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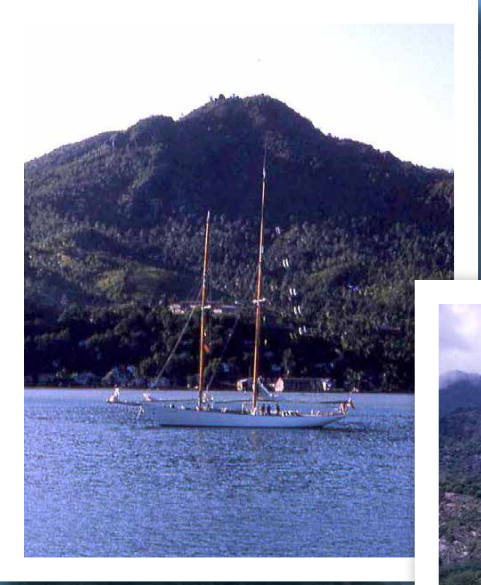
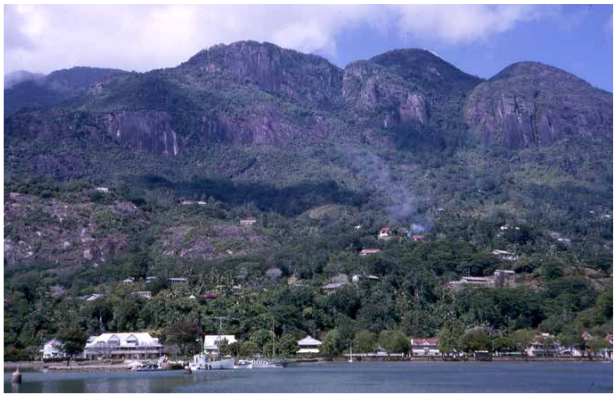
An Experiment in Graduate Education

A MARINE SCIENCE ADVENTURE ACROSS THE INDIAN OCEAN

By Vicki Buchsbaum Pearse, John C. Ogden, and Sharon J. Proctor



R/V *Te Vega* riding at anchor at Mahé Island, Seychelles Islands. *Photo courtesy of Richard Mariscal*



Port Victoria at Mahé Island in the Seychelles, one of the prettiest ports in the world. These massive islands are granitic and continental in origin. *Photo courtesy of Richard Mariscal*

ABSTRACT. In the fall of 1964, Stanford University's R/V *Te Vega* Cruise 5 crossed the equatorial Indian Ocean from Mombasa to Singapore, one of many ships participating in the International Indian Ocean Expedition. The cruise achieved two goals: (1) it provided hands-on oceanography training for graduate students in marine sciences, and (2) it documented the deep scattering layers of the Indian Ocean, only poorly known at the time. Taking place on the other side of the globe from the United States, the cruise also exposed students to cultural and personal experiences that shaped their lives and professions. It demonstrated the importance of experiential learning for future ocean scientists.

EMBARKING ON THE EXPERIMENT

In 1964, Abraham Maslow defined the concept of "peak experience" as a fleeting, euphoric, and mystical moment. More broadly interpreted, and without a trace of the mystical, a peak experience can occupy a far more sustained interval. It can be joyous and exciting, inspired by exposure to scientific knowledge, creative work, and the overwhelming beauty of nature (Privette, 1983).

Such were the elements underlying the experience of the graduate students who boarded Stanford University's R/V *Te Vega* in Mombasa, Kenya, for Cruise 5 in the fall of 1964. The voyage lasted 10 weeks, and the ship's track spanned the Indian Ocean from Mombasa to Singapore, with significant ports of call at the Seychelles, Maldives, Ceylon (now Sri Lanka), and the Phi Phi Islands of southern Thailand.

