

**OBSERVATIONS ON THE IMPACT OF
SHRIMP ROLLER FRAME TRAWLS OPERATED OVER
HARD-BOTTOM COMMUNITIES, BISCAYNE BAY, FLORIDA**

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ABSTRACT

The impact to benthic organisms on hard bottom substrate by bait shrimp roller frame trawls was observed at a study site in south Biscayne Bay, Dade County, Florida. Pre-trawl and post-trawl observations were made of dominant benthic organisms including sponges, scleractinian and gorgonian corals, and algae. Highest incidence of damage was to the stony corals Porites porites and Solenastrea hyades where 80% of those corals encountered were turned over, or crushed. Over 50% of the sponges of the genera Neopetrosia, Spheciospongia, Spongia and Hippiospongia were damaged when in the trawl path. Thirty-eight percent of the gorgonians Pseudopterogorgia and Pterogorgia were uprooted. Most algae were not significantly affected by trawling with the exception of Halimeda and Sargassum. Results indicate disruption of commercially valuable sponges by trawling activities may be seriously affecting the sponge fishery in Biscayne Bay. Eleven months after shrimp trawling ceased, the benthic community had not fully recovered. Repeated seasonal trawling at the study site could therefore lead to permanent alteration of naturally occurring organisms.

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FRAME TRAWLS OPERATED OVER HARD-BOTTOM COMMUNITIES,
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The impact to bottom communities by roller frame trawls commonly used in Florida's commercial bait shrimp industry has not been intensively studied. During the 1950's, when the bait shrimp fishery was undergoing rapid expansion in response to increased tourism and live bait demand, a number of studies were commissioned by the Florida State Board of Conservation to evaluate this fishery (Higman 1952 and 1955; DeSylva 1954; Woodburn, et al., 1957; Tabb 1958; Futch and Beaumarriage 1965). Emphasis of these studies centered on economics, species harvested, and possible impacts to other fisheries in the location of bait shrimp operations. During this period, methods used to capture shrimp were also rapidly evolving to the modern roller frame trawl (Tabb 1967).

Early concern was expressed by sport and commercial fishing interest as to the impact of bait shrimping on other near shore fisheries (particularly the spotted sea trout, Cynoscion nebulosus) and to the marine grasses in areas shrimped. Detailed observations of the number of organisms captured during shrimp trawling operations has been reported in every study. However, evaluation of impact to the bottom community was limited to inspection of material retrieved in the trawl. The pink shrimp (Penaeus duorarum) was found to be the species primarily exploited by this fishery and fishing operations usually concentrate on dense turtlegrass (Thalassia testudinum) beds where it occurs. The amount of sea grass and algae recovered in the trawl has therefore been assumed to reflect trawl damage.

Within Dade County Florida, the bait shrimp fishery has historically centered around the dense seagrass beds occurring in central Biscayne Bay. One of the earliest accounts of shrimp activities in Biscayne Bay is that by Siebenaler (1953). A discussion of the historic growth of bait shrimp activities up to 1966 was provided by Tabb (1967). Three species of shrimp are caught; Panaeus duorarum, P. brasiliensis, and P. aztecus. Panaeus duorarum and P. brasiliensis comprise the largest portion of the catch. All of these species are associated almost exclusively with dense stands of the seagrass Thalassia testudinum (Soloman, et al., 1968).

In 1972, Florida DNR marine biologists reported that shrimpers were conducting sample trawls south into southern Biscayne Bay and Card Sound (Eldred, et al., 1972). Investigations conducted by National Park Service biologists since 1976 have revealed that the Biscayne Bay bait shrimp fishery now regularly extends into southern Biscayne Bay and, during portions of the year, as many as twelve boats work areas as far south as the Arsenicker Keys (Figure 1).

Benthic communities within central and southern Biscayne Bay consist of two major habitat types; seagrass community and bay hard-bottom community (McNulty, et al., 1962; Voss, et al., 1969; Bader and Roessler 1971). Because of the diversity of conditions within Biscayne Bay, these bottom communities are complex and vary in environmental type. Near shore, pure dense stands of sea grasses dominate. Thalassia testudinum is the most common component, but it is replaced by or found mixed with Syringodium filiforme in some locations and Diplanthera wrightii in shallower regions. Seaward from shore, seagrass beds become more patchy with a resulting mosaic of dense seagrass and open hard-bottom eventually characterizing the substrate. The most conspicuous organisms of the hard-bottom community are the sponges (including many commercial species), soft corals, stony corals, and calcareous algae. Shrimp trawlers operating more than 2 km off shore frequently cross hard bottom zones while trawling.

