



Marine habitats and related fishery resources in Ly Son and adjacent waters in the Northern part of Quang Ngai province

Nguyen Van Long^{1,2,*}, Thai Minh Quang¹, Mai Xuan Dat¹, Tong Phuoc Hoang Son¹

¹*Institute of Oceanography, VAST, Vietnam*

²*Graduate University of Science and Technology, VAST, Vietnam*

Received: 2 January 2022; Accepted: 26 May 2022

ABSTRACT

The study assessed the distribution of key marine habitats and related fishery resources and spawning and nursery grounds of target species in the waters of Ly Son islands and adjacent locations of Tra Bong and Sa Ky estuaries using data from analysis of the Sentinel-2 satellite image and ground-truthing. There were about 1,787 ha of coral reefs, 117.3 ha of seagrass beds, and 309 ha of nipa palm (*Nypa fruticans*) distributed in this area, in which the water surrounding Ly Son marine protected area (MPA) supported more than 1,706 ha of coral reefs and 116 ha of seagrass beds. The area also supported 12 nursery grounds of 10 target resources, including giant trevally, mangrove-red snapper, orange-spotted spinefoot, orange-spotted grouper, malabar grouper, barramundi related to nipa palms in Tra Bong and Sa Ky estuaries. In contrast, sea cucumbers, turbo snails, top shells, and giant clams were associated with coral reefs in Ly Son MPA. Related fishery resources, spawning, and nursery grounds of target species involved 8 consultations of local experienced fishermen and a field investigation of the presence of spawning and nursery grounds from November 2019 to September 2020. A total of 1,278 tonnes of commercial resources were harvested in the coral reefs and some 4.647 thousand juveniles of fish and crabs were collected from the adjacent estuaries, in which some essential species of reef fishes indicate linkages between juveniles collected from the nipa palm and seagrass beds in Tra Bong and Sa Ky estuaries and adults fished in the coral reefs in Ly Son MPA. So, conservation and management of exploitation of fish juveniles related to the nipa palm and seagrass beds in Tra Bong and Sa Ky estuaries are considered important solutions for the maintenance of the linkages of fish resources associated with critical marine habitats and fisheries in the waters of Ly Son MPA and adjacent locations in the future.

Keywords: Marine habitats, resources, spawning and nursery grounds, Ly Son islands, marine protected area.

*Corresponding author at: Institute of Oceanography, 1 Cau Da, Nha Trang, Khanh Hoa, Vietnam. *E-mail addresses:* longhdh@gmail.com

<https://doi.org/10.15625/1859-3097/16607>

ISSN 1859-3097; e-ISSN 2815-5904/© 2022 Vietnam Academy of Science and Technology (VAST)

INTRODUCTION

Coastal marine ecosystems play a critical role protecting the coastline, providing food, shelter, spawning, and nursery grounds for organisms, maintaining ecological processes and primary productivity and developing marine aquaculture and tourism [1–3]. Several studies reported that many target fish species used mangroves and seagrass beds in estuaries for their settlement, feeding, and growth in their early and juvenile life stages before migrating to adjacent coral reefs as adults [4–6]. Therefore, studies and assessments of marine ecosystems and their associated resources, especially mangroves, seagrass beds, and coral reefs, have become essential in providing scientific baselines for the developing of orientation and management planning and sustainable uses of marine biodiversity and resources.

Ly Son islands and adjacent waters of Tra Bong and Sa Ky, Quang Ngai province, provide favorable conditions for forming and developing distinct marine ecosystems such as coral reefs [7] and seagrass beds [8]. Most of the previous studies have mainly focused on assessments of the distribution of seaweed and seagrass beds using remote sensing and GIS technology [8–10], diversity of hard and soft coral communities [11, 12], seaweeds [13], molluscs [14], coral reef fishes [15, 16], biodiversity and community structure of coral reefs [17]. Besides, the preliminary results assessing the survival rate of transplanted species of hard corals for restoration of coral reefs were conducted in 2016–2017 [18].

During the last few decades, the marine biodiversity and resources surrounding the Ly Son district and adjacent waters (Binh Son and Son Tinh districts) have played an important role in local socio-economic development. However, these activities have caused negative impacts on ecosystems and resources due to over-exploitation, destructive fishing, and coral bleaching [7]. Coral-sand excavation for planting onions and garlic has caused erosion of islands and material imbalance [19]. Additionally, local authorities' strategies for future socio-economic development are

ongoing to put more pressure and impact on marine biodiversity and resources in the surrounding waters.

