Sustainability of Grouper seed supply to the aquaculture industry in Khanh Hoa, Vietnam

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Khanh hoa is a south central province of Vietnam with an area of 5,258 square kilometres and a population of nearly one million. It has 7 districts and 1 city. Three of the districts are mountainous, four are located along the coastal area, and one is an island district (Spratly). Khanh hoa has a 200km-long coastline with the sea area of more than 400,000 square km including the Spratly archipelago.

Grouper culture has developed in recent years in Khanh hoa in response to high market value, the availability of unused shrimp ponds because of disease, and a cage culture tradition related to the fattening of lobsters. Grouper culture is dependent on wild seed.

A broad based study was undertaken between January and July 1998 which examined technical, environmental, and socio-economic issues related to wild grouper seed supply in Khanh Hoa in order to assess the prospects for the sustainable development of grouper culture in the province as well as elsewhere in Vietnam.

Research objectives

The *overall objective* of the research was to assess the sustainability of wild grouper seed collection as an input to marine cage culture of groupers.

Operational objectives of the study were as follows:

- to identify the species collected in the seed fishery of the province;
- to identify the sources of the seed supply, their habitats and environmental requirements, and their distribution areas;
- to analyse technical aspects of the seed supply;
- to analyse catch, effort, and production trends;
- to determine the status and potential of the local and international markets for grouper seed;
- to analyse social and economic aspects of the seed supply; and
- to determine main directions in management of grouper seed fishery.

Research Approach

Field work for the study was carried out from December 1997 to April 1998 in four

districts of Khanh hoa Province (Van Ninh, Ninh Hoa, Nha Trang, and Cam Ranh) which are the main areas for grouper seed supply and grouper culture in Central Vietnam.

The study used existing information, supplemented with an interview survey of fishermen, and a physical/ecological survey of catching grounds.. Parameters related to grouper seed supply, such as physical and ecological characteristics of catching areas, technical attributes of seed fisheries, and market and socio-economic aspects of seed supply, were recorded and investigated using a framework adapted from the matrices in "Handbook for Rapid Appraisal of Fisheries Management Systems" (version 1) (Pido et al. 1996). The method of determining the coverage of seaweed, sea grass and coral was modified from the mangrove survey method in " Survey manual for tropical marine resources" (English et al., 1994). Grouper samples were collected and identified based on the FAO key (FAO 1993).

Secondary data collection

Existing reports, papers, maps and informal data were collected from a wide range of organisations and individuals, including government departments and institutions, commune offices, collection stations, traders and export companies. Checklists were used to guide informal interviews with individual specialists. Information collected related to the markets for grouper seed of Khanh Hoa; type of product; species collected; use for local culture and/or export; prices and mark-ups; market trends; and estimated quantity of grouper seed traded annually.

Primary data collection

Rapid appraisal

A "rapid appraisal" of fishermen, nursery farmers, traders and exporters and some villagers (commune leaders, village head, teachers) was undertaken as a foundation for more detailed questionnaire surveys described below. Semi-structured interviews were loosely based on a short checklist. Additional questions were asked during the interviews in order to probe for in-depth details. Key issues addressed included the condition of the grouper resources in the area; the composition of the grouper collected; the identity of the collectors; when and how seed is collected; species, quantity, and relative importance of grouper used for local grow-out and for export; timing, quantity and nature of labour requirements for seed collection; and significant constraints to the collection of seed.

Outputs from this appraisal included maps and calendars related to seed collection sites, labour schedules, activity sequences and decision trees. Important information was also collected on the way in which collection work was organised.

Collector survey

A random sample of fishermen/collectors was chosen for more formal and in-depth questionnaire interview. 260 fishermen/collectors, out of a total population of 649 were interviewed.

Catch site survey

Four main *areas* were found to be important for seed collection. General physical, ecological and hydrological data relating to these areas was collected from secondary sources and direct observation. Within these general areas specific catching sites were identified through discussions with fishermen. These sites were then surveyed in detail in the company of the fishermen/collectors. Sites were assessed for cover of coral, sea-grass and seaweed, depth, salinity, and distance from mangrove. Information was also collected on the gear used at the site, species collected, and the (perceived) intensity of exploitation.

Nursing farmer survey

The (six) nursing farmers in the province were interviewed in depth using a prepared questionnaire. Questions covered a broad range of social, economic, environmental and technical issues.

