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Ecological Monitoring of Two Beach Nourishment Projects In Broward County, Florida

By
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INTRODUCTION

In recent years concern has grown with regard to the real or potential ecological damage resulting from dredge and fill activities associated with beach restoration and nourishment projects. There are few data on this subject in the scientific literature, and this study represents the first of its type in southeastern Florida coastal waters.

The first of our two study areas is located in north-central coastal Broward County from off the northern end of the public beach at Pompano Beach southward to off Washingtonia Avenue in Lauderdale-by-the-Sea. A 3.2 mile length of beach was filled in late 1970 as part of the Broward County Beach Erosion Control Project and is the only segment of this project which has been completed to date.

The first or inshore reef in this area divides into two portions just south of Hillsboro Inlet (Figs. 1, 2a). The reef platform is old, probably dating back to the Pleistocene. It is populated with both hard and soft (sea fans and sea whips) corals of more recent age (Goldberg, 1970). The inshore portion of this reef is of low profile with an average relief of less than 3 feet and lying in 9 to 12 feet of water. The seaward portion is of higher profile with its outer edge abutting wide sand flats in average depths of 30 feet. An area consisting of rocks and sand lies between the two portions of this reef (Fig. 2a).

Beyond the outer portion of the first reef are extensive sand flats, locally termed the "sand bowl," which extend for slightly more than 200 yards before being broken by a series of patch reefs. A second area of the sand bowl extends from beyond these diffuse reefs for a distance of approximately 350 yards where it ends at the edge of a high profile second reef in 36 feet of water. Additional sand flats extend for approximately 500 yards beyond the offshore ledges of this reef.

In contrast, the study area off Hallandale consists of diffuse patch reefs representing the first or inshore reef and a more distinct, continuous second reef platform farther offshore (Figs. 1, 2b). The patch reefs are formed primarily of hard and soft corals. Fewer soft corals were observed on these reefs than on the reefs between Pompano Beach and Lauderdale-by-the-Sea. Nevertheless, biological communities with the single exception of soft coral density are approximately equal to those on the more northern reefs.

Borrow areas are located in the sand flats between reefs. These flats, as previously noted, are relatively extensive off Pompano Beach to Lauderdale-by-the-Sea (Fig. 2a) between the first, second, and third reefs. Off Hallandale sand flats used as borrow areas are beyond the second reef platform (Fig. 2b).

This study was primarily qualitative. We primarily utilized as indicators of reef damage those attached marine organisms which are unable to avoid the effects of turbidity and sedimentation by moving to another area and those species which are motile but typically

