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Pioneers of Plankton Research: Carl Chun (1852-1914)

Carl Chun (Fig. 1) may not be a familiar name to you. However, he was a very important figure in the development of our knowledge concerning the distributions of planktonic organisms. In his time, Carl Chun was very well known. He was given credit for establishing the existence of deep-sea plankton, describing dozens of deep-sea species, as well as discovering the phenomenon of seasonal vertical migration into deep waters (e.g., Haeckel 1893). While Chun is today recognized as a pioneer investigator of seasonal vertical migration (Bandara et al. 2021), his role in establishing the existence of deep sea plankton is rarely noted. In part this is likely due to the fact that Chun was an early investigator. His career corresponded with the era of the great campaigns of exploration in oceanography, the times of the *Challenger Expedition* and the *Plankton Expedition*. Chun himself organized one of the last major oceanographic expeditions of exploration, the *German Deep-Sea Expedition of 1898-1899*, but he did not live long enough to see the results fully exploited, as he died at age 62 in 1914, a few months before the outbreak of World War One. Here an introduction is provided to the interesting life and the major contributions of Carl Chun, especially with regard to plankton research in the deep sea. No detailed biography of Chun exists. The following account of the life and career of Carl Chun was pieced together from a variety of sources: Braem (1914), Braun (1914) Calman (1914), Mertens (1957), Vogt (1896), and Winter (1914).



Fig. 1. Carl Chun at about age 30.

Carl Chun was born in 1852 into an academic family; his father was the principal of a high school, a '*Gymnasium*'. After graduating from the '*Gymnasium*', Chun enrolled in the doctoral program of the University of Leipzig, under the supervision of Rudolf Leuckart, an invertebrate biologist of renown. Leuckart had first been a Professor at the University of Giessen replacing Carl Vogt, also an invertebrate biologist, and a political activist. In a self-imposed political exile, Vogt left Germany for Geneva in 1850 and would later appear in Chun's life. Leuckart left Giessen when he was named Professor in Leipzig in 1869, just a few years before Chun enrolled. Leuckart had many Ph.D. students. Chun was his 13th Ph.D. student but one of his favorites, and Leuckart would eventually ask that Chun replace him when he retired. In 1875, at age 23, Chun defended his doctoral dissertation on insect anatomy, published first as a booklet (Chun 1875) then as a journal article (Chun 1876). These were his first publications, and would be only ones on insects as he soon turned to marine invertebrates, which would be the focus of his entire career.

In 1877, Chun spent several months in Naples, at Anton Dohrn's *Zoologischen Station Neapel*, a very popular destination for biologists at the time (see Dolan 2023). In Naples, he devoted himself to the study of ctenophores, organisms typical of the delicate gelatinous zooplankters easily destroyed in plankton nets. Chun's first publication on marine plankton was his "Habilitation Dissertation". The "*Habilitation*" was a terminal diploma allowing immediate academic appointment as '*Privatdocent*', who was paid for giving lessons, but more importantly, it was a qualification to be appointed eventually as a university faculty member (Goldschmidt 1956). Chun's Habilitation Dissertation was on the anatomy of ctenophores, and like his Ph.D. dissertation, it was published first as a booklet (Chun 1878) and then as an article (Chun 1879). Chun's first monographic study, also on ctenophores, followed soon after. Entitled "*Die Ctenophoren des Golfes von Neapel*", it was a very large work composed of 313 pages of text and 18 plates (Chun 1880). It was volume one of the famous series, the *Flora und Fauna des Golfes von Neapel*. Chun next turned his attention to another group of plankters, the siphonophores. He worked out the exceedingly complicated life cycles of siphonophores (e.g., Fig. 2 from Chun 1882). Today Chun is recognized as one of the early experts who elucidated the anatomy and development of siphonophores (e.g., Mackaie et al. 1987). Recognized as an expert on gelatinous zooplankton, Chun would later author the Plankton Expedition reports on both the siphonophores (Chun 1897) and the ctenophores (Chun 1898).

