The First Century

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The Bermuda Biological Station for Research

The Bermuda Biological Station for Research, Inc.
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Like most projects at the Bermuda Biological Station for Research, this history of BBSR's first century was very much a collaborative effort.

The primary author of the history was a volunteer, Michael Windsor, who was aided by BBSR Education Officer Helle Patterson in writing the first draft during the 1990s. The text was updated to include the final years of BBSR's first century.

Dr. and Mrs. G. Hein Besselaar graciously offered to underwrite the cost of this printing in honor of BBSR's centennial.

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Premier of Bermuda

In this very special year, when **the Bermuda Biological Station for Research (BBSR)** celebrates 100 years of science and education, it is a special pleasure to have the honour of providing an introductory message for the long-awaited history of this extraordinary institution.

When **the BBSR** was established in 1903, the founding scientists could hardly have imagined that their labour would lead to the longest continuous oceanic database in the world.

The Bermuda Biological Station for Research has come a long way since its inception, and over the years, it has provided the scientific community with quality facilities to conduct research and science education. In addition, the wider Bermuda public has benefited from the internationally renowned, award-winning JASON Project and the Bermuda Schools' Science Enrichment Program, both of which have enriched the lives and the quality of the environment for present and future generations.

Over the last one hundred years, increasing numbers of visiting scientists have made amazing discoveries off Bermuda's shores. This special book, a long awaited history of the Bermuda Biological Station for Research, allows us to proudly reflect on the valuable contribution that the BBSR has made to Bermuda and to global oceanography. It also serves as a reminder of the significant impact that **the BSSR** has had on our understanding of the ocean and provides added resolve to renew our commitment to oceanographic protection and preservation.

As a Trustee of the Bermuda Biological Station for Research, I am a dedicated supporter because of their enduring efforts to promote a greater consciousness and concern for the quality of our environment. On behalf of the Government and people of Bermuda, I want to acknowledge and applaud the work and achievements of **the Bermuda Biological Station for Research** and extend sincere best wishes and congratulations on reaching this important milestone.

The Hon. Jennifer M. Smith, DHumL, JP, MP

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FOREWORD

The founding of the Bermuda Biological Station for Research (BBSR) was part of a rapid expansion of seaside laboratories in Europe and the United States at the turn of the century. This expansion was driven in part by Darwin's revolutionary ideas on biological evolution and the opportunity to test these concepts by exploring the vast realm of marine organisms. Bermuda was a special opportunity. It was an isolated island, and, unlike European and U.S. laboratories, deep water was only few thousand meters away. Most importantly before air travel, it was not too far distant from major East Coast ports in the United States.

BBSR has both nurtured and launched the careers of a number of very important scientists in the past, and there is every reason to believe that this tradition is continuing. As this recapitulation of the first hundred years suggests, BBSR was a success from the beginning. It attracted leading scientists such as Wesley Coe and Henry Bigelow, whose publications in the *Proceedings of the American Academy of Arts and Sciences* contributed to BBSR's reputation and indicated the opportunities available for future work. Subsequent studies have shown that the Beebe-Barton dives in the Bathysphere in the mid-1930s were more than the media spectacle some feared. Beebe described with considerable accuracy some of the strange biological world one meets beneath the surface layer of the ocean.

Nowhere can one better appreciate the growth and diversity of BBSR than by reviewing the 1,783 scientific publications associated with BBSR during its first hundred years. As might be expected, most of this effort has come since World War II, in line with the worldwide explosive growth of science in the latter half of the twentieth century. But what I find most exciting is the breadth of these publications. They range from the taxonomy of a land snail unique to Bermuda to the measurement of complex ocean eddies first found near the island and later shown to be an ocean-wide phenomenon. Some of the first definitive measurements of the biological production rate in the supposed desert of the Sargasso Sea were made by scientists working out of Bermuda, as were measurements of human-produced chemical tracers carried to Bermuda in the westerly winds from the East Coast of the United States.

There were few resident scientists at BBSR until recently. During most of the first hundred years, there was at most a caretaker-director who may have taken advantage of the opportunity to engage in his own science, but whose main task was to ensure adequate facilities for the visitors who came to the laboratory. Those who visited came because of the opportunities the island offered for both observations and sampling. Consequently, all BBSR publications were associated with the Bermuda environment. That began to change in the mid-'80s as the full-time resident scientific staff began to grow. All came to BBSR because of the opportunities provided by Bermuda and its central-Atlantic location, and nearly all research continues to be Bermuda centered. But occasionally the scientific trail leads far from home; for example, Dennis Hansell and Craig Carlson have studied the complexities of organic carbon distribution not just in the waters near Bermuda but as far afield as the Antarctic Ocean.

Perhaps the programs for which BBSR is currently best known are studies associated with the small year-to-year changes in the open-ocean environment. They were first begun in 1954, nearly 50 years ago, with the goal of continuously monitoring mid-ocean temperature and salinity from the surface to the near bottom. Trips are made approximately every two weeks to the same location some 15 miles offshore. Chemical observations were soon added to the measurement list. Later an additional site some 50 miles offshore was added and the menu of observations further enlarged. Together these sites provide some of the most detailed open-ocean data available, and the 1954 site provides the longest continuous set of open-ocean observations anywhere in the world.

For many years BBSR has not limited itself to fundamental research. It has in the past and continues in the present to provide assistance to the Bermuda Government on issues ranging from possible pollution of the nearby reefs from human activity to monitoring the air emanating from the island's incinerator. Since 1960, BBSR has played host to a growing number of both visiting high school groups and undergraduates from the United States, Canada and Europe. A limited number of formal summer courses for both graduates and undergraduates also began in the '60s, and currently BBSR runs programs ranging from a joint educational effort with Duke University to hands-on laboratory experience for selected undergraduates.

As a reading of this history makes very clear, the success of BBSR owes much to the continuing efforts of a number of dedicated people from Edward Mark and Edwin Conklin in the early years to Alfred Redfield and Tony Knap in more recent times. It has not always been easy. It was not until 1931 that BBSR found its present permanent home after four moves in its first 28 years. There was the problem of rebuilding and regaining momentum after the laboratory shut down during World War II. As with scientific and cultural organizations everywhere, the task of securing adequate baseline financial support continues, although I believe a case can be made that the task is more daunting in a relatively isolated environment such as Bermuda than it might be elsewhere. But BBSR has been a success, and it is a success. I believe it is stronger now than it has ever been. As it rides into its second century, those who have been associated with the Bermuda Biological Station for Research have reason to be proud.

John A. Knauss, Ph.D.
Former Administrator
National Oceanic and Atmospheric Administration
January 17, 2003

The First Century

ONE

Early Expeditions

The first BBSR expedition group arrived in Bermuda in the summer of 1903

On December 21, 1872, an adventurous group of biologists, chemists and physicists set sail from Portsmouth, England aboard the *HMS Challenger* on a journey around the world. Among the expedition's ports of call: the tiny mid-Atlantic islands of Bermuda.

Those researchers are now credited with the birth of modern marine science. During their three-and-a-half-year expedition, an extraordinary quantity of data was collected under the direction of Wyville Thomson, a professor of natural history at Scotland's University of Edinburgh. In the field of oceanography, the depths of the oceans were established, and temperature and salinity were measured. Just as significant was the expedition's contribution to taxonomy, with 4,717 new species classified, probably the greatest single contribution in history to that field.

Over the subsequent two decades, expedition naturalist Sir John Murray and more than 100 other scientists produced a 50-volume report that details the cruise's many scientific discoveries. Upon the publication of the report's final volumes in 1895, Sir John described it as "the greatest advance in the knowledge of our planet since the celebrated discoveries of the fifteenth and sixteenth centuries." The venture, like Charles Darwin's 1859 *The Origin of Species*, captured the public's imagination and did much to promote biological sciences, particularly marine biology.

During the late 1800s, many of the most famous and influential biological research institutions were established, including Naples Biological Station in Italy in 1872; the Marine Biological Laboratory at Woods Hole, Massachusetts, in 1888; and the Hopkins Marine Station in California in 1892. The Scripps Institution of Oceanography was launched as the

Marine Biological Association in San Diego, California, with William E. Ritter performing research in the region from 1892 onward. A grant from the Scripps family in 1903 led to the subsequent name change.

Following the successful establishment of these scientific stations in other locations, some scientists turned their attention to Bermuda. It is a natural place to investigate, which is an assertion that crops up frequently in the history of the Bermuda Biological Station for Research (BBSR).

Bermuda does not sit on a continental shelf: the islands are the exposed portion of an ancient and extinct volcano. The sides of the volcano fall steeply down into the ocean, providing not only an island more than 500 miles from any other landmass, but one surrounded by deep water. In contrast, a ship would have to travel for two days from any East Coast research station to reach such deep ocean.

At the end of the nineteenth century, deep water was desirable for oceanography, but of relatively little interest to most biologists. Indeed, the man most responsible for BBSR's creation, Professor Edward Laurens Mark, gave an address at Harvard University in which he listed the main advantages of a station in Bermuda as the relatively short time it took to get to the island from New York and the good climate and conditions of life to be found, as well as the "brilliantly colored animals that inhabit [Bermuda]; a source of surprise and delight."[1] However, the sea surrounding the island offered abundant collections of a limited number of organisms. This was an ideal situation for researchers needing large quantities of a particular species and those wishing to conduct their studies in a controlled environment.

Although Professor Mark is regarded as the "father" of BBSR, perhaps the title of pioneer should go to Professor Charles Bristol. He first came to Bermuda in 1897 with a group of students from New York University and decided that it would be a good place to start a proper research institution. When Mark received a similar suggestion from the president of Harvard University, Professor Charles Eliot, Mark and Bristol decided on a joint undertaking of the project.

At the invitation of the Bermuda Natural History Society (BNHS), Professors Mark and Bristol arrived in Bermuda in April 1903 to assess possible locations for both a new research station and an aquarium. Their goal was to find a site that might serve until the colonial government would be able to establish a permanent station for biologists. Professor Mark soon provided a detailed account of BBSR's first days in the *Proceedings of the American Association for the Advancement of Science* (AAAS).

Through the enthusiastic interest of Dr. Bristol, in cooperation with the BNHS, the colonial government had been encouraged to consider the idea of establishing a public aquarium for residents and tourists, as well as a marine laboratory for biological investigations. A Joint Committee of the Legislative Council and the House of Assembly, consisting of Sir S. Brownlow Gray, chief justice, Hon. Eyre Hutson, colonial secretary, and assemblymen J.H. Trimingham, Nathaniel Vesey and A. Gosling, was appointed to consider the advisability of establishing such a station, and in due time reported favorably on the undertaking. The governor, Lieutenant-General Geary, at the suggestion of the committee, entered into correspondence with many institutions and individuals both in Europe and America with a view to ascertaining their opinions as to the desirability of establishing such a station and the possibility of their cooperation. The replies were all favorable, and a certain amount of support was promised.

Upon their return to the United States, with sufficient funding secured, they issued an

The Hotel Frascati in Flatts, photographed here in the early 1900s, was BBSR's first home

invitation to biologists in the name of the BNHS and the universities they represented. They invited the scientists to share in the privileges of a temporary biological station in Flatts, Bermuda, for six weeks. As Professor Mark noted, "The generosity of the BNHS and the liberality of our friends allowed us to provide ample means for collecting and all the requisites for laboratory work, except that we had no running water in the laboratory. The building, however, was only a short distance from the sea, so that this deficiency was not very serious."[2]

Through the favorable terms for transportation secured from the Quebec Steamship Co., and for board and lodging at the Hotel Frascati in Flatts (now the site of the St. James Court condominiums) it was possible to make the cost of staying six weeks at the station, together with transportation from New York and back, only $100. Thirty-seven people took advantage of this opportunity, and of those, 33 were engaged in the study of zoology or botany and four were travel companions. About a dozen of the visitors sailed from New York on June 20, 1903, with the remainder traveling two weeks later.

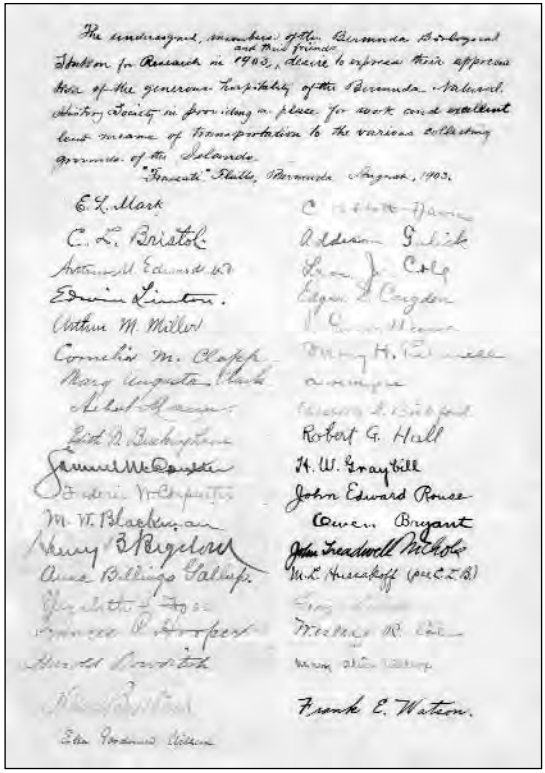
Arriving in Hamilton, the party was welcomed by Archdeacon Tucker, president of the BNHS, U.S. Consul W. Maxwell Greene, the vice-president, F. Goodwin Gosling, the honorary secretary, and other members of the society. A carriage ride of four miles over Mt. Langton and along the north road, from which there are magnificent views of the great north lagoon, brought the party to the hotel in Flatts.

Professor Mark's subsequent report to the AAAS Proceedings described the first BBSR laboratories, located in a new building on the hotel property, which had been divided by light partitions into several rooms.

> The laboratories were furnished with substantial work tables having ebonized tops and banks of drawers. A library of specially selected books and pamphlets from the libraries of the Museum of Comparative Zoology, the Boston Society of Natural History and the writer, several hundred in number, were arranged in the largest workroom. An ample supply of glassware, reagents and preservatives, dissecting lenses, microtomes, paraffin imbedding devices, and all the other usual equipment of a zoological laboratory were provided, as well as the necessary appliances for collecting, such as dredges, nets, seines, tubs, buckets, sieves, water glasses, etcetera, so that few wants were felt in this

direction by any of the party. The number of students was, however, so large that the laboratory was inadequate for the accommodation of all. When the second party arrived, therefore, a large ground-floor room in one of the stone buildings of the hotel was fitted up with portable tables for microscopic work.[2]

Therefore, when the first group of students arrived under the banner of the new organization on June 22, 1903, it was as a joint venture between Harvard University's Professor Mark, New York University's Professor Bristol and the Bermuda Natural History Society. The director of the expedition was Professor Mark, with Professor Bristol taking the title of associate director. Professor Bristol continued in this role for only three years, whilst Professor Mark remained the director of BBSR until the beginning of 1932 and was associated with it for the remainder of his life.


The undersigned, members of the Bermuda Biological Station for Research in 1903, and their friends desire to express their appreciation of the generous hospitality of the Bermuda Natural History Society in providing a place for work and excellent means of transportation to the various collecting grounds of the Islands.

"Fantome" Flotilla, Bermuda August, 1903.

E. L. Mark
C. L. Bristol
Edwin Linton.
Arthur M. Miller
Cornelia M. Clapp
Robert G. Hall
H. W. Graybill
John Edward Rouse
Owen Bryant
Frank E. Watson.

A letter of thanks, signed by all the participants and dated August 1903, was sent to the BNHS following the first expedition. It read: "The undersigned, members of the Bermuda Biological Station for Research in 1903, and their friends desire to express their appreciation of the generous hospitality of the Bermuda Natural History Society in providing a place for work and excellent means of transportation to the various collecting grounds of the islands."

During that first summer, regular excursions to collecting sites were made either by road or by boat. At this time, three boats were available. Professor Mark described them as follows:

> In addition to a 30-foot sail boat, with its glass-bottomed fish-well, such as the native fishermen use, the station was furnished in the summer of 1903 with a steam launch some 35 feet long – the *Minnow*. For three-fourths of her length she had a light wooden deck and side curtains, which could be lowered to keep out sun, rain or spray. Her pilot house was low but roomy and served as a forward cabin as well as a wheel house.[3]

In this launch, almost daily excursions were made to various parts of the archipelago, as the conditions of wind and tide favored this or that location. Professor Mark noted, "For all purposes except that of dredging, she was well suited to our needs, for, being of light draught, she could be used about the shoals and flats with safety and ease."

For dredging, a larger steamer, the *Intrepid*, was used for a part of the time in place of the *Minnow*. This steamer was provided with a boom in front of the pilothouse, which facilitated dredging operations.

This pattern of operation was continued for the next two years: the station was set up at the Hotel Frascati for just a few weeks during the summer in much the same manner. There were minor differences: a larger boat, the *Flora*, a 45-foot launch, was used in place of the *Minnow*. Money for equipment was donated by graduates of Harvard, and funding for BBSR was provided by agreement between Harvard and New York Universities. "All properly qualified persons (women as well as men), from whatever institution they came, were admitted without fees on equal terms."[4]

In 1906, the idea of establishing the research station on a more permanent basis was brought up again. The Natural History Society had arranged that the colonial government would build an aquarium and research laboratory near the bridge in Flatts, on land known as the Allen Estate. The government received a significant amount of its money in those days from the British War Department, which had army and navy bases in Bermuda. Unfortunately, these bases suffered a 50-percent cut in funding at that time and the department withdrew many of their men from Bermuda, which was a significant financial loss for the colony. Although the land had been purchased for the aquarium and laboratory, the building plans could not go ahead and there was nowhere to perform experiments. Therefore, no research program was held in 1906.

Among the pieces of land vacated because of troop withdrawal was Agar's Island, located in Hamilton Harbour just off Point Shares. By 1907, the BNHS had arranged to lease Agar's Island from the War Department for the small sum of £25 a year. This site would remain BBSR's home until 1931. Also by 1907, the agreement between Harvard and New York Universities had been dissolved and BBSR started afresh in its new location with Mark as the sole director. All the laboratory equipment was transferred to a building on Agar's Island and the large powder magazine on the island was transformed into a public aquarium, as Mark describes:

> The powder magazine is a massive structure of masonry built in the hillside; it is 150 feet long by more than 100 feet broad, and consists of 10 deep

BBSR moved from the Hotel Frascati to this site on Agar's Island in 1907

> alcoves with heavy arched ceilings, opening into a central passageway; the whole is roofed over with earth and surrounded by a broad deep moat open to the sky... The alcoves on one side are already finished and stocked with attractive animals. In this way, from 20 to 30 such aquaria are to be provided.
>
> It is safe to say that with the means so near at hand for keeping these aquaria freshly stocked with showy fishes and the other brilliant animal and plant forms of the sea, there are few, if any, places more favorably situated for maintaining an attractive public aquarium.
>
> Agar's Island is on the direct line of the ferry boats running between Hamilton and Ireland Island; it is distant from Hamilton only about a mile and a half... The aquarium will therefore be easily accessible to tourists and the public generally.[5]

The aquarium opened in 1908 and proved to be very popular. Mark Twain was invited to speak to raise funds and, no doubt, to provide advertisement for BBSR. A steam ferry took passengers to and from the island and the number of visitors was very encouraging. Records for 1910 show that 6,000 visitors were entertained that year – twice that of the previous year. This sharp rise was credited to interested tourists and a dependable steam ferry from Hamilton; it seems the service had been erratic until that point.

The rest of the three-acre island was leased to BBSR for a "nominal sum" by the BNHS, which also promised "to aid in all ways possible the development of the station." The property consisted of three cottages, with quarters plainly furnished for a dozen or more students. Fourteen people were at work there during the first summer. The laboratory was housed in a 20-foot by 70-foot building. The initial plan was for the building to be piped for running seawater and for fresh water, stored in immense subterranean cisterns. A valuable bronze pumping apparatus was secured, with a capacity of 2,000 gallons per hour, to pump seawater for both laboratory and aquaria. The laboratory was equipped with worktables, shelving and cupboards for chemicals, books and supplies, and afforded liberal work space for 15 or 20 students. Mark noted that the building had a verandah on one side and one end, "standing as it

does on a plateau about 30 feet above the sea, it catches the sea breezes and affords a delightful place for work." Mark's initial plan was for BBSR to be open year-round to investigators at a moderate expense, and during the summer months to have its facilities utilized, up to the limits of its capacity, for researchers in both botany and zoology. No formal classroom instruction was contemplated at the time.

The occupation of Agar's Island by the research station continued until the island was temporarily reclaimed in April 1917 by the British War Department during the First World War. Space was found "by the generous terms of the owner" on a nearby island, known variously as Dyer's or Denslow's Island, where BBSR transferred its property and reestablished the laboratory for the duration of this temporary eviction.

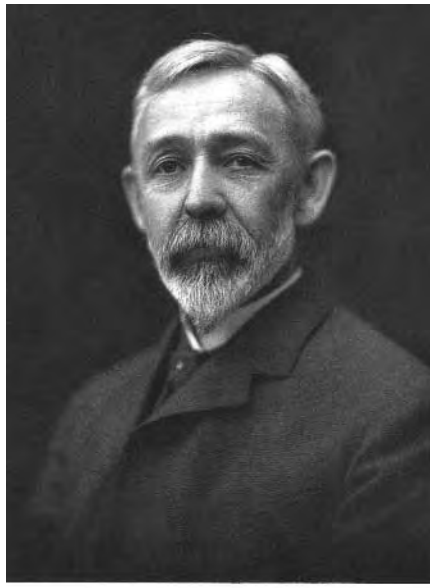
Gradually the concept of the station as a year-round venue for conducting research was beginning to be realized. In 1915, naturalist William J. Crozier was appointed to a year-round position at the station, with his wife occupying the posts of librarian and recorder. During this period, Crozier produced the majority of the papers, 14 between the years 1914 and 1916 alone, mainly in the field of mollusks.

In May 1919, BBSR moved back to Agar's Island and remained there until the present site in Ferry Reach was acquired. Despite the sale of the island in 1919 to the shipping line Furness, Withy and Co., the laboratory was allowed to continue occupying the property until relocating to its new premises in June 1931.

BBSR scientists work in their temporary facilities on Dyer's Island in 1917

TWO

Mark and the Natural World



E. L. Mark

BBSR's story is one of discovery. Perhaps more accurately, it is the story of a series of fascinating and intellectually inquisitive individuals who have built the institution over the last century and, in the process, made discoveries that have significantly advanced our understanding of the natural world.

The first of these individuals, BBSR founder Edward Laurens Mark, deserves a chapter to himself. Mark was born in Halet, Chatauqua County, New York, in 1847 and started his scientific career at the University of Michigan, obtaining his bachelor's degree in 1871. He spent the following three years as a mathematics instructor and an assistant astronomer on a boundary survey. This stirred his interest in the natural world and he subsequently traveled to Germany to study zoology in Leipzig under Leuckart, who was considered a leader in the field.

The work produced by Mark shows a high level of proficiency in German. Later in his life he would translate German scientific works into English, opening up a whole new perspective in some areas of study to English speaking scientists.

In 1877, he was given a post as instructor in zoology at Harvard University. In 1883, he was promoted to assistant professor, and three years later he became Hersey Professor of Anatomy. He was also director of the zoological laboratory from 1900 until his retirement in

1921. He was awarded two honorary degrees from his *alma mater* and from the University of Wisconsin. He was a member of a number of learned societies both in the United States and abroad, including the American Philosophical Society and the National Academy of Sciences. Not surprisingly, he was made a professor emeritus upon his retirement.

Mark was not only a founder of BBSR and its director until 1932, but also continued to be involved with station activities throughout the rest of his life. His preoccupation with Bermuda's natural environments is illustrated by a passage from his address at the inauguration of BBSR:

> I recall with pleasure not only my own fascination, but also the expression of delight which involuntarily came from the lips of all who, with water-glass in hand, peered down into the fairy-like gardens of the sea, as we slowly drifted with the tide, or lay at anchor in the midst of one of the great coral patches that flourish over the extensive areas of the north lagoon. I confess the pleasure was so great that the spirit of the collector was suppressed for the time being; it seemed sacrilege to touch with violent hands a picture that showed such harmony of form and color, the waving plumes, the graceful branches of the gorgonias; sea fans in purple splendor; coral heads of gold and green; great splotches of colored sponges encrusting the rocks; the soft seaweeds; here and there deep channels with nothing but the clear water and the white sand beneath it; and in and out among this maze of growing things, the graceful, noiseless fishes in such array of colors as is scarcely credible, much less describable. I believe it may be truly said that one who has never seen such a tropical sea garden cannot have the remotest idea of its charms. There was only one consideration that could reconcile me to the wanton work of collecting these beautiful things and robbing them of all their native charm; that was the fact that, work as diligently as we might, we could not deface one in a thousand of these fascinating spots. I think there is no other single experience I would willingly exchange for this, and yet I recall one other, of a somewhat different nature, that made a strong impression on me. As three of us were out one afternoon off the south shore beyond the reefs fishing in about 60 fathoms, there came floating past with the tide a school of jellyfishes, the common *Aurelia*. I have before seen *Aurelia* almost cover the surface of the sea, but never before had I been able to look down, as then, and see them in the depths of the sea. They were seemingly without end, a vast procession, smaller and smaller the deeper one gazed, until they seemed mere specks, such was the clearness of the water.[1]

During his long career, Professor Mark conducted research in many different areas – slugs, egg membranes, arthropod eyes, pigs and flatworms, amongst others – and his final piece of research centered on fireworms.

Anybody who has spent any length of time in Bermuda will be aware of the Bermuda fireworm (*Odontosyllis enopla* – "the toothed and necklaced worm"), a marine relative of the familiar earthworm. These curious creatures appear glowing brightly in a yellow-green tint in the sea between 56 and 61 minutes after sunset on the third evening after full moon. The females swim around in glowing circles until a mate comes, himself flashing a bright light, and fertilizes her eggs. Mark was often to be found down at the water's edge, watch in hand, to

Visiting scientists time fireworms on Castle Island

Watching for the fireworm mating ritual – still a highlight for BBSR staff and visitors

record the exact time of the first fireworm's appearance. In fact, this was probably to be the subject of his next publication since notes and a carefully worded dedication were found in his effects upon his death, at the age of 99, in Cambridge, Massachusetts, on December 16, 1946.

Even after his retirement, BBSR remained Mark's chief interest. He continued to visit until the age of 92 and remained a trustee of BBSR and chairman of the Library Committee until his death.

He was held in very high regard by Bermudians. Those who remember Dr. Mark today recall a kindly man with a few eccentric quirks. Dr. William Sunderman, who has been visiting BBSR since 1927, notes that Dr. Mark was independent well into his nineties, refusing offers of assistance in getting into a boat. Dr. Sunderman also remembers the time when Dr. Mark lost his laboratory notebook and the entire staff of BBSR was obliged to down their tools and search until it was found.

During his later years, whenever Mark visited BBSR he would reorganize the entire library. Although it was not a big one at that stage, rearranging all the journals took a considerable amount of time and effort. It was his view that volumes should be arranged in numerical order from right to left, instead of the more conventional left to right, because this was how the page numbers ran through the journals; all the pages throughout the collection would then run consecutively along the shelf.

Today's E.L. Mark Memorial Library was established in its present location at BBSR in 1947, a year after Professor Mark's death. It has grown into a valuable resource for resident and visiting scientists and students. Open to the general public, it also serves as the main scientific library on the island. Cognizant of the library's valuable public service role, the Bermuda Government has provided an annual grant to BBSR to help support its operations for more than two decades. A challenge grant from the Andrew W. Mellon Foundation in 1983, matched by donors in Bermuda and the United States, has provided a source of additional endowed funds for journal acquisition and general upkeep.

Among the library's most significant holdings is one of the few remaining complete 50-volume sets of the report of the *HMS Challenger* expedition. Perhaps most significant, though, is Professor Mark's true legacy: the collection of 1,783 peer-reviewed scientific publications resulting from research conducted at BBSR during its first century.

