

Master of the Oceans: Personal Memories

Walter H. Munk
(1917-2019)

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After an incredible life full of outstanding achievements, discoveries, and adventures, Walter Munk died on 8 February 2019 at age 101. In his early days, together with his mentor Harald Sverdrup, he saved thousands of soldiers' lives by forecasting the breaking waves for amphibious landings in World War II (Figure 1). Later on, he explained basic ocean circulation and developed new research fields that delivered new models for tides and waves and for geophysics in general. Starting in the 1970s, he demonstrated that sound in the ocean could be used to measure global ocean temperature changes and other ocean characteristics. Above everything, Walter Munk was a warm and charismatic personality who always encouraged scientific discussion. The story below summarizes my personal encounters with Walter, initiated by inviting him to the ESOMM-2014 ("Effects of Sound in the Ocean on Marine Mammals") conference in Amsterdam.

Inviting Walter to the ESOMM-2014 Conference

Early in 2014, the idea arose to invite Walter Munk to be the opening speaker for the ESOMM-2014 conference that would be held later that fall. Walter had been working on ocean acoustic tomography from the very beginning. It was actually his original idea, together with Carl Wunsch from MIT (Munk & Wunsch, 1979), to exploit underwater acoustics for climate and oceanography purposes. This idea eventually led to the famous Heard Island Feasibility Test in 1991 where signals from a sound source in the Southern Ocean were received on the other end of all oceans, up to 20,000 km away from the source (Munk & Baggeroer, 1994; Munk et al., 1994). For this experiment, the permitting process was a delicate procedure, as described by Von Storch &



Figure 1. Walter Munk and Harald Sverdrup around 1940 (Photo courtesy of Scripps Institution of Oceanography Archives, UC San Diego Libraries)

Hasselmann (2010), both on the U.S. side and also on the Australian side. There was also resistance from environmental groups, however, and a front page article in the *Los Angeles Times* with incorrect numbers (misinterpreting the decibel [dB] scale for underwater sound pressure level) was not helpful to this process. This article in the *LA Times* was later rectified (also on the front page), but resistance remained, much to Walter's frustration.

These first encounters with environmental groups and the required permitting procedures were a very interesting experience that Walter could share in his presentation at the start of the ESOMM-2014 meeting. His talk would put the discussions on the impact of underwater sound into a historical perspective. However, in early 2014 when we prepared the invitation, I wasn't really sure if Walter (aged 96 then) would still be available and willing to travel to Europe. At the same time, I was reluctant to approach Walter, realizing he was the biggest post-war oceanographer

still alive. Even so, I recalled that Walter could be very open to good science discussions. When I met him for the first time in Cambridge, UK, in 1995, where he was a guest lecturer at the summer school of Geophysical and Environmental Fluid Dynamics, Walter insisted on having at least one dinner date with all the students (including me), and he appreciated these informal discussions outside of the structured lectures. Furthermore, my PhD thesis on internal tides and waves (Lam, 2007) was also related to one of the many topics that Walter had been working on (later I learned this was actually the topic of his very first scientific publication, based on his MSc thesis [Munk, 1941]). Walter had provided encouraging feedback when I shared a copy of my thesis with him in 2007.

All this information together made me decide that I had to give it a shot. So, I invited Walter to come to Amsterdam to give the opening lecture for ESOMM-2014. I just had to make sure to use the right arguments to pique his interest! Fortunately, there were quite a few interesting interactions with our ongoing work and the conference to share and entice him.

The Incredible Career of Walter Munk

As mentioned earlier, when we were putting together our ESOMM-2014 invitation to Walter, he was considered the biggest post-war

oceanographer of all time who was still alive. A nice overview of his life is provided in the (auto) biography that is sketched in the reported week-end discussion of Walter with Von Storch & Hasselmann (2010). Walter got started at Scripps Institution of Oceanography as a student of then-director Harald Ulrik Sverdrup, the famous Norwegian oceanographer:

Harald was working on his epic The Oceans [Sverdrup et al., 1942]. He was a wonderful teacher; among other things he taught Walter how to write English (Harald was Norwegian). He and his wife, Gudrun, remained Walter's life-long friends. At the time, the total Scripps staff consisted of 15 employees, including the gardener. For several years Walter was the only Scripps student. (Von Storch & Hasselmann, 2010, caption of Figure 2.11, p. 19)

