Caribbean Marine Mass Mortalities:

A Problem With A Solution

By Ernest H. Williams, Jr., and Lucy Bunkley Williams

When the largest fish kill known in the Caribbean occurred, the authors were in the Dominican Republic as guests of the Chief of Fisheries. Fortuitously, his guests were a fish-disease team. Unfortunately, unknown reasons prevented him from mentioning the fish kill to us. When he politely put us on a plane to Puerto Rico, we had no idea we were flying away from a massive fish kill and into a barrage of questions from Puerto Rican and U.S. agencies. Newspaper stories even reported that we were bringing fish samples from the Dominican Republic. This was only the beginning of the mass confusion that left a major Caribbean-wide catastrophe poorly studied and completely unexplained.

Unfortunately, aquatic animal health in the Caribbean has been characterized by chaos, ignorance, and disorder. The great epizootics* of commercial sponges, fishes, sea urchins, and corals roar through the Caribbean like prairie fires—bringing destruction, but shedding little light on their cause. We remain as vulnerable as ever to these highly publicized kills, and to equally important localized and minor mortalities.

The IRS and The Sea

Disease normally acts like the Internal Revenue Service of the marine environment. Disease extracts a surprisingly standard tax off-the-top of most plant and animal populations. A certain percentage of organisms die, many of them do not grow as large or as quickly as they could, and many experience reduced reproduction. Dying or sick organisms simply disappear, and disease is all but invisible—and easily ignored. But, over the long term, these losses are enormous. Diseases are a natural and vital part of marine ecology. Food webs are well studied, but little attention is paid to the equally intricate parasite and disease/host webs.

Millions of fishes perished in the Caribbean-wide mass mortality. Many of them washed up onto Caribbean beaches.

Occasionally a disease rampages through the marine environment, killing great numbers of organisms. The recent die-off of dolphins along the East Coast of the United States is an example. What should we do about these episodes? Let us examine two of the largest and most recent Caribbean-wide *disasters*, the *disorder* in attempting to study and solve these mortalities, and the future *direction* in Caribbean aquatic animal health.

Disasters

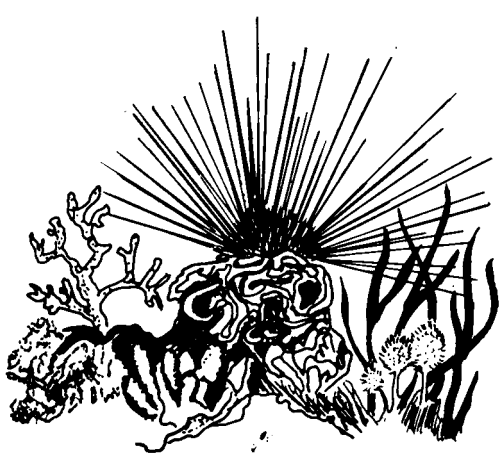
The Fish Mass Mortality. The Caribbean-wide die-off of fishes in August and September of 1980 had all

* Diseases that affect many animals of one kind at the same time. "Epizootic" is the animal version of an "Epidemic." Only humans have epidemics. Some newspapers reported an "Epidemic of Urchins." That describes the very painful condition of people wandering around with urchins stuck all over themselves.

the elements of a thriller. It started with the most powerful hurricane recorded in the Caribbean; caused an international conflict over ocean dumping of chemical or radioactive contaminants; was blamed for human deaths; caused the economic disruption of most fish sales in the Caribbean; and provided cover for murder. It was characterized by the spectacle of listless, helpless fishes swimming up to the surface or lying just beneath the surface. Even the normally wary and elusive giant snappers and other game fishes could easily be grabbed by hand. For more than two months following hurricane Allen, uncounted tons of dead and dying fishes washed onto beaches, filled the bellies of humans and other predators, or sank unheralded into the depths. Anecdotal accounts of fishes that could not be held alive by previously established methods, and odd behavior in wild and captive fishes, suggests that fishes that survived the mortalities were "sick" for three to four additional months.

