The Re-construction of Artificial Reefs for octopus using discarded electric poles.

(Anou Refaire Nou La Cage Ourite[1])

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Abstract

The accelerated post-independence[2] lagoon sand mining activities[3] had deleterious effects on the marine ecosystem. The dredging, silting and boat movement had led to severe ecosystem destruction including octopus habitat. This resulted in a drastic drop of fresh octopus on the local market.

This study aims at reconstructing the damaged habitat at the affected sites[4] using Artificial Reef (AR) with a view to increase the population of 0ctopus and to meet the demand of at least the local market.[5] This will also help overcome the income loss which has been accrued over the years and ensure once more a daily bread for octopus fishers(ensure sustainability for low income group).

The Artificial Reef was made from discarded concrete electric poles which have been cut and worked out into a habitat for Octopuses strong enough to resist underwater current and also easily maneuverable by fishers using existing practices.

Fishers were attributed a limited number of Artificial Octopus habitats so as to maintain a low, sustainable catch per unit effort. These artificial octopus nests were to be used strictly outside the 'Not Take Zone' which has been demarcated in the fishing ground after consulting the local fishers.

The 'Not Take Zone' or Marine Protected Area (MPA) ensures replenishment of stocks and protects the species thus enabling them to attain adult productive size. Adult octopus allows spawning and larvae production.

Results have shown that the artificial reef is productive after eight months stay in the marine environment. Fishers fishing with 8 ARs have a minimum additional monthly income equal to one fifth the salary of an unskilled local worker.[6]

Results have also shown that avoiding conflict among fishers, proper monitoring and management of ARs, using sound fishing practices and harvesting the resource at adult size, will increase production considerably.

The project can be undertaken in other sites, provided all the implementation measures are strictly respected

Key words: *Sand mining, Octopus, Artificial Reef, Habitat Re-construction, Sustainable resource exploitation.*

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[1] 'Let us reconstruct habitats for octopuses'
[2] Mauritius obtained independence in 1968
[3] Sand mining was a lucrative business due to flourishing construction industry.
[4] Give a brief details of affected sites
[5] There is a big demand for octopus and other seafood due to the blossoming tourism industry.
[6] Salary of unskilled worker is equivalent to 7000 MUR (about $230) monthly.

INTRODUCTION

The use of Artificial Reef was first recorded in Japan in the late 1700s (Meier, 1889). These early structures were used to replace other natural or man-made structures in response to decline in fisheries in previously productive areas (*Christian et al., 1998*).
The artificial reefs have the ability to attract and may potentially increase local fish stock which makes them an attractive tool for stock management (*Meier 1989*).

However, the debate over whether Artificial Reefs act to simply attract fish or enhance their production, continues and remains an unresolved issue concerning the management of marine resources (*Pirkerling & Whitmarsh,1997*).

Contrary to usually stated benefits, Artificial Reef can potentially have harmful effects on fish population by increasing the catch per unit effort or increasing access to previously unexploited stock, which may lead to an increasing probability of overexploitation by concentrating stocks (*Grossman et al, 1997*).

Due to scientific uncertainty on their effectiveness, Artificial Reef is still commonly used in the hope of enhancing fisheries. (*Mc Glennon & Brandon, 1994*)

In addition to fishery enhancement, Artificial Reef can be used to replace or re-construct damaged productive sites. These sites can be improved to substantially greater economic gain by increasing stock, which can be beneficial for the coastal community, who is directly dependent on these resources for their basic living.

Artificial reef can also be used as a resource management tool (*Meier 1989)* so as to substantially benefit from these resources for a longer period and in a wise manner.

MATERIALS AND METHODS

Study sites

The project started in October 2005 and it is still ongoing. It was under taken in the North- East of Mauritius (20.00^{o} S, 57.45 ^{o} E), along the coastal villages of Grand Gaube and Poudre D'Or where sand mining has been a practice for the last three decades.