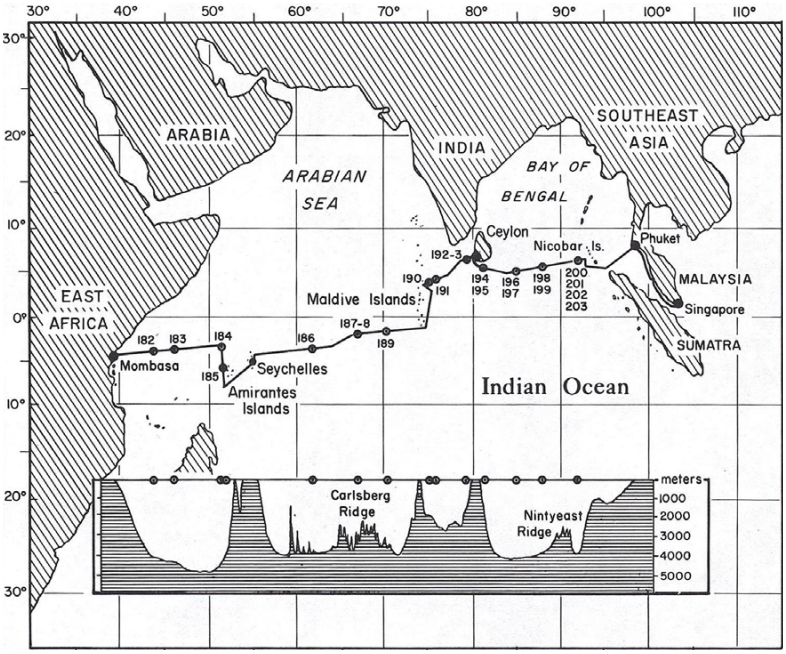
For us young marine scientists, *Te Vega* Cruise 5 would change our lives and last throughout our careers, leaving such strong impressions that some 50 years later, many of us, and dozens of other *Te Vega* participants, would travel long distances to gather together and exchange outcomes and memories.

At its very first meeting in 1957, the Scientific Committee on Oceanic Research identified the Indian Ocean as an area needing research, and in 1959, it launched the International Indian Ocean Expedition (IIOE). As the United States was keen to be represented, money was forthcoming, and the National Science Foundation (NSF) was tasked with providing federal support for participation in the IIOE. In spring of 1961, NSF funded Stanford's request for converting a ship into an oceanographic vessel, for its maintenance, and for support of research on board. The schooner *Te Vega* came to be that ship. The conversion included adding a deckhouse that housed the laboratory, with space for microscopy and the ship's sonar equipment, both essential for Cruise 5's research objective: to study the deep scattering layers (DSL) in the Indian Ocean. The ship served to educate Stanford graduate students from 1963 to 1968 on roughly 20 cruises, with the students receiving credit for a college quarter.

In addition to achieving research goals, all *Te Vega* cruises were intended to provide hands-on training for graduate students in marine sciences, an introduction to the study and methods of biological oceanography. A professional crew manned the ship, and the faculty members varied with the cruise.

The Cruise 5 faculty consisted of Donald Abbott, chief scientist (Stanford University), Richard Bovbjerg (University of Iowa), and Margaret Bradbury (San Francisco State College). Richard Mariscal, having participated in Cruise 1, served as teaching assistant, and Wesley Fielding was the ship's physician. The students, mostly from Stanford, a few from other universities (University of Hawaii; University of Alabama; University of California, Berkeley; Northern Illinois University), were Richard Barber, Vicki Buchsbaum (Pearse), Jay Christofferson, Jeanne Christofferson, Merrill McPhearson, John Ogden, Sharon Proctor, Paul Stromborg Jr., Leighton Taylor Jr., John Wourms, and Michael Wynne. The summary cruise report is available at http://tevega.stanford.edu/c5.htm.

Our goal here is to highlight the benefits of field research and experiential learning for young scientists. We briefly describe Cruise 5's DSL research and try to capture the nature of the experience and the long-term influences on our lives and careers.



The ship's track from Mombasa to Singapore, with 22 station numbers. The inset shows a section profile of the cruise track. *From Bradbury et al. (1971)*

THE CRUISE 5 EXPERIENCE

Te Vega's Cruise 5 was an unforgettable experience for both students and faculty. Whether we were trawling the DSL, examining collected specimens, exploring tropical islands, sailing the open ocean, or just taking breaks, there was always something new to discover.

Living arrangements were close and cozy. The nine male students slept in the "bullpen," a large cabin full of bunk beds beneath the afterdeck. The four women (three students and a faculty member) were assigned two tiny nearby cabins, each with a pair of bunk beds. The male faculty and ship's physician occupied two other small cabins off the same hallway. The 16-member crew was essentially a community apart. They had their own work to do, separate meal times, and their own quarters in the bow.

Our meals were served at 7:00 a.m., 12:00 p.m., and 5:00 p.m. in the central salon, which also functioned as a classroom and research space. Following an old sailing tradition, "dinner" was at noon. We ate at a long gimbaled table. The food was ample and generally good. On a special occasion, however, it could be *splendid!* But, as this was a Stanford University "campus," *Te Vega* was a dry ship; no alcohol was allowed on board.

