

Reef related fisheries resources, spawning and nursery grounds of target species in Quy Nhon bay, Binh Dinh province

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Abstract

Coral reef-related fishery resources in Quy Nhon bay were assessed at four communes in 2016, using an investigation note with additional input from consultations with experienced local fishermen. This information was ground-truthed during field survey assessments of spawning and nursery grounds of target resources (December 2016 and April–June 2017). The total catch of reef-related target resources was about 637 tons/year, including 536 tons of fish, 130 tons of mollusks, 0.34 tons of spiny lobsters, 19 tons of collector urchins, and 3 tons/year of *Gracilaria* seaweeds. There were some 936,450 juveniles of fishes and lobster caught in each year, in which some 576,000 individuals of grouper juveniles (orange-spotted grouper and six-bar grouper) were mainly caught by Ghenh Rang commune, and some 360,450 individuals of lobster ‘seeds’ were caught by the four communes (Nhon Ly, Nhon Hai, Ghenh Rang and Nhon Chau). The total revenue from fishing at the 4 locations was some 90.81 billion VND (about 4,128,000 USD), with the highest value being recorded in Nhon Hai (41.23 billion VND), Nhon Ly (28.53 billion VND), Ghenh Rang (13.06 billion VND), and the lowest in Nhon Chau (7.99 billion VND). Commercial resources contributed 35.43% (32.17 billion VND) and seed collection 64.57% (58.64 billion VND). There were 16 important grounds found in Quy Nhon bay, including three spawning grounds of cuttlefishes and murex snails, and 13 nursery grounds of swimming crabs, lobster ‘seeds’, sea cucumbers, rabbitfishes, and groupers, in which Nhon Hai and Ghenh Rang supported six grounds for each.

Keywords: Commercial and seed resources, spawning and nursery grounds, Quy Nhon bay.

INTRODUCTION

Coral reefs are the dominant marine habitat throughout shallow tropical seas, providing significant economic goods and services and contributing to the livelihoods, food security, and safety of millions of people worldwide [1]. Reef fisheries are worth 6.8 billion USD globally and 395 million USD a year in the Caribbean [2], and 2.4 billion USD a year in Southeast Asia [3]. However, rapid human population growth, increased demand, more efficient fishery technologies, and inadequate management and enforcement have led to the depletion of key reef species and habitat damage in many locations [3, 4]. Overfishing is one of the most pressing human activities on coral reefs, leading to differential declines in key ecosystem functions and radical variations in coral reef dynamics [5–7].

In recent years, assessments of coastal fishery resources have become increasingly important for sustainable management in many countries globally. In Vietnam, several studies of reef-related fisheries resources were conducted at Nha Trang bay, Ninh Hai coastal waters, Phu Quoc islands, and Tho Chu islands during 2010–2014 using a standard approach of consultations with experienced local fishermen [8]. The results from those studies showed that the calculated yields were different among the studied areas, giving the lowest in Ninh Hai waters (19 tons/km²/year) to the highest in Tho Chu islands (200 tons/km²/year), and the calculated revenues ranging between 500–800 thousand USD per area. Collection of juveniles for cage culture also contributed high revenue for fishermen, around 1 and 1.5 million USD from lobster juvenile in Ninh Hai waters and Nha Trang bay respectively, and approximately 600,000 USD from grouper juvenile in Phu Quoc islands.

To conserve the coastal area of Quy Nhon bay, the Quy Nhon Locally Managed Marine Area (LMMA) was established under the Decision No. 3470/QĐ-UBND of the Provincial People's Committee of Binh Dinh dated 24th October 2016. The Quy Nhon LMMA comprises of 36,530 ha with the core zone of 10,007 ha and the buffer zone of 26,350 ha, located at four communities/wards (Nhon Ly, Nhon Hai, Ghenh Rang and Nhon

Chau) of Quy Nhon city, Binh Dinh province. Previous studies showed that the coastal waters of Quy Nhon LMMA supported favorable conditions for the formation and development of typical ecosystems with high biodiversities, such as coral reefs [9] and many valuable marine creatures, especially sharks [10, 11].

