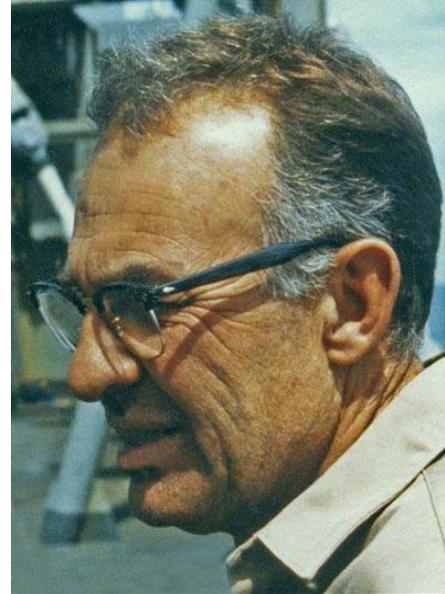


Frank Edwin Snodgrass

Thelma Snodgrass Bratt, Mary Snodgrass Betancourt, Peggy Welch. June 2012

Born 9th February, 1920, Red Lodge, Montana. Died 29th June, 1985, Silverton, Oregon. **Fields:** Oceanography, geophysics, electrical engineering. **Notable awards:** Marine Technology Society's first Award for Ocean Science and Engineering (1969, co-recipient with [Professor Walter H. Munk](#)) Institute of Electrical and Electronic Engineers' Award (IEEE); Doctor of Science, [Flinders University](#), Australia (1970).

Frank E. Snodgrass was a [physical oceanographer](#) and electrical engineer. He spent nearly all of his career working with [Prof. Walter Munk](#) at [Scripps Institution of Oceanography](#) (SIO). The Cecil H. and Ida M. Green branch of the University of California Systemwide Institute of Geophysics and Planetary Physics (IGPP), in La Jolla, California has been strongly linked to Scripps since the 1960s through joint faculty appointments, research interests, and shared facilities. Other IGPP branches can be found at the Los Angeles, Irvine, Santa Cruz and Riverside campuses.^[1] Snodgrass spent many years researching and measuring the ocean tides and waves. During his career he had opportunities to work with fellow scientists around the world, including collaborations through the IGPP campuses with [Woods Hole Oceanographic Institution](#) in Massachusetts and the [National Institute of Oceanography](#) in England.



Frank E. Snodgrass

Early Years

Raised in [Red Lodge, Montana](#), Frank Snodgrass joined the merchant marines as a young man, beginning what would become a long and deep connection with the sea. A strong swimmer, he enjoyed fishing, skin diving, snorkeling, scuba diving and body-surfing, and he relished the many opportunities that took him to sea on various oceanographic research vessels at Scripps Institution of Oceanography (SIO). Trained as an electrical engineer, Frank received his Master's degree from the University of California, Berkeley in 1952 where he

worked with other scientists in the 'newly developing field of coastal engineering' under [Joseph William Johnson](#).^[2]

The War Years

Frank was inducted into the Navy in 1944. He served at the Naval Training School (NTS), Great Lakes, NTS Radio Chicago and the Naval Training Center, Gulfport, Mississippi as an instructor on the radio technology program, teaching math, slide rule and radio theory. He was honorably discharged in 1946.^[3]

Scripps Institution of Oceanography (SIO) and the Institute of Geophysics and Planetary Physics (IGPP) in La Jolla, California

Snodgrass joined Scripps in 1953 as an Assistant Research Engineer beginning his long association with Prof. Walter Munk. He became an Associate Research Engineer in 1961 and later a research engineer at Scripps Institution of Oceanography (SIO) and the Institute of Geophysics and Planetary Physics (IGPP) in La Jolla, California.

As a research engineer, Snodgrass' major fields of interest were oceanographic instrumentation and digital recording techniques. He was the first scientist to recall ocean instruments from the sea floor utilizing acoustic techniques. 'Frank pioneered dropping instruments to the sea floor and recalling them some months or years later by acoustic commands.'^[4]

Frank's time at IGPP was given the following tribute by Prof. Walter Munk who spoke of him as 'my partner for 23 years prior to his retirement in 1976'^[5] – a partnership in which Munk describes Frank as 'a superb ocean experimentalist.'^[6] Munk and Snodgrass worked together from 1953 to 1975, co-authoring a number of papers (listed below). The following tribute was written by Walter Munk when Frank died June 29th, 1985. This tribute is also published in the *History of Geophysics, Vol 4*^[7] and describes Frank's work in detail (links and references have been added).