THREE

A New Role, a New Home

An early 1900s postcard depicts the Shore Hills Hotel and tennis courts

In August 1925, 12 men who had an interest in the Bermuda station and its future met at the Marine Biological Laboratory in Woods Hole, Massachusetts, to discuss the future direction of BBSR. Among these men were Professors Mark and Bristol, H.W. Rand, Edwin Grant Conklin and Edmund V. Cowdry.

Of the men named above, Professor Conklin was destined to play a particularly important role. He would be elected president of BBSR in 1926, and would remain in that position until 1937, overseeing the transformation of BBSR from an informal summer gathering of scientists to a much more structured institution devoted to year-round scientific research. Highly respected as a scientist, with several honorary degrees and membership in many international societies, he was also a very good administrator and was responsive to the concerns of BBSR.

Conklin was born in Ohio in 1863 and earned a Ph.D. in biology in 1891. Most of his career was spent at Princeton, where he became chairman of the Department of Biology. He also maintained close ties with the Marine Biological Laboratory (MBL) in Woods Hole in Massachusetts and used what he learned there to help in the reorganization of the Bermuda research station.

Significantly, the 1925 meeting was held at MBL. Its main purpose was to reconfirm that Bermuda was a suitable place to set up a permanent biological research station, and the "unanimous expression" of those attending was that Bermuda was indeed an ideal location for a biological laboratory because of a number of different factors. The assortment of sub-tropical flora and fauna was considered to be well worth studying, but this was by no means the

Edwin G. Conklin

only advantage. In addition, Bermuda was only 48 hours from New York City by steam ship, it boasted good living conditions, had a pleasant climate, and offered "no exposure to dangers that accompany living in a less civilized tropical region."[1]

The outcome of the meeting was a plan for the complete reorganization of BBSR, more or less along the lines of the organization of MBL, itself a very successful operation. A corporation was to be set up, with control of BBSR placed in the hands of a board of 12 directors who were to be elected from the corporation members. One hundred and seventy-five people from the United Kingdom, the United States and Canada were invited to join the corporation and were also asked to nominate a reorganization committee. Of those asked, 134 accepted, and Mark, Conklin, Bristol, Cowdry and Rand were elected to form the reorganization committee. Professor Conklin was the chairman of the committee, with Professor Cowdry as secretary.

This committee met in New York City in November of 1925. They organized the election of the 12 directors and initiated a number of other changes. Perhaps most importantly, they recognized the need to get Bermudians involved in BBSR. As a result, Bermuda's director of Agriculture, Dr. E.A. McCallan, became one of the elected directors, and invitations to join the Corporation were sent out to the former members of the Bermuda Natural History Society (which by that time had been disbanded) and to a number of other Bermudians who had shown particular interest in BBSR. The invitation was accepted by 15 Bermudians.

The committee also drew up application papers for BBSR's incorporation in the state of New York. This was accomplished in 1926, marking a turning point in the institution's history. The Certificate of Incorporation of the Bermuda Biological Station for Research, Inc., as it was now to be known, details a number of objectives for the newly reorganized institution:

> The principal objects for which the corporation is formed are: to establish and maintain a laboratory or station for scientific study in biology; the acceptance and holding of funds, whether from bequest, devise, gift or otherwise; and the application of such funds and the income there from to the purposes of this corporation.[2]

The other significant move made by the trustees at this time was to petition the Bermuda Parliament to approve the Bermuda Biological Station Act. This was accomplished in 1927. This Act granted the Corporation the right to hold real estate in Bermuda and conveyed to BBSR around 12 acres of land, known as the Hunter Tract, in St. George's Parish, providing the trustees could raise £50,000 or more as an endowment for BBSR. The Hunter Tract was chosen as the best site then available for BBSR after 20 or so had been considered.

This Act also exempted BBSR from customs duty on laboratory equipment and other supplies to be brought into the country and provided a £200-a-year grant for BBSR for a period of 10 years.

Thus, in the years 1926 and 1927, the organization that was established in 1903 was replaced by the structure that has been maintained to the present day. In April 1930, the number of directors was increased from 12 to 24, and they were renamed trustees in the same document.[3] The number of trustees has changed several times since then, but the incorporation in 1926 is regarded as the birth of the modern Bermuda Biological Station for Research, and much of its history is measured from this point.

The new order was marked by the creation of the official BBSR seal, bearing the date 1926. The seal, featuring an angelfish, was designed by Olive Earle, a New York artist; she was later commissioned by Professor Conklin to make a new, smaller drawing of the fish which was then used for BBSR's letterhead.

Olive Earle, on a visit to Bermuda in 1931, takes a 15-foot dive off BBSR's dock. The shoes weigh 30 pounds.

Soon after these developments took place in Bermuda, leaders of the U.S. scientific community began to examine more closely the needs for advancement of marine science. In 1927, the U.S. National Academy of Sciences appointed a Committee on Oceanography to "consider the share of the United States of America in a worldwide program of oceanographic research."

The result was the Lillie Commission, named after its founder, Frank R. Lillie, director of MBL at Woods Hole. The six-member group also included BBSR director Edwin Conklin. It consulted with other leaders of the oceanographic world, including Norwegian scientist H.U. Sverdrup, Harvard Professor Henry B. Bigelow and future BBSR president Alfred Redfield.

The Lillie Report is perhaps best known for its recommendation to establish the Woods Hole Oceanographic Institution (WHOI) in 1930 as a necessary East Coast counterpart to the Scripps Institution of Oceanography in California. The report also proposed two substations for "investigations of special conditions," noting that, "consequently the success of their operations would depend chiefly on the choice of suitable locations; in this case the geographic requirement is, therefore, paramount."

The Commission identified two key areas for substations: the Arctic and the open ocean. The location deemed most accessible to the Arctic was St. John's, Newfoundland. For the open ocean, the clear choice was Bermuda. Compared to alternatives in the Azores, the Canaries, Cape Verdes, the Bahamas and the Antilles, Bermuda offered immediate access to the open ocean due to the steep drop to the sea floor at depths of greater than 2,000 fathoms. As the report notes, "This would make it possible to carry on serious investigations at great depths with small and inexpensive vessels. And the fact that such work could be done in one-day trips would allow an advantageous unity between field and laboratory work." The assets of Bermuda's mid-ocean location would indeed justify the Lillie Commission's recommendation in future decades with the advent of Hydrostation "S" and other long-term time-series measurement programs of the open ocean off Bermuda.

The Commission noted that "Bermuda seems to the committee the best situation in the North Atlantic for investigation into the phenomena that are fundamentally characteristic of the ocean basins." It highlighted a range of other benefits that Bermuda might bring to the U.S. oceanographic community. Besides the accessibility by steamer from New York, the range of inshore environments, and excellent communication and support services on the island, the Commission noted the commitment locally to science in Bermuda. "The negotiations that have been carried out with regard to the reorganization of BBSR have shown that the local government and population would welcome scientific activities on the island, which is a consideration of some importance."

The Commission suggested that BBSR be reorganized as the substation. The Lillie Report concluded with a recommendation that would facilitate BBSR's role for U.S. science in years to come:

> The central (East Coast) institution should be supplemented as soon as possible by two branch stations, one sub-arctic and the other truly oceanic in location. The latter location would be served admirably by the Bermuda Biological Station for Research, Inc., which has the support of the Committee in its efforts to complete its organization.[4]

The completion of that organization would come thanks to an application by the BBSR

A host of visitors socialize at the bathing pavilion in the 1930s

trustees to the General Education Board of the Rockefeller Foundation, which at the same time also provided start-up funds for the Woods Hole Oceanographic Institution through Dr. Lillie's efforts.

The foundation agreed to endow BBSR with the £50,000 necessary to meet the terms laid out in the Biological Station Act of 1927. The selected land was purchased and an architect was employed to begin plans for the buildings that BBSR would need in order to operate. It was about this time, fortunately before construction on the site had started, that the trustees were offered a different site, very close to the Hunter Tract, on which the Shore Hills Hotel was located.

The hotel had been in operation since its completion in 1911. The land – some 14 acres – had been owned by a wealthy doctor named Austin Hollis, having been given to him by his father, who had owned it since 1878.[5]

When Hollis acquired it, the site already contained five small cottages, stables and a bathing pavilion (now called Barnacle), all of which are still in existence today. He decided to develop it into a commercial operation, adding the main building, which was renamed Wright Hall in the 1980s, and associated power plants.

Hollis first billed the new development as the Bermuda Sanatorium and advertised it as a place for recuperation from various diseases, from heart problems to convalescence from surgery. Despite the huge range of dysfunctions the management claimed the Bermuda Sanatorium was ideally suited to rectify, it seems that the profits were not as high as they might have been. After a few years, therefore, the Sanatorium reinvented itself as the Shore Hills Club, with the Shore Hills Golf and Country Club affiliated with it. A brochure from this period talks of the nine-hole golf course and shows pictures of the tennis courts. The site is described as follows:

> The property comprises the hotel and several cottages, bathing pavilion, electric and ice plants, vegetable and dairy farms, stables, lawns and picturesque

The main building, now Wright Hall, featured unique sleeping porches

> grounds... The hotel was completed in 1911, and its plan presents the most recent and progressive American ideas of beauty and comfort without the oppressiveness of excess luxury.[6]

BBSR was offered the property by Amy Hollis, Austin's widow, after the land passed to her. This presented something of a dilemma for the trustees of BBSR, who had committed themselves to the Hunter Tract. It was clear that the Shore Hills property was far superior to the Hunter Tract: it already had good buildings standing on it, had slightly more land and would be cheaper to develop, since little would need to be added to the site to make it into a perfectly adequate research station. In addition to the cottages, the main building offered residential accommodation for 30 people, and there was ample space for conversion into laboratories.

The trustees decided to make an offer to Amy Hollis for the building and grounds. The Bermuda Government was asked to take back the Hunter Tract and to donate to BBSR a sum equivalent to the one they had paid for that property. The trustees also requested permission for BBSR employees to cross the Hunter Tract in order to use the docks in Stocks Harbour.

This proposal proved to be a small sticking point with the Legislature. Some of the members felt that BBSR had already been helped enough. What would the country now do with 12 acres of unwanted land in St George's? The trustees' proposition was debated for one-and-a-quarter hours, with the main objectors saying that the Hunter Tract would depreciate in value, especially if access were granted to BBSR to cross at will. Also, if the Bermuda Government were to take the land back, BBSR should certainly not be given the full amount paid for the Hunter Tract. Finally those objecting pointed out that the trustees of BBSR had changed their minds and should not now expect the Colony to change arrangements to suit their whim.

In the end, fortunately, these objections were overruled and the trustees got what they wanted. Government decided that the benefits of BBSR to Bermuda would far outweigh the costs. Authorized by a new Biological Station Act of 1931, the government took back the

Hunter Tract and granted £5,500 to BBSR. Amy Hollis sold the Shore Hills Hotel to BBSR for the sum of £80,000: £75,000 for the land and properties on the site and £5,000 for the furnishings within the buildings. BBSR was even granted access to the Stocks Harbour dock via the Hunter Tract.

While all these negotiations were going on, research by visiting scientists continued on Agar's Island. On July 26, 1930, *The Royal Gazette and Colonist Daily* reported that in the past month BBSR had hosted 12 investigators, and that the areas of research had included the life cycle of parasitic *Trematodes*, the color changes in the lizards of Bermuda, experimental work with the Ascidian *Clavelina*, and the biological aspects of the pigment of the sea slug, *Chromodoris.*

The Shore Hills Hotel property was transferred to BBSR towards the end of March 1931. A local architect, Lawrence Smart, was engaged to redesign the premises and work began immediately to change the old hotel into a new biological research facility.

By June, most of the laboratory equipment had been transferred from Agar's Island to the new property, and the first research session at Shore Hills commenced on June 15, continuing until August 10.

The transfer of the Shore Hills estate brought with it three members of staff, Willie and Marie Gleeson, and Chester Burgess, who managed the grounds and remained with BBSR until 1966.

During the time that the Shore Hills property was being renovated, the trustees were actively seeking a scientific director, someone who would actually stay at BBSR all year and look after the place and its interests. As the trustees were hoping to secure a grant from the British Government to ease financial concerns, a Briton was preferred for the post.

A few possible candidates were considered, but at the inaugural ceremony for the new station on January 6, 1932, Dr. John F.G. Wheeler, an Englishman, was inducted as director of BBSR. In fact, the recession that hit Britain at this time meant that the hoped-for grant was not

The lounge, with its cane furniture, was typical of Bermuda in the 1930s

Dr. and Mrs. Wheeler at BBSR in 1932

forthcoming. Only an emergency grant of $12,000 by the Rockefeller Foundation saved BBSR from a possible financial crisis. When the application for the grant was made, it was requested as being necessary to make the books balance, rather than as a luxury extra. In fact, Professor Conklin commented that:

> In view of the economic depression throughout the world, no serious attempt has been made to increase our endowment or our regular income from cooperating institutions, although this must be undertaken at the earliest appropriate time. There has been no default of interest in our investments and this income, together with the emergency grant of $6,000 [for the year 1932] from the Rockefeller Foundation and the grant of $2,000 from the Woods Hole Institution have enabled us to close the year with a safe operating balance to our credit.[7]

The Woods Hole grant was simply money donated to help BBSR run; similar grants were sought elsewhere. Over the next two years, sufficient funds would be accumulated to convert the power house into a library, thus freeing more laboratory space in the main building.

The opening ceremony at Shore Hills was a grand affair. *The Royal Gazette and Colonist Daily* commented in its front-page article, "Dr. Mark, who was warmly greeted on rising to speak, was obviously overjoyed that his dream of so many years had come true."

The paper also mentioned the assortment of dignitaries who attended the function and the journey they took to get to Shore Hills:

> The gathering was the most distinguished and representative seen on any public occasion for many years... Special trains conveyed the guests from Hamilton and St. George's, and many travelled for the first time over this section and were loud in their praises of the scenic route.[8]

Among the speechmakers was Dr. Conklin. He commented:

> This new station differs from any and all others in this hemisphere or in the entire world, so far as I know, in being really international in its organization. There are now more than 200 members of this Corporation, representing 10 different countries.[9]

This international approach has continued to the present day.

The new director, Dr. Wheeler, had been recommended by the two British BBSR trustees at the time, E.J. Allen and J.H. Ashworth. Other letters of recommendation were received by the board, and, as Wheeler had previously held a similar position of responsibility, it was believed that he would be a good choice.

Wheeler had earned a degree in zoology in 1922 from the University of Bristol. Following graduation, he held several academic posts, including spending a number of years on board the research vessel *Discovery II*, on expeditions from 1924 to 1927 and again from 1929 to 1930. From September 1929 to June 1930, he was in charge of the Marine Biological Station on South Georgia Island in the southern Atlantic Ocean, east of Cape Horn. During that period, he researched the length of time necessary for fin whales to reach maturity, and this work became the basis for his doctorate. After discovering that his next tour of duty on the *Discovery II* could well turn out to be a circumnavigation of the South Pole, he opted for the job offered him in Bermuda.

Dr. Wheeler's scientific contributions during his stay at BBSR were in a number of different fields. His work included, for instance, studies of both worms and whales. One of his

BBSR's official opening at Shore Hills on January 6, 1932

Above: *Professor Conklin is third from the left; the Governor of Bermuda, Sir Thomas Astley Cubitt, is seated in the middle*

Right: *Professor Conklin and the Governor inspect tanks*

discoveries was that of a worm never before found in Bermuda, but which, once identified, was found quite abundantly. In fact, the same worm had only recently been discovered, having first been described from a site on the Australian coast. This information led Wheeler to conclude, despite all the available evidence to the contrary, that some form of spontaneous generation had occurred: this particular species had simply sprung up simultaneously all over the world from nothing. He even wrote a paper on the subject entitled "The Discovery of the Nemertean Gorgonorhynchus and its Bearing on Evolutionary Theory."[10] This paper was published in 1942, some 83 years after Darwin published *The Origin of Species*.

In October 1941, the trustees informed Wheeler that they could not foresee money being available for his position for the coming year. BBSR's buildings had been requisitioned by the United States Army for the duration of World War II and income was not great. Wheeler tendered his resignation and went on to become an employee of one of Bermuda's banks.

FOUR

Beebe and his Bathysphere

Charles William Beebe (left) and Otis Barton with their Bathysphere

In the early 1930s, a good deal of publicity, viewed by Dr. Wheeler as too sensational, was brought to BBSR by the work of a man who pioneered underwater exploration.

He was born Charles William Beebe in 1877 in Brooklyn, New York, and had a mother who was, by all accounts, a force to be reckoned with. Once it became clear that the young William wanted to become a naturalist, she ensured that he met all the most influential people in that field, and it seems that he spent the rest of his life trying to impress people.

His prolific writings often hint at personal danger. Despite trying to give the impression he had seen active service in the First World War as a fighter pilot, he suffered a wrist injury during training and never fought once during the war. Other descriptions of incidents involving fierce natives in far-flung jungles appear to be slightly conflicting in different versions – the only constant seeming to be that Beebe courageously shot them with his gun.

Beebe's approach to science, while frowned upon in those days by many of the "institution," certainly helped to make the field popular. In that role his writings served an important purpose, and, in general, his scientific work is not without merit. In his correspondence with

Beebe on March 20, 1934, Professor Conklin refers to the former's paper on *Idiacanthidae* as "... a beautiful and thorough piece of work."

Beebe certainly had a passion for new discovery. His favorite book was Lewis Carroll's *Alice's Adventures in Wonderland,* and he believed that he was "discovering everything in nature that Alice discovered in Wonderland."[1]

The description given by Stuart Sherman emphasizes Beebe's mystique: "As long and lank and brown as the Ancient Mariner... he is as bold and dictatorial and ambitious as Julius Caesar... he opens up the wonders of the Universe like Prospero... he is as hungry to extend the frontiers of experience as Faust."[2]

Beebe's greatest fame arose as a result of the historic dives he made at the beginning of the 1930s into the ocean depths off the south coast of Bermuda in Otis Barton's thick-walled, pressure-resistant Bathysphere. However, these explorations led to frosty relations with BBSR's director, who on several occasions caused difficulties over Beebe's requests for accommodation. On February 8, 1932, Wheeler wrote to Conklin, "We shall in future have wider aims than going down a full half mile underwater and I cannot see that the presence of Dr. Beebe and his people is going to advance our plans in the slightest degree."

Beebe tried hard to show a generous and congenial front. In a letter to the editor of *The Royal Gazette and Colonist Daily,* he writes, "We have been permitted this privilege [of staying at BBSR] by the kindness of the president, Professor E.G. Conklin, and the director, Dr. J.F.G. Wheeler."[3] In the same letter, he expresses his feelings about the Bermudian people:

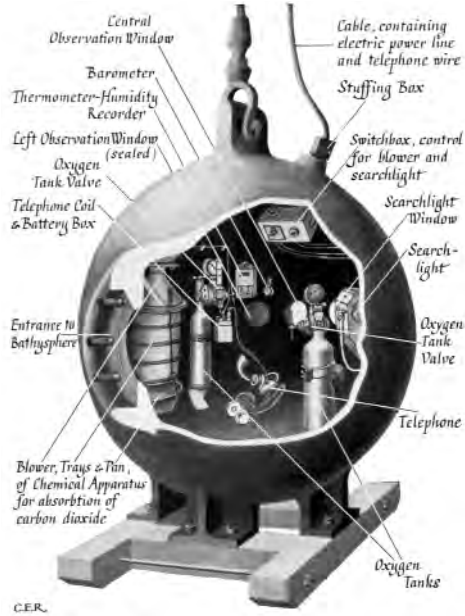
> For four years I and my staff have been the recipients of every form of kindness from Bermudians from Somerset to St. David's, but the credit for our discoveries of 1932 belong especially to St. George's, to the owner and the crew of the *Freedom*. In especial Mr. James Sylvester and Mr. W.R. Perinchief deserve our thanks for the care they have taken to make our dives safe. The apparatus for lowering and hoisting the Bathysphere has never failed in any emergency, and more than once, the instant reaction and judgment of Sylvester at the winch has pulled us out of rather tight places.

Beebe's fervent desire to explore the unknown underwater world ("... a field which, hitherto, has never been entered and studied at first hand") had long been in evidence, and he had tested many different diving suits when Otis Barton presented him with opportunities to dive longer and deeper than ever before.

The record for a human dive at that period was 525 feet – the Bathysphere ultimately descended to 3,028 feet.

In *Half Mile Down,* Beebe writes:

> Many years ago I spent the best part of an evening with President Theodore Roosevelt discussing ways and means of deep-sea diving. There remains only a smudged bit of paper with a cylinder drawn by myself and a sphere outlined by Colonel Roosevelt, as representing our respective preferences. We worked out many details...
>
> During 1927 and 1928 I considered various plans for deep-sea cylinders that would be strong enough to sink deep into the ocean, but all of them, due to their flat ends, proved impractical. With each 33 feet of depth the pressure



The Bathysphere

increases one atmosphere (14.7 pounds to the square inch), so at the depth of half a mile the pressure is over half a ton to each square inch. Any flat surface would be crushed in unless it were impossibly thick or braced by an elaborate system of trusses.

And so, since there is nothing like a ball for the even distribution of pressure, the idea of a perfectly round chamber took form and grew. By 1929 Mr. Otis Barton had developed and actually constructed a steel sphere, large and strong enough to permit us to enter, to be sealed up and keep ourselves alive, to descend into and return safely from the depths of the ocean. Mr. Barton deserves full credit for the contributions of time, thought and money which he devoted to this work, while Captain John H.J. Butler designed and worked out the various details of the sphere... it weighed 5,400 pounds. A first casting had weighed twice as much, but it would have been too heavy for any of the winches available in Bermuda and was scrapped.

There were to be three windows – cylinders of fused quartz eight inches in diameter and three inches thick fitting into steel projections resembling the mouths of very short cannons. Quartz was used for two excellent reasons – it is the strongest transparent substance known and it transmits all wavelengths of light. In all, five windows were ground. Mr. Barton has written that the first was chipped in an attempt to grind it into its seat. The second gave way under an internal pressure test of 1,250 pounds to the square inch. It seems probable that the frame in front was bent out, and that the resulting shearing strains broke the glass. The third was broken when the frame bolts were tightened unevenly. The remaining two, however, passed every test successfully and subsequently, during

Mr. J. Sylvester, Mr. W.R. Perinchief and a crewman winch up the Bathysphere

the actual dives, never leaked a drop. Through one of these it was planned to send a searchlight out into the water, far below the surface. The third window aperture was filled with a steel plug.

Opposite the windows was the entrance, politely termed the "door." This round, 400-pound lid had to be lifted on and off by a block and tackle, and fitted snugly over 10 large bolts around the manhole – the latter just big enough to permit the passage of a slender human body. Several years later, when the sphere was on exhibition at the American Museum of Natural History, a lady of very ample proportions walked slowly all around the apparatus and was looking in through the 14-inch door when she asked the attendant, "Is that the thing in which they went down in the ocean?" "That's it, Ma'am." "Well – where in the world is the door?" Any intending diver in the sphere, in addition to having a sufficient interest to risk possible dangers, must also be provided with a physique whose greatest diameter is less than 14 inches!

In this entertaining passage, Beebe fails to mention that the hatch of the Bathysphere was only 18 inches wide, and that both he and Barton were well over six feet tall. Despite their slenderness, it must have been a challenge for them even to climb into the Bathysphere.

Like Wheeler, Beebe had his detractors. He was a very effective self-publicist and many people considered him not to practice "real" science, just popularist science, although his contributions to the scientific literature of the day were many and his work was widely known.

In fact, it seems the administration of BBSR did not know what to do with him. Even before the Bathysphere dives, Beebe's talent for narrative writing and ability to attract publicity had made him famous. Correspondence between officers and trustees of BBSR contains a variety of references to disputes about Beebe, often not disputes caused by him specifically, but concerning him.

In May 1929, Professor Conklin invited Beebe to become a Corporation member, an offer which Beebe finally accepted on January 23, 1930. However, the outside world attributed

far higher status to him. Olive Earle, also a Corporation member, commented to Professor Conklin in 1932, following the official opening of BBSR at Shore Hills:

> ... Mr. Richardson [publisher of the *Bermudian* magazine] said he had a very good photograph of the governor with the group of trustees... including Dr. Beebe! And a friend of mine went to the meeting of zoologists at the Waldorf and came away with the idea that Dr. Beebe owned the new Station.[4]

Other letters of concern are typified by one from Henry Bigelow, one of the visiting scientists to BBSR and a member of the Board of Trustees, to Professor Conklin. He writes, "Rumors seem to be flying around to the effect that Beebe and his train of servitors are apt more or less to monopolize the Bermuda lab, etcetera, etcetera, and that Wheeler is apt to be unhappy. Tell me what to say when the next person asks questions."[5]

The emotions Beebe stirred up, allied with his physical stature, are illustrated by the nickname given him at the time – "the camel." So widespread and commonly recognized was this sobriquet that in her correspondence with Professor Conklin, Olive Earle refers to the "camel" without appending a name, and Professor Conklin responds with: "I am very much disturbed about the 'camel' ..."[6]

Beebe's fame caused problems at various levels. F. Goodwin Gosling, a member of the Bermuda Legislature as well as a trustee of BBSR, who secured for Beebe the use of Nonsuch Island for several years, felt that the association of Beebe with BBSR would probably attract badly needed funds, as he wrote to Professor Mark, "If Beebe's expedition is successful, perhaps it may lead to a substantial grant being made by the Rockefeller Trust for... the Biological Station..."

William Beebe (second from right) with Gloria Hollister (left), Barbara Saunders (seated) and other guests outside New Nonsuch

Mark disagreed, in no uncertain terms: "To tie up with such an explorer and exploiter would certainly kill our chances, if I can see straight."[7]

Dr. Wheeler requested that BBSR be kept out of any of Beebe's publicity. It is notable that in the Director's Report for 1934, he makes no mention at all of Beebe or his achievements. His view, however, was not shared by all of the officers, some of whom complained to each other about Beebe's rudeness in using the services of BBSR without acknowledging them in any way. Beebe himself wrote a letter to Professor Conklin shortly after his most successful dive of half a mile in 1934, telling him, "Dr. Wheeler said he wanted no publicity so I have kept the Biol. Station out of all preliminary reports. I would like to mention it in my final treatment and in the technical results."[8]

An anecdote which illustrates the level of regard on which his "amateurish" science was held comes from the name he gave one of the new species of fish he claimed to have seen from the Bathysphere. Two of these fish, he said, swam past the window of the Bathysphere on one of the descents and, although he could observe for only about a minute, he gave a name to the fish and published its discovery in a paper. The name he chose was the Untouchable Bathysphere Fish, which he translated in Latin to *Bathysphæra intacta*.

Upon reading about this, one zoologist is supposed to have had the following reaction: "*Intacta*?" he shouted across a crowded library. "Beebe doesn't even know his Latin. *Intacta* means virgin!"[9]

Others criticized the fact that he described a whole new genus and species simply from one observation through the Bathysphere window, although the description he gives of the fish is detailed enough to ensure its recognition should an example ever be seen again:

> Two fish went very slowly by, not more than six or eight feet away, each of which was at least six feet in length. They were of the general shape of barracudas, but with shorter jaws which were kept wide open all the time I watched them. A single line of strong lights, pale bluish, was strung down the body. The usual second line was quite absent. The eyes were very large, even for the great

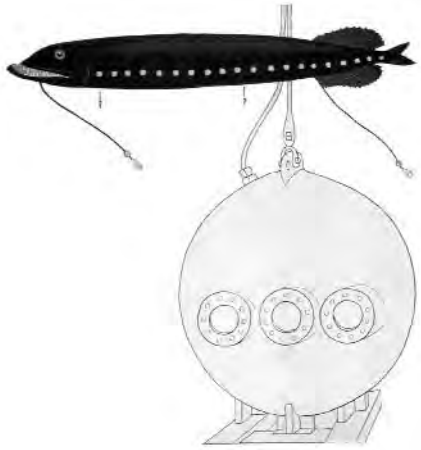


Illustration of the Untouchable Bathysphere Fish, drawn by Helen Tee-Van, from Half Mile Down, Harcourt, Brace & Co., 1934

length of the fish. The undershot jaw was armed with numerous fangs which were illumined either by mucous or indirect internal lights... There were two long tentacles, hanging down from the body, each tipped with a pair of separate, luminous bodies, the upper reddish, the lower one blue. These twitched and jerked along beneath the fish, one undoubtedly arising from the chin, and the other far back near the tail.[10]

Else Bostelmann's painting of Saber-toothed Viperfish

During the dives in the Bathysphere, Beebe was in telephone contact with the boat above, and described in as great detail as he could the marine life that could be seen at various depths. His rapid and disjointed descriptions were taken down in shorthand by Gloria Hollister, another visiting scientist. Later, using the notes and his memory, Beebe described new genera of fish to the artist Else Bostelmann. The Bostelmann paintings not only became the definitive illustrations of Beebe's dives, but have proved astonishingly accurate representations of those species, many of which have been photographed during more recent dives, or caught in fishermen's nets. The Untouchable Bathysphere Fish, however, continues to elude capture.