How does a whole ocean basin turn inhospitable to the fishes that live in its depths? What can keep so many fishes dying for two months and sick for months longer, over such a vast area? A monstrously important marine process? We do not know. We would not have believed that such a process could occur. We suspect that a Caribbean-wide physical process (or a series of processes) generated by hurricane Allen directly, or indirectly stressed the fishes (possibly by upsetting the plankton ecology of the region and increasing the abundance of toxic organisms). The fishes resistance against parasites and diseases broke down, and they succumbed to the common secondary* pathogens that are always on, in, or around them. Whatever the "monster" was, when the next great Caribbean hurricane hits, it may be released again. We hope that next time it occurs we are ready to understand this phenomenon.

* Secondary pathogens do not harm hosts unless the host defenses are reduced by other stresses. They are the "back shooters" of the disease world.



Black longspined sea urchin (Diadema antillarum) *on a Caribbean reef.*

Black Urchin Plague. In 1982, the black, long-spined sea urchin (*Diadema antillarum*) was probably the most abundant, large animal in the Caribbean. Untold billions munched algae and covered the bottom in dark, prickly mats. This urchin may have effectively regulated the environment of the coral reef—something man cannot begin to do. Man, in all of his collective might, could not have killed this urchin. Then along came a little pathogen and blew 99 percent of the urchins away. In the year it took the disease agent to spread through the Caribbean and subtropical Western Atlantic, the urchins were all but gone. The time from the first sign* of this disease in an area, to the utter dissociation and death of the urchins, was little more than two days. The typical signs (the few times they were recorded) were almost what you would expect had someone poured a powerful, concentrated acid on the urchins. This incredibly destructive disease makes the victims dissolve almost before your eyes. The pedicellaria (small, tube-shaped feet between the spines) stopped cleaning sediment and debris off the top of the urchins; spine control (for example, turning spines toward a disturbance) was lost; spines began to fall out, littering the bottom; and eventually, sections of the test (shell) fell apart.

This disease was first noticed off the Caribbean coast of Panama, and followed the main current patterns around the Caribbean. If anyone had wished, and had been prepared, they could have chased it, caught it, studied, and solved the mystery of this disease. Since this agent is so virulent, so host specific, and survives so well in seawater, it may be a spectacular virus that attacks the integument (outer layer) and spine musculature of the urchins. The "virus" is now spread all over the tropical and semi-tropical western Atlantic. The number of virus particles generated in destroying and replicating in billions of urchins is truly mind boggling.

This primary** pathogen either evolved from a more benign form (we are seriously degrading our near-shore and reef environment, and the microbes change more rapidly than the multicellular animals), or was imported. A disease of a Pacific black longspined urchin (*Diadema mexicanum*) might do little damage to its original host population because of natural host defenses, but an Atlantic population of hosts with no resistance, might succumb to it as a plague. The narrow isthmus of Panama is an easy location for an inadvertant transfer of a pathogen of this kind.

* "Sign" of a disease is like a "symptom" in humans. Symptoms are vocalized by a patient, signs are observed. No matter what question you ask an urchin, the most it will do is waggle its spines.

** Primary pathogens kill without any help from stress or fortuitous circumstances. They are the "Professional Killers" of the disease world.

Coral Reef 'Bleaching' Peril Reported

Colors are fading fast from Caribbean coral reefs. They are being replaced by white blotches, visible even from shore on some reefs. Stony corals (Coelenterata: Scleractinia), fire corals (Milleporina), gorgonians (Gorgonacea), sea anemones (Actiniaria), zoanthids (Zoanthidea), and sponges (Porifera: at least two orders) are losing their brown-green colors. Some are turning completely white, as if soaked in household bleach—thus the term "bleaching."*

After we submitted the adjacent article about mass mortalities, another mass mortality monster reared its ugly head. This one is not looking for a few sticky urchins (1983–84) or some fishes (1980), it is after the very basis for inshore marine life in our tropical and subtropical seas—the coral reef.