"So many oceanographic techniques that are taken for granted today were introduced by Frank. He pioneered digital recording. He was the first (in 1965) to drop gear in free-fall to the sea floor for subsequent acoustic recall. I believe that he was the first to use a portable sea-going laboratory. We still use the frame of Frank's first model, which dates back over 20 years.

Frank was born in Red Lodge, Mont., on February 9, 1920. At the age of 16 he signed up with the Merchant Marines. At the end of WWII, Frank was a junior member of the famous group of engineers under the

renowned M. P. O'Brien, Dean of Engineering at the University of California, Berkeley. He was working with John Isaacs, Joe Johnson, and Jack Putnam on the evaluation of the amphibious DUKW vehicle when we persuaded him to come to the Scripps Institution of Oceanography (SIO), La Jolla, Calif., in 1953. He started his work on ocean waves by adapting a "Vibratron" transducer to measuring pressure fluctuations on the shallow sea floor. Frequency analysis of the records (using IBM punch cards) occasionally revealed a sharp spectral swell peak whose frequency would advance day by day and double in a week. This rate of frequency dispersion suggested a very distant origin, halfway around the earth. Where did these waves come from? Frank installed a directional array west off San Clemente Island, off the California coast. The results were spectacular. All the distant wave sources were within a beam from 210° to 220° true, which is the angle subtended between Antarctica and New Zealand and which offers a great circle window to antipodal storms in the Indian Ocean. Subsequently, six wave stations were established along the great circle route: New Zealand, Samoa, Palmyra (an uninhabited island in the Pacific), Hawaii, [FLIP](#) (a SIO special special-purpose vessel, which was moored in position for about a month), and Alaska, to track wave packets originating in the southern storm belt. Frank established all six stations, using sea floor pressure recorders (for all but FLIP) connected by cable to shore-based digital paper punches. The records went on for 3 months, with a 98% data return.

Following the wave work, Snodgrass pushed towards even lower frequencies, from swell to surf beat to edge waves to tsunamis, and finally to tides recorded by freely dropped pressure sensors on the deep sea floor. Frank led an expedition to measure the transition of tides across the southern oceans between Australia and Antarctica. Subsequently, Frank's colleagues in Adelaide, Australia, invited him to bind his two-score publications into a coherent volume and awarded him the degree of Doctor of Science. ^[8]

The last of Frank's instrument drops were in 1974 in 5.5 km of water south of Bermuda as part of the [Mid-Ocean Dynamics Experiment](#) (MODE) bottom experiment. Bernard Zetler, who was a member of our Scripps group, analyzed the deep-sea pressure. The measurements were in splendid accord with the traditional Atlantic cotidal charts. Two independent drops at the same location gave the following M2 amplitudes and Greenwich epochs: 32.067 cm and 2.5°; 32.074 cm and 2.6°. The agreement to four figures was a triumph to Frank's engineering achievements. Inevitably, it led to a decision to look for new ocean challenges. Frank built a 20-km acoustic current meter, the forerunner to ocean acoustic tomography. Yet his heart was not in this, and he decided to take up his old love of growing things and his hobby of studying the

genetics of rabbits. Frank and his wife Thelma bought 10 acres (4 ha) of untended Oregon land and built their dream farm.

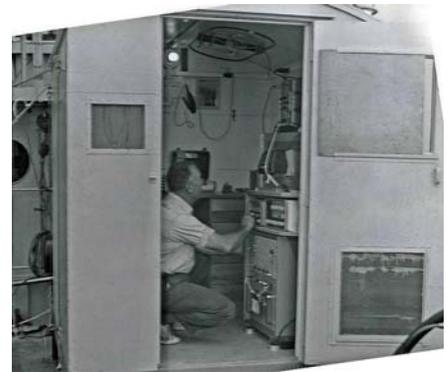
Frank was a quiet and deliberate man, and he was most considerate. He nurtured a generation of Scripps students: Gordon Groves, Gaylord Miller, Jim Irish, Wendell Brown, Mark Wimbush, Jim Cairns, Gordon Williams, and Peter Worcester. Frank loved going to sea, where his benign beach manners were transformed. Standing on the fan tail, sleeves ripped to the shoulders and drenched in spray, he would "hollo" commands to all those about him.^[9]

Engineering achievements

Frank's most notable achievements are described below by those who worked with him.