In recent years, coastal resources for socio-economic development such as fishing, tourism, aquaculture has contributed to providing benefits for local communities. However, these activities have caused stresses on marine biodiversity and resources in Quy Nhon bay and adjacent areas, which contributed to the degradation of the quality of ecosystems and the decline in resources. There existed some studies in the past on marine biodiversity of Quy Nhon bay aiming at different goals and covering a range of study areas. However, their results have not met the requirements for resource management.

As a part of supporting the sustainable management of Quy Nhon bay, we examined the status and utilization of marine resources. These were used to develop recommendations of solutions for the enhancement of management effectiveness of marine resources of the bay in the future. Specifically, this study will provide updated data and information on the exploitation of reef-related fisheries resources and identification of spawning and nursery grounds of target species.

MATERIALS AND METHODS

Assessments of fishery resources related to key marine habitats

Reef-related fisheries, spawning, and nursery grounds of target resources were assessed using an investigation note and consultation with local communities (PRA) at four communes (Nhon Ly, Nhon Hai, Ghenh Rang and Nhon Chau) surrounding Quy Nhon bay in November 2016.

At each consultation, biological scientists from the Institute of Oceanography, together with local authorities selected 12–20 representatives, including experienced fishers from different fishing gears, local dealers and marine aquaculturists to consult needed information. Information and data on target

fisheries resources which were identified as species or groups of species contribute high yield and revenue for the local communities. A

total of 67 representatives contributed to the investigation notes and local consultations at four communes (table 1).

Table 1. Number of persons that contributed to investigation notes and local consultations at each commune surrounding Quy Nhon bay

No.	Commune	Investigation notes	Local consultations
1	Nhon Ly	20	20
2	Nhon Hai	12	12
3	Ghenh Rang	18	18
4	Nhon Chau	17	17
Total		67	67

Questions were focused on target species and fishing activities (fishing gears and seasons, number of fishing boats, number of fishers per fishing boat, catch per boat per day/night, average production of each resource per time unit, farm gate price of each resource group, impacts and trends of change in catch of each group of resources). In addition, information on spawning and nursery grounds and seasonal occurrence of target resources at each location was also collected for later ground-truthing.

Assessments of spawning and nursery grounds of target resources

Assessments of location and time of occurrence and distribution of spawning and nursery grounds of target species were based on local fishers (local knowledge) and field surveys for ground checking at each spawning/nursery ground. The surveys conducted in December 2016 and April–June 2017 were only focused on assessments of the ‘eggs and juveniles’ of target species settled in the habitats.

At each putative spawning/nursery ground, the survey was conducted at five sites, in which four sites were at the corners and one site was in the middle of the ground. Dive surveys were conducted using scuba by trained staff of the Institute of Oceanography and hookah diving by experienced local fishers. The surveys sought the presence of eggs/juveniles of target resources. Once the divers located eggs/juveniles of the target species, they moved in to evaluate the number of egg nests/juveniles of each target species.

Then, the area of each ground was identified by moving the boat surrounding the area while recording positions with an onboard portable GPS (GPSmap 76CSx) and guidance from experienced local fishers.

Data analysis

Equations were used to calculate: i) *Annual yield of each target species/group resource = Number of boats × Fishing time × Average yield per time unit (CPUE)*, and ii) *Revenue of each species/group resource = Annual yield × Farm gate price at the study period.*

RESULTS AND DISCUSSION

Reefs related fishery resources

The results of local consultations conducted in November 2016 show that there were 16 fishing gears used in Quy Nhon bay. The main fishing types were barrier net (1,338 boats), lift net catching lobster seeds (1,264 boats), lift net catching fishes (641 boats), trammel net (538 boats), plant-fixed trap (520 boats), hand longline fishing (457 boats), day and night purse seine net (362 boats), moved longline fishing, hookah diving and net catching swimming crabs (121–140 boats/gear), trap (71 boats) and others with 8–13 boats (squid trap, nylon net, net catching flyingfishes and stick-held dip net) (table 2).

