ISBN 983-9114-13-1
OCTOBER 2004
SEAFDEC MFRDMD/SP/6

A GUIDE TO MAKE AND SET DURABLE ARTIFICIAL REEF FISH AGGREGATING DEVICES (ARFAD's) FOR COASTAL AREAS

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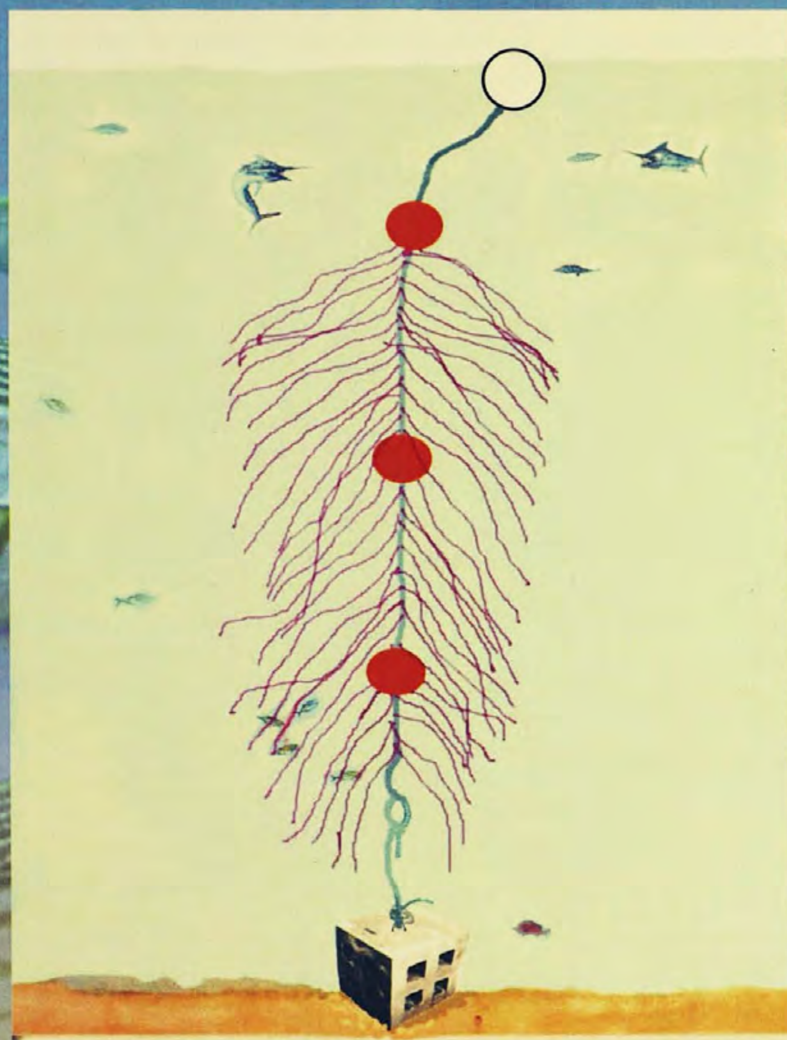

Department of Fisheries Malaysia
and
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First Edition January 2004
Second Edition October 2004

Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

A guide to make and set durable reef fish aggregating
devices(ARFADs) for coastal areas/Ahmad Ali...[et al.].
ISBN 983-9114-13-1
1.Artificial reefs. 2.Fish habitat improvement. I. Ahmad Ali
639.977

ACKNOWLEDGEMENT

This guideline was made possible based on accumulated knowledge and experiences of the authors through their studies in the coastal waters of Peninsular Malaysia from 1996-2002. Considerable improvement in the basic design has been achieved in 2002, by trial and errors, with minimal specialist consultancies.

The overall project is funded by SEAFDEC Regular Fund (2000-2001) under the Marine Conservation and Stock Enhancement Program, entitled "Construction and Setup of Durable Fish Aggregating Devices (FADs) for Coastal Fishermen in SEAFDEC Member Countries"; Ministry of Science and Technology Malaysia (1996-1998) under the Intensification of Research in Priority Area (IRPA Fund No: 01-03-01-0078 entitled "Ecology, carrying capacity, habitat enhancement of some selected sport fishes); and also from the Department of Fisheries Malaysia under Artificial Reef Program (2001-2003).

The authors wish to thank the Director General of Fisheries Malaysia, Dato' Junaidi Che Ayub, Chief of MFRDMD, Mr. Raja Mohammad Noordin Raja Omar, former Chief of MFRDMD, Mr. Ibrahim Saleh for their endless supports and permissions to carry out this project. Last but not least, the authors are indebted to all staff of MFRDMD, especially Mr. Abdul Aziz Yusof, Mr. Nik Nasruddin Nik Ismail, Mr. Rosdi Md. Noor, Mr. Mohd Nasir Mohd. Kasni, Mr. Nik Rani Nik Mat and Mr. Abdul Rashid Ismail, who are actively involved in the deployment, monitoring and underwater photographing of activities.

We are particularly grateful to Mr. Sukarno Wagiman, Senior Fisheries Officer, Marine Park and Recreational Fisheries Section, Department of Fisheries Malaysia, Kuala Lumpur for reading and reviewing our manuscript critically, in formatting our style of writing, correction and comments made for the improvement of this guideline.

PREFACE

The objectives of the study are to improve currently used traditional Fish Aggregating Devices (FADs) known as "unjam" for coastal fishers in Malaysia, to increase catch rates with minimal fishing cost and to enhance biological productivity and fisheries resources in the coastal waters especially within the 5 nautical miles from the coastline. This area is protected from commercial fisheries and only traditional fishers can operate within this area. We introduced a durable design of Artificial Reef Fish Aggregating Device (ARFADs) that will provide a more stable and dependable enriched ecosystem for fishers to exploit fisheries resources.

This newly design of ARFADs are made up of 3.2 tones concrete anchor, plastic appendages and floats. After a few years of deployment, this structure has turned into new habitats that resembles natural habitat for several demersal fish species as well as sanctuaries for fish and other marine lifes. The concrete anchor may also act as hindrance from illegal trawlers encroaching in the areas as well as creating new fishing spots close to villages for subsistence or recreational purposes. The aggregation, enhancement and diversification of pelagic and demersal fish resources resulting from this ARFADs structure could, in many cases, lead to economic gains of the coastal fishers.

This environmental friendly ARFADs only be applicable to traditional fishers using selective gear, especially hook and lines. The catch from this fishing gear is known to be very selective and only marketable sized fish is being caught. This will eventually increase catch performance of traditional fishers as well as not causing any possible effect of overfishing in the coastal areas.

The ARFADs are also popular sites for recreational anglers and divers because they provide convenient sites with concentration of fish and multitude of unique flora and fauna of marine lifes which is similar to the natural coral reefs. This will give an indication that coastal areas could be considered as potential sites for recreational fishing activities.

The sites of ARFADs can be managed through the establishment of Locally Based Coastal Fishery Management which is highly recommended and encouraged for the sustainable exploitation of fisheries resources.

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1.0 INTRODUCTION

Artisanal fishers have developed various designs of Fish Aggregating Devices (FADs) to create fishing ground close to their villages. In Southeast Asian Region the use of FADs is widespread for between 30-100 years ago. In Malaysia it is commonly known as "unjam" (Sakri, 1991); Indonesia called "rumpon" (Hardjono, 1991); and the Philippines called "payao" (Aprieto, 1991).

