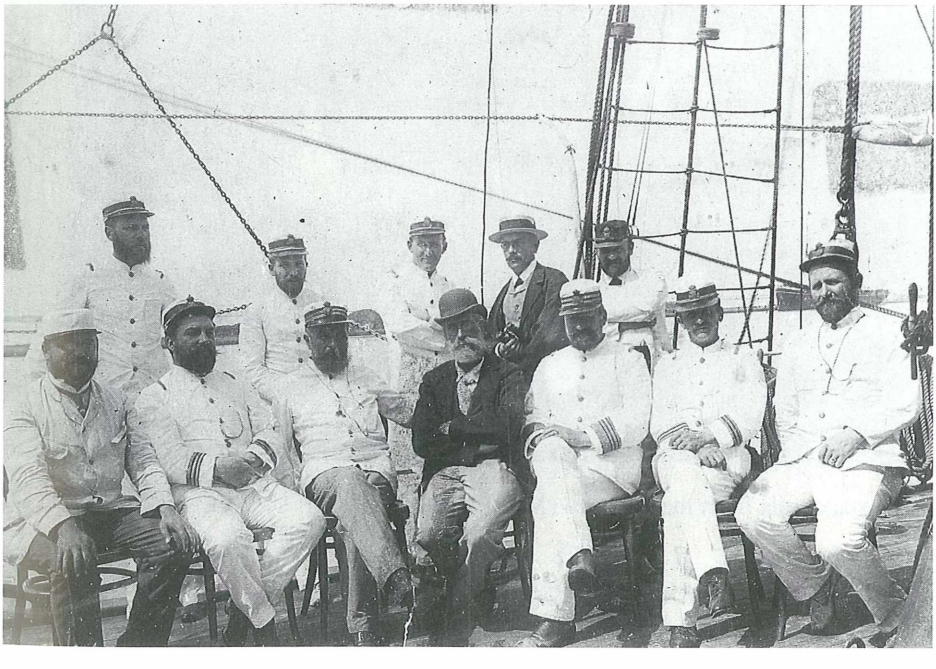
The observation station on Noman Island, Red Sea



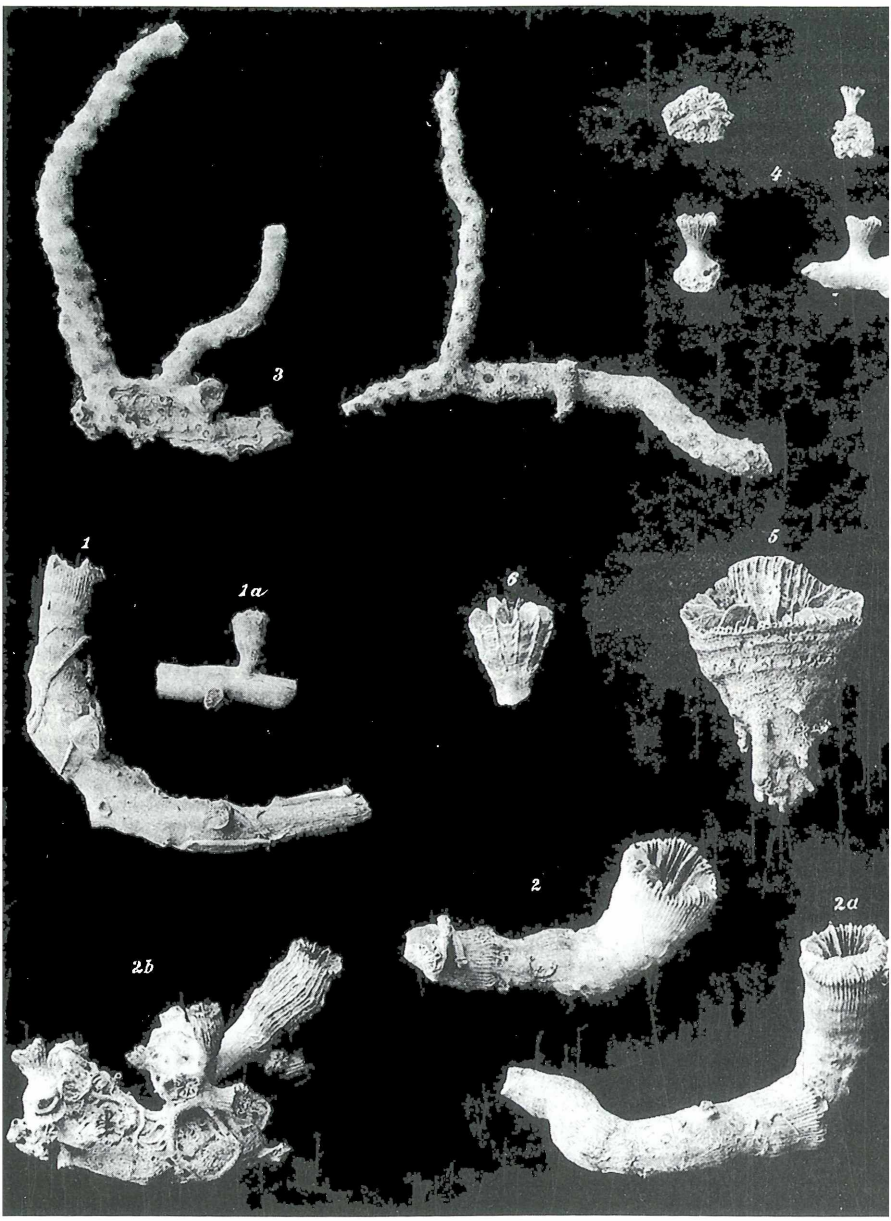
Hauling in the nets at Scherm Scheich, Red Sea (December 31, 1895)