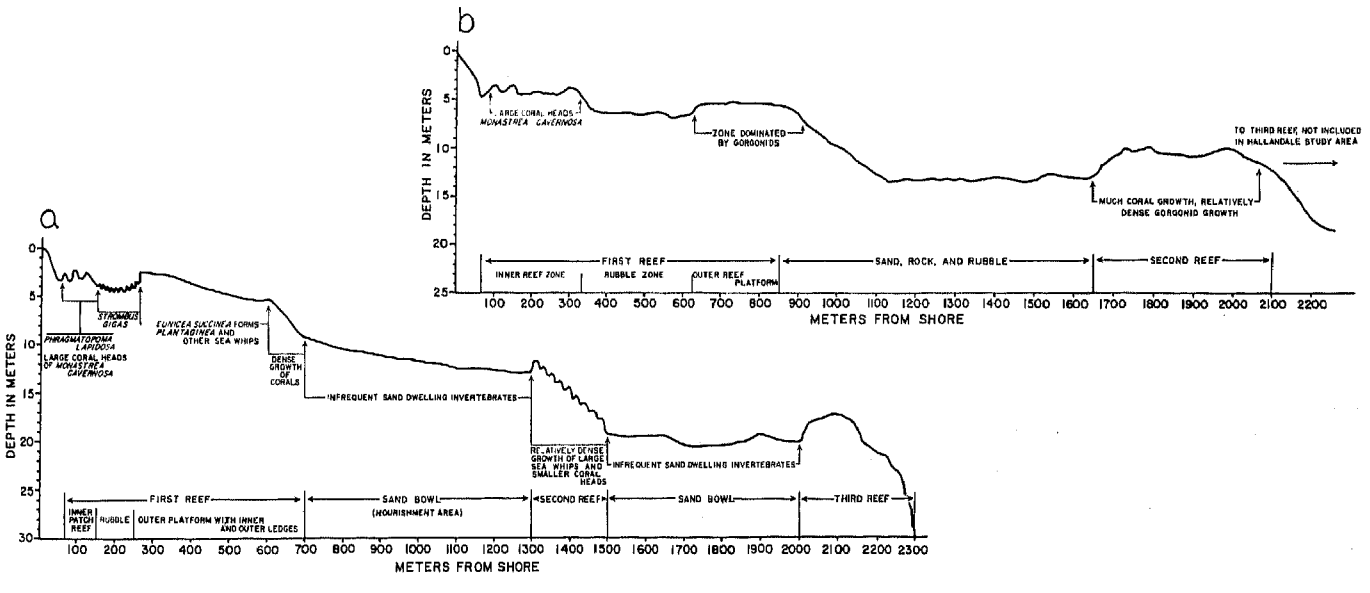

Fig. 2. Generalized ocean bottom profiles in study areas. a—off Pompano Beach to Lauderdale-by-the-Sea. b—off Hallandale.

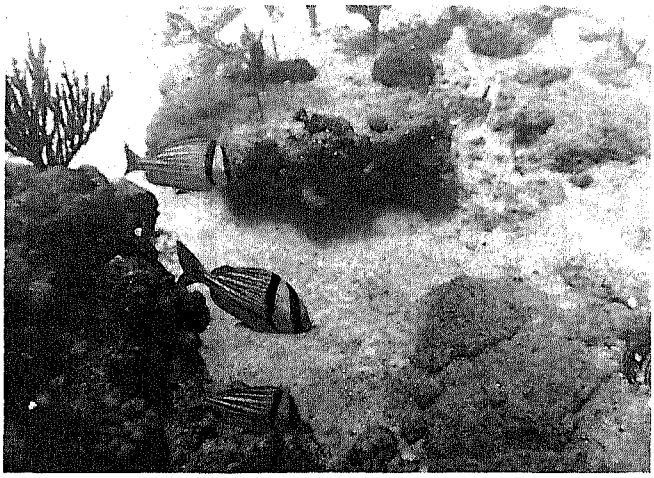

Fig. 3. Second reef platform near borrow areas off Hallandale. Layer of sediment from dredging covers low profile reef areas.

burrow into the reef or into surrounding substrates. Evaluation was by underwater observations, photography, and collecting.

RESULTS

Our observations indicate that there are two primary ways in which coastal dredge and fill operations for purposes of beach restoration and nourishment can adversely affect marine organisms. Along the southeastern Florida coast the most potentially damaging factor is sedimentation (including excessive turbidity) which may occur as a direct result of dredging, generally at and surrounding the dredging site, or from erosion of beach fill by waves, currents, or rain, or combinations of these factors. Excessive sedimentation and turbidity may bury portions of reefs (Fig. 3) and organisms living within these reefs or suffocate fishes by clogging their gills (Robins, 1957). More commonly, however, fine particulate matter (silt) will settle on and smother bottom-dwelling attached (Fig. 4) invertebrates and algae. Certain species such as flat-surfaced hard corals and broad-leaved algae appear to be more susceptible than other organisms to this type of devastation.

Corals consist of many tiny polyp-shaped colonial animals encased in a hard, calcareous skeletal matrix. These polyps feed primarily on plankton which they actively take from the water. Sedimentation and turbidity interfere with feeding activity and, under such conditions, the polyps often withdraw into their skeletal matrices thus reducing their respiratory surface exposure to a minimum, enhancing the possibility of suffocation. Moreover, many corals, particularly the soft corals, contain within the tissues of their polyps cells of a green alga known as zooxanthellae. These plant cells exhibit a symbiotic relationship with the coral polyps (Smith, 1971; Bayer, 1961) although all of the processes of this relationship are not as yet fully understood. Nevertheless, the zooxanthellae do require adequate light to carry out their basic process of photosynthesis and, therefore, are intolerant of reduced light conditions that would result from excessive turbidity or from their hosts, the coral polyps, being covered by sediments. Goldberg (1970) has demonstrated that symbiotic zooxanthellae are essential for the survival of some local reef-dwelling soft corals (sea whips) and that reduced light conditions will cause death of these organisms within 3 to 7 weeks even though an adequate food supply exists in the surrounding water. Reduced light will similarly affect other species of algae, particularly the broad-leaved species presenting flat surfaces for the accumulation of sediments.

