

Obituary

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A life for science and seaweeds: Klaus-Otto Lüning (1941–2023)

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On 22nd November 2023, Klaus-Otto Lüning passed away and with him a restless and inspiring person of seaweed research. Klaus was a free spirit and enthusiastic algae researcher with boundless energy and a good sense of humour, who never bowed to convention, refused to be forced into any system, motivated many students and colleagues and gave inspiring lectures. When Klaus entered the room, it was quickly filled with a special intensity that was impossible to escape. He managed to captivate the ignorant and those new to algae and convince them of the beauty of these 'plants', but also of their scientific importance (Figure 1).

He was born on 14/3/1941 in the middle of World War II in Kaliningrad and, like many of his generation, was greatly affected by the war. While his father was reported missing from 1941, the mother escaped together with Klaus and his elder brother on a horse-drawn carriage. After a lot of hardship, they finally arrived in western Germany. The family found accommodation in a small northern German village on a farm where Klaus and his brother spent a happy childhood. In 1950, the family moved to a bigger city in the middle of Germany (Kassel) where his mother found work as a teacher to nourish the family on her own. Here Klaus attended a Gymnasium (secondary school) and received his baccalaureate in 1960. He was deferred from military service upon application for 5 years and afterwards he was forgotten. This was good for science! As a child, he had always done microscopy and 'Biology' was his passion. Therefore, 'Biology' was the only study program that came into question. He started his studies in 1960 at the University of Freiburg, and continued in northern Germany in Hamburg between 1961

and 1964. His last university station was Kiel, situated on the Baltic Sea, where he came into contact with Marine Biology. The well-known marine ecologist Fritz Gessner became Klaus's mentor and supervisor for his PhD thesis, which Klaus completed in January 1968 [title of thesis (translated): *Vertical distribution and phenology of the Laminaria vegetation off the island of Helgoland*]. Very unusually for those times, his single parent mother financed his studies and, even more unusually, his wife Heide financed his PhD thesis as she was already earning as a young teacher. Klaus and Heide had met many years before in Kassel, studied together in Hamburg and married in 1965. This modern and unusual relationship ran through the whole of Klaus's life. Later, when the two sons (1970/1972) and one daughter (1985) were born, Klaus and Heide always shared the educational and care work, so that both spouses could pursue their own professional careers. This is especially noteworthy as it was in times when there was no regular day-care available in Germany, when females were not supposed to follow their professions and when males were not supposed to take leave for paternal duties. Thus, Klaus together with his wife Heide behaved as unconventionally in their private life as in their professional life.

In April 1965, Klaus moved to the rocky island Helgoland situated in the southern North Sea, 60 km off the mainland, for his PhD, soon followed by his wife who got a teaching position on the island. Klaus worked at the renowned German field station 'Biologische Anstalt Helgoland' (BAH). This institute had a long-lasting tradition in marine and seaweed science and hosted the world-known phycologists Paul Kuckuck and Hans-Peter Kornmann. As both had focused on the taxonomy and life cycles of seaweeds, there was not much known about their ecology and eco-physiology, and especially not in the sublittoral. Klaus stepped into this research gap by using the emerging SCUBA diving technique for the first time at the station. When he first jumped into the water, the whole station gathered to watch! His approach was always forwards, sometimes a little rushed and sometimes banging his head against the wall, but never discouraged and always optimistic and keeping his goal in mind. With SCUBA diving he investigated the sublittoral seaweed association surrounding the island for the first time, its

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Figure 1: Klaus Lüning in different phases of his professional and private career. (A) Klaus and his wife Heide together with Matthew (Matt) Dring near the Giant's Causeway, Northern Ireland, in 2017 (photo: © Maïke Dring); (B) Klaus shows the splendour of his cultivated *Palmaria palmata* in his greenhouse on Sylt (photo: © Petra Kadel, AWI); (C) Klaus holding up a *Saccharina latissima* in his hand on the land-based farm of Leiv Mortensen in Lysefjord, Norway, 2012 (photo: © Klaus Lüning/Heide Lüning); (D) Klaus and Shaojun Pang use every spare minute for science. Here, they were calculating the yield of tank cultivation before the food is served in a restaurant (photo: © Klaus Lüning/Heide Lüning); (E) Klaus and PhD student Anja Schanz at the current flume in List/Sylt (photo: © Birgit Hüssel, AWI). All authors of the photos as well as the persons shown on the photos (Anja Schanz, Matt Dring, Heide Lüning, Shaojun Pang) have given permission to have the photos reproduced in *Botanica Marina*.

species diversity, depth limits and biomass, and thereby set a general base line which assisted later comparative studies. For his post-doc phase starting in 1968, Klaus stayed at the BAH, funded via the German Research Foundation, but received a permanent position in 1974, when Hans-Peter Kornmann retired.

From his PhD onwards, he had fallen in love with kelps and over his career generated a series of influential papers on kelp biology. Together with Matt Dring with whom he collaborated over many years on a series of topics, he studied the physiological details of the 'blue light' effect which had first been reported by Hsiao and Druehl in 1971. The fact that female gametophytes become fertile under 'blue light' and stay vegetative under 'red light' was a major break-through in kelp research as it enabled clonal kelp gametophyte cultures to be kept vegetative over decades in biobanks and also empowered kelp aquaculture. Many kelp hatcheries keep their gametophytes under red light to increase gametophyte biomass for seeding.