Collector community survey

A representative of a group of collectors within a fishing village was interviewed to gain an insight into the socio-economic status of collectors, and their general attitude and approach to seed collection and resource management.

Analysis

Most of the socio-economic data was assimilated and analysed using the basic tools of sorting, ranking, frequency distributions, analysis of variance, regression and correlation. Simple financial ratios and indicators were used to summarise financial data. The ecological data was analysed using cluster analysis, as developed in the ADE 4 package (University of Lyons). The variables used in the cluster analysis were: depth, salinity, coral cover, seagrass cover and sea weed cover.

The methodology has been described in detail elsewhere (Tuan 1998).

Results

Ecological attributes of catching areas

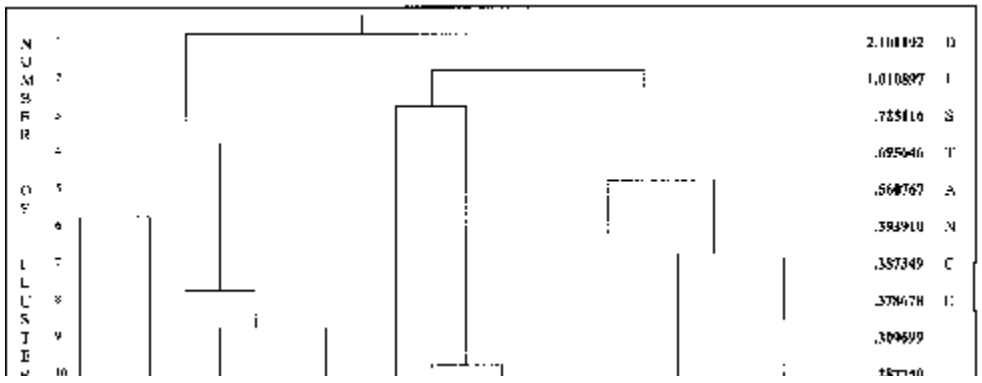
Four *catching areas* were identified: Van Phong, Nha Phu, Nha Trang and Cam Ranh, corresponding broadly to the four coastal districts of Van Ninh, Ninh Hoa, Nha Trang and Cam Ranh respectively. These areas were all characterised by the presence of sea-grass "forest" or seaweed beds. Two sea-grass species were common to all areas: *Thalassia hemprichii* and *Enhalus acoroides*. Within each area were several catching sites where the bulk of fishing for seed took place, amounting to a total of 16 *catching sites.*

The cluster analysis revealed three broad types of catching site, corresponding to the conventional classifications of coral reef, lagoon and estuary. These are shown in the dendrogram (Figure 2). Sites 13 (Nam Thuy Trieu), 9 (Bai Tien), 10 (Hon Mun), 16 (Cam ranh), 8 (Cay Bang) and 4 (Khai Luong) form a single distinct and cohesive cluster at the first division. This cluster includes three coral islands (Hon Mun, Cay Bang and Khai Luong), and is considered as coral reef group. The second division results in two additional distinctive clusters. Sites 3 (Hon Khoi), 7 (Nha Phu), 12 (Bac Thuy Trieu) and 2 (Xuan Tu) form a cluster corresponding to sites within lagoons, and is therefore called the lagoon group. Sites 11 (Song Lo), 5 (Song Gang), 15 (Song Cai), 14 (Ba Ngoi), 6 (Ro Tuong), and 1 (Hien Luong) form a cluster named the estuary group, since all sites are located close to river-mouths.

The distance axis at the point of division indicates how disparate two clusters are. The distances progressively decrease as the analysis proceeds. A large distance indicates that at least two very different observations exist, one from each of the two clusters just combined. Two of the sites (2 and 12 in the lagoon group) were almost identical, with a distance of less than 0.08.

A rank sum test (a non-parametric statistic) was applied to determine whether there are three significantly different habitat types. The results are summarised as follows:

- there are significant differences (at 0.05 level) between the coral reef and lagoon clusters in terms of salinity, coral cover, and sea-grass cover;
- the lagoon group and the estuary group are significantly different (0.05 level) in terms of depth and salinity.



