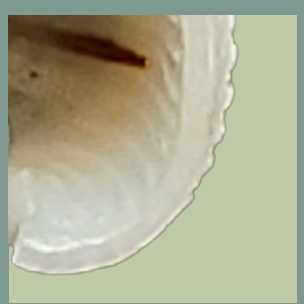
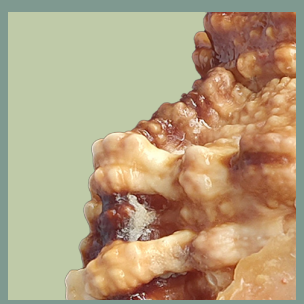
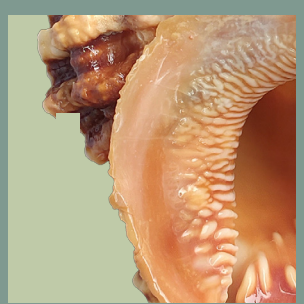
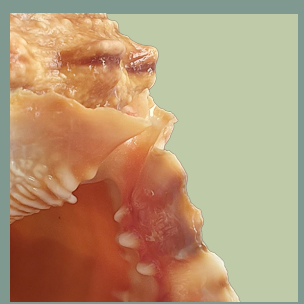
Marine Molluscs in Jagna Bay, Bohol

First Edition

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Nothing but respect, gratitude, and love
for our beloved Ma'am Marivic
our mentor, friend, and angel,
whose legacy shall live on.

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Preface

Science is based on observed facts from which a hypothesis, a theorem, and the laws of nature are extracted. These observations often start with the characterization and identification of the system as well as the elements of the system and how they are related to each other and their evolution in time. One system which still has to be deeply understood is the phylum Mollusca which is the second largest animal phylum with probably over 100,000 species. With continuous evolution and mutation, each species is a product of its genetic lineage as well as its adaptation to a specific location – an environment which also changes in time. As we read this Preface, a new mutated molluscan species is probably born. The task of identifying and characterizing molluscs which can be unique for each marine location is daunting. It has even been observed that more than 70% of marine life is not known to science.

This Catalogue focuses on marine molluscs inhabiting Jagna Bay at the northern part of Bohol Sea. The aim is to combine morphologic and genetic information in the identification of molluscs and to sharpen the gray areas in mollusc identification. Hence, we have also involved the Philippine Genome Center at the University of the Philippines (UP) in the barcoding of specimens. Our initial journey in barcoding marine molluscs was catalyzed by the Co-Founders of Science Corps, in particular, Dr. Benjamin E. Rubin of the University of California, Berkeley, and Dr. Stephen Harris of the State University of New York.

We have also received on-going advice from Dr. Joshua P. Torres of the University of Copenhagen. The Catalogue is meant to document the initial results of the project so that a wider audience can benefit. We hope that succeeding editions could provide added insights and portray a more complete picture – small steps aimed at pushing the boundaries of science.

It is indeed a pleasure to mention Prof. Baldomero Olivera of the University of Utah for jumpstarting this project. Dr. Olivera's team conducted a marine science camp at the Central Visayan Institute Foundation (CVIF) during the summers of 2016 and

2017 headed by Dr. Noel A. Saguil with Jose Arbasto. In moving forward, this marine science project – from the collection of molluscs to their morphologic identification and preservation, as well as coordination with other marine experts – we thank the team of the JAZC Marine Sciences Laboratory of CVIF for their time and effort. Members of the team ably headed by Dr. Janneli Lea Soria include Jodivine Navarosa, Kimverly Ranoco, and Mary Dored Ann Cadeliña. We also greatly appreciate the scientific input in mollusc identification from Dr. Emmanuel Ryan De Chavez who is currently the curator for molluscs at the Museum of Natural History, UP Los Baños. The editing skill of Dr. Ma. Cristina C. Bernido-Fabella is also gratefully acknowledged.

This activity received added impetus from the Department of Science and Technology (DOST), especially through Ms. Vina R. Antopina. We acknowledge DOST's generous support for the project, "Studies and Creation of a Gene Bank of Phylum Mollusca from Bohol Sea."

Christopher C. Bernido, PhD
Project Leader

The Philippine Archipelago

The Philippine archipelago is strategically located at a conjuction of major tectonic, oceanographic, and climatic systems (Figure 1). Over 7,000 islands, mostly volcanic in origin, rose above deep ocean basins, trenches, and internal seas along the covergence zone between the Philippine Sea Plate and the Eurasian Plate (Aurelio et al., 2013). The internal seas of the Philippines serve as gateways of ocean currents that transfer waters from the Pacific Ocean across the straits of Indonesia and Malaysia, and eventually into the Indian Ocean (Hu et al., 2015; Sprintall et al., 2019). Surface waters in the region remain warm the entire year at temperature >28^{o}C, signifying the extent of the Indo-Pacific Warm Pool (De Deckker, 2016). Two major climatic systems operate across the Indo-Pacific Warm Pool: Asian Monsoon and Intertropical Convergence Zone (ITCZ). The switching wind directions between northeast monsoon and southwest monsoon along with the excursion of ITCZ southwards and northwards result in a distinct seasonal rainfall pattern, but broadly high rainfall the entire year over the tropical maritime region (De Dekker, 2016).

Notably, the Philippines is also recognized as a biodiversity hotspot within the Indo-Polynesian region, the largest marine biogeographic province over the tropical Indian and Pacific oceans (Toonen et al., 2016). This expansive maritime zone holds the record for the most biologically diverse marine domain in the world (Sanciangco et al., 2013; Petuch and Berschauer, 2021). Species richness of maps representing over 10,000 species of coastal fishes, crustaceans, molluscs, corals, seagrasses, and mangroves show that across the Indo-Pacific it is highest in central Philippines (Sanciangco et al., 2013).

