# A Pilot Project to Determine the Effectiveness of an Artificial Tire Reef as a Fish Attraction Device in the Gulf of Paria, Trinidad

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ABSTRACT

An experimental artificial reef was established in Trinidad and Tobago by a fishing cooperative, with financial and technical assistance from several Government agencies. The project investigated the feasibility of using artificial structures to attract fish in overfished areas. The reef was constructed of discarded automobile tires, at a cost of US $3,550. It consisted of four pyramidal modules, each containing 60 tires bound together by polyethylene rope. The completed structure measured 20 $m^2$ at its base with a maximum height of 4 m. The reef was deployed at a depth of 12 m in the Gulf of Paria, off the west coast of Trinidad. The substrate at the site was flat, muddy and featureless, with no visible presence of fish life. The tire surfaces were rapidly colonized by filamentous algae, barnacles, bryozoans and ascidians, followed by sponges and octocorals. Fish life in proximity to the reef increased from one school of herring on the first monitoring to fifteen fish species from nine families seventeen months after placement. Over the entire monitoring period, twenty species from twelve families were observed on the reef. Thirteen of these were species of commercial value, the most important of which were groupers, snappers and grunts. The results indicated that the artificial reef was successful in attracting both adults and juveniles of fish of commercial value.

## INTRODUCTION

The fisheries of Trinidad and Tobago have traditionally been artisanal and have been conducted in the nearshore waters of both islands. Due to the existence of inadequate fisheries legislation and difficulties in enforcement, fishing has been largely uncontrolled with respect to fishing effort, gear types and gear specifications. This has resulted in the depletion of many of the inshore fish stocks, particularly those of demersal species. In recent years, fishermen have reported declining catches and a decrease in the size of individual fishes caught.

Another problem has arisen from fishing by trawlers, often in shallow waters close to shore. The use of small mesh sizes (3.6-7.4 cm) in the trawl nets results in high mortality of juveniles of commercially important species, thus reducing recruitment to the fishable stocks. This situation has also led to serious gear conflicts among fishermen, many of whom attribute the present state of the fish stocks to the trawlers.

Habitat degradation and destruction due to pollution of coastal waters and land reclamation may have also contributed to declining fish catches. Many of the marine areas impacted by pollution and reclamation, for example the Gulf of Paria on the west coast of Trinidad, are nursery and feeding grounds of some commercially important fishes. Destruction of these essential habitats would adversely affect recruitment to the fish stocks thereby reducing the available biomass on which important fisheries are dependent.

Based on the foregoing, a fishing cooperative, the Almoorings Fishing Co-operative Society Limited, embarked on a pilot project to establish an artificial tire reef in the Gulf of Paria, Trinidad. Although some doubt exists about the functions of artificial reefs (Meier *et al.*, 1989; Polovina, 1989a), the ability of these structures to enhance coastal fisheries is well documented (White *et al.*, 1990; De Silva, 1988; Bohnsack and Sutherland, 1985; Buckley, 1985; Goodwin and Cambers, 1983). Artificial reefs have also been used to prevent trawling in some areas (De Silva, 1988, in White *et al.*, 1990).

The reef was established in the Gulf of Paria which is a semi-enclosed body of water between the west coast of Trinidad and the northeast coast of Venezuela (Figure 1). The Gulf is a sedimentary basin with a maximum depth of about 30 m (Kenny, 1989). The waters of the Gulf are subjected to marked seasonal changes in salinity and turbidity, due to the influence of runoff from the Orinoco and Amazon Rivers (Gade, 1961) and local rivers.

This project was undertaken to determine the feasibility of establishing artificial reefs constructed from discarded automobile tyres in the coastal waters of Trinidad and Tobago and to evaluate the effectiveness of the design and construction of the reef.

## METHODS

### Site Selection and Description

Site selection was conducted in the northeastern Gulf of Paria from July to September 1989. Factors considered for this were water depth and visibility, bottom type, accessibility and current usage of the site. In addition, approval of the site had to be obtained from the Maritime Services Division (Ministry of Works and Transport). Eight sites were evaluated, six of which were found to be unsuitable since they were located in the shipping lane, while another was rejected due to conflict of use.

The site chosen was located in the northeastern Gulf of Paria, about 5 km from shore at a depth of 12 m (Fig. 1). During the selection exercise, visibility varied from 2-3 m at a depth of 1 m and decreased to less than 0.25 m at the bottom. The sea floor at this site was muddy and featureless.

