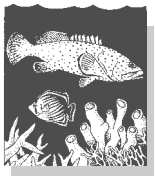

Collecting grouper seed for aquaculture in the Philippines

by R.E. Johannes [1] *& N.J. Ogburn* [2]

Abstract

Fourteen collection methods for grouper post-larvae, fry and fingerlings (collectively referred to as seed) for growout were studied in 60 coastal towns and cities in the three regions of the Philippines. Green groupers, especially *Epinephelus coioides*, dominate the catch in all areas. Peak seasons vary widely geographically, but generally occurred during wetter months. Interannual variation in catches occurs, with the worst catches in El Nino or drought years. Some collection methods cause high mortalities of by-catch, damage to habitat, and/or allow monopolisation of the local fishery by a few individuals. These include scissors nets and fyke nets, which are already banned in some areas. Mangrove nets and lift nets are also destructive, particularly in terms of by-catch.

Although devices that attract (rather than trap) seed do not show obvious negative effects, significant destruction of by-catch is possible in all but bamboo shelters; when harvests are not handled properly unnecessary mortalities occur. This can be addressed (and in at least two areas has already been addressed) by educating fishers. Grouper seed collection from the wild provides employment for fishers, middlemen and fish farmers and has several environmental benefits. Farm production of groupers reduces the demand for wild-caught adults and the attendant impacts of cyanide fishing and targeting of spawning aggregations. The seed fishery also provides an alternative livelihood to fishers who might otherwise be using cyanide or explosives. Grouper seed fishers often patrol their fishing areas to prevent the use of these methods by others because of negative effects they are seen to have on their grouper harvests. Grouper seed fishing using *gangos* and miracle holes (types of seed aggregation devices) have been officially encouraged in one province as a means to tide fishers over while they wait for their mangrove reforestation plots to mature. Methods that target post-larvae (or 'tinies') seem less likely to deplete wild stocks because of the high natural mortality that probably characterises this stage in the wild. However, no evidence was found that there is indeed depletion of wild stock when fry and fingerlings are harvested.

Fishers using *gangos* or miracle holes reported no declines in catches per unit effort except in areas where substantial environmental degradation resulting from human activities such as pollution and accelerated erosion had occurred. Perception of grouper fry and fingerling shortages is at least partly due to a mismatch between seasonal and interannual availability and demand. If and where a real decline in grouper numbers has occurred, it should be determined whether this decline is due to overfishing of seed, overfishing of adults, habitat degradation and/or pollution. Information concerning the sustainability of fisheries for grouper seed requires research on a range of harvest methods over several years (to account for interannual variability), for a variety of species, and in a number of countries. In this connection many grouper seed collection devices constitute convenient objects for replicated and controlled experimental manipulation.

Introduction

The demand for live reef food fish has grown enormously in the past decade. The environmental impacts of the resulting fisheries are of great concern, especially because of the targeting of spawning aggregations and the use of cyanide (Johannes & Riepen, l995; Pet-Soede & Erdmann, l998). Increased farm production of groupers is one means of reducing this damage. However, hatchery technology for groupers is not yet well established.

Many grouper species have been spawned in captivity. But, despite more than a decade of research in at least sixteen different countries, commercial success has proved elusive because of the fragility of grouper larvae, the difficulty of obtaining suitable food for them, disease, and high rates of can-

1. R.E. Johannes Pty. Ltd. E-Mail: bobjoh@netspace.net.au
2. AJ Aqua Intercon Pty. Ltd. E-Mail: NOGBURN@msn.com.au

nibalism. Typically, mortality rates have been either uniformly high or very variable.

Taiwan has had some modest success in the hatchery raising of some species of groupers commercially. Most of its hatchery production consists of the two species *Epinephelus coioides* and *E. malabaricus* (The World Bank, 1999). The price of hatchery-raised seed (this term is used in this report to refer collectively to post-larvae, fry and fingerlings) has been too high for them to compete with wild-caught grouper seed in many cases. So grouper farming in Southeast Asia continues to rely heavily on wild-caught seed. Indeed, Taiwan itself still imports wild-caught seed of grouper species that it has not yet been able to produce in sufficient numbers in its hatcheries (The World Bank, 1999).

Despite the importance of fisheries for grouper seed in tropical Asia (see below) and concern about their sustainability (e.g. Sadovy & Pet, l998) published information on their nature and sustainability is limited and cursory. To be environmentally sustainable, fisheries for wild-caught grouper should not deplete wild stocks of the target species (e.g. Sadovy & Pet, 1998). Nor should they cause significant environmental damage to habitats or to stocks of other species. The information needed to determine whether these conditions are being met is unavailable for any grouper seed fishery. To obtain it would require several years of field research in a number of Asian countries, on a number of species, and with reference to a variety of harvest methods.

Here, as a beginning, we describe a number of methods used in the Philippines that appear undesirable environmentally and / or socioeconomically. We describe others that seem less problematic but that require more research before definite conclusions can be drawn about their sustainability. We also describe fishers' perspectives on the advantages and disadvantages of the different methods.

We conducted our main survey in September–October 1997. Briefer surveys had been carried out in 1989–91 by N.J.O. and in April 1996 by R.E.J. In total we covered 60 coastal towns and cities in three regions of the Philippines: Luzon, Visayas and Mindanao. Research at N.J.O.'s former Artemia – Finfish Integrated (ARTFIN) Farm in Medellin, Cebu (Ogburn & Ogburn, 1995) also yielded some of the information used in this report. This report is a revised and condensed version of a report to The Nature Conservancy (Ogburn & Johannes, 1999).

Information was obtained primarily by interviews with experienced local grouper seed fishers and grouper aquaculture investors, managers and researchers, and secondarily from literature and record searches.

Study area and grouper species

Except for areas where massive damage to coastal waters has occurred, groupers are collected throughout much of the Philippines for export, local consumption and for aquaculture.

The major species used for aquaculture in the Philippines are the green groupers, *Epinephelus coioides* Hamilton (also referred to as *E. suillus*) and *E. malabaricus* Bloch & Schneider (often confused in the literature with *E. tauvina*). In this report the word 'grouper' refers specifically to the two green grouper species unless otherwise indicated.

