Fred Noel Spiess (1919–2006)
A Tribute

BY WILLIAM R. NORMARK AND BRUCE P. LUYENDYK

Anyone who spent time at sea with Fred Spiess came to understand his superb capabilities as an expedition leader and his effectiveness as a mentor of young scientists. His quiet style of directing operations masked the thoroughness with which he not only had planned for the activities to come but also for contingencies that might arise. As a result, most of his cruises not only achieved the goals stated in the funding proposal but, in many cases, a lot more. The key to Fred's accomplishments as an ocean scientist was his ability to not only recognize the problems that needed to be investigated but also to design and develop new observation systems where existing technologies were inadequate for the task at hand. Throughout his career, Fred continued to "push the envelope" when it came to new ways to observe, map, and understand processes operating on the floor of the deep ocean.

Spiess is probably best remembered for his role in the creation of FLIP, a unique 355-foot-long research platform that is towed to the work area and then rotated to a vertical position to form a stable observation post in deep water. FLIP has remained in use for more than 40 years primarily for physical oceanographic and acoustic experiments.

The development of the echosounder for seafloor mapping was refined during World War II. Soon research ships crossing the oceans outlined the mid-ocean ridges, fracture zones, and deep-sea trenches. Because these devices sent out broad-beam sound waves from the sea surface, details of the seafloor shape remained obscured by fuzzy smeared-out echoes. Ship navigation was so inaccurate that features smaller than a few kilometers across could not be mapped with any certainty. Spiess' solution to the resolution and mapping problem was two fold: bring the echosounder close to the seafloor and locate the device within a seabed survey network.

During the 1960s, Spiess and his engineers at the Marine Physical Laboratory of Scripps Institution of Oceanography developed the deep-tow instrument for mapping the deep seafloor from an altitude of tens of meters. The deep-tow instrument used a narrow-beam downward-looking echosounder, side-looking sonars, and subbottom profiling system to map features in unprecedented detail (e.g., geologic observations that approached that of outcrop mapping for land geologists). Evolution of the deep-tow to improve seafloor mapping saw the addition of a magnetometer, cameras, video, water samplers, plankton nets, and other instruments as more varied seafloor environments were examined.

Spiess recognized that obtaining detailed images of the seafloor was only one component that is necessary for making geologic maps of the deep seafloor. The position of the deep-tow vehicle must be known to within a few meters, thus leading to the development of the first seafloor acoustic-transponder positioning system for working in deep water. The acoustic transponder capability eventually evolved into instruments for acoustic geodetic measurements by combining the technologies of seafloor acoustic beacons with shipboard GPS positioning. This geodetic system has been successfully deployed for directly measuring the direction of movement and speed of the oceanic Juan de Fuca lithospheric plate and for documenting movement on submarine landslides.

Two decades after introducing transponder use, Spiess led the development of a wireline reentry system to allow instruments to be placed in boreholes drilled by the Ocean Drilling Program.

Fred Spiess received many awards and honors during his distinguished career; among these are: Franklin Institute's Wetherill Medal for his role in the development of FLIP; Distinguished Achievement Award from the Marine Technology Society;

Fred Spiess looking over his deep tow instrument before a 1977 lowering to the crest of the East Pacific Rise in the mouth of the Gulf of California.

Maurice Ewing medal from the American Geophysical Union; elected to the National Academy of Engineering in 1985; and in 2006 he received the Distinguished Technical Achievement Award from the Oceanic Engineering Society of the Institute of Electrical and Electronics Engineers "for six decades of advances in ocean engineering while developing sea-going research tools." A more complete review of Spiess' contributions to marine science can be found at: http://ucsdnews.ucsd.edu/newsrel/science/spiess.asp.

These well-deserved honors and awards, however, focus mostly on Spiess' innovative and technologic accomplishments and don't present an adequate summary of his contribution to understanding the geology of the ocean floor. In the summer of 1966, we, along with fellow graduate student Roger Larson, accepted Fred's offer to participate in a geologic mapping cruise on the Hawaiian Arch using the then new deep-tow vehicle. That summer marked the beginning of several decades of work to understand the structure of and the geologic processes affecting the deep seafloor by Spiess and his graduate students.

Through the years, studies using the deep-tow instrument have brought critical new insight to our understanding of oceanic spreading centers, subduction-zone trenches, abyssal-hill terranes, deep-sea fans and channel systems, submarine landslides, and neotectonics of continental margins, just to name a few. During the mid 1970s, several deep-tow cruises to the mouth of the Gulf of California at 21°N resulted in production of a geologic map of the East Pacific Rise spreading ridge axis. The map was then used as the base for conducting diving programs using both French and U.S. manned submersibles.

One of Fred's pet projects during the diving expedition was to use the manned submersible *Alvin* for seafloor gravity measurements across the axis of spreading, also a first. The diving expedition ultimately resulted in the discovery of high-temperature black-smoker vents for which Fred and his coauthors received the Newcomb Cleveland Prize for the best paper published in *Science* in 1980.

Fred Spiess loved a challenge and frequently tackled projects that others deemed impossible. Although he was not a geologist, he had an innate ability to recognize worthy geologic problems. His calm and reasoned approach to work whether at sea or in the office and lab allowed him to assemble teams of individuals that to an outsider would seem to doom the effort to failure. Fred's students remember him for his quiet manner, his wry wit, and his steadfast support. He was not one to closely manage a student's work, but he provided the environment where his students could flourish. Those who had worked or sailed with him will remember Fred as a brilliant innovator, a risk taker, and a kind human being.

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