During February 1978, the movement of shrimp trawlers into an area on which commercial sponge studies were being conducted resulted in an opportunity to document the impact of shrimp roller trawls on the hard-bottom community in south Biscayne Bay. The study site is located 0.5 km west of Pelican Bank within Biscayne National Monument (Figure 1) and was known to have not been trawled for at least five years prior to 1978. Concurrent investigations of commercial sponges in this area had provided observation and documentation of benthic organisms prior to trawling. Observations evaluating the impact of trawling were conducted following eight weeks of bait shrimping operations in the general vicinity of the study site. Ten to twelve boats were observed operating an average of five nights a week during this period.

METHODS

Prior to trawling, two 5 m x 50 m plot transects had been randomly established at the study site. Corners of the plot transect were permanently marked with 92 cm "copperweld" survey markers driven into the rock substrate. All sponges of the genera Spongia and Hippospongia occurring on or immediately adjacent to the plot transects had been tagged and their locations mapped. Tags were affixed to the sponges with monofilament line as described by Storr (1964). Random swims had been conducted over the entire area to obtain general community descriptions and compile species occurrence lists. Sediment depth was determined at the study site through the use of a hand probe pushed down to rock substrate and read to the nearest centimeter. The study site was visited at least every three months (usually more frequently) to conduct observations of sponges and had been monitored for 19 months prior to February, 1978. All observations were made with the use of SCUBA.

Following shrimp trawling operations, the 5 m x 50 m plot transects were reestablished and the number of damaged and undamaged organisms occurring within each 5 m segment of the plot transect recorded. Observations included sponges, soft corals (Gorgonacea), hard corals (Scleractinia), and macro epibenthic algae. In addition, a 50 m line transect was established along an observable trawl axis for comparison to the 5 m x 50 m plots. Seagrass density in areas not affected by the trawl at the study site was documented by counting blades within 25 one-tenth meter plots at 2 m intervals along a line transect. Algal density, measured in untrawled zones was documented utilizing 25 one-quarter meter plots at 2 m intervals along a line transect.

RESULTS

Prior to Shrimp Trawling

A total of 63 sponges of the genus Spongia and two Hippiospongia had been located and tagged at the study site and were being monitored for growth. These sponges represented an average commercial sponge density of 1300 per ha. Sediment in the vicinity of the study site varied from 1.3 cm to 7.7 cm. Forty probings averaged 3.7 cm (s 1.85). Seagrass density within the hard-bottom community averaged 28 Thalassia blades per m². Within adjacent dense grass communities average blade density exceeded 660 blades per m². Calcareous green algae of the genera Penicillus, Halimeda, Rhipocephalus, and Udotea; the green algae Batophora; and the brown algae Sargassum were common. Penicillus ranged in density from 1 to 32 plants per m² and Halimeda averaged 18 plants per m² (range 8-36). Noncommercial sponges included Oligoceras hemorrhages, Ircinia

campana, Neopetrosia longleyi, Haliclona spp., Spheciospongia vesparia, Callyspongia vaginalis, Tedania ignis, Tethya crypta, Chondrilla nucula, Epipolasis lithophaga, and Dysidea etheria.

Three Scleractinia were found to be abundant; Porites porites, Siderastrea siderea, and Solenastrea hyades. A fourth stony coral, Manicina areolata, occurred occasionally. Four large well-developed clumps of Porites existed on or near the study plots. These ranged from approximately 50 cm x 30 cm x 20 cm to 50 cm x 50 cm x 30 cm. Gorgonacea, typical of the hard bottom community in Biscayne Bay, included Pseudopterogorgia acerosa and Pterogorgia aniceps. A third genera, Plexaurella, occurred only occasionally. Density of soft corals at the study site averaged 0.92 per m².

Although no systematic recording of the incidence of damage to algae, coral and other organisms was conducted prior to trawling, no obvious damage was noted. Of the 65 sponges tagged, only one was found to be loose from the bottom. During the 19 months observed, this loose sponge had not disappeared from the study plot. All large stony corals on and near the study plot had been closely examined with no signs of damage evident. Three small den sites were regularly inhabited by juvenile spiny lobster (Panulirus argus) on the study site. One of these was associated with one of the large clumps of Porites.