The unscaled post-larvae of green groupers, which are transparent or reddish, usually average 1 to 2.5 cm (<1 inch) total length; the scaled fry, which begins to darken, range from around 2.5 to 7.5 cm (1–3 inches) (often measured from the eye to the caudal peduncle) and fingerlings from 7.5 to 12.5 cm (3–5 inches). The term 'tiny' used as a noun, (the plural is 'tinies'), is commonly used to refer to the post-larvae. *E. coioides* usually dominates the seed catch (90–100%), while *E. malabaricus* rarely occurs in large numbers. In some places, the flowery cod (*bantolon*), *E. fuscoguttatus* Forsskäl, may be found in similar numbers to *E. malabaricus.*

Green grouper fry and fingerlings are usually found near river mouths or in muddy estuaries and bays, whereas the seed of many other grouper species are reported in the scientific literature as being found in deeper more saline water associated with coral reefs.

In 1997 grouper fry sold live to traders at US$ 0.03–0.24 / inch (conversion is approximately Philippine pesos 38 / US$) and fingerlings sold live for about US$ 0.08–0.25 / inch. Tinies sold from the source for US$ 0.05 per fish when in large numbers or US$ 0.18–40 per fish when less abundant, or for US$ 0.18–0.32 per fish in Manila. In some towns, per-inch sizing starts only at 3 inches or is used only when the catch is low. During peak production periods, the price is fixed for a range of sizes to minimise processing delays, which could stress the fish.

During the 1997 survey, seed prices had decreased considerably compared to the boom period in the early 1990's when exports to Hong Kong and other Asian countries were at their peak. The formation of a grouper buyers' cartel in the Philippines, the increased Taiwanese hatchery output of fingerlings and the start of El Nino (which is associated with

poorer grouper production) in 1997 had reportedly resulted in the lowered prices. Current (1999) grouper seed prices have returned to the higher levels of the early 1990's because of expanding grouper fry and fingerling demand locally and internationally. Importers from Korea and Singapore have joined the original group from Hong Kong and Taiwan.

Grouper collection devices

Fourteen grouper seed collection devices were observed during this study. The different devices select different grouper seed stages. Where trading of one stage is dominant in a particular locality, the other stages are often not collected or bought, or if they are, it is on a minimal basis. If any trading does occur for the minor catches, the price is usually not as good as for the preferred stage. This is because each stage requires somewhat different handling procedures and the buyer is often set up for handling only one stage.

The different grouper collection devices we examined, and their uses, history and location are described below.

Fish nests or gangos

Synonyms: Micro-fish aggregating devices (micro-FADs), artificial nurseries, *arong, atob, dugmon, padugmon, tambon, amatong, awung*

Gango set-up

A *gango* is a conical pile of waterlogged, criss-crossed wood or of rocks, sometimes used in combination, together with old car tires, PVC pipe cuttings, bamboo sections or other shelter materials (Fig. l). The wood includes different kinds of mangrove, which is used green and lasts 4–5 years. Land-grown wood is not used if it floats. Wood is preferred on muddy bottoms where rocks are more easily buried during heavy rains. Rocks are used more often on sandy substrate.

Because of their preference for certain species of mangroves, most *gango* operators we interviewed reported that part of their work is to replant mangroves to replace mature trees that are cut. Not all parts of the mangrove trees are for *gango* construction. The larger diameter portions are used for house construction or repairs, or other domestic purposes. In some cases, wood is bought from other owners of mangrove micro-forestry projects. In other cases, mangrove trees are merely pruned.

Gangos vary from 5–10 m^2, with a 2–3 m diametre, or 2.5–3 m x 2-3 m base and 0.5–1.5 m height. The largest may be 5 m diameter at the base. There are many regional variations in the composition and design of the device. They are typically built and harvested during low spring tides at spots where the water is no deeper than neck-deep, i.e. where it is easy for fishers to work on foot. They may also be built in areas that become uncovered at low spring tides, provided trenches are dug around the base so that fish can retreat there when the *gangos* are exposed. Depending on the area, 2–3 people can construct two *gangos* per day.

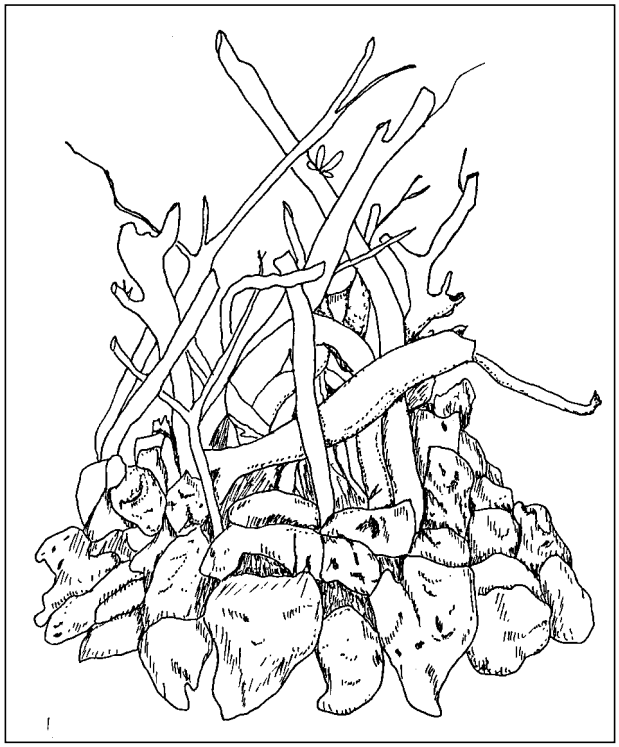

Figure 1. **Diagram of a gango set-up used in Mactan, Sebu**

Gango *harvest*

Harvest starts 2–3 months after construction when the epibiota that is thought to attract fish is well established. The *gangos* are then harvested once every 2–4 weeks, depending on the season. For the harvest, operators use a short beach-seine-like net, 1 m or more in height, 6–8 m long with 1.5 cm stretched mesh, to encircle the *gango*. Both ends of the net are attached to vertical 2.5 m bamboo poles. The bottom of the net is weighted with sinkers while the top is kept above water by floats.

After encircling the *gango* with this net, the operator climbs inside and tosses the gango materials out over the net. Any hiding areas like bamboo sections and holes in the wood or rocks are carefully checked for fish. After the removal of the *gango* materials, fish are now without shelter and can be chased into a 2–5 m-tapered pocket in the middle

of the net. The net is then gathered up, the pocket is undone and the fish collected. A new *gango* is then reconstructed with the same materials. In some places a flexible fence of bamboo slats is used to surround the *gango* instead of a net.

An experienced fisher harvests 1–2 *gangos* at very low spring tide, but in many cases the fisher is assisted by at least one family member or a partner and up to 5 units are harvested in a day.

