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## THE DIVERSITY OF COMMERCIAL MARINE BIVALVES IN THE NHA PHU LAGOON, KHANH HOA PROVINCE, SOUTH-CENTRAL VIETNAM

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The study was conducted as part of the Joint Vietnam–Russia Tropical Science and Technology Research Center's project on indicator organisms in the marine environment of south-central Vietnam. The research focused on coastal areas with significant anthropogenic impacts, revealing that biological resources directly affect the livelihood and activities of coastal populations. These resources are dynamic and subject to both human and natural factors. The material from the soft-bottom zone was collected using a grab rake with a mesh bag at the end. Scuba diving equipment was used in areas with a hard substrate and mudflats. In addition, during sample collection, several mollusc specimens were acquired from fishermen who caught marine organisms in that lagoon. Comparing the results with previous studies on bivalve resources in the area, the Nha Phu Lagoon was found to harbour a wide range of economically valuable bivalve species. A total of twenty-seven bivalve species from thirteen families were identified, with the family Veneridae having the highest number of species (eight). The most abundant catches were from the families Ostreidae and Mytilidae, primarily consisting of *Magallana gigas* (Thunberg 1793) and *Perna viridis* (Linnaeus 1758), both cultured in the lagoon. Apart from their economic value, these two species also play crucial roles in the ecosystem by filtering water and retaining organic debris in the environment.

**Keywords:** sea molluscs, economic value, ecosystem roles

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There are approximately 10,000 known living species of bivalve molluscs worldwide; they are the second largest taxonomic class within the Mollusca (Bieler et al., 2013). Marine bivalves account for about 8,000 species, including those found in estuarine and brackish water environments (Huber, 2015). They are widely distributed, highly adaptable to various habitats and have diverse life habits, such as burrowing in sand and mud, clinging to shells and rocks, burrowing into wood and rock corals, crawling through seaweed thickets (Turgeon et al., 2009) and even clinging to mangrove leaves in mangrove forests. Due to their diverse species composition, extensive distribution and consumption of organic matter, they play a crucial role in marine ecosystems and contribute to ecosystem metabolism (Weitzman et al., 2019; Smyth et al., 2017; Gosling, 2003; National Research Council, 2000). In addition to their ecological significance, bivalves are a highly nutritious food source that helps ensure global food security (Martins et al., 2014; Landman et al., 2001).

Currently, the fisheries and aquaculture industry is experiencing rapid development in response to the increasing global demand for food. According to statistics from the Food and Agriculture Organization (FAO), the total production of fisheries and aquaculture in 2020 reached 214 million tons (FAO, 2020), including 178 million tons of animals and 36 million tons of seaweed. The global production of marine bivalves exceeds 15 million tons per year, with aquaculture accounting for 89% and wild catches 11% (Wijsman et al., 2019). Asian countries dominate the production of bivalves, contributing to more than 85% of the global production, and this is expected to further increase to ensure food security (Steeves et al., 2018).

However, under economic pressures, fisheries in general and for bivalves in particular have significantly increased. The consequences of overfishing and other forms of exploitation (Hiscock, 2014; Costello et al., 2021), destruction of mangroves, loss of coral reefs and seaweed beds, changes in wetland, water, estuarine,

sandbar and mudflat landscapes (Lotze et al., 2010; Fredston-Hermann et al., 2013), pollution and marine debris (Pitacco et al., 2018) are causing biodiversity loss, including bivalves (Halpern et al., 2015; Boyce et al., 2020).

Vietnam is one of the world's leading seafood exporters and plays a crucial role in the global seafood supply. According to the Vietnam Seafood Exporters and Producers Association (Ministry of agriculture and rural development, 2021), marine molluscs are the second-largest biological resource after marine fish, with an export value of 141,000 million USD in 2021. Favourable natural conditions contribute to the development of exploitation and aquaculture in Vietnam. Firstly, Vietnam is located in an area of global marine biodiversity. Studies on species richness of bivalves in Southeast Asia have identified approximately 1200–1500 species (Adrianov, Lutaenko, 2016), including 594 species in the Gulf of Thailand, 368 species in the Gulf of Tonkin, 299 species in Hong Kong and 815 species in Vietnam (Hilleberg, Kilburn, 2003). Do and Le (Do, Le, 2015) reported that Vietnam's marine waters contain approximately 2200–2500 species of molluscs, with more than 1000 species belonging to the class Bivalvia.

Secondly, Vietnam's long curving coastline forms semi-enclosed bays stretching from north to south, including Ha Long Bay (Quang Ninh), Tam Giang Lagoon (Thua Tien Hue), Thi Nai Lagoon (Binh Dinh), Vung Ro Bay and Xuan Dai Bay (Phu Yen), Van Phong Bay, Nha Phu Lagoon, Thuy Trieu Lagoon (Khanh Hoa) and Nai Lagoon (Ninh Thuan), which are key areas for aquaculture and exploitation. However, unplanned aquaculture, a lack of control over space and density and direct dumping have led to environmental degradation in these areas. Pham, Nguyen (2006), Pham et al. (2010), Nguyen et al. (2009), Nguyen et al. (2010), Nguyen et al. (2016) and Vo et al. (2018) have shown that localized pollution occurs in most marine areas along the coast.

Nha Phu Lagoon is the main agricultural area in Khanh Hoa Province, providing seafood for the province's residents, especially serving tourists in Nha Trang City. The main forms of fishing in this area are fishing by motorized or non-motorized boats, scuba diving equipment was used in areas with hard substrate and manual collection on tidal flats. Around the lagoon, there are shrimp ponds, fish and molluscs raised in cages on the lagoon water surface. Considering the increasing demand for seafood consumption and export alongside economic and life development, there is a need to promote resource research and evaluation activities. This study focuses on investigating the composition of economically valuable bivalve molluscs in Nha Phu Lagoon (Khanh Hoa) to assess their resources and provide a scientific basis for management, monitoring and exploitation.

## MATERIAL AND METHODS

### Research area

Nha Phu Lagoon (Fig. 1) is situated to the north of Nha Trang City, in Khanh Hoa Province. Spanning an approximate area of 4,500 hectares (Strehlow, Peter, 2004), this lagoon is protected by the Hon Ho Mountain range and is accompanied by small islands such as Hon Hoai, Hon Sam, Hon Thi and Hon Khi Island. It is recognized as one of the prominent sites for development and aquaculture in Khanh Hoa Province. Shrimp ponds can be found surrounding the lagoon, while cages on the water surface are primarily used for farming fish and molluscs.

### Samples collection

The material was collected six times between 2019 and 2022. A grab rake with a mesh bag at the end was used to sample from the soft-bottom zone (depth 3–20 m). The sample was then washed through a sieve with a mesh diameter of 1 cm. Scuba diving

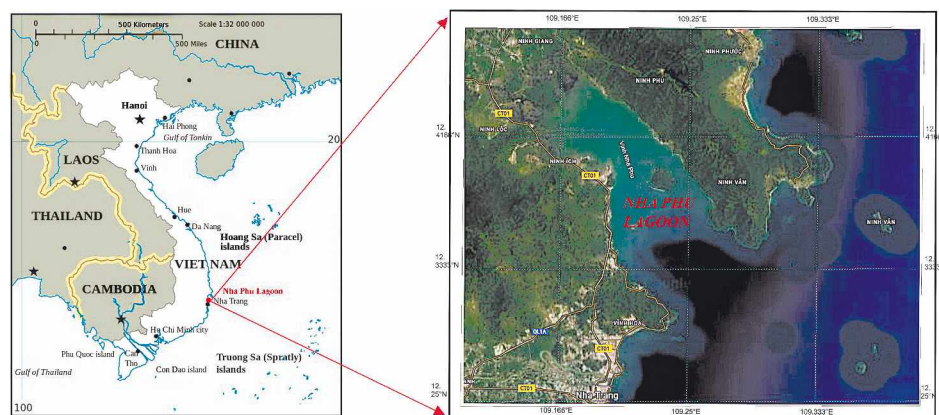


Fig. 1. The study region. Nha Phu Lagoon.

equipment was used in areas with hard substrate and mudflats (depth 6–25 m). Three 1 m<sup>2</sup> frames were randomly placed underwater at each sample collection site. All detected bivalve specimens were collected from the frame area and transported to the laboratory for further identification. In addition, during the sample collection, several mollusc specimens were acquired from fishermen who catch marine organisms in this lagoon. Information on the location and type of the bottom substrate at the fishing spot was obtained.

To obtain information on the biological resources of the lagoon, our group conducted a survey in small markets around Nha Phu Lagoon (e.g., Vinh Luong, Ninh Ich, Ninh Hoa markets) to find molluscs that are actively caught by fishermen and determine their fishing season.

Identification of bivalves was carried out using a comparative-morphological method based on morphological criteria of external and internal body structure following the works of Abbott and Dance (1982), Carpenter and Niem (1998), Hylleberg and Kilburn (2003), Nguyen N. T. (2005), Do and Le (2015), Adrianov and Lutaenko (2016). In this study, the classifications and accepted names of Bivalvia taxa are used as given in the WoRMS database (WoRMS, 2023). Higher taxa and species in frame of families are presented in alphabetical order.

## RESULTS

A total of 27 commercial marine bivalve species were identified in Nha Phu lagoon, Khanh Hoa Province, Vietnam (Table 1).