In Nhon Ly, more fishers use lift nets to catch fishes, lift nets to catch lobster ‘seeds’ and purse seine, while the Nhon Hai fishery was dominated by moved and hand longline fishing and snorkeling. In Ghenh Rang, fishing activities were mainly concentrated in plant-fixed trap catching grouper juveniles and

net catching swimming crabs, while barrier net and trammel net were common in Nhon Chau (table 2).

Some fishing gears were popular in all locations, including hand longline fishing, barrier net, lobster lift net, and purse seine.

Some other gears were specific for each location, such as squid trap and stick-held dip net (Nhon Ly), trammel net and nylon net (Nhon Chau), net catching flyingfishes (Nhon Hai), snorkeling and net catching swimming crabs (Nhon Hai and Ghenh Rang) (table 2).

Table 2. Numbers of fishing boats using different fishing gears at the 4 communes in Quy Nhon bay (Fishing month in lunar calendar)

No.	Fishing gears	Fishing month	Numbers of boats (boats, persons)				Total
			Nhon Ly	Nhon Hai	Ghenh Rang	Nhon Chau	
1	Squid trap	5-7	13				13
2	Moved longline fishing	1-12		70	20	40	130
3	Hand longline fishing	1-12	132	200	90	35	457
4	Plant-fixed trap	1-12	20	20	480		520
5	Hookah diving	2-8	14	57	50		121
6	Barrier net	1-12	40	120	22	1,156	1,338
7	Trammel net	8-2				538	538
8	Crab trammel net	1-12		40	100		140
9	Trap	1-12	15	36	20		71
10	Nylon trammel net	10-1				8	8
11	Flyingfish net	6-8		10			10
12	Fish lift net	2-9	350	221		70	641
13	Lobster lift net	9-3	500	430	300	34	1,264
14	Stick-held dip net	1-7	8				8
15	Purse seine	1-12	256	12	4	90	362
16	Snorkeling fished in reefs	2-8		150	50		200

Analysis of information from local consultations indicated that 29 species/groups were considered important target resources on coral reefs in Quy Nhon bay. Among them, there were 13 species/groups of fishes including orange-spotted grouper (*Epinephelus coioides*), six-bar grouper (*E. malabaricus*), duskytail grouper (*E. bleekeri*), common trevallies (*Caranx* & *Carangoides* spp.), doublespotted queenfishes (*Scomberoides* spp.), leatherjackets (*Aluterus* spp.), emperors (*Lethrinus* spp.), rabbitfishes (*Siganus* spp.), mangrove-red snapper (*Lutjanus argentimaculatus*), blackspot snapper (*L. ehrenbergii*), sweetlips (*Plectorhinchus* spp.), needlefishes (*Tylosurus* spp.), chubfishes (*Kyphosus* spp.); 9 mollusk species such as *Septoteuthis* squids, cuttlefishes (*Sepia* spp.), abalones (*Haliotis* spp.), conchs (*Strombus* spp.), top shells (*Tectus* & *Trochus* spp.), murex snails (*Chicoreus* spp.), turbo shells (*Turbo* spp.), pinna color (*Pinna bicolor*), and flag pen shells (*Atrina vexillum*); 4 species

of crustaceans including ornate spiny lobster (*Panulirus ornatus*), scalloped spiny lobster (*P. homarus*), longlegged spiny lobster (*P. longipes*) and slipper lobsters (*Scyllarides* spp.); 2 species of seaweeds (*Gracilaria* spp.); and 1 species of echinoderm (collector urchins *Tripneustes gratilla*).