On the subject of the undersea lights possessed by many of the creatures living at these depths, an extract from John Tee-Van's account of accompanying William Beebe on one of his dives provides a wonderful description of what can be seen a few hundred feet below the surface:

> Somewhere about 700 feet, as we looked downwards through the windows into the darkness below, a flash of light reached our eyes, its brilliancy accentuated by the blackness. It was unexpected, and for a moment I became inarticulate (a common condition in the Bathysphere). From this depth on, lights were constantly visible, sometimes single and shining continuously or flashing

on and off, sometimes in groups that moved along without changing their relationship to one another, which indicated they belonged to a single fish or other animal. At other times the lights moved about independently of each other, showing that they were lights on different fish in a school.[11]

Beebe started working in Bermuda in 1928 and continued for 11 years. Although he is best remembered for his Bathysphere dives, these were only performed over three summers. He made a substantial number of other scientific contributions while in Bermuda, his research focusing on new species of marine animals.

Crew members cast a plankton net from Beebe's boat

While living on Nonsuch Island, Beebe convinced himself that he heard the distinctive cry of the cahow in the night, and linked the cry to a bird he saw. The cahow, formally titled the Bermuda petrel, is endemic to Bermuda and was thought to have become extinct by 1620, after over-hunting by Bermuda's original settlers and aggressive predation by rats and hogs. Its chief breeding place had been Cooper's Island, to the east of Nonsuch, and when famine struck in 1615 the governor sent all sick and elderly people there, so that they could easily obtain food. An eyewitness account of that period reads:

> The first night I lay on the island I saw, in every Cabbin, Pots and Kettles full of birds boyling and some spits roasting and the silly wilde birds comming so tame into my cabbin and goe so familiarly betweene my feet and round about the cabbin and into the fire with a strange lamentable noyse as though they did bemoan us to take, kill, roast and eate them.[12]

Yet the tales of their haunting cry, which reminded sailors of devils and led to Bermuda's other sobriquet, Isle of Devils, had such a hold on the popular imagination that, over the centuries, the cahow grew into a creature of legend.

Louis Mowbray, curator of the Bermuda Aquarium, had found a live cahow in 1906, but it was not definitely identified as the "extinct" bird until 10 years later. When Beebe published a paper in late 1935, in the bulletin of the New York Zoological Society, and announced the rediscovery of the bird but with no scientific evidence to back up his claim, he was greeted with a good deal of skepticism, especially on the part of Mowbray, who had already had

occasion to question Beebe's expertise in the matter of fish identification.

It would be another 16 years before the truth about the cahow's survival would be revealed. In 1951, Dr. R.C. Murphy and Louis Mowbray, son of the previously mentioned Louis Mowbray, found a small number of nesting pairs on rocky islets near Nonsuch Island, where they had found some relief from the competitive pressures of another nesting seabird, the longtail.

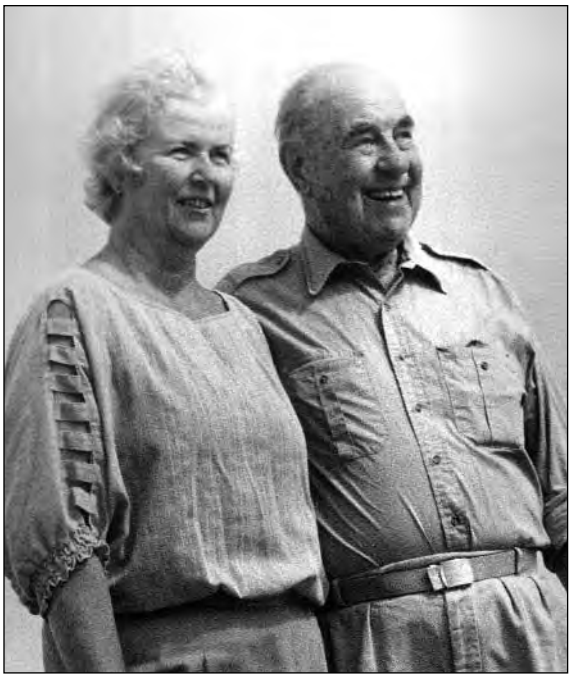
A young Bermudian boy, David Wingate, was with them at the time of the discovery. He has since then devoted his life to both the re-establishment and protection of the cahow population, and the turning back of the hands of time on Nonsuch Island through the restocking of native fauna and flora. But those are stories which require a book of their own.

As for William Beebe, he died in 1962 at the age of 89. Despite his ambition, and his use of the title "Doctor," he had never actually gained a university degree. During his years spent at Columbia University, he never attended enough classes to graduate and left no more qualified than when he entered,[13] despite claims of a B.S. from Columbia University in 1898, and a Sc.D. and L.L.D. in 1928 from Tufts and Colgate Universities respectively. Nevertheless, he had many major accomplishments; he excited people everywhere about the world of the deep, and his achievements etched his name indelibly in the annals of marine exploration.

Fifty years after the historic half-mile dive, Otis Barton paid a brief visit to Bermuda in his ship, the Sea Diver, in May 1984. BBSR Director Wolfgang Sterrer and Otis Barton chat in front of a replica of the 1934 Bathysphere.

FIVE

Sunderman and the Lobsters



William and Martha-Lee Sunderman visit Nonsuch Island during a trip to BBSR in 1989

Although a full seven decades would pass before BBSR's research center on the links between ocean and human health was founded, scientists at BBSR became curious about these connections as early as 1927. That year brought Dr. F. William Sunderman to Bermuda to conduct his research. He was destined to become a leading figure in the world of medicine and a longstanding friend of BBSR.

A regular visitor for the last 75 years, Sunderman has known all of the major figures in BBSR's history, dating back to its founding scientists. His reflections provide an interesting perspective on life at BBSR in the 1920s and '30s. In 2002, at age 104, he again led a visiting group from the Association of Clinical Scientists, a Philadelphia-based organization he founded, on the biannual BBSR trip he has organized for more than two decades.

When he first came to BBSR, the 29-year-old Sunderman was working on his doctoral degree in physical chemistry at the University of Pennsylvania. He had already gained a medical doctorate in pathology there in 1923. His early research was designed to help sufferers of typhoid and pneumonia and involved taking blood from different animals. In one of

Scientists collect specimens on the south shore boiler reefs in 1933

many interesting stories he has to tell, Sunderman says he started by taking blood from leopards, lions, orangutans and other animals at the local zoo, but then:

> We went onto studying cold-blooded animals. I worked on boa constrictors. They were very fragile animals – they died after you took blood from them. And they were very expensive, so somebody said, "Well, why don't you use alligators?"
>
> Everybody who came back from Florida in the spring would bring back a little alligator, but, when they got to be a foot or so long, would donate them to the zoo. [The zoos] had so many alligators, they didn't know what to do with them. So we built a tank and put in the alligators, filled it with water. I had a couple of men, day and night, to keep the temperature. Keep it up to 98°F and [the alligators] are vicious things, but you lower it down to 40°F and they are just like logs, because they have no internal temperature regulation. Conklin heard about this and said, "Why don't you go to the Bermuda Biological Station and work on crustaceans there?" So we did.

Sunderman and his colleagues took blood from both sharks and lobsters, the latter apparently making him very popular with others staying at BBSR. "They were particularly glad to have me work on this because lobster was out of season and there's nothing more delicious than lobster – we had plenty of lobsters, you see?"

However, Dr. Sunderman was less popular with the U.S. customs officials:

> I remember going back to the States one time. This was during the prohibition era. I had an old Gladstone bag with three bottles in it: a bottle of seawater, a bottle of shark's blood and a bottle of lobster blood. The customs fella opened up the bag and said, "What's in this bottle?"
>
> "Salt water," I told him. Could have been gin, of course.
>
> He looked at me, very curious, and said, "Now, what's in this bottle?"
>
> "That's shark's blood," I said, "shark's blood." Shark's blood is a beautiful pink color.
>
> And he looked, and he shook his head, and he said, "What about this?"

I said, "That's lobster blood."

He said, "I'll have to see my boss."

He got his boss over. I said, "This fella won't believe me. I've got lobster and shark blood..."

He looked at the fella and said, "When someone says they've been to the Biological Station, never open the bags. There may be snakes and so forth."

In that second quarter of the twentieth century, scientists visiting Bermuda were given privileged treatment. Sunderman remembers the cruise ships:

There were two ways of getting down then, the *Queen of Bermuda* and the *Monarch of Bermuda*. They used to alternate between here and the States. You got a special rate if you came down with the Station. It was $60, if I remember. For that you got the best, you never got to choose, but you got the best suite or state room available. I remember one time I had the finest room on the ship. That was built for royalty. The ship came into St. George's, and a little boat came down to the Station. Either that or you got a horse and carriage; no motor vehicles were allowed then. Almost everybody had a bicycle. This was in the days before those motor-assisted bicycles.

The transportation into Hamilton was very good. We used to have to go up the hill from the Biological Station to the railway station and take the train. Other transportation was always by horse and carriage or bicycle. They had a few trucks here, but that was all until after the war.

The incidence of tetanus was very high here on the island, very high. It went straight down with the horse population. Horse droppings have a high tetanus content. I followed that a good bit with the hospital group, and we were interested in that for a couple of years: following the incidence of tetanus.

Visiting scientists and Harvard students prepare to sail home from Bermuda in 1938

A laboratory at BBSR in the 1930s (now the Kresge Dining Room)

During his visits to Bermuda, Sunderman had contact with many of the long-term scientists. He developed a liking for William Beebe, even though he noted that Beebe tended to be aloof. Of Beebe's party, Sunderman said it was his fellow scientists and staunch assistants, Gloria Hollister and John Tee-Van, who were the sociable ones. They seemed to be the more knowledgeable, too, and, if someone asked Beebe a question, he would turn to Tee-Van and pass the question on to him. Sunderman believes that Beebe was a good organizer who knew the value of a reliable team.

"I always had a lot of respect for what [Beebe] was doing," Sunderman said recently. "I think it was a great feat for him to go down. Two people living in that Bathysphere for eight or 10 hours? Awful!"

Dr. Sunderman also recalled that Beebe had a sharp eye for a pretty woman. "We were standing on his porch one day when I was over there and he had this telescope. He was following a girl in a boat. He looked out and he says, 'She has a wedding ring on.' We had a lot of fun about this."

Sunderman has been visiting Bermuda on a regular basis ever since those early days. He has also amassed an impressive list of accomplishments and is world-renowned for his contributions in a number of fields: electrolyte metabolism, research medicine, clinical chemistry and toxicology. He originated the practice of interlaboratory proficiency testing. He also founded the College of American Pathologists and the Association of Clinical Scientists. He became a member of the BBSR's Board of Trustees in 1950 and was named a life trustee in 1986.

SIX

BBSR and the Second World War

BBSR President Columbus Iselin on the cover of Time magazine, July 6, 1959

Edwin Conklin remained president of the Board of Trustees until Columbus Iselin took over in 1937. A great deal of Conklin's correspondence during his time as president has survived, clearly revealing a passion for the affairs of BBSR. He was responsible for introducing many scientists to Bermuda; despite the fact that he lived in Woods Hole, he would actually help in the administration by allowing visits to be booked through him as well as through BBSR's director.

Conklin only resigned his post after all the outstanding problems of his tenure had been resolved. His last report as president finishes with these comments:

> I have served as president of the Corporation and chairman of the trustees and Executive Committee for 10 years. During these years BBSR has been reorganized, it has received in grants and gifts approximately $300,000, it has now the promise of large support from the British Development Commission, and its future as an important center of research in marine biology and oceanography

seems assured. I beg leave, therefore, to retire from presidency at this time to give place to a younger man who may, with the aid of its many friends, see that the Bermuda Biological Station for Research advances into a new day of greater service and international cooperation.[1]

This report also announced that Willie Gleeson, after many years of service first to the Shore Hills Hotel and then to BBSR, was resigning to go to a post elsewhere on the island.

Conklin had stayed until he felt BBSR was in a fairly comfortable position – difficulties during Wheeler's tenure and questions about the quality of food served had settled down, BBSR was on more sound financial footing, and the library was in much better condition than it had been at first. This was mainly due to the work put in by William Cutter, the librarian, who had been working there since the Shore Hills property had been taken over.

Cutter was responsible for moving the book collection from its temporary home in the main building into the old power house for the hotel. This became the library, and continues to fulfill that function, although the building has been extended.

The library in 1936

One of the results of the ascension of Columbus Iselin to the post of president was an increased interest in oceanography. Since Iselin was himself a noted oceanographer, celebrated in the cover story of *Time* magazine for July 6, 1959, he was eager to involve BBSR in this field, keenly aware that the mid-ocean location of Bermuda lent itself to studies of this kind. He announced at the Bermuda Advisory Council meeting in April 1937 a joint venture between the relatively young Woods Hole Oceanographic Institution and BBSR to investigate changes in the rates of flow of the Gulf Stream past Bermuda and the effect this had on fisheries.

During the 1930s, the boats used by BBSR were an old Navy lifeboat and, from 1938, a large sailing vessel, the *Culver*. A small launch, the *Lancelet*, was also mentioned in the director's report of 1935. The Woods Hole/BBSR oceanography venture used the *Atlantis*, a research vessel from Woods Hole.

With the advent of the Second World War, life in Bermuda, and at BBSR, was greatly changed. The shape of Bermuda changed, too. The U.S. Government entered into a lease agreement with the British Government for a large part of St. David's Island, leveled a chain of islands between St. David's and the causeway to Hamilton Parish, and filled land between

The building of the U.S. base in Bermuda, 1942

the islands with material dredged from Castle Harbour in order to build an air base, the site of the current commercial airport.

BBSR, conveniently located directly opposite the airport across the narrow stretch of water called Ferry Reach, was commandeered by the U.S. Army in June 1941 for use as a place of recuperation from injuries suffered during the war until a proper hospital could be constructed on the U.S. base.

For a while it had looked as if the trustees might have to look for a new site for BBSR. Early plans for the air base would have placed a runway directly through BBSR's main building (now called Wright Hall), but fortunately this did not come to pass. Though the use of the Shore Hills buildings by the United States Army may not have seemed ideal, things could have been a lot worse.

During this period, BBSR was looked after by Hilary Moore, who held the post of director until the end of the war. With the departure of Wheeler and the lack of scientific work at BBSR, the staff all found employment either outside BBSR or performing their jobs at BBSR but for the U.S. Army.

In the end, BBSR's buildings were rented by the army for two years. By June 1943, a proper military hospital had been built elsewhere on the island and BBSR property was released by the Americans. An extract from Moore's report for the years 1943 to 1944 shows a little of what had to be done to restore the buildings and grounds:

> The Biological Station has now been returned to us for over a year. By the terms of the agreement it was handed over as it stood with little attempt to clear up the buildings or grounds. Chester Burgess has spent most of his time during the year doing this, with such outside assistance as was needed. The main building has had its roof painted and lime washed and is generally in good condition. Minor repairs have been made to the rest of the building and the pumps and refrigerating unit kept in running order.
>
> All the cottages have been put into good repair and rented. A pipeline was laid from the main building to the west cottages to supplement their fresh water supply, which was inadequate when all three were occupied. Only the most essential clearing of the grounds themselves has been attempted. A small part of them is under cultivation, and they also provide pasture for several cows.

> The books in the library have been arranged on the shelves and show no damage resulting from their period of storage.[2]

The subsequent year's report continues the story of rebuilding:

> The estate and buildings have been kept in order during the year, and such essentials as lime washing attended to, but owing to the present high cost and poor quality of available materials, such items as repainting have been postponed wherever possible.[3]

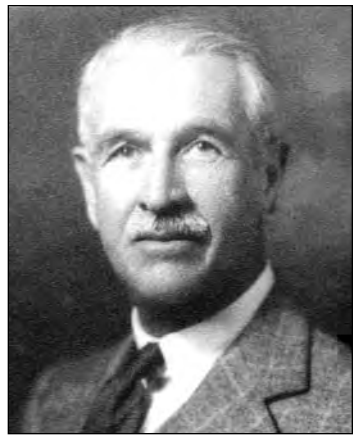
By the end of the war, Bermuda had changed forever. Not only had the air base been built, claiming some seven percent of Bermuda's land area, but the presence of the United States forces brought other innovations to the island, notably motor vehicles. For the first half of the century, Bermuda's Parliament had resisted the lure of motorcars, and, before the war, only a few trucks were allowed for essential purposes. In 1946, partly due to pressure from military personnel who wanted better transportation between their various outposts at the opposing ends of the island, the law was changed to allow motor vehicles. Bermuda's Parliamentarians, who had argued for 50 years that American visitors preferred a resort where motorized traffic was banned, now consoled themselves that very few Bermudians would be able to afford to buy a car.

The lawmakers miscalculated, with dramatic results. By 1948 the Bermuda Railway, which had served the island well since 1931, ceased to exist. The competition from private cars was such that the income from train tickets would not cover the costs of necessary repairs, and the railway's rolling stock was sold to British Guiana, now Guyana.

Not surprisingly, it took some time to rebuild scientific momentum at BBSR. In each of the years 1939 and 1940, before BBSR buildings had been requisitioned by the United States Army, 12 scientific papers were published by BBSR. Following the end of the war, the first paper came out in February 1946 and was written by the director, Hilary Moore, in conjunction with his wife. It was titled "Preglacial History of Bermuda" and was based on the work he had done during the war. A planned part of the paper was not included, since the principal investigator in that area was called up for active service. The next paper to be published, Ethel Browne Harvey's "Bermuda Sea Urchins and their Eggs," was the only one released by BBSR in 1947. By 1948, matters were improving: eight papers were published.

One benefit to BBSR of the war effort in Bermuda was that it was able to purchase some equipment from the Imperial Censorship after this operation left the island. In addition, Hilary Moore's report for the years 1944 to 1945 noted that some scientific equipment had been donated by a visiting scientist, Dr. Mees, "on the understanding that it should be available for his use whenever wanted." This included a good microscope, an electric oven, a vacuum pump and other useful items. Last but not least, Dr. Beebe, having now finished his research in Bermuda, had left a number of pieces of equipment in the house where he had stayed. These were also donated to BBSR. Both men left books and, since expanding the library was considered an important goal, these were very welcome gifts. At the end of the report, Moore thanked Sir Stanley Spurling, a long-time and influential Bermudian friend of BBSR, for "constant advice and help."

Moore was keen to see whether the war effort had damaged the reefs and associated wildlife of the region. In particular, he was concerned about the dredging carried out to



Sir S. Stanley Spurling

reclaim the land where the airport was built. When he had time, he surveyed the area in front of BBSR, the rest of Ferry Reach, and also Castle Harbour and North Rock:

> I have kept up observations on the rehabilitation of the fauna in the neighborhood both by general shore collecting and by fishing from the jetty with a fish trap and with an electric light. Although the area is still rather muddy, it is improving and many forms are returning. When BBSR reopens, I do not think that we shall have much difficulty in finding all the types to which we are accustomed, although a good deal of exploration of new locations will be called for. This is difficult at present without the use of a boat. Although the dredging has produced many local changes in the fauna and flora, I do not feel that the area has been in any way ruined for collecting.[4]

Various other measures were overseen by Moore, such as improvements to the water supplies, restoration of tanks and the provision of electric power to places where it would be advantageous. By mid-1946, BBSR was once again deemed more or less ready to entertain working scientists, and eight visitors were present that summer. That year also saw the appointment of the next director in BBSR's history, Dugald Brown.

The trustees also developed plans for expansion. A letter to the Bermuda Government in 1947 explained:

> The plans of the trustees of the Station include -
> 1. the expansion of its income to approximately £10,000 a year. The present income is about £4,000, derived from investments and other sources;
> 2. the provision of more laboratory accommodations; and
> 3. the re-construction and lengthening of the jetty on the foreshore of the Station property so as to permit larger vessels to come alongside.
>
> In pursuance of these plans, the trustees have this year spent all available funds on the restoration to its original conditions of the main building on the property, which was considerably altered during the American occupation. They

have also repaired and equipped the other buildings on the property and fitted them for living quarters for visiting scientists and their families. These works are now well advanced and will be completed before the end of the year.

During 1948, the trustees propose to devote any funds available to constructing the new jetty and building a new laboratory, 90 feet by 30 feet, in order to increase the space available for scientific research. At the present time, all laboratory space is fully occupied. In addition, the trustees propose during that year to raise funds to be used for equipping the new laboratory with the most modern scientific apparatus, so that the Bermuda Station may take its place in the front rank of scientific institutions of its kind.

I have been instructed by the trustees to submit these facts to the Bermuda Government, with the object of enquiring whether the Legislature will be disposed to contribute financial assistance towards the carrying out of the above plans.[5]

Dr. Walter Garstang

Dr. Dugald Brown

The next few years were primarily concerned with money for the BBSR's expansion and for completing the repairs to the property. Early in 1948, the Bermuda Government granted £6,000 to the Corporation for the building of a new laboratory, and this was almost completed by the end of the year. Also in 1948, one of BBSR's boats, the *Diadema*, ran aground on Nonsuch Island. The resulting damage, together with some necessary alterations, cost $1,250 to fix. The reason for the mishap was given as "personnel failure."[6]

The year 1949 saw the death in England of Dr. Walter Garstang, one of the visiting scientists to BBSR and someone who was well respected in the field of marine biology. He started his celebrated career in 1888 at the opening of the Plymouth Laboratory in England, and was subsequently appointed the first Buckland Professor of Fish Culture at the University of Leeds, where he taught from 1907 until 1933.

Garstang was a good friend to BBSR. Despite his relatively few visits, he was a very active fundraiser for BBSR in England, and the *Culver*, the 80-foot ketch bought by BBSR in 1938, was acquired largely through funds raised by him from the Royal Society.

In addition to his excellent contributions to the scientific field, one of Garstang's most well-known legacies is a collection of poetry of a distinctly whimsical, scientific nature. One of these poems extols the virtues of Bermuda for the study of the ocean.

An Oceanographer's Dream

(with apologies to Tennyson)

I built my soul a stately treasure house
Beside the rolling ocean's swell,
With cunning apparatus to disclose
The gems below that dwell, –

Those living gems "of purest ray serene,"
Oft frail, fantastic, strange and rare,
Whose lives sheer mysteries have ever been,
But need not be – with care.

'Twas not in marbled luxury it grew,
With spacious courts and colonnades;
A boat and colling tanks were most in view,
And tackle of all grades.

An isolated pinnacle I chose,
Five hundred miles from every shore;
Sheer from the th' Atlantic's deep abyss it rose,
Three miles in depth or more.

Around it limpid dark blue water flows
From distant equatorial seas:
It feels, above the pulse of melting snows,
The Gulf Stream's vagrancies.

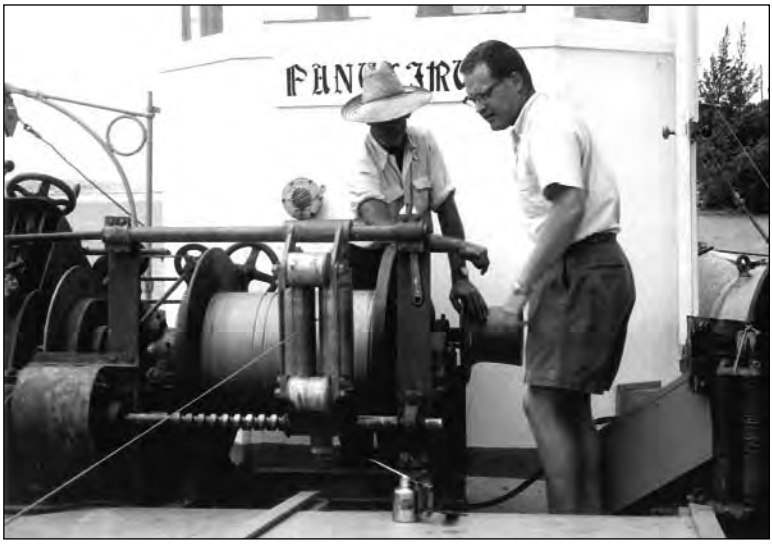
A sturdy, broad-beamed, fishing boat I planned,
Equipped with motor winch and screw,
For quick excursions out and back to land –
A man and boy for crew.

The zone of waters which concerns us most,
Where mighty currents change their beat,
Can here be sampled three miles off the coast
To full 3,000 feet.

BERMUDA, watchtower of the Sargasso Sea!
Its coral cap twelve miles across,
On this one spot my treasure house would be, –
Its absence the world's loss.[7]

SEVEN

Panulirus and the Birth of Hydrostation "S"



William Sutcliffe (right) examines the winch on the research vessel Panulirus

In 1949, Dr. Louis W. Hutchins became the director of BBSR, heralding a new period of exciting progress for BBSR on both the inshore and open-ocean environments surrounding Bermuda.

Dugald Brown, who vacated the post of director to accept an opportunity in the United States, continued to take an active role by becoming president of the BBSR Corporation at almost the same time as he resigned the directorship. He was succeeded as president in 1955 by Gordon Riley. Dr. Riley was a professor at Dalhousie University in Halifax, Nova Scotia, and specialized in the study of plankton ecology.

Hutchins was employed as a part-time director, dividing his time between Bermuda and Woods Hole. He started his first report as director by noting the progress made to rebuild BBSR since the war, and by looking to the future:

> I wish to make clear my outspoken admiration for what has been accomplished. The program of rebuilding and re-equipment of the last three years, however, must be continued, for there are still important shortcomings in plant and facilities. These must be met, largely by further capital improvements, if the Station is to continue to attract business.[1]

Hutchins emphasized that researchers from other institutions, particularly oceanographers, were anxious for opportunities to work in Bermuda. The Bermuda Government had

been showing interest in funding projects, at this time notably an investigation into the Bermuda Spiny Lobster, *Panulirus argus*. Nevertheless, Hutchins catalogued a large number of problems which he believed must be addressed before long, such as renovations necessary to the cottages, main building and laboratories; new nets, dredges and collecting bottles; and repairs to the two research vessels, the *Diadema* and the *Abedefduf*. He also mentioned the real need for a larger boat capable of performing deep-ocean work, which neither of these two relatively small boats was equipped to do.

In response, the board agreed that BBSR should try to cope with a deficit for a few years while doing as much as possible to rebuild and expand the facilities in order to attract a larger number of investigators. The idea was that these scientists would in turn initiate research programs that might subsequently become self-supporting through outside sources, as had been the case with the lobster program. The available capital would support such a deficit financing policy for some five to seven years.