The harvests from *gangos* usually include the green groupers, especially *Epinephelus coioides*, which makes up 90–100% of total grouper catch and *E. malabaricus*, which sometimes makes up 5–10% of grouper catch. Flowery cod, *E. fuscoguttatus*, are also occasionally caught.

A variety of other fish can be found, and sometimes dominate the catch. These include various species of siganids or rabbitfishes, particularly *Siganus vermiculatus, S. guttatus* and *S. canaliculatus*; mangrove snappers, especially *L. argentimaculatus*; gobies and flatfish. Also found are lower numbers of small species, fry / fingerling of some bigger species like eels, surgeonfish, puffers, sweetlips and many others, together with crabs and shrimps. Occasionally, fry / fingerlings of coral trout or mouse groupers are found in *gangos*. An average grouper catch from a single *gango* is 10–15 grouper fry and fingerlings, with a good day bringing 20–30. During the season, groupers typically make up between 10–50% of the total fish catch from *gangos*.

The non-grouper catch in *gangos* are either:

a) eaten or sold, especially bigger sizes of mangrove snappers, siganids and other commonly eaten species,
b) returned alive to the water or to the *gangos*, especially tiny stages of fish or species not used for food, or
c) dried for use as trash fish if already weak or damaged.

Experienced *gango* operators are critical of new or young operators who, wanting to rush the harvest, are not careful in handling the catch, resulting in mortality of fish. They disapprove of those who do not bother returning unwanted species back to water while still alive. From two years purchase records of groupers and other species for nursery / pond culture at ARTFIN Farm and from interviews done during the survey, it was noted that many older or long-experienced fishers routinely return non-grouper species (except selected big-sized fish for food) to the water with the belief that they will be blessed with a more productive water if they do not destroy everything they find. Some even refused to sell grouper tinies from *gangos* and insisted on returning them to other unopened or newly-reconstructed *gangos* to let them grow bigger. G*angos* usually bring in fewer grouper than attractants like the *habongs* and *pailaw* (see below) which catch mainly tinies. But prices for the larger, *gango*-caught fish are higher.

In Ibo, Mactan, Cebu the biggest harvest was obtained during a Signal # 2 typhoon, with 60 kg of fish (mainly siganids and groupers) taken from a 6.25 m^2 *gango*. An *amihan* or northeast wind onshore is reported to increase the likelihood of a good *gango* harvest. During the survey, a sample harvest from a 6.2 m^2 unit produced about 17 kg of fish, mostly siganids (it was off-season for groupers). An average of 15–20 *gangos* out of 62 was harvested per month at this location. Since *gangos* are well guarded in this area, poaching is not a problem and harvests per *gango* have not decreased over the years, according to *gango* owners.

In Ormoc, Leyte, *awung* are similar to a traditional wood and rock *gangos*. They are not 'opened', however, but used rather as artificial reefs for recreational fishing, and installed in the Naungan River.

In Guiuan, Western Samar, *gangos* and *arongs* are used to collect big groupers (0.5–1.0 kg), and are thus left unopened for periods of 6 months or more.

For fishers who open *gangos* more frequently and harvest fry instead of fingerlings, the term fish nest was coined because it indicates grouping together of young fish. Because tinies and grouper fry are observed to grow inside the *gango* to fingerling size, the term artificial nursery is sometimes used to describe the *gango* instead of fish nests.

Once *gangos* are installed and aged enough (i.e. have sufficient coverage of epibiota) to attract fry and fingerlings, bigger fish are also seen to be attracted to the *gango*. Fishers sometimes collect these fish for food, and sometimes find newly eaten grouper fry in their stomachs.

Gango history

In some parts of North Cebu, *gangos* were in use at least as long ago as 1939. In Mactan, Cebu, Councillor Reynaldo Lauron introduced *gangos* in the Ibo export-processing zone in 1981. From the two *gangos* he started with, he has increased operation to his current 62 units. For his pioneering efforts he was awarded by the Bureau of Fisheries best fisherman of the year in the region for 1987.

In Bohol, fishers report the use of *gangos* as early as they can remember, which is at least 50 years ago.

Yao and Bohos, Jr. (1988) reported that *amatong* fishing (referring to both *gangos* and miracle holes, see below) was introduced in Banacon Island by Damang Ismael, a Muslim who was apparently stranded in the island.

In Bulalacao, Mindoro Oriental all-wood *gangos,* or *dugmon,* were used for 5 years in the 1980s, but this was discontinued because buyers preferred the numerous tiny groupers obtainable from post-larvae attractants such as *habongs* (see below) rather than the fewer fingerlings caught in *dugmon*.

In Tubod, Lanao del Norte *gangos*, or *gala*s, were in use by 1985. In 1990, the Municipal Fisheries Office studied *galas* and found them to be good aggregating devices for fish. But since it was feared that their uncontrolled use of *galas* led to the removal of too many fish, the Fisheries Office recommended *galas* be used mainly for fish protection and not for collection.

Before grouper trading became a lucrative business, *gangos* were used in all the above provinces mainly to collect fish to be eaten or sold in the local seafood market. Typically, fishers left the *gangos* unopened for much longer (at least 6–9 months) than since the mid-1980s, when the market developed for grouper seed.

According to our interviews, many *gango* owners had used cyanide to collect fish in the past, but renounced these practices when they saw the advantages of using *gangos*. Indeed, *gangos* operators in various provinces said they routinely police their areas against the use of cyanide and explosives by others because they experience significantly lower harvests from *gangos* constructed where these other, illegal fishing methods are used. Moreover, they volunteered, grouper seed caught with cyanide usually die after a few days. Buyers sometimes blacklist the suppliers of such fish.

In over 50 years of continuous *gango* operation, F. Neiz of North Cebu has never observed a marked decline in catches of grouper and other fish. On the contrary, he says, fish numbers in adjacent waters increased as more *gangos* were introduced. He, like other gango operators, does, however, report year-to-year variation in catches apparently related to interannual variations in weather conditions (see below).

Fish fences, on the other hand, have shown significantly lower catches since he began to use them 40 years ago. Of the collectors he has used, including scissors nets (see below), *gango* is the best and most consistent moneymaker he reports. As his main source of income, *gangos* enabled him to rear and educate 11 children, who he could not support adequately with produce and profits from his farmlands and fish fence. Similar observations were made by younger *gango* operators around San Remegio and in Medellin, Cebu. In Carles, Iloilo, S. Palaver similarly reported with pride that the profits from his *gangos* enabled him to raise and educate (in one case through university) 10 children. This is no small feat in communities where most houses have dirt floors and education is not free.