The Research Concept

Organizing the scientific program for Cruise 5 was a challenge for Don Abbott. We would cross three huge ocean basins as deep as 4,000 m, and we would spend long periods far from land. Furthermore, most of the faculty had limited experience in biological oceanography, and the graduate students virtually none. Don had a former student at the US Naval Postgraduate School in Monterey, Eric Barham, who had done his PhD thesis on the deep scattering layer—the acoustically dense layer of organisms characteristic of the deep ocean. The DSL was known to migrate toward the surface at night and return to the depths with dawn. Fishes with gas-filled swim bladders were thought to be the basis of the sonically dense bands, but a diversity of planktonic invertebrates was associated with them. The Navy was interested because it had become clear during WWII that a submarine could mask its movements below the DSL. Don Abbott designed the DSL project based on a research course at Stanford's Hopkins Marine Station that concentrated on a single broad research topic or a particular organism, with the students taking on individual pieces of the whole project. "Since the cruise was to cover over 5000 nautical miles of open sea," Don wrote, "plans were made in advance to organize the major work of the ship around a community-type ecological study of the mesopelagic or DSL biota." Our long, open-ocean cruise track provided an ideal opportunity to study the DSL in a relatively unknown region. Don assembled a large library of relevant references, ensured we had adequate equipment, and wrote a draft research outline. As the cruise began, he guided us toward making this outline our own.

In many ways, we were remarkably lucky. We had two depth sounders, each recording on long rolls of thermal paper. The primary unit was a Simrad sonar with a stable power supply that was set to record the upper 1,500 m. The backup was a Simrad echo sounder, which was less useful because it lacked a power supply, so the fluctuations of the ship's generators affected the record. The rolls of paper from these sonar units were our only means of visualizing the DSL and targeting particular features with our trawls. Even more risky, we had only one Tucker trawl, and it lacked an opening and closing feature to limit collecting to particular depths. We partially compensated by shooting the trawl rapidly and vertically to depth and then retrieving it vertically and rapidly. We determined the depth of the net from the deck by the length of wire out and its angle at the sheave as measured with a simple wire clinometer. We made some modifications to the trawl as we went along, including adding a flow meter. Fortunately, this relatively primitive gear functioned reasonably well and we encountered no difficulties exceeding our limited repair capabilities.

Mombasa to Seychelles

Cruise 5 left Mombasa, Kenya, in the early afternoon of October 5, 1964. Five miles (8 km) out, the skipper ordered the sails raised, and the schooner sailed for the rest of the afternoon with engines turned off. It was a marvelous beginning!

Or it *should* have been. The sea soon became quite rough. And so, after three hours, most of those aboard were queasy or downright seasick, stretched out on the deck or down below in their bunks. This, despite all having taken anti-seasick pills. It was several days before everyone was back in top form. Meanwhile, faculty and students quickly discovered the cook's sense of humor. First day out, he served greasy pork chops and cauliflower. The smell was nauseating, especially to those who could keep down only corn flakes and milk.

Despite lingering seasickness, we at once began a series of sonar and trawl stations that continued almost daily, standing assigned watches and rousing additional help when there was difficult work such as pulling in the trawl. On deck, the trawl bucket was emptied into plastic basins and large organisms were taken out and photographed. The animals were sorted to major groups (siphonophores, molluscs, crustaceans, chaetognaths, urochordates, and fishes), and they were assigned to "specialists" in our party.

This was exciting work—you could never predict what would be in the trawl when it arrived on deck. Further sorting, however, was another, more tedious story. Anyone who has tackled microscopy at sea, on specimens sloshing back and forth with every pitch and roll of the ship, will relate to our need for frequent breaks. One of our group composed a little ditty honoring this task: *Micro-penaeids, those dirty little nippers, I see them in my sorting glass and crush them with my clippers*.

We made good use of our shipboard library of taxonomic reference works.

For example, key references for the midwater crustaceans were a series of folio-sized tomes published as long as ago as 1852 with amazingly intricate black-and-white line drawings and diagrams of many species.

Our job was to describe and correlate the DSL's content and how it moved over time and depth as revealed by measuring the blurry brown bands on the thermal paper of the echo sounder.

As time went on, it was clear that a classification of the sonically dense bands on the echo sounder was needed: some features were consistently present while others appeared only at certain times of day or at particular depths or locations. The very dense bands were called "layers" and were further defined by depth and by time of day. Lighter traces were called "curtains" and similarly distinguished. We recognized that this classification was a matter of convenience, but it helped to bring order into the search for patterns correlating the sonic traces with our trawl hauls.