It was estimated that 4 square kilometers of the sites (as allocated by the Ministry of Environment) were subjected to a daily removal of about 80 tones of lagoon sand[7]. The most affected areas were ***Bassin Humbert***, ***Pointe Oscorne*** and ***Bassin Bernard.***

The two coastal villages also include some **30** octopus fishers who usually fish within the reef barrier from ***Pointe de lascar*** to ***Anse la Raie***, which covers an area of **20** square kilometers, including a **marine protected area** (**MPA**) of **6** square kilometers, protected by the national coast guard and the Ministry of Fisheries.

Data Collection

[7] Information obtained from sand miners.

1. **Fishmongers' interview**

Initially, an interview was carried out among fish mongers working in the two coastal villages so as to determine the current amount and qualitative octopus catches in the villages. At the same time the aim of this exercise was to get more information on the existing situation and to ascertain whether any remarkable change of octopus catches have been noticed over the past years.

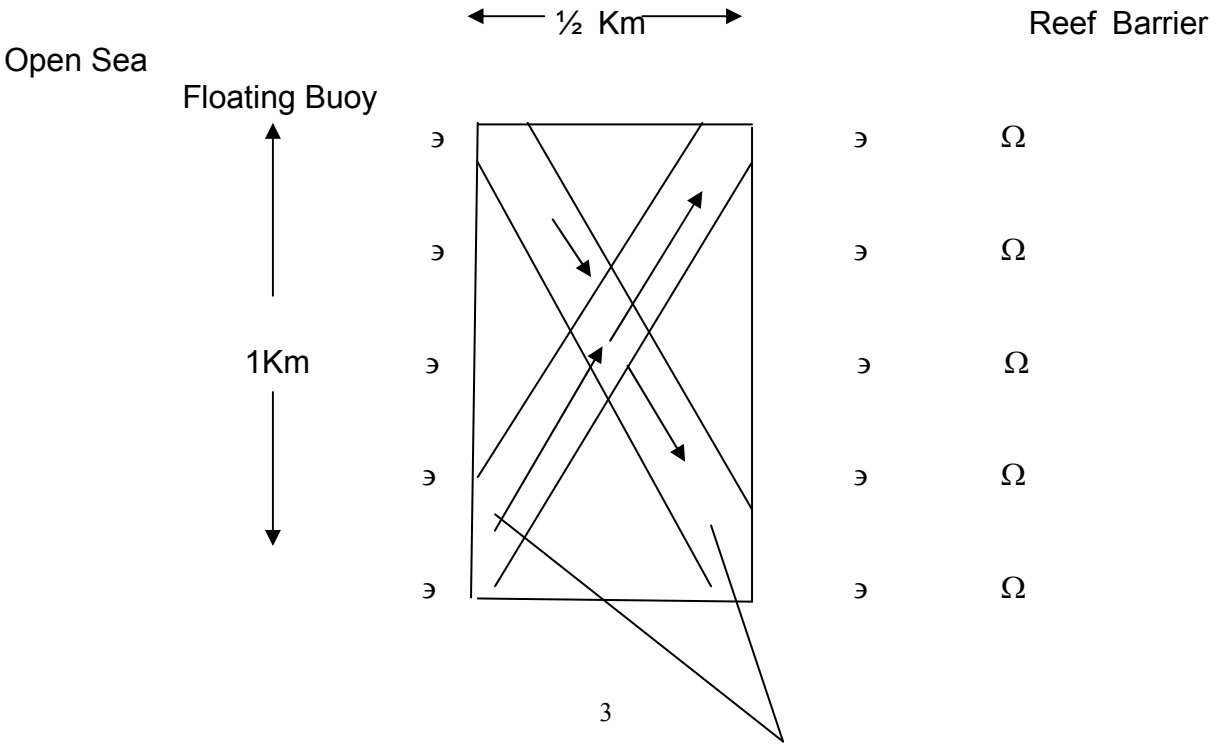
2. **Survey on natural burrows & their occupancy**

The first set of data obtained from the survey carried out, was to determine the number of remaining octopus burrows in the affected sites due to post-sand mining activities, as well as to establish the occupancy rate. The results were compared with unaffected sites in the same locality.