Observations Following Shrimp Trawling

On the first visit to the study site following shrimping operations it was immediately evident that significant damage to the bottom community had occurred. A general survey of the site revealed that in some locations, the exact path of the trawl across the bottom could be discerned. Heavy damage was observed within the trawl path and little or no damaged organisms along either side

(Figure 2). Damage observed along a 50 m transect established parallel to the axis of a trawl is presented in Table 1.

Along the trawl path, the highest incidence of damage was to stony corals. Over 80% of the Porites and Solenastrea encountered were turned over or crushed. The four large clumps of Porites at the study site were crushed (Figure 3). However, the low growing species Siderastrea sideria was little affected. Over 50% of all sponges encountered were torn loose from the bottom. The highest incidence of sponge damage was to the finger sponge Neopetrosia longleyi. Approximately 38% of all soft corals encountered were torn loose and lying on the bottom.

Post trawl observations conducted on the previously established 5 m x 50 m plot transects revealed a lower overall incidence of damage than the line transect. Some portions of the sponge plot transects had apparently not been trawled across and organisms within these zones were not damaged. A summary of observations from the plot transects is presented in Table 2. Since the exact number of repeated trawls crossing the study plot was not known, the data presented in Table 2 are assumed only to represent the general overall impact of trawling in the vicinity investigated. This impact followed approximately 44 nights of fishing by an average of 10 shrimp boats (440 boat nights) working in the area studied.

The detailed accounting of commercially valuable sponges on the plot transects prior to trawling activities enabled an accurate evaluation of total impact to these species. Damage expressed in Table 2 for organisms other than commercial sponges represents only the proportion that were found overturned or crushed and remaining on site. Organisms physically removed from the site by trawling are not included. Of the 65 commercial sponges (Hippiospongia lachne and

Spongia spp.) that had been located prior to trawling, only 32 (49%) remained on the plot following trawling. Twenty of these remaining commercial sponges were torn loose or overturned, twelve were left attached.

Some of the tagged sponges torn loose by shrimp trawls were found several meters from their original tag site. The longest movement of an individual sponge within the study plot and immediately recovered was about 15 m. It is believed trawling was responsible for this movement. Fourteen of the sponges missing from the study plot were later recovered between 15 m and 75 m north of their original tag site. It is not known whether this movement was a direct effect of the trawl or a combination of trawl and water currents.

Size did not appear to be important in determining whether a sponge was affected by the trawl. No statistically significant change in the size distribution of the pre-trawl and post-trawl population was noted ($\chi^2 = 0.979$). Prior to trawling activities, the average size sponge tagged was 100 mm while following trawling, the average size of those commercial sponges remaining attached and undamaged was 103 mm.

Of the four genera of macro algae most abundant on the study site, Halimeda and Sargassum were most heavily damaged. The less calcareous and more flexible Chryophyta Penicillaria and Udotea were only slightly affected (Table 2). The primary impact on Sargassum was to tear it loose from the bottom resulting in an early release to the free floating state. It is doubtful whether this action is harmful to Sargassum unless occurring during early column formation.

Observations conducted at the study site eleven months after shrimp trawling stopped still revealed evidence of trawl damage although recovery was in progress. Approximately 15% of the gorgonians encountered were previously damaged specimens which remained alive although lying flat on the bottom. Stony corals of

the genera Porites showed growth from broken clumps although most Solenastrea encountered were dead. Algae appeared to have shown complete recovery with the number of damaged specimens appearing comparable to pre-trawl observations.

DISCUSSION

Observations recorded during this study indicate that the roller frame trawl used in commercial bait shrimp fishing, while not uprooting sea grass beds, does have a significant impact on certain benthic organisms encountered. These impacts are greatest to those organisms which are either rigid (e.g., hard corals or highly calcareous algae) or that protrude substantially from the bottom (e.g., sponges, soft corals, and Sargassum weed).

Repeated shrimp trawling over long periods of time would be expected to greatly alter the abundance and species composition of naturally occurring organisms found on hard bottom substrate. During 1978, trawling activities lasted for only two months in the vicinity of the site observed and therefore many organisms susceptible to the roller trawl survived. However, recovery from damage was not complete when observed 11 months following trawling activities and therefore annual seasonal trawling in this vicinity would eventually lead to permanent alteration of the benthic community.

