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THE DIVING BOTANIST VIRGIN ISLANDS 00820

by

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The bottom of Biscayne Bay could be considered the source of some of the world's most valuable land. From that bottom, not too many years ago, emerged the fill for some of the most publicized, most fabulous, most expensive real estate anywhere--Miami Beach.

But Biscayne Bay itself, with its blue, tropical waters, was without fame or publicity until one Richard Nixon selected its now illustrious Key Biscayne for his summer White House. Now Biscayne Bay, and particularly its invaluable bottom, have recently been in the headlines for quite another reason: an ecological dispute involving the currently controversial subjects of atomic power and thermal pollution.

A booming tourist traffic, coupled with a tremendous influx of new residents and industry, has sent the area's demands for power spiraling. To meet these needs, two large fossil-fuel plants are in operation and two atomic generators (760,000 kilowatt) are under construction, eventually all would draw cooling water from Biscayne Bay; returning it to the Bay at elevated temperatures.

The problem is evident: would the normal processes and balance of marine life in Biscayne Bay be unfavorably affected by the heated water? If so, would damage be confined to a limited area, or is there likelihood for it to expand over extensive areas of the bay? Perhaps even to adjoining shore regions?

The problem is complex, involving as it does the highly complicated environment of a relatively shallow tropical estuary. But in seeking help

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for answers to the question, it was not necessary to look far. For the waters of Biscayne Bay also lap at the docks of a prestigious marine institute, the University of Miami's School of Marine and Atmospheric Science, unsurpassed for its work in tropical waters. The institute's scientists who were called in began a search for whatever pertinent data existed.

The critical issue concerned the exact temperatures which marine life could be expected to survive unharmed. It was generally agreed that sufficient knowledge of the overall thermal effects on each of the various forms of life involved, and the resultant interactions and reactions that might occur under the fluctuating seasonal conditions that occur in the particular marine environment, simply is not available to predict the results.

So the question remained: would temperatures of 95 degrees be tolerable, as some had assumed, without upsetting normal processes and balance? Perhaps 96? 97? Or would temperatures low as 90 degrees have deleterious effects?

There was the likelihood that any study to be made might be used as a yardstick for upcoming atomic installations elsewhere in the tropics. Obviously, the study would have to be broad enough to include authoritative observations of every facet of the affected tropical marine environment. To the observations of the botanist must be added those of the chemical oceanographer, the physical oceanographer, and the other related disciplines. For the botanist working alone, as an example, could not be expected to fully comprehend the physiological changes that might be expected to occur, unless he could at the same time also know about simultaneous physical, chemical, geological and zoological interactions.

Accordingly, a team of 20 scientists from the University of Miami School of Marine and Atmospheric Science, representing all related disciplines, was

organized in a research program under the leadership of and coordinated by Professor Richard Bader. But due to the nature of the undertaking, a tough physical qualification was added to some of the research: in addition to being completely competent in his discipline, the participating scientist examining the plants would have to be an accomplished diver. Because the unique feature of the team program, which would establish the authenticity of its observations beyond any question was the stipulation that all studies would be carried out on the spot by first-hand observation--underwater!

But before we go into the story of the botanist's share in this program, let's pause for scientific identification, and have a closer look at the origins and evolution of this curious breed. The sight of the botanist preparing to plunge into the sea somehow evokes a mental picture of the reverse process, in which life itself emerged from those very same waters, millions of years ago. The history of botany is also the history of man.

Although early man could not have been expected to possess an awareness of the concept of botany as such, botanical life was nevertheless all things to him. It provided food in the most abundant, easily available form. It was also the trees, and the leaves from which he contrived shelter. It furnished him the wherewithal from which to improvise clothing, personal adornment--yes, tools and implements for his primitive crafts.

Then there came a day when an increasing awareness of botanical processes prompted our man to plant and cultivate his own foods, rather than range far and wide in search of them. So, in his crude way, he had unwittingly discovered a basic concept that has become increasingly important down through the years: ECOLOGY*.

* the study of plants and animals, and plant and animal communities, as related to their surroundings

His first awareness of aquatic (not marine, but fresh water) life possibly was brought about when man noticed the weeds in which lurked the fish he tried to catch. Or was it when the Egyptians found they could build boats from the buoyant reeds? And later he converted plants into papyrus for recording his deeds.

And the day man followed that river to its terminus at the great sea, his awareness of botany received a great impetus when the sea momentarily drew back her waters to reveal the abundant marine life of her rocks and tidal flats.

Perhaps we could set the diving botanist in better-understood perspective, were we to take a brief look at the history of recorded marine botany. It was a Greek, the naturalist Theophrastus, who first included several varieties of seaweeds in a listing--albeit he grouped them with terrestrial plants. The subsequent passage of some 1800 years saw little, if anything, added. Until, in 1747, the famed Swedish classifier Linnaeus included in his work a separate classification for algae. But, as has been largely true until even quite recent times, classification alone was about as far as the marine botanist took it.