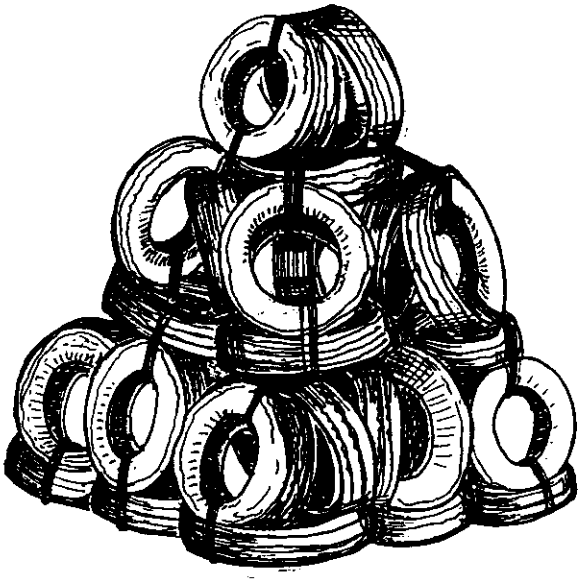

Figure 1. Location of artificial tire reef.

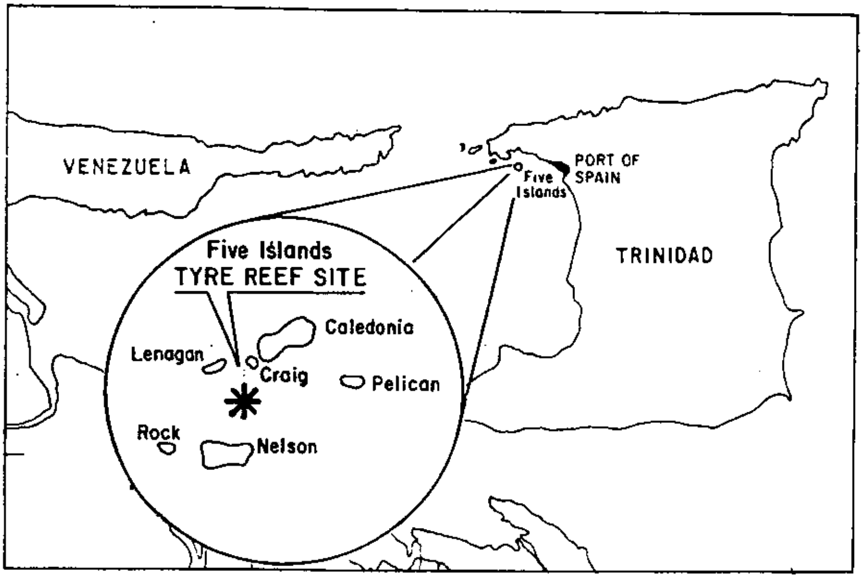


Figure 2. Design of artificial tire reef.

**Reef Design, Construction and Placement**

The artificial reef was constructed by members of the Almoorings Fishing Co-operative Society Limited. The reef consisted of four pyramidal modules (Fig. 2), each of which was constructed from 60 discarded automobile tires held together by polyethylene rope. The basal tires of each module were filled with cement to enable it to sink and to provide stability on the sea bottom. All tyres were punched with holes to expel trapped air when the reef was submerged. The completed reef measured 4 m in height and was an estimated 20 $m^2$ at its base. The total weight of the reef was approximately 2.3 tonnes.

The cost of construction and placement of the reef was US $3,550 and was broken down as follows: monitoring $1,650, barge hire $1,200, materials $700 (US$1 = TT$4.25). A total of 400 man-hours was devoted to the construction of the reef.

The four modules were tied together on a barge and lowered to the designated site on the sea floor by a crane on 8 December 1990.

**Reef Monitoring**

Fishing surveys using baited handlines were carried out between 10 and 100 m east and west of the reef site in July and November 1990, prior to placement of the reef. On both occasions the time of day, tide, number of persons fishing and number of lines per person were generally similar. The duration of fishing was approximately one hour. In addition, a visual fish survey using SCUBA was conducted at the reef site seven days before placement of the reef.

Fishing and visual surveys were conducted on the reef 49, 133, 224, 343, 415 and 520 days after placement. In addition, colonization of the reef surfaces by algae and invertebrates was monitored using wire quadrats. These were attached with nylon string to the tire surface at the top (8 m depth), mid (10 m depth), and bottom (12 m depth) sections of each of two of the four pyramidal modules. The composition and percentage of tyre surface covered by marine organisms within each quadrat was recorded at each monitoring.

RESULTS

**Colonization of Reef Surfaces**

After 49 days, all the tire surfaces were encrusted with a combination of filamentous algae and barnacles (*Balanus* sp.). The latter were abundant, covering up to 95% of the surface in the upper part of the reef, and diminished both in size and abundance towards the middle and base. Bryozoans and serpulid worms were also observed on the tire surfaces.

