Walter Heinrich Munk Biography

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Scripps Institution of Oceanography Archives
31 August 2005

Walter H. Munk, June 1956

Walter Heinrich Munk was born in Vienna on 19 October 1917 into a cosmopolitan Austrian family. His father, Dr. Hans Munk, and his mother, Rega Brunner, were divorced when Munk was a boy. His maternal grandfather was a prominent banker. His stepfather, Dr. Rudolf Engelsberg, was briefly a member of the Austrian government of President Engelbert Dollfuss.

The Munk family spent holidays at the Egelgus in Altaussee, near Satzburg, where Munk learned tennis and skiing. In 1932 when Munk was fourteen, he was sent to a preparatory school in New York State. The family selected New York because they envisioned a career in finance for Munk in a New York bank with connections to the family business. Munk worked at the firm for three years, hated banking, and decided to go to the California Institute of Technology to study physics. He got a B.S. degree in physics there in 1939 and a master's degree the following year, studying under Beno Gutenberg. Robert Millikan was impressed both with Munk's intelligence and his application to studies. During this period, Munk's parents escaped from Austria and settled in Pasadena, but significant family assets were lost.

In 1939, Munk applied for a summer job at the Scripps Institution of Oceanography in La Jolla, California. He visited the director of the Scripps Institution of Oceanography, the distinguished Norwegian oceanographer Harald Ulrik Sverdrup, looking for work. The following year, Munk asked Sverdrup to accept him as a graduate student. Sverdrup accepted him as a doctoral student, but told Munk that he did not know of a single job in oceanography which would become available in the next ten years.

The Scripps Institution of Oceanography (SIO) was a research institution with only a few students at that time. Munk moved into bachelor quarters at the Community House on campus and met the entire staff, including a young research oceanographer, Roger Revelle, who had just completed his doctorate. They became good friends.

During the prewar years, Munk had an opportunity to observe Sverdrup and his coauthors, Martin W. Johnson and Richard H. Fleming, as they wrote the first modern textbook in oceanography, The Oceans, Their Physics, Chemistry, and General Biology (New York, Prentice-Hall, 1942). Munk assisted Sverdrup by following the manuscript of the book as Sverdrup dictated whole chapters, and this certainly sharpened both his language skills and mind. Munk credits Sverdrup with teaching him English. This is an exaggeration; Munk learned English as a child from his nanny.

Munk applied for American citizenship in 1939 after the Anschluss and enlisted in the ski troops of the U.S. Army as a private. This was unusual as Roger Revelle and all the other young men at Scripps joined the naval reserve. Munk was eventually excused from military service to undertake defense related research at Scripps. The opportunity to make a contribution soon arose in connection with the Allied plan for an amphibious landing in northwest Africa. The area is known for a large winter surf which could have prevented LCVP landing craft from reaching the shore. The scientific problem was to predict and select two days of low surf for the landing. Sverdrup and Munk developed formulae and methods to predict surf conditions and later began training groups of military meteorologists in their methods at SIO. This training was connected to a UCLA course

in military meteorology taught by Sverdrup and his Norwegian colleagues, Jacob Bjerknes and Jorgen Holmboe. The surf prediction methods were used successfully to predict conditions for Allied landings in North Africa, the Pacific theater of war, and finally the beaches of Normandy. This work was credited by the Allies with saving the lives of many men in combat.

Harald Sverdrup and Walter Munk, 1946

Munk completed his doctorate in 1947, a degree granted by UCLA for work done at SIO, the same year his mentor decided to return to Norway. During the summer of 1947, Munk participated

in an Arctic cruise on a navy vessel to study submarine operations in Arctic waters. Munk spent six months at the University of Oslo in 1949 on a Guggenheim Fellowship studying the dynamics of ocean currents. Throughout their association, Sverdrup taught Munk to take a very wide view of oceanography from the point of view of physics. He and Munk shared an international view of science which, though it might be applied to national goals, nevertheless sprung from an international community of scientists.

Munk matured as a leader in the field of oceanography as it made an important transition from wartime funding for defense-related research to a broad effort in basic science funded by the Navy and National Science Foundation, pursued cooperatively by scientists around the globe. During the postwar period, oceanography changed from a ship-based science focused on expeditionary research, to one characterized by the use of a variety of remote instruments. These instruments and observations included radar, acoustics, seismology and satellites. They are used to get a wide scale synoptic view of planetary phenomena such as ocean circulation, waves, circulation, tides, and other physical processes of the ocean and interactions with the atmosphere. All of these trends made it possible for oceanography and for Walter Munk to make major contributions to the science of the whole earth, not just a science of the sea. Munk's scientific work and reputation grew beyond oceanography, and he is recognized as one of the great geophysicists of his generation.