Although some studies have been conducted in this area, the data and results from the mentioned studies have not been updated and mainly focused on marine biodiversity and seaweed resources, and there have been no studies to assess resource exploitation and spawning and nursery grounds of target species. Therefore, this study will contribute to providing updated comprehensive data and information on the distribution of vital marine habitats (coral reefs, mangroves and seagrass beds) and additional information on spawning and nursery grounds of target resources associated with aquatic ecosystems in the waters of the Ly Son islands and adjacent coastal areas which are formed as scientific baselines for local authorities to evaluate the temporal changes and to develop strategies for conservation and sustainable uses of marine biodiversity in the future.

MATERIALS AND METHODS

Assessments of marine habitats



Figure 1. Sentinel-2 satellite image covering the coastal area of Ly Son islands and adjacent locations, Quang Ngai province taken on 19 March 2019

The satellite image used in this study was Sentinel-2 No. S2A_MSIL1C_20190319T030541_N0207_R075_T49PBT_20190319T075154) with a high resolution of 10 m taken on 19 March 2019 in the coastal area of Quang Nam - Quang Ngai provinces (Fig. 1).

Procedures for mapping the distribution and calculating the area of key marine habitats, including mangroves, seagrass beds, and coral reefs, were based on a review of available data and information from previous studies and combined with data from the classification of the Sentinel-2 image and ground-truthing. The field ROI (regions of interest) data were separated into 2 groups to interpret the distribution of coral reefs and other substrates by the *DII* method. Group 1 included 150 homogenous sand sites at each location in the study area taken at different depths to calculate *DII* in band pairs for image classification of underground habitats). Group 2 was 100–150 sites in different substrates (corals, mangroves seagrasses, rock, and sand at each location in the study area) for image classification and habitat mapping.

Based on principles of image classification by calculating Depth Invariance Index [20, 21], we classified the distribution of coral reefs, mangroves, and seagrass beds.

Analysis of *DII* from the Sentinel-2 image, we identified Depth Invariance Index (*DII*) for each band DII_{23} , DII_{24} , and DII_{34} , equivalent to the values of 1.911; 1.7139, and 0.8958 (Fig. 2). In this case, we selected the blue band ($B2$ with $l = 497$ nm), green band ($B3$ with $l = 560$ nm) and red band ($B4$ with $l = 664$ nm) for analysis of Depth Invariance Index (*DII*). The calculated formula of images DII_{ij} for each band includes:

$$DII_{23} = 1.911 * \ln(\rho_2) - \ln(\rho_3)$$

$$DII_{24} = 1.7139 * \ln(\rho_2) - \ln(\rho_4)$$

$$DII_{34} = 0.8958 * \ln(\rho_3) - \ln(\rho_4)$$

The image bands of DII_{23} , DII_{24} , and DII_{34} have formed a baseline for isolation and classification of key habitats with a visual comparison of a combination of a color image of RGB321 (image before analysis) and $DII_{34,24,23}$ (image after analysis *DII*) in the Ly Son islands and adjacent waters. By classification of Maximum LikeLihood from the three bands of DII_{23} , DII_{24} , and DII_{34} , the area of distribution of coral reefs, seagrass beds, and mangroves in the coastal waters of the Ly Son district and adjacent locations were identified.