**Table 1.** List of species, habitat and some commercial information

№	Species	Habitat, commercial information			
		Soft-bottom zone	Hard substrate and mudflats	Acquired from fishermen	Actually sold
1	<i>Solen vagina</i> Linnaeus 1758	+		+	+
2	<i>Vasticardium pectiniforme</i> (Born 1780)	+		+	+
3	<i>Asaphis violascens</i> (Forsskål 1775)	+	+	+	+
4	<i>Lutraria rhynchaena</i> Jonas 1844	+			+
5	<i>Anomalodiscus squamosus</i> (Linnaeus 1758)	+		+	
6	<i>Gafrarium pectinatum</i> (Linnaeus 1758)	+	+	+	+
7	<i>Marcia hiantina</i> (Lamarck 1818)	+			+
8	<i>Meretrix lyrata</i> (G. B. Sowerby II 1851)	+		+	+
9	<i>Meretrix meretrix</i> (Linnaeus 1758)	+		+	+
10	<i>Paphia euglypta</i> (R. A. Philippi 1847)	+		+	+
11	<i>Paratapes undulatus</i> (Born 1778)	+		+	+
12	<i>Periglypta exclathrata</i> (Sacco 1900)	+		+	+
13	<i>Anadara antiquata</i> (Linnaeus 1758)	+	+	+	+
14	<i>Tegillarca granosa</i> (Linnaeus 1758)	+		+	+
15	<i>Trisidos semitorta</i> (Lamarck 1819)		+	+	+
16	<i>Perna viridis</i> (Linnaeus 1758)		+	+	+
17	<i>Isognomon isognomum</i> (Linnaeus 1758)		+	+	
18	<i>Pinctada imbricata</i> Röding 1798		+	+	
19	<i>Pinctada margaritifera</i> (Linnaeus 1758)		+	+	+
20	<i>Magallana gigas</i> (Thunberg 1793)		+	+	+
21	<i>Atrina pectinata</i> (Linnaeus 1767)		+	+	+
22	<i>Atrina vexillum</i> (Born 1778)		+	+	+
23	<i>Amusium pleuronectes</i> (Linnaeus 1758)	+	+	+	+
24	<i>Annachlamys striatula</i> (Linnaeus 1758)	+	+	+	+
25	<i>Decatopecten plica</i> (Linnaeus 1758)	+	+	+	
26	<i>Mimachlamys sanguinea</i> (Linnaeus 1758)	+	+	+	+
27	<i>Spondylus squamosus</i> Schreibers 1793		+	+	+

### Systematic account

Infraclass Heteroconchia J. E. Gray 1854  
Order Adapedonta Cossmann & Peyrot 1909  
Family Solenidae Lamarck 1809  
Genus *Solen* Linnaeus 1758

#### 1. *Solen vagina* Linnaeus 1758

(Fig. 2A)

*Solen vagina* Linnaeus 1758 (Linnaeus, 1758)

*Solen vagina*: Abbott and Dance, 1982: p. 338; Carpenter and Niem, 1998: p. 289, p. 285 fig. 6; Hylleberg and Kilburn, 2003: p. 194; plate 6 fig. 4; Nguyen, 2005: p. 280, plate 86 fig. 2.

**Description.** Shell medium sized, reaching 8–14 cm in length. Sculpture consists of numerous fine concentric lines and growth pauses. Colour externally purplish (under the greenish periostracum) and internally whitish.

Season of capture fisheries – from May to November.

**Distribution in Vietnam.** Along the coast of the Gulf of Tonkin, along the coast of Nha Trang (Do, Le, 2015), in the Khanh Hoa, Can Gio, Ha Tinh, North Vietnam, etc. areas. Habitat: sandy bottom at 1–50 m (Nguyen, 2005).

In Nha Phu Lagoon – occurs on sandy, sandy-silt bottoms.

Order Cardiida A. Férussac 1822

Family Cardiidae Lamarck 1809

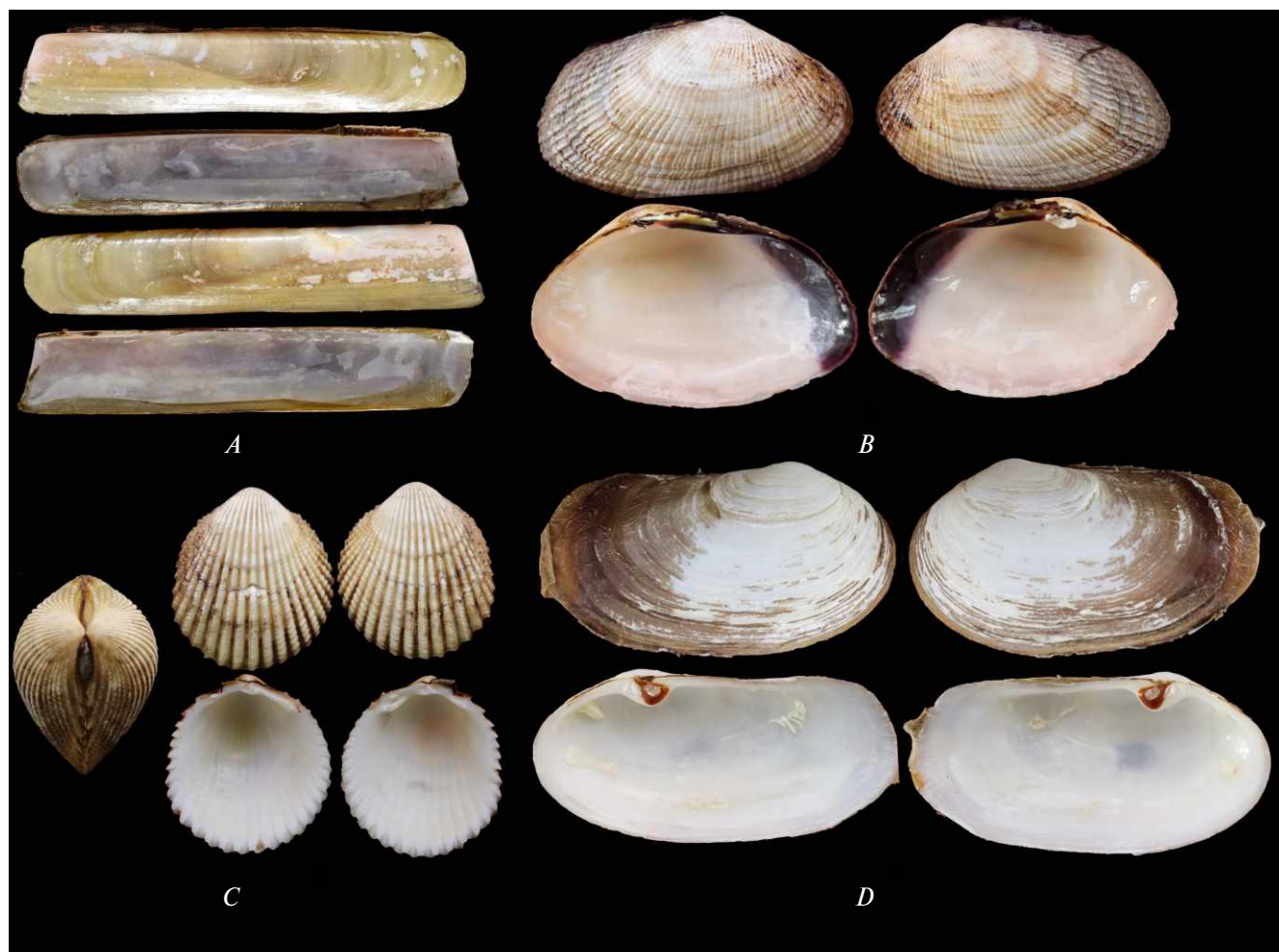
Genus *Vasticardium* Iredale 1927

#### 2. *Vasticardium pectiniforme* (Born 1780)

(Fig. 2C)

*Cardium pectiniforme* Born 1780 (Born, 1780)

*Vasticardium pectiniforme*: Abbott and Dance, 1982: p. 328; Carpenter and Niem, 1998: p. 256, p. 252 fig. 13; Hylleberg and Kilburn, 2003: p. 185, plate 4 fig. 15 a, b, c; Adrianov and Lutaenko, 2016: plate 13 figs C, D.



**Fig. 2.** A – *Solen vagina* (93 mm), B – *Asaphis violascens* (49 mm), C – *Vasticardium pectiniforme* (32 mm), D – *Lutraria rhynchaena* (64 mm).

**Description.** Shell medium sized, reaching 4–6 cm in height. Shell moderately thick, oblong-ovate and higher than long, slightly inequilateral with posterior part tending to be slightly expanded. Thirty prominent, rounded and rugose radial ribs at each valve. Outside of shell whitish, periostracum straw colour to olive-brown, sometimes with a scattering of black spots. Interior completely white, or more or less stained yellow.

Season of capture fisheries – from May to September.

**Distribution in Vietnam.** Usually found in coastal waters (Do, Le, 2015).

In Nha Phu Lagoon – found on soft bottoms near the estuary.

Family Psammobiidae J. Fleming 1828  
Genus *Asaphis* Modeer 1793

### 3. *Asaphis violascens* (Forsskål 1775)

(Fig. 2B)

*Venus violascens* Forsskål 1775 (Niebuhr, 1775)

*Asaphis violascens*: Abbott and Dance, 1982: p. 347; Carpenter and Niem, 1998: p. 307, p. 305 fig. 1; Okutani, 2000: p. 987, plate 491 fig. 15; Hylleberg and Kilburn, 2003: p. 204; Nguyen, 2005: p. 285, plate 87, figs 8, 10; Adrianov and Lutaenko, 2016: plate 17 figs A, B.