Following implementation of this financial policy, BBSR attracted enough scientists (and funding) to survive. Furthermore, there were the projects funded by the Bermuda Government, such as the lobster research about which Dr. Hutchins wrote:

> Around 500 lobsters now have been tagged and released for study of movements and growth rates. At present about 15 percent have been recovered, although at times recovery has been as high as 20 percent. From the recoveries to date, the lobsters in Bermuda seem to display a marked homing instinct which has not been recorded for the species elsewhere.[2]

Hutchins stated that the lobsters would return to the location from which they were collected when released a long distance away, even if obstacles, such as islands, were in the way. BBSR scientists have subsequently learned, using modern genetic techniques, that the Bermuda Spiny Lobster and the Florida variety are identical, so such behavior is unlikely to be unique. In fact, the likelihood is that many of the lobsters growing up in Bermuda were carried here as larvae from Florida in the Gulf Stream, which passes both places. For those larvae, it is fortunate that they stop here, as the next land mass they are likely to encounter is Iceland. In any event, the lobster project proved to be very useful, outliving its original three-year plan and leading to Bermuda's current legislation on lobster fishing.

The lobster study is an illustration of the more general way in which BBSR, by virtue of the isolation of Bermuda, is such an ideal spot for research projects of this nature. In this regard, Hutchins commented:

> The lobster work is interesting amongst other ways in demonstrating the relatively unique value of Bermuda as a locale for studies in population ecology. The small size of the area, together with its extreme isolation, makes possible the treatment of whole, discrete populations of many types. Undoubtedly there are many opportunities along this line for extremely significant research, and it is to be hoped that their development can be encouraged.

Hutchins was replaced on September 1, 1953, by Dr. William Sutcliffe, Jr., another scientist from the Woods Hole Oceanographic Institution in Massachusetts. Sutcliffe already knew BBSR, having been a staff member for two years before his appointment, and proved to

Dr. Hutchins (left) and Dr. Sutcliffe (right) with visiting scientists

be a more enduring director than the previous incumbents, staying until 1969.

Around the time that Dr. Sutcliffe took over, BBSR acquired a new boat, named for the genus of the Bermuda Spiny Lobster. The *Panulirus* was a "61-foot round-bottomed and round-sterned wooden vessel of uncertain age," noted a future BBSR president, Dr. W. Redwood Wright. "One quality she shared with her successors was a sickening roll in the oceanic swells off Bermuda." [3]

Despite that limitation, the acquisition of the *Panulirus* represented a major step forward in BBSR's ability to meet the research needs of oceanographers clamoring for access to the open ocean surrounding Bermuda. And through the vision of a Woods Hole scientist, Henry "Hank" Stommel, in collaboration with Sutcliffe, the availability of the *Panulirus* would lead to what is arguably the most significant scientific contribution by BBSR during its first century.

Dr. Stommel was one of the foremost physical oceanographers of the time and taught many of today's leaders in that discipline. In 1954, at a site off the south shore of Bermuda, he initiated the longest running, year-round data collection program for any one point in the open ocean. The Hydrostation "S" Project, or *Panulirus* Station Project, as it was often called, set out to record at regular bi-monthly intervals a number of different variables at varying depths down to approximately 2,500 meters, at a spot 15 nautical miles south-east of Bermuda (32°10'N, 64°30'W). Records of salinity, temperature and dissolved oxygen content were kept. Sutcliffe soon built on this base by adding nutrient and productivity studies.

Stommel was attracted by the deep water surrounding Bermuda, extolled by Garstang in his poem *An Oceanographer's Dream*. But as he subsequently reflected, "It wasn't at all clear then what such a series would reveal, or if it would be interesting." In fact, the data proved to be far more useful than he originally estimated.

This long series of data becomes more valuable each year for scientists monitoring long-term changes in ocean conditions. Like its atmospheric equivalent, the Mauna Loa Observatory in Hawaii, Hydrostation "S" has greatly advanced our understanding of global climate change. For instance, human-influenced global warming may seem obvious from

Hydrostation data; judging from the figures of the last few years of the twentieth century, the temperature of the water is clearly rising. However, if one considers the entire data series, one finds evidence of natural temperature variability in the ocean, with cycles lasting a decade or longer.

In addition to an instrumental role in the establishment of Hydrostation "S," Sutcliffe made his mark on BBSR in many ways. The numbers of visiting scientists per year increased steadily over the first few years of Sutcliffe's tenure, although this was in part due to Hutchins' efforts to rebuild BBSR. Within a year or so after Sutcliffe took over the directorship, BBSR had initiated with Stommel the Hydrostation "S" project; begun a five-year grant from the National Science Foundation, receiving $2,000 a year simply to assist investigators doing research in Bermuda; sold the troublesome boat *Diadema*; commenced landscaping the grounds with around 60 trees donated by the Government Agricultural Department; and finally managed to replace a saltwater pumping system that had been beset by leakage problems since at least 1932.

The Bermuda Government appreciated the research conducted by BBSR, both on the lobsters and on other forms of fisheries, and actively supported these programs. The U.S. Office of Naval Research (ONR) and Atomic Energy Commission (AEC) also supported a number of research projects, ranging from "Quantitative effect of the sun's position on submarine light polarization" (Talbot H. Waterman and William E. Westell, Yale University) to Henry Stommel's "Serial observations of drift currents in the central North Atlantic Ocean."

Over the next few years, the scientific program was strengthened and improvements were made to the physical plant. In 1958, the National Science Foundation granted $19,000 for "repairs and improvements"[4] to the site. This much-needed money was spent on a new dock for the small boats and repairs on the laboratories and water tanks. A new storage room was also constructed, which was kept dry to prolong the life of chemicals and electronic equipment damaged by the humid atmosphere of Bermuda.

In 1959, two scientists conducting a project called Productivity of the Sargasso Sea produced a report on their findings of the previous two years, and this was deemed successful enough to justify the employment of a full-time bacteriologist. The same year, a grant from the Rockefeller Foundation enabled the building of three new cottages on the site, which were finished in April, in time for the summer season. They were named Downwind, Driftwood and Jetstream. In his report for 1959, Dr. Sutcliffe noted, "Partly as a consequence of this new housing, there has been a greater use of laboratory facilities during the year."

A deep-sea angler fish collected by Dr. Waterman off Bermuda, 1950s

Dr. Menzel (left) and Dr. Sutcliffe conduct a plankton tow on the Panulirus in the 1950s

Unfortunately, by the end of the decade, ONR had discontinued funding research at BBSR, and a number of research initiatives slowed or were ended. In 1958, Stommel was no longer able to make full use of his laboratory at BBSR, and the Woods Hole Oceanographic Institution decided to close down his facilities in Bermuda. Hydrostation "S" would continue under the direction of a new resident scientist at BBSR, David Menzel, who began his BBSR career as a graduate student. But the samples, once collected, were sent to Woods Hole for analysis.

Menzel was a graduate student at the University of Michigan when he was given the opportunity in 1956 to conduct his dissertation research at BBSR. The focus of his work, which was sponsored by the Bermuda Government, was determining the efficiency of food utilization by the Queen Angelfish and the Red Hind. Once he had completed his degree, he was offered a position on BBSR's faculty to work with John Ryther on a variety of problems in biological oceanography, on which they jointly published 10 papers.

During this period, BBSR came under fire from the Bermuda Society for the Prevention of Cruelty to Animals, when a letter to the government from their secretary questioned BBSR research practices with regard to the treatment of animals. The letter explained that this was a new definition of animals, to include all animate life, not just the four-footed variety. Society members had just become aware of an article by Rachel Carson, author of "The Sea Around Us" and "The Silent Spring," whose writings in the '50s and '60s sounded the alarm against pollution worldwide and led to many of the conservation measures presently in place. Dr. Sutcliffe's reply read:

> I think you can understand that the concept put forth in the letter could be carried to extremes. For instance, in a great quantity of the water that we drink we consume some species of minute crustaceans and the young or larval stages of a great variety of aquatic organisms. Also, the manner in which lobsters are prepared for consumption in the local restaurants could not necessarily be considered a pleasant one from the point of view of the lobster, wherein they are immersed alive in boiling water.[5]

Sutcliffe went on to explain that the research carried out at BBSR could be important for medical purposes. The controversy soon drifted away.

In September 1960, Menzel was appointed assistant director. His role was to stand in for the director, who was only present during the summer months. He continued his involvement with Hydrostation "S," although the *Panulirus* posed increasing challenges for continuing the bi-monthly series of measurements. Late that same year, the *Panulirus* narrowly avoided a major disaster. A faulty stern tube caused the *Panulirus* to sink at the dock one night in December. Although she did not capsize, several feet of water entered the engine room, drenching all machinery. Prompt action floated the vessel the following morning, and the main engine was cleaned out and found undamaged. All electrical machinery was sent to the proper agencies for drying out and repairs, and the boat was back at sea within a week.

This accident was not the first to befall the *Panulirus*. In 1956, Sutcliffe had written to the colonial secretary to inform him of her first mishap:

> We should like to notify you of an accident affecting the progress of our Fisheries Research Program. On the morning of April 3, 1956, our boat, the *Panulirus*, put to sea to pursue scheduled oceanographic studies connected with the program and on proceeding through St. George's Harbour suffered the following mishap. An explosion was heard below decks and upon investigating, it was found that the No. 1 cylinder of the main engine had completely torn loose from the crankcase with the resulting shattering of the front end of the engine base. The engine is considered to be a total loss.[6]

And there were more accidents to come. In 1990, Menzel commented, "... It's not clear how any research was conducted off her and why we didn't perish in the attempt to do so." In 1962, Menzel accepted an appointment at Woods Hole. In 1970, he became the director of the University of Georgia's Skidaway Institute of Oceanography.

Margaret Emmott, who arrived in 1966 to work as the station secretary and director's assistant, had this to say about the *Panulirus*: "She actually sank twice at the dock. When

The Panulirus II replaced the Panulirus in 1967

people went out on Hydrostation trips, we used to cast flowers on the water for them, because we thought we'd never see them again."

In May 1967, the *Panulirus* was retired from her duties and sunk in Great Bay, St. David's. She was replaced by the *Panulirus II*, a 65-foot steel surplus U.S. Army supply boat, which shared its predecessor's unfortunate predilection for sinking at dock, but which served until 1983. By then, though, these vessels had aided the collection of more than three decades of valuable data at Hydrostation "S." They had set the stage for expanded, complementary suites of measurements to be conducted by two other critical programs off Bermuda: the Oceanic Flux Program, started by Woods Hole scientist Werner Deuser in 1978, and BBSR's Bermuda Atlantic Time-series Study, started in 1988.

EIGHT

A Magnet for Top Talent

Dr. Alfred Redfield

The 1960s were years in which funds were in short supply, the plant awaited much-needed renovations and the maintenance staff were indeed jacks-of-all-trades. At the same time, this period saw the arrival of a new wave of young scientists who broadened the field of research undertaken in Bermuda and built themselves distinguished careers. Some continued their interest for years to come as BBSR trustees.

In 1961, Gordon Riley was succeeded as president of the Corporation by Dr. John Ryther, whose career in marine biology led him first to the Woods Hole Oceanographic Institution. Later, Ryther acted as a consultant to the boards of the National Science Foundation, the U.S. Fish and Wildlife Service, the National Institute of Health, the President's Science Advisory Committee (1965-66) and numerous other organizations.

Ryther was president for only one year and was followed in 1962 by Dr. Alfred C. Redfield, senior biologist at Woods Hole, who had already served as a BBSR trustee for 18 years. Redfield came from a distinguished scientific family, which included his great-grandfather, William Redfield, who in 1848 was elected the first president of the American Association for the Advancement of Science. An oceanographer and physiologist, Alfred Redfield specialized in the areas of ecology, tides and salt marshes, and served on numerous national boards.

To generations of oceanography students, though, he is perhaps best known for the

"Redfield Ratio," in which the atomic ratios between the chemical components of marine plankton (nitrogen, phosphorus and carbon) are identical with their relative proportions in the open ocean. So for every atom of phosphorus, there are 15 atoms of nitrogen and 105 of carbon. Redfield made this discovery while at Woods Hole in the 1930s and advanced the understanding of the global oceanic carbon cycle and the primary productivity of marine plankton for many years to come.

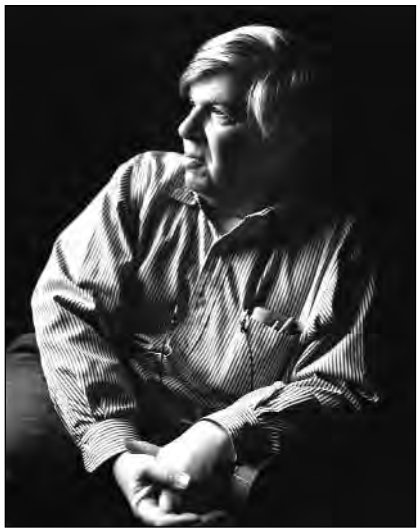
Decades later, data collection and analysis at the Bermuda Atlantic Time-series Study site and its sister site in the Pacific, the Hawaii Ocean Time-series, would reveal that the ocean is a far more variable place than Redfield's theory suggested. But, as Redfield said, "Life in the sea cannot be understood without understanding the sea itself." This basic assumption has held true for future generations of oceanographers.

Among Redfield's students was the man who would succeed him as president, George Scott, and Rudolph Nunnemacher, who served BBSR well for more than 30 years as an investigator, educator, trustee and volunteer.

With Redfield as president of the Corporation and William Sutcliffe as director, BBSR continued to attract leading young scientists. Among those who came to conduct research during this period was Dr. Robert M. Garrels, whose career subsequently included professorships at Harvard and Northwestern Universities, two years at Scripps Institution of Oceanography, and the Captain James Cook Professorship in Oceanography at the University of Hawaii. Garrels wrote a standard textbook of geochemistry in conjunction with Dr. Fred Mackenzie, also at Northwestern University and, following that, at the University of Hawaii.

Mackenzie, who was the staff geochemist and BBSR's acting director, published diligently throughout the '60s and '70s. His research included "Hydrogeochemistry of Bermuda: a case history of ground-water diagenesis of biocalcarenites," "Strontium content and variable strontium-chlorinity relationship of Sargasso Sea water," and "*Homotrema rubrum* (Lamarck), a sediment transport indicator." Mackenzie subsequently served as a BBSR trustee and life trustee.

Drs. Fred Mackenzie (left), Doug Whelpdale (center) and James Galloway meet on Wright Hall porch



Dr. Stephen Jay Gould, 1999

The investigator from this period whose name is best known, in that his fame and writings have far transcended the scientific realm, is Stephen Jay Gould, who first arrived at BBSR in 1959. Then a doctoral candidate at Columbia University, Gould quickly found a topic for his dissertation: a genus of Pleistocene land snails endemic to Bermuda called *Poecilozonites*. He found that as many as 15 species in Bermuda evolved from one snail that evidently strayed from North America, although all but two of the species had become extinct. His work was destined to give him his first indication that evolutional progress is not regular, but proceeds by "punctuated equilibrium."

His work in Bermuda, which continued into the 1970s, was assisted by many Bermudians, most notably by two individuals who would later serve with Gould on BBSR's Board of Trustees, Drs. Walwyn Hughes and David Wingate. "Bermudians were very nice to me," Gould told *The Royal Gazette* in 1999. "They would let me snoop around their back yards. I don't think anyone told me no. I would go around on my rented Dowling's cycle all over the place. Good men like David Wingate and Walwyn Hughes could tell you all about the *Poecilozonites* – they were in on it as well."

As Hughes later noted, "Stephen saw in this group a mollusk equivalent of the Galapagos finches made famous by his great idol, Charles Darwin, and he and I spent many a happy hour scouring the countryside for specimens, both living and fossil."

Gould became Professor of Geology (Paleontology) and History of Science, and Alexander Agassiz Professor of Zoology at the Museum of Comparative Zoology, Harvard University. A widely read author, his monthly columns from *Natural History* magazine made up best-selling books, such as *Bully for Brontosaurus* and *Dinosaur in a Haystack*, and enabled him to educate, stimulate and entertain thousands whose scientific credentials may be non-existent.

On subsequent visits to Bermuda, he found that the two living species of snails he had studied in Bermuda had evidently become extinct due to predation by imported snails. He died in 2002, just a few weeks before Alex Lines, a Bermudian college student working with

Dr. Wolfgang Sterrer at the Bermuda Aquarium, Museum and Zoo, rediscovered one of the species at Spittal Pond.

For Walwyn Hughes, his work with Stephen Jay Gould in the 1960s was an early involvement with BBSR that in 1969 would lead to his election to the BBSR Board of Trustees. He was encouraged to stand for nomination by Bermuda Aquarium curator Louis Mowbray, Jr. when Mowbray retired from the board. Mowbray was preceded on the BBSR board by his father, also a Bermuda Aquarium curator.

Hughes was Bermuda's assistant director of Agriculture and Fisheries for many years and continued his government service as permanent secretary of the Ministry of the Environment then the Ministry of Finance, and as a member of the Senate. Hughes has continued as a BBSR board member for the remainder of BBSR's first century, including many years as a vice-president of the Corporation, making him one of BBSR's longest-serving trustees.

Other leading young scientists were an important part of a transition that would in subsequent years find BBSR transformed from a largely seasonal operation to a year-round institution for research and education.

The first scientists to be considered resident were oceanographer Roger Pocklington and geologist Len Vacher, who were supported by a grant from the U.S. National Science Foundation. Both left when the grant expired, although their involvement with BBSR would continue in a range of capacities.

The lack of funding for scientists signaled even less to spend on the physical plant. At the end of the '50s it had been clear that the main building needed major renovations. The sleeping porches on the first and second floors were found to be unsafe. Consequently they were all removed between 1960 and 1961. However, no one had taken into consideration the possibility that the pillars which edged the porches were essential support posts for the walls, which now began to buckle. Hasty replacements had to be built.

Another danger to both buildings and people was that occasional summer threat, the hurricane. Fred Mackenzie experienced first-hand the one that struck in 1964:

> We all went outside during the eye of the hurricane to check out the damage, although we had been running all over the Station during the storm, trying to patch damage that was occurring to buildings, etcetera. Then, as the winds reversed, we were [caught] outside. During the intensity of the returning winds, a large stone block blew off the roof of the main building and fell directly in the center of three of us [as we were] trying to decide what to do next. The decision was promptly made – go back inside the labs!
>
> Also during that storm, the director, Bill Sutcliffe, touched an outside electrical contact and was frozen to it as the charge went through his body. I had to hit him with a football block to free him and prevent electrocution.

Late in the 1960s, Roger Pocklington and his wife, Patricia, came to BBSR soon after he gained his doctoral degree. Pocklington's main responsibility was to run the Hydrostation "S" trips every couple of weeks, but he also found himself doing BBSR's first studies of pelagic (oceanic) tar. He too has memories of hurricanes:

> We really did look up into the calm in the eye of the hurricane. I had gone

Dr. Sutcliffe (left) presents Chester Burgess with a farewell gift after 53 years of service at the Shore Hills property

over to the lab, doing some work. I only had a small window; I was inside, I didn't realize. Pat called and said I should come home. By the time I got out, the palm trees were bent double and were touching the ground. I had to put on a wetsuit to get home – I crawled from the main building.

BBSR had a very small maintenance staff during the 1960s, led by Brunell Spurling and Chester Burgess, both of whom demonstrated BBSR's enviable ability to attract and hold on to outstanding support staff.

Chester Burgess, who had started his relationship with the Shore Hills Hotel in 1913, had taken care of the buildings and grounds when it became the Shore Hills Golf and Country Club and continued to do so when the property was converted into the Bermuda Biological Station for Research. He remained as custodian during the U.S. Army's occupation of BBSR during the war years and finally retired in 1966 after 53 years of loyal service.

Most of the needed maintenance work was done by Brunell Spurling, who by this time had been working at BBSR for nearly 20 years. Spurling's father owned the hill to the east of BBSR's property, and he and his brother Dixon had grown up next to the Shore Hills lands. Spurling was originally employed as a general worker. He wore numerous hats, including boat captain, carpenter, stonemason, builder, plumber – name it and he could, and did, do it.

Spurling's work also encompassed helping out with scientific endeavors such as water sampling and, on one occasion, assisting a scientist who wanted to attach radio tags to whales in order to track their movements. The way to do this was to fire a bolt, with the transmitter attached, from a crossbow into the whale.

Before Spurling took him out in the boat, the scientist spent a long time practicing with the crossbow. Unfortunately, the difference between the practice runs and the actual whale tagging was that during practice, the scientist kept his shots level, but once he was in the boat, the whales were below him, the crossbow had to be pointed downwards and the bolt fell out. Spurling kept the boat over the whale for some time while the whale sounded and breached, sounded and breached, since it was trying to avoid them but didn't have enough time to

Brunell Spurling builds BBSR's new library in 1969 as librarian Leida Piip looks on

inhale, so couldn't swim away. Every time the whale dived, the tail slapped against the side of the boat, the bolt fell out of the bow, and eventually they gave up for fear the whale would drown.

Spurling's many years of service to BBSR were recognized when he was elected a life trustee in 1975.

No matter what the research, no matter what the differences in outlook, every scientist of that era mentions the *Panulirus*, be it *I* or *II*, and Captain George Taggett, her officer. In addition to her predilection for sinking at the dock, she also reeked of diesel, and, according to Mackenzie, "...everyone who boarded her got seasick, except for Captain Taggett, Butch Stovell [Brunell's young assistant] and Brunell Spurling!"

Pocklington commented that the *Panulirus* was "a most unsuitable boat for oceanic expedition. However, we used it. It didn't sink with us aboard, but we had some close runs."

> One day it looked nice enough. I said, "How does the weather look, George?" And he looked around and said, "Hmm... Don't like it." I thought, well, bow to local knowledge, and we didn't go. Of course, it was clear as glass all day.
>
> Next day, same thing – clear as glass, but George hemmed and hawed. I said, "I really have got to get the water samples. We're going." We went out and put the Nansen bottles in. And over the horizon came a very intense darkness. I didn't really notice it but George had. Up above us the light clouds were moving very fast. George pointed over to the horizon and said, "You'd better get them up, Rog, we gotta get out of here." Already the wind was getting up and started to whip up the water. This wasn't like a modern CTD [conductivity, temperature and depth instrument] where you just drop one thing down. There were lots of bottles – you put one on the line, send it down, put one on, send it down, sequentially. There were only the two of us and it was hard work. Take one off, hang it on the rack...

> This darkness came over the horizon. I'm telling you, it was like the hand of God in some of those Norse legends. I was as scared as I have ever been at sea, and I've been scared at sea. George claimed to have known about it all along. After that, I never overrode him again. If he said, "Well, looks okay now but later...," I'd say, "Fine. Same time tomorrow."

It was about the time the Pocklingtons first came to BBSR that plans were being made to find another director. Sutcliffe had been mostly absent for the previous few years because of work he was doing in Halifax, Nova Scotia. He had brought in an Englishman named Gerry Dale to manage BBSR while he was absent.

In their press release of July 18, 1969, the trustees gave credit to the departing director:

> During his tenure as director, Dr. Sutcliffe built the Biological Station into a modern scientific institution and added to its international reputation as a distinguished marine biological laboratory. A modern wing, the Conklin Laboratory, more than doubled the research space originally available in the main building and provides facilities for the most sophisticated electrical and biochemical measurements. Six additional residences for investigators were constructed, and the new library, soon to be constructed, was planned. Courses in biological sciences for college and postgraduate students were instituted, so that in addition to its prime role as a research institution, the Biological Station is now also known for its contribution to scientific education.

With Sutcliffe's decision to resign the post of director, BBSR was about to move into a new era under the hand of a new, fully resident director.

NINE

BBSR Becomes a Year-round Institution

Dr. Wolfgang Sterrer (left) gives Bermuda Governor Sir Peter Ramsbotham (right) a tour of BBSR

Each of BBSR's directors has brought a new energy and direction to BBSR, and created an atmosphere that identifies the period.

Dr. Wolfgang Sterrer first came to BBSR at the suggestion of the Department of Zoology chairman at the University of North Carolina, Dr. H. Eugene Lehman, a future BBSR life trustee who was at that time in charge of BBSR's embryology courses.

Sterrer's description of this visit tells of his first encounter with Butch Stovell, then Brunell Spurling's assistant:

> One chilly day in the spring of 1969, the year I spent as a freshly hatched postdoctoral fellow at the University of North Carolina, [Dr. Lehman] approached me with the question: "Would you be interested in becoming director of the Bermuda Biological Station?"

Wilfred "Butch" Stovell, 1970s

"Sure," I replied, without the slightest hesitation – after all this was the first job offer I ever had. "Where exactly did you say?"

Several weeks – and some frantic geography lessons – later, I found myself on the promised isle for a pre-job-interview visit, in a launch piloted by BBSR's boatman, Wilfred "Butch" Stovell, and headed for Harrington Sound where I intended to check out the sea urchin population. Snorkeling in and out of sponge-encrusted caves was a thrilling initiation to Bermuda's undersea world, and I counted plenty of purple urchins under the algae and shell debris with which they camouflage themselves against predators.

As we got back, Butch apparently realized that his wallet had somehow disappeared, together with his driver's license and a bundle of dollar bills. He never mentioned it to me (was I his prime suspect?), and I might never have heard of his misfortune if he hadn't taken a bunch of biology students to the same place a few months later to collect sea urchins. Imagine everyone's surprise when the first urchin was brought up with a dollar bill draped over its back, then another with a wallet and a third flaunting a driver's license in Butch Stovell's name... By that time I had accepted the job, and was all set to delve into what was to become an enduring fascination with Bermuda's environment, and with the unique riches of its underwater life in particular.[1]

The fascination Bermuda's flora and fauna held for Sterrer kept him at BBSR for 16 years, and after the end of his tenure he remained on the island as the curator of the Bermuda Natural History Museum, part of the Bermuda Aquarium, Museum and Zoo in Flatts Village.

When he was appointed director, Dr. Sterrer was only 28 years old. It was late 1969, and he came with an agenda that was reported fully in the local papers:

> The Station would like to get more of a connection with Bermuda, and this can be of interest for Bermuda insofar as it contributes to a better knowledge of what is going on around the island in the framework of natural history. Any public interest in the Station would be very welcome.[2]

When he came to BBSR, Sterrer found one scientist on staff, postdoctoral researcher Roger Pocklington. Then came Byron Morris to write his thesis on plankton. Morris became interested in pelagic tar and was made a research associate. Soon BBSR's scientific horizons were broadened with the introduction of a wider range of scientists, both as residents and as visitors, many of them through Sterrer's connections in Europe.

BBSR was still far from perfect in a financial sense – most of the endowment had been used up after the war and the Army occupation of BBSR property to get BBSR back in some sort of order. The lack of money meant that important repairs had been stalled for as long as possible, with the result that they were piling up.

In fact, on the very day that Sterrer took up his new post as director, he was confronted with the beginnings of two fairly major projects. The first was the construction of a much-needed addition to the library building, despite the fact that there was no money to finish the building. The plan was to start the work and hope that this would encourage donations from trustees or other sources. The second, and potentially the more alarming project, was the complete rewiring of the main building due to threats from the fire marshal of closing the place down – something else for which, according to Sterrer, no one really knew where the money was coming from.

It is therefore particularly notable that by July of the following year, the library had been enlarged and a second floor added. Furthermore, said the *Mid-Ocean News* headline for July 25, 1970: "It's the impossible – a building cost $48,000 under the estimate." This achievement was illustrative of the BBSR spirit, which Sterrer spent the next 15 years encouraging: the library was built by BBSR staff (and occasionally scientists), under the guidance of superintendent Brunell Spurling.

There is no doubt that Sterrer's time as director was very important. BBSR expanded its outlook, extended its operations from essentially a few months in the summer to a year-round schedule, and began the task of fundraising that sent the organization on its way to what it is today. As Dr. Sterrer puts it:

> [Bermudians] said that it was... not a place where visitors were welcome... where a lot of classified naval research was carried out under contract. Funding had been available, mainly as a consequence of the United States realizing how important it was to know the oceans for submarine warfare and so on, and BBSR had also received a lot of money through subcontracts from the Woods Hole Oceanographic Institution. As a result, there had been no reason really for BBSR to have an open door policy. Obviously the first thing was to open up BBSR to make Bermudians aware that there was a Station. We needed a lot of money and we wanted to attract potential donors, so we started an Associates Program. We felt that Bermudians, too, might very well benefit from this institution, not only in terms of the academic image of BBSR – a research institution is not so bad to have in a place that doesn't have a university – but also that BBSR might be useful in terms of gathering information about the island.