The second primary way in which reefs are damaged by dredge and fill activities is through direct physical destruction (Figs. 5, 6). This may occur when cutting heads of the dredge dig into reef surfaces or dredging equipment is dragged across a reef. In general, it appears that these unnecessary accidents are often due to inadequate surveying of the borrow and adjacent areas.

The area of dredge and fill between Pompano Beach and Lauderdale-by-the-Sea was studied from 3 August 1970 to 29 July 1972. This study was started near the termination of dredging; thus, a "before" study of this area was not undertaken. For this reason areas not immediately adjacent to the borrow and fill regions were used to compare viability of reef communities. During the first year of study major efforts were devoted to fishes inhabiting the area. Algae and attached invertebrates were surveyed along with fishes during the second year.

The larger reef-building corals with both flat and hemispherical surfaces did not show any indication of damage from turbidity or excessive sediment fallout in the study area. No differences in coral viability were noted in this and comparable areas. The same was observed for the soft corals which had an average density of 55 per 1.196 square yards, or 1 square meter (based on 10 samples) on a reef bordering a borrow area as compared with an average of 22 per square meter (10 samples) on a comparable reef off Deerfield Beach and 59 per square meter (10 samples) off southern Lauderdale-by-the-Sea. Algae in the study area were also similarly comparable in quantity and species composition to those in adjacent areas. Other groups of invertebrates, particularly the attached sponges and several species of burrowing mollusks, were indicative of negligible reef community damage from dredge and fill activities in the Pompano Beach to Lauderdale-by-the-Sea area.

During this survey a total of 204 species of fishes were collected on and between the reefs of this first study area and in nearby marine waters of Broward and southern Palm Beach counties. Included within these collections were 7 species of fishes not heretofore recorded from continental North America and one undescribed species of cardinalfish. We believe that the marine waters off Broward and Palm Beach counties are almost as rich in numbers of fish species as are the waters off the Florida Keys (Starck, 1968).

Certain fish species such as cardinalfishes, clinid blennies, combtooth blennies, and gobies which are closely associated with the substrate and possess limited mobility would be the most likely fishes to be affected by sedimentation and turbidity from dredge and fill activities. These fishes were found in abundance on the outer portion of the first reef just shoreward from the borrow areas. Comparisons were made with similar non-dredged areas and population densities appeared to be the same.

Monitoring of the Hallandale area began in early August 1971 and continued to 16 August 1972. Dredging activities in this area began on 21 July 1971 and continued until 21 September 1972. During the dredge and fill operations the water at and surrounding the dredge was very turbid. These same conditions prevailed along shore where fill was being leached from the nourished beach. Underwater visibility during this period was restricted to 3 to 6 feet. The bottom was laden with silt in areas slightly over ½ mile north of the dredge. Part of this effect was apparently due to the rehandling of fill material between the dredge and beach during the last phases of this beach nourishment project.

The inshore patch reefs which were initially bathed for several months with eroded beach fill sediments showed no damage in the months following termination of dredging activities and clearing of inshore waters. Beach erosion subsided subsequent to the formation of a sandbar created from eroded beach fill. This sandbar is presently located between the beach and inshore patch reefs.

An extensive area of more offshore patch reefs extending out to and including the offshore edge of the second reef platform was damaged by dredging activities. This damage is most evident within a radius of ¼ to ½ mile of the borrow areas. Algae were covered by sediment and subsequently died. Nevertheless, algae are now repopulating this area. Motile invertebrates such as several species of lobsters, crabs, and shrimp, and most fishes left this area during and following cessation of dredging. Recent observations indicate return of these species to this area. Some species of motile invertebrates were absent from this region for 9 months. Attached mollusks were killed by suffocation from sediment accumulation on their gills. To date there is no indication of reestablishment of these molluscan species but suitable substrate is now present.

Soft corals in the study area off Hallandale showed no damage (Fig. 6), primarily because their vertically-directed, cylindrical branches lack substantial surface for sediment accumulation. This also indicates that turbidity did not reduce light transmission to a level which would have been lethal to the zooxanthellae living within the coral polyps.