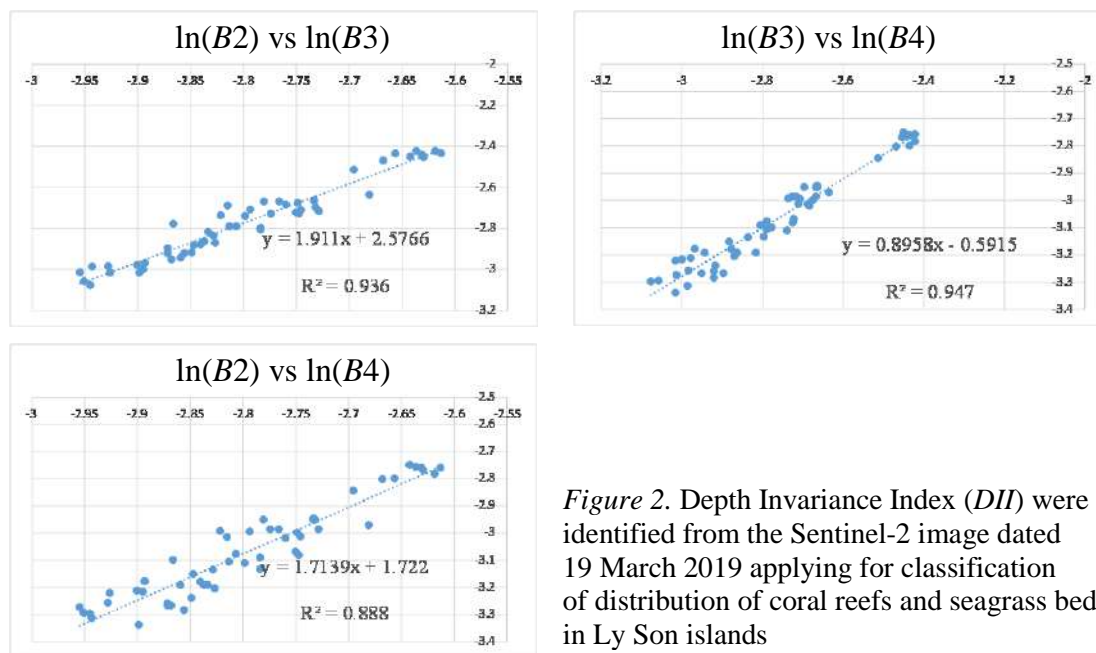


Figure 2. Depth Invariance Index (*DII*) were identified from the Sentinel-2 image dated 19 March 2019 applying for classification of distribution of coral reefs and seagrass beds in Ly Son islands

Based on the distribution of key habitats identified from the classification of the satellite image, we selected 80 sites of key substrates (corals: 30 sites, seagrasses: 20 sites, mangroves: 10 sites, rock: 10 sites, and sand: 10 sites) for ground truthing to check the accuracy of image classification. At each checking location, we recorded the presence and dominant habitat species. Data from ground truthing indicate that the classification accuracy for each substratum was 100% for nipa palm (*Nypa fruticans*), rock, and sand, 95% for seagrasses, and 92% for corals. Based on ground-truthing results, we corrected data from the classification of satellite images and mapped the distribution of vital marine habitats.

Assessments of commercial resources and seeds associated with marine habitats

Assessments of resource exploitation and fisheries were conducted using consultation with the involvement of local communities (PRA) [22]. Although there are some limits to accuracy, information and data collected from regional consultations using local ecological knowledge (LEK) have been widely applied in many countries where sufficient scientific data with high accuracy is lacking [23, 24]. Data from local consultations were considered “semi-quantitative data” for rapid assessments of the status of habitats and related resources, which contribute to providing a comprehensive baseline for appropriate planning and sustainable utilization of resources in the Latin - American countries [25] and in Vietnam [26–31]. In addition, data and information from local consultations have been contributed to provide a baseline for further detailed studies.

The local consultations involved 8 communes, including Binh Thanh, Binh Dong, Binh Phuoc (located along Tra Bong estuary, Binh Son district); Tinh Ky, Tinh Hoa, Tinh Khe (Sa Ky estuary, Son Tinh district); An Hai and An Vinh (Ly Son district) in November–December 2019. At each consultation, biological scientists from the Institute of Oceanography and local authorities selected 10 consultants, including experienced fishers using different fishing gears, local dealers, and

marine aquaculturists, to provide the needed information. Data and information collected were focused on fishing activities for seed production of target resources, including fishing gear and seasons, number of fishing boats, number of fishers per fishing boat, catch per boat per day/night, and the average production of each resource per time unit (kg, individuals), farm gate price, impacts from exploitation and trend of changes in the catch of target resources.

Assessments of spawning and nursery grounds of target species associated with habitats

Based on the location and time of occurrence of spawning and nursery grounds of target species from local fishers (local knowledge), we conducted field surveys for ground checking at each spawning/nursery ground with the involvement of experienced local fishers. Field surveys were conducted in November 2019, March 2020, July 2020, and September 2020, suitable for the occurrence of each target species.