With this in mind, the staff endeavored to get BBSR recognized as a useful part of the Bermudian community. The first step towards this goal was the establishment of the Associates Program, so that Bermudians and non-Bermudians alike could have a stake in the activities and growth of BBSR.

In 1971, a meeting was held of people who became the nucleus of this new group. Sterrer describes it:

> Than [Nathaniel] Butterfield was one, Harry Cox and some others, but it was no more than 10 people at that time and we said we'll call it the Associates of BBSR, with an annual membership and a newsletter. Rudi Nunnemacher became very interested in the newsletter idea. He was a professor at Clark University and was very dedicated to BBSR. One of his former students came, first as a volunteer, then we hired her. That was Jill Cadwallader who then became editor of the newsletter and for a long time was in charge of all PR and fundraising.

The Associates Committee included Nunnemacher and Cadwallader, Bermudians Butterfield, Cox and Dewey Marquardt, David Lonsdale of the Bermuda Aquarium, and Sterrer. Associate membership was to be $20 per year.

The first newsletter came out in the fall of 1971 and included a small section explaining the Associates Program and the reason for the new publication:

> The Bermuda Biological Station has been home and host to many scientists and laymen from its incorporation. Many others have a deep interest in knowing a little more about the sea around us. To make this possible an associate membership has been established. It is the aim of the association membership to learn about the sea through the work of the scientists at the Station, lectures and publications, and to support the Station morally and financially. To this end the NEWSLETTER has been established.

As luck would have it, a milestone occurred at this time that provided an appropriate event with which to introduce BBSR to the community. The new library building was completed during the first half of 1971; it was to be named the Alfred C. Redfield Building, in honor of the eminent scientist and former BBSR president.

A dedication ceremony marked the occasion. Invitations for the event were sent out to a number of Bermudians who had connections with BBSR or who were considered to be prominent in the community. Displayed on the front of the invitation card were the words: "Donations Towards the BBS Development Fund are Invited." This could be considered to set the tone for the next few years of BBSR's history.

Thus, the inaugural newsletter of fall 1971, which announced the Associates Program, also included this headline on its first page: "Alfred C. Redfield Building Dedicated July 17, 1971." The article noted:

> Bermuda's governor, Lord Martonmere, officially opened the latest addition to the Biological Station before 300 distinguished visitors. The new building, located in front of the original Mark Library, triples the library space, and on the second floor provides a lecture hall for 80 and new business offices and a handsome office for the director, Dr. Wolfgang Sterrer.
>
> Under blue skies, Dr. Sterrer welcomed the honored guests and gave special thanks to two people who brought the building to completion in record

Lord and Lady Martonmere visit BBSR

time: Brunell Spurling, superintendent, [who] by his own labors converted the blueprints into the handsome Bermuda stone building, and [BBSR President] Dr. George Scott, who was the driving force from inception of the project and in raising funds for the $95,000 building.

Dr. Scott followed with a brief history of the Station, commending the Bermuda Government for their long and continuous support of the Station. He then introduced the main speaker, Dr. Paul Fye, a leader in international discussions on all problems pertaining to the world's oceans and the president of the prestigious Woods Hole Oceanographic Institution. The need for the continued emphasis on the study of the oceans and the particularly vital role which marine stations play was emphasized by Dr. Fye. He spoke of the significant role which Dr. Redfield had exercised, not only in the study of the oceans, but also in the training of oceanographers and the development of both the Bermuda and Woods Hole laboratories.

Dr. Alfred C. Redfield, dean of oceanographers and president of the Bermuda Biological Station 1962-67, was obviously pleased by the honor bestowed upon him....

After the speeches, the trustees, led by Vice-President Dr. Walwyn Hughes, conducted guided tours of the laboratories. The tours were followed by a buffet meal and dancing to the Somers Isles Jazz Band, featuring Dr. Sterrer on clarinet.

The event was certainly considered a success. From then on, for many years, BBSR held an open house every year, whether or not there was a new building to dedicate. This occasion became a significant event on the social calendar of the island. It was succeeded by an even larger annual event for the community, Marine Science Day, in 1987.

Another strategy for raising funds was to fill the hotel premises by introducing increased educational programming, and Dr. Nunnemacher was a leader in this area, too. He had first visited BBSR in the 1950s, carrying out research on Bermuda's night-feeding shrimp. In the mid-'60s he started bringing groups of Clark University students each year for a field course in Bermuda, and encouraged others to do the same.

By 1971, Nunnemacher was bringing his fifth group to Bermuda. In addition, other groups arrived from Union College, McGill University, Hobart College and Orange County Community College. The same year, the first group from Europe – Wolfgang Wieser and 11 graduate students from the University of Innsbruck – spent a month at BBSR, studying the marine life of the western Atlantic. The following year, the number of visiting groups doubled and thereafter increased steadily year by year.

While Nunnemacher led the way with college groups, the pioneer in bringing high school groups to BBSR was Jane Cheney, who first visited BBSR in 1960 and began bringing students in 1966. Cheney was senior scientist and former executive director of the Children's Museum of Hartford, Connecticut. Her first group consisted of graduate students from Hartford University, where she was an adjunct professor, but she gradually started bringing high school students to BBSR. One of the teachers who accompanied her from 1968 onwards, Duffy Brookes of Vernon Center High School, Connecticut, has been bringing groups from his own school ever since.

So notable was the presence of visiting high school students at BBSR that *The Royal Gazette* devoted an editorial to it on April 23, 1969, called "Educators Take Note." The editor started by saying, "Bermuda is being taken seriously by a group of young Americans who have come here to study Bermuda." He went on to rhapsodize over the benefits this would bring to the students concerned, and came to his point:

A young Rudi Nunnemacher casts a plankton net in 1936

> The youngsters, who come from Hartford, Connecticut, and their leader provoke the question: Why can't Bermuda have something like this? It is doubtful that we have come as far as to be thinking in terms of scientific trips abroad, but the facilities of the Biological Station are there, just down in St. George's, and the likelihood is that the station would welcome their facilities being used during the winter when things are generally slow.
>
> ... A fascinating point to be noted about the Connecticut students is their age. These students are not just a few months away from university but are rather just starting the run up to college entrance standards – a period when the stimulation of such an experience may well be most valuable. Connecticut has led the way – it should surely be possible for Bermuda to follow.

Over the ensuing three decades, BBSR would implement several successful educational programs for Bermudians, such as the JASON Project educational broadcasts, the Bermuda Programme internships and the Bermuda Schools Science Enrichment Program.

Like Nunnemacher, Cheney was instrumental in persuading other teachers that Bermuda would be a good place to bring students. Her single-minded dedication to things biological is remembered by Roger Pocklington's wife, Patricia:

> Jane Cheney was delightful. She knew every plant, every tree, every shrub on the island. I would be taking my young baby for a little walk to find her coming along the road with her students. I would get off the road to let them go by and, as they passed me, Jane would say, "This is a sabal palm and this is what they make tapioca out of; this is Mrs. Pocklington and she has just had a baby and she is nursing this baby and she can't eat chocolate or cabbage; and this is a Chinese fan palm..."

"Just another biological specimen," commented Patricia's husband.

As a result of Mrs. Cheney's enthusiasm, Dr. Sterrer decided to go after the high school and college market in a serious way. He took a six-week trip to the United States to visit a number of schools, giving scientific talks and showing slides, and thereby persuading more groups to visit BBSR.

Part of the reason BBSR needed new school groups was the decision in 1972 of the National Science Foundation to stop funding graduate summer courses, a result of the Nixon administration's policy of reducing funding drastically for "non-essential" science. Sterrer explains:

> When I came to the Station there were two very highly regarded NSF-funded six-week summer courses, one in embryology and one in ocean sediments, for graduate students who were selected from the top students from all over the States. The first was run by Gene Lehman, the second by Fred Mackenzie, Bob Garrels and some others. These courses ran until 1972.
>
> From 1974, we scrambled madly to rebuild a summer course program and the first year was dismal. We got very good instructors – for instance Dr. Bob Barnes [of Gettysburg College, whose book on tropical marine ecology is a virtual bible for those in the field]. I sent information on it to all my European

Bermuda Programme interns Jack Ward, Graham Hillier, Winifred Hughes and Robbie Smith gain laboratory experience with instructor John Barnes, 1976

contacts, but we had no money to fund it, so we had to take any and all students who were willing to pay, which meant that we had some postdocs and some recent high school graduates who had money and wanted to spend a bit of time in Bermuda.

We kept the program going, but realized that the only way was to find scholarship money so we could support the best students and pull them in regardless of their ability to pay.

Although the 1950s and '60s saw a good deal of oceanographic research with military applications conducted at BBSR, by the '70s this was outweighed by non-military basic research, which resulted in publications such as Stephen Jay Gould's "The molluscan fauna of an unusual Bermudian pond: a natural experiment in form and composition" (1968); Ronald R. Cowden's "Cytological and histochemical observations in connective tissue cells and cutaneous wound healing in the sea cucumber *Stichopus badionotus*" (1968); Hugh Dingle and Roy L. Caldwell's "The aggressive and territorial behavior of the mantis shrimp *Gonodactylus bredini* Manning" (1969); Robert M. Garrels and Fred T. Mackenzie's "Sedimentary rock types: relative proportions as a function of geological time" (1969); Donald M. Maynard and Andrew Sallee's "Disturbance of feeding behavior in the spiny lobster, *Panulirus argus*, following bilateral ablation of the *medulla terminalis*" (1970); and Bruce C. Coull's "Shallow water meiobenthos of the Bermuda Platform" (1970).

To fund visiting investigators, Dr. Sterrer approached four women whose husbands had been active supporters of BBSR. Mrs. Montgomery Moore, Mrs. H.B. Wilkinson, Mrs. Samuel Riker and Mrs. Sydney Wright all contributed to fellowships. The first grants were small – $500-$1,000 each – and at the end of the year a report and copies of any resulting publications were sent to each donor, with a request for further contributions. Once the fellowships were established, each of the donors agreed to endow them.

With the revival of the summer course program, the first years saw two to three courses offered per summer. The courses were taught by BBSR staff members Dr. Sterrer, Dr. Conrad

Gebelein and Dr. Byron Morris; by Dr. James Burnett-Herkes, then curator of the Bermuda Aquarium; and by a number of overseas instructors, including Robert Barnes.

Student numbers in the 1970s averaged 42 per summer, or 14 per course. This was good news for BBSR, because the courses filled all available laboratory and lecture space. Since then, the construction of more lab space, as well as scholarship funding from the Exxon Mobil Corporation, the Starr Foundation, the Ernest E. Stempel Foundation and other funders, has made it possible to increase the number of courses to six or seven per summer, but the courses are still limited to 15 students each.

In an effort to interest young Bermudians in careers in marine science, the Bermuda Programme was created in the mid-'70s. With funds provided by local businesses and charities, a handful of Bermudian college students were chosen each summer to assist BBSR scientists in their research. The donated funds were used as student stipends to cover basic housing, food and travel costs.

Since 1976, more than 100 students have taken advantage of the Bermuda Programme. The significance of this initiative can be demonstrated by looking at Bermuda Programme students from the year 1977. They included Robbie Smith, whose experience catalyzed his interest in science and the ocean, and who became a BBSR faculty member, leading its coral reef research program; Jack Ward, who worked first at the Division of Fisheries and is now director of the Department of Conservation Services; and Joan Blades, education officer for science at the Bermuda Department of Education. Later notable alumni include BBSR scientists Kent Simmons, Joanna Pitt and Rachel Parsons.

In 1976, BBSR celebrated its fiftieth anniversary as a U.S. non-profit organization. An estimated 600 guests – the biggest number yet – attended the open house celebration. The prestigious anniversary was also celebrated with the largest symposium held at BBSR up to

Wolfgang Sterrer (front left) and Roger Pocklington (front right) celebrate the fiftieth anniversary of BBSR's incorporation with the 1976 symposium participants

that point, "Bermuda – Anatomy of an Oceanic Island." It was attended by 39 scientists who were working in Bermuda at the time or had previously conducted research at BBSR. The governor of the day, Sir Edwin Leather, gave a reception at Government House for symposium participants.

With a broad but increasingly more technical spectrum replacing the construction and maintenance tasks undertaken by Brunell Spurling, the post of technical manager replaced that of supervisor, and Spurling retired to commence a new life as a fisherman.

Art England, a retired U.S. military helicopter mechanic, became BBSR's first technical manager. He was succeeded by Charles Trumbell, whose wife, Janie, was BBSR's librarian for many years.

In 1979, Sterrer hired Harry Barnes to replace Trumbell as technical manager. Barnes oversaw a range of activities at BBSR, including the acquisition and refit of its next two oceanographic vessels, as well as the inshore vessels *Culver* and *BBS II*, and the renovation of all existing buildings on the campus. Barnes implemented many advances in support services, notably the oceanographic support program, laboratory support services and the AAUS diving program. He also obtained membership for BBSR in the University-National Oceanographic Laboratory System (UNOLS) and started the NSF ship-funding program.

Sterrer brought still other changes to BBSR. Born in Austria and raised on a farm, he tried to introduce a degree of self-sufficiency to BBSR by bringing in a number of farm animals and using the arable land to produce vegetables for the BBSR kitchen.

Dr. Sterrer augmented the agrarian theme by keeping a horse on the property. June was a very friendly animal who enjoyed human company, a tendency that was to lead to her unfortunate demise. The story of June is related here by Harry Barnes:

> I lived "on Station," and as the person responsible for BBSR's operational activities, I was often called upon to deal with unusual events.
>
> June lived in a paddock on Station, but she escaped frequently in her search for human company. At night she would come to my house, Langton Villa, and snort through the bedroom window. Her nocturnal rambling

Harry Barnes joined BBSR's staff in 1979 as the technical manager

undoubtedly surprised neophyte visitors who encountered a large, heavily breathing animal in the dark.

On the day of June's fatal accident, Wolfgang was off the island. It was early one morning when I received a call at home from Phil Reeves [BBSR's accountant]. He said, "Here's a new one for you, Harry. June's in the trench outside the library." It appeared that while wandering her normal route around the grounds in the dark, she had been surprised by the recently dug trench and fallen in, breaking one of her front legs. The vet quickly put her out of her misery but couldn't put me out of mine; June had been a dear friend.

June's accident happened at the start of Cup Match weekend in August. It was very hot and all potential "dead horse disposal services" were sure to be closed for the duration. What should I do? The hard-baked earth, the prospect of spending Cup Match digging a grave and the difficulty of moving the dead weight to a suitable cemetery site precluded traditional burial in the ground. Clearly, there was only one option: burial at sea.

I purloined a piece of rope and bound June's legs together. Using the bindings as a lifting point for the forklift truck, I hoisted her from the trench and moved her to the dock. With thoughts of a corpse rising from the deep, but not being prepared to dishonor my friend by perforating her abdominal cavity, I decided that a heavy weight was needed. With a mooring weight secured and the *BBS II* [now the *R/V Stommel*] alongside *Weatherbird* [BBSR's research ship], I fired up the ship's crane. Before loading June onto *BBS II* for her final trip, I conducted a test to ensure that she would actually sink. I dipped her into the Reach and, sure enough, she hit bottom. I brought June up and hoisted her high over *Weatherbird*.

What a sorry sight she was: To enhance the macabre appearance, she was dripping water tinted by red mud, looking for all the world like blood. It was at this moment, as I swung the crane out over *BBS II* with "the package" at a height of about 20 feet, that the tour boat *M/V Georgiana* appeared through the Swing Bridge, chugging up the Reach, her upper deck crowded with midday revelers drinking Dark 'n' Stormies and dancing to "Hot Hot Hot." As the boat approached, I heard the tour guide announce over the PA, "Coming into sight on our starboard side is the world-famous Bermuda Biological Station." Then all went quiet as chins dropped and June started her final journey to the deck of *BBS II* from a height equivalent to their eye level.

My brother Graham and I headed out to sea with June shrouded in a blue tarp to avoid more unfortunate publicity. I had not participated in a burial at sea before, but I had seen this done in movies. I noted that the corpse was placed on a plank that, at the appointed moment, would be tipped, thereby allowing the deceased to slide gracefully overboard with nary a splash. Accordingly, I placed June on a very large plank that stretched out through *BBS II*'s open transom.

St. David's was dipping below the horizon when I finally stopped the boat and gave the order to untie and remove the rope binding June's feet. Unfortunately we found that the rope was entangled under June and couldn't be freed. Undaunted, I tied the free end of the rope to the towing post so that it would be saved when June was rolled overboard. We paid our last respects and

lifted the end of the board. It worked like magic: June rolled, although perhaps not gracefully, out the transom hatch. Imagine our chagrin, therefore, when the rope attached to the towing post suddenly went bar-tight. June was still with us! Somehow the rope was still entangled.

"Don't worry," I said. "I'll start the boat moving; that'll shake her free."

Slowly we moved, but the rope remained tight. I sped up; the rope started to angle back, still bar-tight as we gained speed. More speed, the rope was now approaching horizontal. Then it happened: June broke surface, weight and all, water-skiing. As Graham brought the fire axe down on the rope, I heard him say, "Let's get the hell out of here."

Small wonder that those who recall the BBSR of that era remember it fondly as a time of energy, teamwork, laughter and broadening horizons. But far more significantly, it was a period of rapid scientific growth, notably through a series of research programs on Bermuda's inshore environment, which gained BBSR a global reputation.

Staff and volunteers lend a hand to build the Scott Lab in 1977

TEN

Protecting Bermuda's Environment

Tom Sleeter conducts an experiment, anxiously watched by a young student, 1976

Issues affecting the environment have by their very nature played a continuing part in BBSR's mission. BBSR Director Hilary Moore showed keen concern over the land reclamation work during World War II and spent time checking the reefs for damage. Subsequently, areas of environmental concern included radioactive fallout in the '50s and beach tar 20 years later. These and other issues have attracted many scientists from Europe and North America over several decades. They have since made important contributions to Bermuda and the world of science.

In the 1970s, tar in the ocean was a worldwide problem. The famous adventurer Thor Heyerdahl, crossing the Atlantic during his "Ra" expeditions, reported that, in three months at sea, only three days went by when lumps of tar were not spotted from his raft. In some places, there was so much tar in the water that it became uncomfortable to wash.

The enormity of the threat from tar is reflected by the numerous headlines of that period: "Beach oil 'worse than N. Jersey'" (*Bermuda Sun*, May 2, 1970); "Oil pollution now 'a major problem'" (*The Royal Gazette*, May 20, 1970); "Pink beaches – all black with tar" (*Mid-Ocean News*, May 30, 1970). A headline from *The Royal Gazette* on November 29, 1977, "Sargasso blamed for beach tar," shows that the issue continued causing concern and confusion throughout the '70s.

A shoe is placed next to a lump of tar to show scale

Most Bermudians know methods for removing sticky patches of tar from feet, collected while swimming at Bermuda's beaches. Baby oil, Lestoil, mayonnaise and the like all work wonders for a substance that soap won't touch. In fact, in the 1970s there was little chance of leaving a beach without transporting quantities of tar home with you.

The lumps, some large and hard, others like treacle in consistency, were mostly a result of oil tankers cleaning out their tanks with the seawater taken on as ballast when the tanks were empty. For many years it has been an offense under the MARPOL[1] Convention to empty out the tanks near shorelines, but during the '60s and '70s ships needed to be only three miles off Bermuda to do this. Actually, little oil was dumped off Bermuda, with most arriving from the west coast of Africa via ocean currents.

The dangers of oil in Bermuda's waters were realized much earlier in the twentieth century. BBSR trustee, and curator of the Bermuda Aquarium, Louis S. Mowbray wrote in 1971:

> In the year 1930 the first oil spill of consequence took place in Bermuda and occurred in the Flatts Inlet when a small oil barge overturned in the strong current. The amount of oil spilled into the surrounding waters amounted to about 15 tons, with the result that the entire Inlet, much of Harrington Sound, Gibbet Island and Shelly Bay beaches were heavily coated with thick oil between the low and high tide levels. In 1930 there were extremely few craft that used oil as fuel.
>
> The next significant spill occurred in early 1942 when a tanker of the U.S. Navy grounded in the main ship channel. In order to lighten ship and refloat her without delay, several hundred tons of oil were pumped into the surrounding waters. This spread throughout the Great Sound, all of Hamilton Harbour, Mangrove Bay, Ely's Harbour and the west shore of Sandys and Southampton parishes, the Dockyard, and eastward to Flatts Inlet, Harrington Sound, Shelly Bay, Ferry Point and Ferry Beach... Today... some of this oil can still be found a few inches below the sand at Gibbet Island and Shelly Bay.[2]

In 1954, British oceanographer Peter David discovered pelagic (oceanic) tar in the Atlantic Ocean between Portugal and the Azores. In the early 1960s he began to make neuston

nets (special nets for collecting neuston, or surface dwelling organisms) and used them to collect further samples in the Indian Ocean and the Mediterranean Sea.[3] The public became aware of this when Heyerdahl reported the immense problem of tar in the ocean during his 1970s Ra expedition. By then, what had been a concern had grown into a major problem. Roger Pocklington collected samples from 1969 to 1971:

> On some of the beaches, like the south-facing beach on Nonsuch Island, [the oil lumps] were like potatoes, with a kind of skin on them. Sand would stick to them, and they would bounce along the bottom of the sea and then get thrown up on the beach where the sun would melt them. You may find some now, the size of the end of your thumb, but we're talking about a cowpat of sticky asphalt. It would adhere to everything and this was off-putting to tourists.

Patricia Pocklington adds, "Early in the morning, before dawn, when you could barely see, someone from the hotels would go and rake the beaches to take all the oil away."

Biologist Byron Morris, cruising from Halifax to Bermuda, was alarmed to find that his neuston net collected more tar than plankton. When he later came to Bermuda to write his thesis and to take over Hydrostation "S" from Pocklington, his interest in pelagic tar deepened.

The problem was two-fold: first, they had to determine how to stop the tankers from discharging the oil; and second, they had to work out how to detect tankers that were breaking the rules. In addition, they needed to discover exactly how bad the problem really was.

About this time, a grant of $10,000 was given by the Bermuda Government. This was matched by BBSR's first major corporate grant, from Esso Bermuda, which enabled Dr. Sterrer to hire the postdoctoral scientist Conrad Gebelein and his wife Nancy Maynard, a University of Miami graduate student in paleooceanography, to establish a field and lab program on the effects of tarry hydrocarbons on Bermuda's rocky shores. The team of Gebelein, Maynard, Adam Zsolnay and several dedicated technicians carried out an intensive study, which resulted in a series of fate and effects publications and presentations. It is worth noting here that, in order to document the role of exposure in the seasonal dynamics of the hydrocarbon deposition and ecology of the intertidal zone on Bermuda's shores, it was necessary to sample, measure and collect on both gentle as well as precipitous rocky cliffs year round. The extreme wave pounding at vertical sampling sites on the north shore in the winter, not to mention occasional high winds and driving rains, made collections possible only through some true heroics by a very dedicated, although occasionally mutinous, team.

In 1984, Maynard published a 153-page BBSR report, "The Effects of Petroleum Residues on Intertidal Organisms of Bermuda," which included a characterization of the intertidal ecosystem on Bermuda's rocky shores as well as the tar distribution and its effects on the biota of the rocky intertidal zone. Sadly, the delay in preparation of this report was due, in part, to the untimely death of Gebelein in 1978, which occurred during a research field trip to Andros Island in the Bahamas. Dr. Maynard subsequently served in the White House Science Office under presidents Ronald Reagan and George H.W. Bush. She then became associate director of the NASA Environment and Health Program at Goddard Space Flight Center.

When Dr. James Butler, Gordon McKay Professor of Applied Chemistry at Harvard University, first visited Bermuda in 1971, bringing his family with him, it could not have been foreseen how greatly BBSR would benefit from the association. Butler has long served as a

Dr. James Butler and his wife Rosamond, 1977

trustee, is a past president and is now a life trustee. His wife, Rosamond, also a member of the Board of Trustees, served as secretary of the Corporation from 1982 until her retirement in 2002. Dr. Butler says:

> In January of 1971, my wife Roz and I were in Santa Barbara at an oceanographic conference. I was not an oceanographer, I was a physical chemist, but I organized matters so that the electrochemistry and oceanography conferences should be held at the same time and same place. As a result, we met Roger Pocklington, who invited us to Bermuda. A couple of weeks later we took him up on his invitation.
>
> We spent the whole week talking about the tar on the beaches, because it had become a major problem for the tourists. I wrote a couple of pages for a proposal for a mid-ocean monitoring station for pollution. Wolfgang Sterrer took it around to Washington and there was some interest, but nothing came of it.

In fact, something did come of it a few months later. A letter was posted from the National Science Foundation in the United States on October 1, but it had been franked as domestic mail. As a result it didn't arrive in Bermuda until December 1, saying that if the full proposal were submitted by December 15, the project would be funded.

With Byron Morris, Butler outlined a proposal to investigate how the pelagic tar affected the ecology of the Sargassum community. The proposal met the deadline, and by January 15, the project had been funded. The funding was to continue for eight years.

Each oil sample has a distinctive "fingerprint" depending on where it was drilled and the condition of the tanks in which it was kept. The fingerprinting work was done by Butler's graduate student, Tom Sleeter, a future BBSR faculty member who is now director of Bermuda's Department of Environmental Protection.

As a result, techniques developed in part at BBSR helped persuade oil companies to stop the pollution, and BBSR was recognized for the part it played in helping to solve the pelagic tar problem. Butler himself became distinguished in this field.

Tanker operators had developed methods to separate the oil remnants from the ballast water, with the desirable result that the discharged water was relatively free from oil and the residue could be kept and refined. This method, called LOT, or Load On Top, was remarkably simple; the idea is essentially that oil floats on water. A tank of ballast water is left to settle, and after a while the oil floats to the surface and is siphoned off into another tank. However, this method is dependent on a few consecutive calm days at sea, which is not always a reality.

Other more rigorous, and more expensive, techniques have also been developed, such as COW, or Crude Oil Washing. This method requires inert gas from the cooled engine exhaust and machines to wash the oil physically, but manages to keep virtually all the oil out of the sea.

The hotels had constantly fought the unpleasant lumps of tar on local beaches. Good news came when Bermuda bought a beach-cleaning machine to remove all the tar mechanically. Dr. Tony Knap, who joined BBSR's faculty in 1977, continued these studies in the 1980s and 1990s and was able to show a significant decline in beached tar over this period, indicating that mitigation techniques were working.

Whatever the overall reasons, Butler says that beach tar observations show that pelagic tar appears to be much reduced.[4] "The occasional samples we have taken [since the 1980s] indicate that there is about 10 times less tar in the North Atlantic than there was in 1980."

A publication around this time concluded that the amount of Sargassum had decreased dramatically over the previous 50 years. Butler reanalyzed the data using more sophisticated statistics and showed the apparent decrease resulted from the method of averaging the data. In fact, there had been no change in the amount of Sargassum in the Sargasso Sea.[5]

BBSR's involvement in protecting Bermuda's environment from the effects of oil spills has continued through participation in the oil spill contingency planning exercises conducted with the Bermuda Government and BBSR's neighbors Esso and Shell. BBSR also became a leader in peer-reviewed published research on the effects of oil and oil dispersants on coral reefs and mangroves, with more than 20 years of long-term research programs in Bermuda, Panama and other locations funded by ExxonMobil, British Petroleum and the ARCO Foundation. For more than two decades, BBSR offered a popular summer course, Analysis of Marine Pollution, with faculty that included Butler and Knap.