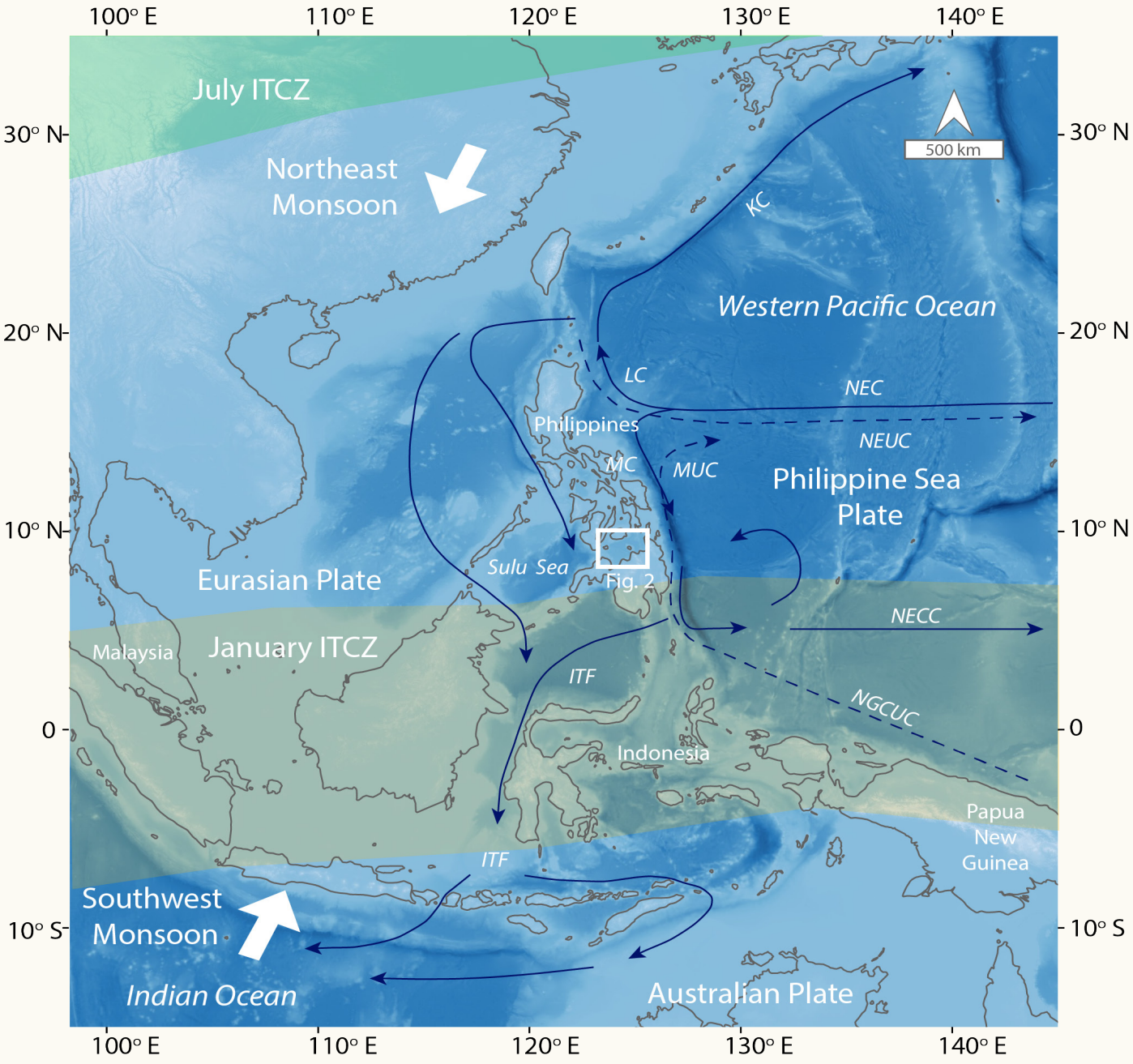


Figure 1. Major tectonic, oceanographic, and climatic systems that affect the Philippine archipelago. *Ocean currents from Hu et al. (2015): NEC (North Equatorial Current); NEUC (North Equatorial Under Current); KC (Kurishio Current); LC (Luzon Current); MC (Mindanao Current), MUC (Mindanao Under Current); NECC (North Equatorial Counter Current); ITF (Indonesian Throughflow); NGCUC (New Guinea Coastal Under Current) Location of July ITCZ and January ITCZ from Lechleitner et al. (2017).*

Bohol Sea

Bohol Sea is one of the internal seas of the Philippine archipelago surrounded by the islands Negros, Cebu, Bohol, and Leyte in central Philippines and Mindanao island of southern Philippines (Figure 2). Bohol Sea receives its waters from two different sources. Surface waters come from Pacific Ocean on the east through the Surigao Strait, while deep waters from Sulu Sea on the west through the Dipolog Strait (Cabrera et al., 2011). Notable oceanographic features across Bohol Sea include:

- the Bohol Jet - a strong surface current that flows from Surigao Strait south-westwards through Bohol, and reaching as far as Cebu, Negros, and Siquijor islands.
- the Iligan Bay Eddy - a cyclonic eddy on the southwestern basin off the coast of Misamis Occidental adjacent to Iligan Bay.
- riverine plumes - strong river discharge from large rivers that are draining extensive rugged terrains in northern Mindanao like Agusan, Tagaloan, Cagayan, Mandulog, and Agus rivers.

Bohol Sea is considered as a biodiversity hotspot of marine mammals including whales, dolphins, rays, and mobilids (Green et al., 2004; Acebes, 2013). For the record, 18 out of the 25 species of whales and dolphins in the Philippines can be found in Bohol Sea (Alava et al., 2002; Ponzo et al., 2011). Bohol Sea is also a priority area in the conservation of mangroves, cetaceans, corals and whale sharks (Green et al., 2004).

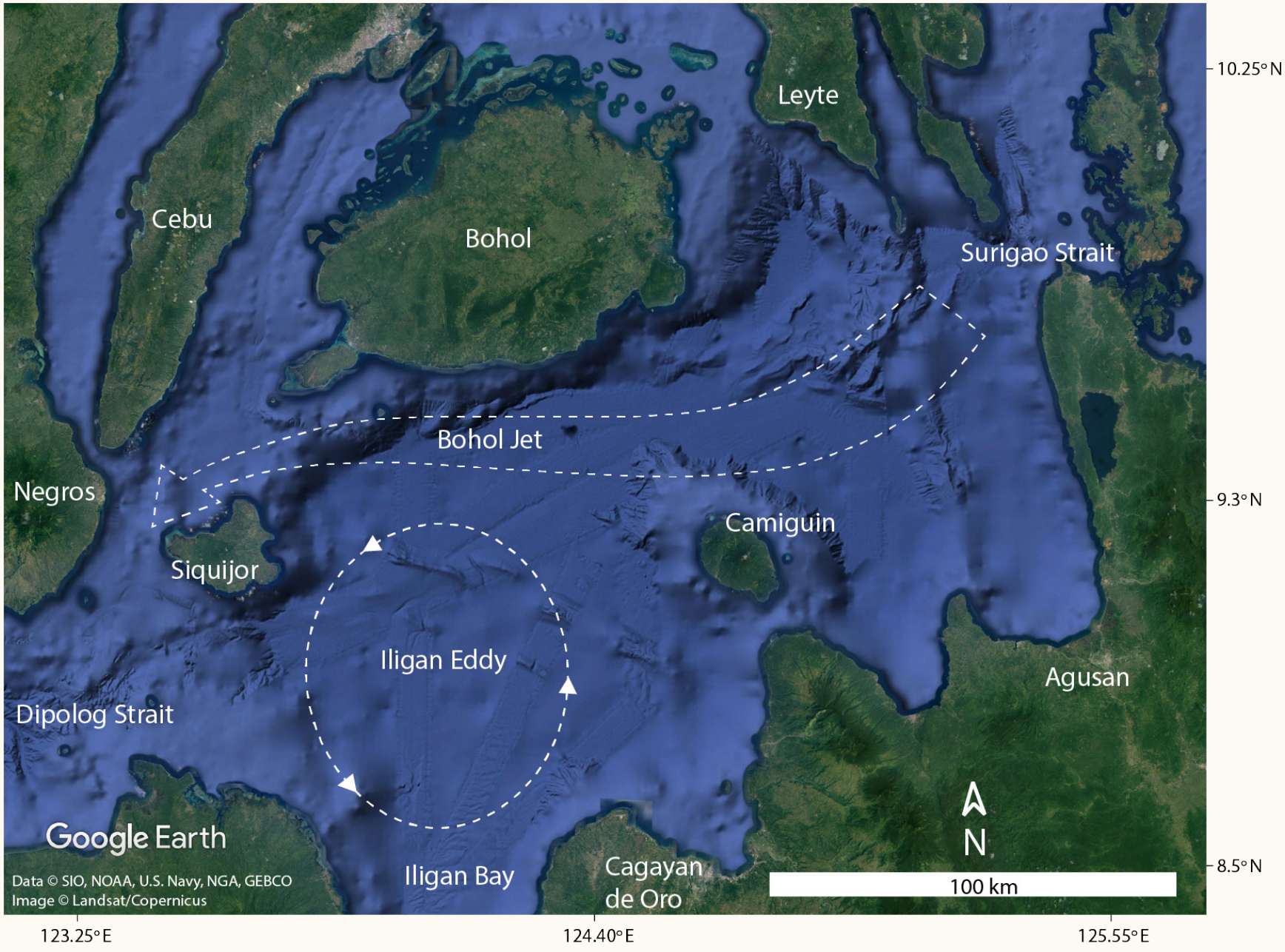


Figure 2. The Bohol Sea. Also known as Mindanao Sea, it is one of the internal seas of the Philippine archipelago and known as a biodiversity hotspot for marine mammals such as whales and dolphins.