Although it has been the unanimous conclusion of previous studies that shrimp trawling probably has little effect on other fisheries within the area trawled, this may not be true within south Biscayne Bay where a substantial commercial sponge fishery occurs. The extent to which the sponge fishery is impacted depends to a large extent on the fate of sponges that are torn loose from the bottom. If the growth rate, reproductive activity, or commercial quality of a sponge is reduced by the fact that it becomes unattached, then the sponge fishery may be significantly

impacted by present shrimp trawling operations. DeLaubenfels (1950) reported that loose sponges, buffeted by rolling action along the bottom, would not grow in areas where buffeting occurs. Smith (1973) reported that approximately 60% of the commercial grass sponges (S. graminea) observed in Card Sound which adjoins Biscayne Bay were loose. However, growth observations were conducted on transplanted cuttings only. The single loose sponge observed during the present study prior to trawling, which did not move substantially during a 19 month period, grew an average of 0.93 mm per month. This rate is lower than the overall average of 1.06 mm per month found for 29 attached sponges showing continuous growth. However, some attached sponges also had low growth rates (less than 0.93 mm per month).

During an eight month period following shrimp trawling, seven loose sponges that remained on the study plot appeared to have a slower average growth rate than the remaining twelve attached sponges. Loose sponges averaged 1.25 mm increase in diameter per month (se = 0.41, range 0.86 - 2.60), while remaining attached sponges averaged 2.23 mm growth per month (se = 0.67, range 0.29 - 5.60). However, this difference was not found to be statistically significant at the .05 confidence level ($p = 0.08508$) with the small sample observed.

The destruction of hard coral formations and uprooting of large sponges, soft corals, and algal clumps may also result in a substantial impact to other near shore fisheries. These organisms provide habitat for numerous small crustaceans, mollusks, annelid worms, and other important invertebrates within the food chain. Sponges, when representing a significant portion of the biomass, have been shown to be particularly important in providing shelter to primary consumers (Pearse 1950). Juvenile spiny lobsters (Panulirus argus) and stone crabs (Menippe mercenaria) associated with near shore grass beds during their developmental life

stages are also known to depend heavily on small den sites provided by branching corals, algal and sponges (Khandker 1964; Voss, et al., 1969; Eldred, et al., 1972). The destruction of three such den sites occurred within the plot transect at the study site reported herein alone. The loss of such necessary habitats could directly affect lobster and stone crab fisheries within and adjacent to the trawled areas and could indirectly affect other fisheries through alteration of organisms within the required food chain.

Results of these observations warrant further detailed investigation into impacts of shrimp trawls on important benthic and invertebrate organisms comprising known food chains. Over hard bottom areas, substantial damage to organisms and alteration of habitat occurs once shrimp trawling operations are conducted. Within dense grass bed communities, removal of epiphytic algae, tunicates, sponges and other primary producers may also be significant. While riding aboard bait shrimp trawlers working in Biscayne Bay during the period April 1976 through August 1977, NPS researchers recorded Atlantic Bay Scallops (Aequipecten spp.) in 44% of 639 trawls observed. Other slow moving or sessile invertebrates occasionally observed in trawls included polychaetes, nudibranchs, tunicates, clams, scyphozoa, echinoderms, and sponges. Past studies of bait shrimp trawling have not reported on the frequency of similar invertebrates and primary consumers caught in the trawls, nor investigated this aspect of possible ecological impact underwater. If significant impact to the lower invertebrate consumers occurs on dense grass beds, long range impacts to estuarine and coastal lagoon fisheries could be substantial at regularly trawled sites.

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LIST OF FIGURES

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- Figure 2. Damage to gorgonian corals observed in path of shrimp trawl, hard-bottom substrate, Biscayne Bay, Florida.
- Figure 3. Stony coral, Porites porites crushed by bait shrimp roller frame trawl operating over hard-bottom substrate, Biscayne Bay, Florida.

Table 1. Roller frame shrimp trawl damage to benthic organisms observed along a 50 m line transect place on the axis of an observable trawl path. Study site represents hard bottom community, Biscayne Bay, Dade County, Florida.

Species	Undamaged	Damaged	% Damaged
Scleratinia			
<u>Porites porites</u>	1	4	80
<u>Solenastrea hyades</u>	1	5	83
<u>Siderastrea sidera</u>	6	0	0
Gorgonacea			
<u>Pseudopterogorgia spp.</u>	19	9	32
<u>Pterogorgia spp.</u>	20	15	43
Porifera			
<u>Spongia spp.</u>	4	5	56
<u>Spheciospongia vesparia</u>	1	1	50
<u>Neopetrosia longleyi</u>	1	3	75

Species	Undamaged	Damaged*	% Damaged
algae			
<u>Penicillus</u> spp.	165	13	7
<u>Halimeda</u> spp.	0	6	100
<u>Udotea</u> spp.	75	3	4
<u>Sargassum</u> spp.		30+	100

*Damage includes those Spongia and Hippospongia missing from the study plots following trawling activities.