The structures were traditionally constructed using sticks, pole, bamboo, or bundles of brush or fronds. A fish aggregating device is any structure or device of permanent, semi-permanent or temporary nature made from any material and used to lure or aggregate fish. The definition of these devices as described by Prado (1991) can take many forms and these fall into three basic categories as shown in Table 1.

Table 1 : Categories of Fish Aggregating Devices (FADs)

Categories	Depth	Types
1. Surface	Deep water	Free floating
	Shallow water	Anchored
2. Mid water	Inshore	Luring/harvesting
	Offshore	Aggregating
3. Bottom	Deep water	Wrecks
		Artificial reefs
		Offshore structures
	Shallow water	Natural reefs
		Offshore structures
		Shoreline, protection structures, pipelines, etc.

Source: Prado (1991).

Among the above categories, bottom FADs (artificial reef) have been found to be the most popular form of fisheries resources enhancement in many parts of the world. But due to destruction of reefs through coastal development and illegal trawling activities, many reefs have been destroyed. This will reduce areas for feeding, spawning and nursery grounds of fragile marine ecosystems. Many efforts had been spent to rebuild this destroyed ecosystem. The appropriate strategy to achieve a healthy ecosystem is through the development of artificial reefs (Edward, 1991).

The principle objectives in the construction of artificial reefs in the coastal waters of many countries in the Southeast Asian region are to enhance biological productivity and fisheries resources, to rehabilitate and conserve marine habitats that have been adversely affected by fishing activities and to generate the recovery, conservation and increase the fisheries resources (Edward, 1991).

The artificial reefs are able to aggregate many varieties of fish species especially demersal fish species of various sizes. With combination of midwater FADs, this structures able to attract both pelagic and demersal fish species. This is a new approach to aggregate multiple fish species as well as a means to enhance fisheries resources of coastal areas (Sainsbury *et al.*, 1988).

2.0 ECONOMIC OF ARTIFICIAL REEF AND FADs

Fishers have learned from experience that fish aggregates around flotsams, reefs, and sunken boats in the ocean (Sakri, 1991). Once a school of fish found an artificial reef or FADs, it will stay there for days, weeks, months or permanently reside there for ages. Artificial reefs and other fish aggregating devices can improve the economics of fishing operation by reducing time and fuel spent in fish searching. The aggregated schools of fish tend to increase catch per unit effort due to increase in vulnerability or availability of the targeted species. This will eventually improve the catch and economic returns of the small-scale fishing operations. Experiences have shown that most fishers are reluctant to abandon proven fishing ground for new ones. But for artificial reef and FADs with exact location will enable fishers to moor and concentrating fishing for several hours.

3.0 ARTIFICIAL REEF, FADs AND FISH BEHAVIOR

Fish are attracted to artificial reef and FADs just as bees are attracted to honey, vultures and crows are attracted to dead animals and sea birds are attracted to the schools of fish. Studies have shown that evolution of succession has occurred around FADs with predators preying on small prey species that came earlier. To avoid predation, these small preys will look for hiding places such as FADs and artificial reefs. The fish do not stay close at the reef and FADs all the time. They may go away and come back to it at different times of the day. Some fish are attracted to artificial reef and FADs throughout its entire life cycle, where others seem to exhibit the behavior only during part of their life cycles (Ben-Yami, 1989)

4.0 PROBLEMS WITH LOCAL TRADITIONAL FADS ("UNJAM")

An "unjam" comprises a bamboo pole of approximately 10 m long as a float (sometimes oval polyurethane float), attractors (underwater appendages) made of coconut fronds (sometimes alternate with cinnamon, nipa, casuarinas) tied to the whole length of the anchor line, and sandbags or wooden boxes filled up with sand as an anchor (Figure 1). The underwater appendages are normally tied to the anchor line at interval of 2 m. For the anchor, usually two sandbags of 100 kg each were used for each "unjam". The average life span of a productive traditional "unjam" is around one to two months old. Hand-lining using jigs or baited hooks are a very popular method of fishing around "unjam" by traditional fishers (Sakri, 1991).

Premature lost of traditional unjam in coastal water due to illegal trawler activities is a common phenomena. Conflicts between trawler operators and other unjam associated gear operators are common. Trawler operators often encroach to coastal water and take advantages of the aggregations of fish at or around the unjams to sweep beside, and sometimes over the unjams which result in a great financial loss to the coastal fishermen who deployed them (Ahmad, 2000).

The present deployment technique of unjam does not follow any specific arrangement, but is solely based on the traditions and experiences of the fishermen. An important fact is that by having a well-arranged unjam in smaller number, it would serve to reduce the cost of unjam installation in a fishing area, as well as making the area of water more easily navigable, while at the same time maintaining a high catching probability of the fishes in the area (Sakri, 1991).