Jagna Bay

The Jagna Bay is a small embayment, ~5 km wide between the headlands of Larapan Point on the northeast and Cantagay Point on the southwest (Figure 3). A fringing reef ~50 m to ~250 m wide borders almost the entire length of the ~9 km shoreline. Seagrass beds, patches of mangroves, and sandy to boulder beach systems complete the suite of coastal habitats in Jagna Bay. The most extensive seagrass beds grow on the reef flat off Pangdan and Can-upao. Mature stands of *Sonneratia* and *Rhizophora* are established on a mangrove patch in Can-upao – encompassing a total area of around 4,500 m^2.

Mangroves in Can-upao, Jagna Bay.

Massive corals in Pangdan, Jagna Bay at low tide.

Rocky substrate of Can-upao, Jagna Bay.

Seagrass beds in Pangdan, Jagna Bay at low tide.

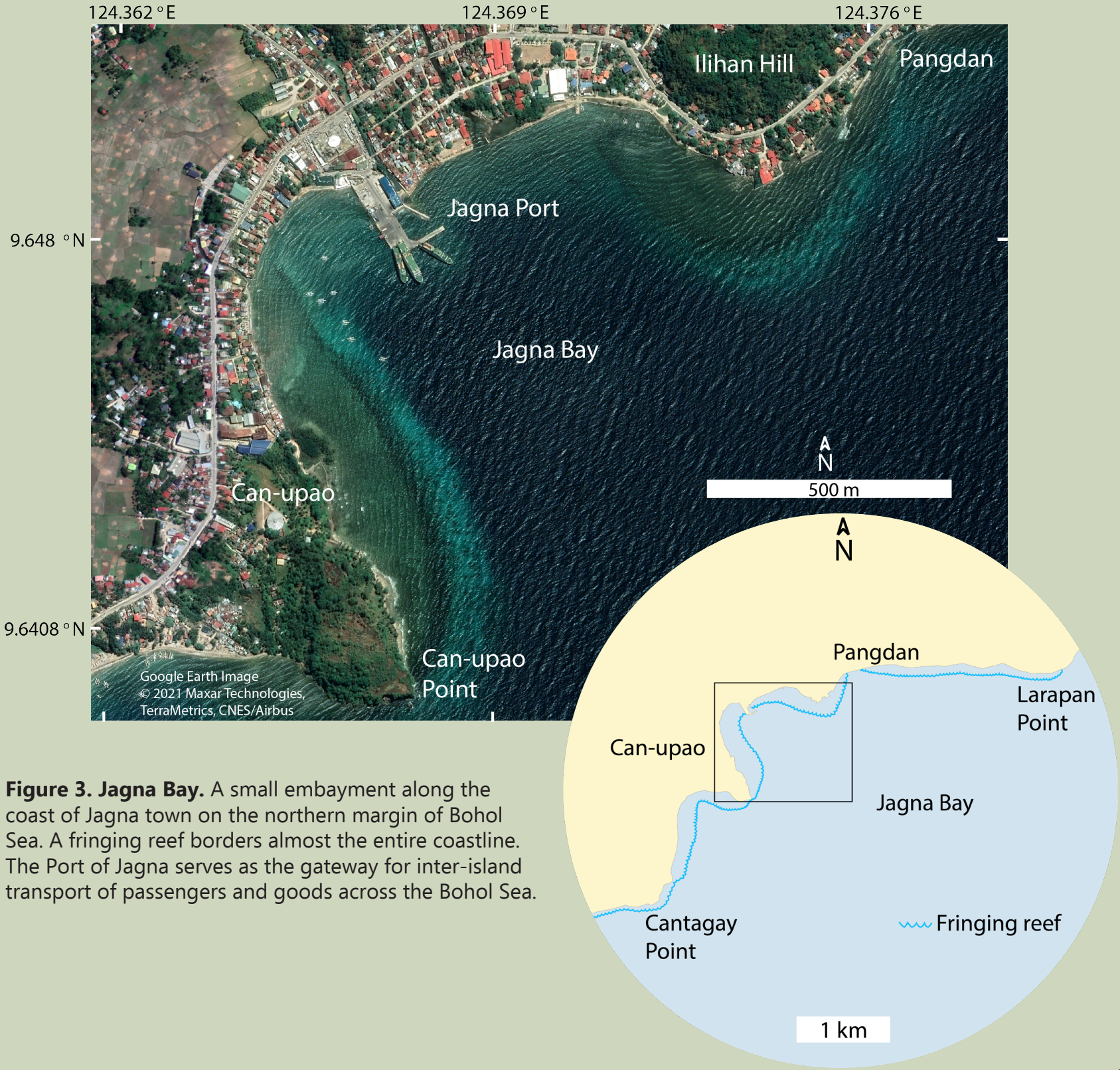


Figure 3. Jagna Bay. A small embayment along the coast of Jagna town on the northern margin of Bohol Sea. A fringing reef borders almost the entire coastline. The Port of Jagna serves as the gateway for inter-island transport of passengers and goods across the Bohol Sea.

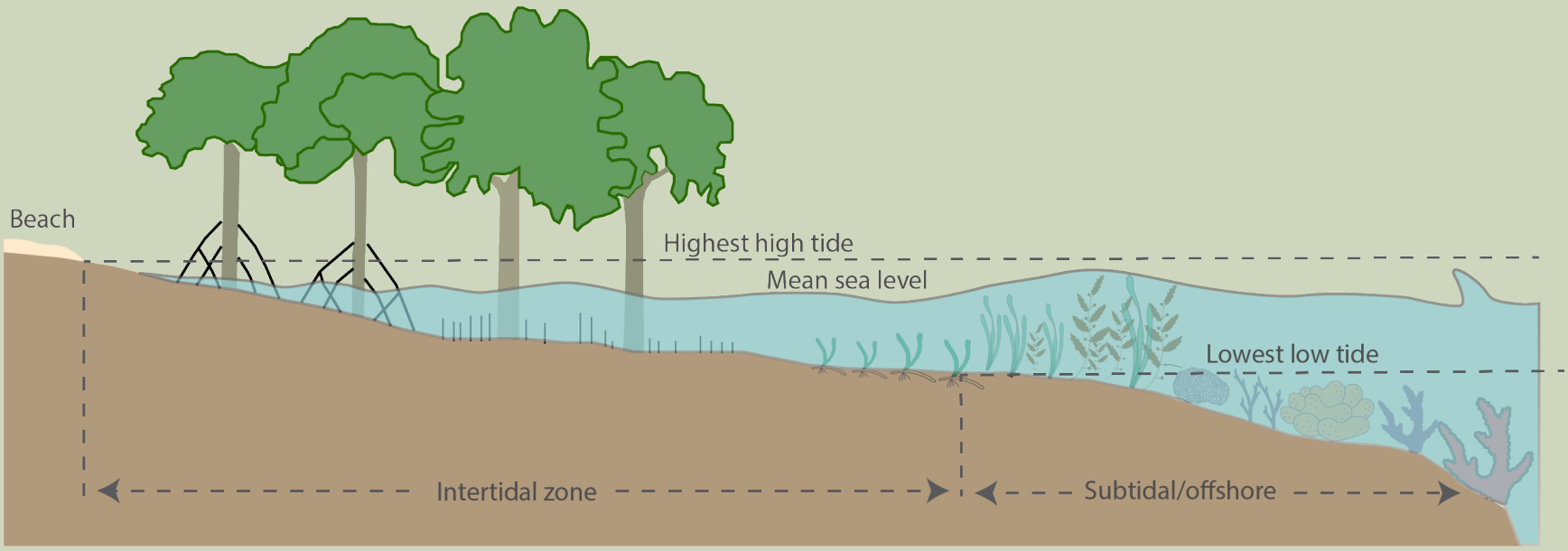


Figure 4. Coastal zonation along Jagna Bay coastline bordered with fringing reefs.