Sverdrup himself was a student of the well-known Vilhelm Bjerknes, also called the father of modern meteorology. Sverdrup worked as a scientist with the great explorers Roald Amundsen (sailing six years together in the Arctic on the vessel *Maud*) and Fridtjof Nansen. In the early years of World War II, Sverdrup and Munk developed a theory for surf waves (published after the war in Sverdrup & Munk, 1946a, 1946b, 1947), which enabled the allies to forecast conditions for amphibious landings. These forecasts were used



Figure 2. The Norwegian research vessel *H. U. Sverdrup II*. Picture taken during the 3S-2019-OPS sea trial to study the behavioral response of sperm whales to military sonar. (Photo courtesy of the 3S-project, Jackie Bort, U.S. Navy)

for the landings in Africa and the Pacific, and ultimately, for D-Day (6 June 1944) in Normandy, France, and prevented the sinking of many vulnerable landing craft.

Munk's connection with Harald Sverdrup was also nice in relation to our own work. Within the 3S-project, Sea Mammals and Sonar Safety (Lam et al., 2016), we have conducted many behavioral response experiments with the Norwegian research vessel *H. U. Sverdrup II* to study the response of whales to naval sonar (Figure 2).

Walter always clearly stated that Sverdrup was one of his three most influential mentors (together with Roger Revelle at Scripps and G. I. Taylor from Cambridge). After Sverdrup left Scripps and returned to Norway, Walter did a sabbatical in Oslo and published another famous paper on wind-driven ocean circulation. This is how I remembered from college that ocean circulation dynamics had been explained for the interior ocean by Sverdrup (1947), for the boundary currents (like the Gulf Stream along the North Atlantic) by Stommel (1948) and Munk (1950), and later added to with nonlinear effects by Fofonoff (1954).

Walter returned to Scripps and worked on several different major topics. In Von Storch & Hasselmann's (2010) foreword, Carl Wunsch explains how Walter could make a difference in new topics by publishing ground-breaking insights, then moving on to another topic while leaving the details to be sorted out by others ("flesh[ed] out" in the words of Wunsch, p. vi). Thus, Walter did set the scene for all those working in the fields of waves, tides, planetary (geo)physics, and later, also, in underwater sound (Von Storch & Hasselmann, 2010). For many years, Walter was director of the Institute of Geophysics and Planetary

Physics (IGPP), the institute he founded with the characteristic building that was co-designed by his wife Judy (an architect), who passed away in 2006 after 53 years of marriage.

During his lifetime, Walter received many prizes and awards such as the National Medal of Science (awarded by Ronald Reagan), the Kyoto Prize (awarded by the Japanese emperor), and the Crafoord Prize (awarded by the Swedish king), just to mention a few. For a long time and until his death, Walter held the secretary chair of the U.S. Navy. A new species of manta ray was also named after him—the *Mobula munkiana*. He was part of the inner circle of the Pope and the Dalai Lama, but—typical Walter—he was also proud of being assigned as an honorary member of the California surfing community. He was actually the person who discovered that the long breaking waves of California could originate as far away as the Indian Ocean, a pathway he later followed with the sound waves of the Heard Island experiment (Von Storch & Hasselmann, 2010).

Walter Munk at ESOMM-2014 in Amsterdam

Within a day of our invitation to Walter to come to Amsterdam to do the opening lecture of the ESOMM-2014 conference, his positive reply came back from La Jolla with the words, "Yes, we would certainly consider this." On Monday, 8 September 2014, following the opening remarks of Rear-Admiral Bauer of the Royal Netherlands Navy, Walter did his opening lecture, and the conference room at the Naval Barracks was whisper quiet for 40 minutes (Figure 3). The paper of this opening lecture was published in the previous



Figure 3. Walter Munk at ESOMM-2014 giving his opening lecture. The slide in the background shows the propagation paths of the Heard Island Experiment. (Photo on the left courtesy of René Dekeling and photo on the right courtesy of Wouter Coomans, StudioBiB)