In Bohol, as in North Cebu, fishers and researchers have never observed a marked decline of grouper and other fish associated with the use of *gangos* (C. Pahamutang, pers. com.). They do report interannual variation, however, with significantly more fish collected every 3–7 years. Best catches according to most fishers are associated with wetter years.

The number of *gangos* or *padugmon* in Tinagong Dagat, Capiz has greatly declined with time due to increased siltation in the area; the water has become mostly too shallow for their operation (e.g., in Palungpong Bay). Unlike other provinces, harvests reportedly never exceeded 5 kg per unit.

Miracle holes

Miracle holes (the English term is preferred by fishers to any local name) are man-made holes, excavated with hand implements, optionally diked with the dug-up substrate, and filled with coral rocks, mangrove branches, coconut fronds and other waste material that attract fish seeking shelter. They are usually excavated in the shallow sides of estuaries or bays on bottoms that are exposed on spring low tides. The holes are typically 1–3 m wide, 2–3 m long and 1 m deep, although we saw some larger ones. Variations in shape and dimensions have developed as the technology spread. Coconut or buri palm fronds are often used to cover the holes to reduce fish disturbance. The holes are described as miracles because no effort or fry stocking expenditure is involved, and the harvest is looked upon as a gift from nature. Yao and Bohos, Jr. (1988) refer to both miracle holes and *gangos* as *amatong,* which, they say, originated in pre-WWII days.

Like *gango* owners, users of miracle holes carefully guard them against poachers, who sometimes use cyanide or other poisons to steal their fish. Sometimes, a guard hut is constructed near the holes. Harvesting is similar to that for *gangos* in that a net is used to encircle the hole prior to removal of aggregating materials inside. They are harvested every 2–3 months, usually starting 4–6 months after establishment. The hole is refilled with the shelter materials after harvest.

Harvests from miracle holes are usually similar in species composition to those from *gangos*. Peak grouper production in Cebu is from August to December although smaller numbers are available year-round. The miracle holes are covered in March / April and uncovered starting May–July. As with *gangos* grouper catches from miracle holes were often reported to be lower in drought years.

The Central Visayas Regional Project office in Cebu City introduced miracle holes in Bohol and south-western Cebu starting 1984 as part of its World Bank–funded rural project to increase agricultural productivity and create employment opportunities while maintaining ecological stability and conserving resources. According to fishers interviewed in Cebu, the use of miracle holes has been increasing since then (when 2 people had 10 and 20 units respectively). Some miracle holes have been in use for over 10 years. Approximately 100 units exist at present in Badian alone. Owners stated that they stopped using cyanide and explosives when miracle holes were introduced.

Fish (post-larvae) shelters

a) Habong

Synonyms: *Bon-bon, palumpong*

Habongs are formed by hanging brush, nets, or clusters of grasses or leaves or other materials (Fig. 2). They provide hiding places for grouper tinies as well as smaller numbers of grouper fry. They are used with or without lights. They are the most widely used grouper collection device in Bulalacao, Mindoro Oriental. *Habongs* were introduced in 1983–84 from San Jose, Mindoro Occidental where Taiwanese and Japanese grouper buyers who preferred tinies were based.

Those without a light are generally made of nets hanging from a rope suspended from a float. They are set on the substrate in shallower river portions. At low tide they are lifted gently one-by-one into a scoop net where the tinies are shaken out. Adults can catch an average of 2,000–7,000 tinies per fortnight with up to 10,000 caught per person in peak season.

Fishers say that good tiny weather is windy but not stormy, with light rain. Tinies do not accumulate during typhoons. When the weather bureau issues typhoon alerts, tinies are still found if it is around the time of the new moon and the rain / wind is not yet too strong. During the season, tinies are usually most abundant from 4 days before until 4 days after new moon. The main season occurs in the relatively wetter months, although some tinies may still be found mixed with larger groupers in *habongs* in the less rainy months of summer when collection stops.

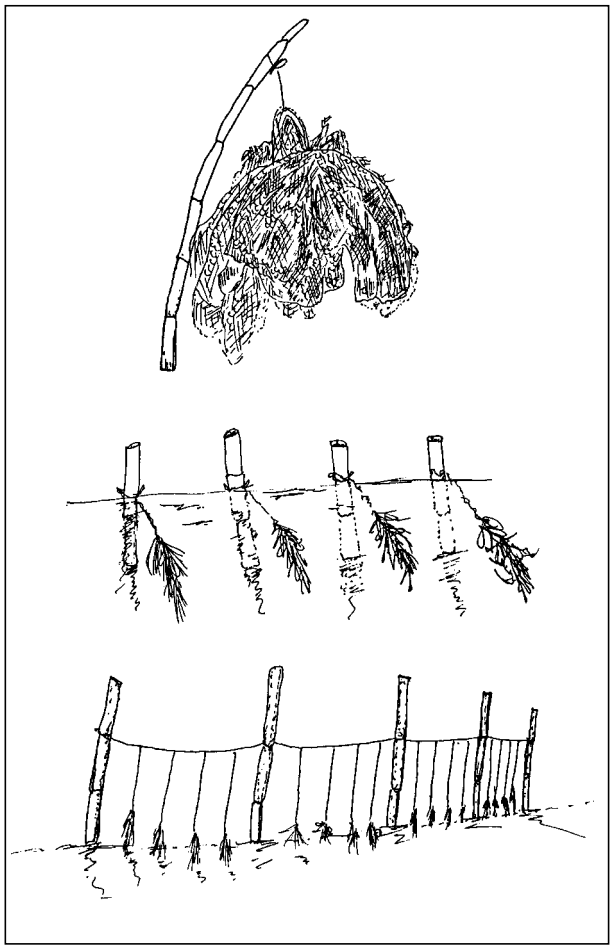

Figure 2. Different types of fish shelters (*habong*)

In Sapian Bay, Capiz, where mussel culture is widespread, the mussel clusters serve as attractants for tinies. The mussels are harvested from November to February, while the tinies peak in production in September according to the fishers. They also report that the Bay's productivity of tinies and other fish has decreased over time due to siltation and human activities.

In Tubod, Lanao del Norte, coconut fronds and many kinds of debris are used in fish seed shelters based on the Mindoro *habong* design. They are called *galas* and are used for both groupers and prawns. They may be suspended from the surface with floats, or anchored to the bottom.