Hard corals, however, were almost completely decimated near the borrow areas off Hallandale. Every species of hard coral which has a large, horizontally-exposed surface was killed or showed extensive damage due to sediment fallout. Those corals with hemispherical surfaces showed extensive damage within a belt across and below their presently-viable colonies of polyps (Fig. 4). It appears that viable polyps were able to rid themselves of sediment cover which subsequently settled over the other polyps in depths sufficient to kill these portions of the colony. In some corals with similar shape which were closer to borrow areas, the entire colony was killed by sediment fallout.

Physical destruction was found in the borrow areas off Hallandale and on adjacent patch reefs. Scouring of the ocean bottom produced many gorges, some as deep as 6 feet from surrounding surfaces. These gorges presently remain indicating inadequate nearby deposits of sand which currents would otherwise redistribute into this area. Some large coral heads of patch reef formations had been overturned (Figs. 5, 6). Along the offshore face of the second reef there were indications that the cutting head of the dredge had operated over the reef surface.

CONCLUSIONS AND RECOMMENDATIONS

The result of sedimentation damage is a reduction in species diversity which in turn degrades the ecological health of marine communities. Weakening of natural populations may permit certain species, not otherwise affected, to become more sensitive to other environmental stresses. Therefore, a single factor affecting any one species in a complex of species may alter the entire complex, more often than not resulting in a weakening of the complex. Somewhat parallel cases

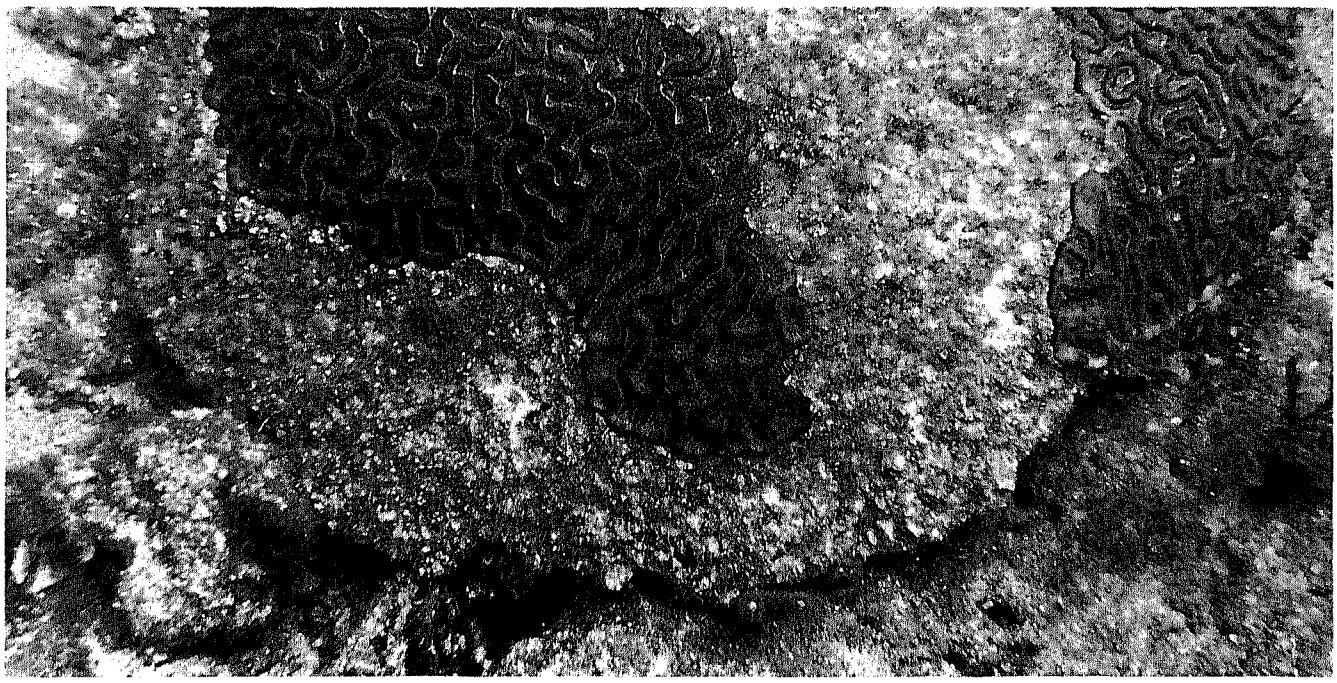

Fig. 4. Coral head partially killed from sediment fallout. Darker areas are live coral.

can be found in the field of engineering where a structure composed of many parts and elements (the complex of species) becomes subject to unanticipated stresses when one or more structural elements becomes defective (the affected species) due to any number of factors. In extreme cases, the entire structure may collapse if the defective elements are key structures or if the stresses continue over a period of time.