Roger Pocklington (right) and visiting scientist John Cooper, 1970

Perhaps the defining moment in the increase of BBSR's expertise in marine contamination measurements was PanCal 80. This was run by Tony Knap and involved 50 scientists from 20 nations, and many ships and instruments. BBSR raised money for the renovation of three of the Conklin Laboratories to be converted to clean rooms. Hewlett-Packard, Perkin-Elmer and Varian sent the state-of-the-art instrumentation and the technicians needed to keep the instruments running. Many institutions sent their scientists with specific sampling equipment and hydrographic wires. The purpose was to develop methodologies to make precise measurements of trace metals and organic contaminants in seawater. This three-week exercise led to new measurement strategies for these compounds worldwide and to individual isomer analysis of PCBs and pesticides. The manuals developed during this program were distributed worldwide through the United Nations system. It also left BBSR with state of the art laboratories and instruments to take part in many international contaminant programs. Knap was asked to serve on the U.N. Group of Experts for Methods Standards and Intercalibration (GEMSI), eventually becoming its chairman. Knap says:

> I had to do a great deal of work to take advantage of this opportunity, however, it was provided to BBSR by Dr. Neil Andersen, then chairman of GEMSI, working with Dr. Jan Duinker [Netherlands], Dr. Karsten Palmork [Norway], Dr. Mike Bewers [Canada], Dr. Herb Windom [United States] and Dr. Graham Topping [United Kingdom]. Neil's faith in us pulling this off really put our environmental work on the map.

One scientist involved in oil pollution research at BBSR during this period, Dr. Tom Iliffe, soon veered toward a very different research focus. An avid scuba diver, he quickly developed an interest in Bermuda's caves. As Wolfgang Sterrer relates:

> Iliffe discovered that lots of these caves don't just stop, they go on underwater, so he started diving through these caves. At this time I was busy working on my book, *Marine Fauna and Flora of Bermuda*, and I was doing a lot of work on shrimps. One day Tom Iliffe came back from a field trip and told me that he had seen several very wonderful shrimps with long antennae, and I went with him to the cave. The cave had a lake, and a cone in the center of it, like most caves have from the debris that falls down, and an old rotten dock. We went out with a small hand net and whenever I saw a shrimp, I tried to catch it. We came out of that cave with four species of shrimp. One had been known for Bermuda, but not from a cave. It was probably a subspecies. One was a new record for Bermuda, one was a new species and one was a new genus. That was quite exciting.

Sterrer gave Iliffe encouragement to change his area of expertise from hydrocarbons to caves. For 10 years, Iliffe explored and charted caves; in the process he found some 80 biological species, including a new order of crustaceans never discovered anywhere else.

Another major environmental project during the '70s investigated the changes in Bermuda's ecosystem caused by human-introduced contaminants in the water: the Bermuda Inshore Waters Investigation (BIWI). The BIWI project was started in 1975 after BBSR scientists Fred Mackenzie, Byron Morris, Dieter Meischner and Wolfgang Sterrer noticed that life in the "inshore" waters, i.e. those at least partially enclosed by land, was being affected by the

human population nearby. An added stimulus was a plan (never approved) to build a causeway between the Dockyard area and Spanish Point, in effect joining the end of the Bermuda "hook" to the shaft and closing off the Great Sound from the main ocean currents to an even greater degree.

The proposal to the Bermuda Government for the BIWI project explained these and other aims of the investigation, citing the prospect of further development on the island in the decades to come. Of special concern were shallow inshore areas that served as nursery grounds for fish and shellfish. Examples of specific degradation or threats included seepage from sewage outfalls into Harrington Sound and the mass-killing of corals in Castle Harbour, triggered by sedimentation and water stagnation resulting from the construction of the airport in the 1940s and documented by BBSR researchers. The investigators proposed the following set of objectives:

- to make a thorough faunistic, physical and chemical survey of present conditions;
- to monitor and record changes, short-term and long-term, of factors and organisms;
- to determine and analyze the causes of such changes; and
- to make recommendations as to how undesirable changes could be reversed or prevented.

The initial principal investigator of the program was Morris, assisted by John Barnes and Foster Brown. An initial two-year survey would "allow the program to measure the important basic water-quality parameters and to determine seasonal and yearly variations."[6]

The first year's findings were published as *The Bermuda Marine Environment* and included a comprehensive review of the literature pertaining to the Bermuda inshore waters. The second phase acquired Dr. Bodo von Bodungen as principal investigator and produced the publication of *The Bermuda Marine Environment II.* Other notable participants in the gathering of information were Bermuda Programme instructor John Barnes and students Robbie Smith, Jack Ward and Graham Hillier. Tim Jickells began working on the project in 1979.

The project was a major undertaking for Bermuda and for BBSR. It lasted five years and resulted in a staggering amount of data, despite a budget of only $60,000 a year. It was achieved in cooperation with 38 scientists from eight universities throughout the world, with more than 40 different parameters measured and more than 75,000 individual data collected. It culminated in a final report, *The Bermuda Marine Environment, Vol. III,* written by Bodo von Bodungen, Tim Jickells, Robbie Smith, Jack Ward and Graham Hillier. The 1980 BBSR annual report summarized the findings:

> After five years of intensive studies, no clear evidence of significant sewage pollution has been found in the inshore waters. At present, the marine environment copes adequately with the sewage inputs. However, the Bermuda marine ecosystem is delicately balanced and depends on many equilibria. An increased sewage input or even continuation of the present inputs may eventually lead to an unbalanced situation. This is largely unpredictable and could deteriorate the marine environment in an unknown dimension.

Tim Jickells (right) teaches students at BBSR

As the BIWI project highlighted, on a small island like Bermuda, environmental problems are magnified. If a mistake is made, a good deal of damage can be done very quickly. This point is underlined by a narrowly averted potential disaster that was responded to by BBSR staff. Late in the morning of February 14, 1981, the director of Marine and Ports for Bermuda telephoned BBSR to say that a ship, the *Eastern Mariner I*, had run aground over a reef to the north of Bermuda, leaking fertilizer into the sea. The ship had been chartered by the United States Government to take 10,000 tons of (uninsured) fertilizer to Bangladesh. One of the storage compartments had ruptured at sea, causing the leak. The original plan was to put into port at Dockyard and unload the cargo, but the situation worsened rapidly.

Tim Jickells, at the time a research assistant at BBSR, conducted a preliminary chemical analysis of the ammonium phosphate fertilizer. His results showed that dilution of three million parts water to one part fertilizer would be necessary to reduce the concentration to that present in normal seawater. BBSR personnel estimated that if the tanker had sunk – a real possibility – its contents would have blanketed an area approximately six miles square, thus devastating a large area of the reef.

The problem was eutrophication: excess fertilizer means that plant life and algae have a field day. The algae overwhelm the seabed, covering space held by coral and killing it. All the nutrients are quickly used up by this huge algal bloom, which then dies. Bacteria feed on the dead algae, at the same time using up oxygen and therefore making the area uninhabitable. This is clearly a devastating circumstance. To make matters worse, in addition to fertilizer, the *Eastern Mariner I* was carrying 700 tons of fuel oil.

The Bermuda Government finally ordered the ship towed out to sea with the plan that it be taken back to the United States. In fact, it sank before it could get very far. Six-and-a-half miles south of St. David's Island it started to let in much more water and the tugboats cut their lines free and let it go. It came to rest in 5,000 feet of water, where the fertilizer was deemed to be of little threat to Bermuda. Some of the fuel did leak out, forming three oil slicks, but the slicks were relatively small and fortunately the wind and currents took them away from Bermuda to be dispersed in the Atlantic.

The government's order had been made at least in part on the advice of Wolfgang Sterrer, acting as the environmental advisor on these matters. He notes:

> When asked by the insurer's representatives what the environmental effects would be if the ship sank in inshore waters, I likened the impact to that of a bomb: depending on the rate of dilution, all life would probably be killed almost instantly within a certain radius; beyond that radius, reef life could be severely damaged; and beyond that, growth of algae on the bottom and in the water column could be over-stimulated so as to smother reefs either directly, or by filtering out light, or by the amount of dead organic matter that would eventually settle out on the reef. Information received... estimated that an area of at least six miles by six miles would be affected.[7]

The BIWI project gave way to a new project in 1980, the Marine and Atmospheric Program (MAP) under Tony Knap's direction and with support from the Bermuda Government and Esso Bermuda. Tim Jickells and Robbie Smith continued with both the nutrient and benthic biological monitoring studies through the mid-'80s. Doug Connelly joined the team as the inorganic chemist at this time to replace Jickells, who left after concluding his doctoral research on trace metals cycling.

The recommendation of the BIWI project was that certain inshore water parameters be continually monitored. MAP initiated this inshore monitoring program as well as acting as environmental consultants for the Bermuda Government. Monthly measurements were taken in the Great Sound, Hamilton Harbour, Harrington Sound, Castle Harbour and St. George's Harbour. The Hamilton Harbour measurements led to an investigation of the composition of effluent waters discharging into the harbor. Among the variety of investigations were analyses of trace metals in the inshore waters; the occurrence of organochlorine pesticides in whales, birds and fish; the effects of oil and oil dispersant on coral; and the development of sensitivity categories for the coastline.

These studies on aspects of Bermuda's environment were to lead to yet another series of investigations in the late 1980s and 1990s as new threats were identified. The money provided by the government provided a core of funding and Knap was able to increase the funding significantly with help from industry, foundations and the U.S. Government.

ELEVEN

A Quantum Leap

The 65-foot research vessel Weatherbird was purchased in 1982 with funding from BBSR's first major capital campaign, A Quantum Leap

Although in the 1970s BBSR was receiving funding for a number of courses and research programs, it was always money with strings attached – enough money was granted to pay the costs of the program itself, with very little left over for building maintenance and other infrastructure expenses.

Wolfgang Sterrer's assistant, Margaret Emmott, would say, "Wolf, I need a new typewriter. I'm pushing this back manually and it's supposed to be an electric typewriter."

Sterrer would reply, "And, my darling, you deserve one."

"Can I have one?"

"Well, you can if you can raise the money." So out Emmott would go to raise money to buy her own typewriter.

> I remember the first time I did it, I got in touch with Dowling Cycles and Hillcrest Guest House, where we would send overloads of people, and said, "I desperately need a new typewriter, but I don't have any money. Could you give me $50?" And so people would send me $50 and I'd send them a birth announcement saying it had arrived and it was blue and it weighed 35 pounds and came in at such-and-such a time and the proud owner and mother is... Please come by and see the baby and so on. Of course, it isn't fundraising like people do now, you know, "Dear Madam, Dear Sir." This was very informal and great fun.
>
> And people had to keep giving, because the next year I'd need a filing cabinet: "Mr. Dowling," I'd say, "you really helped me out with my typewriter. Can you help me get a filing cabinet?" And he'd say, "Sure, my darling."

Director's assistant Margaret Emmott

There was, of course, a much more serious side to the fundraising efforts, of which the Associates Program was only a part. In BBSR's annual report for 1979, Dr. Sterrer indicated the gravity of the problem:

> The Station's present position is characterized by the discrepancy between its activity and needs. While our research and teaching programs are rapidly gaining in strength and international appeal, our assets – through many years of benign neglect – have reached a point where a major infusion of capital is overdue. Our facilities are in varying states of health, from excellent to inadequate to crumbling (e.g. the main building) or rusting *(Panulirus II)*. At $250,000 (capital, not interest!), our endowment is in no relation to our budget ($600,000) or our fixed assets ($2 million). BBS needs help now.

Clearly something needed to be done, and in 1981 the trustees initiated the largest single fundraising program that BBSR had yet attempted. By the end of the campaign, BBSR would be in a much stronger position to provide opportunities for research and education and to stay financially viable year round.

Given the eye-catching name of "A Quantum Leap," the program was described in detail in the newsletter sent out to the Associates of BBSR in October 1982:

> "Interesting things happen within atoms when stimulated by outside forces. They leap to states of greater energy, to be sure – but without appreciable change in size or character. I like to think of our QUANTUM LEAP as stimulating the Bermuda Biostation to a new pitch of activity – while yet remaining a small institution." – *Dr. W. Redwood Wright, BBS President*
>
> And so launched the Biological Station's first capital fund drive, a campaign developed over the past year and a half as the need for major improvements in our facilities and programs became more crucial.

> The official announcement of A Quantum Leap was made at the reception held at the Biostation on July 17th. Over 200 invited guests gathered in the late afternoon sun on the patio overlooking Ferry Reach and listened to the remarks of five men whose official responsibilities tie them closely to BBS. Dr. Wright opened the proceedings with a welcome to all and introduced BBS Director Wolfgang Sterrer, who described the vital need in today's world of institutions like the Biostation.

The first grant to be received by the campaign was from the Starr Foundation: 500 shares of American International Group (AIG), which were worth more than $40,000. The funds enabled BBSR to establish the C.V. Starr Scholarship Endowment Fund, named for AIG's founder. Thanks to subsequent grants from the Starr Foundation over the ensuing two decades, the fund has grown into a major source of scholarships for students at BBSR.

Some projects were so urgent that they needed to be launched immediately.

> Built in 1910 as the Bermuda Sanatorium... this structure is an excellent example of local architecture. It was the first building of its size to dare use a single span of Bermuda stone roof; prior to that time, the immense weight of the stone led builders to use double-gabled roofs in larger structures.
>
> ... In 1980 it became clear that immediate renovations were needed. The most urgent problem was seen in the iron plumbing system: the seawater had caused a rust buildup which clogged some pipes and which ate away at others, resulting in leaks and flooding at regular intervals... Work on the east wing began in early 1982... Dormitory rooms on the second and third floors were reorganized and bathrooms added... West wing renovations are more extensive, and began in January this year...[1]

Perhaps the most significant goal of the campaign was realized in June 1982 with the purchase of the 10-year-old, 65-foot research vessel *M/V Whitefoot,* which had been based in Martha's Vineyard, Massachusetts. The ship was a lucky find, since the trustees had been considering buying a new vessel at much greater expense. This acquisition was made possible by a $125,000 grant from the Bermuda Government and the keen fundraising efforts of a Bermudian, Sir Richard Gorham, who coordinated the campaign on behalf of BBSR. In a break from BBSR tradition, the new vessel was not named after a sea creature, but after a well-loved Bermudian, Alfred "Weatherbird" James Mills. He was something of a street philosopher and a very well-known character around the streets and docks of Hamilton, who, as a child, told other children, "I'm like a bird. I only wash my face when it rains. I'm a weatherbird."

Redwood Wright made the initial journey with the ship after she had been purchased. Not the best, as it turned out – 30-foot seas were reported:

> I'd gone to sea a number of times on the *Weatherbird* when she was the *Whitefoot,* and I knew she was a very capable ship and about the size that we needed, or that I thought we needed; it turned out we needed a bigger one. But she was big enough so you could put a portable lab on the deck and do analyses in it, and there was a steering station back aft. I came down here when she was

delivered and it was quite a trip, with Harry Barnes and Roy Campbell and my son Bill coming along.

It was January and we ran into a gale. The ship rolled and rolled. Captain Campbell went to bed. He shut everything down – as captain, he was in the worst place on the ship, behind the wheelhouse – and he said, "Wake me when it moderates," while we kept on rolling and rolling.

Dr. Wright had been the secretary of the trustees for five years before taking over as president from George Scott in 1977. His father, Dr. Sydney Wright, had bought a house in Bermuda in the 1960s and become friends with Sterrer, and also served as a trustee of BBSR until his sudden death in 1971. When son Redwood became president, he was working in the National Marine Fisheries Service lab in Woods Hole as an oceanographer. In 1981 he retired in order to concentrate full time on the Quantum Leap campaign. During the four-year campaign, which concluded in 1985, BBSR raised $2.25 million. Dr. Wright noted:

> We weren't known at all in the States. In fact, we weren't really known very well in Bermuda at that point. [Raising the profile of BBSR] is something that Wolfgang did very well, and Tony [Knap] has pushed the barriers beyond that in bringing the Station to the attention of Bermudians and involving Bermudians in what the Station does. There had always been Bermudians involved, like the Spurlings [BBSR trustees Sir Stanley and his son, Sir Dudley]. Now the third generation of Spurlings are involved, and they've begun to bring in other people.

This third generation includes Sir Dudley's son, Richard, who was elected to the Board of Trustees in 1982 and headed the development efforts that expanded BBSR's facilities and endowment in the late 1980s and early 1990s. In 1986 the main building was renamed Wright Hall and an apartment was dedicated as the Spurling Suite in honor of the long connection of these families with BBSR.

While the Quantum Leap campaign was in progress, the Board of Trustees was restructuring itself. Wright relates:

> We set out to strengthen the board – bring on more people with business knowledge because the board consisted mainly of scientists, and mostly U.S. scientists. We began to bring knowledgeable and influential Bermudians onto the board and tried to get people in the U.S. We got a number of really good people who were very loyal and helpful, and they in turn have helped us move out into a much broader sphere of interested people. We created a more international and better balanced board.

One of these new faces was New York lawyer Christopher du P. Roosevelt, who later became the first non-scientist president of BBSR's Board of Trustees.

Change was in the air, and it affected BBSR's scientific projects, too. Wright continues:

> Strengthening the physical plant [was a major concern] – it wasn't so much building new buildings, but rehabbing them all and making them

Redwood Wright on a 1975 Hydrostation cruise

inhabitable. A lot of the money we spent went that way: building the Scott Lab, rebuilding Wright Hall. The first *Weatherbird* was a major plus. At that point we were in serious danger of losing the Hydrostation, which had only been going for some 20 years and people were really not yet getting that much value out of it. You have to study something for at least 10 times the length of the period you want to learn about before you can separate signal from noise, so it was important to have a ship that was capable of continuing that work.

In those days, the contract for the Hydrostation was through Woods Hole, the Oceanographic Institution. They farmed out the work to the Biostation. We wrote a proposal to NSF to fund it directly through us, with Tony as chief scientist. He was not director at that time and he wasn't a physical oceanographer either, but he knew the boat and he knew the ropes. NSF approved the proposal in 1980. Also, [Woods Hole scientist] Werner Deuser came down with his sediment traps and began his long-term series. [The NSF approval] I think really helped things to take off, and scientists from Woods Hole and other places began hanging other things off it and suddenly we had a tremendous time series going.

Dr. Deuser's Oceanic Flux Program, subsequently run by Woods Hole scientist Dr. Maureen Conte, marks its 25th anniversary in 2003.

With the Hydrostation "S" project secure again and A Quantum Leap in full swing, the major challenge facing BBSR was making it economically feasible year round. To achieve this, the educational thrust would have to be expanded. As Sterrer puts it:

Our main aim was to fill the beds... because come the beginning of October, the Station went totally quiet. It was obviously far too big and too expensive to keep up 15 acres and 20 buildings on the income of 2 or 3 months

during the summer. How were we to fill the thing for the rest of the year? Gradually we started bringing in off-season student groups, just to keep the kitchen going, keep the housekeeping staff on, which required a certain minimum occupancy. Like a hotel, we figured that – I calculated it once – the Station had to have two-thirds occupancy to break even: 66 percent.

Occasionally arrangements were made between an overseas college and BBSR to establish a yearly program. At the start of 1972, for instance, Carleton College held a 10-week tropical biology and geology course for 20 students. BBSR staff were involved in the teaching. In 1978, the University of Bridgeport brought along 15 students for an eight-week marine biology semester, in what was meant to be a biennial event. A further 15 students spent a semester at BBSR in 1980.

It wasn't until 1982, though, that BBSR truly became a year-round educational institution as part of the Elderhostel Program. Elderhostel provides high-quality, affordable educational opportunities for older adults. In a typical program, a group of about 30 seniors spends a week on a college campus, learning about the culture, history and environment of the area they are visiting. Initially the program operated in a few New England colleges, but soon expanded to other parts of the United States and then Canada.

BBSR's Elderhostel Program was very successful right from the start – six groups of 28 people visited in the first year – for the same reasons it had become popular elsewhere. Courses can be offered as and when the organization needs to fill space, but can be halted at times when the accommodation is needed for less flexible programs, such as summer courses. Enrollment numbers increased steadily with the addition of extra courses, and, by the mid-1990s, more than 800 annual visitors took part in 24 Elderhostel courses at BBSR.

Dr. Sterrer taught some of the original courses himself and still lectures to some groups. He comments:

> Elderhostel was really a nice find... At the time it was purely a domestic undertaking in the States. We were, I think, the first foreign destination. Very soon it turned out to be a really great thing, and not only because it could be run with a small staff...
>
> That must have been about the time we did the book *Bermuda's Delicate Balance*[2] because we actually offered that as a title. I pulled in all the people who had been involved in that – Stuart Hayward and several others. We took the hostellers on a bus tour, showing environmental highlights of Bermuda, the dump and so on, and explained how a small island organized its affairs. That worked very well.
>
> We soon realized this was an ideal thing to slot into the weeks when our more academic groups let us down – when we didn't have any. So now we could fill the Station year round. We also had some Earthwatch groups [led by Dr. Susan Cook]. That was also interesting because it brought some new trustees in. Roger Perry, a lawyer trustee, came in through one of these Earthwatch groups.

In 1983, Susan Cook was hired as education director to administer the Elderhostel Program and to develop BBSR's educational role. Dr. Cook remained director of education until 1992, when she moved on to the Harbor Branch Oceanographic Institution and

Education Director Susan Cook assists a student in the 1980s

subsequently to the National Science Foundation as the associate program director for ocean sciences. By speaking at relevant conferences in the United States, she enrolled new high school and college groups.

Cook introduced the Work-Study Program, which also brought multiple benefits to BBSR. With the increasing numbers of visiting groups came increasing demands for general support staff, but hiring new staff would have cancelled any financial gain. Science students, on the other hand, are about to enter a field that is generally under-financed and therefore vie for opportunities to work on a research project in order to bolster their credentials.

Applications were sought from undergraduate and graduate students who would work as technicians in the laboratories and would pay for their room and board by performing other tasks at BBSR. The typical length of stay was four months. The program was popular: between 20 and 39 students, including many Bermuda residents, took part in the program each year.

The program was reorganized in 1994 into what is now the Volunteer Internship Program. Like the Bermuda Programme, since the 1980s the Work-Study and Volunteer Internship Programs have helped BBSR train the next generation of marine scientists, including three who subsequently became graduate interns and then BBSR faculty members: Nicholas Bates, Craig Carlson and Samia Sarkis.

At the time of Dr. Sterrer's arrival in Bermuda, BBSR boasted an overall staff of approximately 20. When he left in 1986, this number had grown to 40. Among them were people whose longtime service has been exemplary: maintenance superintendent Butch Stovell, who joined the BBSR staff in 1960, and administrative assistant Margaret Emmott, who had been there since 1965; carpenter Chesley "Sunny" Foggo, who has been at BBSR since the 1970s; Sharon Minors, who came to BBSR in 1974 as a maid and who headed BBSR's housekeeping staff in the late 1980s and 1990s; and Virginia O'Connor and Natalie Williams, who were part of the housekeeping and kitchen staff for a span of several decades. These and other support staff form the backbone of BBSR; without them the scientists and students could not do their

Maintenance superintendent Wilfred "Butch" Stovell (left) joined BBSR's staff in 1960. Chesley "Sunny" Foggo has been the BBSR carpenter since the 1970s

work. Nor would there be the sense of continuity that gives an institution character and history.

Thanks to facilities and programs put in place by these staff members, as well as the educational marketing efforts by Wolfgang Sterrer, Sue Cook and others, BBSR had indeed made "A Quantum Leap."

TWELVE

Knap Takes the Helm

New scientist Tony Knap on a 1970s Hydrostation cruise

Tony Knap, BBSR's director, tells this story about his first contact with BBSR: "I was on the British Onion Patch sailing team, and we sailed to Bermuda from Newport [Rhode Island] in the Bermuda Race, 1976." Knap continues:

> Our yacht, *Noryema*, was the top points scorer in the Admiral's Cup in 1975 and England won the Cup that year. It was one of the top yachts in the world in those days, and I was fortunate to have sailed on her for two years previously while working on my Ph.D. at Southampton University. I ended up getting injured in the Bermuda Race: I got a piece of metal in my finger, which got infected. As a result, I didn't go on to the transatlantic race back to England, but stayed in Bermuda in the hospital for seven days. While I was recuperating, I visited BBSR.
>
> After recuperating, I went back to the U.K. to finish up my Ph.D. Someone sent me a four-month-old advertisement from *Nature*, saying, "I hear you were in Bermuda." BBSR was looking for a chemical oceanographer to do oil pollution studies, and I happened to be doing my Ph.D. on oil pollution at Southampton University. I applied and got the job.

Wolfgang Sterrer adds, "Tony turned out to be interested in administration. I appointed him assistant director and then associate director in due course, and then he became my successor."

While he was director, Sterrer – a scientist at heart – found he had less and less time to devote to research; the administration of BBSR occupied most of his time. Knap took over some administrative responsibilities, but even so, Sterrer felt guilty about his priorities: "I felt that every time I disappeared from the office into the lab it was resented by people, 'There he goes again, with his book project, when in fact so many things need to be done.' That taught me that maybe if I wanted to do science, this was not the place to do it."

In 1985, Sterrer took a year's sabbatical leave from BBSR in order to finish his book project, *Marine Fauna and Flora of Bermuda*,[1] which had been eagerly awaited for years and was finally published in 1986. It is the definitive work on the subject, detailing thousands of species found in the waters of Bermuda. Most of the meticulous illustrations were drawn by Sterrer's then wife, Christiane Schoepfer-Sterrer. Knap took over as acting director.

The sabbatical gave Sterrer some time to think and to get "back into science." By the end of 1985, he announced his resignation as BBSR director. Fortunately for Bermuda, however, he remained on the island, taking a position as curator of the Natural History Museum, located with the Aquarium in Flatts, which enabled him to continue his research.

After Wolfgang Sterrer's departure, there was an international search for a director. In March 1986, the BBSR Board of Trustees appointed Dr. Knap as director. Knap comments:

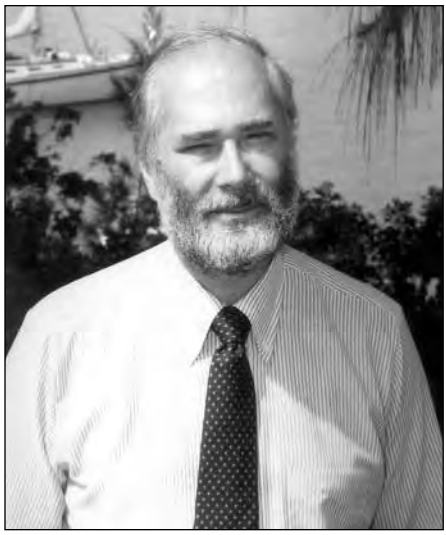
> I wasn't interested in being a director in the way it had been done, because I didn't want to give up my science. The board and I agreed that I would be director and receive compensation for about three months a year and take the rest from research projects I did, and that I would try to rearrange the management of the institution in a way that would reflect the fact that I had other things to do than be director. We all agreed to that approach and it seemed to work, I think. This has continued and I still spend about five months a year working on my various research projects.

Soon the management of the institution was reorganized. Five people were given responsibility for the areas of education, development, business management, hotel operations and operations, and each was given financial and administrative responsibilities, relieving the director of some day-to-day management duties.

The year 1986 also brought BBSR a new president. Dr. James Butler, involved in BBSR's affairs since his pelagic tar studies in the early 1970s, took over from retiring president Redwood Wright.

Butler's aim was stated in the annual report for 1986: "To increase the quality of science and service so that the Bermuda Biological Station moves into the first rank of international marine science laboratories."

That year did in fact see the beginnings of a sharp increase in research and education programs that would more than double the BBSR annual budget by the end of the decade. The Marine and Atmospheric Program continued to develop under Tony Knap's leadership, and with funding from the Bermuda Government and Esso Bermuda. Dr. Clay Cook, in collaboration with Chris D'Elia of the Chesapeake Biological Laboratory, continued research on nutrient sources for the symbiotic algae zooxanthellae, which is essential for corals. With



Dr. James Butler

funding from the U.S. Environmental Protection Agency, Susan Cook and Tom Sleeter conducted research on the effects of crude oil and oil dispersants on subtropical limpets.