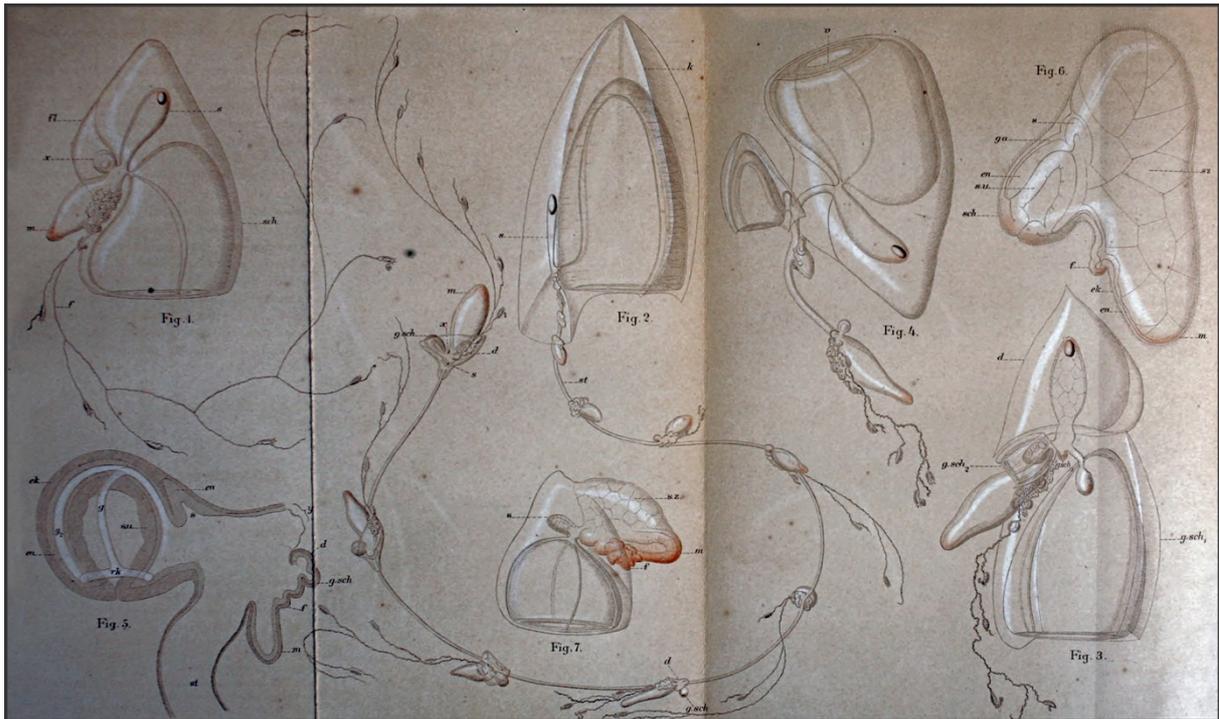


Fig 2. The plate from Chun's 1882 study of the development of siphonophores showing different life-history stages of *Monophyes* (now known as *Sphaeronectes*), *Muggiaea*, and *Eudoxia* (now known as *Muggiaea*).

Chun returned to Naples in 1882 and there met Carl Vogt and his daughter Lilli. Vogt was a friend of Anton Dohrn, and a frequent visitor to the Zoologischen Station. Vogt was actually a precursor of Chun whose work was no doubt well known to Chun. Many years earlier, while in his 30's, Vogt had authored landmark monographs on gelatinous zooplankton of the Mediterranean (Vogt 1854a,b). When Chun met him, Vogt was Professor of Zoology and Geology of the University of Geneva. Chun himself would soon have an academic position that would allow him to marry. He was offered a professorship in Königsberg in 1883. Shortly thereafter, in 1884, Carl Chun and Lilli Vogt married. They soon had two daughters, Anny born in 1885, and Lily born in 1887, both married scientists. Lilly Chun, as Lilly Pringsheim, had a remarkable career as a politician and writer.

In early summer of 1886, according to Chun's own account (Chun 1887), he received, from an Italian naval officer of the vessel *Vetor Pisani*, a specimen of a siphonophore found on a line from 1000 m depth. The finding of plankton in deep water was of considerable significance. At the time, it was well established that benthos of the deep sea was inhabited by a large diversity of organisms from results of the sampling in the North Atlantic during cruises of the *Porcupine* and *Lightning*, the global explorations of the *Challenger Expedition* and the voyages of the *Travailleur* and *Talisman* (see Dolan 2020). However, little was known about life deep in the water column. In the opinion of Alexander Agassiz, who had sampled in both the Pacific and Atlantic Oceans, there was little or no life between the surface layer of the oceans and the benthos (Mills 1980, 1983). Thus, the sample Chun received prompted another visit to Naples specifically to

sample deep waters with a closing net he had constructed by Peterson, the engineer of the Zoologischen Station. Chun, accompanied by Peterson, used the net to sample deep water near Naples and the Island of Capri from August to October in 1886.