In Pagadian City, *habong*-like tiny attractants known as *palumpongs* are made of certain weeds (*sagbot*) and a local fern commonly found along fishpond or estuary dikes, known as *pagaypay*. Less wave-resistant materials than coconut fronds can

be used there because waves action is much less than in more exposed waters.

Tiny grouper collection started in 1983 when a Japanese buyer taught children to catch these fish. It stopped when the Japanese ceased operation after 1985. Other grouper buyers set up in the late 1980s.

Usually there are four seasonal peaks for tiny groupers reported in Pagadian City—April, August, September and December. Year-to-year variations in catches are observed, with more tinies in drier years. This is contrary to observations in many other provinces where small groupers are more abundant in wetter years. However, it rains relatively uniformly throughout the year in this area. Thus, dryer periods are still relatively wet compared to dry periods in provinces with more pronounced seasons. Since collection of tinies began in 1983, no significant decrease in numbers has been noted. Tinies are reported to be less hardy than the 1-inch fry collected in the area.

In Tagabuli, Davao del Sur, where *habongs* are also widely used, there are also 3–4 tiny seasons per year, with interannual variation relating, fishers say, to rainfall. Tiny numbers are highest in wetter years and lowest in El Nino years. The collection period is from 3 days before until one week after new moon. The *habongs* are made of used nets as in Mindoro. They are not laid directly on the muddy bottom, but rather suspended from bamboo sticks about 10 cm above the bottom. Sometimes, guava branches are used, but they last only 3 days. *Habongs* are installed one day after the presence of tiny groupers in the bay is observed. They are harvested on the next low tide. A similar system is found in Palembong, Sultan Kudarat.

After introduction of intensive milkfish / grouper cages in Tagabuli Bay in 1996, operators expanded from two to more than 40 cages. Tiny grouper production has reportedly become increasingly erratic, with unpredictable peak production months. Water quality is reported to have deteriorated with intensive feeding in the densely–packed and often overfed cages, so that the skin lesions and fin rot sometimes found in groupers in warm periods now occur year-round. Tinies stocked in cages often develop these lesions, red bloody mouth and whitish eyes, within 3 months of stocking.

In Balasinon Bay, *habongs* are made of buri / coconut fronds, used sacks and *pagaypay* fern. Used together with *pailaw* (see below), habongs can yield 15,000 tinies per season per operator.

In Tinagong Dagat, Capiz, *habong*-like fish shelters known as *bon-bons* are made of coconut fronds with the ends tied together with a nylon rope, and connected to a stake in the substrate. *Bon-bons* are well guarded by their operators to prevent poaching.

In Hagonoy, Bulacan, income from *bon-bons* was sufficient until installation of numerous big grouper seed collection devices (e.g. mangrove nets—see below) led to a decline in the number of fish entering the *bon-bons.*

b) Pailaw

Synonym: *Paapong*

A *pailaw* consists of a series of *bon-bons,* i.e., small shelters for tinies made of nets or vegetation, hanging from ropes attached to the outrigger of a pump boat located in 3–6m deep water. An average pumpboat may have as many as 40 *bon-bons* hanging from each outrigger. They are harvested at night after lighting *Petromax* lamps (2–4 units) on the boat, fixed near the outer support of the outriggers. Half an hour after lighting, one *bon-bon* is tested by lifting up slowly into a scoop net. If tinies are numerous, all *bon-bons* are lifted consecutively.

Pailaws are commonly used together with unlighted *bon-bons* in Bulalacao, Mindoro Oriental where in season, one can collect as many as 15,000 tiny groupers per night from a boat with 40 *bon-bons* per outrigger. *Pailaws* are used mainly in deeper, clear coastal waters.

In Balayan, Batangas, where there are no rivers nearby and collection is along the coast, the *pailaw* is the only device used. Around new moon prior to our September survey, 300,000 tiny groupers were collected in the bay over a period of 3 nights.

In Tagabuli, Davao del Sur, *paapongs (*another name for *Pailaws)* hang from the boat only about 10 cm above the bottom as the bay has become increasingly shallow. In good seasons, as many as 3,000 tinies can be collected from the bay each night.

For both *habong* without light and lighted *pailaw*, non-green grouper species make up as much as 25% of the total catch. *E. fuscoguttatus* as well as some banded groupers are considered rejects because attempts by many Filipino farmers to culture them yielded in far slower growth than green groupers fed and grown under similar conditions.

In many provinces possessing suitable habitat for catching grouper fingerling and fry using gangos or miracle holes, the use of other collection devices such as *pailaws* or *habongs* is found only where buyers prefer tinies over larger seed (e.g., in Bohol;

Bulalacao, Mindoro; Mindoro Oriental, and Balayan, Batangas).

Lift net or paapong

Synonym: New look

Very large lift nets for collection of small groupers are similar to those used widely in the region for other fish and squid, except that finer-mesh (2–5 mm) netting is used (Fig. 3). Large quantities of tinies and fry can be obtained in season—hundreds to thousands per lift. A *Petromax* light is used during harvest to attract the fish. This device results in wastage of large numbers of non-target species due to priority for processing of green grouper tinies.

Figure 3. Lift net or *paapong*

Bamboo shelter or sugong

Synonyms: *pasok*, fish *lagung*

Different configurations of cut bamboo segments which serve as fish shelters range from assemblages of bamboo flotsam to deliberately cut and shaped wood. Sometimes, coconut shells and cans replace or add to the bamboo, as in Isla Verde, Batangas and Ormoc, Leyte.

In Tinagong Dagat, Capiz, *pasok* are usually made of several layers of bamboo sections, arranged one on top of the other. Holes are drilled to allow the fish in. A simpler design is a 2.5-inch diameter bamboo internode with both ends open and a hole through the middle where a stick is inserted for use in staking the bamboo in the mud to anchor it (Fig. 4). This is similar in design to the fish *lagung* in Tubod, Lanao del Norte. One person usually operates 200 *pasok*, with an average catch of 1–3 grouper fingerlings per *pasok* per harvest.

Unnecessary fish mortalities seldom occur in connection with these devices. During typhoons, however, most *sugong* are blown away, even if they are anchored to the substrate. Poaching can be a problem due to easy removal or movement of these small shelters.

Figure 4. Bamboo shelter or *sugong*

Mangrove net or sira-sira

Synonyms: *Bukatut, tampung, lapad*

In Bohol, *sira-sira* are nets about 2 m high and may be 100 m or more long. The mesh is fine, around 5 mm. They are placed so that they run along the outer edges of mangrove communities. As the tide drops and fish are forced to leave the mangroves, they are trapped in the net pocket.