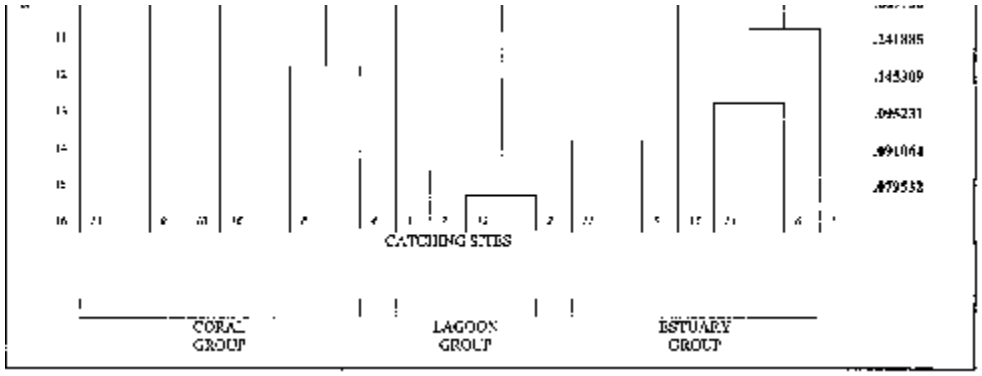


Figure 2. Dendrogram of Standardised Catching Area Data

Grouper species caught

In total, seven species of seed grouper were caught regularly at the various sites. Using the key provided by FAO (1993), the species were identified as in table 1 below. The key generally refers to fish with standard length of more than 10cm. In this study about 50% of fish samples had standard length of less than 10cm. However, identification was based mainly on morphological characters, including number, configuration and form of fins, teeth, nostrils, scales and gill rakers, which are fully developed in species such as *E. akaara* in fish with standard length as little as 1-2.5cm (Fukuhara and Fushimi 1988).

Table 1. Grouper species collected in Khanh hoa

Scientific name	FAO English name	Local name
Cephalopholis miniata	Coral hind	Ca mu do
Epinephelus akaara	Hong Kong grouper	Ca mu cham do, Ca mu tieu do
Epinephelus bleekeri	Duskytail grouper	Ca mu soi, Ca mu tieu den
Epinephelus coioides	Orange-spotted grouper	Ca mu song
Epinephelus malabaricus	Malabar grouper	Ca mu me
Epinephelus merra	Honeycomb grouper	Ca mu cham to ong

Epinephelus sexfasciatus	Sixbar grouper	Ca mu sau soc

Cephalopholis miniata was not recorded as caught at these sites for aquaculture seed supply. However, about 10 metric tones of 0.1-13kg size fish of this species was exported to Hong Kong in the year of 1991 (Phan, 1997). This species is called "red grouper" and the rest are "black grouper" by local people.

Seed production[2] was related to some ecological variables, and the nature of the relationship varied between species. Production of most species increased with increasing sea grass cover. *E. akaara,* on the other hand, was collected at sites with a specific level (31-50%) of seagrass cover. Sea-grass cover was the most important variable explaining variation in abundance of seed of most grouper species. For example, it explained 94% of the variation in seed production of *E. coioides* and *E. merra*, but less in other species.

In the six "black grouper" species, seed production declined with increasing depth and increasing salinity. Production was negatively related to coral cover in all species except for *E. coioides* (no relationship) and *E. akaara* (positive relation). Production of *E. akaara* and *E. merra* was positively associated with seaweed cover, while this relationship was negative for other species.

Status of critical habitat

In the rainy season, especially from October to November, sea grass beds die back because of low salinity. From January forwards, they recover steadily (Hoa, 1996). Recently, many seagrass beds, especially in the Nha Phu lagoon, have been heavily damaged by motorised push-nets and trawling nets. There were about 200 motorised boats fishing in the lagoon using push-nets and trawling nets, despite a prohibition on the use of these destructive gears.