At each putative spawning/nursery ground, the survey was conducted at 5 sites, of which 4 sites were at the corners, and 1 site was in the middle of the ground. Dive surveys were conducted using Scuba by trained Institute of Oceanography staff and hookah diving by experienced local fishers. The surveys sought the presence of eggs/juveniles in the target species. When a specific ground was identified with the presence of eggs/juveniles of the target species, the number of egg nests/juveniles of each target species was assessed. 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 fishers.

Data storage and analysis

Seeds are considered fingerlings or juveniles of fishes collected for aquaculture growth with a size range of 150 mm depending on species.

Son islands supported some 1,705.7 ha of coral reefs, mainly distributed surrounding the big island (Ly Son island: 1,563 ha) and small island/Cu Lao Bo bai (An Binh island: 142.7 ha), and together with some 81 ha found at Ghenh Yen and Binh Chau (Fig. 3). The seagrass beds were mainly distributed in the intertidal zone of the two islands in Ly Son district with a total of 115.8 ha and dominated by *Cymodocea rotundata* and

Thalassia hemprichii. The adjacent coastal locations had 1.5 ha and were distributed alongside the nypa palms at Tinh Khe with dominance by *Halophila beccarii* (Fig. 4). Nipa palms (*Nypa fruticans*) were mainly distributed along the branches of Tra Bong river (Binh Nguyen, Binh Thoi, Ca Ninh, and Binh Tri of Binh Son district (288.2 ha), and Sa Ky river (Tinh Khe of Son Tinh district: 20.8 ha) (Fig. 4).

Table 1. Area of key habitats (ha) in the Ly Son islands and adjacent waters

Location	Coral reefs	Seagrass beds	Mangroves
Big island, Ly Son	1,563	115.8	
Small island/Cu Lao Bo Bai, Ly Son	142.7		
Ghenh Yen, Binh Son	57.5		
Binh Chau, Binh Son	23.6		
Tra Bong river, Binh Son			288.2
Tinh Khe, Son Tinh		1.5	20.8
Total	1,786.8	117.3	309



Figure 4. Coral reefs and seagrass beds on Ly Son islands (left and above), seagrass beds, and nipa palms at Tinh Khe, Sa Ky estuary (bottom left and right)

Compared with 189 ha of seagrass beds based on a classification of a satellite image taken in 2007 reported in the Ly Son waters [9], the results from the present study were some 73.2 ha lower than that found in 2007. The decline of the area of seagrass beds between times may be related to encroachment on the sea to develop infrastructure projects for civil works and tourism in the past, or the differences in images used and the methods of classification of satellite images applied between the two studies that may have made the above decline. The satellite image used in the previous survey in 2007 was Landsat 4-5TM with low resolution (30 m), and the distribution of seaweeds and seagrass beds is mixed, which may be given some limits on the accuracy of the results. Meanwhile, the satellite image applied in the present study was Sentinel-2 taken in 2019 with a much higher resolution (10 m) with a combination of ground truthing and correction of data from the classification of satellite images, which may provide the results with higher accuracy and reliability. For coral reefs, the area recorded from the present study on Ly Son islands (1,705.7 ha) was similar to those reported by the Research Institute of Marine Fisheries based on a manta tow survey in 2006 (1,704 ha, [32]), although the methods used from the two studies were different.

Distribution of spawning and nursery ground of target species

Information from local consultations indicates that there were 15 spawning and nursery grounds of 12 target resources such as bigfin reef squid, murex snails (spawning grounds), turbo shells, top shells, abalones, sea cucumbers, giant trevally, mangrove red snapper, orange-spotted spinefoot, malabar grouper, dusktail grouper and giant clams (nursery grounds). However, the field surveys identified 12 nursery grounds of 10 target species/groups of species, including giant trevally (*Caranx ignobilis*), barramundi (*Lates calcarifer*), mangrove red snapper (*Lutjanus*

argentimaculatus), orange-spotted spinefoot (*Siganus guttatus*), orange-spotted grouper (*Epinephelus coioides*), malabar grouper (*E. malabaricus*), sea cucumbers (*Stichopus* & *Holothuria* spp.), turbo shells (*Turbo* spp.), top shells (*Trochus* & *Tectus* spp.) and giant clams (*Tridacna* spp.) (Table 2 & Figs. 5–6). There was no appearance of eggs of bigfin reef squid and murex snails at the spawning grounds, and no juveniles of abalones were found in the nursery grounds.