**Description.** Shell length commonly to 4–6 cm. Shell solid, rather large, inflated, slightly gaping posteriorly, elongate-ovate in outline but quite variable in shape and sculpture. Outer sculpture of numerous, strong, rounded and often forked radial ribs, developed throughout the valves and crossed by concentric lines that do not interrupt the ribs but make them slightly scaly or nodulose, at least on posterior slope. Outside of shell dull coloured, usually creamy white with a pale greyish brown periostracum. Interior slightly glossy, whitish, often with yellow or orange hue centrally and a dark purplish blotch posteriorly.

Season of capture fisheries – from May to September.

**Distribution in Vietnam.** Commonly found in coastal waters (Do, Le, 2015), in the Khanh Hoa, Southwest Vietnam, North Vietnam, etc. areas. Habitat: coarse sand or gravels near rocks at 1–15 m (Nguyen, 2005).

In Nha Phu Lagoon – occurs in the muddy zone (place between low and high tide) and hard bottom zone.

Order Venerida Gray 1854  
Family Mactridae Lamarck 1809  
Genus *Lutraria* Lamarck 1799

### 4. *Lutraria rhynchaena* Jonas 1844

(Fig. 2D)

*Lutraria rhynchaena* Jonas 1844 (Jonas, 1844)

*Lutraria rhynchaena*: Abbott and Dance, 1982: p. 336; Hylleberg and Kilburn, 2003: p. 187; Nguyen, 2005: p. 279, plate 86 fig. 1; Adrianov and Lutaenko, 2016: plate 14 figs G, H.

**Description.** Shells medium-sized (4–8 cm in length), elongated oval. The shell is fairly thick. Outer sculpture fine concentric lines corresponding to periods of growth. The basic colour is white and the periostracum is brown, but the latter is usually abraded. The interior surface is glossy white.

Season of capture fisheries – exploited year-round, concentrated from May to November.

**Distribution in Vietnam.** Occurs in tidal areas in the Khanh Hoa Province. Habitat: sandy bottom at 1–15 m (Nguyen, 2005; Dang et al., 2009).

In Nha Phu Lagoon – occurs in the coastal alluvial zone (between low and high tide).

Family Veneridae Rafinesque 1815  
Genus *Anomalodiscus* Dall 1902

### 5. *Anomalodiscus squamosus* (Linnaeus 1758)

(Fig. 3A)

*Venus squamosa* Linnaeus 1758 (Linnaeus, 1758)

*Anomalodiscus squamosus*: Carpenter and Niem, 1998: p. 328, p. 324 fig. 24; Okutani, 2000: p. 1003, plate 499 fig. 7; Hylleberg and Kilburn, 2003: p. 209; Do and Le, 2015: p. 162 fig. 113; Adrianov and Lutaenko, 2016: plate 18 figs E, F.

**Description.** Shell ranges 2–4 cm in length. Shell small, solid, inflated and strongly inequilateral in shape, subtrigonal in outline. Anterior side of shell rounded, posterior side produced and tapering to posterior end. Outer sculpture of valves strong, of dense radial riblets and low concentric cords, giving the surface a finely granulated and latticed aspect. Outside of shell dull yellowish white, often flushed with slightly darker greyish to purplish brown on lunule and escutcheon areas. Interior whitish.

Season of capture fisheries – from May to November.

**Distribution in Vietnam.** Found only in the southern Vietnam Sea (Dang et al., 2009) in the Khanh Hoa, Hoi An, Southwest Vietnam, North Vietnam area along the coast and around islands (Do, Le, 2015; Nguyen, 2005).

In Nha Phu Lagoon – found in sand, near mangrove forests.

Genus *Gafrarium* Röding 1798

### 6. *Gafrarium pectinatum* (Linnaeus 1758)

(Fig. 3C)

*Venus pectinata* Linnaeus 1758 (Linnaeus, 1758)

*Gafrarium pectinatum*: Carpenter and Niem, 1998: p. 332, p. 322 fig. 9; Okutani, 2000: p. 1007, plate 501 fig. 24;

Hylleberg and Kilburn, 2003: p. 213; Nguyen, 2005: p. 294, plate 90 fig. 24; Do and Le, 2015: p. 114–115, fig. 77; Adrianov and Lutaenko, 2016: plate 20 figs C, D.

**Description.** Shell length 2–4 cm. Shell thick and solid, with a variable, relatively compressed, elongated shape, elliptical-ovate in outline. Outer sculpture rather fine but well-marked, with many small concentric ridges and slightly nodulous, diverging radial riblets rapidly weakening medially and anteriorly. Main sculpture of median area of valves of concentric ridges. Outside coloration of shell variable, off-white to buff-coloured and generally with fawn or brown blotches or spots throughout. Interior porcelaneous white, often with yellowish hue inside the pallial line, and with purple-brown blotching on lunular margin, posteroventral part of hinge and posterior margin of valves.

Season of capture fisheries – from April to November.

**Distribution in Vietnam.** Found along the shore to a depth of 20m (Do, Le, 2015) in Khanh

Hoà, Ca Na, Hue, Southwest Vietnam, Quang Ninh, Hai Phong. Habitat: sand at 5–25 m (Nguyen, 2005).

In Nha Phu Lagoon – widespread, occurring at most sampling sites.

Genus *Marcia* H. Adams & A. Adams 1857

7. *Marcia hiantina* (Lamarck 1818)

(Fig. 3B)

*Venus hiantina* Lamarck 1818 (Lamarck, 1818)

*Marcia hiantina*: Carpenter and Niem, 1998: p. 334; Hylleberg and Kilburn, 2003: p. 215; Nguyen, 2005: p. 299, plate 89 fig. 15; Adrianov and Lutaenko, 2016: plate 18, figs A, B.

**Description.** Maximum shell length 5 cm. Shell solid, with a variable, moderately inflated, inequilateral shape, roughly rounded-ovate in outline. Outer surface of valves covered with numerous, somewhat irregular concentric grooves and cords, the latter



**Fig. 3.** A – *Anomalodiscus squamosus* (29 mm), B – *Marcia hiantina* (37 mm), C – *Gafrarium pectinatum* (29 mm), D – *Periglypta exclathrata* (58 mm).

sometimes flatter and less apparent, but always present, near posterior half of ventral margin. outside of shell variable in colour and pattern, whitish to grey, fawn-coloured or brown, frequently with various patterns of white, fawn or purplish radial bands, zigzags or trigonal spots or irregular blotches. Interior dirty white, often dark coloured on hinge area.

Season of capture fisheries – from March to November.

**Distribution in Vietnam.** Found in Khanh Hoa, Long Hai, Ca Na, Northern Vietnam, etc. Habitat: sand at 1–15 m (Nguyen, 2005).

In Nha Phu Lagoon – found alive buried in sand in coastal areas.

#### Genus *Meretrix* Lamarck 1799

##### 8. *Meretrix lyrata* (G. B. Sowerby II 1851) (Fig. 4B)

*Cytheraea lyrata* G. B. Sowerby II 1851 (Sowerby II, 1851)

*Meretrix lyrata*: Carpenter and Niem, 1998: p. 336, p. 323 fig. 18; Hylleberg and Kilburn, 2003: p. 216; Nguyen, 2005: p. 295, plate 89 fig. 6; Do and Le, 2015:

p. 168–169, fig. 118; Adrianov and Lutaenko, 2016: plate 20 figs A, B.

**Description.** Shell length 3–5 cm. Shell thick, moderately inflated with a variable, inequilateral shape, subtrigonal in outline. Outer surface of shell with incised concentric grooves fading out toward anterodorsal and posterodorsal margins, and sometimes also at ventral margin of larger specimens. Outside of shell light fawn to brown under the translucent, glossy, yellowish periostracum. Interior porcelaneous white.

Season of capture fisheries – exploited year-round.

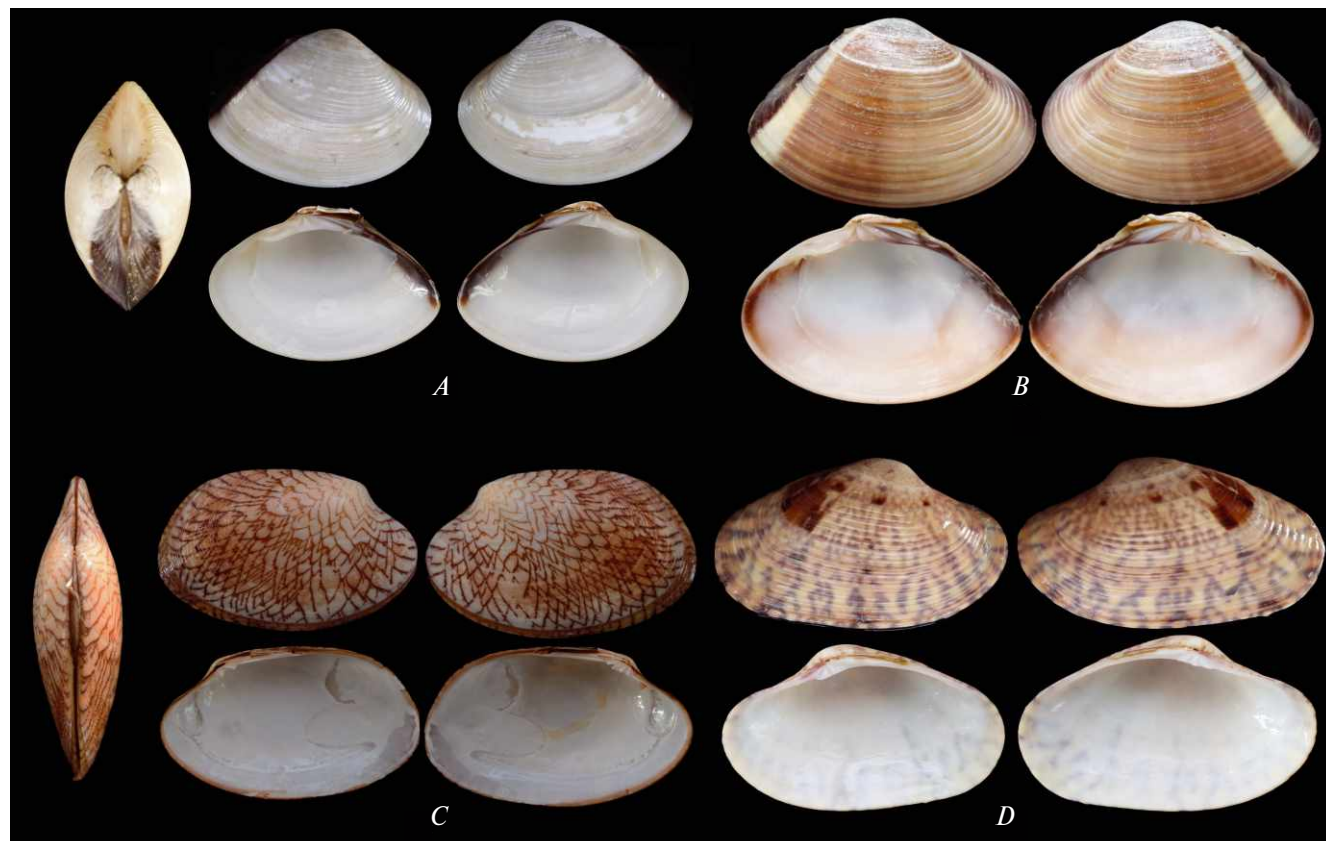
**Distribution in Vietnam.** Found along the coastal region of South Vietnam and can now be found in Central and North Vietnam (Do, Le, 2015). According to Nguyen, 2005: Ben Tre, Soc Trang, Bac Lieu, Go Cong, Tien Giang, Tra Vinh, Ca Mau, Rach Gia, Khanh Hoa. Habitat: sandy mud at 1–15 m.