Intertidal Zone

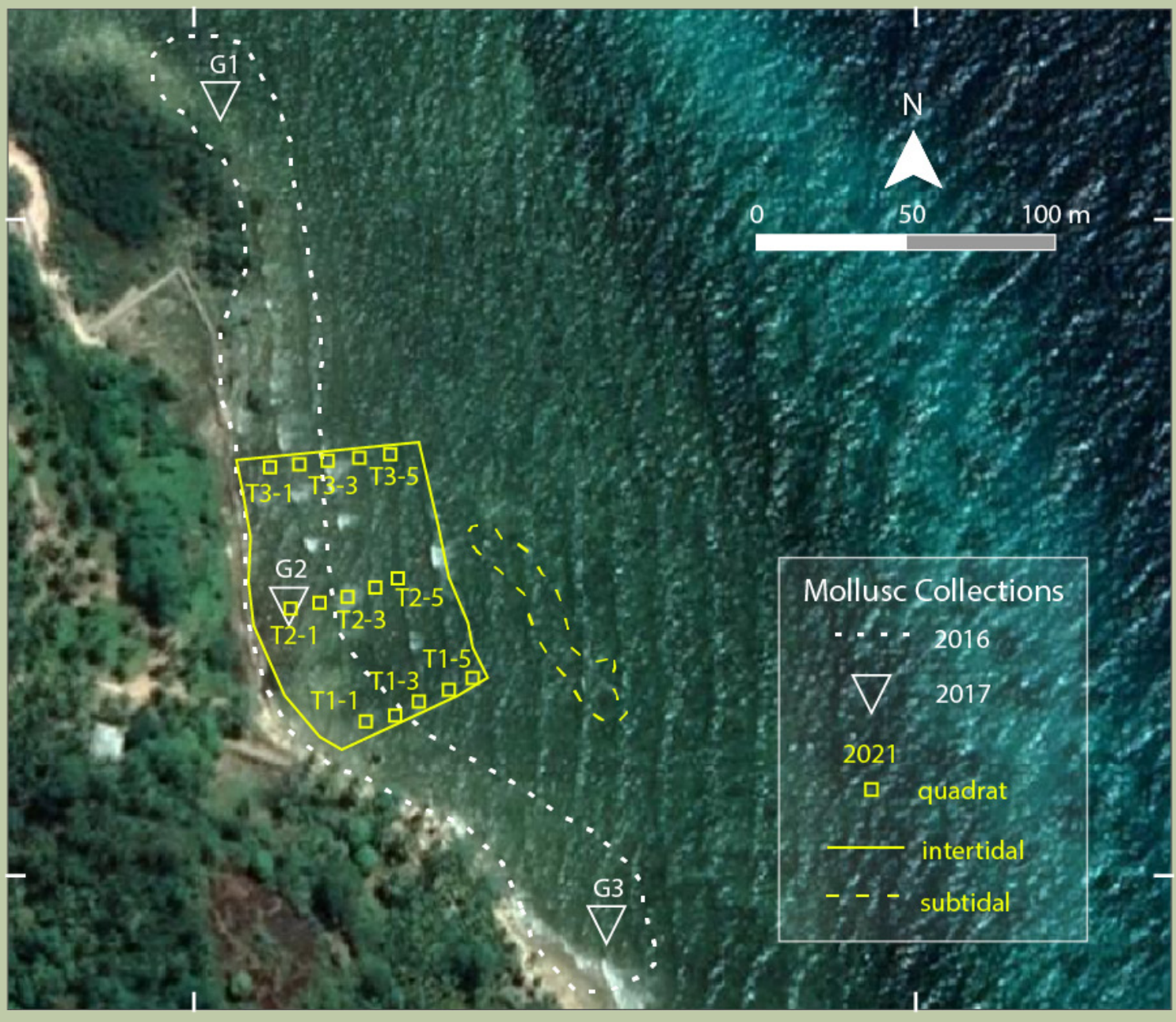
The intertidal zone is the area between the lowest tide and highest tide. Areas within the intertidal zone are submerged during highest tide, but exposed during lowest tide. Daily fluctuations in tide levels result in changing oxygen, nutrients and plankton supply that primarily support life in the intertidal zone. The wide variety of plants and animals on the intertidal zone also receives the highest concentrations of nutrients from land.

Bottom substrates in the intertidal zone are also quite varied, including sand flats, mud flats, rocky reef flats. In Jagna Bay, sand flats at rocky reef flats are dominant substrates that support coral, seaweed, seagrass, and mangrove ecosystems.

PANGDAN, JAGNA BAY

The intertidal zone is an important source of food and means of livelihood to coastal communities. A variety of edible seaweeds and marine invertebrates such as molluscs, sea urchins, and sea cucumbers are commonly harvested in the intertidal zone (De Guzman et al., 2019). Gleaning of edible invertebrates and seaweed, locally known as *panginhas*, during low tide remain as a common local practice in Jagna.

Mollusc Collection Site



Date and Time (GMT +8)	Tide Level (m)	Location ID	Longitude (E)	Latitude (N)
15-16 Mar 2016		Lumun-lumun net Larapan Cantagay	124° 24'E	9° 39'
18 Apr 2016 17:15 - 18:00		Can-upao (intertidal)		
19 Apr 2016 16:00 - 17:00	0.32 *	Canupao (intertidal)		
3 May 2017 05:20 - 06:20	38 cm below sl * 0.44 - 0.5 **	G1	124° 21.965´	9° 38.662´
		G2	124° 21.977´	9° 38.570´
		G3	124° 22.035´	9° 38.512´
18 Sept 2021 15:30 - 17:30	seagrass beds are entirely exposed above water* 0 - 0.05**	T1-1	124° 21.991´	9° 38.548´
		T1-2	124° 21.997´	9° 38.549´
		T1-3	124° 22.001´	9° 38.552´
		T1-4	124° 22.006´	9° 38.554´
		T1-5	124° 22.011´	9° 38.556´
		T2-1	124° 21.978´	9° 38.569´
		T2-2	124° 21.983´	9° 38.570´
		T2-3	124° 21.988´	9° 38.571´
		T2-4	124° 21.993´	9° 38.573´
		T2-5	124° 21.997´	9° 38.575´
		T3-1	124° 21.974´	9° 38.595´
		T3-2	124° 21.979	9° 38.595´
		T3-3	124° 21.984´	9° 38.596´
		T3-4	124° 21.990´	9° 38.597´
		T3-5	124° 21.996´	9° 38.597´

*Tide levels based on actual water level at the sampling site during the mollusc collection.
**Tide levels referenced to mean sea level from WXTide32 Garcia Hernandez station, about 8 km southwest of Jagna.