At 133 days after placement, filamentous algae and barnacles again dominated, the latter covering up to 90% of the surface at the top. Other organisms such as ascidians (*Microcosmus exasperatus*) and octocorals (*Telesto riisei* and *Leptogorgia setacea*) began to appear. *M. exasperatus* was abundant on the mid and bottom sections of the reef, with a coverage of 60%, while octocorals provided about 5% coverage on the surfaces on the bottom part of the reef. Numerous arrow crabs (*Stynorhynchus seticornis*) and star fish (*Echinaster* sp.) were observed on the reef and on the mud bottom adjacent to the base of the reef.

After 224 days, the number of invertebrate species increased to 13. In addition to those previously present, the sponge *Callyspongia vaginalis* and two unidentified species, encrusting bryozoans, mussels, hydroids, and ahermatypic stony corals (*Astrangia solitaria*) began to colonize the reef.

On the last two occasions 343 and 415 days after placement, poor water visibility inhibited the monitoring exercise. However, it was apparent that a new settlement of barnacles had occurred on the uppermost tires.

**Colonization by Fish**

During fishing conducted prior to reef placement, no strikes were felt and no fish caught, indicating that fish were not present around the reef site or if present, were not attracted by the bait. During the visual surveys prior to placement of the reef, only one school of herring (*Harengula* sp.) was observed.

Strikes were felt but no fish caught on three occasions - at 27, 133 and 413 days after placement. On the other four sampling occasions, several strikes were felt and two lane snappers (*L. synagris*), one grunt (*Haemulon* sp.) and two lane snappers, two sea trout (*Cynoscion* sp.), and one lane snapper were caught respectively.

A list of all fishes recorded on the reef on each day of monitoring is given in Table 1. The fish fauna on and around the reef increased from one school of herring before placement to fifteen fish species on the last monitoring, 520 days after placement of the reef. It is possible that the number of species was underestimated due to poor water visibility and the crepuscular habit of some fishes. A total of 20 species of fish from 12 families were recorded on the reef (Table 2).

The tire reef attracted both demersal reef fish, such as snappers, groupers and grunts, as well as small coastal pelagic fish such as herrings and Atlantic bumper (*Chloroscombrus chrysurus*). All the fish observed were of relatively small body size, except for one jewfish (*Epinephelus itajara*) estimated at 23 kg. Although adult individuals were observed, many juvenile fish were present on the reef. Sixteen of the species seen are edible and of commercial value (Table 2). The most valuable families evident on the reef were those of snappers, groupers and grunts.

## DISCUSSION

Several countries in the Caribbean region have already undertaken the establishment of artificial reefs, for example, the Bahamas (Alevizon *et al*,

**Table 1.** Fishes observed on the artificial tire reef on each day of monitoring.

| Days after placement | Fishes observed |
|---|---|
| 7 days before | 1 school herring |
| 49 | 1 school herring |
| | grunts |
| 133 | grunts |
| | groupers |
| | 1 school herring |
| 224 | grunts |
| | groupers |
| | 1 school herring |
| | French angelfish |
| | snapper |
| | spadefish (poaua) |
| 343* | grunts |
| | groupers |
| | 1 school plateau |
| 415 | grunts |
| | groupers |
| | 1 school plateau |
| | French angelfish |
| 520 | grunts (3 spp.) |
| | groupers (4 spp.) |
| | 1 school plateau |
| | spadefish (paoua) |
| | reef croaker |
| | black margate |
| | snook |
| | sharksucker |
| | soapfish |
| | bicolor damselfish |

*Poor water visibility on this occasion may have resulted in some fishes not being seen.

1985), Cuba (Lee, 1975), and the Virgin Islands (Randall, 1963). The reef established by this project is the first artificial reef to be documented in Trinidad and Tobago.

The extent to which the artificial reef functions as a fish attraction device (FAD) and at the same time results in increased fish production in the area is unknown. The attraction versus production function of artificial reefs has been previously discussed (Meier *et al.*, 1989; Polovina, 1989a) and it has been reported that in some instances these structures primarily aggregate fishes

**Table 2.** Fishes observed on the artificial reef during the monitoring period.

| FAMILY | SPECIES | COMMON NAME |
|---|---|---|
| Carangidae | *Chloroscombrus chrysurus* | *Bumper |
| Centropomidae | *Centropomus undecimalis* | *Snook |
| Clupeidae | *Harengula* sp. | *Herring |
| Echeneidae | *Echeneis naucrates* | Sharksucker |
| Ephippidae | *Chaetodipterus faber* | *spadefish |
| Grammistidae | *Rypticus* sp. | Soapfish |
| Haemulidae | *Anisotremus surinamensis* | *Black margate |
| | *Haemulon bonariense* | *Black grunt |
| | *H. parrai* | *Sailor's choice |
| | *H. steindachneri* | *Latin grunt |
| Lutjanidae | *Lutjanus* sp. | *Snapper |
| | *L. synagris* | *Lane snapper |
| Pomacanthidae | *Pomacanthus paru* | French angelfish |
| Pomacentridae | *Eupomacentrus partitus* | Bicolor damselfish |
| Sciaenidae | *Cynoscion* sp. | *Sea trout |
| | *Odontoscion dentex* | *Reef croaker |
| Serranidae | *Epinephelus itajara* | *Jewfish |
| | *Mycteroperca* sp. | *Grouper |
| | *Serranus dewegeri* | *Vieja |
| | *S. flaviventris* | Two-spot bass |