In Nha Phu Lagoon – occurs on the sandy bottom along the shore.

##### 9. *Meretrix meretrix* (Linnaeus 1758) (Fig. 4A)

*Venus meretrix* Linnaeus 1758 (Linnaeus, 1758)

*Meretrix meretrix*: Carpenter and Niem, 1998: p. 37, p. 323 fig. 17; Hylleberg and Kilburn, 2003: p. 216;



**Fig. 4.** A – *Meretrix meretrix* (47 mm), B – *Meretrix lyrata* (32 mm), C – *Paratapes undulatus* (73 mm), D – *Paphia euglypta* (56 mm).

Nguyen, 2005: p. 295, plate 90, fig. 8; Do and Le, 2015: p. 170, fig. 119.

**Description.** Shell length to 6 cm. Shell thick, moderately inflated with a variable, nearly equilateral to rather strongly inequilateral shape, trigonal-ovate in outline. Outer surface of shell smooth, except from low concentric growth marks. Outside of shell very variable in colour and pattern, under the transparent and glossy, pale straw-coloured periostracum; basically white and often flushed with deep purple brown on posterodorsal slope, or fawn to chestnut brown, plain or variously spotted, blotched or streaked with darker grey or brown. Interior porcelaneous white, sometimes stained with dark brown along posterodorsal margin.

Season of capture fisheries – exploited year-round.

**Distribution in Vietnam.** Common along the coast of Vietnam (Do, Le, 2015) in Long Hai, Vung Tau, Binh Tuan, Khanh Hoa, Sa Huynh, Hoi An, Da Nang, Hue, Quang Chi, Quang Binh, Ha Tinh, Nghe An, Thanh Hoa, Tay Binh, Quang Ninh, Hai Phong, etc. Habitat: sandy mud at 1–15 m (Nguyen, 2005).

In Nha Phu Lagoon – occurs on the sandy bottom.

#### Genus *Paphia* Röding 1798

##### 10. *Paphia euglypta* (R. A. Philippi 1847)

(Fig. 4D)

*Venus euglypta* R. A. Philippi 1847 (not document).

*Paphia euglypta*: Okutani, 2000: p. 1015, plate 505 fig. 53; Hylleberg and Kilburn, 2003: p. 216; Nguyen, 2005: p. 299, plate 88, fig. 12; Do and Le, 2015: p. 176–177, fig. 123.

**Description.** Shell is medium-sized, height to 6 cm, elongate oval that is crushed to some extent. The outside surface is embellished with unevenly spaced low commarginal ribs. Colour orange-brown with rectangular dark brown spots. Interior white.

Season of capture fisheries – from April to November.

**Distribution in Vietnam.** Common along the coast of Vietnam (Do, Le, 2015). In Nha Trang, Hue, Hoi An, etc. Habitat: sandy bottom at 5–35 m (Nguyen, 2005).

In Nha Phu Lagoon – found on sandy and muddy bottoms.

#### Genus *Paratapes* Stoliczka 1870

##### 11. *Paratapes undulatus* (Born 1778)

(Fig. 4C)

*Venus undulata* Born 1778 (Born, 1778)

*Paratapes undulatus*: Carpenter and Niem, 1998: p. 39, p. 324 fig. 25; Okutani, 2000: p. 1015, plate 505 fig. 58; Hylleberg and Kilburn, 2003: p. 217; Nguyen, 2005: p. 300, plate 90 fig. 3; Adrianov and Lutaenko, 2016: plate 18 figs K, L.

**Description.** Shell length to 8 cm. Shell moderately inflated, transversely elongate, elliptical-ovate in outline. Outer surface smooth and glossy, with shallow concentric growth marks. Outside of shell highly glossy, cream to brown, with a netted pattern of darker tan zigzag lines. Interior whitish.

Season of capture fisheries – exploited year-round.

**Distribution in Vietnam.** Commonly found in coastal waters (Do, Le, 2015); according to Nguyen, 2005: in Ha Tien, Ca Mau, Khanh Hoa, Phan Thiet, Da Nang, Hue, Hoi An, Quang Ninh, etc. Habitat: muddy bottom at 5–25 m.

In Nha Phu Lagoon – found on sandy and muddy bottoms.

#### Genus *Periglypta* Jukes-Browne 1914

##### 12. *Periglypta exclathrata* (Sacco 1900)

(Fig. 3D)

*Venus exclathrata* Sacco 1900 (Sacco, 1900)

*Periglypta exclathrata*: Carpenter and Niem, 1998: p. 349, p. 322 fig. 12; Hylleberg and Kilburn, 2003: p. 217; Do and Le, 2015: p. 139–140, fig. 96.

**Description.** Shell length to 7.5 cm. Shell moderately inflated, markedly longer than high. Outer sculpture relatively fine, not strongly nodulose; hinge white. Outer with both concentric and radial sculpture. The outside shell is plate-shaped, with brown spots and dark brown stains. Inner side white.

Season of capture fisheries – from April to November.

**Distribution in Vietnam.** Found along the coastal strip of Vietnam, around islands (Do, Le, 2015).

In Nha Phu Bay – found in sand and mud.

#### Infraclass Pteriomorphia Beurlen 1944

##### Order Arcida Stoliczka 1871

##### Family Arcidae Lamarck 1809

##### Genus *Anadara* Gray 1847

##### 13. *Anadara antiquata* (Linnaeus 1758)

(Fig. 5A)

*Arca antiquata* Linnaeus 1758 (Linnaeus, 1758)

*Anadara antiquata*: Abbott and Dance, 1982: p. 292; Carpenter and Niem, 1998: 145, fig. 18; Hylleberg and Kilburn, 2003: 146, plate 1, fig. 1; Nguyen, 2005: 242, plate 75, fig. 12; Do and Le, 2015: 50, fig. 31; Adrianov and Lutaenko, 2016: plate 1, figs E, F.

**Description.** Shell length commonly to 6 cm. Shell equivalve, solid, inequilateral, obliquely ovate and elongate in outline, with an extended posteroventral part. Forty radial ribs (35–44) at each valve. Outside of shell greyish white, often stained darker grey on umbonal and posterior areas; periostracum dark brown. Inner side white.

Season of capture fisheries – exploited year-round, concentrated from May to September.

**Distribution in Vietnam.** Commonly found in coastal waters (Do, Le, 2015). Occurs in the following areas: Tuy Hoa, Khanh Hoa, Ninh Thuan, Phan Thiet, Mui Ne, Ho Chi Minh City, Southeast Vietnam, Con Son Island, Hoi An, Cat Ba Island. Habitat: sandy mud at 1–5 m (Nguyen, 2005).

In Nha Phu Lagoon – found on many types of bottoms such as sandy bottoms and hard bottoms, the composition of which is mainly composed of dead corals and rocks.