As an effort to establish a baseline data on the marine biodiversity in Jagna Bay, molluscs were successively collected on the intertidal zone in Can-upao in April 2016, May 2017 and September 2021. The molluscs featured in this catalogue were from the April 2016 and September 2021 collections only. While different types of habitats or substrates including mangrove, seagrass beds, and rocky reef flat are found in Can-upao, the 2016 and 2021 collections were mostly focused on the seagrass beds on the reef flat. Also featured in this catalogue is a *Cycloscala* specimen retrieved using lumun-lumun net in March 2016 (Bernido et al., 2017). This is the first documented sighting of *Cycloscala* off the southern part of Bohol Island.

2021

Mollusc Collection

Gastropods

Gastropods belong to Class Gastropoda, the largest group in the Phylum Mollusca. They are asymmetrical, usually with a shell coiled in a spiral pattern.

CAN-UPAO, JAGNA BAY

Seagrass bed exposed at low tide in Can-upao, Jagna during the intertidal mollusc collection on 18 September 2021.

Bursidae

Bursidae are commonly known as frog shells. Its shell shape varies from being ovate to slightly elongated. There are two strong axial varices which are oftentimes aligned on the sides of the spire. Periostracum is obsolete to absent and the operculum is corneous. Shell aperture has a short anterior siphonal canal and a deep posterior canal (FAO, 1998).

Natural Habitat:
Frog shells can survive well in coral reefs compared to most gastropods. They also thrive in rocks, deeper waters, and on sand and mud bottoms.

In Jagna Bay, this intertidal species was found:

- ***Tutufa rubeta*** (Linnaeus, 1758)

Local Name: Not yet identified

Scale bar: 1 cm

Scale bar: 1 cm

Tutufa rubeta (Linnaeus, 1758)

Distinct characteristics of the sample:
The shell has two prominent axial varices. The aperture is orange to reddish in color with two (2) rows of defined teeth on the outer lip and transverse ridges on the inner lip. It also has anterior and distinct posterior siphonal canals. The outer sculpture has coarse knobs and fine beads.

General diagnostic characteristics of genus/species:
The shell length is usually 9 cm but could go up to 11 cm. Two (2) rows of denticles can be found inside the outer lip and the shell aperture is reddish.

Cerithiidae

Ceriths have elongated and thick shells that are sharply conical and a high, many-whorled spire. Sculpturing is variable, usually containing spiral and nodulose patterns, axial ribs, and varices. The aperture is small with a distinct anterior siphonal canal and an expanded outer lip. Operculum is corneous (FAO, 1998).

Natural Habitat:
Cerithiidae is found in all tropical and subtropical waters, from the coastal zones down to depths of 100 m. Some species graze on algae, while other species thrive on hard substrates (Poppe, 2008).

In Jagna Bay, the following intertidal species were found:

- ***Cerithium*** sp.
- ***Cerithium tuberculatum*** (Linnaeus, 1767)
- ***Cerithium zonatum*** (W. Wood, 1828)

Local Name: Not yet identified

Scale bar: 1 cm

Cerithium sp.

Distinct characteristics of the sample:
The shell has a high conical spire.

Cerithium tuberculatum (Linnaeus, 1767)

Distinct characteristics of the sample:
The shell has a large body whorl, small aperture, short anterior siphonal canal and a posterior siphonal canal. Axial varices are absent.

Scale bar: 1 cm

Scale bar: 1 cm

Cerithium zonatum (W. Wood, 1828)

Distinct characteristics of the sample:
The shell is conical with many spiral whorls and coarse sculpture. There is a sharp banding of colors.

Columbellidae

The shells of Columbellids are small, vividly colored, and fusiform to biconical in shape, with an elongated spire. The outer surface is either ribbed or smoothish without axial varices. The aperture is long and narrow with a short siphonal canal, thick outer lip, and smooth or denticulate inner lip that is not folded. If present, the operculum is corneous (FAO, 1998).

Natural Habitat:
Columbellids are abundant in intertidal and shallow subtidal zones. They are active omnivores living in warm and tropical marine environments (FAO, 1998).

In Jagna Bay, this intertidal species was found:

- ***Pictocolumbella ocellata*** (Link, 1807)

Local Name: Not yet identified

Scale bar: 1 cm

Pictocolumbella ocellata (Link, 1807)

Distinct characteristics of the sample:
The shell has a short siphonal canal and purple teeth on the outer lip.

Conidae

Conidae are called “cone shells” for their shape. They have a moderately low, conical to flat spire, a well-developed body whorl, and a long, narrow aperture with a small notch at the posterior end. They have short and wide anterior siphonal canal, thin and small outer lip, and callus- and fold-free inner lip. Operculum is corneous and quite small (FAO, 1998).

Natural Habitat:
Cone shells are marine snails that live over a wide range of water depths: from the intertidal zone, shallow sublittoral zone, and at depths down to several hundred meters (FAO, 1998). They are venomous predators; they feed on fishes, worms and other molluscs (Poppe, 2008).

In Jagna Bay, the following intertidal species were found:

- ***Conasprella*** sp.
- ***Conus coronatus*** (Gmelin, 1971)
- ***Conus ebraeus*** (Linnaeus, 1758)

Local Name: Not yet identified

Scale bar: 1 cm

Conasprella sp.

Distinct characteristics of the sample:
The shell is biconical in shape with the body whorl tapering towards the narrow anterior end. It has a long aperture, a smooth and thin outer lip, and brown to dark brown wavy stripes.

Conus coronatus (Gmelin, 1971)

Distinct characteristics of the sample:
Beaded spiral cord or ribs are prominent on the surface of the shell. The body whorl has convex sides.

General diagnostic characteristics of genus/species:
Body whorl has convex sides, with a blue-white interior that becomes purple-brown near the margin (FAO, 1998).

Scale bar: 1 cm

Scale bar: 1 cm

Conus ebraeus (Linnaeus, 1758)

Distinct characteristics of the sample:
Body whorl is nearly smooth with several anterior spiral grooves and dark brown to black rectangular spots. The spire is low; not protruding. Outer shell has a pinkish tinge.

General diagnostic characteristics of genus/species:
Shell is short and small with size up to 5 cm; it is white in color with blackish square patterns. Spire is short and rounded, and colored bands are present in the aperture (WoRMS Editorial Board, 2022).

Costellariidae

Shells of Costellariidae have a fusiform-ovate shape, with a high, tapering spire. The surface has predominantly axial sculptures, and the aperture is narrow and elongated, with a short siphonal canal in the anterior end. Generally, the outer lip is smooth on the margin and finely lirate on the inside. Strong columellar folds are present, with the larger ones located posteriorly. Operculum is absent (FAO, 1998).

Natural Habitat:
Members of this family are common in littoral and shallow subtidal or subtropical areas. They are active predators usually found in rock crevices, coral areas, and sand (FAO, 1998).