Primary among the key structures of coral reef communities are the hard and soft corals. If these forms are killed, a "chain reaction" can follow. If the corals die from excessive sedimentation or turbidity, the entire reef ecosystem is changed as species diversity decreases. A structure which was once productive becomes unproductive. The entire system from basic plant life (algae) up to and including fish population is affected. The loss of a portion of a reef or of an entire reef reduces man's recreational and commercial use of the waters in such areas. Reefs also act as natural barriers in reducing effects of wave action against open beaches.

While many species of aquatic organisms can repopulate an area in a relatively short time following dredging activities, this is not true of the larger reef-building corals. Many of these local forms are living at the extreme northern end of their distributional ranges. Coral growth is very slow and additional environmental stresses in this area could present reestablishment of some of these coral species. It is imperative, therefore, that man utilize utmost care in protecting and preserving these key species of subtropical marine waters.

Potential damage to reef communities is minimized where adequate offshore borrow areas are not immediately adjacent to viable reefs. Simultaneously, proper selection of dredging equipment and care in dredging activities are of equal importance. Rehandling of fill material between borrow areas and the beach should be avoided wherever possible as this practice greatly increases sediment suspension in surrounding waters.

While damage to reefs and sand flats off Pompano Beach to Lauderdale-by-the-Sea was negligible, damage off Hallandale was extensive over a substantial area near dredging activities. We can only attribute the resulting ecological differences in both areas to inadequate planning and costing for the latter project. Mr. Thomas M. Turner of Ellicott Machine Corporation, Baltimore, Maryland, has informed us that the physical design and capabilities of the dredge used in the Hallandale project are such that large rocks, coral heads, and sediments are thrown free from the cutting heads into the immediate area of dredging and adjacent areas.

Based on the results of our ecological monitoring surveys as reported above, we submit that surveys of biological communities within any area proposed for dredging and filling or beach nourishment and restoration be costed into every such project proposal. These surveys should be conducted by both competent biologists and engineering surveyors working as a team prior to any dredging activities. A report should result from these investigations which is submitted to the agency contracting the project, the agency approving the project, the engineering - surveying - design group, the