Although harvest figures using this method have not been obtained, catches of groupers are reported to be high. As with many other collecting devices, the catch often contains an assortment of other species. The mangrove net poses the problem of wastage of much by-catch, since rescuing the large numbers of groupers in the catch before they die has priority.

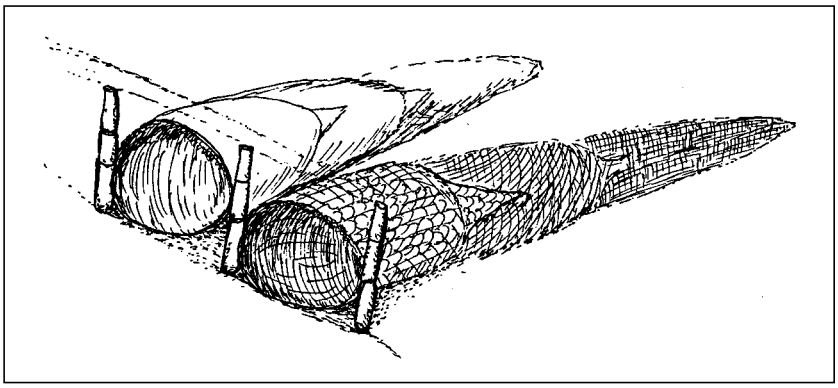

Figure 5. **Diagram of the fyke nets or *sangab***

Fyke net or sangab

Synonyms: Filter net, *tangab, kimpot, bayakon, puyo*

Fyke nets or *sangab* are big collectors, consisting of a group of stationery nets installed in river mouths during high tides. Figure 5 shows a *sangab* that consists of only two nets. *Sangab* are held to the substrate with hooks, with weights and a bamboo support along the bottom edge of the opening, and are suspended from the surface by a rope and floats, with a stake support in front. Three mesh sizes are usually used, beginning with larger mesh at the aperture followed by medium and finally finer net at the end. They are installed at low tide, two days before new moon, and harvested at high tide at night. They are used primarily for tinies. Collection lasts until 4–5 days or more after new moon.

Such nets are also heavily used in Pola and Mansalay, Mindoro Oriental where they are known as *kimpots.* Units may line entire river mouths. An average of 15,000 to 40,000 tinies can be collected in one night per *kimpot*, mostly in good condition. As many as 1.4 million tiny groupers can be collected using ten *kimpots*, together with *pailaw*, in one collection period—or up to 2 million fish in total, including rejects (damaged tinies or non-green grouper species).

In Ormoc, Leyte, fyke nets called *sangab* are smaller than those in Mindoro Oriental. A 7 m *sangab* with a 1.5 m pocket equipped with a ring is commonly used in November–December when tinies are abundant. The average yield is around 5,000 tinies per *sangab.* The catch also includes crabs and shrimps. Tinies can be held awaiting buyers for at least a week and up to a month if well fed with mosquito larvae, brine shrimp nauplii or tiny shrimp (*uyap*).

In Ormoc, more grouper seed are caught in rainy years than in dry, hot years. More fry, including those of milkfish and shrimp, are collected during storm warning / signal days, just before the storm hits. Around the new moon prior to the September 1997 survey, 10,000 tiny groupers were reportedly collected using this method.

The fyke net is a very effective device for collecting tiny groupers and other small fish and invertebrates. It can easily obstruct river mouths and estuaries, especially as the net dimensions increase, thus imperilling entire runs of tiny or small fish. Any unwanted species for aquaculture will likely die because post-harvest processing, which is a time-consuming process, gives priority to the massive numbers of groupers caught.

Fyke nets, therefore, appear to be of questionable ecological soundness. They can also reduce social equity in the fishery since a few people can dominate the operation. With smaller gear, in contrast, many fishing families can be supported.

For these reasons, fyke nets have been banned in some municipalities, like Bulalacao, Mindoro Oriental and Tubod, Lanao del Norte where many fishers need to share the fisheries resources or where *sangab* has reportedly led to an apparent reduction in seed of many species, including prawns, shrimps, crabs, etc.

In Pagadian City, only a few *sangab* can operate in the small Kawit estuary, which is connected to Bulanit, the river / estuary mouth. Five *sangabs* are enough to block the river almost completely.

Scissors net or sudsod

The *sudsod* is a modified version of the scissors net commonly used for milkfish fry collection. A triangular net is attached to two crossed bamboo poles. Wooden 'shoes' are fitted to the bottom ends of the poles to enable them to be pushed along rough bottom. One person pushes the *sudsod* like a lawn mower in shallow water near shore or in estuaries and certain open coastlines at low tide (Fig. 6). *Sudsod* are used mostly for collecting tiny groupers and 1-inch fry. Five-to-ten groupers can be harvested per lift, with an average of 500 small groupers per day being caught per unit.

In Tubod and Panguil Bay, Lanao del Norte, *sudsods* are the major and often the only collector used for tinies. When there is a boom in tinies, *sudsod* are sometimes operated from motorised boats. *Sudsod*

are usually operated during the daytime, starting at dawn. Harvested tinies are temporarily stocked in pails and fed boiled egg yolk or formulated feeds provided by buyers. Peak tiny grouper season in this area is in November–December, with fingerlings increasing towards February. In the boom year of 1992, as many as 100,000 tiny groupers were collected with *sudsod* per day by around 1,000 people. Fry and fingerling groupers are found from March to October, and are collected by *bubo* (see below), *sugong* or other devices.

In some provinces, *sudsod* are illegal (e.g. Davao and Bohol) because of their destructive effect on benthic habitat. Areas scraped by *sudsods* for several months are denuded of the grasses, molluscs and other benthic organisms. Although grouper seed collection may continue in these places, fishers say their catches gradually decrease.

Figure 6. **Scissors net or *sudsod***

Other minor methods

The *Sabay* is similar to a very small beach seine and is sometimes used for catching grouper seed in the Bohol area.

Bungsod, or fish corrals, are used mainly for catching milkfish and prawns. Grouper fingerlings caught incidentally by this device, are not always in good condition because they get gashes from the bamboo fencing.

Kawil, or hook and line, is sometimes used to collect grouper fry and fingerlings. It use for this purpose is widespread but probably does not account for large percentages of the catch in most areas. Catch per unit effort is probably relatively low, although in Roxas City, Capiz, up to 2,000 grouper fingerlings have been caught in a day at peak season by hook and line fishers collectively.