The aim of the survey was to find out whether the octopus is burrow-limited or not. Moreover, it can also indicate the effective number of artificial burrows placement needed in the affected sites

All the sites were demarcated within the lagoon using floating buoys, which were placed for about 1Km in length along the inner reef barrier with a width of about ½ Km. Buoys were placed at a distance of about 250 meters. Local habitual octopus fishers carried out the survey.

All demarcated sites were selected in consultation with the local fishers, within the lagoon, along the coral reef barriers. The sites were declared 'No Take Zone' for about two weeks preceding the survey.



Verification area

Figure 1: Survey of natural burrows and occupancy rate at the affected and unaffected sites due to previous sand mining activities

The sites were investigated diagonally along the verification areas, shown in **Figure 1.** Using snorkelling equipment, a width of about 3 meters was surveyed, all natural burrows were mapped and occupancy recorded. The selected sites were surveyed **six** times, once every week.

3. Consultative meetings and field visits with fishers

The second set of data was collected to determine the existing legal practices for catching octopus and also to gather maximum information before designing the Artificial Reef (AR) model. Data was collected through several consultative meetings with octopus fishers and other stakeholders. Field visits were organised to study the octopus natural burrows and habitat.

4. Testing of AR model.

The third set of data was collected from the test carried out with the AR model, on the outputs, efficiency, and practicability of the AR and also to determine the number of ARs to be attributed to each fisher. A sample of five fishers was selected for this exercise, each was given 8 ARs. Data was recorded two months later. Squatting was reported after **six months** of AR placement.

RESULTS

1. Fishmongers' interview.

Five fishmongers from the two coastal villages with over 20 years of experience were interviewed. They all confirmed the presence of **three types** of octopus (*Disab, Mamzel and Corail*), two of which (*Mamzel and Corail*) are of commercial values.
Mr C. Michel of the Mauritius Institute, confirmed the present of *Octopus cyanea* (Gray), *Octopus filamentosus* (Blain), *Octopus macropus* (Risso) and *Octopus rugosus* (Bosc).

All the five fishmongers confirmed an increase in the number of fishers and decrease in catches. They also agreed that decrease in resources and an increase in number of fishers are causing conflict among octopus fishers. They all noticed a daily decrease in collection of octopus per fisher, undersize collection is very frequent.

In summer monthly catches that was 8-10 kilo per fisher, some 20 years back has drastically decreased to 2-5 kilo.

All the fishmongers agreed that **MPAs** or '**No Take Zone'** can help in protecting the breeding grounds of octopus.

2. Survey on natural burrows & their occupancy

A total of four sites were surveyed within the lagoon at **Merville** and **Grand Gaube** the number of burrows and their occupancy were recorded, results are given in **Table 1** below:

	Merville -1 Unaffected[1]	Merville -2 Affected[1]	Grand Gaube -1 Unaffected	Grand Gaube -2 Affected
No. of burrows	12	4	11	3
Occupancy	6 5 6 5 5 6	3 2 3 2 2 3	6 5 4 6 5 5	2 2 2 2 1 3
Average % Occupancy	45.8	62.5	46.9	66.6

1. Affected or unaffected due to previous sand mining activity

Table 1: Natural burrows and occupancy rate.

3. Consultative meetings and field visits with fishers

A. Characteristic of Natural burrows and burrowing habits of Octopus

A study of the characteristic of the natural burrows and burrowing habit was carried out in consultation with octopus fishers and other stakeholders. The results revealed that octopus burrows are mainly found in shallow water 1-5 meters deep, inside the coral reef barrier.

Octopus burrows are more often found in the proximity of openings in the reef barriers and are mostly located in hard sand sediments or holes of big heavy coral, locally called ‘Corail Tête Mor ‘, and the burrows do not necessarily face up-ward.

Most of the octopus fishers are well acquainted with the location of the natural burrows of their locality. Natural burrows usually do not have a permanent occupant and are squatted by passer-bys. Octopus burrows with rather small openings seem to give more protection and are more popular. Once in nest, the occupant closes the entrance with small corals and other debris. In general, octopuses in natural burrows are not usually found closed to each other. Octopus is nocturnal, go out for feeding and return to their respective burrow before day light.