Figure 4. Walter Munk (center) at ESOMM-2014 after his opening lecture, together with organizers Lam (second from right) and Commander Dekeling (far left), TNO director Geveke (far right), and Rear-Admiral Bauer (2nd from left; presently commander of The Netherlands armed forces in the rank of 4-Star Admiral)



Figure 5. Walter and Mary Munk together with the ESOMM-2014 organizers (*Top Row:* Marije Siemensma, Sacha van Zanen, Mathieu Colin, and Kristianne Dreteler; *Bottom Row:* CDR René Dekeling, Walter & Mary Munk, and Frans-Peter Lam; Photo courtesy of Wouter Coomans, StudioBiB.nl)

special ESOMM issue of *Aquatic Mammals* as the Historical Perspectives essay (Munk, 2015), which would be one of his last publications.

During the conference, and also the weekends before and after, there was ample opportunity to have personal encounters and interesting discussions with Walter and Mary (Walter and Mary married in 2011) (Figures 4 & 5). Later in the week, they also visited the Royal Netherlands Institute for Sea Research, where Walter met with students who gathered from different parts of the country for the occasion. His visit to Amsterdam was a big success. I received a lot of positive feedback, and some people even thanked me for having provided the opportunity to meet the famous Walter Munk in person. In fact, some people actually informed me they had not been aware that the Munk they knew from (sometimes pretty old) literature was still alive!

The Years After ESOMM-2014

In 2015, almost one year after the ESOMM meeting, I had the opportunity to visit Walter and Mary in La Jolla, California. I was instantly invited to stay at *Seiche*, their wonderful house overlooking Scripps Canyon, and I was further introduced to the lifestyle of Walter. In the daytime, we were not supposed to bother him too much because he had work to do. However, during lunch and dinner, there was plenty of time for discussions, and other people from the area were invited to join the company. I was also asked to bring over colleagues for dinner,

gathering during Happy Hour on the terrace overlooking the Pacific.

After this visit to La Jolla, there were several more occasions when I was invited to *Seiche*, and I experienced the same spirit each time. All of the opportunities I had to spend time with Walter and Mary were moments that I will never forget, including the visit to Paris in summer 2018 where Walter was knighted by the French government (Figure 6). I was inspired by the insights, the memories, the wisdom, and the joy of all the words of Walter. Meeting Walter Munk changed my (attitude to) life. He will be missed and so will be his insights. We should all take on his message of taking care of our planet and, in particular, our oceans.

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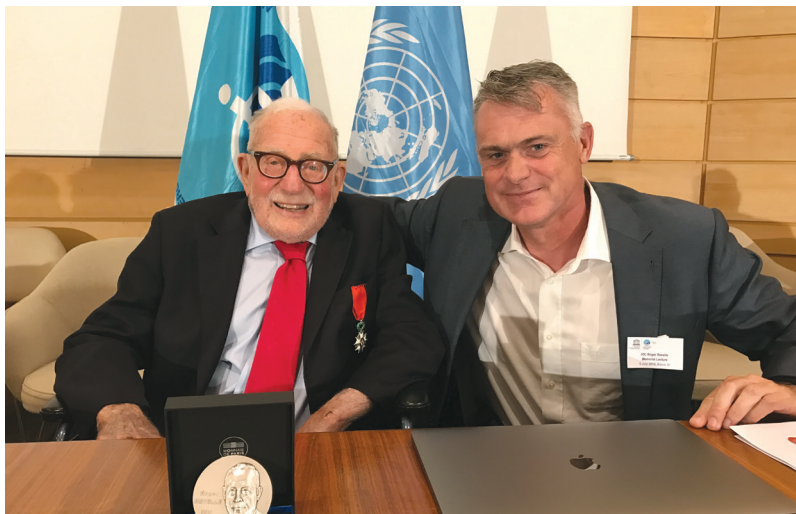


Figure 6. Walter and the author at the UNESCO building in Paris in July 2018 after the Roger Revelle memorial lecture, and two days after being awarded the Legion d'Honneur in the rank of Chevallier (knight).

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Further Reading and Viewing

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- The “Heard Island” chapter of the interview refers to the ESOMM-2014 visit to Amsterdam.
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