Seeking to extend the horizons of his knowledge beyond what the intertidal flats offered, the scientist next took to the sea in vessels equipped especially for oceanographic research. And so the era of the round-the-world oceanographic expedition was launched some hundred-odd years ago by H.M.S. Challenger. As she circled the globe, her scientists probed the bottom, took soundings, and collected water samples as well as phytoplankton and zooplankton. Adapting fishing techniques, they trawled using nets to gather specimens of plant and other forms of marine life from various levels, ranging down to the bottom. Round-the-world was suddenly the "in" thing, with the

French, Russians and Swedes joining the English in scientific rivalry.

Deep-sea research enriched many fields of marine science. Numerous new species were added to the botanical systematics. Much new was learned about their world-wide geographic distribution. But the difficulty and expense of penetrating the oceans' depths still foiled the botanist in his effort to get a clear, close look at the life in the sea. Traditionally, the laboratory was his milieu. The thought of going himself into the sea was as remote as its darkest depths. To be sure, a professional diver was occasionally delegated to gather specimens or perform some other task by proxy. But first-hand observation--no! The interior of the sea was still off limits. The botanist contented himself with what he snatched from the waters by such means as he could devise.

The voids in marine botanical knowledge were great. The living plant community, as it existed in the seawater itself, was still a mystery. Little had been done on the physiology of the larger marine plants or seaweeds, in comparison to that on aquatic varieties. What about their cellular composition, their biochemical processes, their manner of growth. Most importantly, what about the interactions between various forms of marine life--plants and animals?

But the greatest void of all covers a vast area of the sea most basic to the food supply and growth of a large segment of marine life. This involves the offshore areas beyond the intertidal region and the bays and estuaries. Amazing, but nonetheless true, the fact remains that less is known about the coastal regions, extending from the breaker zone to a distance 50 miles offshore of even the world's most densely populated centers, than about some of the areas most remote from civilization, such

as the Antarctic--or the backside of the moon! All this is a portion of the sea most important to man, since it contains the nursery grounds for his fisheries, as well as his most used pleasure and recreational waters.

The challenge of penetrating these teeming unknowns to fill some of marine botany's great voids has waited until the historic moment when the advent of underwater breathing apparatus gave the botanist the opportunity to become amphibious.

Strangely enough, it was man's desire to destroy his fellow man that triggered the development of an independent undersea life support system. Sponsored by the French government during World War II, Jacques Cousteau pioneered and refined the self-contained underwater breathing apparatus, as a means to planting underwater demolition charges. Now able to shed the cumbersome, restrictive old diving suit, and no longer tethered to a boat by umbilical air hose, man suddenly found that SCUBA endowed him with the ability to remain underwater for extended periods, where he could move about with unlimited mobility. The sea had opened to him at last! He was free to explore at will, and at length.

But while his fellow scientist, the marine zoologist, was quick to go underwater to study his fish in its habitat, the botanist remained reluctant to take the plunge. Consequently, even though a few more venturesome systematists have learned to collect and observe underwater, botanical physiology and ecology have figuratively remained, by and large, still in the spawning stage.

The challenges that confront the diving botanist are well illustrated in the Turkey Point project of Biscayne Bay. The heart of the team program is intercommunication between members. Each discipline makes its independent, but simultaneous, observations. As the research program proceeds, all new

information is immediately made available to those in the other disciplines. But, if information passed on from the other team members is to be fully meaningful to the botanist's own observations, the botanist also must understand the language and techniques employed by others.

This is not always simple. There are often wide differences in approach to the problem, due to differences in training or background of the physical oceanographer from that of the botanist. So the botanist must learn the language of the physical and the chemical oceanographer, and others as well as the coastal engineer.

The continuing discussion between all scientists involved have established such close intercommunication that all members of the team are constantly aware of all changes and reactions. The frequent interdisciplinary discussions, on both formal and informal basis, are proving of tremendous mutual benefit (Figure 1).

The program at the University of Miami School of Marine and Atmospheric Science consists basically of continuing, independent observation of 30 separate stations, so located about the bay at various distances from the point of discharge bay as to best monitor the effects of the heated effluent water on the various forms of marine life in the bay.

Each station is identified by a 1-meter-square form made of 1 inch flat stock. This square is subdivided into quadrants formed by 1/4 inch steel rod or tying 1/8" polyethylene cord across the midpoints. This form is embedded firmly into the bay bottom, taking care not to otherwise disturb it.

One of the botanist's many tasks is to make a population count, quadrant by quadrant, of the precise number of grass blades and algae--an operation ordinarily performed with the observer lying flat on the bay bottom to get

the closest possible view. These figures are recorded, along with data describing appearance, color, condition and other variables, on a "slate" (Figures 2 and 3) which the diver carries with him.