B. Previous attempt in making artificial reef for octopus and identifying the failing factors

Some fishers agreed having made an attempt to create artificial reef for octopus using broken concrete blocks. Many of them also confessed having caught octopus in artificial reef such as broken pots, bottles and empty cans.

The difficulties experienced by the fishers, in an attempt to use the concrete blocks as artificial reef, were that concrete blocks were light with large rectangular-shaped

holes. Thus the form and structure offered low resistance to the water current and were more likely to be moved or carried away by water current. The large opening seemed to be unpopular for the occupant as it seemed rather unsafe. In addition, concrete blocks which are usually soft, tend to be subjected to harpoon damages during the fishing process. Finally, concrete bricks artificial reefs were not easy to remove for cleaning and maintenance and were fragile with a relatively short life.

C. The fishing techniques taking into consideration the existing legal framework

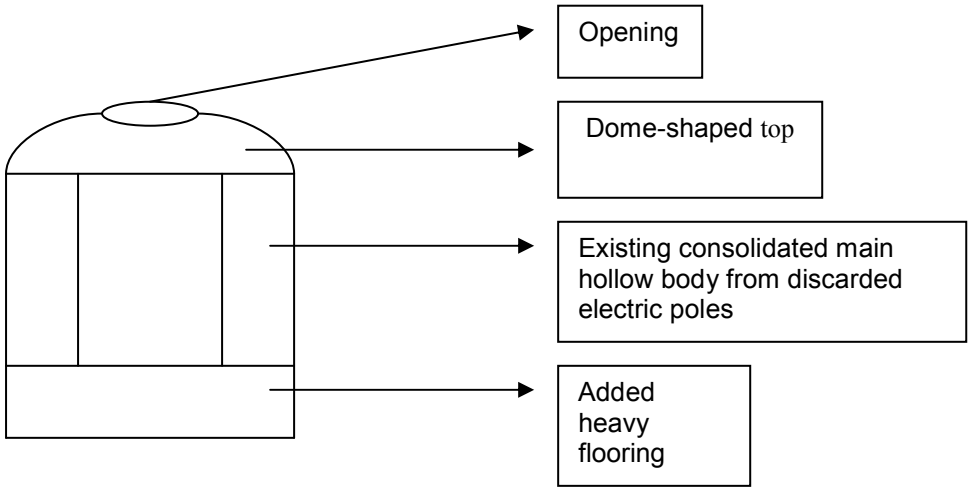
The Ministry of Fisheries controls all the fishing practices and techniques used under existing legal framework[8]. Octopus fishing is only allowed using long harpoon from fishing boat only. The fishers are not allowed to step out of the boat. Snorkelling, diving and using small harpoon or using spear gun to fish octopus are not allowed in Mauritius.

4. Artificial Reef

A. Making the Artificial Reef

The Artificial Reef was designed to be heavy so as to be able to resist under water current. The wall of the Artificial Reef was consolidated with galvanised iron. The walls of the AR were made of concrete. The concrete thick flooring of the AR made it heavy and kept it straight with its opening facing sea surface. The Artificial Reef was cylindrical and dome-shaped on top with a small opening to allow water flow with minimum resistance in all directions.
The opening of the AR was kept small[9] to provide protection to the occupant while at the same time allowing for hand cleaning of the inside space.
The design has also taken under consideration the manipulation of the AR, that is, careful placing and easy removal of the Artificial Reef for cleaning and maintenance purposes or for shifting to different location.

The Artificial Reefs were made from discarded electric poles which are already consolidated with steel wires and are still very strong to resist marine water environment. The 15m discarded electric poles were cut into 200-300cm length. Thick flooring and the dome-shaped top is added to the chopped cylindrical hollow pieces for the making of the AR as describe in **Figure 2** below:



[8] Spear guns, short harpoons are prohibited. Fishers are allowed to use only long harpoons from fishing boat.
[9] The diameter is about 6 to 8 cm.