Genus *Tegillarca* Iredale 1939

14. *Tegillarca granosa* (Linnaeus 1758)

(Fig. 5C)

*Arca granosa* Linnaeus 1758 (Linnaeus, 1758)

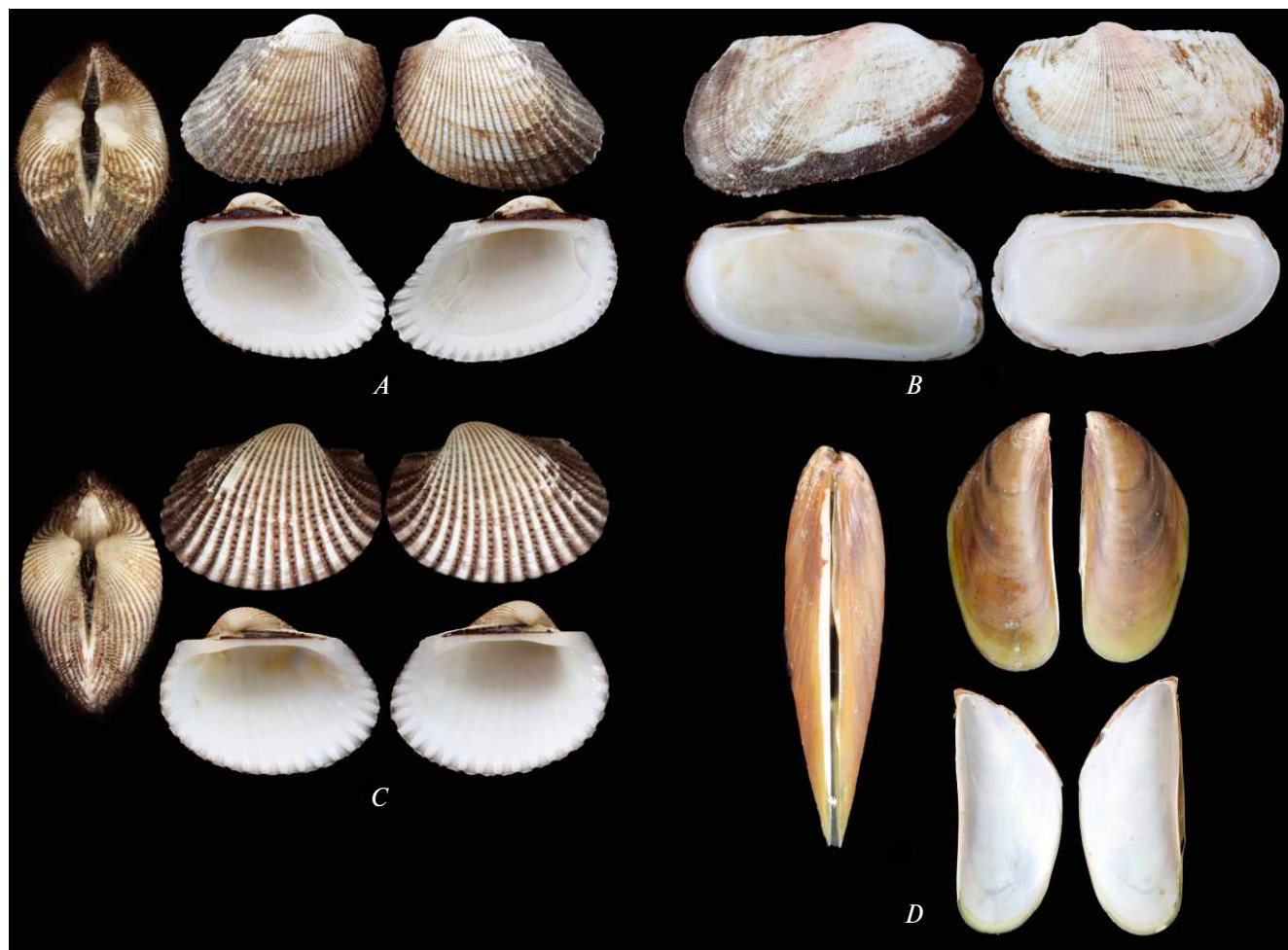
*Tegillarca granosa*: Abbott and Dance, 1982: p. 293; Carpenter and Niem, 1998: p. 147, p. 145 fig.16;

Hylleberg and Kilburn, 2003: p. 148, plate 1 fig. 3; Nguyen, 2005: p. 244, plate 75 fig. 8; Do and Le, 2015: p. 57, fig. 36; Adrianov and Lutaenko, 2016: plate 2 figs I, J.

**Description.** Shell length commonly to 5 cm. Shell equivalve, thick and solid, ovate, strongly inflated, slightly longer than high and feebly inequilateral. Eighteen radial ribs (15–20) with wide interstices at each valve; ribs stout and distinctly rugose, bearing regular, often rectangular nodules. Outside of shell white under the yellowish brown periostracum. Inner side white, often tinged light yellow towards the umbonal cavity.

Season of capture fisheries – from March to September.

**Distribution in Vietnam.** Commonly found in coastal waters (Do, Le, 2015), Khanh Hoa, Ninh Thuan, Phan Thiet, Vung Tau, Long Hai, Ben Tre, Go Cong, Tra Vinh, Bac Lieu, Hon Khoi. (Ca Mau), Hon Trong (Kien Giang), Phu Yen, Binh Dinh, Da Nang, Hue, Quang Chi, Quang Binh, Ha Tinh,



**Fig. 5.** A – *Anadara antiquata* (42 mm), B – *Trisidos semitorta* (84 mm), C – *Tegillarca granosa* (31 mm), D – *Perna viridis* (65 mm).

Nghe An, Thanh Hoa, Ninh Binh, Tay Binh, Cat Ba Island, Quang Ninh, etc. Habitat: mud at 1–10 m (Nguyen, 2005).

In Nha Phu Lagoon – occurs on soft bottom near the estuary.

#### Genus *Trisidos* Röding 1798

##### 15. *Trisidos semitorta* (Lamarck, 1819)

(Fig. 5B)

*Arca semitorta* Lamarck 1819 (Lamarck, 1819)

*Trisidos semitorta*: Abbott and Dance, 1982: p. 294; Carpenter and Niem, 1998: p. 145, p. 143 fig. 1; Hylleberg and Kilburn, 2003: p. 153; Nguyen, 2005: p. 241, plate 75 fig. 12; Do and Le, 2015: p. 64–65, fig. 41; Adrianov and Lutaenko, 2016: plate 4 figs F, G.

**Description.** Shell large to 10 cm in length, heavy and inflated, sharply twisted on the posterior surface, umbones inflated off-centre and curved anteriorly. Surface sculptured with concentric growth folds and fine radial riblets. Outside of shell white to pink in colour. Inner side white.

Season of capture fisheries – exploited year-round, concentrated from May to September.

**Distribution in Vietnam.** Coastal waters (Do, Le, 2015), Khanh Hoa, Con Son Island, Northern Vietnam, etc. Habitat: sandy at 1–15 m (Nguyen, 2005).

In Nha Phu Lagoon – occurs on sandy, hard bottom and rocky areas.

#### Order Mytilida Férussac 1822 Family Mytilidae Rafinesque 1815 Genus *Perna* Philipsson 1788

##### 16. *Perna viridis* (Linnaeus 1758)

(Fig. 5D)

*Mytilus viridis* Linnaeus 1758 (Linnaeus, 1758)

*Perna viridis*: Abbott and Dance, 1982: p. 301; Carpenter and Niem, 1998: p. 172, p. 166 fig. 3; Okutani, 2000: p. 881, plate 438 fig. 12; Hylleberg and Kilburn, 2003: p. 156; Nguyen, 2005: p. 246, plate 79 fig. 10; Do and Le, 2015: p. 97, fig. 65; Adrianov and Lutaenko, 2016: plate 7 figs G, H.

**Description.** Shell length to 8 cm. Shell elongate, roughly trigonal-ovate in outline, swollen and pointed anteriorly, rounded and compressed posteriorly. Outer surface nearly smooth apart from concentric growth marks and faint radial lines. Outside of shell whitish under a bright periostracum which is dark brownish green anteriorly and olive-green to bright green posteriorly. Interior an iridescent pale bluish green, with a vivid green margin of periostracum.

Season of capture fisheries – exploited year-round, concentrated from March to November.

**Distribution in Vietnam.** Usually found in coastal waters at 0.5–5 m depth (Do, Le, 2015). Occurs in the provinces: Khanh Hoa, Phan Thiet, Can Gio, Phu Quoc Island, Hatien. Binh Dinh, Hue, Ha Tinh, Quang Ninh, Hai Phong, etc. Habitat: attached to rocks or wood in cluster 1–15 m (Nguyen, 2005).

In Nha Phu Lagoon – found in coastal alluvial areas (place between low tide and high tide), clinging in groups on rocky beaches.

#### Order Ostreida Férussac 1822 Family Isognomonidae Woodring 1925 Genus *Isognomon* Lightfoot 1786

##### 17. *Isognomon isognomum* (Linnaeus 1758)

(Fig. 6A)

*Ostrea isognomon* Linnaeus 1758 (Linnaeus, 1758)

*Isognomon isognomum*: Carpenter and Niem, 1998: p. 192, p. 190 fig. 1; Okutani, 2000: p. 885, plate 440 fig. 5; Hylleberg and Kilburn, 2003: p. 158; Nguyen, 2005: p. 252, plate 78 figs 5, 8, 9; Adrianov and Lutaenko, 2016: plate 5 figs E, F.

**Description.** Shell height to 15 cm. Shell relatively high and narrow in outline, with undulating commissure and strong posteroventral elongation. Shape often very irregular, due to the confined space in which the shell grows and to the effect of repair. Outer surface with irregularly concentric lamellate processes, often encrusted with marine growths and corroded towards the umbones. Outside of shell bluish purple to almost black, often paler to whitish umbonally. Interior porcelainous and similarly coloured on non-nacreous area; nacreous area much paler, with bluish purple hue.

Season of capture fisheries – from March to November.

**Distribution in Vietnam.** Nha Trang, Hai Phong, Quang Ninh (Do, Le, 2015), Khanh Hoa, Phan Thiet, Con Son Island, Northern Vietnam, etc. (Nguyen, 2005). Habitat: attached by byssus to rocks at 1–15 m (Nguyen, 2005).

In Nha Phu Lagoon – found in tidal areas with hard bottoms.