Chun's report of the results of his deep water sampling with the now so-called 'Peterson Closing Net' was soon published (Chun 1887) and showed unequivocally that deep waters of the Mediterranean Sea were inhabited by a large variety of zooplankters, including gelatinous forms (fig. 3), crustaceans, pteropods, and radiolarians, many of which were rarely found in surface waters. Chun dedicated his report to Carl Vogt, his now father-in-law, in honor of Vogt's 40th year as a Professor.

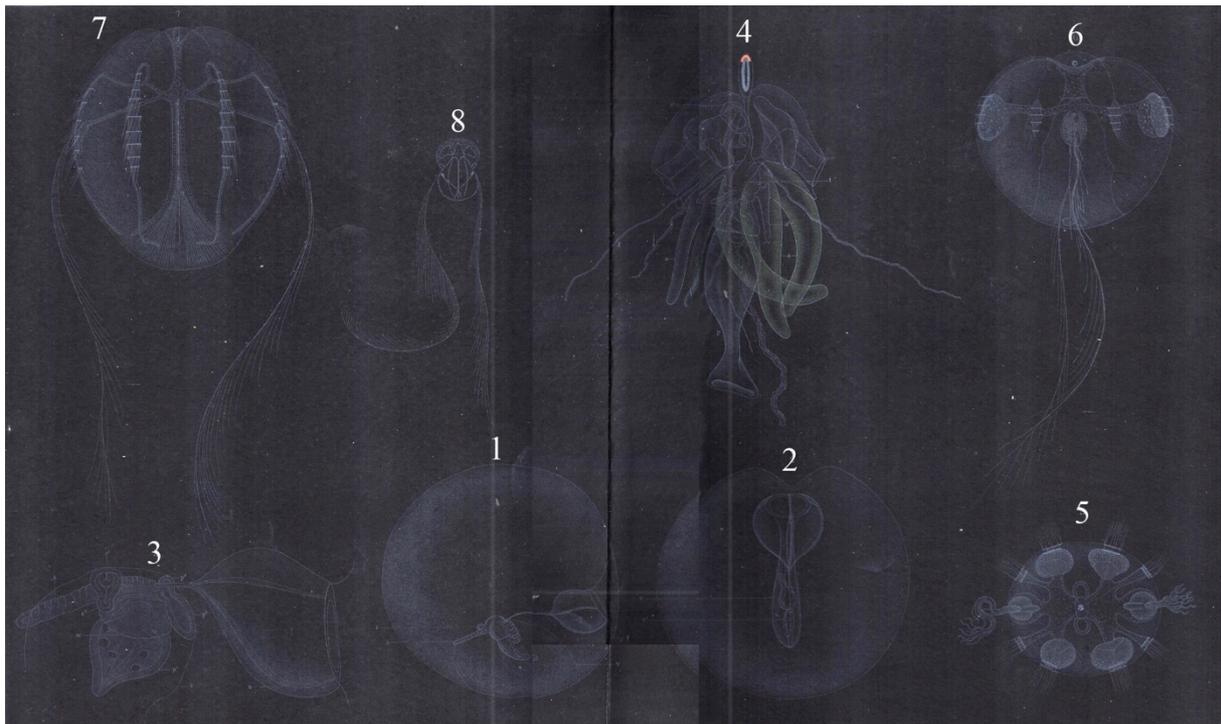


Fig. 3. Plate 2 from Chun 1887 (white numbers added) showing gelatinous zooplankters found in deep water samples of the Mediterranean Sea. In the plate: figures 1-3 are larvae of the siphonophore *Hippopodius luteus* (now known as *H. hippopus*) from a sample taken at 1200 m; figure 4 is a larva of the siphonophore *Physophora hydrostatica* from a sample taken at 800 m; figures 5-8 are larvae and young specimens of the ctenophore *Bolina hydatina* (now known as *B. vitrea*).