Yield and revenue from fishing

Daily catch and yield

Marine resources in Quy Nhon bay were exploited to supply food and input materials for marine aquaculture. The annual output of commercial production was about 637.43 and 936,450 seeds, in which grouper seeds including orange-spotted grouper (*E. coioides*) and six-bar grouper (*E. malabaricus*) were about 576,000 individuals (occupied with 61.5% of the total catch) and some 360,450 individuals of lobster ‘seeds’ (38.5%). In terms of commercial resources, fishes provided the highest yield (76.12% of total catch), next to

mollusks (20.32%) and echinoderms (3.03%), while crustaceans and seaweeds had the lowest yield (0.53%) (table 3).

Ghenh Rang was the only location collecting grouper seeds for aquaculture (576,000 seeds/year). For lobster seeds, the catch in Nhon Hai was the highest (153,000 'seeds'; 42.5%), next to Ghenh Rang (126,000 seeds; 35%), Nhon Ly (78,000 seeds; 21.6%), and Nhon Chau (3,150 seeds; 0.9%) (table 3).

Among 15 target species/groups of fishes listed in table 4, commercial and juvenile

rabbitfishes were caught with the highest yield (437.28 tons/year), mainly dominated by juveniles (500 kg/day and 360 tons/year) and commercial catch (8.24 kg/day and 77.28 tons/year). In addition, there were some 360,000 'seeds' of orange-spotted grouper (*E. coioides*) and 216,000 'seeds' of six-bar grouper (*E. malabaricus*) mainly collected along the shore of Quy Nhon bay (from Thi Nai river mouth to Bai Xep) by the fishermen of Ghenh Rang village.

Table 3. Yield of exploited resources at locations in Quy Nhon bay in 2016

Kind of resources	Nhon Ly	Nhon Hai	Ghenh Rang	Nhon Chau	Total
<i>Juveniles (individuals)</i>	78,000	153,300	702,000	3,150	936,450
- Groupers			576,000		576,000
- Lobsters	78,000	153,300	126,000	3,150	360,450
<i>Commercial (tonnes)</i>	97.28	442.02	31.80	66.33	637.43
- Fishes	36.36	397.20		51.67	485.23
- Molluscs	60.92	40.50	13.80	14.32	129.54
- Echinoderms		1.32	18.00		19.32
- Seaweeds		3.00			3.00
- Crustaceans				0.34	0.34

Table 4. CPUE (kg, inds./day) and yield (tonnes, inds./year) of fish resources in 2016

Group of resources	Ghenh Rang		Nhon Chau		Nhon Hai		Nhon Ly		Total
	CPUE	Yield	CPUE	Yield	CPUE	Yield	CPUE	Yield	
<i>Juveniles (inds.)</i>		576,000							576,000
Orange-spotted grouper	80	360,000							360,000
Sixbar grouper	120	216,000							216,000
<i>Commercial (tonnes)</i>				51.67		397.20		36.36	485.23
Common trevallies			2.25	5.13					5.13
Double spotted queenfishes			2.5	8.86					8.86
Leatherjackets			0.5	1.02					1.02
Emperors			15	14.65	0.65	2.7			17.35
Comercial rabbitfishes			1	14.28	10	27	10	36	77.28
Juvenile rabbitfishes					500	360			360.00
Mangrove-red snapper			2	6.14	0.75	3	0.17	0.08	9.22
Sweetlips					0.65	2.7			2.70
Groupers			1.75	1.18	0.65	0.81	0.1	0.08	2.07
Flyingfishes					5.5	0.99	-	-	84.60
Black spot snapper							0.31	0.2	0.20
Chubfishes			0.2	0.41					0.41

For mollusks, there were nine major commercial species/groups harvested with the highest production of *Septoteuthis* squids (98.80 tons/year) and *Sepia* cuttlefishes (11.36 tons/year), while other groups were recorded with low production (< 10 tons/year)

(table 5). In terms of location, higher total catches were found in Nhon Ly (60.92 tons/year) and Nhon Hai (40.5 tons/year), while Nhon Chau and Ghenh Rang supported similar catch (13.8–14.32 tons/year).