Between October 1976 and March 1977, the young family spent a busy and adventurous half year in Santa Barbara, California, where Klaus was a guest researcher in Mike

Neushul's laboratory, another gifted kelp researcher, before heading back to the small North Sea Island. In the same year, Klaus became a scientific director of the institute. This was also the time when Klaus worked on his *Habilitation* [translated title: *Investigations into the light and depth related development of gametophytes and sporophytes of Laminaria digitata, Laminaria saccharina and Laminaria hyperborea (Phaeophyceae)*]. A *Habilitation* is a special advanced thesis that was a prerequisite in Germany to become a university professor. In October 1978, he received the 'Venia legendi' of the University of Hamburg, but he was awarded the academic title 'Professor' only in 1989. Together with his Hamburg colleague, Ludwig Kies, Klaus led an annual 2-week spring excursion to the island of Helgoland and convinced many students (including one of the authors) that seaweeds are an especially interesting subject and beautiful at the same time.

Klaus, the facilities at the BAH on Helgoland, and the surrounding seaweed forest always attracted other researchers and he established many long-lasting relationships with national and international researchers covering a wide array of interests. He worked with Tony Chapman, Jim

Markham, and John Bolton on kelp growth, kelp temperature tolerance and kelp hybridization potential. With his German colleagues Klaus Schmitz and Johannes Willenbrink he showed that assimilated carbon is translocated through kelp blades from the distal end to the meristem. Another break-through in kelp research was the observation of the sexual attraction that kelp eggs exerted on sperm, which he published together with his German colleague Dieter Müller, and led to the detection of the pheromone lamoxiren – this was only made possible through cooperation with the BAH chemist Günther Gassmann who invented a special extraction procedure for this volatile substance. As with the blue light effect, this knowledge is still used in research and kelp hatcheries worldwide.

In 1981, the family left the island of Helgoland and moved to a suburb of Hamburg, so that the two sons could attend secondary school, which was not available on Helgoland. The establishment of a new ‘central’ building of the BAH in Hamburg facilitated this step. Although laboratories and seawater supply were available, the landlocked institute was not the same as a field station. Thus, Klaus’s book project on the biogeography of seaweeds came just at the right time. During his first years in Hamburg, he mostly worked on the book *Meeresbotanik*, which appeared in 1985. Five years later in 1990 the English version appeared (*Seaweeds. Their environment, biogeography and ecophysiology*), translated with the help of international colleagues, Charles Yarish (United States) and Hugh Kirkman (Australia). This book, for the first time, described the seaweed communities present over all biogeographical zones from polar regions to the tropics and became a ‘seaweed bible’ for many years for university teachers and students. During the late 1970s and 1980s, seaweed biogeography was a hot topic and many researchers, including Klaus, started to investigate the thermal requirements of seaweeds for growth, reproduction and survival to explain their biogeographical distribution limits – the concept developed by C. van den Hoek that in principle is still valid.

In Hamburg Klaus developed new research initiatives, adapted to the logistics available at the new building. He established a recirculating tank system, which he had developed on Helgoland years before and thereby was able to cultivate his favourite research organism, kelps, for extended periods onshore under different combinations of temperature and photoperiod. This led to the detection of the free-running circannual growth rhythms in kelp species, for the first time in seaweeds, and of short-day sorus induction in the kelp *Saccharina latissima*. In Hamburg he also developed an automatic photographic system to monitor the day-night kinetics of growth in seaweeds. This stimulated a long-lasting collaboration with diverse researchers, especially Elena

Schoschina and Vladimir Makarov from Murmansk and Eduard and Tamara Titlyanova from Vladivostok who worked out the details of the circadian rhythmicity of growth and mitosis in a series of seaweeds. As it was becoming clear that the hormone ‘melatonin’ governs the circadian rhythmicity in many organisms, including unicellular algae, Klaus expanded his research to detect this substance in seaweeds. His PhD student Carsten Pape unequivocally identified melatonin in several seaweed species but its physiological function as a *Zeitgeber* for ‘darkness’ remained unclear as there were no diurnal changes in melatonin content.

During his time in Hamburg, Klaus also became a regular supervisor of diploma, PhD and post-doc students, including all three of the current authors. Many who had worked in his laboratory achieved permanent algal research positions, ranging from Germany, through Greece to Australia, South Africa, China and the USA.

As Klaus had so much energy, he kept his Helgoland laboratory running in parallel during his time in Hamburg. This was only possible through the committed supervision of his island technicians. During that time, a series of visiting scientists worked on Helgoland and Klaus became an occasional guest in his own island labs. Matt Dring, Rodney Foster, Linda Franklin, Bill Henley and Ralph Kuhlenskamp further collaborated on harmful UV-effects in seaweeds. A later project partner, Cornelia Buchholz, showed that sorus induction in kelps could be independent of the seasons if distal blade tissue was separated from the meristem, which led to the hypothesis that the growing meristem of kelps generates a ‘sorus inhibiting substance’. This technique was of great relevance for kelp farmers and subsequent kelp researchers, although the biochemical background has yet to be elucidated. During that time, Klaus also initiated the first attempts to cultivate algae off Helgoland, braving the stormy seas by using huge ring systems – the forerunners of today’s Open Ocean Aquaculture.