#### Family Margaritidae Blainville 1824 Genus *Pinctada* Röding 1798

##### 18. *Pinctada imbricata* Röding 1798

(Fig. 6B)

*Pinctada imbricata* Röding 1798 (Röding, 1798)

*Pinctada imbricata*: Abbott and Dance, 1982: p. 302; Carpenter and Niem, 1998: p. 187, p. 183 fig. 8; Hylleberg and Kilburn, 2003: p. 156; Nguyen, 2005: p. 250, plate 79 fig. 15; Adrianov and Lutaenko, 2016: plate 7 figs I, J.

**Description.** Shell rather thin and small to medium sized (to 9 cm in height), relatively inflated,

subquadrate in outline, with a short and ill-defined posterior ear which is not drawn out into a wing-like process. Outer surface of shell, when not worn, with densely set, appressed and flattened, imbricating concentric scales and moderately small, radially projecting spines mostly preserved towards the margins. Outside of shell variable, uniform or with darker markings or radial rays, mostly of reds and browns, but sometimes of green and bronze coloration. Internal nacreous area highly iridescent.

Season of capture fisheries – from March to November.

**Distribution in Vietnam.** Khanh Hoa. Attached by byssus to sea whips, rocks or corals at 1–15 m (Dang et al., 2009).

In Nha Phu Lagoon – occurs on hard bottoms consisting mainly of rocks and dead corals.

19. *Pinctada margaritifera* (Linnaeus 1758)

(Fig. 6D)

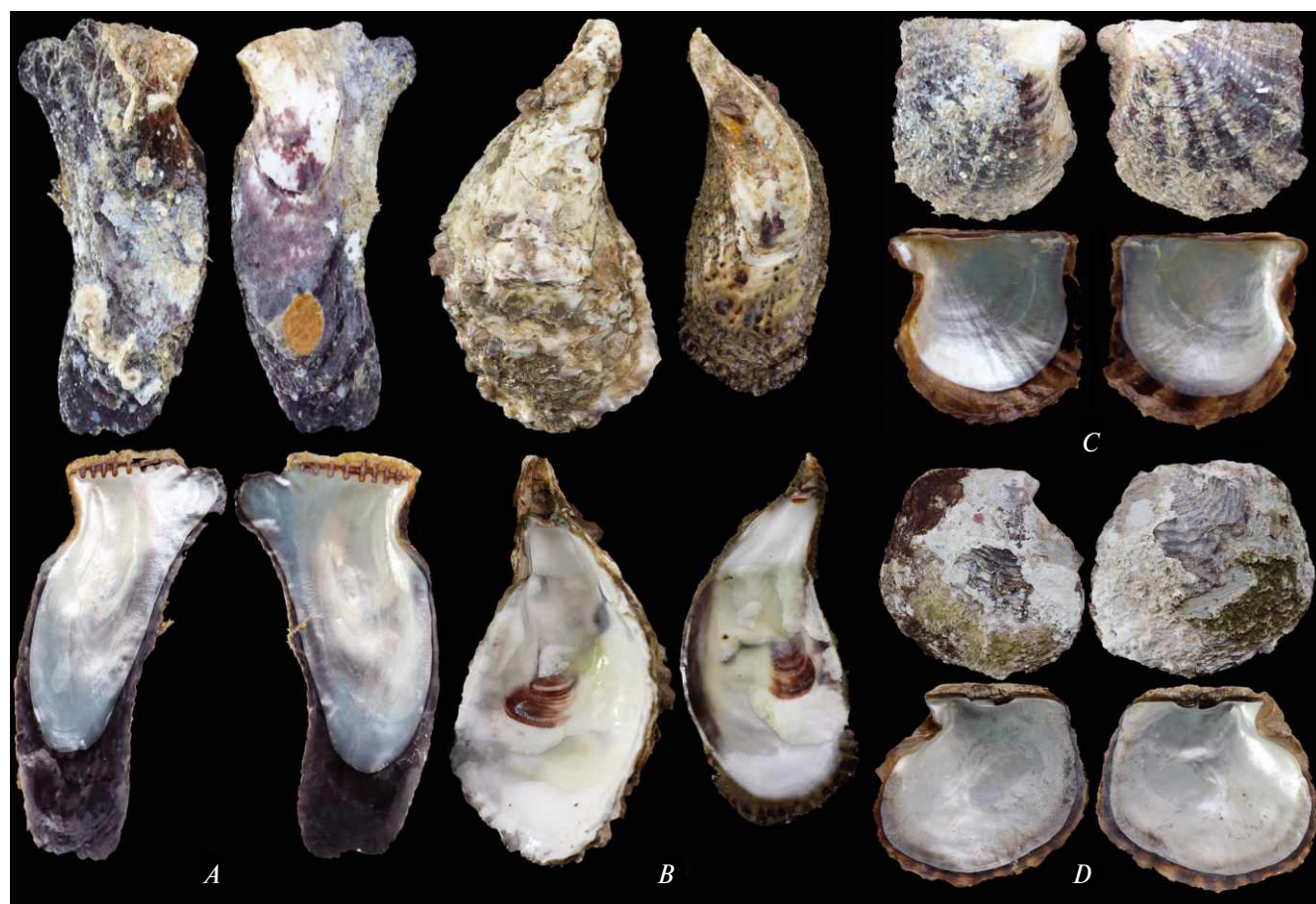
*Mytilus margaritiferus* Linnaeus 1758 (Linnaeus, 1758)

*Pinctada margaritifera*: Abbott and Dance, 1982: p. 301; Carpenter and Niem, 1998: p. 185, p. 183 fig. 6; Okutani, 2000: p. 881, plate 438 fig. 12; Hylleberg and Kilburn, 2003: p. 156; Nguyen, 2005: p. 249, plate 79 fig. 3, 5; Adrianov and Lutaenko, 2016: plate 7 figs G, H.

**Description.** Shell rather thick and large to very large (to 15 cm in length). Outer surface of valves, when not worn, with densely set, flattened, imbricating concentric scales and moderately long, parallel-sided and flattened spines with tapering or rounded ends; spines lying relatively flat on surface of valves, arranged in radial rows and often strongly projecting on shell margins. The shell is externally coloured greyish green with white or yellowish radial rows of scales, and brown to black margins. The inside of the shell is pearly with a pale blue or violet cast.

Season of capture fisheries – from March to November.

**Distribution in Vietnam.** Khanh Hoa, Phan Rang, Phan Thiet, Con Son Island, Phu Quoc Island, Nam Du Island, Quang Ninh, Hai Phong.



**Fig. 6.** A – *Isognomon isognomum* (58 mm), B – *Pinctada imbricata* (37 mm), C – *Magallana gigas* (120 mm), D – *Pinctada margaritifera* (63 mm).

Habitat: byssally attached to sea fans or rocks at 1–15 m (Nguyen, 2005).

In Nha Phu Lagoon – occurs on hard bottoms consisting mainly of rocks and dead corals.

Family Ostreidae Rafinesque 1815  
Genus *Magallana* Salvi & Mariottini 2016

20. *Magallana gigas* (Thunberg 1793)

(Fig. 6C)

*Ostrea gigas* Thunberg 1793 (Thunberg, 1793)

*Magallana gigas*: MolluscaBase eds. (WoRMS, 2023)

**Description.** Shell small- to large-sized (length of about 8 cm), irregular but commonly higher than long, more or less inequivalve, attaching to hard objects by the umbonal part or whole surface of left valve. Shells can be white to off-white to grey, sometimes with brown or purple on the ridges.

**Remarks.** Based on molecular phylogenetic analysis, Sigwart et al. (2021) showed that the genus *Magallana* should be considered as a subgenus of the genus *Crassostrea*; however, in this study we rely on the information on species validity based on the WoRMS database.

Season of capture fisheries – exploited year-round.

**Distribution in Vietnam.** Commonly found in coastal waters (Do, Le, 2015).

In Nha Phu Lagoon – main species growing in the sea, in the wild; occurs on stony ground, clinging to substrate.

Family Pinnidae Leach 1819  
Genus *Atrina* Gray 1842

21. *Atrina pectinata* (Linnaeus 1767)

(Fig. 7A)

*Pinna pectinata* Linnaeus 1767 (Linnaeus, 1767)

*Atrina pectinata*: Abbott and Dance, 1982: p. 300; Carpenter and Niem, 1998: p. 178, p. 177 fig. 4; Okutani, 2000: p. 887, plate 441 fig. 1; Hylleberg and Kilburn, 2003: p. 159, 160; Nguyen, 2005: p. 255, plate 77, fig. 7; Adrianov and Lutaenko, 2016: plate 9, figs C, D.