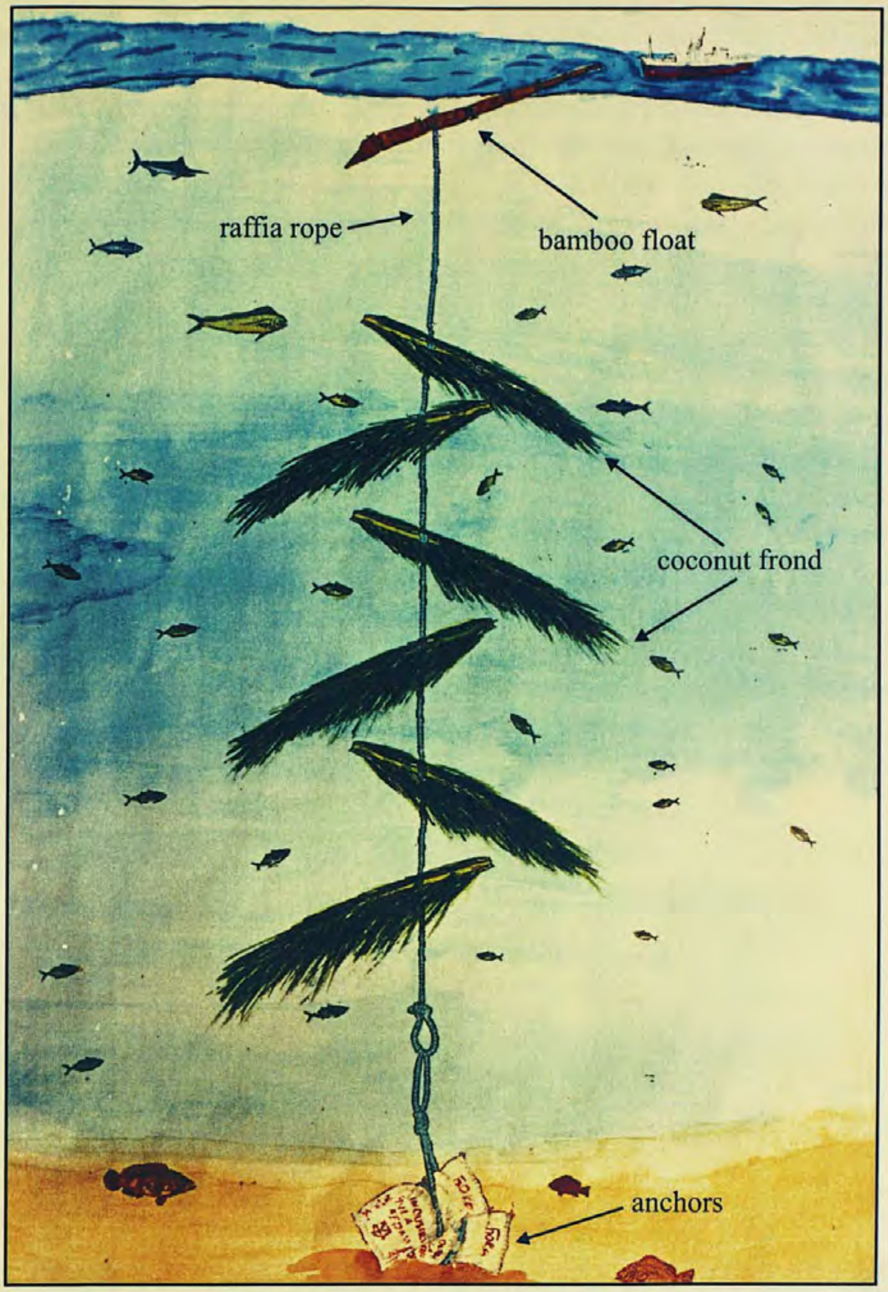

Figure 1 : An unjam, a kind of FADs commonly used by Malaysian fishermen

Beside the damage which usually occur to the floats and underwater appendages of the unjams, another reason contributing to the short endurance period was the anchoring mechanism of the unjams which use sandbags as the anchor which only can last for about 2 months.

Illegal trawlers have the tendency to destroy newly deployed of "unjam". This cause a great loss to the traditional fishers as well as creating conflicts among fishers in the coastal areas. The use of newly design ARFADs tend to prohibit the activities of illegal trawlers because of the congregation of 3.2 tonnes of concrete anchors for each unit in the area.

5.0 CONSTRUCTION OF DURABLE ARFADs

The most commonly used method in aggregating fish in the coastal waters of east coast Peninsular Malaysia is the usage of traditional FADs. These devices are commonly used to attract and hold schools of pelagic fish species only. Installation of several groups of FADs in one site with proper arrangement will attract a substantial school of fish. The devices are beneficial to the small-scale fishers in term of their effectiveness in augmenting catches.

The combination of FADs and artificial reef in one unit is referred to as ARFADs. Figure 2 shows a diagrammatic drawing of ARFADs. The device has three components; floats, an attractor, and an anchored mooring. The upper part of the structure consists of float, appendages and mooring line. This part is commonly referred to as fish aggregating device and it is used to attract pelagic fishes only. The float is attached to a heavy molded concrete anchor resting on the bottom of the sea by means of a long anchor line made of polyethylene rope, known as mooring line. This anchor acts to hold the FADs in position as well as acting as artificial reef to attract demersal fishes. A very important part of the FADs is the fish attractor. This part is made of plastic strips and attached to an anchor line. The attractor and concrete anchor have the tendency to lure both pelagic and demersal fishes to the ARFADs.

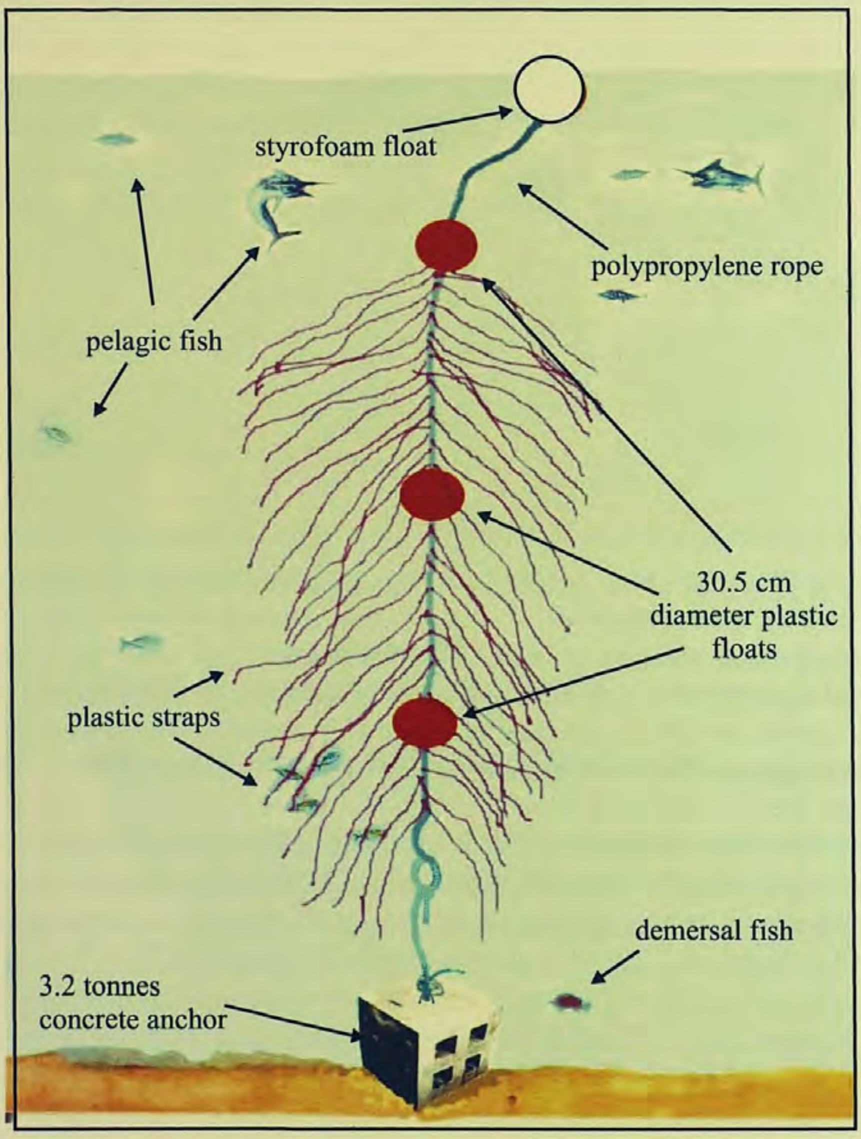

Figure 2 : A durable ARFADs that is recommended for attracting both pelagic and demersal fish species in coastal areas

5.1 Floats

Floats must be strong enough to support the weight of appendages and to make the anchor line into vertical position. Figure 3 shows submerged floats which are the major part of ARFADs in supporting anchor line and appendages. The surface floats that are attached to the FADs are primarily used to assist fishers to locate location. These floats are made of styrofoam as shown in Figure 4.

The submerged floats used for these ARFADS are made of hard plastics of 30.4 cm in diameter with a 2.5 cm hole in the middle. Each ARFADs has 4 to 6 floats according to the water depth. Spacing between each float is about 4 meter.

Figure 3 : The submerged floats used for these ARFADS. The size of each float is 30.4 cm diameter with a 2.5 cm hole in the middle

Figure 4 : Styrofoam floats used as surface float. The size of each floats is about 33 cm diameter

5.2 Anchors

An anchor is used to keep the FADs in its proper location. Well-constructed massive anchors such as those made from concrete are essential for holding ARFADs in place over a long term period. These concrete anchors are recommended for durable ARFADs and they are well suited especially for course sand and rocky bottoms. Those anchors that are constructed according to recommended specification will have a longer life span. A square, concrete anchors with 4 holes at every side with a mass weight of about 3.2 tonnes are recommended (Figure 5). The holding power of this concrete block in the water is 1:2. In other words, a properly-design concrete anchor can withstand forces up to 50% of its mass, or weight. A 3.2 tonnes concrete anchor has a holding power of 1.6 tonnes in seawater. Detail measurements of this anchors are tabulated in Appendix A.