At the suggestion of Professor Jack Dainty, we broadened our part of the program to include a continuing photographic record of each station made with underwater camera. In determining whether marine plants are being affected by heat, color becomes an important criterion. Laboratory tests had previously established that many of the typical green plants, when dying due to excess heat, turn a shade of brown noticeably different from the brown tone of a plant dying a natural death due to old age. Consequently, accurate color rendition became of paramount importance. Fortunately, our photographer, Bob Stearns, possessed the skill and resourcefulness to capture the critical colors faithfully on film. And by photographing each square from precisely the same point and same angle each month, the plant succession was clearly and completely observable in the photos.

We also maintain a photographic record from the air. In this, the elements were most always in our favor. A bay normally calm, water rather shallow and clear, and sunshine quite constant provided such favorable photographic conditions that Bob was able to pick up the individual stations in his monthly aerial photos (Figure 4). So well, in fact, that we could identify various formations in the photos with the plants in that particular area.

The diving botanist expects to encounter problems, above water as well as below. Assuming that he possesses the requisite background in marine science as well as botany, he must additionally be a strong swimmer, able to swim at least 1,200 yards. He must know basic life-saving techniques. Then he must possess a complete knowledge of SCUBA technique and gear, and

have passed a series of tests on handling in order to be certified by a dive master. Before he enters the water, he must be familiar with human diving physiology, and be capable of operating a decompression chamber (see Figure 5). In the antagonistic world the diver enters, he is at the mercy of and completely dependent on his equipment. Therefore, he must be capable of meeting all emergencies. Finally, if he is to operate effectively, he must be comfortable with his equipment.

As with most diving operations, a suitable boat is needed to get to the scene of action. In our Biscayne Bay project, the 20-odd mile run to make the rounds of the 30 stations is well negotiated by a 20-foot open skiff, which accomodates extra tanks for replacement (Figure 6).

Even the seemingly simple operation of marking the station sites presented problems. A too easily-spotted marker quickly becomes an irresponsible boater's booty. The first markers were concrete blocks painted with orange Day-Glo and submerged at the site. But just try to spot a block underwater in choppy, turbid water! The next markers were buoys of the type used on lobster nets. These proved equally irresistible as "trophies". The final solution was a small wooden marker buoy anchored with a 1/8" stainless steel cable and 100 lbs. of the concrete block immediately adjacent to the station. To avoid interference with visibility at the station below, we anchored a small styrofoam buoy 20 feet distant.

Problems arising from the corrosive effect of saltwater have been solved in many cases by the use of plastics. A two-foot long plastic streamer, for instance, serves to identify the individual meter squares. A particular plant is identified, when desired, by a small plastic number attached by monofilament. If we tie the line at the very base of the stalk, we can later measure its growth--a task for which a plastic vernier caliper answers admirably.

The aforementioned "slate" on which the diver makes his notations is actually a thick acrylic plastic sheet. No problem marking on it (must have been our only non-problem)--a plain ordinary lead pencil works beautifully once the "slate's" surface has been sanded lightly. Specimens destined for the laboratory are handily carried in a plastic bag, to be stored, if necessary, in an ice chest on shipboard. The sun's heat can complicate holding of live specimens during the tropical summer. An awning can be very helpful here.

Observation of the undisturbed plant or cell in situ yields much information not obtainable by other means. But even the most painstaking observation doesn't always furnish the diving botanist with all he needs to know. Often the changing conditions are too many and too confusing. If the molecular mechanisms underlying the effects he sees are to be fully understood, he must bring marine plants into the laboratory where they can be investigated under carefully controlled conditions. Some of the results of the biophysical investigation of temperature dependencies of membrane transport now being carried out in the author's laboratory are shown in Figures 7 and 8. It is expected that this investigation will bring us a step closer to understanding the molecular basis of heat death. The physiology of the complete organism--and, the biological level of organization existing between the population and the cell is being investigated as well.

It may be asked: "Just what is this commotion concerning estuarine ecology all about?" If we pause to recall that Professor L. R. Blinks, more than twenty years ago, stated that in the area close to shore the macroalgae not the phytoplankton played the dominant role as primary producers of food materials. The role of these macroalgae has been largely overlooked in the principles of marine biology, because focus was on the deep sea. Now as

our attention is drawn to control of the estuaries, the macroalgae become much more important.

The Biscayne Bay study is but one example of the fast-growing awareness of the urgency for and general concern with estuarine management--a matter which presents a set of problems unique to itself.

Proper estuarine management calls for a balancing of the needs and rights of all parties concerned. It becomes imperative that we make a frank statement to ourselves as to how far mankind can be allowed to disturb the local environment. To arrive at such a balance, Dr. Bader points out, consideration must be given to all three factors involved--aesthetic, economic, and recreational.