In Jagna Bay, this intertidal species was found:

- ***Vexillum plicarium*** (Linnaeus, 1758)

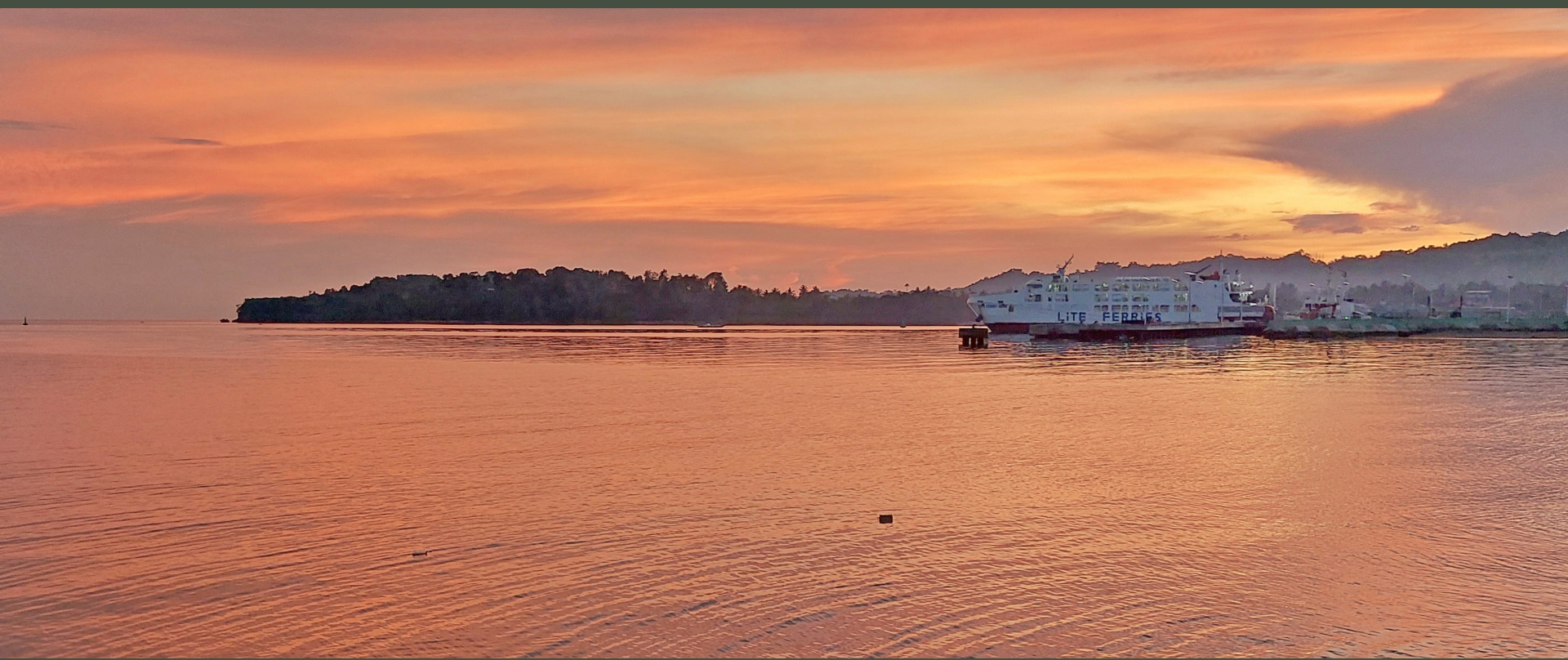
Local Name: Not yet identified

Scale bar: 1 cm

Vexillum plicarium (Linnaeus, 1758)

Distinct characteristics of the sample:
The shell has widely spaced axial folds on the body whorl, crossed by fine spiral grooves and weak spiral cords anteriorly.

JAGNA BAY



View from Pangdan, Jagna Port at sunset.

Cypraeidae

Cypraeidae or "Cowries" have a sturdy, highly polished, ovate to oblong shell and a short spire that is concealed under the body whorl. Their aperture is long and narrow and is channeled at both ends. Teeth are present on the inner lip and outer lip. Operculum is absent (FAO, 1998).

Natural Habitat:
Cowries are nocturnal species that feed on algae or sponges. They can be found in shallow waters and at depths of over 500 m (Poppe, 2008).

In Jagna Bay, the following intertidal species were found:

- ***Mauritia eglantina*** (Duclos, 1833) *possibly juvenile*
- ***Monetaria annulus*** (Linnaeus, 1758)

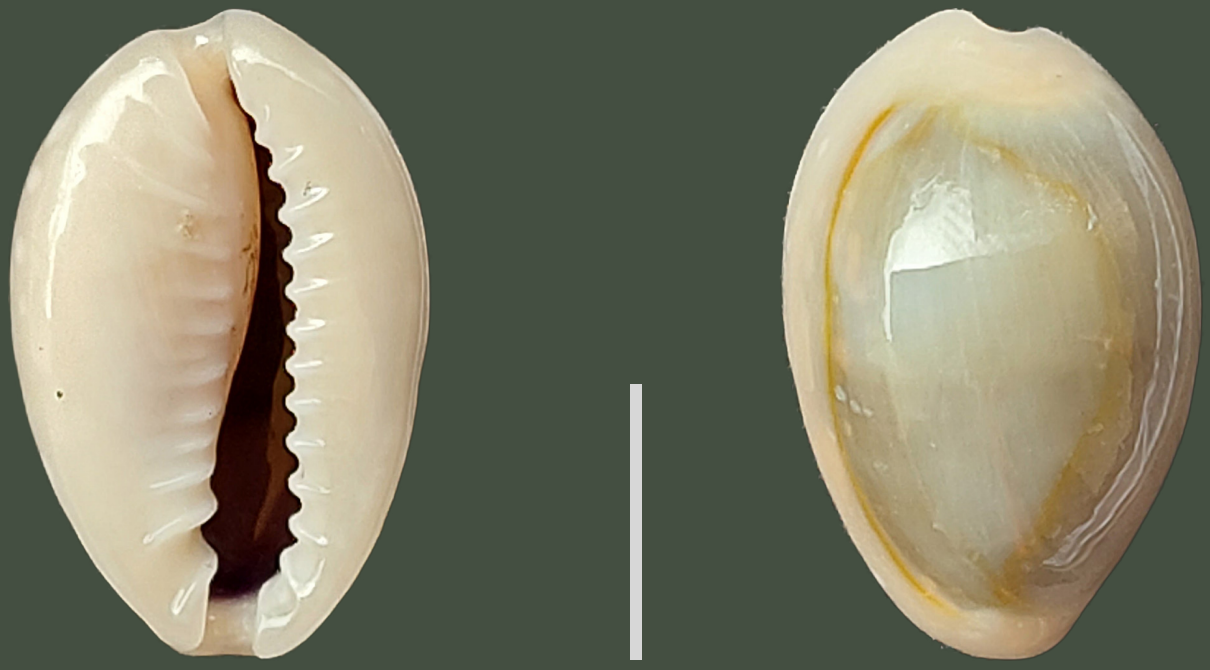
Local Name: *Buskay*

Mauritia eglantina (Duclos, 1833)

Distinct characteristics of the sample:
The surface of the shell is smooth and highly polished. The aperture is long and narrow, channeled at both ends. Teeth is present on both the inner and outer lip. The shell also has a brown blotch and a convex ventral side.

General diagnostic characteristics of genus/species:
The shell has a convex ventral side. The dorsal side has a small brown blotch next to the spire (FAO, 1998).

Scale bar: 1 cm



Scale bar: 1 cm

Monetaria annulus (Linnaeus, 1758)

Distinct characteristics of the sample:
The shell is ovate and surface is smooth.
Coloration is almost uniform without dark spots

General diagnostic characteristics of genus/species:
The shell has an ovate shape with rounded sides. The ventral side has a concave shape and the dorsal surface has a yellow ring (FAO, 1998).

Discodorididae

Discodorididae belong to the order Nudibranchia, which are characteristically soft-bodied molluscs due to the absence of shell protection. Members of the Discodorididae family usually show an oval to elongated body, with a thick mantle that extends over the foot found on the underside of the body (Valdés et al., 2006). The mantle has varied texture across species including smooth, ridged, or rough (Poppe, 2010; Goodheart et al., 2016). Most species have thick mantles that are covered by tubercles resulting in a rough texture of the dorsal side (Poppe, 2010).

Natural Habitat:
Many species live in the intertidal zone, feeding mostly on siliceous sponges (Poppe, 2010).

In Jagna Bay, this intertidal species was found:

- ***Atagema*** sp.