Figure 5 : A side view of a 3.2 tonnes concrete anchor

The recommended concrete block anchor resists slippage due to friction between the anchor's base and the seabed. The anchor will slip, or become displaced; when the force exerted on the anchor exceeds the force of friction between the base of the anchor and the seabed. The smaller the area of the base, the less friction between the anchor and the seabed, and the lower the amount of force needed to displace or slip the anchor. The larger the base, the greater is the friction and the greater the force that the anchor can resist. Based on several studies by MFRDMD in the South China Sea, a square-block concrete anchor with base dimension of 129 cm x 129 cm and 136 cm height is recommended for coastal waters in the Southeast Asian region (Ahmad, 2002 unpublished). The total weight of this anchor is about 3.225 tonnes. The mixture ratio of 3:1.5:1 for sand, gravel and cement was used in the construction of a concrete block. A total of 1,650 kg sand, 825 kg gravel, 550 kg of cement and 200 kg steel bars was used to build one anchor. The total volume of each concrete anchor is about 1.6 cubic meters and a stainless steel bar was used as an attachment point for the anchor.

A concrete block requires 28 days of moist curing to attain its maximum strength. The moist curing technique requires that the concrete block be kept constantly damp. This is best done by covering the block with sacking and having water trickle onto it through a hose. A complete 28-day cycle of moist curing will produce the strongest concrete possible (Gates et al. 1996).

5.3 Construction of Concrete Anchor

5.3.1 Anchor Attachment Point (bail)

The anchor bail was constructed using a single piece of 1.5 cm diameter stainless steel round stock. The detail of the bail is shown in Figure 6. The anchor attachment point is about 10 cm from the base of concrete as shown in Figure 7.

Figure 6 : Details of anchor attachment point (bail). Total length of round stock is approximately 316 cm

Figure 7 : Anchor attachment point (Bail)

5.3.2 Reinforcing Concrete Anchors

Reinforcing the anchor will strengthen the concrete against cracking which were caused by the impacts during deployment and while in use. Reinforcing consists of a rebar cage constructed using 1.0 cm solid steel bar. All steel bars should be wire or welding together so that the cage forms a single unit as shown in Figure 8. There should be a gap of 7.5 cm between the steel bar and any external surface. The 7.5 cm cover of the concrete forms a barrier and this protects the steel from any corrosion caused by seawater. Detail measurement of this reinforcing concrete anchors are tabulated in Appendix B, C and D.

5.3.3 Iron Mould

Iron mould is made of iron sheet of 3.0 mm thickness. The material is recommended since it is strong enough to sustain the original shape of the mould during the process of pouring the wet cement mixture. The mould is designed in such away so that it could be easy to disassemble and stored for later use (Figure 9 and Figure 10).

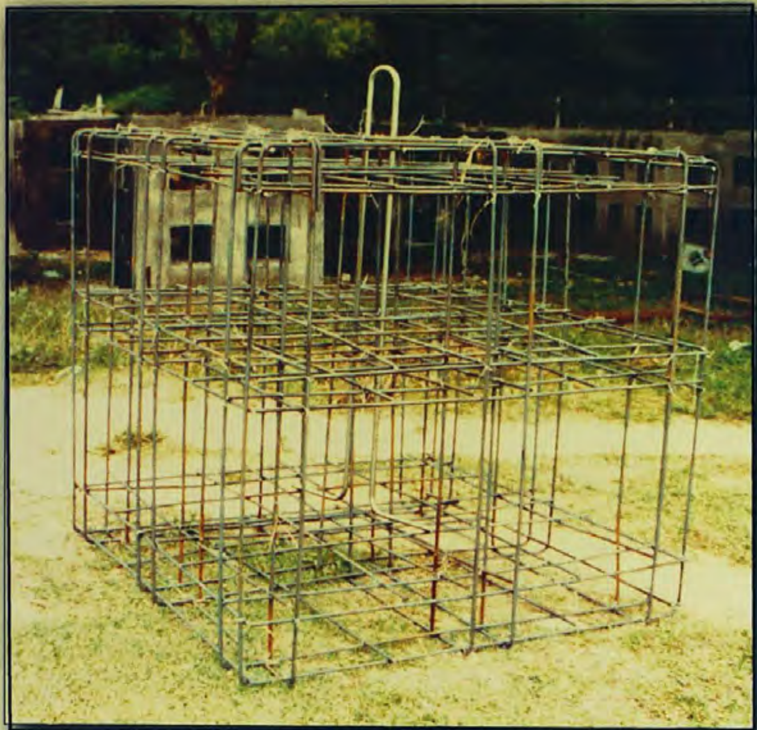

Figure 8 : Reinforcing concrete anchors consists of a rebarcage constructed using 1.0 cm solid steel bar

Figure 9 : A side view of the iron mould for concrete anchor

Figure 10 : A top view of the iron mould

5.3.4 Mixing Concrete

General-purpose cement is used for the construction of concrete anchor. The most practical method of constructing concrete anchor is by using a ready-made cement mixture with a mixture ratio of 3:1.5:1 for sand, gravel and cement (Figure 11). A good quality aggregate should contain sand and gravel which comprises 76% of concrete. The concrete is strongest and most dense when the aggregate material of sand and gravel contain particles of varying sizes. River sand is recommended because it contains fine aggregate. Beach sand, crushed coral and crumble rock are not recommended because they contain a lot of shells and weak during bonding.

The aggregate should remain clean and free from contaminants, especially silt and organic matters that can prevent the concrete from bonding.

For concrete anchors, the recommended maximum size of gravel is about 2.0 cm. The standard weight of a cement bag is 50 kg. In order to make a large batch of concrete anchors, the bag of cements can be used as a measuring standard and it can be used to measure all dry materials. Table 2 gives measurements of materials used for the construction of 3.225 kg concrete anchor.

Figure 11 : A ready-made cement mixture with the mixture ratio of 3:1.5:1 for sand, gravel and cement

Table 2 : Material required for the construction of 3.225 kg concrete anchor

Materials	Measurement
Cement	11 bags x 50 kg= 550 kg
Sand	33 bags x 50 kg = 1650 kg
Gravel (max size 2.0 cm)	16.5 bags x 50 kg = 825 kg
Water (23 liter per bag of cement)	253 liters

6.0 APPENDAGES

Appendages streaming along anchor line increase FADs effectiveness in attracting and holding schools of pelagic fish. There are many theories supporting the effective aggregating aspects of appendages. The appendage provides shelter, allowing a build-up of prey species, which provide a strong visual stimulus to the predators. Others believe that by increasing the underwater profile of the FADs, appendages increase the likelihood that fish will find the FADs and associated with it.

A wide variety of material and configuration have been used to construct appendages. Coconut and nipa fronds, mangrove leaf, rubber tyres, plastic strapping, old rope and netting have widely been used. Plastic straps that are used to bind cartons were found to be the most effective material for appendages (Figure 12). It is durable, inexpensive, present minimal drag on FADs system and simple to attach to the mooring line. It was widely used and considered very effective in most countries. Its efficiency in attracting fish species was proven through series of research in Malaysia (Ahmad, 2001).

The appendages were tied along the anchor line starting at 2 meters from the anchors up to the first submerged float (hard plastic float) which is about 2 meter below the sea surface. The simplest method for fastening the strap to the anchor line is by passing the straps through the anchor line (a-2.2 cm diameter polypropylene, 4 strands, z-twisted) and makes an over-hand knot. The straps should be knotted at the mid-point of 6 m length rope so that each of the two ends is 3 m long (Figure 13). The total weight of soft polyethylene tape used was based according to the water depth (Table 3).