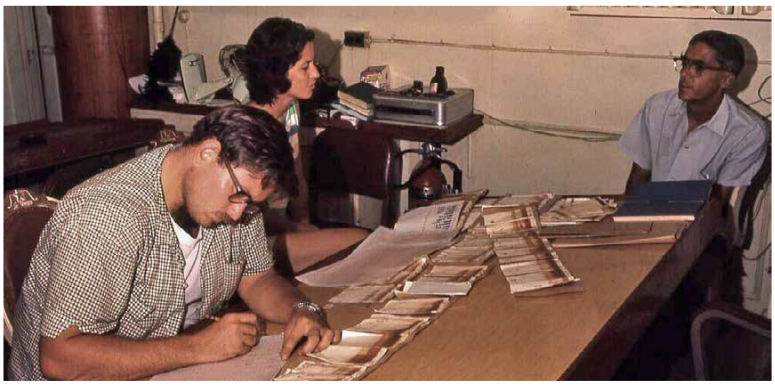
Indeed, we had plenty of work to keep us occupied. But being cut off from family and friends was a bit hard. With luck, there might be mail from home at the islands where the ship called. The sole other connection was radio—"Voice of America" kept us updated on the US presidential election, Goldwater versus Johnson. Can today's oceanographers even *imagine* being so disconnected? No satellites, no GPS, none of the sophisticated navigation that guides ships now. Our crew navigated by charts and a sextant (invented in the eighteenth century). No movies on laptops, no music on iPods, no email or Internet, indeed, no computers of any kind. Oh, well, we did have some music, from a tape player in the salon. Favorite student pastimes were darts (made especially challenging by the ship's roll); playing bridge, casino, or cribbage; writing in diaries; or just reading, talking, loafing on deck, or sitting on the ship's bowsprit, watching flying fish. And when the sails were up, the bow of the rocking and rolling ship offered a wet roller-coaster ride.

What we did have was more time to connect person to person and to watch the world go by. The ocean's surface was a continual show. Like the Grand Canyon in Arizona, it changed hues and moods as each day progressed. It was sometimes the gaudiest blue imaginable. Then, it would gradually soften to a cooler hue and turn grayish. In the late afternoon, it might take on a metallic tint—turning dark with silvery highlights at sunset.

Evenings often found students and faculty sitting on the deck, watching brilliantly luminescent spots in the water. At night, depending on the tack, the ship's lower ports might be below the surface, offering a spectacular underwater light show, with sparkles and skeins of light, and occasional large flashes in the distance.

After about a week at sea, we arrived at Port Victoria on Mahé in the Seychelles, then a British colony occupying a series of granitic, continental islands. We moored at the end of the port's Long Pier, where there were many local sailing vessels that carried bananas, coconuts, and other goods throughout the archipelago. We were the only foreign ship to call in quite a long time, and so *Te Vega* was met by Madame Mancham, half French, half Greek, the large and jolly wife of a wealthy beer and liquor importer. The couple welcomed us with a party in their beautiful home, together with other guests. Their son James Mancham, then in law school in England, would become the first President of the Republic of the Seychelles in 1976.

The island's rocky cliffs and rugged volcanic mountains covered with lush greenery, the botanical garden with its rich array of local plants, and Seychelles giant tortoises, flying foxes, and black parrots all piqued our interest in tropical biology. A later highlight was a trip to Praslin Island, home of the endemic black parrot and coco de mer or sea coconut



[above] A deckhouse contained a compact lab space with microscopes for examining plankton from the trawls; gimbaled tanks occasionally accommodated fishes. *Photo courtesy of John Ogden*

[left] Tabulating data from the DSL records: Dick Barber, Sharon Proctor, and Don Abbott, analyzing and discussing the DSL traces. The darkest tracing at the top is the surface echo. Below this are the bands of creatures whose bodies reflect the sound waves at different depths. Cruise participants called the darker bands "layers" and the lighter ones "curtains."

(both species now listed as threatened).

Our two-week stay in the Seychelles enabled us to do individual projects. Early on, we collected fishes near Sainte Anne Island in Cascade Bay by distributing rotenone from plastic squeeze-bottles over an area of coral reef. For a while, the deck of *Te Vega* was crowded with pails and basins as we sorted and preserved the collection for eventual shipment to the Smithsonian Institution. In addition, Mariscal studied anemone fishes and Ogden damselfishes that appeared to divide their coral habitat behaviorally, much like warblers in temperate forests. Wynne focused on collecting seaweeds, and later described the new red algal genus *Rhodolachne* from the Seychelles.

The Seychelles proved to be the tropical paradise of everyone's dreams. For many of us, these islands laid the foundation of a lifelong fascination with the tropics and a firsthand appreciation of the risks now faced by the tropics, so exceptionally biodiverse in their lands and waters.