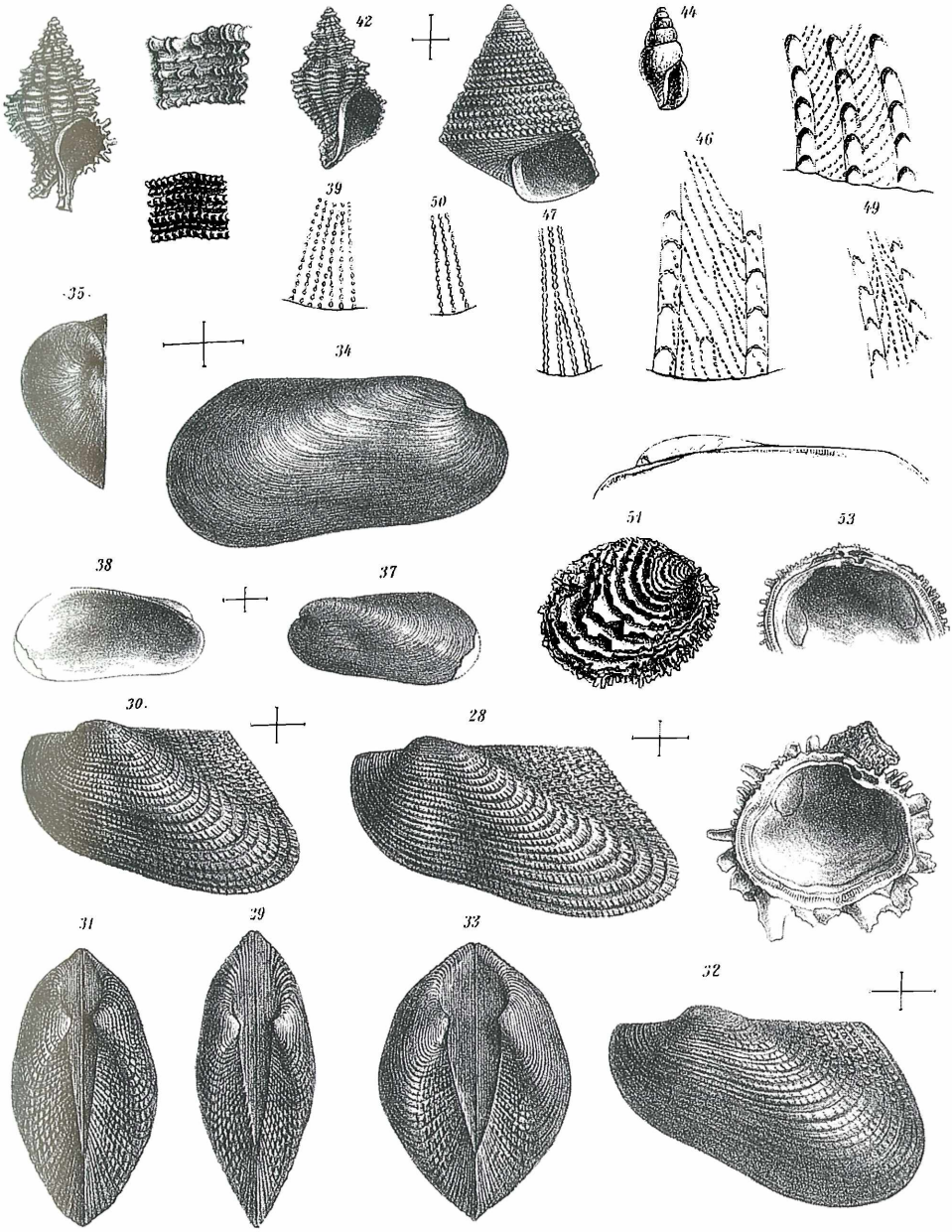
Deep-sea work aboard the "Pola". Hauling in the Harken dredge



Members of the scientific staff and the ship's officers during the first expedition to the Red Sea in 1895/96



Deep-sea corals from the Red Sea (MARENZELLER.1907)



Mediterranean molluscs (STURANY 1896)