Table 5. CPUE (kg/day) and yield (tonnes/year) of molluscs in 2016

Group of resources	Ghenh Rang		Nhon Chau		Nhon Hai		Nhon Ly		Total
	CPUE	Yield	CPUE	Yield	CPUE	Yield	CPUE	Yield	
Flat pen shells	-	-	-	-	2	0.24	-	-	0.24
Abalones	0.3	0.6	-	-	1.1	0.36	-	-	0.96
Septoteuthis squids	1	7.2	1	10.24	0.83	23.76	5	57.6	98.8
Cuttlefishes	-	-	0.6	4.08	0.5	6.48	0.5	0.8	11.36
Conchs	-	-	-	-	1	0.12	-	-	0.12
Top shells	3	1.8	-	-	5.25	1.5	-	-	3.3
Murex snails	4	2.4	-	-	15.5	4.2	5	1.8	8.4
Turbo snails	3	1.8	-	-	11	3.6	2	0.72	6.12
Pinna color	-	-	-	-	2	0.24	-	-	0.24
Total		13.8		14.32		40.5		60.92	129.54

For crustaceans, lobsters are mainly harvested by Nhon Chau commune with a mean CPUE and total catch being 0.03 kg/day and 0.34 ton/year, respectively (table 6). In addition, there were some 360,450 ‘seeds’ of

ornate spiny lobster (*P. ornatus*) and scalloped spiny lobster (*P. homarus*) mainly collected in the waters surrounding Nhon Hai (153,300 ‘seeds’) and Ghenh Rang (126,000 ‘seeds’).

Table 6. CPUE (kg, inds./day) and yield (tonnes, inds.) of crustaceans in 2016

Group of resources	Ghenh Rang		Nhon Chau		Nhon Hai		Nhon Ly		Total
	CPUE	Yield	CPUE	Yield	CPUE	Yield	CPUE	Yield	
Juveniles (inds.)		126,000		3,150		153,300		78,000	360,450
Ornate spiny lobster	2	84,000	1.67	2,100	2	91,700	4	62,400	240,200
Scalloped spiny lobster	1	42,000	0.83	1,050	1.5	61,600	1	15,600	120,250
Commercial (tonnes)				0.34					0.34
Lobsters			0.03	0.34					0.34

The total catch of echinoderms was about 19.32 tons/year, mainly collected by the fishers of Ghenh Rang and Nhon Hai communes (table 7). However, sea urchins were commonly collected to feed lobsters, especially in Nhon

Ly, Nhon Hai and Nhon Chau communes. Seaweeds (*Gracilaria* spp.) were mainly harvested in Nhon Hai with a production of some 3.0 tons/year. Lower production of seaweeds was also harvested in Ghenh Rang.

Table 7. CPUE (kg/day) and yield (tons) of echinoderms and seaweeds in 2016

Group of resources	Ghenh Rang		Nhon Hai		Total
	CPUE	Yield	CPUE	Yield	
Collector urchins	30	18	3.50	1.32	19.32
Seaweeds				3.0	3.0
- <i>Gracilaria eucheumatoides</i>			4	2.4	
- Other <i>Gracilaria</i>			1	0.6	

The results from this study show that the total yield was higher than that in Nha Trang bay (328 tons/year in 2014 [12]), Phu Quoc islands (258 tons/year in 2010), Ninh Hai coastal waters (435 tons/year in 2011) and Tho Chu islands (541 tons/year in 2013) [8], but this was lower than that of Cu Lao Cham islands (506 tons [13]).