Chun's report appeared in the first issue of a new zoological journal edited by Leuckart and Chun, *Bibliotheca Zoologica*. It would come to be known as "perhaps the most lavishly illustrated of all zoological periodicals" (Calman 1914). However, in one of the first reviews of the new journal, Alexander Agassiz pointedly criticized Chun's report stating that Chun's results did little to prove the general existence of deep-sea plankton. Agassiz argued that Chun's sampled only near-shore deep waters that are subject to terrestrial inputs, and also that the deep waters of the Mediterranean Sea were unusual, a relatively warm 13° C, compared to the much cooler deep waters of the Pacific or Atlantic Oceans (Agassiz 1888).

The critique of Agassiz was taken seriously by Chun and likely motivated Chun's next major field studies of deep water plankton in the North Atlantic, near the Canary Islands, far from continental input (Mills 1980; Thiel & Türkay 2002). Chun requested, and received funding from the Academy of Sciences to travel to the Canary Islands. He set out with the closing nets and 1,600 m of thick rope, and sampled on his voyage to the Canaries, and from the Canaries, as well as using chartered boats. Chun's findings with regard to deep sea fauna were published in the second of two papers he published on the results of his Canary Island travels. The first was the systematics and anatomy of siphonophores (Chun 1888a) and it was also translated and published in English (Chun 1889a). The second Canary Island travel report (Chun 1889b) was subtitled: "Observations on the deep and surface pelagic fauna of the eastern Atlantic Ocean".

Chun reported that in the waters near the Canaries, like in the Mediterranean Sea, deep waters harbored taxa, some found also in surface waters while others appeared to be largely restricted to deep waters. Chun lamented the fact that he was able only sample deep waters a few times and urged that a dedicated expedition be organized. He admitted that his findings may not be generalized to all the seas but proposed nonetheless some conclusions. Chun's first declaration was that the closing net showed that some organisms previously known only from surface water sampling can be found at depths ranging from 500 to 1000 m in the North Atlantic where deep waters are considerably cooler than in the Mediterranean Sea. Furthermore, he found what he called new taxa in deep water samples (Fig. 4), some free-living and some parasitic, that are apparently absent in surface waters.