In the waters surrounding Ly Son islands, the present study recorded 6 nurseries of sea cucumbers, turbo shells, top shells, and giant clams, which were mainly distributed on coral reefs. Among them, the nursery grounds of turbo shells were recorded in the largest area, the next followed by sea cucumbers and other species with a sparse distribution. The grounds distributed in the Tra Bong and Sa Ky estuaries were the nursery grounds of fishes, including orange-spotted grouper, mangrove red snapper and orange-spotted spinefoot. Giant trevally, barramundi, and malabar grouper were sparsely distributed in some nursery grounds in the Tra Bong estuary (Table 2).

In general, juveniles of target fishes were mainly found in the Tra Bong and Sa Ky estuaries, where the nypa palms and seagrass beds were recorded, and this is similar to the findings from the Thu Bon estuary, Quang Nam [30]. In coral reefs, the number of grounds and species recorded from the present study was higher than that in Cu Lao Cham MPA, Quang Nam (2 spawning grounds of bigfin reef squid and murex snails [30]). No appearance of eggs of murex snails and bigfin reef squid in the spawning grounds reported from the present study may be explained by the difference in the time of surveys. The previous research in Cu Lao Cham MPA was conducted in May–June 2016 and confirmed the spawning season of bigfin reef squid and murex snails occurred from April to June [30], while the present study was carried out in November 2019, March 2020, July 2020, and September 2020 with missing surveys between April–June, so we did not record the presence of eggs of the bigfin reef squid and murex snails.

Table 2. Summary of information on spawning and nursery grounds in the Ly Son islands and adjacent waters

No.	Location	Area (ha)	Habitat	Resources	Season of occurrence (month in lunar calendar)
1	Mui Ru-Da Chat (Tra Bong estuary, Binh Son)	23.6	Rock, muddy bottom with dead shells of organisms	Juveniles of giant trevally, barramundi, orange-spotted grouper, malabar grouper, mangrove red snapper, orange-spotted spinefoot	10–12 & 1–7
2	Sa Can river mouth-Tra Bong bridge (Tra Bong estuary, Binh Son)	17	Muddy bottom with dead shells of organisms	Juveniles of giant trevally, barramundi, orange-spotted grouper, malabar grouper, mangrove red snapper, orange-spotted spinefoot	10–12 & 1–7
3	Ca Ninh (Tra Bong estuary, Binh Son)	25.2	Nypa palm	Juveniles of giant trevally, orange-spotted grouper, mangrove red snapper, orange-spotted spinefoot	2–7
4	Go Tay- Sa Ky river mouth, Son Tinh	10.3	Muddy bottom with dead shells of organisms	Juveniles of giant trevally, orange-spotted grouper, malabar grouper, mangrove red snapper, orange-spotted spinefoot	2–7
5	Tinh Ky (Son Tinh)	27.6	Muddy bottom with dead shells of organisms, mangroves	Juveniles of orange-spotted grouper and malabar grouper	2–7
6	Tinh Khe (Son Tinh)	21.3	Nypa palm, seagrass, and seaweed beds	Juveniles of orange-spotted grouper, mangrove red snapper, orange-spotted spinefoot	2–7
7	An Hai-Radar station (Ly Son)	62.1	Coral reefs	Juveniles of sea cucumbers, turbo shells	2–5
8	Chua Hang channel (Ly Son)	111.5	Coral reefs	Juveniles of sea cucumbers, turbo shells, eggs of cuttlefishes	2–5
9	South of Go Nui Lua (Ly Son)	33.1	Coral reefs	Juveniles of giant clams, turbo shells, sea cucumbers	2–5
10	Tam Toa temple (Ly Son)	20.3	Coral reefs	Juveniles of sea cucumbers, turbo shells, top shells	2–5
11	Da Den of An Binh island (Ly Son)	34.8	Coral reefs	Juveniles of sea cucumbers, turbo shells	2–5
12	To Vo gate-An Vinh (Ly Son)	113.2	Coral reefs	Sea cucumbers, turbo shells	2–5

Catch and seed production harvested from marine habitats

Commercial resources: Analysis of data and information from local consultations shows that the total catch and revenue of associated-reef resources in 2019 were 1,278 tonnes and 212 billion VND, of which spiny lobsters had the highest revenue