Seychelles to Maldives

One day, between the Seychelles and the Maldives, the water was too rough to trawl. The crew, however, chose to keep the sails up. That evening, students and faculty were in the salon reading, relaxing, playing cards, talking. Suddenly, a squall threw the ship over, close to her beam-ends, and the gimbaled table hit someone's knees, sending plates, cutlery, and papers flying across the salon. There were crashing sounds above and below deck, as furniture and equipment broke loose. As if this weren't enough, a loud burst of sound announced release of a self-inflating lifeboat. The ship hung there, heeled over—until the mainsail and a smaller sail suddenly blew out with more explosions of sound, and the schooner heaved upright.

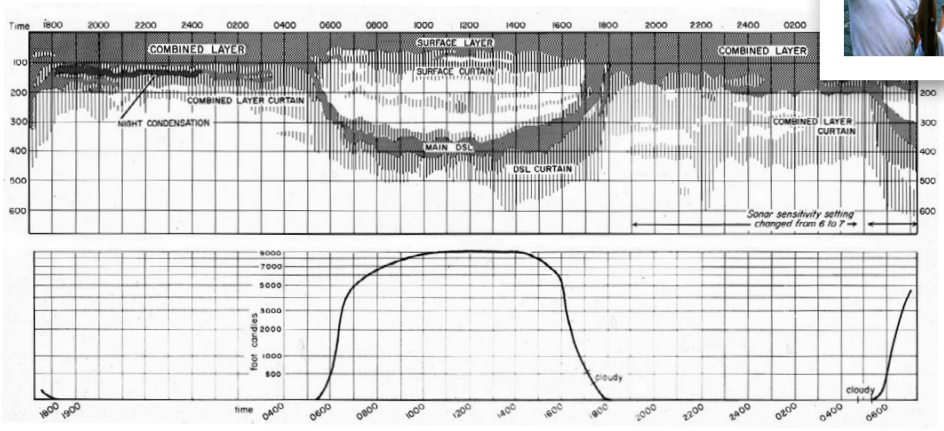
The captain was determined to retrieve the lifeboat. Students were ordered to stay below deck while the crew maneuvered the schooner. Looking out through the portholes, we could see the boat's red light bobbing in the choppy waters. And every so often, lightning flashes would illuminate it. With great difficulty, the crew finally recovered it. From this point on, with the lifeboat perched atop the forward deckhouse like a graceless hat, *Te Vega* moved under engine power only, and our DSL research resumed with little interruption.

After another week at sea tracking the DSL on the Simrad and working the trawl, we arrived in Malé, in the Maldive Islands. As in Mahé, Seychelles, we were the first foreign ship to call in a long time. The Maldives were ruled by a sultan, and the island and dwellings, while poor, were meticulously maintained—gleaming white, as many buildings and walls were made of coral blocks and the roads of neatly swept coral sand. The residents were eager for foreign currency so they could buy international goods, and our ship provided a ready source. All kinds of things were thrust at us for sale. Several on board bought builders' models of the Maldivian *doni,* a graceful lateen-rigged sailboat, or beautifully carved coconut-wood boat bailers, whose price rapidly inflated with the sudden demand.

Malé's friendly inhabitants were Muslims, and the women dressed in traditional attire with long sleeves and long skirts. What it meant, of course, was that we visitors from North America stood out dramatically, especially our women in short dresses. But the cultural distance soon shrank. When Don pulled out a Polaroid camera and presented the instant prints to their subjects, the children's excitement drew everyone together.

The small islands surrounding Malé were largely uninhabited except for a few

[right] Cruise 5 scientific party in Singapore at the end of the trip. Left to right foreground: Richard Mariscal, Don Abbott, Jay Christofferson, Wes Fielding, Richard Bovbjerg, Leighton Taylor, Jeanne Christofferson, Vicki Buchsbaum (Pearse), Margaret Bradbury, Sharon Proctor. Behind: Mike Wynne, John Wourms, Richard Barber, Merrill McPhearson; above, John Ogden, Paul Stromborg.



[left] Diagram of scattering layers from a 37-hour long sonar recording in the Bay of Bengal. Vertical scale is exaggerated. Below is a curve representing light-intensity readings (measured in foot-candles) for the 37-hour period. To the right of the light-intensity graph, four triangles show the angle of elevation of the moon at four times during the second night. *From Bradbury et al. (1971)*

families guarding coconut trees and one with a primitive factory turning coconut husks into fiber rope. Perhaps because of the lack of disturbance, the surrounding reefs were exceptional, the corals and fishes even *more* beautiful than those in the Seychelles. We took time to snorkel and scuba dive on these reefs, and some of our best coral-reef photos are from here.