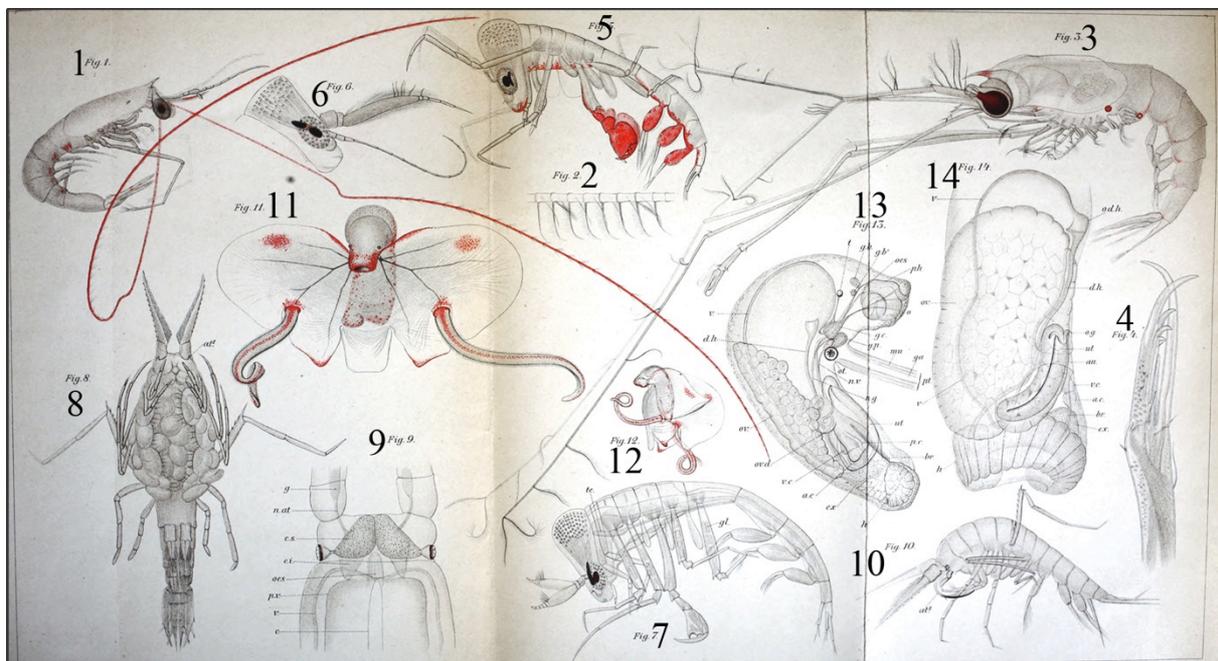


Fig. 4. The plate from Chun 1889b (black numbers added) showing taxa found in deep and surface water sampling near the Canary Islands in the North Atlantic. Shown in the plate are deep sea shrimp *Sergestes* (1 & 2); Euphausiids of the genus *Stylocheiron* (3 & 4); the deep sea amphipods *Phronima* (5-7) and *Fortunata lepisma*, now known to be *Scina marginata* a parasite of siphonophores (8-10); and a new pteropod species, *Desmopteras papilo* found in the surface water samples (11-14).

More data and observations from Chun's Canary Island sampling appeared a few years later, in two sets of papers. The first was a pair of articles on siphonophores (Chun 1890-1891, 1892-1895). Chun then published a set of articles in a special issue of *Bibliotheca Zoologica* entitled "Atlantis: Biological Studies of Pelagic Organisms", dedicated to the 50th anniversary of Leuckart's PhD. It included an article on 'deep sea pelagic shrimp' (Chun 1896a) and one on 'light organs and eyes: a contribution to the theory of life in the great depths of the sea' (Chun 1896b). The Canary Islands studies, as a whole set the stage nicely for Chun's formal proposition to organize an oceanographic expedition specifically designed to carry out investigations of the deep sea, both the water column and the benthos.

Chun formally proposed a new expedition devoted to investigating the deep sea in an address before the prestigious scientific society *Gesellschaft Deutscher Naturforscher und Ärzte* in 1897. He outlined an expedition to sample the deep sea in regions thus far largely unexplored, focusing on both benthic and pelagic fauna of the deep sea, and asked the society to support his petition to the Kaiser requesting financial support (Thiel & Türkay 2002). Showing the flag of the Kaiser using a navy vessel would have been a good selling point. However, Chun specifically requested a commercial ship, which while slower than a military ship, would have relatively more space available for laboratories and storage than a naval ship. Chun received a positive response. His plan was to sample areas not charted during the *Challenger Expedition*. Sampling would include the far north Atlantic, then the coastal waters off West Africa, continue into the Southern Ocean, then north into the South Pacific, up into the Indian Ocean and finally to return via the Red Sea and the Mediterranean Sea. Supported by the Berlin society, Chun was granted funding by the Kaiser. In addition to the government funding, the expedition received support in the form of loans of equipment from various institutions. The commercial shipping company, the Hamburg-America Line put the passenger and freight steamer, the *Valdivia* and an experienced crew, at Chun's disposal. The *Valdivia* was a substantial, 94 m steamer, about the same size as the *Challenger* with a crew of 35. Alterations made included installing laboratory areas, a darkroom, and a library stocked with reports from the *Challenger Expedition* and many later expeditions.

Chun assembled a scientific staff of 10 men (Fig. 5) and most, like Chun himself, were zoologists. One was a former student of Leuckart's, (like Chun) Otto zur Strassen. Two were Chun's former students, Fritz Braem and Ernst Vanhöffen. The other two zoologists were Carl Apstein, who like Chun, had worked on the Plankton Expedition Reports, and August Brauer was an ichthyologist. There was also a botanist, Wilhelm Schimper, a chemist Paul Schmidt, and a physical oceanographer, Gerhard Schott, and a physician and bacteriologist, Martin Bachman. Notably, the staff included Friedrich Winter, responsible for illustrations and photography. He was the son of Wilhelm Winter, the co-owner of the lithography firm of Winter and Werner, the premier lithographers of their time (Goldschmidt 1956), and the director of the Senckenberg Museum (Brand et al. 2017). Friedrich Winter would be the lithographer of many of the stunning plates in the *Valdivia Reports* (e.g., the deep sea fish in Brauer 1906).