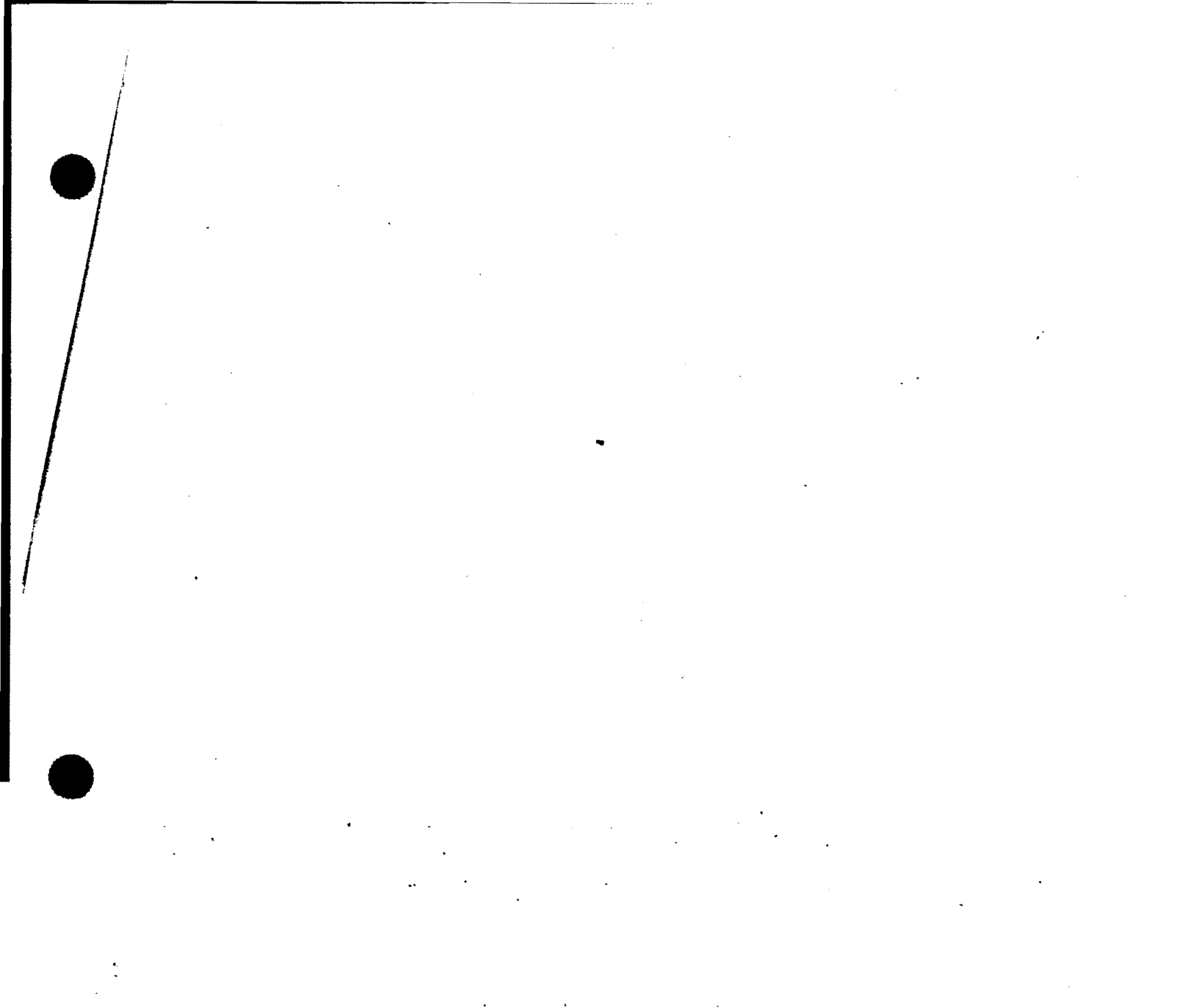


Figure 1. Southern Biscayne Bay, Dade County, Florida. During Jan-Feb 1978, bait shrimp trawling was extended into areas south of Turkey Point and near Arsenicker Keys. Trawl damage study site is located near Pelican Bank. Broken line represents boundary of Biscayne National Monument.