The white color is due to the loss of the symbiotic, single-celled algae zooxanthellae that normally live within the tissues of the marine animals listed previously. Many kinds of severe stress cause these animals to expel the algae from their systems. Divers in Puerto Rico and the Florida Keys, just before the bleaching was noted, described massive clouds of shed zooxanthellae blotting-out the visibility around the reefs down to a depth of 6 feet.

The photosynthetic zooxanthellae normally provide added nutrition, and the loss of this symbiont reduces the coral's ability to compete with other plants and animals. Without zooxanthellae most corals are white, but some show delicate colors that are otherwise hidden by the overpowering brown-green colors of the zooxanthellae.

Bleaching has been observed previously in the western Atlantic in isolated instances, but the present event is far more extensive than ever before recorded. As of 25 October 1987, affected animals have been observed for 6 to 15 weeks in Puerto Rico, Mona Island, the Dominican Republic, Haiti, Cuba, the Cayman Islands, Jamaica, the U. S. and British Virgin Islands, the Turks and Caicos, the Bahamas, the Florida Keys, and the Flower Garden banks off Texas. The bleaching appears to be spreading both geographically and in extent with animals affected from the surface to 200 feet (approximately the full depth range in which zooxanthellae occur).

The bleachings may be caused by unusually high temperatures, which have been reported in many areas; by increased ultraviolet radiation possibly due to ozone depletion, or by secondary pathogens after physical stress (as was suggested for the fish mass mortalities); or by some combination of these. Disease (unless a disease of the zooxanthellae) appears unlikely to be the primary cause, as does sediment damage.

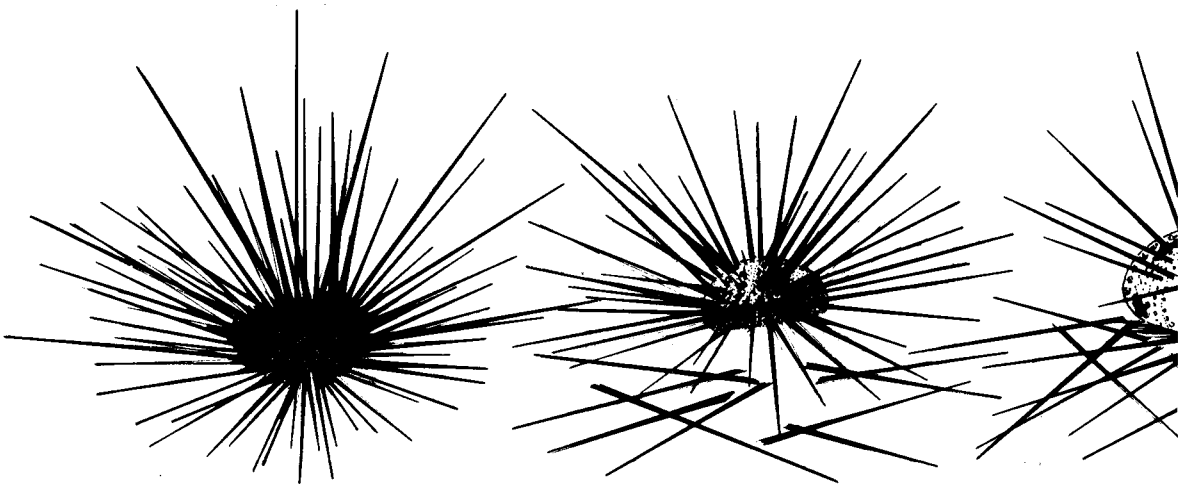
*The Caribbean Aquatic Animal Health Laboratory is attempting to document the geographic extent, timing, species affected and other details of this phenomenon by circulating a questionnaire; and making the data quickly available, in up-dated summaries, to all interested parties.***

Lucy Bunkley Williams, and Ernest H. Williams, Jr.

Star coral, *Monastera annularis*, one of the most important reef-building corals in the Atlantic. An almost totally bleached colony of star coral about 4 feet high with normal colony at right. (Photo taken in 35 feet of water on Enrique Reef, La Parguera, Puerto Rico, by Jack Morelock)

* Civilian satellite photographs cannot distinguish patterns smaller than 10 meters across (33 feet).