Local Name: Not yet identified

Scale bar: 1 cm

Atagema sp.

Distinct characteristics of the sample:
The specimen has no shell. The body is oval with a rough tan-colored mantle.

Marginellidae

This family has a small ovate-shaped shells that are smooth and highly polished. Aperture is elongated with a short siphonal canal. Three to four strong oblique columellar folds are prominent in the anterior end. There is no operculum that can be found in the shell (FAO, 1998).

Natural Habitat:
The Marginellidae family is widely distributed, but preferentially lives in tropical and temperate seas (Souza Jr. and Simone, 2019). Marine species are mostly found in the intertidal zone and associated with sediments surrounding rocks and reefal areas (Poppe, 2008; Souza Jr. and Simone, 2019). Few species live in deeper waters (>200 m). In the Philippines, large species are found in the south and along the Palawan coast.

In Jagna Bay, this intertidal species was found:

- ***Volvarina philippinarum*** (Redfield, 1848)

Local Name: Not yet identified

Scale bar: 1 cm

Volvarina philippinarum (Redfield, 1848)

Distinct characteristics of the sample:
The shell is small and has four (4) strong oblique, columellar folds at the anterior end.

JAGNA BAY

Overlooking view from Cambanog Hill, Tejero, Jagna.

Muricidae

Members of Muricidae have a varying shell shape, generally characterized with a raised spire, strong sculptures (axial varices and spiral ridges), spines and tubercles. The aperture is ovate to more or less contracted with a long anterior siphonal canal. The outer lip is mostly denticulate while the columella can be smooth or slightly ridged. Corneous operculum is present (FAO, 1998).

Natural Habitat:
The Muricidae family is widely distributed in tropical and subtropical waters (FAO, 1998). Species of Muricidae live in sandy and rocky substrates and feed on other molluscs and barnacles (FAO, 1998; Pappalardo et al., 2014).

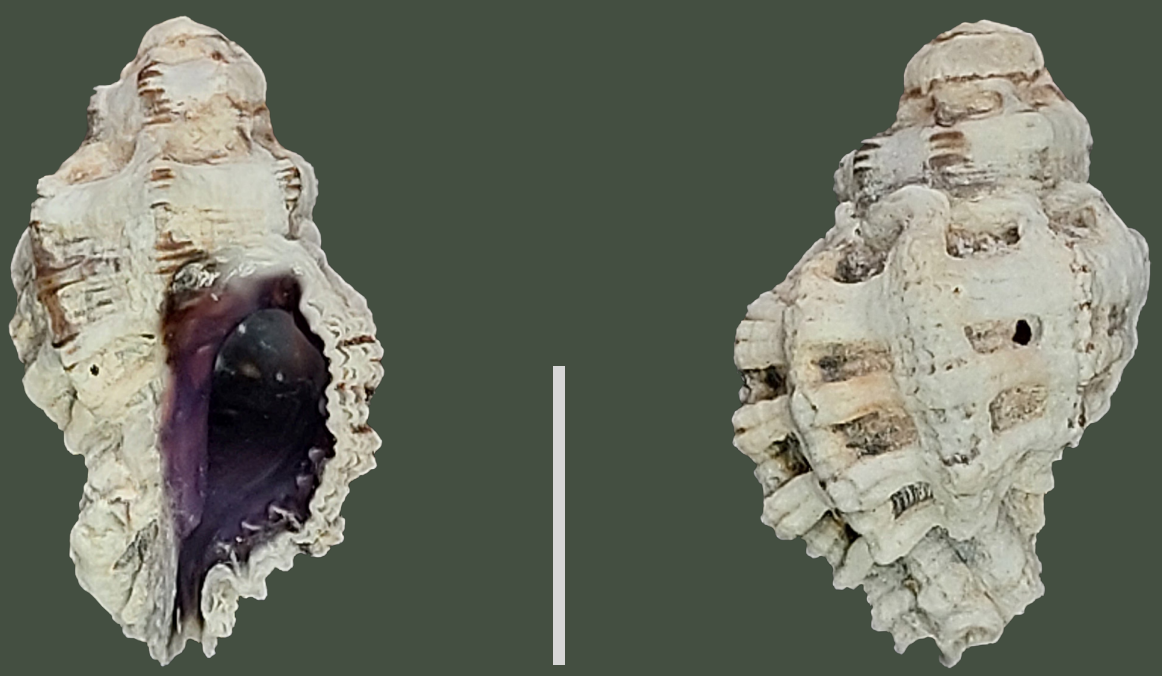
In Jagna Bay, the following intertidal species were found:

- ***Murichorda fiscellum*** (Gmelin, 1791)
- ***Semiricinula turbinoides*** (Blainville, 1832)

Local Name: Not yet identified

Murichorda fiscellum (Gmelin, 1791)

Distinct characteristics of the sample:
The shell has prominent axial and spiral ridges, deep grooves, and a purple interior. It also has lirate outer lip.



Scale bar: 1 cm

Scale bar: 1 cm

Semiricinula turbinoides (Blainville, 1832)

Distinct characteristics of the sample:
The shell is thick with a nodulose shoulder. The siphonal canal is short with no columellar fold. Outer lip teeth are present and tubercles are prominent.

General diagnostic characteristics of genus/species:
Shell with a low spire, prominent shoulder, and spiral rows marked with conical shaped tubercles (Raven, 2016). The tubercles line up to form axial ribs. Aperture is large with the edge of the aperture varying from purple to yellow or white, while the inside is typically cream. The edge of the outer lip is wavy with interior grooves. The shells of *Semiricinula* are closely similar to *Thais* (FAO, 1998; Vermeij, 2001). Both genera belong to the subfamily Rapaninae.

Nassariidae

Gastropods from the family Nassariidae have ovately rounded shells with a high conical spire and a large body whorl with spiral grooves in the anterior side. They have a small, irregularly rounded aperture and a short, recurved siphonal canal. Inner lip is calloused and may be smooth or slightly ridged but never folded. A corneous operculum is present (FAO, 1998).

Natural Habitat:
Often living in colonies, this group of gastropods is commonly found in temperate to tropical regions. They are scavengers common in intertidal and sublittoral regions and soft bottoms of marine and brackish water environments (FAO, 1998).