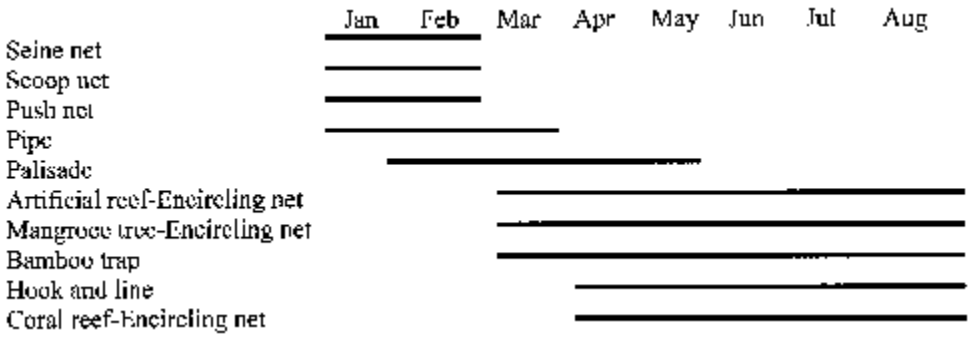
Coral reefs have become over-exploited recently. Approximately 30 explosions were heard a day in The Van Phong Bay in 1996, especially in coral reefs. In addition, dead coral, the main raw material for Hon Khoi Cement Plant, is exploited in the south-west of the bay. Cement production has increased from 5,000 tonnes/year to 10,000 tonnes/year in recent years (Long et al., 1996). Coral reefs may also have suffered some damage from tourism, especially in The Nha Trang Bay.

Seaweeds in the Khanh Hoa Sea, especially *Sargassum spp* "forests" have almost disappeared in recent years. This may be related to the over-exploitation of one species of sea-urchin for export, allowing an increase in the population of another. The latter may have over-grazed the *Sargassum* sea weeds. However, little is known about the depletion of sea weed beds.

Much mangrove has been destroyed for constructing shrimp farms around Nha Phu lagoon. From 1994 to 1997 approximately 500ha of mangrove was destroyed (Hoa, 1997) out of a total area of 810ha recorded in the years of 1981-1983 (Cho, 1996).

Technical attributes of fisheries

Figure 3. Seasonality of fishing gear use



Gears used for collecting grouper seed in Khanh hoa are summarised in table 2. Among the fishing gears, seine net, scoop net and push net were mainly used for collecting small-sized fish of size of 1-3cm. Seine net provided the highest yield (catch per unit effort) in terms of number of pieces per trip. For larger seed, encircling nets, used together with artificial reefs, were the most important in terms of quantity and quality of catch. Different fishing gears were used at different times of year, as presented in figure 3. The change in gear corresponds to the growth of the seed and their move to deeper water as the season progresses.

Table 2. Gears used for fishing grouper seed in Khanh Hoa

Gear	**Description/use**	**Pcs/ trip**	**Trips/ year**	**Gear number**	***Labor/ gear/ trip***	***strength***	***Weakness***
Small Seine net	8-10m long, mesh 2-3mm, drop 2m, with or without pocket. Dragged along river mouth, estuary, creek.	100 ± 53	4 ± 1	55 (n=30)	2	Easy to use. Productive.	Much labor. Large fish (>3 cm) escape.

Scoop Net	Net on pole, mesh 1-2mm. Manual scoop of fixed distance along shores and against banks.	5 ± 2	16 ± 6	130 (n=30)	1	Easy to use; used in inaccessible areas.	Few seed caught;
Push Net	Mesh 1mm, length 5m. Manually pushed along sea-bed in shallow water.	10 ± 6	16 ± 6	210 (n=30)	1	Easy to use. Cheap to construct	Poor quality fish.
Pipe	Bamboo or terracotta pipe, length 20-30cm, diameter 10cm. Left on sea bed (shallow water) for predetermined period.	2 ± 1	6 ± 2	3200 (n=32)	0.02	Easy to use. Very cheap.	Few seed caught; Easily lost!
Palisade	Fence made of bamboo stakes with or without net. Embedded in substrate for predetermined period in estuaries and shallow beds	2 ± 1	40 ± 14	7 (n=7)	1	Easy to use	Few seed caught;
Artificial Reef-Encircling Net	Stones piled up in creeks; 15-20m long net, mesh 5-20mm. "Reef" encircled periodically to collect fish.	15 ± 7	12 ± 6	330 (n=30)	2	Productive	Labor intensive. Only along creeks.