** Summaries and questionnaires are available by writing the authors at Department of Marine Sciences, University of Puerto Rico, Mayaguez, Puerto Rico 00708, or by telephoning (809) 899-2048, or 899-1078.



Signs of the Black Sea Urchin Plague. From left to right: Healthy, loss of spines, test dissociation, and death.

The 1 percent of the urchins that survived probably carry the Black Urchin Plague agent. With a little luck, determination, and money, this virus might still be isolated and studied.

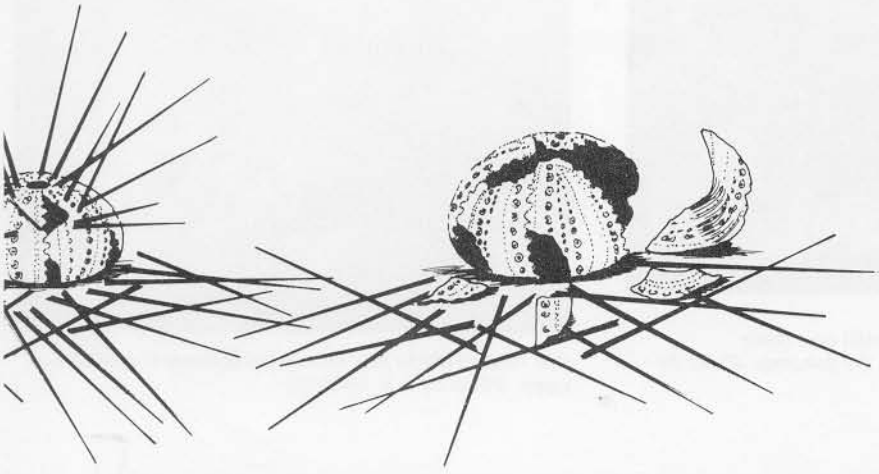
Disorder

The Fish Mass Mortality, and Mass Confusion. During the Carribean-wide fish kills, in most locations, samples were either taken too late or not at all. All investigations and collections were seriously delayed because of confusion over who should study what, and what agencies should examine samples. The seriousness and extent of the mortality was not fully realized until the event was almost over. However, some fish samples were sent to the United States, Venezuela, and other Caribbean countries. Unfortunately, many analyses cannot be performed on preserved or long-dead samples. Few field examinations on freshly dead or dying fishes were made (in fact, fishes were actually denied to local researchers so that samples could be sent to distant "experts"). The kill, we know, was not caused by chemical pollutants. However, the oceanographic community, it would seem, left a monumental marine process virtually unstudied. Whatever happened was a single and unified process over an entire ocean system, damaging many species and numerous individuals. To meet this menace next time, we must have some organization in place.

Much Reporting About Nothing. Ironically, since chemical pollutants were the only thing ruled out as the cause, a noted chemical oceanographer, Donald K. Atwood, brought together interested Caribbean marine researchers in an ad hoc symposium at the Gulf and Caribbean Fisheries Institute Meeting in Mayaguez, Puerto Rico, in November 1981. The accounts of the fish kill were largely anecdotal, and the parasite data inconclusive. Discussions, not surprisingly, found each specialist predicting their interest as the possible villain. Planktologists promoted subtle shifts in plankton ecology; physical oceanographers, temperature shocks due to isotherms; and parasitologists, suffocation due to gill protozoans. Almost everyone concluded that too little information was available to assign a definite cause. While no agent could be agreed upon, the need for future coordinated investigation was strongly emphasized. A report from this meeting was compiled and printed by Atwood (see references), and a committee of nine fisheries and disease experts, representing five Caribbean countries was formed, with the first author of this article as chairman.