Maldives to Ceylon

Compared to the first long legs of the cruise, we fairly jumped across the gap between the Maldives and Ceylon (now Sri Lanka). On arrival in Colombo, the ship had some mechanical problems, and while these were repaired, we set out to experience Ceylon. We shared Colombo Harbor with freighters and other ships from around the world, and the town offered small shops selling goods of equal diversity. On a three-day bus tour of the country, we passed huge tea plantations, elephants dragging large logs to sawmills, and numerous ox carts. A highlight was a visit to Sigiriya, the site of an ancient fortress palace atop a massive column of rock rising nearly 200 m above the flat landscape. Each night was spent in a government guesthouse.

Such changes of pace during our land segments contributed significantly to the cohesiveness of the research team and allowed us as individuals to be more effective during the intense periods at sea, an important element of program design for sea education involving cruises of long duration.

Ceylon to Phuket

Repairs to the ship completed, we departed Colombo and headed toward the Nicobar Islands and Thailand, continuing our DSL recordings and trawl hauls. About midway across the Bay of Bengal, we stopped the ship and did a 37-hour continuous, high-resolution recording of the DSL during a period when the sea was flat calm. Although we had already made many recordings during the cruise, we were always moving. We felt it was important to record a complete daily cycle of the DSL in one location in order to place our other observations within a daily context. Calm water was essential, as during the recording, the main engine would be turned off to minimize sonic disturbance.

The sun was very hot, exaggerated by the sea's mirror-like surface, and we went snorkeling about the ship in the wonderfully transparent water ~4,000 m deep. We saw some of the gelatinous plankton intact for the first time, as in trawl hauls they were torn to pieces by the net. Particularly spectacular was a Venus's girdle (*Cestum veneris*), a meter-long belt-shaped ctenophore, perfectly transparent with glistening comb rows driving its undulating movement through the calm sea. A small oceanic white-tipped shark (*Charcharinus longimanus*) showed up, promptly took a baited hook, and was hauled on board. Its stomach was empty.

At the end of the 37 hours, Don and the captain declared Thanksgiving, a day early, and the cook prepared a fabulous feast. Not only that, but bottles of liquor and wine appeared from nowhere (remember, this was a "dry ship"), and everyone enjoyed a rollicking cocktail hour before dinner.

Underway again, *Te Vega* entered the Andaman Sea, and after several days anchored off Phuket, Thailand, a sleepy fishing village with tiny shops and restaurants unaccustomed to visitors, at the head of a huge, muddy estuary.

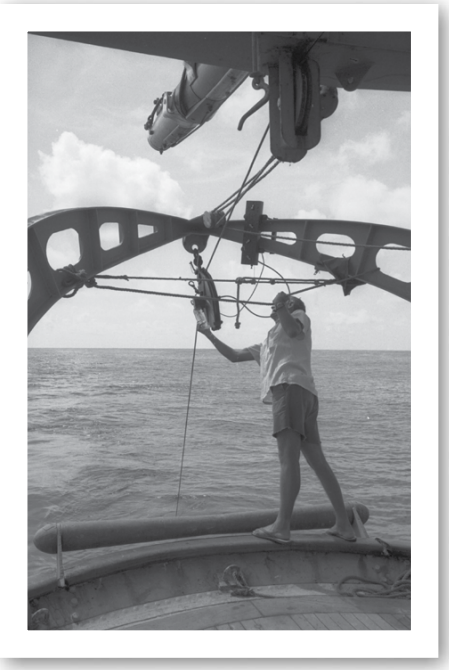
Close by in Maya Bay was Phi Phi Don, then a virtually uninhabited island with a thriving coral reef. From there, we visited the vertical limestone karst islands formed of towering, uplifted coral reef, some deeply undercut by wave action and eons of grazing by small intertidal gastropods. We passed through a narrow channel into the huge hollow center of one of the islands. The echoes of bird calls in the deep silence and twilight of this space, with the circle of sky overhead, were eerie and beautiful. On the tiny beach, we found exotic shells, including those of chambered nautilus. Some islands had a web-like scaffolding of bamboo poles leading from the sea surface to the highest point. People climbed these primitive and dangerous structures to gather swallows' nests for bird's nest soup, a delicacy that we got a taste of a few days later when the ship stopped for two days at Penang, Malaysia.