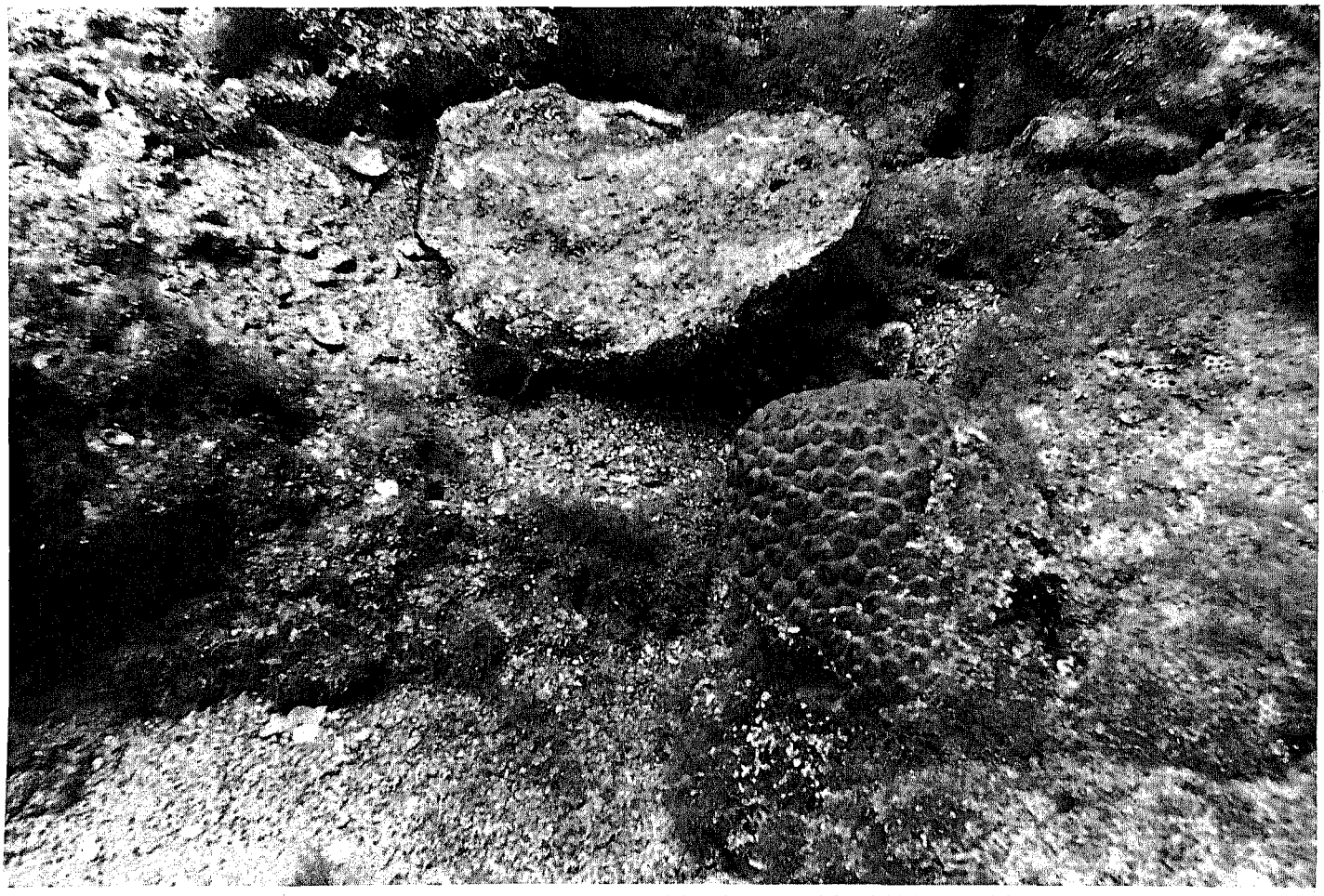

Fig. 5. Coral head (upper center) overturned and killed by dredging. Living coral head (right center) has withdrawn its polyps.