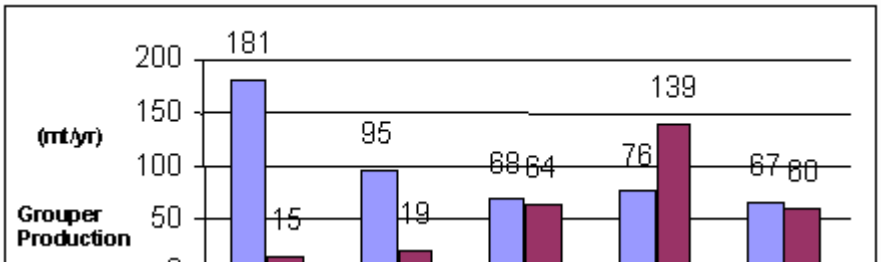
Mangrove Tree-Encircling Net	Numerous mangrove branches cut and embedded in sea bed; 20-30m long net; mesh 10-20mm.Used in shallow water only.	10 ± 4	12 ± 3	25 (n=25)	1	Relatively productive	Labor intensive. Only in shallow sea beds.
Bamboo Trap	Various designs and mesh sizes. Left in water for predetermined period. Set mainly along creeks	5 ± 3	12 ± 3	500 (n=30)	1	Easy to use	Few seed caught; Easily lost!
Hook and line	Small shrimps used as bait Used in deep areas	5 ± 2	32 ± 6	16 (n=16)	1	Easy to use	Yields poor quality fish.
Coral reef-Encir. net	20-30m long, 0.8-1m deep, mesh 10-20mm	10 ± 5	32 ± 7	38 (n=30)	1	Relatively productive	Difficult to use. Deep area.

Notes:

- "Trip" means one fishing time, normally lasting 2-4 hours.
- "n" corresponds to the number of surveyed gears (It means number of samples).

Status of the fishery

According to the fishermen, they had to spend more time to catch the same amount of seed compared with previous years. The seed production appears to be in decline, like the capture trend for grouper in the province (figure 4), and the demersal marine finfish (figure 5) (Tuan, in press).



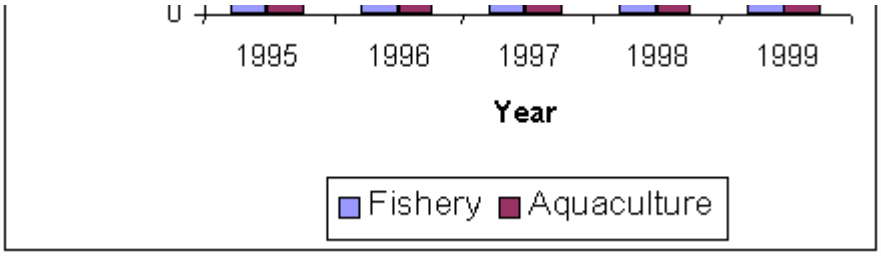


Figure 4. Production trends for aldult grouper in Khanh Hoa Province
(Note: only 6 first month data of 1999 were collected)

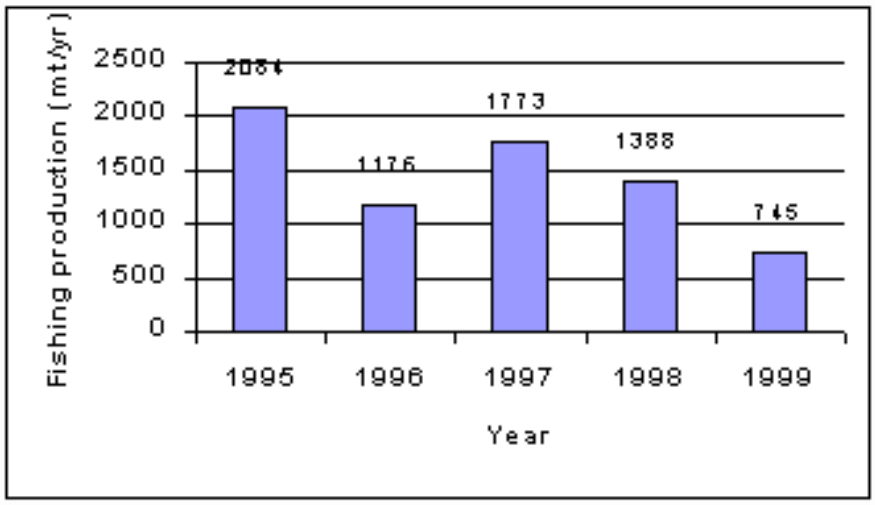


Figure 5. Capture trend for commercially important demersal marine finfish in Khanh Hoa province *(Note: only 6 first month data of 1999 were collected)*

During 1990-1996 period, the annual inshore-fishing production of Khanh Hoa (depth less than 50m) which came mainly from the Van Phong, Nha Trang and Cam Ranh Bays declined over time. According to the provincial DoF, the fishing production declined by 1.5-2 times in comparison with the production in any of the previous twenty years. However, the percentage of trash fish increased significantly, accounting for 50-60% of total inshore-fishing production. The total annual trash fish production in the province was approximately 10,000 tones. Recently, the percentage was higher in some areas, for example, 75% in the Nha Phu lagoon in 1998 (Lang, 1999). This is a serious problem because Nha Phu (Ninh Hoa district) was the biggest supplier of grouper seed to the aquaculture industry in the province.