The aesthetic factors are relatively obvious. Recreational factors include fishing, boating, surfing, swimming and skin-diving. The economic factors, when recreation is operated on a commercial basis, involved all the foregoing plus the strictly economic aspects of construction for housing and industry, power plants included.

Each user--recreational or economic--has an equal right to the use of the water. Clearly, then, some type of management must be established to determine the most effective use for all concerned. Consideration must be given to balancing the various costs in natural resources as well as in dollars--at such time as estuary development is undertaken. Just as we now recognize the value of our trees and forests, and have delegated authority to determine limits on destruction of trees, so we must also recognize that underwater plants and growth have definite economic value and appraise them accordingly.

Perhaps the most odious example of estuarine mismanagement--or rather lack of management--is the fast-fading, fast-sinking city of Venice. Con-

struction that disregarded the natural flushing action of the tides now bottles up the city's sewage, threatening the very life of this glorious, fabled city.

And the future? What does the diving botanist see as he gazes into the depths of his fascinating new world? Two examples hint at some of the possibilities.

Submarine vessels are already furthering the botanist's work. The small submarine "Deep Diver", designed by Ed Link, of Link Trainer fame enables a diver to actually lock out of his vessel and perform work for a limited time at depths as great as 750 feet - all within the reassuring shadow of the sub - and climb safely back in. One such trip resulted in the exciting and important discovery that algae can grow at a depth 700 feet lower than previously thought. Another diving botanist, Dr. Sylvia Earl, has spent two weeks living under the sea in the underwater habitat "Tektite", closely observing day-to-day changes in plants and the animals which may feed on them.

Electronic equipment holds promise of further new marvels for the diving botanist. The rapid advances being made in underwater electronics and electrical monitoring systems will enable him in the near future to literally take his laboratory into the sea and conduct his experiments in situ. A more elaborate laboratory might well be brought to the site in the form of an adequately-powered houseboat, air-conditioned and properly equipped to operate a continuing program.

The computer-symbol of our technological era--has already been enlisted in the diving program. Data gathered by the physical, chemical and geological oceanographer, as well as the benthic zoologist, have been fed into the computer along with our botanist's information on the physiology and dis-

tribution of the algae and grasses. Interesting new patterns are presently emerging from this technique of analysis.

The mini-computer promises to perform a big service facilitating in and speeding up work even as it proceeds. By feeding it data being gathered, and transmitting it via radio from his houseboat laboratory to central computer headquarters, the botanist could quickly get a read-out of information scanned in response.

In the area of mariculture and commercial uses of algae, the diving botanist is eminently qualified to aid. To help solve the increasingly important problems in the realm of pollution, one of the most pressing needs is for detailed data on the physiology of all plants involved. The Biscayne Bay project illustrates this clearly.

Marine botany has now arrived at a stage where, rather than riding the scientific shirt-tails of marine zoology, while blindly accepting zoological techniques, it can assume a role as full partner. And who knows, perhaps it may take the lead by formulating its own new techniques for the exciting future of this challenging new field.

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THE DIVING BOTANIST by Thorhaug

PHOTO CAPTION DATA

BLACK & WHITE (8 X 10 GLOSSY)

- FIGURE 1 - Discussion of Card Sound--Turkey Point among scientists of differing disciplines. Left to right, Dr. R. G. Bader, Marine Geochemist, Dr. A. Thorhaug, Dr. M. A. Roessler, Ecologist, Dr. D. A. Segar, Marine Chemist. (T. Thorhaug, Photo)
- FIGURE 5 - Thomas Mount, Diving Officier, at School of Marine and Atmospheric Science, University of Miami, demonstrating decompression chamber procedure to Dr. Thorhaug. (T. Thorhaug, Photo)
- FIGURE 6 - On the back of small skiff, Dr. Thorhaug and Miss Sharee Pepper, Master Diver and Marine Biologist, prepare to work a station. (R. Stearns, Photo)
- FIGURE 7 - Biophysical experiment on the cause of heat death of a single marine algae. Dr. Marcela Fernandez and Dr. Anita Thorhaug. (T. Thorhaug, Photo)
- FIGURE 8 - Temperature lethal limit apparatus, a polythermostat. Dr. Thorhaug is holding test tube with Valonia cells. (T. Thorhaug, Photo)

COLOR (35mm TRANSPARANCIES)

- FIGURE 2 - The author and Sharee Pepper measure the macro-algal community of a 1 sq. meter area of Biscayne Bay Bottom. (R. Stearns, Photo)
- FIGURE 3 - The author collects marked Turtle Grass (Thalassia Testudinum) for growth measurement studies. (R. Stearns, Photo)
- FIGURE 4 - Aerial photo of part of the northwest shoreline and adjacent bay bottom, Card Sound. Dark patches are sea grass and macro-algae communities. (R. Stearns, Photo)