Figure 12 : Plastic straps were used as appendages

Figure 13 : Plastic strips were knotted at the mid-point of the 6 m length rope so that each of the two ends is 3 m long

Table 3 : Total weight of plastic straps was based according to water depth

Depth	Weight
15-20 m	7 kg
20-25 m	9 kg
25-30 m	11 kg
30-35 m	13 kg
35-40 m	15 kg

7.0 ROPE

The rope is used to fix appendages, floats as well as concrete anchor. The quality and performance of any rope depends on the type of materials used and the way it is manufactured. Other important factors such as specific gravity whether the material floats or sinks in seawater, breaking strength, strength-to-size ratio, elongation and elasticity, resistance to cyclic and shock loading, abrasion resistance, and durability need to be also considered.

Polyethylene rope is inexpensive but it is not recommended because it has poor resistant to repeated loading and will break below breaking strength. The recommended rope material for coastal water ARFADS is polypropylene (Figure 14). Polypropylene has moderate breaking strength, ranging between 4,200 and 8,200 kg for 2.2 cm diameter rope. In seawater, the breaking strength of polypropylene actually increased slightly. Polypropylene has good elastic properties and it can stretch up to 9% of its length and still return to its original length. Having the specific gravity of 0.91 and it can easily float and its buoyant property has the tendency to lift weight. Polypropylene has excellent shock loading capabilities and it is fairly durable. The single most important exception to its durability is that it deteriorates when expose to sunlight.

The weight of a standard length of rope is the ratio between weight and length and it is commonly reported in terms of kilograms per 100 meters (kg/100 m) or kilogram per 220 meters coil (kg/220 m). Breaking strengths differ in similar sized ropes but having different weight due to different in amounts of material. Heavier rope has greater breaking strength, greater workload rating and can withstand greater shock loads. Apart from the strength of the rope, the weight: length ratio of the polypropylene rope is also important. Because of buoyancy, heavier polypropylene rope able to lift heavier hardwares from the bottom. The recommended weight:length ratio for ARFADS is 0.388 kg/m.

Figure 14 : A 2.2 cm diameter polypropylene rope used as anchor line

7.1 Rope Lengths

The length of polypropylene rope required for coastal water ARFADS depend on the water depth of the site. The length is important so as to ensure that the mooring line maintains in vertical position at all times during high and low tide and not entangle with nearest ARFADS during strong currents. The ideals length of rope is the same with water depth during high tide. This to make sure that fishers can easily find ARFADS upper floats.

8.0 SITE SELECTION

In order to benefit small scale fishers, the selected site for ARFADs should not be too far away from any fishing village. The criteria for deployment of these ARFADs in selected area are based on the availability of fish for aggregation, oceanographic and meteorological conditions. In evaluating a particular site, consideration should be given to the bottom topography, wind, wave and current actions and other infrastructure such as jetty and availability of pontoon for transferring ARFADs material to the selected site. The ideal location should be those in shallow calm areas (15-30 m) of low shipping line with bottom type hard enough to prevent the sinking of anchor. The sediment types of coarse sand (0 to +1 phi), very coarse sand (-1 to 0 phi) or granule (-2 to -1 phi) are highly recommended. The selected areas should also be free from any trawling activities or drift netting. It is very important to take sediment sample before any deployment of ARFADs because the anchor will submerge (disappeared) if the seabed is not stable.

9.0 DEPLOYMENT

Installation of these ARFADs involves heavy weight anchor at about 3.2 tonnes each. Before deciding where and when to set ARFADs, the weather conditions need to be considered and they should be set during calm and clear day. Adequate safety procedures must be observed during the deployment of the structure with anchor-last method is recommended to be used. The application of this method is the most safest way during deployment.

Prior to deployment, the site must be thoroughly investigated in order to avoid any unforeseen problems. Once the location is identified, the upper part of ARFADs which contain polypropylene rope with appendages and floats were jettisoned first while the anchor that had tied with the other end of rope remains secured on board. The barge slowly drift away to prevent entanglement of upper part of ARFADs. Once everything is clear, the anchor is released into the sea. Figure 15 shows the barge with ARFADs was towed to the deployment site. The anchor-last method showed in Figure 16 and Figure17.

10.0 ARRANGEMENT OF ARFADS

Normally 25 units of ARFADs are deployed in each location. The ARFADs were arranged according to 5 by 5 units as shown in Figure 18. The distance between each FADs is about 10 meter.

It was found that fishing is more successful around many ARFADs set at one site as compared to only single FADS (Ahmad, 2001). The fishers have the opportunity to fish at all time in any sea current direction within the area.

Figure 15 : Transportation of ARFADs to the deployment site

Figure 16 : The anchor-last method applied during the deployment of ARFADs

Figure 17 : Another style of the anchor-last method applied during the deployment of ARFADs