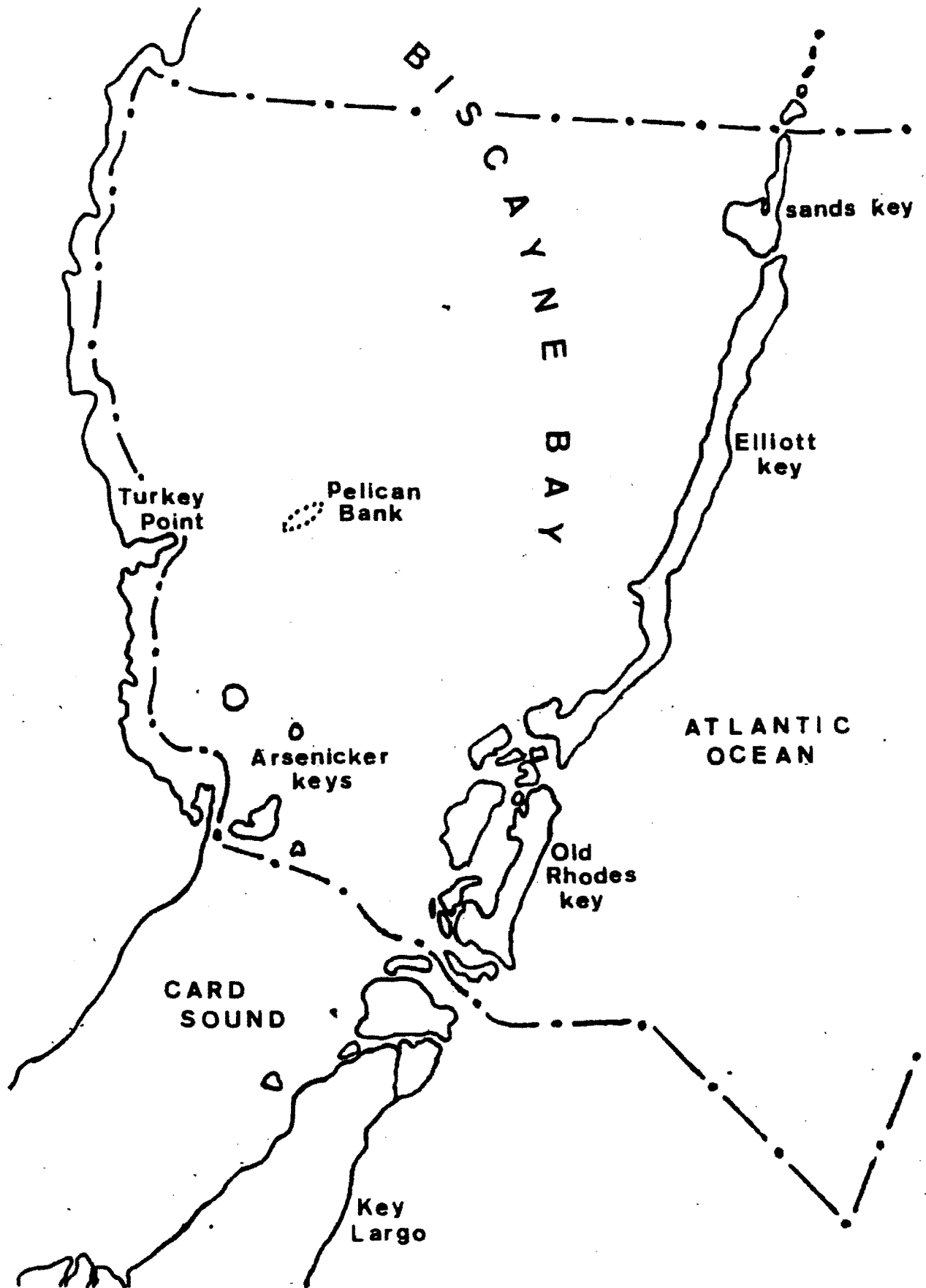


Figure 2. Damage to gorgonian corals observed in path of shrimp trawl, hard-bottom substrate, Biscayne Bay, Florida.

Figure 3. Stony coral, Porites porites crushed by bait shrimp roller frame trawl operating over hard-bottom substrate, Biscayne Bay, Florida.