Munk is very well suited intellectually and temperamentally to his times and to geophysics. He has a taste for adventure and travel, he enjoys working in fields that are just opening up or in the junctions of major fields such as astronomy and physics. He has expressed a preference for publishing papers in new areas of research, rather than contributing to fields well represented in the literature. Munk has observed,

> "If you apply a significant technical innovation to a field of general interest, then you cannot help but learn new things."

He applies himself to problems others consider intractable. He applies new technology to the problems he investigates, he invents new instruments and expands the application of instruments. He is renowned for suggesting daring, some say risky, projects that yield revolutionary discoveries in science.

Munk published most of his papers in close collaboration with several coauthors. His work is sometimes compared to that of his friend and colleague Henry Stommel. Munk first met Stommel at SIO, when Stommel came to visit Sverdrup right after the end of the war. Munk and Gordon MacDonald studied irregularities in earth rotation for a decade and coauthored The Rotation of the Earth, A Geophysical Discussion (Cambridge [Eng.] University Press, 1960). For more than twenty years, Munk's work was assisted by a close collaboration with engineer Frank Snodgrass whom he credits with the success of their operations at sea. Carl Wunsch has said of Munk:

> "What makes him a good scientist is his ability to see right through the math, to what it means physically."

In the immediate postwar years, Munk and other oceanographers worked as consultants on a series of American Pacific atomic tests that began with Crossroads, the test at Bikini Atoll. Munk and William von Arx were given ten days to measure the circulation in and out of Bikini Lagoon and determine the flushing rate. Concerns about the possibility of a tsunami generated by an atomic explosion led Munk to invent the tsunami warning system.

Munk was a participant in the 1952-1953 Capricorn Expedition, one of a long and successful series of expeditions to the deep Pacific organized under the leadership of Roger Revelle. In addition to his other scientific work, Munk joined a small band of scuba divers on Capricorn, the first oceanographic expedition to include a scuba team.

Walter Munk , Capricorn Expedition, 1952

These expeditions encouraged Munk to continue work on currents and waves, including tsunamis and led to the construction of a tsunami recorder. Munk gained insight into waves that he characterized as "moderately confused" phenomena -- not as predictable as a pure sine wave, but not highly chaotic -- creating patterns which can be predicted with moderate skill.

Munk was influenced in the early 1950's by reading scientific literature in astronomy. He decided to studying earth wobble and spin and variations in gravity. This was an early element in Munk's lifelong interest in the earth's dynamics. Munk is a pioneer in the use of acoustics as a method of studying the earth. His scientific studies of deep ocean tides have profound implications for oceanography and astronomy. Munk developed some of the first computer programs used to analyze waves of all lengths. During this same period, he wrote the classic paper on wind-driven ocean circulation. In 1953 Munk's studies of the glitter of the sun on ocean surface waves led him to develop statistics of surface slope which helps explain gravity waves, ripples and the micro scale of surface disturbances.

On June 20, 1953, Munk married Judith Horton. She was a member of a prominent San Diego family and was a student of sculptor Donal Hord. They were introduced by Helen Raitt when Judith Horton was a volunteer at the Scripps Aquarium. Judith Horton Munk became an active participant in the university community and at the Scripps Institution of Oceanography where she made major contributions to architecture, campus planning and the renovation and reuse of historical buildings. She took a leading role in the design of the old and new laboratories of the Cecil and Ida Green Institute of Geophysics and Planetary Physics (IGPP).

Judith Munk inspired her husband to take an interest in the tidal problems of Venice which threaten its art treasures. In 1955 and again in 1962, the Munks spent six months at Churchill College, Cambridge. Judith Munk accompanied her husband on expeditions and scientific visits even to remote locations. During the 1950's the Munks made several trips to scientific meetings in the Soviet Union. They somehow convinced authorities in the Soviet Union to allow them to cross the country in a Land Rover in October 1962, in the midst of the Cuban missile crisis. They traveled to China together in the fall of 1978 when Munk served as a member of the National Academy of Sciences delegation. Through this visit and a return visit of Chinese oceanographers to SIO, Munk became reacquainted with T.C. Tseng, founder of the Tsingdao oceanographic institution, who had done a wartime postdoctoral fellowship at Scripps.