Sigpaw or *sadyap* are scoop nets used by children and fishers for collecting groupers as well as other kinds of fish. In Tubod, Lanao del Norte, they are used to collect bigger grouper fry and fingerlings while diving with a compressor or hookah gear because strong currents can destroy other devices. The method is often limited to fishers who can get their diving gear from grouper traders because it is not often affordable by ordinary fishers. This method can also be observed in good coral reef areas serving tourists where diving gear can be rented.

Bubo, or fish traps, although used mainly for catching bigger food fish, are sometimes used for catching grouper seed. In Bohol, *bubos* are modified using finer-mesh and a smaller aperture so only fry and fingerlings can get in. Like *sabay*, this is not a commonly-used method.

Other survey information

The grouper ball jackpot

In the deeper areas, approximately 7–10 fathoms, of a bay in Mindoro Oriental, fishers have reported seeing what have come to be described as 'grouper ball jackpots'. The balls are actually a membranous material that look, at first glance, like drifting plastic bags. In one instance, a fisherman scooped up one of these balls thinking it was waste and discovered when it burst that there were many thousands of tiny green groupers inside. Since the coral reef areas where groupers spawn is still much farther out, the tiny groupers enroute to nursery grounds may seek shelter in these membranous sacs. Their origin and composition is unknown.

Grouper seasons

The seasons for green grouper tinies, fry and fingerlings in the Philippines vary widely according to provinces and towns and the associated weather and geography of each. In general, the peak grouper seed season is associated with the relatively wetter months of the year. An exception is found in places where it is always rainy and heavier rainfall lowers grouper catch, as in Tagabuli Bay, Davao del Sur. Interannual variation in

grouper season and abundance is observed by all fishers. They generally agree that it depends on the relative wetness of a year and on which months the rains are heavier. The worst grouper seasons are associated with El Nino years or when there is a drought. The number of seasons per year is usually higher in places where there is a relatively uniform or evenly distributed rainfall throughout the year, like Pagadian City and Davao del Sur.

It is noteworthy that, in several areas, grouper seed collectors told us that their best catches were associated with windy weather. This corresponds to a number of recent descriptions by researchers of recruitment pulses of settlement-stage reef fish, including groupers, that accompanied windy weather that apparently transported the fish shoreward (e.g. Shenker *et al.*, l993; Dixon *et al.*, l999).

Evaluating grouper seed collection methods

Is the collection of grouper seed from the wild for aquaculture sustainable in the Philippines? The detailed information needed to make a clear-cut judgment is lacking. However, it is evident from the information gathered in this preliminary study that some grouper collection methods are more problematic than others. Clearly destrucive are methods that result in high mortality of by-catch, are damaging to fish habitat and/or result in monopolisation of the local fishery by a few individuals. As already mentioned, two of these destructive devices, scissors net (*sudsod*) and fyke net (*sangab*) have already been banned in some towns.

Of the eleven major grouper seed collection devices, eight do not possess the above drawbacks; namely, fish nests, miracle holes, fish shelters with and without a boat, lift nets, hook and line, bamboo shelters and scoop net. However, if catches are not handled properly, significant destruction of by-catch as well as high mortalities of grouper seed are possible *after* the fish are harvested. The last three methods listed above are the least worrisome in this regard, but are not among the more important methods used in the Philippines.

To combat this harvest/post-harvest handling problem, education of fishers has been carried out successfully in at least two instances: i.e., in Banacon Island of Jetafe, Bohol (Yao & Bohos, Jr., 1988) and in ARTFIN Farm, Medellin, Cebu (Ogburn & Ogburn, 1995). In the former instance, Bohol fishers were taught by the Integrated Social Forestry Program to harvest catches from *gangos* and miracles holes (collectively referred to as *amatong*) using nets of a mesh size that allows smaller fish to escape. In Medellin, farm suppliers of grouper seed were trained rigorously in fish handling and treatment of weak/sick fish and were discouraged from taking in non-target species, except those that are normally utilised by the fishers as food. Such education could easily be introduced elsewhere and integrated with existing village-based coastal management programs.

Grouper seed collection from the wild using non-destructive methods not only provides employment to fishers, middlemen and fish farmers, but can also have certain environmental benefits. The farmed fish arising from this fishery help reduce the demand for wild-caught adults and thus the use of cyanide and dynamite, as well as the decimation of spawning aggregations by collectors of adult groupers for the live reef food fish trade. In addition, provided the fish are grown out locally, the use of wild fry reduces the risks of alterating gene pools or of tranporting disease (e.g. Munro & Bell, 1997).

Fishers for juvenile groupers actively patrol their fishing areas, believing that the use of cyanide anywhere in such areas will affect their catches. Some *gango* fishers volunteered that they, themselves, were cyanide-users before they discovered the advantages of *gangos*. Fishing using cyanide or explosives are among the few options readily available to poor fishers in the region, and they are more lucrative, and thus more attractive, than is sometimes realised (Galvez *et al.*, 1989; Pet-Soede & Erdmann, 1998).

Fisheries for juvenile groupers in one area have even been described as assisting mangrove reforestation efforts. During community-based mangrove replanting projects organised by the Integrated Social Forestry Program in the Central Visayas, coastal villagers were encouraged to construct *gangos* and miracle holes to obtain cash while waiting for returns from their mangrove stands (Yao & Bohos Jr., 1988).

Sadovy and Pet (1998) noted that the removal of grouper seed from the wild by any method might reduce subsequent adult populations. The seriousness of this threat is unknown, but it would seem to be less where tinies are targeted rather than fry or fingerlings. The first few days of the demersal existence of coral reef fish appear to be a period of high mortality (e.g. Beets, l997 and references therein).

Fishers and researchers in the region agree that they see tinies in much greater numbers than grouper fry or fingerlings. This suggests that, as with the reef fish discussed above, there is considerable natural mortality among the tinies. If true, this indicates that the harvesting of tinies is less

likely to have an impact on future adult populations than the harvesting of fry or fingerlings.

If recruitment of estuarine grouper seed is habitat-limited, then increasing the harvest of wild grouper seed by means of fish nests (*gangos*) and miracle holes may not deplete wild stock. Sadovy and Pet (1998) pointed out that 'the critical question here is whether natural mortality is reduced by artificial habitats such that the 'excess' survivors, i.e. the juveniles that would otherwise have perished, can be harvested, or, alternatively, whether artificial habitats attract significant numbers of juveniles that would otherwise settle successfully in natural habitat, thereby increasing total mortality.'