Phuket to Singapore

As the end of the cruise approached, we used much of our final week to analyze and discuss our data—or as much as we could before we left for home. The pressure to bring our work to a satisfying conclusion played out in intense debate around the salon table in those final days. A major issue was whether or not the DSL was a "community" in the ecological sense. Was it a consistent association of organisms in space and time with a predictable trophic structure and commonality of behavior and interaction? Or were the organisms of the DSL simply living within their individual habitat requirements and moving independently? We understood that resolution of this question might not be possible, as studies of midwater plankton were much like the proverbial blind men and the elephant, but it became important as passionate positions were taken. Don Abbott calmly presided over the contentious discussion and guided it with a gentle hand. Only later did we come to appreciate his "method" approach to teaching.

As we proceeded at night down the Strait of Malacca, alleged to be the world's most dangerous waters on account of piracy, our ship's party became increasingly uneasy, a feeling heightened by a patrolling British frigate. A large, sleek schooner such as *Te Vega* could be a prime target, and someone asked if there was a gun on board—an idea that dismayed Don even more than the possibility of pirates. But we got through without incident.

Cruise 5 ended in Singapore on December 12, 1964. Everyone said their good-byes and left the schooner, knowing they would never forget their incredible *Te Vega* experience. Among the souvenirs we took home, besides our memories, were strips of the mainsail torn by the



[above] Our gear was primitive. The depth of the net was estimated from the length of wire out and its angle. *Photo courtesy of John Ogden*

storm, giant nuts of the coco de mer and seashells (including giant clams) from the Seychelles, star sapphires and other stones from Ceylon, wooden jars and model boats from the Maldives, tin bowls from Phuket, and, of course, photographs (a published collection can be found in Mariscal, 2010).

The Islands Today and Tomorrow

The islands we visited so many years ago have changed dramatically. Expanding human populations, development, and airports bringing tourists have greatly altered the towns, the coral reefs, the forests, and local wildlife. The Maldives, for instance, are now a popular dive destination, with a busy airport, high-rise condominiums, and resorts lining the shore. The formerly luxuriant reefs are damaged.

At the same time, forces larger than new local development are at work. Rising sea level will soon claim the Maldives in spite of extensive armoring of the coast; with an average ground level elevation of 1.5 m above sea level, this is among the lowest countries on Earth. The great earthquake and tsunami of December 2004 destroyed much of the tourism infrastructure in Phuket and the surrounding islands as well as major parts of coastal Sri Lanka. Coral bleaching driven by ocean warming has degraded many of the coral reefs along our track, and reef fishes are in sharp decline.

[above] Giant heteropod (a pelagic gastropod) taken in a trawl. The gelatinous body is nearly neutral in buoyancy, and the relatively small, thin shell (at top) adds little weight. *Photo courtesy of Richard Mariscal*

THE DUAL GOALS OF CRUISE 5: EDUCATION AND RESEARCH

The two major goals of Cruise 5 were (1) the education of graduate students, and (2) research—in particular, representing the United States in the International Indian Ocean Expedition. Combining these goals in an extended shipboard experience on the other side of the planet was a bold experiment.

Our chief scientist, Don Abbott, had practiced this approach in his teaching, and he extended it in his design of Cruise 5. The success of this experiment remains an outstanding testament to Don's wisdom and thoughtful guidance. We dedicate this account to him. He wrote afterwards:

The experiment of trying to organize the main work of the cruise around a single broad and many-sided research project, planned and carried out cooperatively by faculty and students…is recommended for future cruises… The ship and its gear proved adequate for the project, though by no means ideal. However, the intellectual quality and enthusiasm of the students is a much more important factor in the success of a project such as we undertook than the refinement for sophistication of the gear… Indeed, the necessity to improvise and make do with what is available in itself provides a desirable stimulus and intellectual challenge to a competent and energetic group. Periodic interruption of effort on the main project for work on other an unrelated things is highly desirable, and all students should be encouraged to undertake small individual projects of their own, and allowed time to work on them.

Working as a team on exciting research was at the heart of our time on board. Through the hard work of Margaret Bradbury, the results of our DSL study were published, with all students and faculty sharing authorship (Bradbury et al., 1971). We were already a motivated group, enrolled in graduate programs, but we were at different stages in developing our personal research goals. Some of us had already chosen research topics, while others were still broadly seeking a direction. Certainly, all of us gained a deep appreciation for biological oceanography.

That said, it is still worth considering the ultimate value of such an expensive program. It turns out that nearly all of the Cruise 5 and other participants in the *Te Vega* program pursued careers in marine science and education. And they all tell the same story: the integration of onboard instruction with research and the overall experience greatly influenced their lives and careers. The students and faculty lived intimately with the ocean (and with each other) every day around the clock for close to three months. It was life changing.