Revenue

The total revenue from fishing of reef related fishery resources at the 4 locations was some 90.81 billion VND (about 4,128,000 USD), with the highest value being recorded in Nhon Hai (41.23 billion VND), Nhon Ly (28.53 billion VND), Ghenh Rang (13.06 billion VND) and the lowest in Nhon Chau (7.99 billion VND). Among them, commercial resources contributed only 35.43% (32.17 billion VND; about 1,453,000 USD) and 'seed' collection accounted for more than 64.57% (58.64 billion VND; about 2,935,000 USD) (table 8). Nhon Hai, Nhon Ly and Nhon Chau communes harvested a higher catch of

commercial resources than Ghenh Rang commune. The commercial revenue from mollusk harvest was 65.43% of the total revenue, next to fishes (32.33%), crustaceans (1.27%), echinoderms, and seaweeds (0.97%). In the total revenue of 58.64 billion VND (about 2,660,000 USD) from 'seed' collection, lobster 'seeds' harvest accounted for 98% and other 'seed' resources only 2%. In terms of locations, the revenue of Nhon Hai was the highest (30.66 billion VND), followed by Nhon Ly (16.15 billion VND), Ghenh Rang (11.23 billion VND), and the lowest in Nhon Chau (0.60 billion VND) (table 8).

In general, there was a difference in revenues between the fishing communes in Quy Nhon bay due to the difference in target resources. The highest yield in Ghenh Rang was crustaceans (both 'seed' and commercial resources), while Nhon Ly and Nhon Hai were lobster seeds, commercial resources and mollusks. Nhon Chau is an offshore island commune and mainly exploited commercial fishes.

Table 8. Revenue (billion VND) from the exploitation of marine resources in 2016

Group of resources	Ghenh Rang	Nhon Chau	Nhon Hai	Nhon Ly	Total
<i>Juveniles</i>	11.23	0.6	30.66	16.15	58.64
Groupers	1.15	-	-	-	1.15
Lobsters	10.08	0.6	30.66	16.15	57.48
<i>Commercial resources</i>	1.83	7.39	10.57	12.38	32.17
Fishes		4.14	4.41	1.58	10.40
Molluscs	1.65	2.84	6.03	10.53	21.05
Crustaceans		0.41			0.41
Echinoderms	0.18	-	0.01	-	0.19
Seaweeds	-	-	0.12	-	0.12
Total	13.06	7.99	41.23	28.53	90.81

Distribution of spawning and nursery grounds of target resources

Local consultations and field surveys show 16 substantial grounds in Quy Nhon bay, including three spawning grounds of squid (*Sepioteuthis lessonianna*) and murex snails (*Chicoreus* spp.), 13 nursery grounds of swimming crabs (*Portunus* spp.), lobster 'seeds' (*Panulirus* spp.), sea cucumbers (*Stichopus* & *Holothuria* spp.), rabbitfishes (*Siganus* spp.), and groupers (*Epinephelus* spp.) (figs. 1 & 2).

In Nhon Ly waters, there were two important spawning and nursery grounds found in Hon Cao-Bai Dua-Cong Coc cape (spawning ground of squids and murex snails as well as nursery ground of lobster 'seeds') and Bai Chai (the northern part of Seo island) (spawning ground of murex snails). In Nhon Hai waters, there were six important grounds found at NE Kho Nho island (breeding ground of murex snails), W Kho Lon island and Bo Dap (nursery ground of rabbitfishes), SW Kho Lon island (spawning ground of squids and nursery ground

of lobster ‘seeds’), W. Yen cape (nursery ground of swimming crabs), and S Yen cape (nursery ground of lobster ‘seeds’). Details of the ‘seeds’ occurrence time were given in table 9.