The value of suitable shelter for recruiting reef fish has been demonstrated by various researchers (e.g. Brock & Kam, 1994; Beets, 1989; Shulman, 1984). Shelter such as that provided by the six major attractant devices described above, provides not only protection from predation, but also attracts food organisms. In addition, it reduces currents, thus reducing energy expenditure of fish in maintaining their positions. Teng & Chua (1979) demonstrated that the placing of shelter such as PVC piping in net cages with small estuarine grouper, *E. salmoides* (an old name for *E. malabaricus*) more than doubled both optimum stocking densities and net production.

It is worth noting in this connection that the natural habitat for *E. coioides* and *E. malabaricus* fry and fingerlings has been greatly reduced in recent decades. Juveniles of these species commonly inhabit mangrove estuaries (e.g. Sheaves, l995). The destruction of hundreds of thousands of hectares of mangroves in Southeast Asia in this century—an estimated 40–50% of the total mangrove area in the region and 80–90% of the mangroves in the Philippines (see the various papers in the Mangrove Forests section of Wilkinson, 1994) has greatly reduced the shelter available to these fish, as well as to other mangrove dwellers. Creating artificial shelters on featureless estuarine mud bottoms, especially in areas where mangroves have been destroyed, may therefore increase the survival of grouper and recruits as well as that of the other species they attract.

None of this proves, however, that these or other methods for harvesting grouper juveniles do not deplete adult stocks. The question clearly needs research. Fortuitously, the many of the artificial grouper shelter/attractant devices described above offer exceptional opportunities for well-controlled field research to answer this question. They constitute discrete, easily replicated units of artificial habitat that are ideal for experimental manipulation.

Many authors have stated that there is a 'shortage' of wild grouper fry, and some have concluded that they are therefore being overfished. The conclusion does not follow from the observation. Milkfish fry, of which about one billion are harvested annually for aquaculture in the Philippines, offer an instructive parallel. Bagarinao (1998) states that, 'the seasonality of milkfish reproduction has serious effects on the fry industry—fry are abundant and low-priced during the peak months, but scarce and highly priced during lean months. The problem of mismatched timing between fry availability, low prices and pond stocking is commonly perceived as 'fry shortage'.' This same scenario pertains to fisheries for grouper seed in the Philippines.

Most *gango* operators interviewed perceived no decrease in their catches per *gango* over the years, even though the numbers of *gangos* in their waters had increased. When asked how they felt about new entrants to their fishery they almost invariably had no objection. 'There's enough for everyone' was a common reply.

The only areas where catches per *gango* were said by their users to be decreasing noticeably were in bays known to be seriously affected in recent years by sedimentation and/or pollution, and where fishing in general has declined markedly. Thus, although grouper seed catches were decreasing in these bays, overfishing does not appear to be the main cause.

Significant declines in some other species of groupers harvested as juveniles in other countries have been reported. The most often mentioned decline is that of *Epinephelus akaara* along the south China coast, including the waters around Hong Kong. Is this reported decline a result of misperception due to harvest/demand mismatch, or is it real? If it is real, is it due to overfishing of juveniles, to overfishing of adults, to pollution and/or to habitat degradation? In the mid-1990s almost half of the world's dredges were at work in Hong Kong waters in support of land 'reclamation' (Patten, 1998). The feverish pace of development in adjacent coastal regions of the Chinese mainland in recent years is well known. In addition, the pollution of coastal waters in the region due to sewage and industrial waste is notorious (e.g. Morton, 1998). It seems unlikely that juvenile *E. akaara* in their shallow nearshore habitats have wholly escaped this onslaught.

There are some ecological risks associated with any harvest. But focusing on these alone in connection with fisheries for grouper seed ignores not only the socioeconomic but also the conservation benefits. Whatever the arguments in support of fishing for

wild grouper seed, however, it should be stressed that these fisheries yield only certain species of the genus *Epinephelus* in significant quantities[3]. They do not yield many of the most highly-priced groupers, i.e. the highfin grouper (*Cromileptes altivelis*), or plectropomid groupers, i.e., coral trout (*Plectropomus* spp.). (During our study, plausible accounts were given in two areas, however, of post-larval coral trout being caught in significant numbers; this deserves investigation.)

Nor do they provide seed of the most expensive of all live reef food fish—humphead wrasse. In at least some cases this is because the juveniles of these species do not do not aggregate in large numbers (e.g. Doherty *et al.*, 1994; Colin *et al.*, l997). Solving the problems of economic hatchery production of these species thus seems to be the only way to substitute farmed for wild-caught adult fish.

The biological, social and economic features of fisheries for grouper seed are thus complex and not easily reduced to a balance sheet of plusses and minuses, especially in the absence of quantitative data on key questions. We have learned enough about the plusses, however, so that we do not recommend banning wild grouper seed fisheries in the absence of persuasive evidence that it is unsustainable[4]. We have also learned enough about the minuses to be critical of certain collection devices that are, or appear to be, environmentally damaging or socially inequitable. For these reasons the collection of grouper seed using lift nets, scissors nets, mangrove nets or fyke nets should not, in our opinion, be encouraged.

Education of fishers to reduce wastage of by-catch or harvests should be promoted. This would probably not be difficult to build into the many coastal resource management projects carried out by NGOs in fishing villages in the region. As already noted, this has already been done in the Central Visayas.

Methods that target post-larvae are less likely to deplete stocks than methods that target fry and fingerlings (e.g. Bell et al., this issue). But research is needed before it can be determined if either type of fishery threatens stocks. It is somewhat reassuring that fishers interviewed during our surveys do not perceive such a threat in the Philippines. Their catches per unit effort, they say, have not decreased except in areas of pronounced habitat degradation. But to get a definitive answer to this question, definitive long-term research would be needed.

Fishing for juvenile groupers to supply fish farmers occurs in almost every country with a coastline from south China through Southeast Asia at least as far west as Sri Lanka. To clarify this issue then, research must be carried out in selected areas throughout the region on a variety of harvest methods and for a variety of species.

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3. It is the two Indo-Pacific Epinephelid species that spend their first demersal year or so in estuarine waters that are most easily cultured. This is probably no coincidence. Species that can tolerate the large variations in salinity, temperature, turbidity, nutrients and organic loads characteristic of estuarines are more likely to be able to tolerate the environmental insults to which they are typically subjected in ponds and cages.
4. The recent ban on construction of artifical reefs in the Philippines includes devices such as gangos and miracle holes, suggesting that a premature judgement has been made about their effects. However, since the ban is not enforced, it has had no practical impact on grouper seed collection as far as we have been able to determine (Johannes, 1999).

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