Portable labs

"Until the mid-1960s we used to load our gear into numerous boxes and carry them aboard the vessels, only to find that a crucial item had been left ashore. I think Frank Snodgrass was the first to build portable laboratories with the equipment assembled and pretested. The portable laboratory is then brought aboard, ready for action. Decks of all oceanographic vessels now provide bolt-downs 2 feet on center for securing the portable laboratories."^[10]



Frank working inside a portable lab

Pressure sensors for measuring waves

“He [Frank] adapted a "Vibrotron" transducer to measure pressure fluctuations on the shallow seafloor, the purpose being to explore oscillations with frequencies even lower than those of the swell. ...[Later] Frank Snodgrass had found that a newly developed quartz crystal pressure was superior to the Vibrotron pressure transducer, our mainstay for some years.” [\[11\]](#)

The Snodgrass-Designed Deep-Sea Instrumented Capsule

The deep-sea instrumented capsule is a "free" vehicle; that is, it is not tethered to the vessel from which it is dropped. Instruments are carried in two aluminum spheres capable of withstanding three-mile-deep pressures. The only communication between the capsule and the "mother" ship is through acoustic signals. Commands transmitted from the ship control the capsule and cause it to surface at the end of the experiment. The capsule transmits information to the ship describing its operation and condition.



Frank Snodgrass (left) and Walter Munk dropping a capsule

Instruments attached to the capsule measure water temperature, currents, and pressure. Tidal information is obtained by measuring pressure with a sensitivity of 1/25th of an inch in three-mile depths. The capsules have been tested to 18,000 feet. Including the Antarctic drops of the capsules, there have been nearly 50 successful installations with the sophisticated deep-tide instruments. [\[12\]](#)

Acoustic Retrieval

“In about the same period we learned how to drop unattached instruments to the relatively benign environment of the deep seafloor, later to be recalled acoustically. There was a psychological block to overcome; it is not easy to let go of a line from which you have a year' s budget of equipment hanging”. [\[13\]](#)

AWARDS

In 1969, Professor Dr. Walter H. Munk and Frank Snodgrass were named co-recipients of the Marine Technology Society's first Award for Ocean Science and Engineering.^[14]

Snodgrass was later presented the Institute of Electrical and Electronic Engineers' award for outstanding contributions to ocean engineering technology. He was awarded a Doctor of Science degree in oceanography from Flinders University of South Australia in 1970 based on his published papers and his original contributions to oceanography as noted below.

Frank Snodgrass' Published Contributions to Oceanography^[15]

- Snodgrass, F. E. (1950). "Wave Recorders", Proc. First Conference Coastal Engineering, Long Beach, Calif., Chapter 7, 69-81, 1951.
- Snodgrass, F.E. and Stiling, D.E. (1951). "Analysis of Wave Recorders", University of California, Berkeley Institute of Engineering, Series 3, Issue 307, 13p.
- Snodgrass, F. E. (1952) "Wave measurements", In: Conference on Oceanographic Instrumentation. Rancho Santa Fe, CA June 1952, NAS/NRC Publ. 309: 139-65.
- Snodgrass, F.E., Putz, R.R. (1954) "A direct reading wave meter", Institute of Engineering Research, Wave Research Laboratory, Technical Report, Series 3, Issue 37.
- Snodgrass, F. E., Carrier, G. and Munk, W. H. (1956). "Edge Waves on the Continental Shelf", Science, 123(3187):127-132.
- Snodgrass, F. E. (1956). "Mark IX Shore Wave Recorder", In: Proc. First Conference Coastal Engineering Instruments, Chptr. 6: 61-100.
- Munk, W. H. and Snodgrass, F. E. (1957). "Measurements of southern swell at Guadalupe Island", Deep-Sea Research, 4:272-86.
- Munk, W. H, Tucker, M. J. and Snodgrass, F. E (1957). "Remarks on the ocean wave spectrum", In: Symposium on Naval Hydrodynamics, Publ. 515, Chptr. 3:45-60.
- Snodgrass, F. E. (1958). "Shore-based recorder of low-frequency ocean waves", Trans. Am. Geophys. Union, 39(1):109-13.
- Snodgrass, F. E, Munk, W. H. and Tucker. M. J. (1958). "Offshore recording of low-frequency ocean waves", Trans. Am. Geophys. Union, 39(1):114-20.