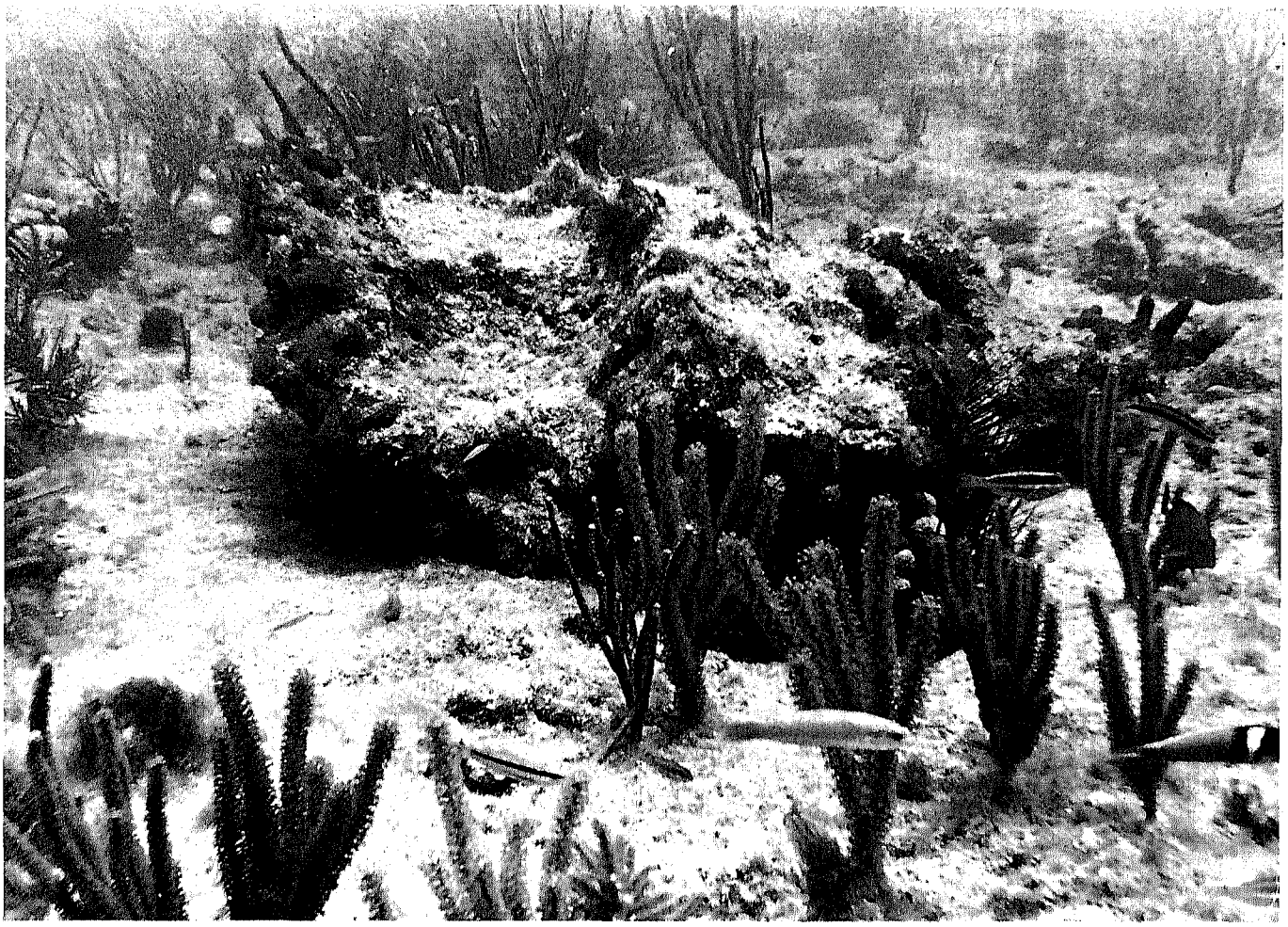

Fig. 6. A dead, overturned coral head lies among live sea whips. Polyps of sea whips are extended.

dredging firm, and any public agency requiring a statement of environmental impact of the proposed project. The team effort with biologists and engineers participating in the initial survey is required since protection and progress are mutually interdependent for all concerned.

Ecological monitoring should be conducted during and after every such project by both biologists and engineers, again working as a team, to (1) advise the dredging firm on protection of reef areas by taking advantage of adequate borrow areas, (2) to prevent direct physical destruction of reef areas, and (3) to assure that the initial recommendations of the survey team were carried out to the best advantage for protection of natural resources and completion of the project. In no case should dredging equipment be used in such projects which, by its design, contributes to unnecessary increases in turbidity and subsequent sediment fallout. The objective is to put the fill on the beach and not at the expense of natural nearshore and offshore resources. With proper planning and monitoring, both objectives can be met.

LITERATURE CITED

BAYER, F. M. 1961. The shallow water Octocorallia of the West Indian region. Martinus Nijoff, The Hague, Netherlands, 373 pp.

DUANE, D. B. AND E. P. MEISBURGER. 1969. Geomorphology and sediments of the nearshore continental shelf Miami to Palm Beach, Florida. Coast. Engin. Res. Cent., U.S. Army, Tech Memo., 29, 120 pp.

GOLDBERG, W. M. 1970. Some aspects of the ecology of the reefs of Palm Beach County, Florida, with emphasis on the Gorgonacea and their bathymetric distribution. M. S. thesis, Florida Atlantic University, Boca Raton.

ROBINS, C. R. 1957. Effects of storms on the shallow-water fish fauna of southern Florida, with new records of fishes from Florida. Bull. Mar. Sci. Gulf & Carib., 7(3): 266-275.

SMITH, F. G. W. 1971. Atlantic reef corals. Univ. of Miami Press, Miami, 164 pp.

STARCK, W. A., II. 1968. A list of fishes of Alligator Reef, Florida, with comments on the nature of the Florida reef fish fauna. Undersea Biol., 1(1): 6-42.