Fig 2. Artificial Reef made from discarded electric poles

Photo 1: Artificial Reef occupied by octopus

The electric poles were hollow and made of weathered concrete used for more than 40 years. The wall of the electric pole are armoured with longitudinal and circular steel wires thus making it very strong and resistant to harpoon strikes during catches. The discarded electric pole is indeed an eyesore in many public places and is a health hazard associated with proliferation of mosquitoes and rodents.

B. Handling the Artificial Reef

The AR can be handled from fishing boat using simple handling technique. The transformed structure can be manipulated easily from the boat as shown in **Figure 3** below:

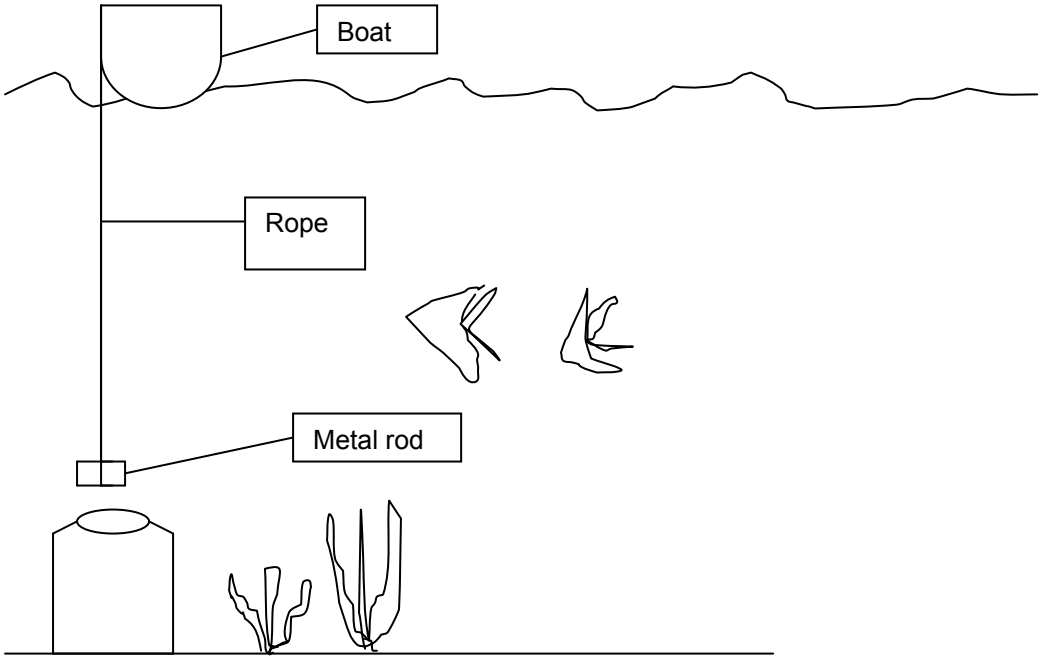


Figure 3: Handling technique of the artificial reef

C. Test the AR model with local fishers.

Results obtained from 5 fishers fishing with 8 ARs, have given an average yearly catch of 194 kg with average 71.2 kg during the winter months and 122.8 kg during the summer months as shown in the table below. The average daily catch per fisher

was 16.1 Kg. This represents an average monthly income of MUR 1617[10], based on the prevailing price of MUR 100.00 per kilo of wet weight octopus at the landing stations. Results are given in Table 2 below:

	Months	Jan	Feb	Mar	Apr[1]	May[1]	Jun[1]	JL[1]	Aug[1]	Sep	Oct	Nov	Dec	Average yearly catch per kg
Fisher 1		21	22	18	16	16	15	15	13	13	14	18	19	200
Fisher 2		19	21	19	15	14	14	13	12	12	13	17	20	189
Fisher 3		20	21	17	16	15	14	13	13	13	14	17	21	194
Fisher 4		19	20	18	17	15	14	13	13	12	13	18	19	191
Fisher 5		20	22	19	16	16	15	14	13	12	14	16	19	196

Table 2: Yearly catch of Octopus on using 8 ARs [1]Winter months

DISCUSSION

Results have shown that the percentage of occupancy is higher in the affected areas (>60%) than the unaffected areas (45%). Increasing the number of burrows in the affected areas to mimic the unaffected areas, with the present occupancy rate, may show a decrease in occupancy rate at the affected areas but would increase the nesting number of individuals at the sites.