- Snodgrass, F. E. and Putz, Robert R. (1958). "A wave height and frequency meter", In: Proc. Sixth Int'l. Conference Coastal Engineering, Chptr. 13:209-24.
- Munk, W. H., Snodgrass, F. E. and Tucker, M. J. (1959). "Spectra of low-frequency ocean waves", Scripps Institution of Oceanography Bulletin, 7:283-362.
- Snodgrass, F. E. (1960) "Ocean waves", McGraw-Hill Encyclopedia of Science, 1st Edition: 259-260.
- Snodgrass, F. E. (1961). "Ocean wave spectra", In: Proc. of panel discussion NAS Conf., Easton, MD:333-45.
- Snodgrass, F. E., Munk, W. H. and Miller, G. R. (1962). "Long-period waves over California's continental borderland. Part I. Background Spectra", J. Mar. Res., 20(1):3-30.
- Miller, G. R., Munk, W. H. and Snodgrass, F. E. (1962). "Long-period waves over California's continental borderland. Part II. Tsunamis", J. Mar. Res., 20(1):31-41.
- Munk, W. H., Miller, G. R. and Snodgrass, F. E. (1962). "Long-period waves over California's continental borderland. Part III. The decay of tsunamis and the dissipation of tidal energy", J. Mar. Res., 20(1):119-20.
- Haubrich, R. H., Munk, W. H. and Snodgrass, F. E. (1963). "Comparative spectra of microseisms and swell", Bull. Seism. Soc. Am., 53(1):27-37.
- Munk, W. H., G. R. Miller, F. E. Snodgrass, and N. F. Barber. "Directional recording of swell from distant storm", Philos. Trans. R. Soc. London, Ser. A, No. 1062, 255:505-84.
- Munk, W. H., Snodgrass, F. E. and Gilbert, F. (1964). "Long waves on the continental shelf: an experiment to separate trapped and leaky modes", J. Fluid Mech. 20(4):529-54.
- Snodgrass, F. E. (1964). "Precision digital tide gauge", Science, 146(3641):198-208.
- Snodgrass, F. E. (1964). "How to tell breakwaters from elephants", The Seahorse, 1(4):1&4-5.
- Snodgrass, F. E., Groves, G. W. , Hasselmann, K. F. , Miller, G. R. , Munk, W. H. and Powers, W. H. (1966). "Propagation of ocean swells across the Pacific", Philos. Trans. R. Soc. London, Ser. A, No. 1103, 259:431-97.
- Snodgrass, F. E. (1968). "Deep sea instrument capsule", Science, 162:78-87.
- Caldwell, D. R., Snodgrass, F. E. and Wimbush, M. H. (1969). "Sensors in the deep sea", Physics Today, 22(7):34-42.

- Snodgrass, F. E. (1969). "Study of ocean waves, 10~5 to 1 Hz", Survey Paper No. 8, Horace Lamb Centre, Flinders, University of Australia, 41 pp.
- Munk, W. H., Snodgrass, F. E. and Wimbush, M. (1970). "Tides off shore: transition from California coastal to deep-sea waters", *Geophys. Fluid Dyn.*, 1(1):161-235.
- Snodgrass, F. E. (1971). "Elqntin Cruise 41", *Antarctic Journal of the U.S.* Vol. VI, No. 1: 14-17.
- Irish, J. D., Munk, W. H. and Snodgrass, F. E. (1971). "M2 amphidrome in the Northeast Pacific", *Geophys. Fluid Dyn.*, 2:355-60.
- Irish, J. D. and Snodgrass, F. E. (1972). "Quartz crystals as multipurpose oceanographic sensors-1 pressure", *Deep-sea Research*, 19:165-69.
- Irish, J. D. and Snodgrass, F. E. (1972). "Australian-Antarctic tides", *Antarctic Research Series*, 19 (Antarctic Oceanology II):110-16.
- Brown, W., Munk, W. H., Snodgrass, F. E. and Zetler, B. (1973). "Bottom pressures in the MODE region", *MODE Hotline News*, 37:1,4.
- Munk, W. H., Snodgrass, F. E. Zetler, and B. (1973). "Oceanography from the bottom up", *Naval Res. Rev.*, 26(9):18-24.
- Snodgrass, F. E. and Wimbush, M. (1974). "Evaluation of deep sea tide gauge sensors", In: *Proc. IEEE Intl. Conf. Engineering in the Ocean Environment*, Halifax, NS, 1:350-53.
- F. E. Snodgrass, Brown, W. and Munk, W. H. (1975). "MODE: IGPP measurements of bottom pressure and temperature", *J. Phys. Oceanogr.*, 5(1):64-74.
- Brown, W., Munk, W. H., Snodgrass, F. E., Mojfeld, H. and Zetler, B. (1975). "MODE bottom experiment", *J. Phys. Oceanogr.*, 5(1):75-85.