The *Valdivia* left Hamburg, Germany on July 31st, 1899. The voyage lasted the planned nine months with the return of the *Valdivia* to Hamburg in May 1900. The progress of the *Valdivia* was reported upon in the international press (e.g. Anon. 1898a,b). Some of the early findings that Chun described in letters he sent to John Murray of the Challenger Office were reported upon as well (Anon 1898b,c, 1899a,b). The reports of the early observations included their findings of diverse forms in deep waters of the North Atlantic and it was specifically noted that this contradicted Agassiz's view on the absence of deep water pelagic life (Anon. 1898b,c). Meanwhile, Agassiz appeared to stubbornly maintain his view on the absence of deep water pelagic life (Anon. 1899c).

Some results were formally presented soon after the return of the *Valdivia*. Three articles, general results, oceanography, and a navigation report were published in 1899 (Chun 1899; Schott 1899; Sache 1899). An oceanography report was also presented at the September 1899 meeting of the British Association for the Advancement of Science (Schott 1900). However, the actual *Valdivia* reports, doubtless Chun's most important legacy, did not begin to appear until 1902. Much like the Challenger Reports, on which they were modeled (Mills 1983), they were by a large number of authors, each an expert in a particular area or taxa, and published over a long number of years, from 1902 to 1940. The reports comprise 98 titles and total over 12,000 pages of texts and 1000 plates. The *Valdivia* reports are formally known as *Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition auf dem Dampfer "Valdivia" 1898-1899*. They were edited first by Chun until his death in 1914 (apparently of a stroke), and then by the *Valdivia* zoologists Brauer and Vanhöffen until their deaths, then edited by yet another *Valdivia* zoologist, Carl Apstein. Chun's own contribution was on the cephalopods (Chun 1910-1914), and it was later recognized to be of such value that a complete English translation was published in 1975 (Chun 1975). With regard to the question of the existence of deep water plankton, the report of Valentin Haecker on the Radiolaria was of considerable significance. He found different species found in different depth strata in an early report (Haecker 1904) and in his *Valdivia* volume report, Haecker proposed a detailed vertical distribution scheme based on the distinct vertical distributions of different phaeodarian taxa (Haecker 1908). The existence of deep sea taxa of phaeodarians is today well-established (e.g., Nakamura and Suzuki 2015).

Chun also practiced what we today call "outreach". The covers of his two books aimed at general audiences are shown in Figure 6. The first book was on microscopy. It was part of a series, "Weber's Illustrated Catechisms", and was a general introduction to microscopes and microscopy, and did, of course, feature some plankton (Chun 1885). The second book was a large volume on the *Valdivia* Expedition "*Aus den Tiefen des Weltmeeres*" (From the Depths of the Ocean). The first edition appeared in 1900, and was very well received with special praise given for the illustrations (e.g., L.A.B. 1902). In recent years, it has been cited as providing the proof against Agassiz's claim of the absence of deep pelagic life forms (Etter and Hess 2015). The book was quite popular. A second edition, with additional illustrations was published in 1903 (Chun 1903) and in 1911 an abridged version was published (Chun and Gansberg 1911). It is no exaggeration to state Chun's book compares favorably with the very similarly titled English books, one that preceded it, "*The Depths of the Sea*" (Thomson 1873), and one that followed it "*The Depths of the Ocean*" (Murray and Hjort 1912).



Fig. 6. The covers of Chun's two books aimed at a general audience: an introduction to microscopy (Chun 1895) and the second edition of his account of the *Valdivia* expedition (Chun 1903), *Aus Den Tiefen des Weltmeeres* (From the Depths of the Ocean).

Shown here is that Carl Chun well deserves to be among the pioneers of plankton research. Chun was the first to shine a light on deep sea plankton. The deep sea remains today a largely unexplored realm. For example, our knowledge of the gelatinous zooplankton of the deep, Chun's specialty, continues to grow with new forms revealed through submersibles, both manned and remotely operated (Tyler 2007). Notably, while our knowledge of deep sea pelagic life is still far from complete, the realm itself is today under dual threats. Deep sea mining could have catastrophic effects on deep water ecosystems (e.g., Drazen et al. 2020) as could the commercial exploitation of mesopelagic fish (e.g., Standal and Grimaldo 2021). A precautionary approach has been urged due to our overall poor knowledge of the mesopelagic (Bisson et al. 2023). We can only hope that international action may soon come into play to prevent, or at least mitigate damage to, the largest biome of the planet, first brought to our attention by Carl Chun.

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