(116 billion VND), the next followed by molluscs (12 billion VND) and echinoderms was the lowest (1.8 billion VND) (Table 3). Orange-spotted spinefoot and other spinefoot rabbitfishes, fusiliers, mangrove red snapper, spiny lobsters, and turbo shells were the most dominant in terms of catch compared to different groups of harvested resources (Table 3 & Fig. 6). Comparison with the

results reported from other coastal areas using similar methods of local consultation, the coral reefs on Ly Son islands supported 2.4–4.9 times higher in a total catch of commercial resources than Cu Lao Cham

MPA (506 tonnes in 2015; [32]), Nha Trang bay (328 tonnes in 2014), coastal reefs in Ninh Hai district, Ninh Thuan province (435 tonnes in 2011), Phu Quoc MPA (258 tonnes in 2010) and Tho Chu (541 tonnes in 2013) [29].

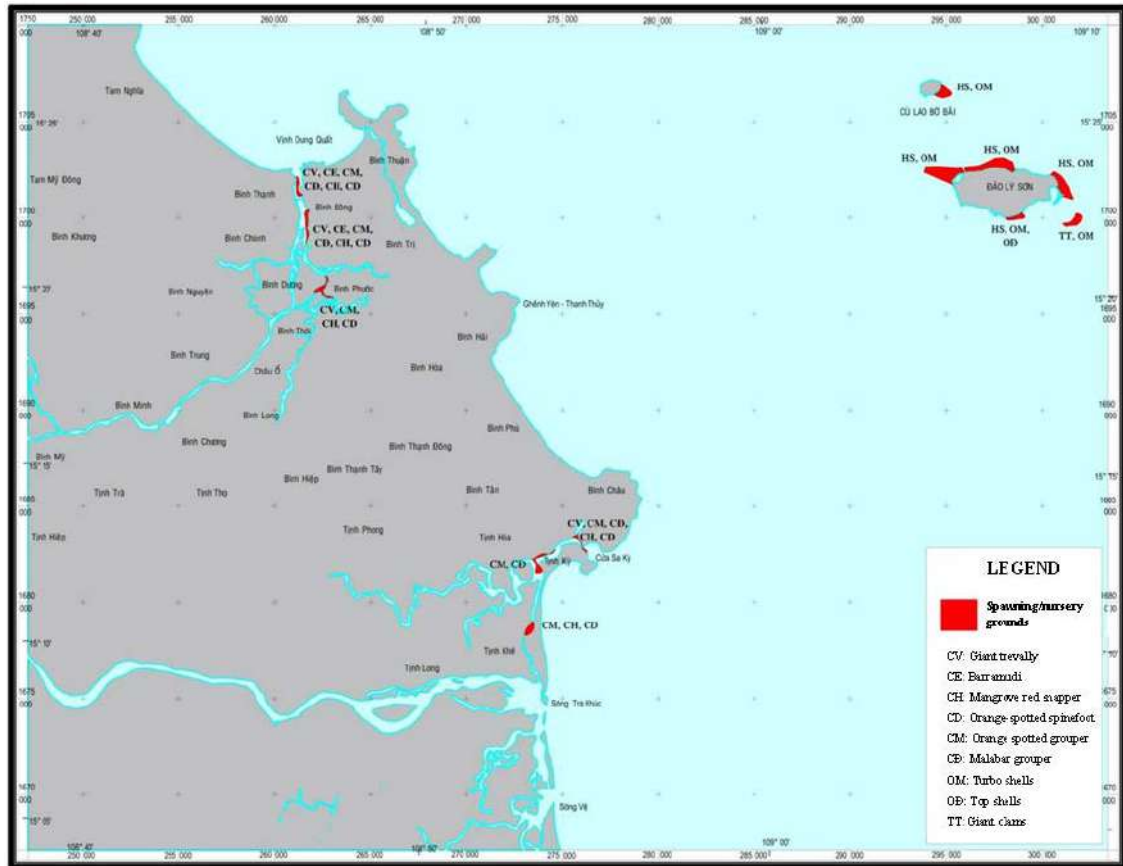


Figure 5. Distribution of important spawning and nursery grounds in Ly Son islands and adjacent waters (reducing the scale of the original map by 1/25,000)