Specifically, several Cruise 5 students emphasized tropical organisms and environments in their research careers, contributing significantly to knowledge of these relatively poorly known faunas, floras, and regions of the world. The *Te Vega* program sought to educate graduate students, but its influence reached beyond the participants to the students they later taught, from kids to adults. *Te Vega* students went on to become *Te Vega* faculty or participated in shipboard education and research in other programs on other ships. And they

applied in their teaching what they had discovered about the value of hands-on experience in the field. For example, Jay Christofferson relates, "The biggest impact of *Te Vega* was on my teaching, in particular the importance of experiential learning." He led students in marine biology projects in Jamaica and Belize, and they said it was a life-changing experience for them, too.

What Else Changed?

In today's biological sciences, women are a majority among graduate students, and the numbers of female faculty members are growing. But in the 1960s, women were a small minority in biology, especially aboard ships. For Cruise 5, Abbott enlisted Bradbury as one of the faculty, but only three of 12 graduate students were women. Although this ratio was pioneering at the time, today's women are far better represented in science.

According to Proctor, she gained aboard *Te Vega* "a strong permanent feeling of self-confidence that has served me for over 50 years." She owes this, she says, to the ship's physician being a natural-born psychologist; several crewmembers also confided in him. Another participant likewise mentioned the importance of finding another sympathetic confidant among the ship's company during a difficult personal time. The confined, isolated shipboard environment, free of outside interference, can facilitate deeply meaningful interactions.

A further measure of the *Te Vega* program's lasting impact is the participants' enthusiasm for three reunions held decades later (in 2005, 2009, and 2013) at Hopkins Marine Station in Pacific Grove, California. Over 50 alumni representing nearly all of the 20 cruises came together from all over the country. They shared with each other what the *Te Vega* meant to their lives and careers and what they felt they learned from it. At all three reunions, the experience was shared with undergraduates in the university's current shipboard program, Stanford at Sea, which offers a broad, maritime curriculum that includes—besides general principles of oceanography—literature, history, marine conservation, navigation, ship handling, and more. Interacting with *Te Vega* alumni appears to be nudging it increasingly toward oceanography and marine science.

Over a half-century later, the influence of the *Te Vega* program continues to spread.

LESSONS LEARNED

From the earliest days of sail, teachers and parents have recognized the benefits of an at-sea experience for educational and personal growth. While research vessels at a number of institutions include graduate students in research at sea, Stanford's *Te Vega* program was unusual in mixing graduate education in marine sciences with an extended shipboard experience. Today, prominent undergraduate programs include Stanford at Sea, already mentioned, and Sea Semester, both affiliated with the Sea Education Association, and Semester at Sea of the Institute for Shipboard Education. In addition, many other organizations and individuals offer educational cruises to students in secondary school and college. *Te Vega* herself, after being sold by Stanford in 1969, continued in education with the Flint School and, from 1981 until the mid-1990s, with the Landmark School, in a program that specialized in secondary students with language-based learning disabilities.

An enterprise such as Stanford's *Te Vega* program does not come cheap. It demands a huge amount of funding and a prodigious amount of work. We are asked, what was learned that could enlighten and motivate ocean science education today? We learned that field time makes us all into advocates for environmental protection and conservation. We experience a greatly heightened, lasting appreciation for natural beauty, a powerful realization of what an incredible treasure our Earth is. With multiple threats looming, never has it been more vital to understand the oceans than it is now. An African proverb says: "You protect what you love. You love what you know." And you know deeply only what you have personally experienced. The central lesson is the importance of experiential learning.

REFERENCES

Bradbury, M.G., D.P. Abbott, R.V. Bovbjerg, R.N. Mariscal, W.C. Fielding, R.T. Barber, V.B. Pearse, S.J. Proctor, J.C. Ogden, J.P. Wourms, and others. 1971. Studies on the fauna associated with the deep scattering layers in the equatorial Indian Ocean, conducted on R/V *Te Vega* (during October–November 1964). Pp. 409–452 in *Proceedings of an International Symposium on Biological Sound Scattering in the Ocean.* G.B. Farquhar, ed., Department of the Navy MC Report 005.

Mariscal, R.N. 2010. The International Indian Ocean Expedition *Te Vega* Expeditions of Stanford University Cruise 5: East Africa to Singapore. Published by the author.

Maslow, A.H. 1964. *Religions, Values, and Peak Experiences.* Ohio State University Press, Columbus, Ohio, 123 pp.

Privette, G. 1983. Peak experience, peak performance and flow: A comparative analysis of positive human experiences. *Journal of Personality and Social Psychology* 45:1,361–1,368, http://dx.doi.org/10.1037/0022-3514.45.6.1361.

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