Judith Munk, 18 January 1978

Walter Munk served as a member of one of the committees of the IGY (International Geophysical Year) and was very pleased with the effectiveness of the IGY Program. However, by the 1950's Munk and other geophysicists became frustrated by the lack of major geophysical research initiatives. They made comparisons between funding for geophysics and space science and searched for a way to capture the public's imagination and win greater support for earth science. Munk and Harry Hess sought increased support for geophysics by proposing a controversial project to drill a hole through the Earth's crust to the Mohorovicic discontinuity, the dividing line between the outer crust of the earth and the mantle. Munk participated in preliminary ocean drilling on CUSS I in 1961, which proved ocean drilling to be feasible. He later regretted that he did not take a more active role in the management of Project Mohole, which became mired in

controversy. Even so, Mohole led to an international program of ocean drilling which has revolutionized human knowledge of geology and earth history. For decades the Deep Sea Drilling Program and its successors was the largest single program within the National Science Foundation and pioneered international scientific cooperation of a complexity unimaginable to scientists in past generations.

During the early 1960's Munk became an active member of JASON, a group of scientists that advised the military on scientific matters. He also served on several panels of the President's Science Advisory Committee (PSAC). Throughout the cold war period, Munk traveled extensively and visited many remote locations. For example, Munk and his family lived in a fale in Tutuila, American Samoa while Munk directed the Waves Across the Pacific Experiment. In this experiment, Munk studied very long Pacific swells and surmised that the source of these swells was in the Indian Ocean and that the waves had entered the Pacific along a great-circle route through the Tasman Sea. Munk and his research associate Frank Snodgrass built arrays to test this hypothesis and established recording stations from New Zealand to Alaska, all the way around the Pacific. This was Munk's first large ocean experiment. Using the array, Munk could trace waves across the entire Pacific back to their origin in great storms in the southern hemisphere.

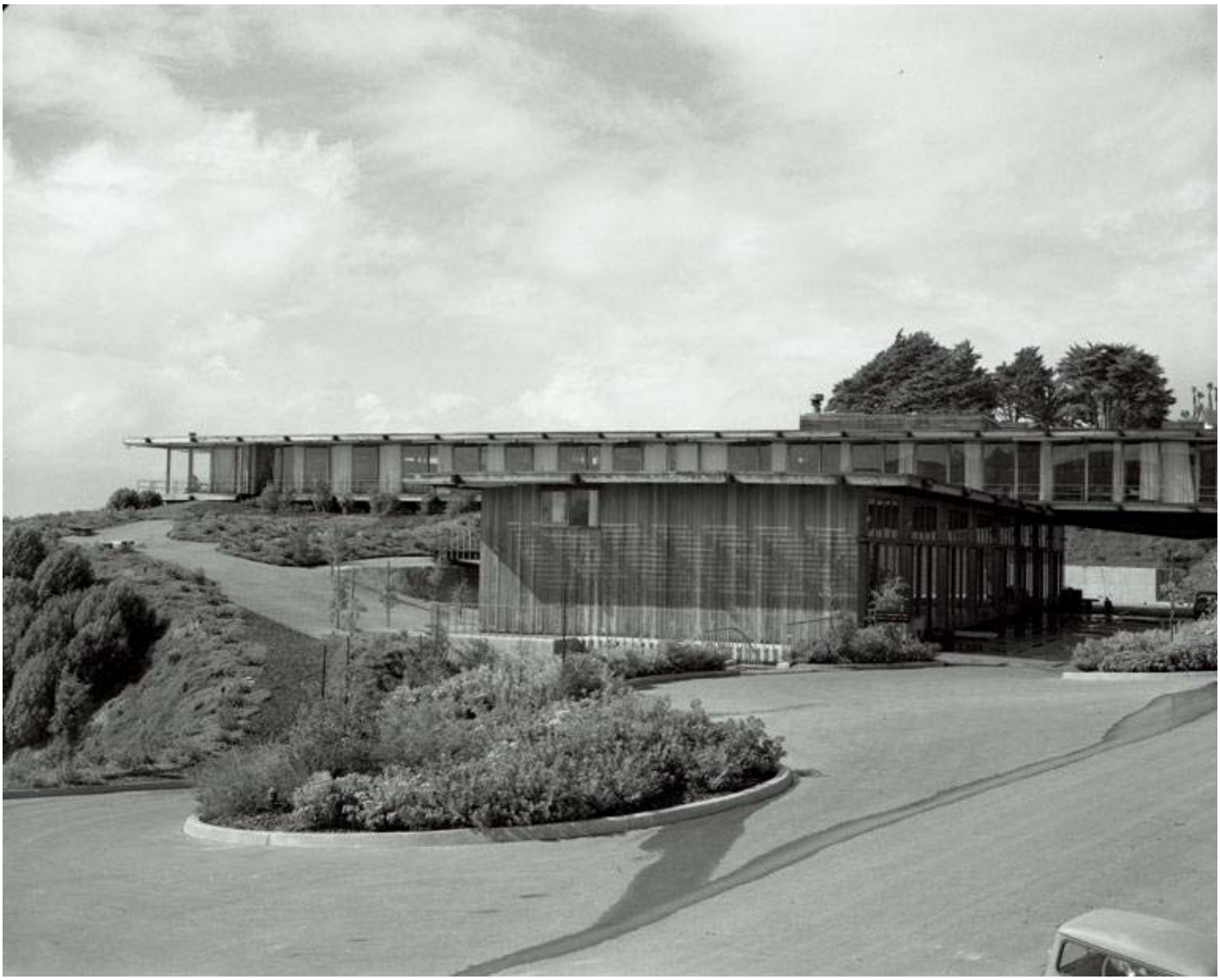
Munk spent his entire career at the Scripps Institution of Oceanography, University of California, San Diego. He served as Assistant Professor of Geophysics (1947-1949), Associate Professor (1949-1954), and Professor of Geophysics (1954-). Munk has always been active in University governance and administration. During the early 1950's he was one of a small number of University of California faculty who refused to sign the California Loyalty Oath. He was closely associated with Roger Revelle in the administration of the Scripps Institution of Oceanography and was an ally of Revelle in the effort to found the University of California, San Diego. He was tapped at least once to be director of the Scripps Institution of Oceanography after Roger Revelle left the institution, but Munk declined to be a candidate for the position.