*Edible/commercially valuable

(Polovina, 1989a; Bojos and Vande Vusse, 1988). The rapid colonization of the artificial tire reef by several species of fish indicate that it is functioning as a FAD. Further research is required to determine the extent to which the reef enhances fish production.

Results indicate that the ability of artificial tire reefs to enhance fisheries in the coastal waters of Trinidad has good potential. However, concern has been expressed in the literature about the dangers of using artificial reefs to attract species that are already overfished, thereby making them even more susceptible to overfishing (Polovina, 1991; Bohnsack, 1989).

This concern does not apply in the present situation since the species attracted to the reef have not been heavily fished in the Gulf of Paria. This is mainly because they are not abundant in this area due to the scarcity of suitable habitats. The benthic fish communities of the Gulf of Paria are of the typical tropical multispecies type, with fishes of the family Sciaenidae being predominant (Manickchand-Heileman and Julien-Flus, 1990). These communities support valuable trawl fisheries, landings from which have declined in recent years. Analysis of the spawning stock biomass per recruit of one species, the whitemouth croaker *Micropogonias furnieri*, has shown this species to be already overfished (Manickchand-Heileman, 1990).

Polovina (1991) recommended that artificial reefs which shift fishing effort from overfished to underutilized species be considered as long as fishing effort is controlled. The reef attracted species such as snappers, groupers and grunts, which are coral reef-associated. Also, high relief habitats for these species are limiting in the Gulf of Paria. Therefore, a positive outcome of an artificial reef program in the coastal waters of Trinidad is envisaged to be an increase in the abundance of valuable species for which suitable habitats are at present limiting.

Snappers and groupers are among the most economically important species caught in Trinidad and Tobago, fetching a retail price of US $4 per kilogram. This is twice the price obtained for some of the fishes typically caught in the Gulf of Paria. For example, the whitemouth croaker (*Micropogonias furnieri*) and the seatrout (*Cynoscion* spp.), some of the most important demersal species caught, usually sell for about $1.50 per kilogram.

Another positive outcome of an artificial reef project, and perhaps the most valuable at this time, is the indirect benefit to the demersal fish stocks which are being overfished. As previously mentioned, trawling activities, particularly in shallow inshore areas which are the nursery grounds of commercially important species, have been blamed for the decline of these stocks. Although fisheries legislation exists to control trawling in the Gulf of Paria, it has not been very effective due to difficulties in its enforcement. Strategically placed, artificial reefs have already been used effectively in preventing trawling in specific areas (De Silva, 1988, in White *et al.*, 1990).

It has already been demonstrated that tires provide an excellent substrate for attachment and growth of sessile organisms (Jothy, 1982). Qualitative and quantitative data obtained from the first monitoring of the artificial tire reef indicated rapid colonisation of the tire surfaces, 49 days after placement of the reef. The early colonizers were barnacles and filamentous algae, developing into a community dominated by sponges, ascidians and octocorals. These organisms are common inhabitants of hard bottom areas in the Gulf of Paria (Hubbard, 1990).

Observations on the physical characteristics of the tire reef over the monitoring period suggest that the methodology used in the construction and deployment of the tyre reef was effective in ensuring its stability and integrity in the marine environment. Tires are also easily and cheaply available, will last indefinitely in the marine environment, and are probably the most practical material for small artificial reef projects (Goodwin and Cambers, 1983).

RECOMMENDATIONS

In view of the results of this project, it is recommended that:

1) a national policy for artificial reef development in Trinidad and Tobago be formulated and implemented.

2) an artificial reef site or sites be officially designated based on fisheries, ecological, oceanographic, socio-economic, maritime, and legal criteria.

3) artificial reefs be used in special areas to restrict the activities of trawlers.

4) different types of artificial reefs (bottom and mid-water) and materials (tires , car bodies, wrecks, etc.) be considered with respect to such objectives as enhancement of commercially important demersal and pelagic fisheries, development of recreational fishing areas, and solid waste disposal.

5) education programmes be developed and implemented for the benefit of fishermen, relevant organisations and the general public.

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