Seed production: Seed resources were mainly caught in and surrounding the nypa palms and seagrass beds in the Tra Bong and Sa Ky estuaries. The total catch and revenue of these resources in 2019 were some 4,647 thousand seeds and 11.23 billion VND, mainly dominated by fishes (4,529 thousand seeds and 9.46 billion VND) and a small proportion of mud crabs (> 118 thousand seeds and 1.77 billion VND). The seeds of target fishes included orange-spotted spinefoot, mangrove red snapper, orange-spotted grouper, malabar grouper, dusktail grouper and giant trevally (Fig. 6). The catch of orange-spotted

spinefoot was about 3,637 thousand seeds (occupied with 78.27% of the total catch of fish seeds), the follower was orange-spotted grouper (246 thousand seeds; 8.82%), mangrove red snapper (253 thousand seeds; 5.45%), however, the revenue was the highest for orange-spotted grouper (4.64 billion VND), mangrove red snapper (2.49 billion VND) and mud crabs (1.77 billion VND) (Table 3). In comparison with the results reported from the previous studies conducted in some coastal estuaries and lagoons, the total catch of seeds in the study area was 5.3 times higher than that in Nha Phu lagoon, Khanh Hoa province

(876 thousand seeds; [33]) but 1.5 times lower in Thu Bon estuary, Quang Nam province (7,020 thousand seeds; [30]).

Among 7 target species of seeds, the Tra Bong estuary had 6 species of fishes with a catch of 4,182 thousand seeds and was 9 times higher than that in the Sa Ky estuary (5 species and 464 thousand seeds), especially giant trevally (> 290 times higher) and orange-spotted spinefoot (58 times), however, the revenue (7.54 billion VND) was 2 times higher than that in the Sa Ky estuary (3.69 billion VND) (Table 4).

With a total catch of more than 4,647 thousand seeds harvested in and surrounding the nypa palms and seagrass beds in the coastal estuaries in 2019, together with some 1,278 tonnes of commercial resources exploited in coral reefs indicate that key marine habitats have

been playing important roles in fisheries and aquaculture industry in the study area and other provinces in Vietnam. It is noted that seed resources of target species of the reefs (giant trevally, mangrove red snapper, orange-spotted spinefoot, orange-spotted grouper, malabar grouper) were harvested in the estuaries while the commercial resources of those species were exploited on coral reefs in Ly Son islands. These indicate a linkage of these resources among key marine habitats during their life cycles. Therefore, conservation and management of exploitation of seed resources related to key marine habitats such as the nypa palms and seagrass beds in the Tra Bong and Sa Ky estuaries should be considered urgent solutions to maintain ecological linkages of resources and fishery activities for both adjacent coastal estuaries and Ly Son MPA in the future.

Table 3. Total catch and revenue of juveniles and commercial production of some target species in the waters of Ly Son islands and adjacent locations

No.	Resources	CPUE (kg, seeds/boat/day)	Catch (tonnes, seeds)	Revenue (billion VND)
1	Seeds (individuals)		4,646,958	11.23
	Orange-spotted spinefoot	1,777	3,637,005	0.94
	Mangrove red snapper	25.4	253.396	2.49
	Orange-spotted grouper	10.8	409.910	4.64
	Malabar grouper	1.2	22.952	0.04
	Duskytail grouper	3.5	36.400	0.27
	Giant trevally	20.7	169.170	1.08
	Mud crabs	17.5	118.125	1.77
2	Commercial catch (tonnes)		1,277.9	211.93
2.1	Fishes		1,032.6	81.83
	Orange-spotted spinefoot	12.6	125.8	12.58
	Spinefoot rabbitfishes	15.8	159.3	9.56
	Mangrove red snapper	17.9	149.7	22.46
	Other groupers	9.7	104.3	15.65
	Trevallies	20.0	56.0	6.72
	Fusiliers	60.0	350.0	10.50
	Parrofishes	25.0	87.5	4.38
2.2	Molluscs		149.9	12
	Abalones	1.0	4.0	1.19
	Bigfin reef squid	2.5	14.0	3.86
	Cuttlefishes	2.6	30.9	5.57
	Murex snails	7.9	21.8	0.20
	Turbo shells	28.8	79.2	1.19
2.3	Crustaceans		77.4	116.10
	Spiny lobsters	10.8	77.4	116.10
2.4	Echinoderms		18	1.80
	Sea cucumbers	2.5	18.0	1.80