Best known as a scientist, Munk was also active as a teacher. His doctoral students included Charles Cox, Gordon Groves and Peter Worcester. He was the major professor of June Patullo, the first woman to receive a doctorate in physical oceanography from SIO.

In 1959 Munk seriously considered leaving California for positions offered to him by Robert Schrock at MIT, Francis Birch at Harvard and Woods Hole Oceanographic Institution (WHOI) which would have given him greater opportunities to pursue broader research in geophysics. Roger Revelle and others sought to dissuade him by suggesting that he establish a research group at SIO in geophysics. With scientific billets and other incentives offered by SIO, Munk raised money from ONR, the Air Force, foundations and other sources and founded the Institute of Geophysics and Planetary Physics (IGPP), the La Jolla branch of an institute founded at UCLA after the war by Joseph Kaplan, Harald Sverdrup and others. IGPP is a University of California statewide research institute situated at the Scripps Institution of Oceanography. Munk purposefully tried to keep it small and intimate. He was able to bring distinguished geophysicists such as George Backus and J. Freeman Gilbert to IGPP. Robert Parker came from the Bullard Laboratory

at Cambridge. Munk attracted renown geophysicists such as Teddy Bullard, Keith Runcorn and J. Tuzo Wilson to IGPP on visiting research positions funded by Cecil Green. IGPP scientists mingled with Harold Urey, Margaret and Geoffrey Burbidge and other distinguished faculty who came to UCSD at the invitation of Roger Revelle.

Munk and his wife Judith Munk were full partners in the design of the IGPP buildings at Scripps. The original Munk lab is a handsome redwood building that won design awards in 1959. The structure came close to establishing a unifying design concept for the Scripps Institution of Oceanography, a campus which before the 1960's tended to build buildings with dispatch rather than style. During this period, the Munks developed a close personal relationship with Cecil and Ida Green. The Greens made it possible for IGPP to acquire the sculpture, "Spring Stirring" by Donal Hord. Eventually, their donations to IGPP grew to several million dollars. Beginning in 1981, the Munks participated in the design of IGPP II, the Ellen and Roger Revelle Building. A significant feature of this design was Scripps' Crossing, an innovative stayed cable foot bridge constructed in 1990 across La Jolla Shores Drive, uniting two sections of the Scripps campus.



Munk Laboratory, IGPP, 1965

Munk chaired the Faculty Senate at UCSD during the turbulent years of Vietnam protests, and he skillfully steered an even course through the Herbert Marcuse controversy. Marcuse's reappointment became a flashpoint between conservative politicians and the politically conservative residents of La Jolla on the one hand and the university community which defended academic freedom in faculty appointments and held in general more liberal political views, on the other. This conflict put great pressure on university governance. While Munk disagreed with Marcuse personally, he successfully advocated his reappointment and defended the faculty position on academic freedom. During this period, Munk interacted with a diverse group of non-scientists including Eldridge Cleaver, Angela Davis, UC Regent Catherine Campbell Hearst, and Ronald Reagan.