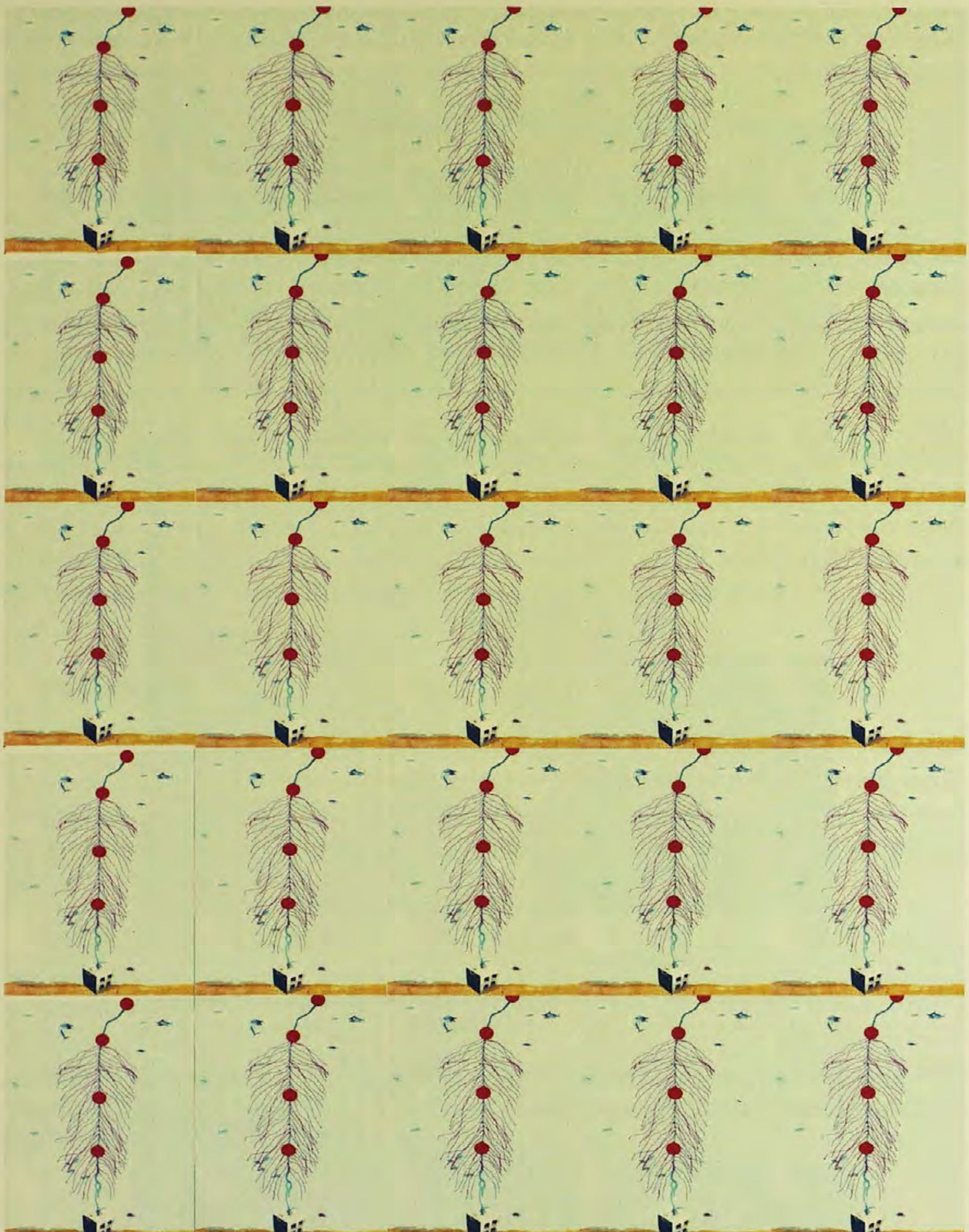

Figure 18 : A-5 X 5 arrangement of ARFADs

11.0 THE FLAG/ BUOY

Some fishers use land marking as reference point for the location of their FADs. However, it is important to put a flag or float so that the fishers can see it far away (Figure 19). It is recommended that the flag or float is brightly red, white or orange in color so it can make them visible from far off.

Figure 19 : Brightly colored float so that it can be seen from distance

12.0 LIFE EXPECTANCY

The life span of each ARFADs is expected to be more than 10 years with the anchors, expected to last longer than 10 years. It is expected that plastic straps will last for more than 10 years in the sea condition. However after 6 months, fishers should put extra floats to support heavy appendages that caused by fouling flora and fauna. Fouling organism of the ARFADs appears to enhance its effectiveness as shown in Figure 20.

Figure 20 : More floats should be placed after 6- month of deployment in order to support the extra weight caused by fouling organisms

13.0 FISHING AROUND ARFADS

Hand lines, squid jigging and trolling were recommended to be used around ARFADs. Hand lines are selective gear and the catch can be controlled by using different size of hooks. Fishers can tie the boat to the floats or drift around and use live or dead baits for fishing. The most effective hours of catching were at dawn, early morning and late evening.

Jigging for small pelagic fish using small feather or plastic lures was also practicably used around ARFADs after 2 weeks of deployment (Figure 21, 22 and 23). Live baits are usually used for catching target species such as Spanish mackerel. In trolling, towing live or dead baits at low speed is more efficient than artificial lures. The fishers of Terengganu use squid jigging around ARFADs during night and day time to catch squids species such as *Loligo* spp. (Figure 24), *Sepia* spp. (cuttlefish) and *Sepioteuthis lessoniana* (bogfin reef squid). Other methods such as trap and gillnets are strongly not recommended because they can easily entangle with mooring line. Uncollected trap around ARFADs will also caused ghost fishing as shown in Figure 25.

Figure 21 : A shoal of pelagic fish around ARFADs after 2 weeks of deployment

Figure 22 : A shoal of pelagic fish swimming close to the sea surface at the ARFADS sites

Figure 23 : Jigging for small pelagic fish using small feather or plastic lures

Figure 24 : Squid jigging around ARFADs were used to catch squids during day and night time

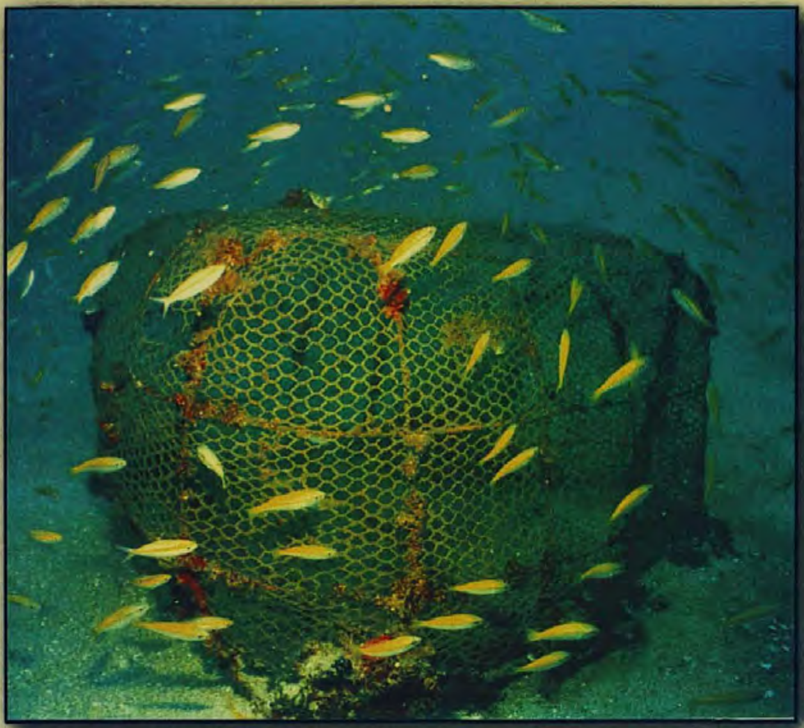

Figure 25 : Uncollected trap around ARFADs will cause ghost fishing

14.0 SPECIES CAUGHT

Fish caught from ARFADs consists mainly groupers, red snappers, sweetlip, Indian mackerel, Spanish mackerel, barracuda, scads, yellow snapper, nemipterids, trevally, starry trigger fish, dolphin fish and sharks. The species composition of the catch differs according to the technique employed. For example, fishers which used mostly trolling caught Spanish mackerel and dolphin fish. For the fishers who used hand lines caught mostly grouper and snapper. Figures 26-28 shows several species caught using hand-lines around durable ARFADs.

Figure 26 : A sweet lip caught at the site where durable ARFADs were deployed

Figure 27 : Demersal and pelagic fish species caught around durable ARFADs

Figure 28 : A grouper caught during fishing around durable ARFADs

15.0 MAINTENANCE OF ARFADS

Fishers should always give more attention to the surface floats (styrofoam float) because once the floats break loose from the ARFADS, the appendages will fall on the sea floor. The propellers of passing boats may cut floats on the upper surface of the sea. To prevent this from happening, fishers should therefore pay more attention each time they do fishing around ARFADS. Rope that is not properly attached to the surface float need to be replaced so as to prevent the surface float from drifting. After 3-6 months of deployment, barnacle and other flora and fauna will covered the appendages and the surface floats will sink. The weight of the appendages needs to be compensated by placing additional floats usually made from plastic drum at the upper section of the rope of ARFADs (Figure 29).