Results have also shown fishers fishing with 8ARs intended to be used in affected locality or otherwise, have shown a daily average catch of 16.1 kg per day. Based on actual local market wet price of MUR 100.00 per kg and calculated on 20 active fishing days per month, the monthly income has increased by MUR1600.00 monthly. Increasing the number of ARs to more than 8 may result in a quick exploitation of the resource and also arouse conflict among fishers on availability of productive sites.

With an estimated number of 30 active octopus fishers in the two coastal villages, a maximum of 240 ARs will cover about 10 km^2 of fishing grounds.

Placing 8 ARs in the affected areas may increase the daily catch to more than 16.0 Kg per month, with an additional income of about MUR 1600.00 per month, which is on the low side of the expected increase in monthly additional income.

However, in the AR pre-distribution workshop, fishers were encouraged to allow the octopuses to attain full adult size[11] which ranges from 1.5 – 2.5 kg or above.

[10] Approximately $50

[11] It takes 4 months for an octopus to reach adult size.

Harvesting adult size octopus attaining an average wet weight 2.00 kilo per unit octopus, will double the monthly income and increase the production considerably on the local market. (The average monthly salary of an unskilled worker is about MUR 7,000 in Mauritius.)

However, the survey was carried out at a limited number of sites and requires further study on occupancy in relation to burrows positions, availability of food resources and existing predators.

This research has shown that the amount of fresh octopus has decreased over time (Fishmongers interview) as well as the size of octopus (≥0.250 Kg). It was also noted that octopuses are harvested well before attaining reproductive sizes.

To ensure recruitment of individuals, spawning and availability of larvae- which is obtained by protecting adult octopuses; male and female were allowed to attain reproductive size in a Marine protected Area (MPA) or 'No Take Zone' (NTZ). The location and size of MPAs or NTZ were chosen in consultation with the local fishers. MPAs may provide further reproductive opportunities by increasing the number of burrows using Artificial Reef, if required.

CONCLUSION AND RECOMMEMDATION

The reconstruction of the damaged habitat at the affected sites using Artificial Reef (AR) was the principal objective of the project. In its wake, it will also increase octopus which was becoming scare while at the same time increasing the income loss over the years. Other objectives are to avoid overexploitation, ensure recruitment and encourage full productive capacity of the resource.

As stated before, contrary to usually stated benefits, Artificial Reef can potentially have harmful effects on octopus population by increasing the catch per unit effort or by increasing access to previously unexploited stock. This may lead to an increase in the probability of overexploitation by concentrating stocks (*Grossman et al, 1997*).

It is therefore always necessary to have a concentration stock or a 'No take' zone in the fishing ground of the locality well before using the ARs, which if needed, has octopus burrows increased by supplementing with ARs to ensure adult protection to allow spawning and larval production.

The number of ARs should be limited to ≤ 8 so as to allow a wise use of the resource and at the same time to ensure a basic income, i.e, income derived from the use of ARs should be over and above the normal fishing activity.

In order to increase this income, further octopus fishers using the same number of ARs, are encouraged make an effort to monitor nesting stocks and to harvest individuals at adult size not only to allow spawning, larvae production and to ensure recruitment but also to increase production on the market

To attain these resource management objectives, fishers should be encouraged to avoid conflict and engage in sound fishing practices so as to improve production to full capacity by harvesting only full size individuals.

To conclude, no management strategy will succeed without the participation of the users. Therefore it is of paramount importance to include all stakeholders in every step involved in the development of the project. In addition, further studies on the food composition and preferences, location of burrows, habits and behaviour of octopus can expand the scope of the present work.

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