Throughout this period, Munk continued to be active as an advisor to government, particularly the navy, on scientific subjects. Munk served as Chair of the Ocean Studies Board of the National Academy of Sciences at the request of Frank Press. He was a member of the Naval Research Advisory Committee (NRAC) and the MIT Visiting Committee. Judith Munk served on a number of influential UCSD university committees, for instance the University Town Center Task Force and the Committee on University Community Planning. In 1964, Walter Munk was a member of the search committee for the chancellor. Munk chaired the search committees appointed by the chancellor which recommended the appointment of William Nierenberg and Edward A. Frieman as directors of the Scripps Institution of Oceanography. Munk was not as active in the administration of science as was Roger Revelle. Munk served on relatively few scientific committees, but these were important and their work was influential on the policy level. He was a member of many scientific organizations. He preferred to use his time on scientific research, although Roger Revelle tried to persuade him to accept high level administrative appointments.

During the period 1965-1975 Munk attempted to improve tide prediction with Dave Cartwright. They developed instruments to measure tides in the open sea as part of MODE (Mid-Ocean Dynamics Experiment) and achieved a precision of better than 1 millimeter in 5 kilometers of water. Munk developed instrumentation to study and model internal waves, the Garrett-Munk Spectrum. This facilitated the study of the up and down movement of water in the deep sea, at internal boundaries between water masses with distinct temperature and density characteristics.

Munk found that internal waves affect the propagation of sound through water. In 1981, he teamed with Carl Wunsch and Robert Spindel, developers of Ocean Acoustic Tomography (OAT), to record mesoscale features -- characterized as "underwater weather."

During the 1980's, Walter Munk met David Packard and joined the board of the Monterey Bay Aquarium Research Institute (MBARI) where he helped focus the research aims of the Institute.

In 1984, Navy Secretary John F. Lehman, Jr. named Walter Munk to one of four Secretary of the Navy Research Chairs in Oceanography. The purpose of the chairs were to reaffirm the strong interest of the Secretary of the Navy in oceanography and to recognize the leading oceanographers in the United States. The generous terms of the SECNAV chairs became a major factor in all of Munk's subsequent work.

Munk's interest in Ocean Acoustic Tomography expanded in 1990 when he began the Acoustic Thermometry of the Ocean Climate (ATOC) project. The simple underlying idea is that the travel time between source and receiver is a measure of the temperature of the intervening waters. To answer the question of how far away man-made signals could be received and decoded, Munk organized the Heard Island experiment. Signals transmitted from this remote island in the South Indian Ocean could be received half way around the world in the North Atlantic and the northwest Pacific. This innovative and promising avenue of research hit a wall of controversy when biologists suggested that the effects of the sound signals on marine mammals and other sea life were unknown. Wide spread publicity stimulated opposition from the public concerned about marine mammals. This made it difficult for project scientists to get the permits necessary to pursue the experiment, even when biologists joined the project and provided data on the environmental effects of sounds in the sea and its impact on marine mammals.

During the decade of the 1990's, Munk became a member of MEDEA, Vice President Albert Gore's environmental task force. This was a group of fifty scientists who advised Gore on scientific matters and suggested ways that data collected for scientific and intelligence purposes could be used to address environmental and other social issues. Other members of this group included Edward A. Frieman, Charles Kennel and John Orcutt.

In 1995, Munk, Peter Worcester and Carl Wunsch published Ocean Acoustic Tomography (Cambridge University Press). Munk, with collaborators including Wunsch and Worcester, published an interesting paper in Science which combined thermometry and satellite altimetry measurements to demonstrate that the seasonal and year to year changes in sea level were only in part due to thermal expansion, as had previously been widely assumed. Munk also published a paper showing that a major contribution to tidal friction is the generation of internal waves at major sea floor topographic features.

Walter Munk has been elected to membership in the National Academy of Sciences in the United States, the Royal Society and the Russian Academy of Sciences. Munk has received many national and international honors including the Vetlesen Prize, Gold Medal, Royal Astronomical Society, Bakerian Lecturer of the Royal Society, Agassiz Medal of the National Academy of Sciences, the National Medal of Science and the Kyoto Prize.

Judith Munk passed away on 20 May 2006 in La Jolla, California.

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