Table 4. Catch and revenue of seeds exploited in the adjacent estuaries

No.	Resources	Catch (seeds)		Revenue (in billion VND)	
		Tra Bong	Sa Ky	Tra Bong	Sa Ky
1	Orange-spotted spinefoot	3,575,355	61,650	0.85	0.09
2	Mangrove red snapper	132,950	120,446	1.63	0.86
3	Malabar grouper	22,952		0.04	
4	Duskytail grouper	36,400		0.27	
5	Orange-spotted grouper	246,075	163,835	3.68	0.96
6	Giant trevally	168,593	578	1.07	0.01
7	Mud crabs		118,125		1.77
Total		4,182,325	464,634	7.54	3.69

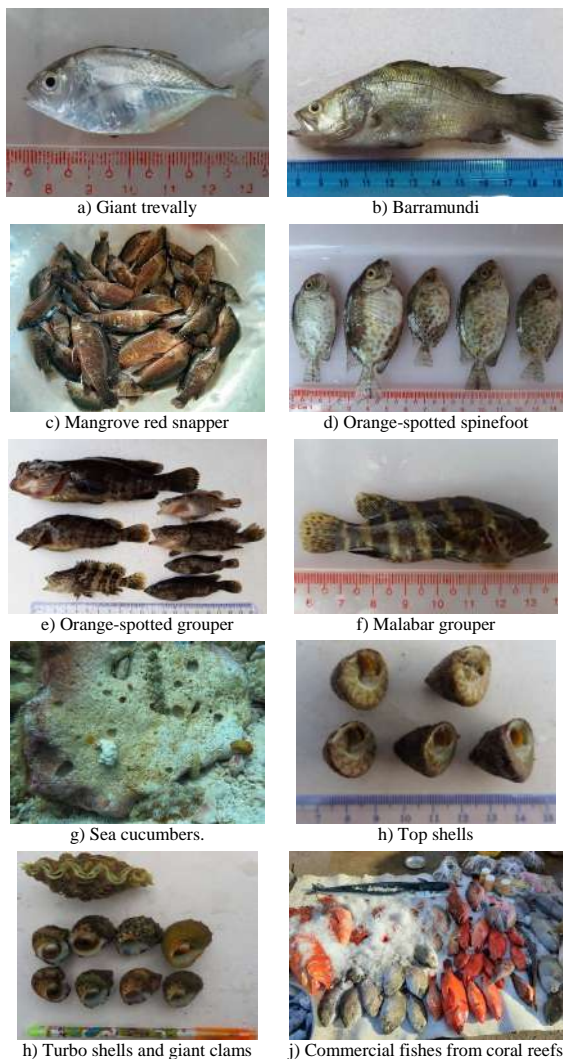


Figure 6. Pictures of juveniles and commercial resources of some target species harvested in the Ly Son islands and adjacent waters

CONCLUSIONS

The waters surrounding Ly Son islands and adjacent coastal locations supported a large area of key marine habitats, including 1,787 ha of coral reefs, 117.3 ha of seagrass beds, and 309 ha of nipa palms, in which Ly Son islands had some 1,706 ha of coral reefs and 116 ha of seagrass beds. Generally, the area of coral reefs was maintained, whereas the extent of seagrass beds declined between 2006 and 2019.

There were 12 major spawning and nursery grounds of 10 target species, in which giant trevally, mangrove red snapper, orange-spotted spinefoot, orange-spotted grouper, malabar grouper, and barramundi associated with the nipa palms and seagrass beds in the Tra Bong and Sa Ky estuaries, sea cucumbers, turbo, and top shells, giant clams were recorded in coral reefs in Ly Son islands.

The results from local consultations indicate that more than 4,647 thousand juveniles of fishes and mud crabs harvested in nipa palms and seagrass beds in the Tra Bong and Sa Ky estuaries, while some 1,278 tonnes of commercial resources were exploited from coral reefs in Ly Son islands.

Acknowledgments: This study was developed within the framework of the project titled “Studies on dispersal mechanisms of larvae and population connectivity of target marine resources for improving management effectiveness of marine protected areas in the coastal waters from Quang Tri to Kien Giang”

(Code: KC.09.41/16–20). We gratefully acknowledge the Ministry of Science and Technology of Vietnam (MOST), the Institute of Oceanography (IO), the Management Board of Ly Son MPA, and the District People's Committees of Binh Son, Son Tinh, and Ly Son, Quang Ngai province to provide support for us to complete this study.

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