Documentaries/Films^[16]

"Waves Across the Pacific" (1963) This documentary showcases Munk's research on waves generated by Antarctic storms. The film documents Munk's collaboration as they track storm-driven waves from Antarctica across the Pacific Ocean to Alaska. The film features scenes of early digital equipment in use in field experiments with Munk's commentary on how unsure they were about using such new technology in remote locations.

References:

1. [^] See history of IGPP available at <http://igpp.ucsd.edu/about/history/1960>, accessed July 2011
2. [^] Joe [Joseph William Johnson] continued his research, teaching, and consulting, becoming a pioneer in the newly developing field of coastal engineering, attracting graduate students and visiting scholars from around the world. These included Charles L. Bretschneider, Per Bruun, Richard C. Crooke, Robert A. Fuchs, Kiyoshi Horikawa, Richard C. McCamy, Jack R. Morison, Egbert Prins, Thorndike Saville Jr., Frank E. Snodgrass, and Robert L. Wiegel.
<http://www.universityofcalifornia.edu/senate/inmemoriam/JosephWilliamJohnson.htm>
3. [^] Taken from personal discharge papers dated 2/17/1946
4. [^] Munk, Walter (1985), Frank Snodgrass 1920-1985, *Eos*, Vol.66, No.45, Pages 753
5. [^] *ibid*
6. [^] Hans Storch and Klaus Hasselmann (2010) *Seventy Years of Exploration in Oceanography: a prolonged weekend discussion with Walter Munk*, Springer, Heidelberg (p.9)
7. [^] Gillmor, C. S. (Ed.) (1990), *History of Geophysics: Volume 4, Hist. Geophys. Ser.*, vol. 4, 283 pp., AGU, Washington, D. C., doi:10.1029/HG004.
8. [^] Frank E. Snodgrass was awarded Doctor of Science from Flinders University of South Australia October 29, 1970,
<http://libraries.ucsd.edu/historyofucsd/newsreleases/1970/19701029.html>, accessed 29/7/11
9. [^] *Eos*, Vol.66, No.45, Pages 753, November 5, 1985 Obituary written by Walter Munk also published in the *La Jolla Light DATE*
10. [^] Munk, W. (2002), *The Evolution of Physical Oceanography in the Last Hundred Years*, *Oceanography*, Vol 15, No 1
11. [^] *Affairs of the Sea*, Walter H. Munk, Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California, available at <http://www.annualreviews.org/doi/pdf/10.1146/annurev.ea.08.050180.000245> accessed July 2011
12. [^] UCSD Libraries Website, Frank E. Snodgrass awarded Doctor of Science October, 1970, available at <http://libraries.ucsd.edu/historyofucsd/newsreleases/1970/19701029.html> accessed July 2011
13. [^] Munk, W. (2002), *The Evolution of Physical Oceanography in the Last Hundred Years*, *Oceanography*, Vol 15, No 1
14. [^] http://www.eoearth.org/article/Munk,_Walter_Heinrich accessed July 2011
15. [^] Frank E. Snodgrass, *Collected Contributions 1950-1975 presented to Frank on the occasion of his retirement by colleagues at IGPP*, Scripps Institution of Oceanography, La Jolla, California, 1975 – with some additions
16. [^] From Wikipedia on Walter Munk – http://en.wikipedia.org/wiki/Walter_Munk accessed July 2011