The major reasons for the decline of fishing production of commercial demersal marine finfish in general, and grouper seed in particular were:

- Overexploitation, especially of broodstock;
- Using harmful fishing gears such as motorised push-nets, trawling nets, dynamite, sodium cyanide, etc.

Market attributes

The fishing production of grouper seed in the province appeared to be maintained at the level of about 200,000 pieces per year. The four species E. malabaricus, E.coioides, E. sexfasciatus, and E.bleekeri were the main cultured species (Figure 6). Six species had the common name "black grouper" as mentioned above, and commanded similar price.

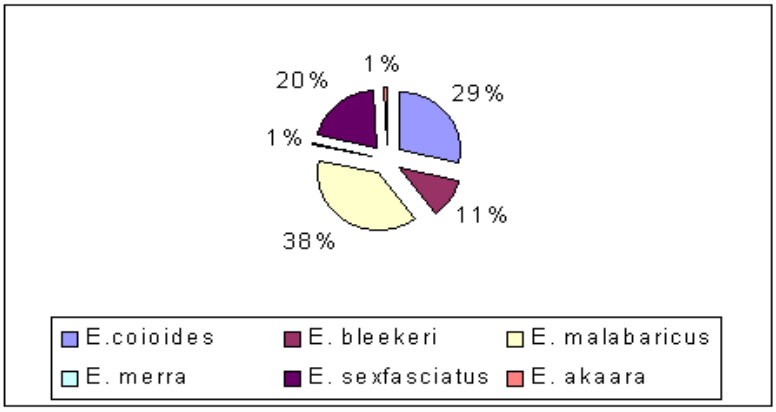


Figure 6. Seed production by species

The pricing system varied according to time and location. The price ranges by fish size in 1998 are shown in table 3 below.

Table 3. Price ranges by fish size

Type of fish	Typical price range per piece (in VND)	
	Fishermen to primary buyers	Middlemen to Farmers/companies
0.5- 5cm (Average 1-3cm)	500-1,000	1,000-3,000
5 -10cm (Average 5-8cm)	2,000-3,000	3,500-5,000

10 -20cm (Average 10-15 cm) • <100g • 100-500g (VND/kg)	4,000-5,000 40,000-50,000	6,000-7,500 60,000-70,000

USD 1 = VND 13,000

The primary buyers were nursing farmers, grow-out farmers and middlemen. The middlemen were the main buyers. The middlemen price was often approximately double the fishermen price. In some cases, especially between February and March, the middlemen price could peak as high as VND 13,000-14,000/piece. The price has shown an increasing trend year on year, probably related to the increase in total culture area (table 4).

Distribution of grouper seed in Khanh hoa is summarised in figure 8. Most seed were purchased for grow-out locally. Fish exported to Hong Kong and Taiwan usually had a size of more than 100g, and were mainly "red grouper" *Cephalopholis miniata* (Phan, 1997). Small quantities of seed were sold to Ho Chi Minh City.