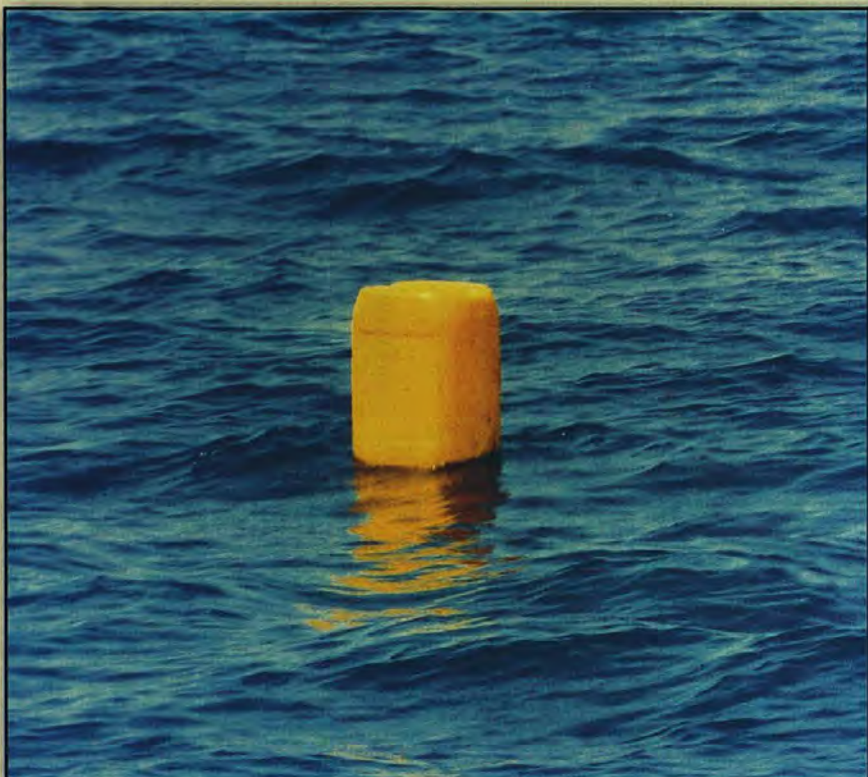

Figure 29 : Additional floats such as plastic drum was used to support an extra weight caused by fouling organisms

16.0 RECREATIONAL FISHING AND SCUBA DIVING

Marine recreational fishing is a well-known healthy activity and has the potential to be developed into profitable economic sector in this region. It is a form of out-door recreational activity where individuals spend their leisure time purely for physical and spiritual satisfactions. The important aspect of recreational fishing is to test the fishing skill of fisher against the fish as well as to give the fish the chance to struggle free. Over the years, there has been a steady increase in the number of people involved in recreational fisheries and it has become one of the most popular out-door recreational activities in Malaysia. An estimate of about 2 million anglers are actively involved in fishing activities during weekend or holidays. Other than this, more than 150 fishing clubs and association, more than 10 monthly fishing magazines and more than 20 websites are involved in recreational fishing activities.

Recreational anglers are fully dependent on the present of sizable stock of fish population, especially sport fishes like marlin, sailfish, grouper, shark, ray, barracuda, red snapper, trevally, dolphin fish, tuna etc. to carry out and enjoy their activities. Not all anglers can effort to pursue large game fish offshore. Some of the fish, which are good for recreational fishing, were also observed inshore. This has given an indication that coastal area could also be considered as a site for recreational fishing. To enhance the coastal fishery resources, these durable ARFADs are useful in attracting and concentrate both pelagic and demersal sport fishes. These durable ARFADs are now among popular sites for recreational anglers and divers (Figure 30 and Figure 31).

Figure 30 : Squid jigging is one of the popular activity among recreational anglers at the ARFADs locations

Figure 31 : Durable ARFADS are now among popular site for scuba diving activities

17.0 ARFADs OWNERSHIP

All ARFADs in coastal waters of east coast Peninsular Malaysia are set by MFRDMD and the Department of Fisheries Malaysia (DOFM) considered them to be common property of local fishers (Figure 32). All traditional fishers and recreational anglers can fish around those ARFADs because DOFM considers the ARFADs deployment program as a needed indirect subsidy to coastal fishers. The introduction of ARFADs allows fishers to obtain supply of fresh fishes throughout the whole year including during northeast monsoon season.

Figure 32 : Traditional fishermen fishing around durable ARFADs during squid jigging season

18.0 MANAGEMENT ISSUES

Fish aggregating devices are meant to retain migratory fish species to remain temporarily or aggregate in scattered schools and this caused for them to be caught easily. This type of activity can lead to a long-term overfishing of stock and such phenomenon has occurred in a purse seine fishery associated with FADs. However, this type of problem has not occurred yet in coastal waters of Malaysia because the exploitation of the resources was only done by trolling, jigging and hand lining. Only big fish is targeted by local fishers. As long as the total fishing effort on the resources is kept at minimal level, the effects of those ARFADs on the resources are also not harmful. The only potential problem caused by ARFADs is competition between gears and fishers.

Fishing effort should be distributed wisely in order to avoid any conflict among fishers. These durable ARFADs are useful mechanism in preventing any trawling activities. These closed areas from trawling activities will protect juveniles in shallow nursery grounds and provide fishing sites for artisanal fishers using selective gear to capture big sized fish. The application of durable ARFADs should be a community project and fishers are encouraged to play a major role during planning, construction and maintenance.

19.0 COSTING OF ARFADs

Table 4 shows the summary of overall cost incurred for ARFADs deployed at 25 m depth in 2003. The total cost for the construction of 66 units of ARFADs is around RM 79,000 (US$ 20,627). The cost for the construction of concrete anchor and deployment is around RM 68,000 (US$ 17,755) and the rest of RM 11,000 (US$ 2,872) is for the construction of the upper part of ARFADs (appendages, floats and ropes). The average cost for a single of ARFADs is around RM 1,197 (US$ 312.50).

Table 4 : Cost for the construction of 66 units of ARFADS

No.	Materials	Unit	Cost (US$)
1.	Construction of concrete anchor and deployment	66	17,775
2.	Hard plastic floats (submerged) Styrofoam surface Floats Construction of appendages Polypropylene rope (2.2 cm diameter)	66	2,872
	Total cost		20,627

SUMMARY

Most of traditional FADs are made from local materials which are easily expendable in nature and are continuously change every 6 to 8 weeks. These light structures require continuous replacement as they are made from plant materials (bamboo and coconut fond), which are rot easily in water. For durable ARFADs, the anchor line and the aggregating devices are costly because of the materials used and the necessity for heavier anchor to resist the forces of wind, waves and currents on the whole structural unit. Experiences have shown that properly constructed and deployed ARFADs at suitable site can create a good and convenient fishing sites especially for hook and lines fishers. These structures have proven particularly effective for artisanal application in which fishing effort is relatively low.

The newly established design of ARFADs especially the upper part of the structure is capable to withstand for more than 10 years in the sea. In addition, the concrete anchor after 10 years can be developed into natural artificial reefs. Therefore, the fishers can continuously carried out fishing activities without any extra effort of deploying new FADs or artificial reefs. This project directly responsible for the enrichment of fisheries resources and eventually increase the livelihood of coastal fishers as well as protect from illegal trawling. The new habitat can also be utilized as breeding ground for several squid species (Figure 33), nursery area for larvae and juvenile of fish and also for recreational diving activities. The introduction of these ARFADs has turned the unproductive area into a rich ecosystem.