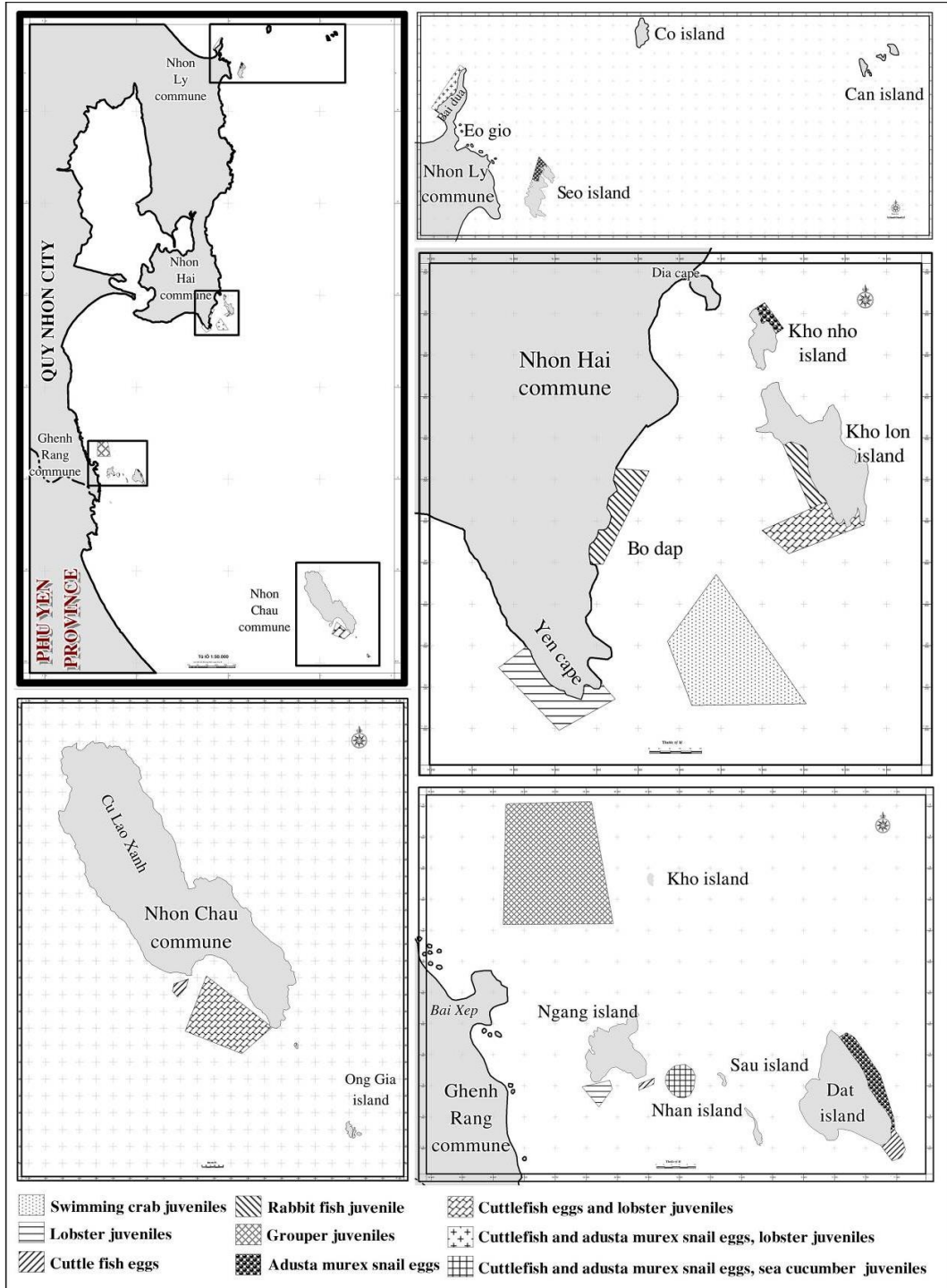


Figure 1. Distribution of spawning and nursery grounds of marine target species at different locations in Quy Nhon bay