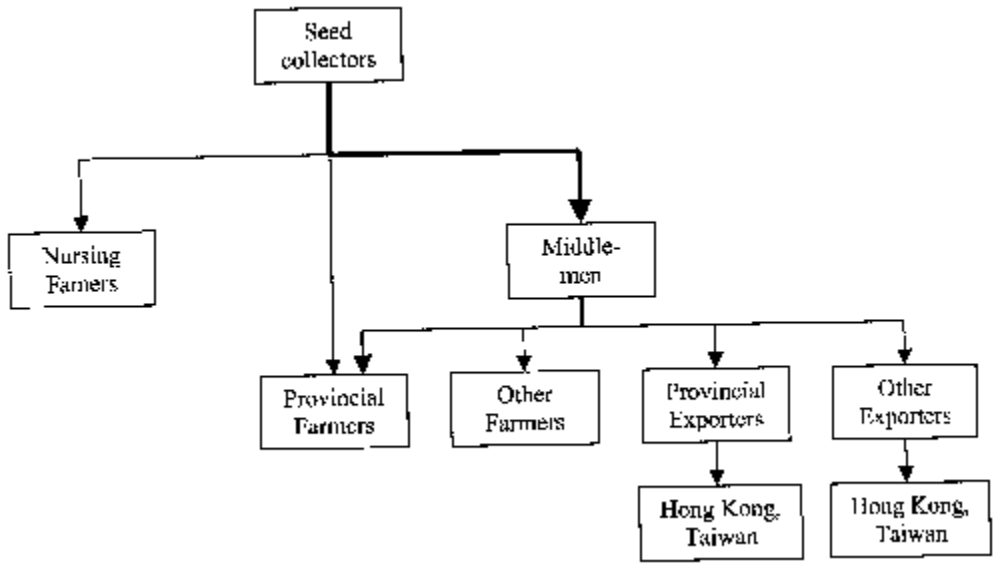


Figure 8. Distribution scheme of grouper seed

In the past, the fishing production of Khanh Hoa met the demand for grouper seed. There was almost no pressure on the seed supply except for the period just after Tet Holidays (Chinese new year's days). Recently, the local grow-out farmers had to import grouper seed from neighbouring provinces such as Phu Yen, Ninh Thuan. The percentage of the imported grouper seed was 15% for the 1998 crop. Current levels of

seed production are inadequate to meet the government's target production for 2010 (table 4).

Table 4. Demand for grouper seed in Khanh Hoa during 1997-2010 period.

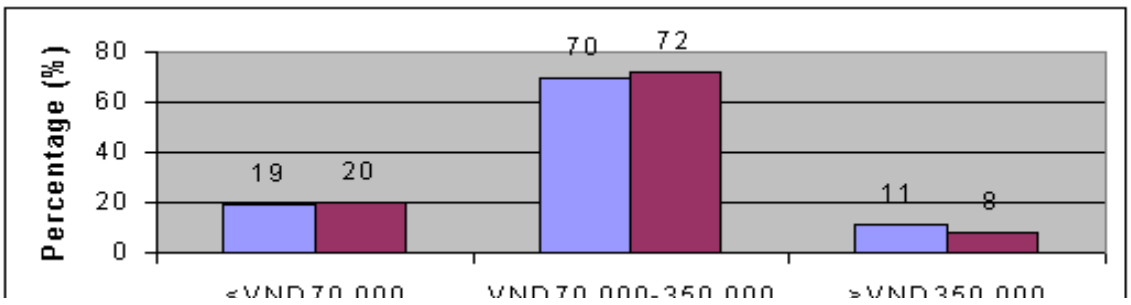
Year	Number of Growout pond/cage	Total area (ha) /Volume (m^3)	Average density	Demand (pcs/crop)	Total demand (pcs/crop)	Product (mt/yı
1997	68 ponds	31.58 ha	0.5 pcs/m^2	157,900	173,440	
	132 cages	3108 m^3	5 pcs/m^3	15,540		
1998	40 ponds	15.24 ha	1 pcs/m^2	152,400	216,140	
	201 cages	6374 m^3	10 pcs/m^3	63,740		
2010	? ponds	820 ha	1 pcs/m^2	8,200,000	8,350,000	4
(*Estimated*)	800 cages	15,000 m^3	10 pcs/m^3	150,000		

(*Sources: Trai, 1997; Tuan, 1998; Tri, 1998; MoF, 1999)*

Socio-economic attributes

The seed-collecting households were only approximately 6.5% and 0.6% of fishing households and rural households in the Province, respectively. This was due to the seed collecting contributing a modest part to a household's income.

The seed collecting households were divided into three classes according to their annual income. The proportion of collector households in the three classes was broadly similar to that for the wider community, although there were marginally fewer in the highest class. This suggests that seed collection has relatively little impact on household wealth, and vice-versa.