Figure 33 : Eggs squid attached to the anchor line

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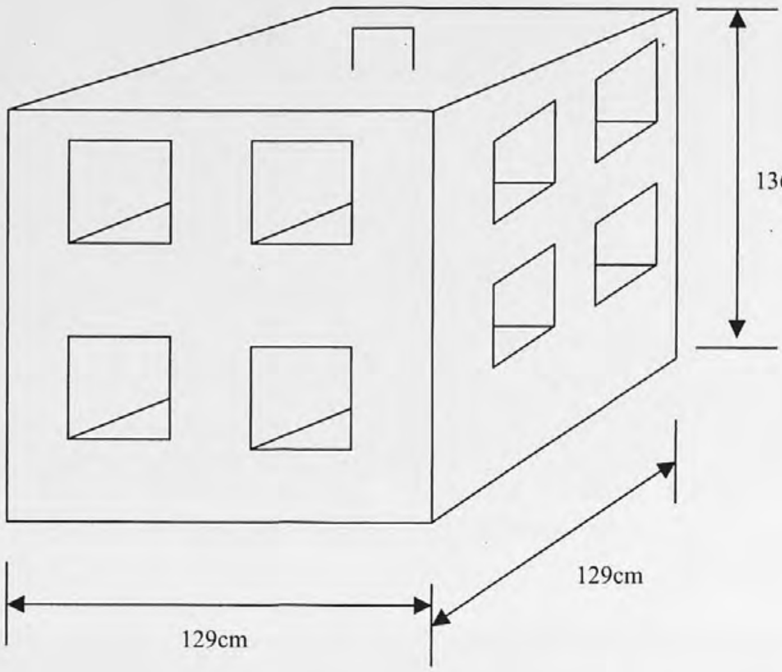
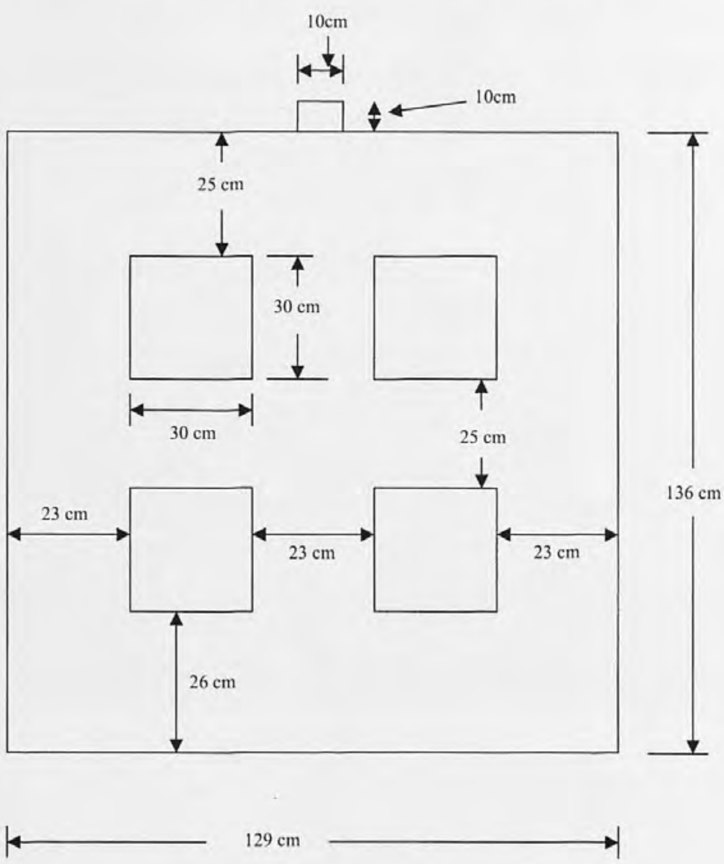
APPENDIX A

Detail of a-3 dimension view of the concrete anchor



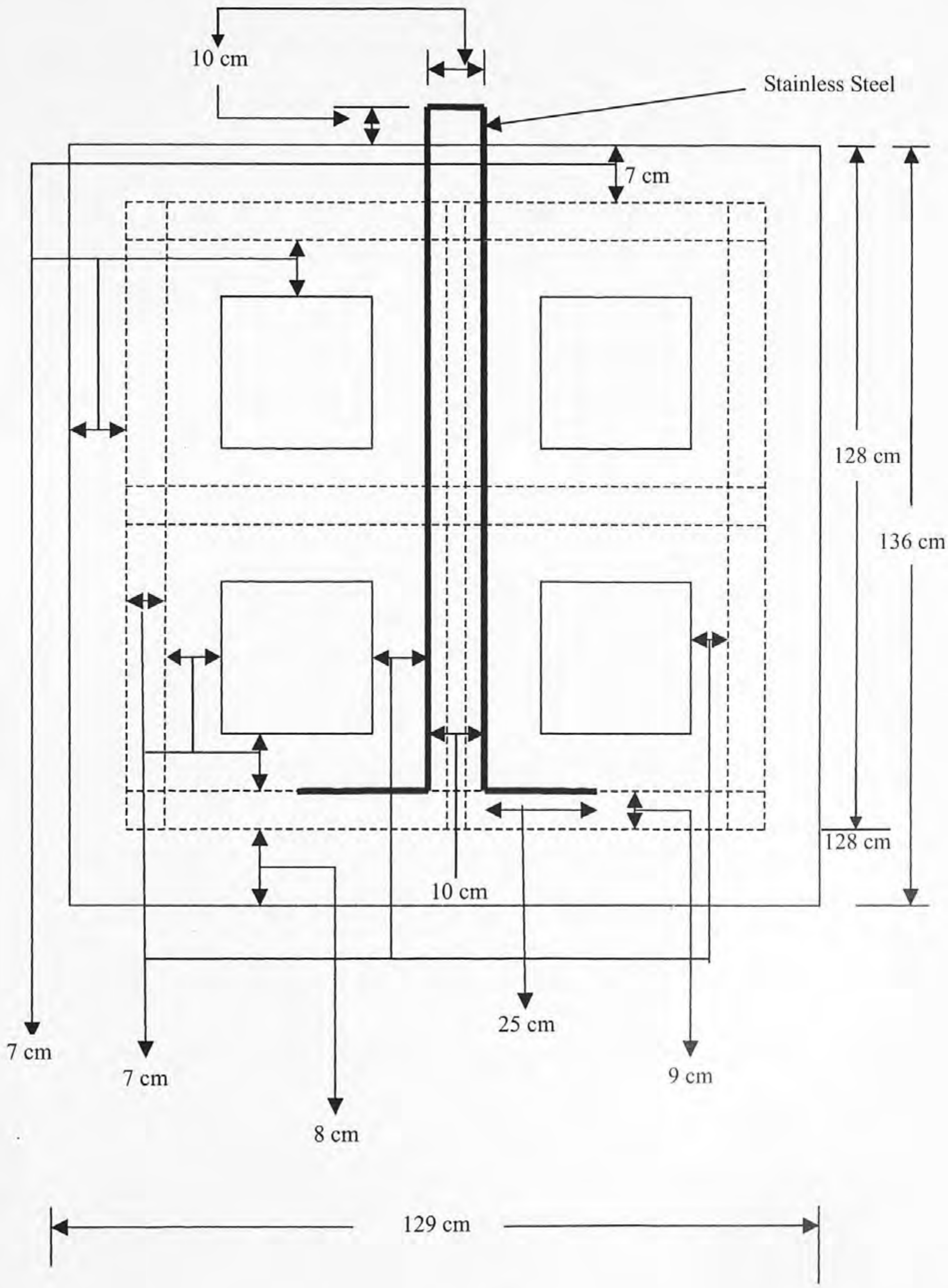
APPENDIX B

Detail of side view of the concrete anchor



APPENDIX C

Detail of 1.0 cm diameter solid steel frame and
1.5 cm diameter stainless steel arrangement (side view)



APPENDIX D

Detail of 1.0 cm diameter solid steel frame arrangement (top view)