In addition to research, Susan Cook also continued to build programs to carry out the other aspect of BBSR's mission: marine science education. In 1986, under her leadership, BBSR formalized the Graduate Internship Program. Under this scheme, a graduate student who has been accepted into a master's or a doctoral program arranges to conduct his/her research under the supervision of a BBSR scientist. To defray housing costs and to pay for the use of the facilities, the student spends a number of hours each month performing tasks determined by BBSR's Education Department: composing teaching guides to various scientific sites in Bermuda; leading tours of such sites; giving lectures to visiting academic groups; conducting lab sessions; and acting as a teaching assistant for summer courses and other in-house programs.

In return, the graduate student not only has fewer financial worries, but also gains valuable experience in research, writing and teaching, skills that every scientist must perfect in order to seek funding. Overall, the program provides much invaluable help to the Education Department and to visiting groups. It enhances BBSR's academic status by training talented young scientists. The first graduate intern in 1986, Julia Parrish, a Duke University doctoral candidate, studied fish schooling behavior while serving as a teaching assistant for BBSR's Biology of Fishes summer course, taught by Dr. Bruce Collette of the U.S. National Marine Fisheries Service. After earning her doctorate, Parrish continued her career as a scientist at the University of Washington. Soon, other graduate students would follow, including three who subsequently served on BBSR's faculty in the 1990s.

BBSR also continued its leading role in acid rain research through the Western Atlantic Ocean Experiment (WATOX), led by Knap, Dr. James Galloway of the University of Virginia and Dr. Thomas Church of the University of Delaware. BBSR scientists had recently discovered acid rain in Bermuda, an island seemingly isolated from sources of industrial emissions in North America and Europe. This led to a key paper in *Nature* and intensified research

Dr. Kent Simmons (right) prepares air-quality monitoring equipment at BBSR's Prospect lab, with the Tynes Bay Incinerator in the background

programs in long-range atmospheric transport. WATOX and related programs soon reinforced the hypothesis that pollution does not respect international boundaries, a theme that would be taken up in earnest in the 1990s. With support from the National Oceanic and Atmospheric Administration (NOAA), WATOX conducted two intensive air-sampling studies in Bermuda in 1986. A specially equipped NOAA P-3 aircraft was enlisted to add to data collected from a rainwater tower constructed at the east end of Bermuda. In 1987 and 1988, the project expanded with grant support from the W. Alton Jones Foundation and the North Atlantic Treaty Organization, which sponsored a major workshop at BBSR on the long-range transport of acid rain. Sampling was expanded to cruise and cargo ships in the Atlantic and a sampling station was established on the west coast of Ireland.

Meanwhile, in 1987 the Bermuda Government began to support another long line of air quality research at BBSR. The project was led by Tony Knap and a young Bermudian, Kent Simmons, who had recently received his doctorate from the University of New Hampshire. Following a stint as a participant in BBSR's Bermuda Programme, Simmons had used BBSR as a base for his dissertation research on groundwater quality in Bermuda. The new government-funded study measured acid rain, aerosols and heavy metals in and around the city of Hamilton. Four years later the program was expanded to measure a wider variety of metals, in the air and in drinking water. Fears about the quality of the environment rose to prominence at this time with the government's controversial plan to build an incinerator on Bermuda's north shore. BBSR scientists used computer modeling to conduct emissions studies, and collected data through remote sensing. In addition, a mobile air-quality testing unit was introduced, which could be moved quickly to any area causing concern.

In 1987, a BBSR scientist began another project that would lead to long-term programs at BBSR. Dr. Tom Sleeter, in collaboration with Dr. Hugh Ducklow of the University of Maryland and Dr. Jed Fuhrman of the State University of New York, Stony Brook, conducted an NSF-funded study of seasonal variations in bacterioplankton biomass in the open ocean. The team also included Craig Carlson, who, soon after completing his undergraduate degree at Colby College, started his career at BBSR in 1987 as a volunteer intern on the

bacterioplankton project. The key question was the role these bacteria and their planktonic predators play in determining how much carbon moves, or "sinks," from the atmosphere into the ocean. This line of research, essential to understanding the ocean's role in global climate change, developed over the next two decades at BBSR.

The connection between marine life and climate was also on the minds of visiting scientists Gerold Wefer and Jurgen Patzold of the University of Bremen. They investigated the distinct annual growth bands in the skeletons of hard corals as a way of monitoring past environmental conditions. The goal of the project was to attempt to reconstruct the climate of the past 1,000 years using these bands, which are similar to growth rings in trees, as a proxy.

While climate was an increasing theme for research in 1987, it was a year perhaps most remembered for the weather: on September 27th, a visit by Hurricane Emily, the most serious storm to hit the island in decades, wreaked havoc on BBSR's grounds. Luckily, the buildings and research vessels escaped serious damage. The *Weatherbird* provided emergency power to the laboratories for seven days and pumped seawater to Wright Hall. Thanks in large part to BBSR's neighbors at the H.M. Co-ed Correctional Facility, the devastation to foliage on the grounds was cleaned up within three months. An emergency grant from the Dorr Foundation helped subsequent re-landscaping efforts.

Despite the operational setback caused by Hurricane Emily, BBSR ended the year by making ambitious plans for the future. In November, a strategic planning workshop attended by more than 50 trustees, Corporation members and local participants assessed possible directions for research and considered necessary resources. The workshop participants used a long time horizon, anticipating challenges and opportunities for research and education at BBSR leading up to BBSR's 100th birthday in 2003.

One of the four panels looked at global geosciences, with Tony Knap and Werner Deuser heavily involved; another, chaired by past visiting scientist Dr. Donald Comb of New England Biolabs, foresaw the development of a department of marine molecular biology at BBSR; the third considered opportunities for research in marine biology and aquaculture; and the fourth reaffirmed the importance of research on Bermuda's groundwater quality, air quality and coral reefs. Soon BBSR developed new or greatly enhanced programs in each of these areas, but first it once again had to find the additional resources and facilities to do so.

The rapid evolution of BBSR's research program was highlighted in 1988, when the Board of Trustees voted to revise the acronym by which BBSR was known from BBS to BBSR. The annual report of 1988 states: "Trustees noted that the term 'Station' implies that BBSR is an outpost or field station, a fact that was once true but is no longer applicable. The term 'Research' epitomizes BBSR's increasing role in global and hemispheric issues. It also reflects the institution's increased activity and visibility in the scientific community."

With Dr. Knap's guidance, BBSR became involved in yet another important initiative at this time, one that would soon lead to the creation of the Bermuda Atlantic Time-series Study (BATS), BBSR's largest resident research program. Discussion among a number of worldwide research agencies brought to fruition the idea of the Joint Global Ocean Flux Study (JGOFS). The purpose of this program was to examine the interactions of dissolved carbon in the oceans and carbon dioxide in the atmosphere, especially in relation to changing climatic conditions, and thus to establish records of global warming data.

The JGOFS program was set up in a number of different countries with monitoring stations organized accordingly. By 1988, BBSR had come on board. A number of variables were added to the Hydrostation "S" program, and the establishment of BATS provided another

long-term set of measurements in the open ocean off Bermuda. The primary goals of BATS are to observe and understand the seasonal variability in the open ocean as it relates to the carbon cycle and global change. Introduction of BBSR into the JGOFS program was a natural development: the research institution cradled in the middle of the North Atlantic would indeed prove to be the ideal open-ocean site, as the Lillie Commission counseled the U.S. National Academy of Sciences in 1929. Knap explains:

> In the mid-'80s, there was a lot of competition [for JGOFS], and we realized how important Hydrostation "S" was, but we also wanted time-series stations in other basins of the world. People were concerned that BBSR couldn't make the measurements that were needed for JGOFS. We were concerned that we couldn't use the ship we had – we had the *Weatherbird I* at that point, but it was a pretty small ship. Our thought was that we'd like to have the BATS station closer to Bermuda than the Hydrostation "S" site. That way we wouldn't have to get a larger ship.

It became very clear, however, that the scientific community felt the BATS measurements would be affected by the closeness of the land, and the idea had to be abandoned.

"We went into partnership with a number of other places," Knap continues, "and we subcontracted the core measurements until we were confident that we had the expertise and personnel to perform them ourselves. Then we would bring in other scientists to do ancillary measurements. There are about 20 groups doing measurements now."

By 1988, about half of the scientific users of BBSR were associated in some way with open-ocean work, either through JGOFS, Hydrostation "S," NSF-funded projects administered by other institutions, or ocean equipment testing. Knap comments, "We had to get a new ship. I worked really hard with NSF to try to get one of the existing ships – of course no one was going to give up one of their ships, even though they were under-utilized."

By then BBSR was a much larger enterprise than at the time of Dr. Sterrer's arrival. Gone were the days of Miss Emmott writing to Mr. Dowling at his motorcycle shop in St. George's to ask for money to buy a typewriter or a filing cabinet. Total institutional funding, including government grants, had increased by 50 percent from 1987 to 1988. Fundraising was conducted on a much larger scale. The Quantum Leap initiative had helped BBSR improve the quality of its research vessels and facilities, and existing buildings had been renovated.

But within two years of that campaign's completion, BBSR faced new capital needs for JGOFS and other programs. Soon BBSR undertook yet another initiative to raise more than $2 million for a range of needs: the larger ship required for BATS, the addition of laboratory and educational space, and increased endowment funding for the library and other needs.

Donors in Bermuda and the United States responded. A $300,000 challenge grant from the Andrew W. Mellon Foundation for endowment of the library was met with help from gifts in memory of BBSR trustee Rudi Nunnemacher, who played an important role in many aspects of BBSR life, including development of the library. His three decades of effort for BBSR had been recognized in 1985 when he was given the Silver Medal Award as Volunteer of the Year by the Council for the Advancement and Support of Education in Washington, D.C.

The National Science Foundation approved a $250,000 challenge grant proposal from BBSR to build an additional floor on top of the two-story Conklin Laboratories. Soon, Frederic

BBSR's 115-foot research ship, the Weatherbird II, was purchased in 1989

M. Reiss made a gift through his company, American Risk Management, to help that project become a reality. With the help of an additional challenge from the Kresge Foundation the following year, the plans were expanded to include a new 200-seat lecture hall adjacent to the Redfield Building. In total, the project goal was $1.2 million.

These new facilities for research and education would be needed soon enough, thanks in large part to another gift received in 1988: real estate in Bermuda donated by Dr. Edward F. MacNichol, Jr. in memory of his parents. At the time, it was the largest gift ever received by BBSR. Proceeds from the sale of the property allowed BBSR to establish the MacNichol Fund, which enabled BBSR to recruit some talented young scientists.

The year 1989 brought not only a new president, Dr. James Galloway of the University of Virginia, who had been a trustee since 1982, but also the sought-after new ship. Knap says:

> NSF was looking to NOAA, trying to find a decent ship. In the end, we bought the *Weatherbird II* ourselves, in 1989, and went into debt to convert it. A few years ago, NSF paid for the re-fit. That really turned it into a ship that was ideal for the work that we did out here. That was a battle – a big battle. We thought about building a ship, but realized we were not going to be able to raise enough money, so we decided to buy an off-shore supply ship and convert it, and that's why the *Weatherbird II* is here. It has turned into a fantastic ship for the work we do. We have used other ships when the *Weatherbird* has been away, but you know, with *Weatherbird* everything is like clockwork when we're out at sea. She now spends an average of 250 days a year on scientific cruises.
>
> This is one of the largest privately owned vessels in the U.S. research fleet. Woods Hole doesn't own its ships, they are all Navy ships. The only ship it owns is a 48-foot motor boat – a bit different from ours. The only other institutions that own ships this size are Scripps and Harbor Branch. All the other ships in the U.S. oceanographic fleet are smaller. The *Atlantis* (an impressive new boat at Woods Hole Oceanographic Institution) cost $25 million. The *Weatherbird* cost two and a half.

Dr. James Galloway

The effort to secure funding for the new ship was led by a new BBSR trustee, Foster Bam, a Connecticut-based attorney who had previously chaired the nonprofit advocacy group the Oceanic Society. His efforts attracted support from the New York-based Charles E. Culpeper Foundation and other donors for the project.

With help from the MacNichol Fund, BBSR was able to recruit leading young scientists to take part in the growing global geosciences program fueled by the BATS and Hydrostation time series. Two new postdocs, biological oceanographers Tony Michaels from the University of California, Santa Cruz, and Fred Lipschultz from Harvard University, joined the BBSR staff. These young scientists brought international recognition to BBSR, with Michaels quoted in a 1989 front-page story in the *Washington Post* on the controversy surrounding iron fertilization of the ocean as a way of mitigating global warming. Both scientists soon attracted NSF and other funding for their research.

Academic programs at BBSR continued to grow, thanks to the continued outreach efforts by Sue Cook. A new summer course, Global Environmental Change, taught by Galloway, Fred Mackenzie of the University of Hawaii, and Doug Whelpdale of Environment Canada, complemented the growing resident global-change research by the BATS program and other projects. In total, BBSR hosted more than 1,800 visitors in 1989, and the summer course program alone attracted students from 17 nations.

These successes reinforced the fact that the scientific world valued Bermuda as an ideal site for research and education, and that laboratory and classroom space at BBSR was more and more in demand. Under the leadership of Development Committee Chairman Richard Spurling, BBSR continued to raise funds from individuals, companies and private foundations in Bermuda and the United States to meet the Kresge Foundation challenge for the planned new laboratories and lecture facility. With two weeks to left to meet the foundation's deadline, BBSR was still $225,000 short. But the challenge was met with help from a gift from United Insurance Company Limited in memory of one of its board members, Gen. Arthur B. "Tim" Hanson. A longtime Bermuda visitor and frequent participant in the Newport to Bermuda

race, Hanson had also helped make possible support to BBSR over the years as a member of the board of the National Geographic Society and of United Insurance. The new lecture hall was dedicated in his memory in 1990, and the new laboratories in honor of Fred Reiss.

As Galloway reflected in the 1990 annual report, it had been a remarkable decade of transformation for the institution: "Substantial growth has become a regular feature at BBSR. That this growth has occurred so consistently is an indication of BBSR's worth to the world." BBSR's annual funding had more than doubled since 1985. Over the course of the decade, its oceanographic research ship had advanced from the rusting *Panulirus II* to the 65-foot *Weatherbird* to the 115-foot *Weatherbird II.* A new floor of laboratories provided a home for the new Bermuda Atlantic Time-series Study. And, perhaps most importantly, BBSR was able to invest in talented young scientists to carry out research and education. BBSR was poised for a new decade and a period marked by contributions from these scientists and others still to come.

THIRTEEN

The 1990s and the Growth of Resident Science

Tony Michaels (left) and Tony Knap (center right) give the Duke of Edinburgh a quick lesson on oceanographic equipment

The investment by BBSR in new facilities and seed funding for young scientists soon produced scientific rewards, resulting in a series of important publications in *Science, Nature* and other leading journals and initiating the dramatic expansion of ocean science connected to the two time-series projects.

Anthony (Tony) Michaels and Fred Lipschultz, the first two MacNichol Postdoctoral Fellows at BBSR, arrived in Bermuda within a few days of each other in September 1989. The MacNichol funds provided a stable initial salary to allow these two scientists the time to spin up their own independent research programs. Both got busy writing proposals and starting new research. They soon secured grant support from the U.S. National Science Foundation (NSF) to carry out new studies related to the ocean's role in global change. Michaels received an NSF grant to study primary production and particle fluxes by large protozoa, each of which have symbiotic algae living in their tissues. Lipschultz received a grant to study the nitrogen cycle in the open ocean, and, with Dr. Clay Cook, support from the Office of Naval Research for a three-year study of marine symbiosis in corals and sea anemones.

The Bermuda Atlantic Time-series Study (BATS) program thrived under the leadership of Knap and Michaels. Michaels assumed operational oversight of the BATS program on his arrival in 1989. "However," Michaels notes, "the real key to the early success of BATS was the dedicated technical staff. Rachael Sherriff-Dow, Rod Johnson and Kjell Gundersen were there at the beginning, and Ann Close came in soon after my arrival." These four were the nucleus of the future growth in the technical staff for BATS, the new oceanographic scientists for BBSR and the ancillary research that it attracted.

There are very few ocean time-series studies worldwide and they have an interesting scientific pace and pattern. In the first years of sampling, everything is new and exciting, much in the way that every cruise tells us something new about our under-sampled ocean. With each subsequent year and decade, the ongoing sampling at BATS and the Hydrostation "S" data shed light on important oceanic processes that are impossible to see with short-term expeditions. These long-term results come more slowly, but they have great power to expand our horizons. For example, in the early 1990s, Dr. John Moen and others noted that, contrary to predictions from climate-change models, the ocean near Bermuda had cooled over much of the past four decades. As Michaels said in 1991, "If the time series had been started in the 1970s, a huge sign of global warming would have been seen. But since we started it in 1954, it looks as if the ocean cooled down and then warmed, and it is not yet up to where it was when we started."

The benefits of the BATS time series in the mid North Atlantic were enhanced through a growing collaboration with BBSR's Pacific counterpart, the University of Hawaii, and its NSF-funded program, the Hawaii Ocean Time-series (HOT). In June 1992, BBSR hosted the first joint workshop with Dr. David Karl and his HOT team, and compared the results of the initial four years of the joint program. For the first time, BATS and HOT had comparative data between the Atlantic and Pacific time series. This first meeting led to many others as the ability to compare the two large open-ocean biomes allowed the investigators at each to begin to see patterns that were global and those that were more unique to the individual basins.

Michaels attracted other support to BBSR as he built collaborative research projects around the BATS time series. NSF funded a three-year oceanographic study of dimethyl sulfide (DMS), a gas that may affect global climate through its effects on cloud formation over oceans. Some scientists have suggested that increases in DMS fluxes from the ocean to the atmosphere will lead to increased cloud formation and albedo (reflectivity) of the earth. The higher albedo will cool the earth by reflecting the sun's energy back into space. Along with Dr. John Dacey of Woods Hole and Dr. Stuart Wakeham of the Skidaway Institute of Oceanography, Michaels and his colleagues embarked on a series of quarterly cruises on the *Weatherbird II* to understand DMS production in the oceans.

With Tony Knap and Dr. Ken Buesseler of Woods Hole, Michaels conducted an NSF-funded study of the performance of sediment traps deployed from the *Weatherbird II*. The project investigated the use of the isotope Thorium in studying the flux of particles in the ocean. A third NSF grant, secured by Michaels with University of California, Santa Barbara scientists David Siegel and Ray Smith, began a long-term program in ocean optics. The project involved using sampling equipment on each BATS cruise to detect light at many different wavelengths. These measurements served as the ground-truth mechanism for satellite observations, measuring ocean color to determine the level of productivity in the ocean. The measurements provide, literally, a picture of ocean processes affecting climate change. Soon BBSR hired a postdoctoral fellow from the University of California, Santa Barbara, Norm

Weatherbird II crew members deploy CTD equipment during a BATS cruise

Nelson, to lead BBSR's bio-optics program. This program continues to this day under the leadership of Norm Nelson and Dave Siegel.

"One of the greatest achievements of Tony Michaels," Knap remarks, "was the creation and promotion of the ancillary research programs that began to work alongside the core BATS and Hydrostation 'S' time series." Michaels created the "time-share technician" program, in which a scientist from another institution could rent a "part" of a BBSR technician to conduct routine sampling on the time-series cruises. This allowed a scientist to gather data 10 to 20 times each year without having to physically travel to the island or go on the cruises. The shares were quite inexpensive. A 10 percent share cost $4,000-$5,000 per year and allowed for a profile every month. These ancillary scientists would typically get a few years of routine time-series data and then come to Bermuda a few times each year for more intensive experiments.

The program proved extremely popular. "By the end of the decade," Michaels says, "60 different research groups had conducted time-series projects near Bermuda. This made the Bermuda time series a truly unparalleled success." For example, Dave Siegel and Dennis McGillicuddy used the time-series and particle flux data to discover the role of eddies in the cycling of nutrients and the dispersion of particles in the sea. Many scientists made fundamental discoveries about the cycling of trace metals and their relationship with ocean biology. The list goes on. Today, there is no other place in the ocean that has so many co-located, time-dependent measurements and so much collaborative, interdisciplinary research. This richness is the reason that the time-series stations were credited with a disproportionate share of the truly novel science during the JGOFS era.

Michaels, Knap and the many other scientists who worked on BATS were able to change some of the basic paradigms in oceanography. Before the time series, this field took for granted the Redfield Ratio, an early observation made by former BBSR president Alfred Redfield that the ratios of elements in organisms and the sea are constant. Even though the original work recognized that these ratios could vary, the canonical ratios had become dogma in oceanography. The BATS data were the first time-series data to include complete measurements of all forms of carbon and nutrients in the sea and revealed some startling patterns.

Carbon would disappear from the system in the apparent absence of major nutrients. These results, published in *Nature* by Michaels and his coworkers, forced a re-evaluation of many of these cherished assumptions.

Later work by Michaels and others explored the very strange ratios among nutrients in the Sargasso Sea, finally coming to the conclusion that biological nitrogen fixation (the conversion of nitrogen gas to organic nitrogen) was more important than previously recognized. Interestingly, the first work to recognize this process in the ocean was done by Dugdale and Goering in Bermuda in the mid-1960s and the renewed importance of the process occurred in the same setting three decades later. These discoveries, along with similar patterns seen by Dave Karl in Hawaii, have paved the way for a new understanding of the ocean carbon and nutrient cycles, one that is leading to a very different understanding of the role of the ocean in the global carbon cycle.

The BATS project had an ongoing role in the growth of BBSR since it became the springboard for many young scientists to become successful members of the faculty. BBSR's global geosciences research team was strengthened in 1992 with the addition of Dennis Hansell, an expert in the measurement of dissolved organic carbon (DOC) and dissolved organic nitrogen (DON) in the ocean. Hansell was originally hired to work on BATS as Michaels became more and more successful in projects of his own. The measurement of DOC in particular is considered an important core measurement of the JGOFS program, and with Hansell on board, BBSR became a global leader in this area. Hansell not only helped expand BBSR's research horizons, but its geographic ones as well, primarily through an active program of similar measurements in the Arabian Sea, the central Indian Ocean, the western Southern Pacific Ocean and the Ross Sea off Antarctica.

This extensive data collection effort resulted in the production of a data set unlike any seen before, and it required creative and insightful interpretation. A key question for the

Dennis Hansell at work in the laboratory

Nick Bates investigates the role of carbon dioxide in the ocean

Hansell research team was the fate of the carbon that is converted into DOC by myriad single-celled plants in the ocean. This carbon largely has two fates: removal to the deep ocean as sinking particles, and immediate consumption and respiration back to carbon dioxide by the numerous consumers in the surface ocean. This research was of great relevance because the importance of DOC for the ocean carbon cycle had recently emerged, becoming the topic of heated debates in scientific circles as to its significance to the larger global carbon cycle and to global climate change.

Hansell was a success and became fully involved in his own projects. Like Michaels before him, he became an independent scientist, while keeping an allegiance to the core BATS time series. Knap and Michaels then looked for additional young scientists to bring on board. It was now clear that the BATS experience with Michaels and Hansell was not a fluke. This project was a wonderful platform for developing successful scientists. BATS provided the funding to get them started, a conduit to a larger community and a vehicle for the preliminary investigations that it took to get large research grants. For the right scientists, this was a perfect incubator. In the mid-1990s, Debbie Steinberg joined the BATS program and the BBSR research staff. She followed a similar research trajectory, developing an innovative program to study zooplankton.

By 1995, the growth of BBSR's global geosciences research effort enabled BBSR to recruit Nicholas Bates, first as a laboratory technician on a NOAA grant awarded to Knap to measure dissolved inorganic carbon. "Nick registered for a Ph.D. through the University of Southampton, following the pattern of Tim Jickells," Knap says. "After receiving his doctoral degree, he became an assistant research scientist and built an incredibly successful program in understanding carbon dioxide in the ocean." Craig Carlson came back to BBSR as a post-doctoral fellow with Dennis Hansell, working on dissolved organic carbon and dissolved organic nitrogen studies. Carlson had started at BBSR as a work-study student and returned to conduct research for his doctorate through BATS. Following his postdoc with Hansell, he became involved with BATS and with his own research. Norm Nelson also diversified his research areas to become more involved with BATS.

The successful investment in young scientists also extended well beyond the oceanography program and BATS. In the early 1990s, BBSR brought Robbie Smith back as a

Robbie Smith (right) conducts coral reef research with a summer student

postdoctoral fellow, also with initial support from the MacNichol Fund. After being introduced to marine science as a young participant in BBSR's Bermuda Programme in the 1970s, Smith had continued as a BBSR researcher on the Bermuda Inshore Waters Investigation and other projects before receiving his doctorate from the University of Georgia. His dissertation was based on his long-term study of the recovery rates of reefs damaged by ship groundings. His fieldwork, based at BBSR, focused on the site of the 1978 wreck of the *Mari Boeing*, a cargo ship that crushed a two-hectare swath of coral reef off Bermuda's north shore. For the main reef-building brain corals, research by Smith suggested that the site would take from 100 to 200 years to return to its pre-*Mari Boeing* condition.

Smith's coral reef research interests led in 1991 to the establishment of the Benthic Ecology Research Program (BERP) under his direction. Its focus was to conduct research on potential coral reef impact areas before the Tynes Bay Incinerator was scheduled to begin operating. The project complemented the air-quality studies that Smith's colleague Kent Simmons and others had been conducting since 1987.

When the incinerator began to operate in May 1994, the baseline studies of both programs ended and the monitoring of emissions from the incinerator began, as did the testing of possible changes in water temperature due to incinerator runoff on the North Shore sea grass beds and patch reefs. Sea grasses are sensitive to increased temperature and researchers suspected that the dominant benthic species off Tynes Bay, eel grass, might be threatened by the temperature change. This concern was laid to rest when the BBSR study found that the incinerator runoff dissipated rapidly in the sea and made no noticeable difference to sea temperature.

The incinerator produces massive quantities of ash, which are made into concrete blocks and used as artificial reefs and shore support in Castle Harbour. Another responsibility of BERP is to monitor these blocks for signs of deterioration. The research team feared, for instance, that marine invertebrates might colonize by boring into the blocks, which would affect the blocks' long-term stability, or that trace metals would leach from the blocks and be absorbed by biological tissues.

Another aspect of Smith's work for the Bermuda Government was the monitoring of the outer coral reefs. Permanent monitoring quadrats were placed to establish the rates of

recruitment, growth and mortality among corals. Studies were also started to compare rates of larval settlement on ceramic tiles suspended off the reefs to rates of recruitment within the permanent quadrats. Like Hansell, Smith did not limit his research horizons to Bermuda, becoming a principal investigator of the Caribbean Coastal Marine Productivity program (CARICOMP), a long-term monitoring project covering the Caribbean and Florida coral reefs, sea grass beds and mangrove forests.

Within several years of the 1987 workshop to outline long-term directions for research and education, BBSR had enhanced its programs in global geosciences through the addition of Michaels, Lipschultz, Hansell, Nelson, Carlson and Steinberg, and on Bermuda's environment, mainly through the Bermudian scientists Simmons and Smith. A third priority identified by that 1987 workshop – establishment of a molecular marine biology program – came to fruition in 1993, thanks to the leadership of BBSR trustee Ray Moore.

Through his networking efforts and personal support, Moore enabled BBSR to establish and fund a laboratory designed to study chemically mediated biological phenomena in the marine environment using the tools of modern biochemistry and molecular biology. Hank Trapido-Rosenthal, at the time a faculty member at the University of Florida's Whitney Marine Laboratory, was recruited to BBSR in 1993 to start the program. BBSR established a working relationship with Boehringer-Mannheim, a German pharmaceutical company, and soon Trapido-Rosenthal had identified compounds from several marine organisms that showed the promise of medicinal value for humans.

Despite the success of the investment in talented young scientists who then brought in additional grant support, BBSR President James Galloway recognized that it would always be a challenge to recruit and retain scientists without a more stable source of institutional funding. BBSR's endowment fund had increased dramatically over the course of the 1980s, but the result, a fund with a market value of just over $1 million, was not sufficient to meet the challenge outlined by Galloway. In 1992, BBSR announced a campaign to raise significant additional endowment, which resulted in more than $2.5 million contributed primarily by BBSR trustees and Bermuda-based corporations.