**Description.** Shell reaching a large size (length to 37 cm), usually rather thin, fragile, moderately inflated and triangularly wedge-shaped in outline, with a highly variable sculpture. Outer surface of valves with 15–30 radial ribs which may be smooth to densely set with short, open spines. Inner surface of shell with shallow grooves corresponding to the external radial ribs. Outside of shell slightly shiny, translucent olivaceous tan, often tinged with darker purplish brown or grey

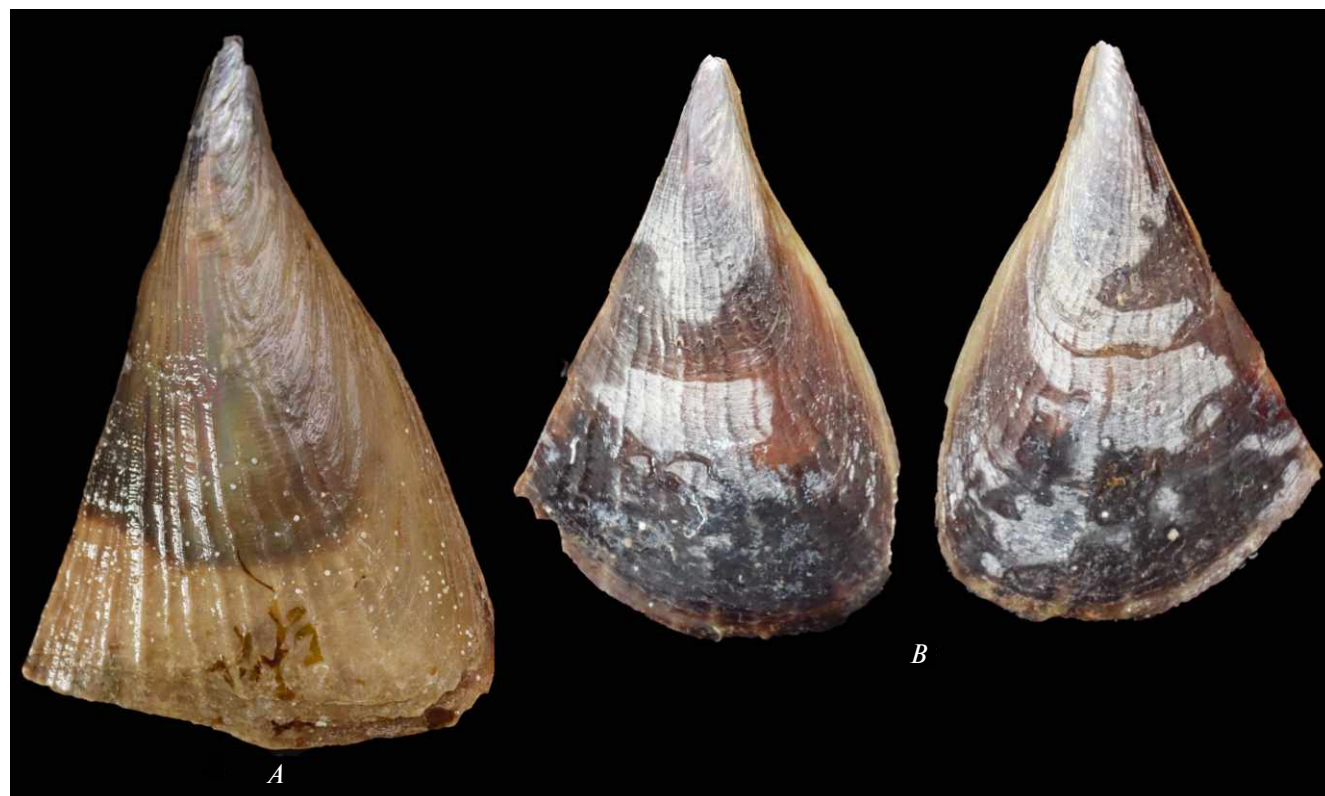


Fig. 7. A – *Atrina pectinata* (175 mm), B – *Atrina vexillum* (113 mm).

toward the umbones. Interior similarly coloured, iridescent on nacreous area.

Season of capture fisheries – from May to September.

**Distribution in Vietnam.** Occurs in the following areas: Khanh Hoa, Southwest Vietnam, North Vietnam, etc. Found at 50–80 m (Nguyen, 2005).

In Nha Phu Lagoon – occurs in areas with hard bottoms consisting mainly of rocks and dead corals.

22. *Atrina vexillum* (Born 1778)

(Fig. 7B)

*Pinna vexillum* Born 1778 (Born, 1778)

*Atrina vexillum*: Abbott and Dance, 1982: p. 300; Carpenter and Niem, 1998: p. 179, p. 177 fig. 5; Okutani, 2000: p. 887, plate 441 fig. 7; Hylleberg and Kilburn, 2003: p. 160; Nguyen, 2005: p. 254, plate 77 fig. 10; Adrianov and Lutaenko, 2016: plate 7, figs K, L.

**Description.** Shell reaching a very large size (to 40 cm in length), thick and solid, inflated, variable in shape from triangular to hatchet-shaped or subglobular. Outer surface of valves with 10–17 main radial ribs, often bearing scale-like spines, and with weaker interstitial riblets. Outside of shell dark reddish brown to nearly black, usually dull. Interior dark brown to black, iridescent on nacreous area.

Season of capture fisheries – from May to September.

**Distribution in Vietnam.** Usually found in coastal waters (Do, Le, 2015). According to Nguyen, 2005 it is found in Khanh Hoa, Phan Thiet, Phan Rang, North Vietnam, habitat: gravel or sandy mud at 5–50 m.

In Nha Phu Lagoon – occurs in areas with hard bottoms consisting mainly of rocks and dead corals.

Order Pectinida Gray 1854  
Family Pectinidae Rafinesque 1815  
Genus *Amusium* Röding 1798

23. *Amusium pleuronectes* (Linnaeus 1758)

(Fig. 8A)

*Ostrea pleuronectes* Linnaeus 1758 (Linnaeus, 1758)

*Amusium pleuronectes*: Abbott and Dance, 1982: p. 303; Carpenter and Niem, 1998: p. 103; Hylleberg and Kilburn, 2003: p. 165; Nguyen, 2005: p. 260, plate 80 fig. 3; Adrianov and Lutaenko, 2016: plate 11, figs A, B.

**Description.** Shell length commonly to 4–8 cm. Shell thin, medium sized, laterally compressed, almost circular in outline, gaping anteriorly and posteriorly. Outside of shell polished and nearly smooth, with only many faint concentric and radial lines. Colour: outside of left valve with light to deep pinkish brown of varying shades along concentric growth marks, and with darker radial lines and tiny white dots on umbo-nal area. Interior of left valve whitish, often with a pin-

kish hue on margins and central area, and with a brown blotch under the hinge. Right valve white externally and internally.

Season of capture fisheries – exploited year-round, concentrated from May to November.

**Distribution in Vietnam.** Commonly found in coastal waters (Do, Le, 2015). Occurs in the following areas: Nha Trang, Cam Ranh, Ca Na, Phan Thiet, Binh Thuan, Vung Tau, Tuy Hoa, Binh Dinh, Quang Ngai, Quang Nam, Da Nang, Nghe An, Thanh Hoa, Nam Dinh, Hai Phong, Quang Ninh. Found on soft bottom at 20–40m (Nguyen, 2005).

In Nha Phu Lagoon – found on sandy bottoms mixed with rocks and dead coral.

Genus *Annachlamys* Iredale 1939

24. *Annachlamys striatula* (Linnaeus 1758)

(Fig. 8E)

*Ostrea striatula* Linnaeus 1758 (Linnaeus, 1758)

*Annachlamys striatula*: Abbott and Dance, 1982: p. 306; Okutani, 2000: p. 905, plate 450 fig. 36; Hylleberg and Kilburn, 2003: p. 165; Nguyen, 2005: p. 260, plate 80 fig. 6; Adrianov and Lutaenko, 2016: plate 11 fig. E.

**Description.** Shell length commonly to 3–8 cm. Shell thick, sub circular in shape and is slightly longer than it is tall. Sculpture consists of approximately 19 broads, widely spaced radial ribs and numerous concentric stria. Colour externally white at right valve with weak comarginal bands and dark red at left valve white auricles. Interior surface white at two valves with dark red comarginal band at left valve, inner margins crenulate.

Season of capture fisheries – exploited year-round.

**Distribution in Vietnam.** Commonly found in coastal waters (Do, Le, 2015). Occurs in the following areas: Phan Rang, Ca Na, Khanh Hoa, etc. Habitat: sandy bottom at 1–25 m (Nguyen, 2005).

In Nha Phu Lagoon – found on sandy bottoms mixed with rocks and dead corals.

Genus *Decatopecten* G. B. Sowerby II 1839

25. *Decatopecten plica* (Linnaeus 1758)

(Fig. 8C)

*Ostrea plica* Linnaeus 1758 (Linnaeus, 1758)

*Decatopecten plica*: Abbott and Dance, 1982: p.307; Okutani, 2000: p. 907, plate 451 fig. 48; Hylleberg and Kilburn, 2003: p. 166; Nguyen, 2005: p. 261, plate 80 fig. 8.

**Description.** Shell thick, height to 5 cm, shell subequilateral, well round ventral margin, flat umbo-nal area. Outer surface of valves with 3–5 main radial ribs with concentric step and fine riblets on internal ribs.

Colour variable, yellow, orange or brown with lighter or darker markings, occasionally uniform in colour.

Season of capture fisheries – from May to November.

**Distribution in Vietnam.** Commonly found in coastal waters (Do, Le, 2015). Occurs in the following areas: Binh Thuan, North Vietnam, etc. Habitat: sandy bottom at 5–15 m (Nguyen, 2005).

In Nha Phu Lagoon – occurs on sandy bottom mixed with rocks, dead corals in the outer zone near the estuary.

Genus *Mimachlamys* Iredale 1929

26. *Mimachlamys sanguinea* (Linnaeus 1758)

(Fig. 8D)

*Ostrea sanguinea* Linnaeus 1758 (Linnaeus, 1758)

*Mimachlamys sanguinea*: Abbott and Dance, 1982: p. 167; Carpenter and Niem, 1998: p. 204, p. 199 fig. 7;

Okutani, 2000: p. 903, plate 448 fig. 24; Hylleberg and Kilburn, 2003: p. 167; Nguyen, 2005: p. 262, plate 80 fig. 5.

**Description.** Shell solid, medium sized, height to 7 cm higher than long and rounded-ovate in outline. Both valves sculptured with numerous, regularly spaced, squamous primary radial ribs (22–27, usually 24), flanked by fine squamous secondary radial riblets, starting in the central part of the disc, and duplicating near the periphery. Inner surface plicated near ventral margin. Colour extremely variable, either patterned or uniform.

Season of capture fisheries – exploited year-round.