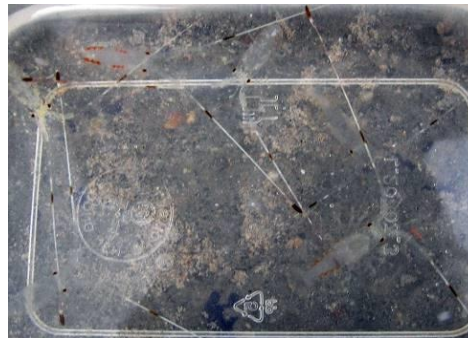
a) Eggs of murex snails at Bai Dua, Nhon Ly



b) Eggs of squids at Ngang and Sau islands, Ghenh Rang



c) Sea cucumber juveniles attached on gorgonian corals, Ghenh Rang



d) Lobster 'seeds' collected at Bai Lang-Bai Lang Ba, Nhon Chau



e) Crab juvenile collected at NE Bo Dap, Nhon Hai



f) School of rabbitfish juveniles in *Sargassum* beds at northern Bo Dap, Nhon Hai



g) Juvenile of duskytail grouper collected at northern Bai Xep, Ghenh Rang



h) Juvenile of orange-spotted grouper collected in northern Bai Xep, Ghenh Rang

Figure 2. Eggs and juveniles of some target species recorded at spawning and nursery grounds

Table 9. Locations and seasonal occurrence of eggs and juveniles of target species in Quy Nhon bay (N: North; S: South; E: East; W: West; occurrence month in lunar calendar)

No.	Location	Site of grounds	Occurrence month	Group of resources
1	Nhon Ly	Hon Cao-Bai Dua-Cong	2-5 and	Spawning ground of squids and murex snails, nursery ground of lobsters
2		Coc cape	10-2	
3	Nhon Hai	Bai Chai	4-6	Spawning ground of murex snails
4		NE Kho Nho island	4-6	Spawning ground of murex snails
5		SW Kho Lon island	3-6	Nursery ground of rabbitfishes
6		Bo Dap		
7		SW Kho Lon island	10-6	Spawning ground of cuttlefish and nursery ground of lobsters
8		W Yen cape	10-1	Nursery ground of swimming crabs
9		S Yen cape	10-3	Nursery ground of lobsters
10	Ghenh Rang	N Bai Xep	3-7	Nursery ground of groupers
11		SW Ngang island	10-3	Nursery ground of lobsters
12		SE Ngang island	4-6	Spawning ground of squids
13		In the water between Ngang and Sau islands	4-6	Spawning ground of squids and murex snails, nursery ground of sea cucumbers
14		W Dat island	4-6	Spawning ground of murex snails
15	Nhon Chau	SE Dat island	4-6	Spawning ground of squids
16		Surrounding of Kho island in the north	2-5	Spawning ground of squids
		Bai Lang-Lang Ba cape	2-5 and 10-1	Spawning ground of squids and nursery ground of lobsters

In Ghenh Rang waters, there were also six important grounds recorded, in N Bai Xep (nursery ground of groupers), SW and SE Ngang island (nursery ground of lobster ‘seeds’ and spawning of squids), in the waters between Ngang and Sau islands (breeding ground of squids and murex snails as well as nursery ground of sea cucumbers), West and SE Dat island (spawning grounds of murex snails and squids). In Nhon Chau waters, only two important grounds were found, at Kho island in the north (spawning ground of squids) and Bai Lang - Lang Ba cape (breeding ground of squids and nursery ground of lobster ‘seeds’) (fig. 1 & table 9).

CONCLUSIONS

A total of 29 target species/groups was exploited for food and aquaculture in Quy Nhon bay. The annual commercial yield of marine resources exploited was 637.43 tonnes and 936,450 juveniles of groupers and lobsters, giving a total revenue of some 90.81 billion VND (including 32.17 billion VND

from commercial harvest and 58.64 billion VND from ‘seeds’) for the local communities of Nhon Ly, Nhon Hai, Ghenh Rang and Nhon Chau.

There were 16 important spawning and nursery grounds of 9 species/groups of target resources (murex snails, squids, ornate and scalloped spiny lobsters, rabbitfishes, groupers and sea cucumbers) recorded in Quy Nhon bay, in which Nhon Hai and Ghenh Rang locations supported a higher number of spawning and nursery grounds than the others. Protection of these spawning and nursery grounds during the occurrence months has become an important need for replenishment and recruitment of target resources to maintain coastal fisheries in the Quy Nhon bay and other adjacent waters.

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