Great Plan, No Action. The United Nations Intergovernmental Oceanographic Commission's Sub-commission for the Caribbean and Adjacent Regions (IOCARIBE) agreed to support a meeting of our fish kill committee as the "IOCARIBE Steering Committee for Regional Contingencies for Fish Kills." The meeting was held on 25 to 29 October 1982, in Mayaguez, Puerto Rico. We formed a plan to train existing local scientists from each Caribbean country with workshops at nine existing Caribbean labs; to organize a center for the coordination of information and investigation at one of six Caribbean facilities already possessing the necessary equipment and personnel; and to provide a detailed investigation and documentation manual for fish kills. We stopped short of recommending fish kill investigation teams and/or fish kill research facilities, to keep the proposal from becoming too costly, and because some members of the Committee felt such a team could seldom be made available in time. The proposal was made to IOCARIBE in a 20-page Summary Report (see references) immediately after the meeting. During the Second Session of IOCARIBE in Cuba, 8 to 13 December 1986, the Fish Kill Committee Report was endorsed and funding was recommended. A suggestion also was made to expand the proposal to cover all mass mortalities, and not just fishes. To date no action has been taken.

Urchin Plague Data Lacking. Caribbean scientists were no better prepared for this epizootic than they had been for the last. While the fish incident killed fish during a two-month period, the urchin disease quickly washed over each area within

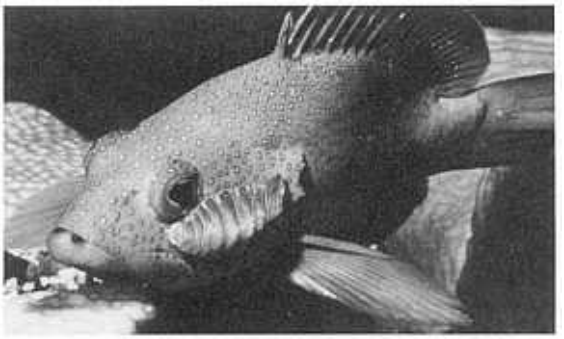


*Black longspined sea urchin (*Diadema antillarum*) tests after the Black Urchin Plague. (Photo by Vance Vicente)*

days, leaving almost all of the urchins dead, and the biologists flabbergasted.

Few investigations were made on this mortality. Haris Lessios and others at the Smithsonian Tropical Research Institute in Panama collected mostly informal and incidental accounts of the black urchin plague. In a report that appeared in *Science*, in October 1984, they surmised that the agent responsible for this plague was a water-borne pathogen that was carried throughout the Caribbean by prevailing currents.

More Urchins? During a SCUBA dive in one of our routine study areas off Puerto Rico, we stumbled onto a die-off of the large, longspined seabiscuit urchins (*Astropyga magnifica*). The signs of the kill were strikingly similar to the Black Urchin Plague! Even though we knew little about urchins, we contacted local and international urchin experts, documented the kill, and reported it, along with another local urchin kill (*Eucidaris tribuloides*), in the *Bulletin of Marine Science* (see references). As a result, people began calling, writing, and talking to us about urchin kills all over the Caribbean. Information exists, although an effective recording system does not.



A parasitic isopod (Anilocra haemuli) *on a conie* (Epinephelus fulvus) *(grouper) in the Bahamas. (Photo by L. B. Williams)*

Red Tilapia (Tilapia *spp. hybrid) being raised in seawater cages. (Photo by L. B. Williams)*

Dead Fish Smell. Fish kills attract more attention than urchin and other invertebrate kills. Not only are fish of more direct economic interest to humans, they also tend to float, bloat, and generally make an unmistakeable nuisance. But, very few of these kills are ever reported. A series of large fish kills that occurred off the coast of Venezuela were reported in local newspapers, but along with a large kill of coastal fishes in Puerto Rico and the U.S. Virgin Islands two years ago, they went scientifically unrecorded. Smaller kills occur quite frequently. Although most Caribbean governments attempt to investigate fish kills, they usually lack the necessary training and equipment.

Diseases of corals and sea fans (*Gorgonia spp.*) have also received recent attention. A capability to adequately record, report, and alert others about all mass mortalities is urgently needed.