**Distribution in Vietnam.** Commonly found in coastal waters (Do, Le, 2015). Occurs in the following areas: Binh Thuan, Khanh Hoa, Phan Rang, Phan Thiet, etc. Habitat: bysally attached to rocks at 1–15 m (Nguyen, 2005).

In Nha Phu Lagoon – found on sandy bottoms mixed with rocks and dead corals.



**Fig. 8.** A – *Amusium pleuronectes* (74 mm), B – *Spondylus squamosus* (87 mm), C – *Decatopecten plica* (37 mm), D – *Mimachlamys sanguinea* (53 mm), E – *Annachlamys striatula* (56 mm).

Family Spondylidae Gray 1826  
Genus *Spondylus* Linnaeus 1758

27. *Spondylus squamosus* Schreibers 1793

(Fig. 8B)

*Spondylus squamosus* Schreibers 1793 (Schreibers, 1793)

*Spondylus squamosus*: Abbott and Dance, 1982: p. 317; Carpenter and Niem, 1998: p. 213, p. 212 fig. 4; Okutani, 2000: p. 917, plate 456 fig. 3; Hylleberg and Kilburn, 2003: p. 171; Nguyen, 2005: p. 265, plate 81 fig. 14.

**Description.** Shell height to 9 cm. Shell highly variable in shape but roughly rounded-ovate to elongate-ovate in outline, inequivalve. Main spinose ribs often slightly more numerous on right valve (8–12 ribs on right valve, instead of 5–8 on left valve). Internal margins with crenulations corresponding with the outer radial sculpture. Colour of interstices white, dark-brown or brown-red, spines white; internally blue-white with a wide, variegated coloured crenulated margin, hinge brown.

Season of capture fisheries – from May to November.

**Distribution in Vietnam.** Commonly found in coastal waters (Do, Le, 2015) in the areas: Khanh Hoa, Con Son Island, Catba Island, etc. Habitat: attached to corals or rocks at 1–15 m (Nguyen, 2005).

In Nha Phu Lagoon – found on hard bottom among dead coral reefs.

## DISCUSSION

In the Nha Phu Lagoon area between 2019 and 2022, a total of 536 commercial bivalves were collected, belonging to 27 species and 13 families. The greatest number of species was from the family Veneridae (8 species), followed by Pectinidae with 4 species, Arcidae with 3 species and the remaining families had 1–2 species each.

Due to natural conditions, bivalves in Nha Phu are primarily exploited during the dry season, which typically lasts from April to the end of September. They play a significant economic role as a food source and are also used in the production of handicrafts and medicines. Two main species, *Perna viridis* and *Magallana gigas*, are cultivated in the area and account for most of the food production. They are found in all cases, both among fishermen and in the market, their weight range 40–60% of all molluscs. They are known for their ability to filter water and thrive in highly eutrophic environments, which is why they are often grown around fish cages or in beds.

Species belonging to the Margaritidae, Pinnidae, Pectinidae and Spondylidae families are predominantly found on coral reefs or hard bottoms and are primarily harvested through direct diving. These species have large shells, which are then processed into

handicrafts after the meat is extracted for food. In particular, *Pinctada margaritifera* is sought after for its nacreous shell and ability to create pearls, leading to its overexploitation. It is listed in the Vietnam Red Data Book, necessitating strict conservation and restoration measures. Species from the Isognomnidae, Psammobiidae and Solenidae families typically inhabit littoral and sublittoral areas, have reproductive capabilities and experience intensive growth, often forming commercial seafood sites.

According to the statistics compiled by Chinh (1980), Nguyen and Vo (1996), Vietnam is home to approximately 28 marine bivalve species of economic significance. These species include *Tegillarca granosa* (Linnaeus 1758), *Anadara antiquata* (Linnaeus 1758), *Arca navicularis* Bruguière 1789, *Perna viridis* (Linnaeus 1758), *Modiolus philippinarum* Hanley 1843, *Amusium pleuronectes* (Linnaeus 1758), *Mimachlamys crassicostata* (G. B. Sowerby II 1842), *Magallana rivularis* (A. Gould 1861), *Pinctada fucata* (A. Gould 1850), *Pinctada maxima* (Jameson 1901), *Pinctada margaritifera* (Linnaeus 1758), *Pteria penguin* (Röding 1798), *Pinna vexillum* Born 1778, *Cyrenobatissa subsulcata* (Clessin 1878), *Geloina bengalensis* (Lamarck 1818), *Lucina philippinarum* Reeve 1850, *Tridacna squamosa* Lamarck 1819, *Dosinia laminata* (Reeve 1850), *Cyclina sinensis* (Gmelin 1791), *Meretrix meretrix* (Linnaeus 1758), *M. lyrata* Sowerby II 1851, *Katelysia rimularis* (Lamarck 1818), *Anomalocardia squamosa* (Linnaeus 1758), *A. flexuosa* (Linnaeus 1767), *Macra fourangularis* Deshayes in Reeve 1854, *Sanguinolaria diphos* (Linnaeus 1771), *Glaucome chinensis* Gray 1828 and *Potamocorbula laevis* (Hinds 1843). Of these species, 12 economically important bivalves were discovered in the South-Central region. Phan D.N. and his colleagues investigated benthic resources in the central coastal region between 2008 and 2013, recording eight economically valuable bivalve species (Phan et al., 2016). The General Department of Fisheries reported a total of 42 economically valuable bivalve species found across Vietnam from 2016 to 2019. The decline of economically valuable benthic species in terms of composition is also widespread in Nha Phu Lagoon. According to Phan Duc Ngai's research, the number of species decreased from 25 species in 1965 to 16 species in 1966, and only 9 species were encountered during two research trips in November 2012 and May 2015 (Phan et al., 2016a). This decrease may be due to the short duration of the species composition survey, so the number of specimens was incomplete. Factors that may affect the benthic resources of the region include active exploitation of resources and destruction of biological habitat (mangroves and seagrasses) (Nguyen, Thai, 2013; Phan et al., 2016a). Therefore, to ensure the benthic biodiversity of Nha Phu Lagoon, it is necessary to develop an exploitation plan and zoning to reasonably exploit this resource.

Biodiversity resources support significantly to the development of economic sectors such as traditional

coastal fisheries, pond aquaculture, cage marine culture, hatcheries and juvenile collection from nature for extensive culture, collection of salangane bird nets and marine tourism. Recent development in Khanh Hoa province has resulted in a number of environment concerns, including: habitat loss and degradation, over-fishing, pollution and land/seascape degradation. In term of marine governance, there exists a series of issues to be considered, composing high conflict among development needs of diverse sectors, high demand on spaces of land and sea for development, competition among economic sectors and reduction of total revenue, social divergence due to conflicts and benefit sharing, and land – sea interaction and land-based impacts to the sea and ocean. In order to address above-mentioned socio-economic and environmental concerns, provincial policy makers and supporting organizations shall execute different solutions, including inter alia: Marine space planning, indicating prior targets of each area; coastal area of establishment of real no-take zone for maintaining living resources and conservation of endangered species; establishment of fisheries refugia to support resource recruitment as a basis for sustainable fisheries; Involvement of private sector and local communities in management and use of resources; development of environment friendly offshore marine culture; application of sea ranching to restore and develop high value fisheries resources such as abalone, sea cucumber, limpet, cone shell...; and research on biodiversity and resilience of coastal ecosystems to changes of anthropogenic activities and natural processes for adaptive management to sustainable tourism and fisheries.

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#### ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This work does not contain any studies involving human and animal subjects that conform to the criteria of Directive 2010/63/EU.

#### CONFLICT OF INTEREST

The authors of this work declare that they have no conflicts of interest.

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## БИОРАЗНООБРАЗИЕ ПРОМЫСЛОВЫХ МОРСКИХ ДВУСТВОРЧАТЫХ МОЛЛЮСКОВ В ЛАГУНЕ НЯФУ, ПРОВИНЦИЯ КХАНЬХОА, ЮЖНО-ЦЕНТРАЛЬНЫЙ ВЬЕТНАМ

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Работа выполнена в рамках совместного проекта Российско-Вьетнамского Тропического научно-исследовательского и технологического центра по изучению организмов-индикаторов морской среды в Южно-Центральном регионе Вьетнама. Данное исследование было сосредоточено на прибрежных районах со значительным антропогенным воздействием и показало, что биологические ресурсы напрямую влияют на средства к существованию и деятельность населения прибрежных районов. Эти ресурсы динамичны и подвержены воздействию как человеческих, так и природных факторов. Сбор материала осуществлялся с помощью грабель с сетчатым мешком на конце для отбора проб из зоны мягкого дна. На участках с твердым субстратом и илистым дном использовалось водолазное снаряжение. Кроме того, при сборе материала несколько образцов моллюсков были получены от рыбаков, которые ловят морских организмов в этой лагуне. Сравнивая полученные результаты с предыдущими исследованиями разнообразия двустворчатых моллюсков в этом районе, можно сделать вывод, что в лагуне Ня Фу обитает множество экономически ценных видов двустворчатых моллюсков. Всего было обнаружено двадцать семь видов двустворчатых моллюсков из тринадцати семейств, причем наибольшее количество видов (восемь видов) приходится на семейство Veneridae. Наиболее многочисленными в уловах были представители семейств Ostreidae и Mytilidae, которые в основном состоят из *Magallana gigas* (Thunberg 1793) и *Perna viridis* (Linnaeus 1758) и которых культивируют в лагуне. Эти два вида не только имеют экономическую ценность, но и играют важнейшую роль в морских экосистемах, фильтруя воду и задерживая органические остатки в окружающей среде.

*Ключевые слова:* морские моллюски, экономическая ценность, роли в экосистеме