The investment in new facilities provided new opportunities to enhance BBSR's educational mission as well. Many of these projects were implemented by Dr. Robert Jones, BBSR's new deputy director and education director, who assumed Susan Cook's responsibilities for education after she and Clay Cook returned to the United States in 1992. Jones had previously been the chairman of the Department of Marine Sciences at the University of Texas.

Jones also took on some managerial responsibility from Harry Barnes, who left in 1993 to become assistant director for scientific services at the Smithsonian Tropical Research Institute in Panama. Barnes then became associate director for administration at the Bodega Marine Laboratory of the University of California, Davis.

With the 200-seat Hanson Hall auditorium in place, BBSR was able to participate in a new global program that would benefit thousands of Bermudian schoolchildren, the JASON Project. Named for the mythological Greek explorer, the JASON Project was the brainchild of Dr. Robert Ballard, a noted oceanographer known to the general public as the discoverer of the *Titanic* wreck.

The aim of the project is to promote in students a love of science and discovery. Each year, a JASON expedition goes to a different part of the world and focuses on an aspect of current research. Students from around the world participate through interactive live broadcasts to about 30 Primary Interactive Network (PIN) sites, where students assemble. During

the broadcasts, members of the audience have the opportunity to participate in the expedition by e-mailing recorded questions to the JASON scientists.

BBSR became a PIN site in 1993, hosting more than 3,000 Bermudian students each year for the live broadcasts in Hanson Hall, with sponsorship and major technical support from Cable & Wireless Bermuda Limited. Direct participation by Bermudian students in the expeditions also began in 1993, when a student at Saltus Grammar School, Roderick Ferguson, was selected in a global competition as one of 23 student "Argonauts" for the JASON expedition to Belize. In 1998, the JASON Project broadcasted from Bermuda and Monterey Bay. These broadcasts were highlighted by live underwater chat sessions between BBSR's Robbie Smith and his counterpart off the coast of California, both wearing bubble helmets equipped with microphones.

The JASON Project led to other distance-learning initiatives at BBSR that utilized the massive new potential of the Internet. One, the Classroom BATS program, was led by new BATS scientist Debbie Steinberg and her husband, Dr. David Malmquist, who arrived at BBSR from the University of California, Santa Cruz in 1995. Working in collaboration with the College of Exploration, a specialist in web-based learning environments, Steinberg and Malmquist used actual BATS data to teach methods of scientific inquiry to high school students. The program quickly received national recognition for its innovative approach.

BBSR's resident education program also grew in the early 1990s when BBSR became one of 10 marine science institutions (and the sole site outside the United States) selected to participate in the National Science Foundation's Research Experience for Undergraduates (REU) program. Designed to encourage American undergraduate students to consider marine and other sciences as careers, the highly competitive REU program enables eight students each year to conduct independent research under the supervision of BBSR scientists.

In addition to managing the thriving education program, Bob Jones assumed significant administrative responsibilities as deputy director. This enabled Tony Knap to focus more time on fundraising and support for new research programs. In one case, a request for endowment support led to a new idea, and a major new program for BBSR.

Local students participate in a live interactive broadcast of the JASON Project

Debbie Steinberg (top left) leads a group of students on a BATS research cruise

During the campaign to raise endowment support, Knap met with Michael Butt, the chairman and chief executive officer of a Bermuda-based reinsurance company, Mid Ocean Re-insurance Limited. While enthusiastic about BBSR's mission, and understanding of the importance of endowment, Michael Butt suggested that a much more significant funding opportunity existed for the institution. "Michael suggested that, if BBSR could make a direct research connection with issues of concern to the reinsurance industry, much broader and deeper support would be forthcoming from his company and other reinsurers," Knap says. About the same time, Michaels was making a different networking connection with the industry. "I began to meet a variety of new additions to the local play group that my children attended on weekends at the Botanical Gardens," Michaels recalls. "These new parents were young, dynamic executives in the recently emerging catastrophe reinsurance industry. They had come to Bermuda to set up the new companies in the wake of the losses incurred by Hurricane Andrew in Florida. They also told a similar story of the need for more science to guide their decisions."

The result, developed by Knap and Michaels, would take advantage of two areas of expertise rapidly expanding in Bermuda: global reinsurance and, at BBSR, climate science. Knap and Michaels returned to Butt with the concept of the Risk Prediction Initiative (RPI), a science-business partnership that would focus on building bridges between the climate science and global reinsurance worlds. Butt said that Mid Ocean Re would put up $100,000 per year if BBSR could find four others to join. Michaels and Knap took this challenge to other Bermuda companies and to prominent companies in the United States and Europe. Quickly, there were 13 companies on board and the program was underway.

The goal was to create a new body of public knowledge on hurricane risks and climate variability. The traditional actuarial approach to hurricane risk, the average of the past losses

being the estimate of the future risk, could not work with a climate feature. Any average of the past will not be the estimate of the future. However, climate models had become sophisticated enough that they could give some useful information about how the future risk might differ from the average of the past.

RPI operated through the direct funding of science and the connection of that science through workshops and other communications. The benefits of the dialogue between reinsurers and climate scientists became evident very quickly. While their respective interests dovetail closely, particularly in the case of understanding phenomena such as tropical cyclones, differences in culture and tradition had precluded effective communication between the two groups. RPI helped fill this void to the benefit of both communities.

In addition to BBSR's resident scientific expertise, funding from these companies enabled BBSR to enlist participation by leading climate scientists from around the world, including Kerry Emanuel of the Massachusetts Institute of Technology, Kam-bui Liu of Louisiana State University, J.J. O'Brien of Florida State University, Tim Barnett of Scripps, Johnny Chan of the University of Hong Kong, Greg Holland from Australia, and hurricane expert Bill Gray of Colorado State University. These scientists came to Bermuda for an ongoing series of workshops with representatives of participating companies.

The first workshop took place in 1995 and discussed recent forecasting advances for the global climate cycle generated in the equatorial Pacific, known as the El Niño Southern Oscillation. Then little understood by the general public, El Niño came to the forefront in 1997 with a major event that affected climate throughout the United States.

The second workshop that year focused on hurricanes and their prediction. It highlighted a simple difference in the respective interests and cultures of the participating scientists and reinsurers. A discussion of the predicted number of hurricanes for the next year led to the observation that reinsurers are not primarily interested in the number of hurricanes; they (and society) need to understand the number of hurricanes expected to make landfall.

In response, RPI developed a range of research projects, both at BBSR and, through requests for specific proposals, by scientists at other institutions. This included the development of climate proxy studies. Although BBSR had developed a four-decade record of climate measurements at Hydrostation "S" and BATS, it still was not enough to tease out long-term climate cycles such as El Niño, some with periods of decades. Using sand deposits in the southern United States, cedar tree rings in Bermuda and other novel resources, RPI scientists began to gain a far better understanding of climate cycles and storm events going back thousands of years.

In 1997, the RPI story was told in a *Nature* commentary by Michaels and Knap. It has become a model for the interaction between business and academia and is now widely copied. In a wider sense, it also illustrates the unique qualities and opportunities inherent in BBSR. A small group of scientists live at the center of a much wider academic community that passes through BBSR as visiting scientists and educators. BBSR scientists are on "soft money" and hence are entrepreneurial and innovative. When a unique opportunity comes along, even something as non-traditional as working with insurers for a common benefit, the culture of BBSR scientists allows them to grab that opportunity and make the most of it.

Between 1986 and 1996, the resident faculty at BBSR almost tripled, growing from six to 17 full-time resident scientists supported by 24 research technicians. The level of research funding from the National Science Foundation increased even more. These two interrelated factors were key signs of BBSR's maturation and successful growth during that 10-year period,

an era that led to a tremendous increase in BBSR's prominence in the academic world. BBSR had always been a beloved part of the community experience in academia and the home of excellent scientists. By 1996, it had a large enough faculty of leading scientists to truly stand among the best institutions in its field, based on both resident research activities and the greater body of science contributed by its visitors.

FOURTEEN

A New Horizon

Hank Trapido-Rosenthal collects samples in Harrington Sound for BBSR's ocean genomics research

Nineteen ninety-six was a year of change for BBSR. Tony Michaels left Bermuda to return to his native California as the new director of the University of Southern California's Wrigley Institute of Marine Sciences. His time at BBSR since arriving in 1989 as a MacNichol Postdoctoral Fellow had been extraordinarily productive: he had played a leading role in the development of both the Bermuda Atlantic Time-series Study (BATS) and the Risk Prediction Initiative (RPI). He was succeeded as the RPI science program manager by Dr. Richard Murnane, a climate modeler recruited to BBSR from Princeton University. Nick Bates, Craig Carlson and Debbie Steinberg assumed leadership of the BATS program.

After seven years, James Galloway stepped down as president of the BBSR Corporation in order to devote attention to his new responsibilities as chairman of the Department of Environmental Sciences at the University of Virginia. (Among the new faculty in that department: Karen McGlathery, a BBSR graduate intern in the late 1980s.) Galloway continued as an active leader on the BBSR board.

Galloway was succeeded by the first non-scientist to serve as president of the Corporation, Christopher du P. Roosevelt, a New York-based attorney. Roosevelt was no stranger to BBSR or the ocean. A BBSR trustee since 1982, Roosevelt served for 11 years as chief executive officer of the Oceanic Society, a nonprofit advocacy organization. He was also the founding president of the Maritime Aquarium in Norwalk, Connecticut, for more than 10 years.

The growth in resident programs since the Reiss Laboratories and Hanson Hall were constructed in 1990 exceeded BBSR's expectations. The programs developed in these new facilities suggested even further opportunities for new research and education. And, despite the success in increasing the endowment fund over the previous decade, the board under Roosevelt's leadership recognized that it still was not sufficient to ensure that BBSR could carry out its mission successfully over the long term.

Thus, in 1997, BBSR began making plans for another significant fundraising campaign, its most ambitious to date. A new trustee, Bermuda resident Michael Naess, became chairman of what became known as the New Horizon Campaign, an initiative to raise at least $20 million for programs, facilities, operating support and endowment.

Naess's career, like Roosevelt's, had largely focused on matters related to the ocean, including involvement in successful shipping and offshore oil development companies. He had also served in the 1970s and 1980s as an appointee of Presidents Jimmy Carter and Ronald Reagan to the National Advisory Committee on Oceans and the Atmosphere. His father, Erling, had served as a BBSR trustee in the 1980s.

Roosevelt, Naess and other trustees soon set about strengthening BBSR's board to help carry out this ambitious new campaign. The Corporation approved a by-laws resolution that authorized an increase in the size of the board from its previous limit of 36 members to 48. New trustees from the Bermuda business world were recruited.

Among the campaign's objectives was support for a range of research initiatives, including those building on BBSR strengths in the fields of global geosciences, coral reef ecology and other areas. In addition, the campaign set as a goal "the development of a solid capability to respond to new research and educational opportunities as they arise."

The campaign began in 1998, the International Year of the Ocean, which presented one such opportunity. A high-profile report released that year by the National Research Council, *Monsoons to Microbes*, urged that more attention be given to the close connections between ocean health and human health. BBSR took an early leadership role in addressing this issue, establishing the International Center for Ocean and Human Health.

BBSR was a logical place for such a center. Largely through Tony Knap's long-term involvement with several United Nations panels, BBSR had developed a strong international network of scientists working on ocean health/human health issues, particularly in the developing world. At the time, Knap was serving as chairman of the Health of the Ocean Panel of the Global Ocean Observing System (GOOS) sponsored by the Intergovernmental Oceanographic Commission of UNESCO. A colleague on that panel, ecotoxicologist Michael Depledge, director of the Plymouth Environmental Research Center at the University of Plymouth, United Kingdom, helped Knap develop the concept for the center. It was considered the first of its kind to address both health of the ocean (pollution threats) and health from the ocean (from nutrients and marine product-derived pharmaceuticals) on an international scale.

Depledge collaborated with Knap, new BBSR scientist Richard Owen and others to develop a range of low-cost tools to enable environmental managers to detect ecological threats before they become disasters. Rather than conducting tests that subjected marine organisms like mussels to lethal doses of toxic substances, these scientists developed methods to detect environmental stress at lower levels that point to the relative health of the environment. "BBSR and others involved in the Health of the Ocean Panel of GOOS recognized some time ago that new, more simple tests that did not harm the organisms were needed," says

Samia Sarkis prepares pearl nets full of juvenile scallops

Knap, "especially in the context of helping developing nations. We are now reaping the fruits of our labor over the past decade and using these tests in the environment." Training workshops in Costa Rica, Brazil and other locations helped launch this effort under the auspices of GOOS and BBSR's new center.

The ocean health/human health concept grew when Canadian scientist and public health expert Dr. Eric Dewailly joined forces with BBSR and enhanced the Center's expertise on the health benefits and risks of seafood. Dewailly had decided to spend a sabbatical at BBSR and, as a physician, helped strengthen investigations into the connections between human health and the ocean.

With funding secured by the New Horizon Campaign from the Bank of Bermuda Foundation and several matching donors, Dr. Samia Sarkis built a different type of "health from the ocean" program at BBSR, developing techniques to bring back Bermuda's scallops through sustainable aquaculture. Sarkis began this research in 1987 as a BBSR graduate intern, her second stint at BBSR, following participation several years before in the Volunteer Internship Program. She soon built a hatchery facility at BBSR and developed techniques for growing scallops to adult size in nets placed at various locations in Bermuda's inshore waters.

Yet another partnership, this time with a California-based biotechnology company, Diversa, enabled BBSR to continue to build its program investigating the potential of marine organisms for pharmaceutical applications and other chemical, agricultural and industrial uses. Again, Bermuda's location, surrounded by deep ocean and coral reefs, and the close access to BBSR's laboratories suggested an ideal setting for this research. The program continues to be developed under the leadership of Hank Trapido-Rosenthal. Another BBSR faculty member, Kathryn Coates, collaborated closely with Trapido-Rosenthal on related biodiversity and systematics research.

Kathy Coates studies biodiversity for the Marine Biology and Invertebrate Systematics program

In 1999, BBSR's ocean and human health center hosted a workshop that developed a series of recommendations for implementing the ocean health/human health initiatives urged during the International Year of the Ocean. Sponsored by the National Institute of Environmental Health Sciences and IOC/UNESCO, the weeklong workshop attracted to BBSR more than 30 scientists from the United States, Canada and Europe, including NIEHS Director Dr. Kenneth Olden.

In February 2000, BBSR presented the findings of the workshop at a briefing it organized in the U.S. Capitol for members of Congress and staff of key federal agencies. Knap chaired a panel that included Olden, workshop participant Dr. Lora Fleming of the University of Miami, and former BBSR trustee Dr. Margaret Leinen, who had become assistant director of the National Science Foundation. The November workshop recommendations were published in the NIEHS journal *Perspectives*, and within two years, NIEHS and NSF had agreed to establish joint research programs on the topic.

One important recommendation of the November 1999 workshop addressed the need to train students, not only at the doctoral level, but also at the master's degree level. Thanks to a grant from the Glaxo Wellcome Foundation, BBSR and the University of North Carolina-Wilmington helped fill this gap by offering the first master's level program in ocean and human health in North America. Courses were taught in North Carolina and, during the summer, in Bermuda.

The program in ocean and human health strengthened the already successful summer course tradition. The New Horizon Campaign also aided BBSR's education program by attracting significant scholarship endowment support from the Stempel and Starr Foundations. A new endowed fund, in memory of BBSR trustee Roger Perry, has enabled BBSR to offer a steady source of scholarships specifically for students from developing

nations. The Canadian Associates of BBS and the U.K. Associates, charitable trusts set up to support students at BBSR from those countries, remained important sources of scholarships. The Exxon Mobil Corporation continued its long tradition of scholarship support as well.

Dr. Fred Lipschultz, now also serving as head of academic affairs, developed two new semester-long undergraduate programs that realized the vision of BBSR as a year-round educational institution at all academic levels. The spring program, called the Beaufort-to-Bermuda semester, brought students from the more than 25 colleges and universities in the Duke University Marine Sciences Education Consortium. Students spend half the semester at BBSR taking courses from BBSR faculty members, then switch with a group of students taking complementary classes at Duke's marine laboratory in Beaufort, North Carolina. A similar fall program, with students staying at BBSR for the full semester, was developed for students at the University of Rhode Island, Roger Williams University and other institutions. In 2001, Lipschultz's contributions to BBSR in both its research and education programs were recognized when he was promoted to senior scientist.

Through the efforts of Dennis Hansell and other BBSR faculty members, a second center was formed at BBSR in 1999 to complement the activities of the International Center for Ocean and Human Health. At the time, marine scientists around the world were mulling over how to create a truly integrated system for observing the ocean from many different perspectives. Bermuda was seen as a model for such a system. With its long history of Hydrostation and BATS data collection through sediment traps, ocean moorings and satellite observations, the ocean surrounding Bermuda was among the most thoroughly investigated in the world. Hansell and others formalized this into the Center for Integrated Ocean Observations. The intent was to create a top-to-bottom view of the ocean and to disseminate data globally via the World Wide Web.

The Center became the BBSR component of the Sargasso Sea Ocean Observatory, a larger program involving scientists from 17 institutions, including Woods Hole, the University of Miami and the University of California, Santa Barbara. It was introduced to the Bermuda

Fred Lipschultz teaches a Beaufort-to-Bermuda student

Norm Nelson (left) and Ru Morrison study the ocean using satellite imagery

public at a symposium in April 2000 that featured seven BBSR faculty members, with closing remarks by BBSR trustee Dr. John Knauss.

Many of the research programs brought under the umbrella of the new center were conducted by Hansell, the BATS trio of Nick Bates, Craig Carlson and Debbie Steinberg, and satellite oceanographer Norm Nelson. While BATS and the JGOFS time series make measurements in one place over time, Hansell, working with U.S. JGOFS process studies and the World Ocean Circulation Experiment (WOCE), continued to make these measurements over distance, working in most of the world's open-ocean systems. "This helps put BATS into a larger perspective," Hansell explained. These studies allow oceanographers to determine how the oceans interact with each other and physically transport elements such as carbon.

Nick Bates, in collaboration with scientists at Princeton University, also helped put BATS into a global perspective, using global JGOFS and WOCE data to determine the rates at which carbon dioxide is exchanged between the ocean and the atmosphere. His laboratory quickly developed a global reputation for the measurement of carbon in the ocean and the exchange of carbon dioxide between the ocean and atmosphere.

Among Debbie Steinberg's research interests was the phenomenon known as "vertical migration" of deep-sea creatures, which rise toward the surface each evening after sunset to feed on microscopic plants growing in the sunlit surface waters. Her studies provided a link to the studies at BBSR seven decades earlier by William Beebe, who was probably unaware at the time that the deep-sea creatures he observed ever left the depths. Steinberg studied the process by which these migrating animals potentially move a vast amount of carbon from surface waters to deep ocean, playing a vital role in the global carbon cycle.

Craig Carlson combined his interests in oceanography and microbial ecology to develop an oceanic microbial observatory in collaboration with Dr. Stephen Giovannoni of Oregon State University. The program utilizes new technologies to perform in seconds a host

of data gathering techniques that would have taken a laboratory technician several hours or days in the not-too-distant past. Carlson and Giovannoni took advantage of this new technology to try to understand the role of oceanic bacteria in the carbon cycle.

While these scientists investigated the surface and deep-ocean waters from the *Weatherbird II* and from moorings and other equipment deployed from the ship, Norm Nelson continued to glean new information from NASA satellites collecting high-resolution color images. These satellites feed data directly to BBSR computers and provide important details about ocean temperature and biological productivity.

The result of the efforts of these scientists, all recruited to BBSR after the Reiss Laboratories were built in 1990, was a remarkable output of scientific publications for an institution of BBSR's size, including influential peer-reviewed articles in *Nature, Marine Chemistry, Deep-Sea Research,* and *Limnology and Oceanography*.

In addition to the output by resident faculty, scientists from around the world were drawn to BBSR to take advantage of the growing, integrated data collection programs. "BATS has become a center of collaboration for the world's top oceanographers," Carlson observed.

By 2001, though, BBSR was a victim of its own success in developing scientific talent, with five key scientists recruited away to leading marine science programs in the United States. Hansell accepted a position at the University of Miami, Steinberg and husband Dr. David Malmquist moved to the Virginia Institute of Marine Sciences, and Carlson and Nelson headed west to the University of California, Santa Barbara. BBSR had provided these scientists with an opportunity to develop high-visibility programs in the world of oceanography, and their success helped make the institution more attractive for the next wave of young scientists soon recruited to Bermuda.

In 2002, the BBSR Board of Trustees also underwent significant changes. Christopher Roosevelt and Rosamond Butler stepped down as president and secretary of the Corporation, respectively. Both remain active members of the board. Roosevelt was replaced by Michael

BBSR visits the Capitol in February 2000 for its briefing on ocean and human health. From left: trustee Michael Naess, President Christopher du P. Roosevelt, Director Tony Knap, and trustees Ray Moore and Sir John Swan

Naess, with a by-laws change authorizing a new title of board chairman in place of the previous designation. Butler was replaced by BBSR staff member Gillian Hollis. Naess's responsibilities as chairman of the New Horizon Campaign were assumed by new co-chairs Robert Cawthorn and Charles Kline. By 2002, the New Horizon Campaign was closing in on its original stated goal of $20 million. Much of that amount had been raised in support of research and education programs.

Yet another new research opportunity arose in 2002 in the form of ocean genomics. At about the same time BBSR launched its campaign, a scientist in Maryland, Craig Venter, formed a company called Celera Genomics, whose goal was to use novel methods to map the human genome faster and at lower cost than a publicly funded research consortium already tackling the project. In 2002, with seed funding provided by several trustees, BBSR began to develop a program in ocean genomics, applying these and other methods to the open ocean and coral reef environments surrounding Bermuda. BBSR's Hank Trapido-Rosenthal, visiting scientist Stephen Giovannoni and Craig Carlson, who retained an active research program at BBSR after his departure, were leaders in this effort. One initial result was the creation of the Marine Genome Bank, which will contain the genomes, or complete genetic codes, of microorganisms found in Bermuda's various marine environments.

Venter developed an interest in the ocean as the next frontier of genomics research, and he recognized the important potential in Bermuda for such investigation. Venter visited BBSR to give a standing-room-only lecture in Hanson Hall, and he joined the Board of Trustees soon after. By the end of 2002, Venter and BBSR were planning initial research collaborations that show promise, not only for possible pharmaceutical applications, but also for understanding and providing solutions to possible global warming.

With the campaign nearing its original target, the BBSR board recognized that additional support would be required to take advantage of these new opportunities. The board approved increasing the goal to $25 million to ensure that BBSR would have the facilities and programmatic support to put Bermuda on the scientific map in this new field as the institution entered its second century.

In BBSR's 100th year, the institution could point out with pride that the four goals of the 1987 long-range planning workshop had been achieved in time for BBSR's centennial celebrations. Particularly in the case of molecular biology and the new field of genomics, advances had been made in ways that could not have been imagined at that time.

BBSR had advanced significantly its programs in the other three areas as well. In global geosciences, its success had enabled BBSR to recruit yet another talented young team (Drs. Alexandra Amat, Michael Lomas and Peter Sedwick) to replace the group that had just departed. Nick Bates continued to build a globally respected carbon measurement program. The basic research programs were complemented by the Risk Prediction Initiative, which, under Rick Murnane's leadership, was a continuing source of both climate science and communication between the reinsurance and scientific worlds.

With Robbie Smith moving in 2002 with his family to the United States, his longtime colleague Kent Simmons assumed leadership of all Bermuda environmental research. Two new postdoctoral fellows, Shane Paterson and former Bermuda Programme intern Joanna Pitt, conducted a study of fisheries and marine protected areas in Bermuda.

BBSR's history of addressing environmental threats also continued as Richard Owen and Tony Knap published in *Marine Pollution Bulletin* the results of a BBSR study which revealed that a herbicide commonly used in new-generation boat antifouling paints is highly

toxic to corals. The use of the compound, Irgarol 1051, is expected to increase in 2003 when a global ban on the use of another popular antifouling compound, tributyl tin (TBT), takes effect.

Owen also teamed up with Hank Trapido-Rosenthal to develop coral health techniques that utilize BBSR's growing molecular biology and genomics expertise. A series of workshops was planned, beginning in 2003, in Bermuda and Caribbean nations to implement these techniques.

And, after a persistent effort dating back 15 years, the sustainable aquaculture project undertaken by Samia Sarkis had developed into a remarkable environmental restoration success story to end BBSR's first century. The project team had indeed brought Bermuda's scallops back, with more than 80,000 raised by BBSR in 2002. Many were sold to Bermuda restaurants and markets, helping to fund future aquaculture research.

In its 100th year, BBSR could also look back with pride on the role it had played in the development of talented scientists. Some, like David Menzel and Tony Michaels, became directors of leading marine science institutions in the United States. Others, like Nancy Maynard and Thomas Sleeter, took on positions of responsibility for the United States or Bermuda governments.

As 2002, and BBSR's first century, came to its conclusion, two further examples illustrated this point. In November, Nick Bates, a former BBSR volunteer intern, graduate student and postdoctoral fellow, was named a BBSR senior scientist in recognition of his outstanding research program.

In December, Craig Carlson, who, like Bates, had come through the ranks at BBSR, was honored by his peers in the American Geophysical Union (AGU). Carlson was the first annual

Craig Carlson examines bacteria in the microbial observatory

recipient of the AGU Ocean Sciences Early Career Award. The award is given to scientists who have made outstanding contributions to this area of research in the first eight years after receiving their doctoral degrees. Carlson was honored for his fundamental contributions to our understanding of carbon cycles in the ocean, based largely on his research while at BBSR. His career at BBSR began in 1987 when he came to Bermuda as a volunteer intern for Tom Sleeter, then a BBSR scientist.

"Craig got his start in my lab counting bacterial biomass," said Sleeter, now director of the Bermuda Government's Department of Environmental Protection. "I could see he had good potential as a scientist, so I introduced him to my colleague Dr. Hugh Ducklow at the University of Maryland [who became Carlson's graduate thesis advisor]. The rest," Sleeter concluded, "is history."

THE SECOND CENTURY

A Living History

The history of a research institution like BBSR cannot be told without reference to the peer-reviewed scientific publications resulting from its many research programs. Indeed, these publications are the true history of BBSR.

The editors of this volume considered adding an appendix of the list of BBSR contributions produced from the first 100 years of research. The list, now almost 1,800 publications long, would have been half as long as this history, even if the smallest readable type size were used.

Instead, BBSR has decided to list the publications in a companion volume, which will also be released in the centennial year. BBSR plans to feature a database of these publications on its web site (www.bbsr.edu). In addition to providing a more useful and accessible tool for students of the ocean, the database will be updated frequently with new contributions from scientists at BBSR in its second century.

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HISTORICAL OVERVIEW

Date	*Location*	*President*	*Director*	*Vessel*
1903	Hotel Frascati		E.L. Mark	*Minnow* & *Intrepid*
1904				*Flora*
1907	Agar's Island			
1917	Dyer's Island			
1919	Agar's Island			
1924				Dr. Mark's launch
1926		E.G. Conklin		
1932	Shore Hills		J.F.G. Wheeler	Navy lifeboat
1937		C. Iselin		
1938				*Culver*
1942			H.B. Moore	
1945				*Abedefduf*
1946			D. Brown	*Diadema*
1949			L.W. Hutchins	
1950		D. Brown		
1953			W.H. Sutcliffe	*Panulirus*
1955		G. Riley		
1956				Navy launch
1961		J. Ryther		
1962		A.C. Redfield		
1967		G.T. Scott		*Panulirus II*
1969			W.E. Sterrer	
1977		W.R. Wright		
1982				*Weatherbird*
1984				*BBS II*
1986		J.N. Butler	A.H. Knap	
1989		J.N. Galloway		*Weatherbird II*
1995				*Henry M. Stommel*
1996		C. du P. Roosevelt		
2002		M.R. Naess		

Compiled by James Butler and Rudolph Nunnemacher

PHOTO CREDITS

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