Direction

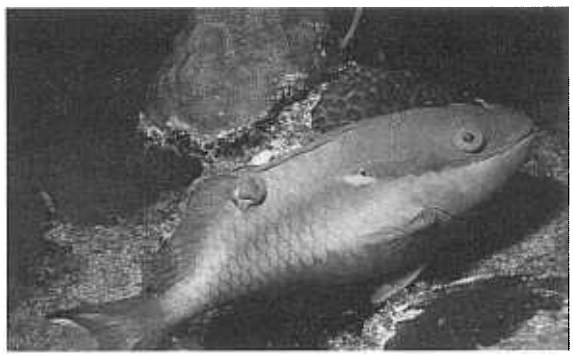
The needs outlined in the IOCARIBE Report, and elsewhere, are as follows:

- **A Mass Mortality Investigation Manual** that describes standard field investigation techniques any lab can conduct; more complex techniques that most labs can conduct; and the proper methods of collecting, preparing, and sending all types of samples.
- **Training Workshops for Local Scientists.**
- **Report and Alert Center** to provide a place to report and document mortalities, and maintain contact with a network of Caribbean field scientists, a pool of mortality experts, and experts for each group of animals.
- **A Field Investigation Team** that can rapidly be sent to mortality areas. Locally trained personnel would be more desirable, but in the beginning a mobile team may serve to publicize the importance of the problem, and to train locals during and after the kill. For large-scale mortalities, an international team may be essential.
- **A Research Center** to diagnose samples, train Caribbean scientists, attract research funding to solve mortality problems, and to provide research facilities for scientists investigating Caribbean mass mortalities.

The Solution

Most people want to go to pristine Caribbean islands with clean white beaches and clear, blue, sparkling waters. Disease specialists are attracted to beaches covered with tons of dying, smelly, slimy marine life, and enjoy trying to determine what happened, and why. Each horrible mess represents a fascinating puzzle. The solutions will bring us better and healthier fishery products, management tools for fisheries, healthier and more economic aquaculture products, the possibility of a better understanding of ocean processes, and insight into combating present and future human diseases.

To fill this need in Puerto Rico and the U.S. Virgin Islands, an aquatic animal health laboratory has been started by the University of Puerto Rico, the Department of Natural Resources of the Commonwealth of Puerto Rico, the Division of Fish



A tumor (dermal fibroma) on a redband parrotfish (Sparisoma aurofrenatum) *from the Hydrolab Undersea Habitat site in Salt River, St. Croix. (Photo by L. B. Williams)*

*Elkhorn coral (*Acropora palmata*) towering over soft corals and sea fans (*Gorgonia *spp.). A reef top scene at Cane Bay, St. Croix. (Photo by L. B. Williams)*

and Wildlife of the Government of the U.S. Virgin Islands, Sea Grant of Puerto Rico and the U.S. Virgin Islands, the Caribbean Fisheries Management Council, and Auburn University. Support is also being sought from international agencies and from individual Caribbean countries to eventually provide regional, multiple country, or Caribbean-wide services in aquatic animal health, and to form a Center for Caribbean Aquatic Animal Health.

A Caribbean facility is urgently needed to record, preserve, and broadcast information about marine mortalities to accumulate the equipment, facilities, and part of the expertise to investigate mortalities, and to train Caribbean scientists and conduct long-term research. A small step is being made in what is hoped to be the proper direction. Comments, suggestions, cooperation, and support are welcomed.

Ernest H. Williams is Director of the new Caribbean Aquatic Animal Health Laboratory, Executive Director of the Association of Island Marine Laboratories of the Caribbean (AIMLC), and Professor of Marine Parasitology in the Department of Marine Sciences of the University of Puerto Rico (DMS/UPR). Lucy Bunkley Williams is a Research Associate in Aquatic Animal Health, and an Associate in Marine Geology in DMS/UPR; she also is a part-time Assistant Professor at the InterAmerican University in San German, Puerto Rico; and is the Secretary-Treasurer of AIMLC.

Acknowledgments

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