In 1997 the Hamburg section of the BAH was closed and the two field stations of the BAH, Helgoland and Sylt, were integrated with the Alfred Wegener Institute. Klaus moved to Sylt although this island was not the same paradise for seaweeds as Helgoland, but the location and facilities had other advantages. Located at the shore, the station had running seawater and plenty of space for experimental setups, and some seaweed habitats, although poor in community structure, are nearby. However, the island provided a good infrastructure for his family. His wife could again pursue her profession as school director on the island – a wonderful and privileged situation for the couple. The logistics at the station offered a perfect playground to expand Klaus’s interests in mesocosm experiments and aquaculture

which had started in the 1990s. On Sylt, he established a first cooled flow-through outdoor seaweed tank system, which was equipped with an automatic cover to create different daylengths. This resulted in the detection that constant short days permitted continuous growth in kelps, even in summer when the growth of natural populations is reduced. These efforts culminated in a huge EU project (SEAPURA: 2001–2004) which Klaus coordinated during his last career phase. SEAPURA was an integrated multitrophic aquaculture project and explored the capacity of seaweeds to effectively reduce the harmful effluents from fish farms. Klaus had recognized that the hour had come for onshore cultivation of marine macroalgae as food and nutritional supplements, or for other usages.

In March 2006, Klaus retired but his ideas and research spirit were unbroken and his irrepressible desire for research and discovery led to the foundation of the Sylt algal farm ('Sylter Algenfarm') in 2007. He cultivated *Saccharina latissima* and *Palmaria palmata*, mostly for the food market. Although he encountered many difficulties, he never became discouraged and always tried to develop new ideas from failures. In the end, it was not a goldmine and the company closed in 2021 without a successor. Shortly before, in 2018, Heide and Klaus moved back to their home near Hamburg after 20 years of enjoying the lovely sandy island of Sylt, which is a magnet for tourists in Germany. However, even in Hamburg, at the age of 77, he established a small laboratory in his cellar where he worked on *Ulva*. This led to his final publication *On long-term cultivation of Ulva in artificial seawater without water change*, which Klaus, unfortunately, did not see in print since it was published shortly after his death.

This last period between 2018 and 2023 was overshadowed by the onset of cancer. Klaus and the physicians fought against it, very much supported by his wife and family, and he never lost his optimism even during this difficult period. Sadly, he lost this combat and passed away peacefully in his home in November 2023.

Klaus was and remained a pioneer in many areas. Although some of the pioneering work failed, it helped to advance macroalgal research. Klaus was often well ahead of his time with his visions. However, it is important to mention that he did not work in a one-dimensional space but was supported by many. In particular, he could not have achieved all his sometimes over-ambitious projects without the constant and loyal support of his technicians, on Helgoland (Maike Kaasche, Hans Reichenberger, Andreas Wagner) and later Petra Kadel, accompanying him for approx. 25 years in Hamburg and on Sylt. During his whole scientific life, he established often long-lasting research collaborations with international experts, which resulted in many co-authored

publications and merged the knowledge and activities of all experts involved. He always resisted being a co-author just because he had collected some material, or supported small aspects of a study, or commented on a manuscript, and he co-authored manuscripts only where he had actively contributed to the experiments. He even forbade his students to do this and, in many instances, did not co-author the PhD papers of his students. When looking back to Klaus's 103 scientific publications, it becomes evident that he had a broad interest. We have been able to cover only some of the topics above and provide a subjective choice of most influential publications in the bibliography (see References for 40 out of 103 publications of Klaus Lüning).

Like many others, the current authors have been 'caught' by Klaus and his charisma and his seemingly limitless energy and ideas. We have all both enjoyed and suffered from his impulsiveness during our PhD and post-doc times but, thereby, Klaus shaped our professional lives. His impressive motto was: "You have to find something new in science every five years – otherwise your scientific life is without legacy. Never just stick to one topic expanding it for ages and ages." He sometimes switched the topic of a thesis within one meeting. We were confronted with lots of ideas that were always better than those of the previous day and, quite often, plans initially carved in stone were changed. But nevertheless, he left most decisions up to us and gave us a free hand. At the same time, he was very hospitable and always ready to help his 'foreign' collaboration partners during their stay in Germany and his wife Heide was a special part of this. His openness, sincerity and determination for science had a great impact on us and many others. Klaus also made us realize how important it is to provide opportunities for the younger generation to grow. He never lost his interest in science and, during our irregular correspondence during his retirement phase, Klaus always came up with stimulating ideas. We have lost an amiable senior scientist and a life mentor. We consider ourselves lucky to have known him, to have learned from him, and to have walked an important part of our path with him. Let us keep his vivid smile and spirit fresh in our minds.

Inka, Bela and Shaojun in March 2024

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