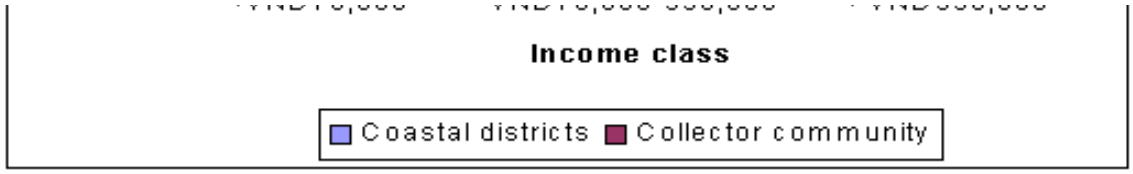


Figure 9. Income classes of the population in the coastal districts (1995) and collector community (1998).

(Source: The provincial statistic bureau, 1995; cited by Trai, 1997 except for community data)

In recent years, the number of collectors has decreased because some of them moved to off-shore fishing activities which were funded by the central government. The fishermen prefer the new job where they can receive a higher return on labour than that in the collecting seed (VND10,906-37,135).

To develop sustainably not only grouper aquaculture but also other sectors in the Nha Phu lagoon area in particular, in the Khanh Hoa's coastal areas in general, an integrated approach of the Nha Phu lagoon Coastal Area Management Plan is necessary (table 6, Modified from NEDA, Region I, 1992).

Discussion and conclusions

Poverty, lack of access to alternative livelihoods, and lack of environmental awareness has resulted in over-exploitation of near shore resources, and continuing poverty in coastal areas of Khanh Hoa Province. Alternative none-fishing jobs such as aquaculture could help the fisher-folk in lower income classes to escape from this "poverty trap".

Small scale, mainly family run cage culture of grouper in Khanh Hoa province is now a significant activity, providing a relatively high return to labour compared with existing alternative activities (Trai and Hambrey 1998). Internationally there is strong and continuing demand for high quality marine fin-fish. However, culture of grouper in Khanh Hoa depends on a supply of seed from the wild.

649 households (6.5% and 0.6% of fishing households and rural households, respectively) collect approximately 200,000 seed each year, mainly "black grouper": *Epinephelus akaara, E. bleekeri, E. coioides, E. malabaricus, E.merra,* and *E. sexfasciatus*. In addition, "red grouper" *Cephalopholis miniata*, a commercially important species, are caught and held temporarily for export to Hong Kong and Taiwan. The average income to collector households from seed collection was VND 720,000 per year (ca 11% of total household income).

The seed are caught with a variety of gears in lagoon, estuarine and coral reef habitat. The seagrasses *Thalassia hemprichii* and *Enhalus acoroides* were closely associated with grouper seed in catching areas in the province in the fishing months from January

to April. Sea-grass cover explained 94% of variation in seed production of *E. coioides* and *E. merra*, but less in other species. The local fishermen considered these sea-grasses as "indicative" of the presence of grouper seed. The relations between seed production and coral or seaweed cover were less strong and consistent, being negative for some species and positive for others. A significant proportion (almost 40%) of the seed came from one catching area, Nha Phu lagoon, a well-known nursing ground for many marine organisms

The seed price (to the collector) varied according to size, time and location, but in general was relatively high, typically around US$0.2 for 5-10cm seed, and significantly higher immediately after Tet Holidays (February-March) and for larger seed. The price charged by middlemen was often double the fishermen selling price. There has been an upward price trend over the last few years, suggesting increased demand.

The supply of wild grouper seed to the cage culture industry appears to be unsustainable in the short term and inadequate in the longer term. There are several reasons for this:

- Catch per unit effort of seed appears to be in decline;
- Catch and catch per unit effort of adult stocks also appears to be in decline;
- Nursery and adult habitat (mangrove, seagrass, coral) has been, and continues to be, severely damaged – from habitat conversion, destructive fishing practices, coral extraction and possibly local pollution;
- Government targets for cage culture are high (an estimated trebling of cages by 2010);
- Stocking densities have shown an upward trend, and this is likely to continue;
- The cost of seed is already high, and is likely to increase. This may threaten the competitiveness of the grow-out sector.

It is clear that to maintain the current wild seed supply will require substantial improvements in stock and habitat management, the latter targeted in the most important nursery areas. Broad frameworks for coastal area management plans and programmes have been developed in the past (Scura, L.F, et al.,1992), but there is an immediate need to take these forward in practice at a local level.

For the future, hatchery production will be the only way to provide sufficient seed to allow the industry to expand. The high and increasing price of seed should make hatchery production economically viable, despite its technical difficulty.

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