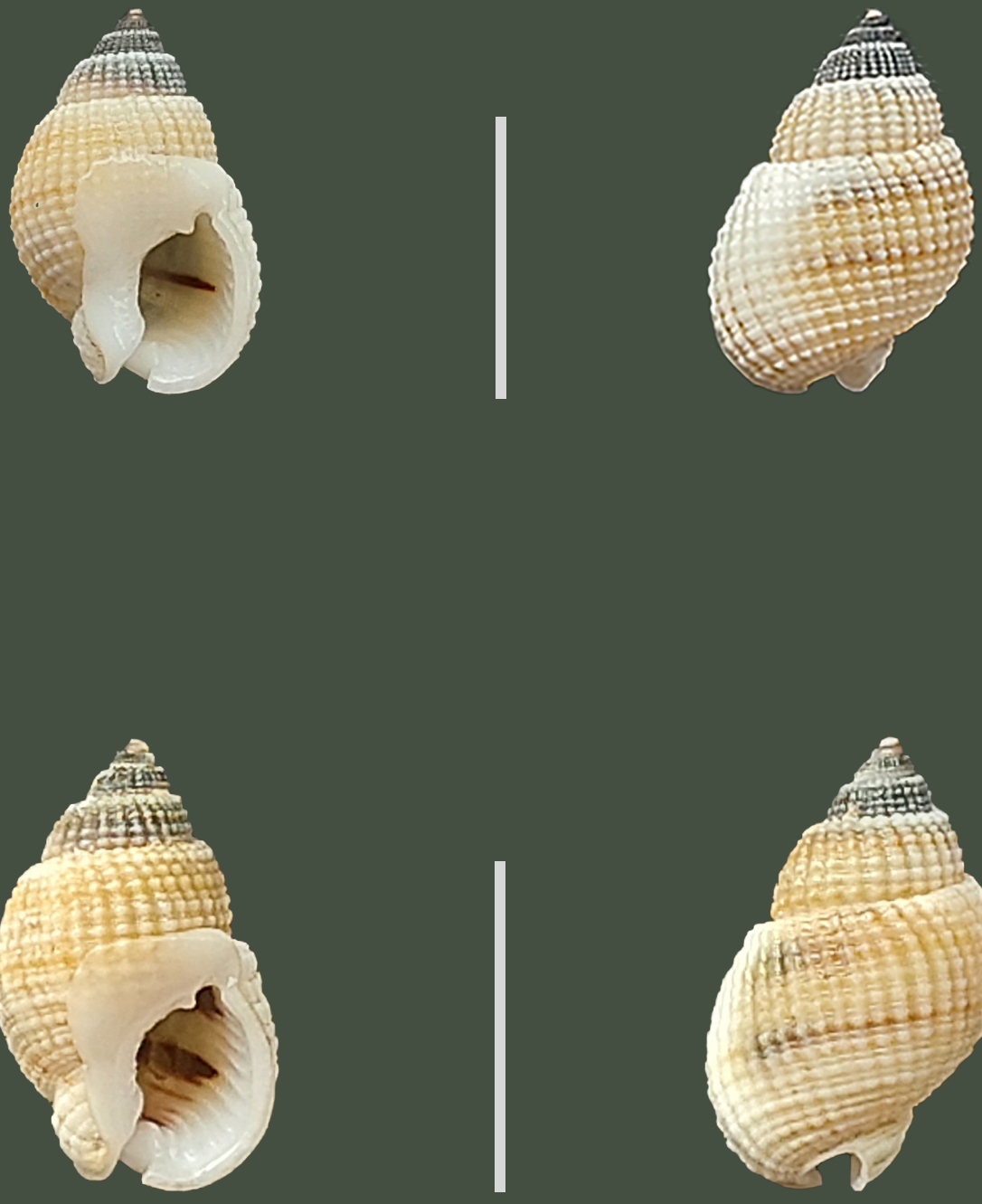
In Jagna Bay, the following intertidal species were found:

- ***Nassarius albescens*** (Dunker, 1846)
- ***Nassarius graphiterus*** (Hombron & Jacquinot, 1848)
- ***Nassarius gruneri*** (Dunker, 1846)
- ***Nassarius limnaeiformis*** (Dunker, 1847)
- ***Nassarius margaritifer*** (Dunker, 1847)
- ***Nassarius*** sp.

Local Name: Not yet identified

Nassarius albescens (Dunker, 1846)

Distinct characteristics of the sample:
The surface of the shell is ornamented with fine beads. It has a short gray spire and light beige body whorl with short grayish brown stripes on the dorsal side. The aperture is round with an expanded, calloused columella (square on top) and toothed inner and outer lip.



Scale bar: 1 cm

Nassarius graphiterus (Hombron & Jacquinot, 1848)

Distinct characteristics of the sample:
The surface of the shell is smooth and has a light to dark brown bands with white axial strips on the body whorl. The aperture is rounded with a toothed inner and outer lip. The insides of the shell is brown.

Scale bar: 1 cm

Scale bar: 1 cm

Nassarius gruneri (Dunker, 1846)

Distinct characteristics of the sample:
The shell is cream in color with dark brown stripes on the dorsal side of the body whorl. On the shell's surface, axial and spiral ribs are defined by coarsely beaded cords. The inner and outer lip is smooth.

Nassarius limnaeiformis (Dunker, 1847)

Distinct characteristics of the sample:
The shell is smooth and polished, colored dark brown with distinct white spots. Brown linear stripes are present in the body whorl towards the margin. The aperture is round with teeth in the inner and outer lip.

Scale bar: 1 cm

Scale bar: 1 cm

Nassarius limnaeiformis (Dunker, 1847)

Distinct characteristics of the sample:
The shell has smooth, polished surface. Its color is light brown with alternating dark brown and white bands. Brown linear stripes are present on the margin of the outer lip. The aperture is round with teeth in the inner and outer lip.

Nassarius limnaeiformis (Dunker, 1847)

Distinct characteristics of the sample:
The surface of the shell is smooth and highly polished. Color ranges from light brown to dark brown with white spots. A series of regularly spaced dark brown spiral lines is marked across the entire length of the shell. The inner and outer lip is smooth.

Scale bar: 1 cm

Scale bar: 1 cm

Nassarius margaritifer (Dunker, 1847)

Distinct characteristics of the sample:
The shell has a banded dark brown and cream color.
Its outer lip and columellar lip are thickened.
Teeth is present in the inner and outer lip.

Nassarius sp.

Distinct characteristics of the sample:
There is a notch on the recurved siphonal canal.
The shell has a deep basal groove.

Scale bar: 1 cm

Taxonomic Ambiguity

Taxonomic discrimination of the *Nassarius* species based on shell morphology alone is often difficult due to the wide variety of shape, color, and sculpturing (Zou et al., 2012). Two individuals of the same species may show varying shell morphology. In the same way, two different species may share similar characteristics. DNA barcoding has resolved the cryptic species diversity of genus *Nassarius* along the China coasts (Zou et al., 2012).

Neritidae

Also known as “Nerites”, this family is characterized by their large, rounded body whorls, low spires, and thick, solid globose shells. The aperture is semicircular without a siphonal canal. They have a toothed outer lip, a calloused inner lip that protrudes as a septum, and a calcified semicircular operculum (FAO, 1998).

Natural Habitat:
Nerites are found in temperate and tropical freshwater, brackish and marine environments, mostly in intertidal zones (FAO, 1998).

In Jagna Bay, the following intertidal species were found:

- ***Nerita albicilla*** (Linnaeus, 1758)
- ***Nerita histrio*** (Linnaeus, 1758)
- ***Nerita undata*** (Linnaeus, 1758)

Local Name: *Sihi*

Operculum:

Scale bar: 1 cm

Nerita albicilla (Linnaeus, 1758)

Distinct characteristics of the sample:
Shell has spiral cords and columellar shield with distinct pustules.

General diagnostic characteristics of genus/species:
The shell is thick and globose with a flat spire. It has a dull outer surface with broad and low, rounded spiral cords. Outer lip has small denticles at the inner margin. It has a wide and flat columellar shield with numerous, distinct pustules over most of its surface and with a few small teeth at the center of its inner margin. Operculum is finely granulose. Outer coloration is very variable and the aperture and columellar shield are whitish (FAO, 1998).

Nerita histrio (Linnaeus, 1758)

Distinct characteristics of the sample:
The shell has spiral cords and axial threads and are mostly white with gray to black bands. Pustules found on the columellar shield are limited (near the teeth).

General diagnostic characteristics of genus/species:
The shell has a very low to flat spire and granular columellar shield. The outer surface has spiral cords and axial threads (FAO, 1998).

Operculum:

Scale bar: 1 cm

Operculum:

Scale bar: 1 cm

Nerita undata (Linnaeus, 1758)

Distinct characteristics of the sample:
The shell has fine, beaded spiral cords or ribs, convex sides of the body whorl, and granular columellar shield.

General diagnostic characteristics of genus/species:
The shell surface is sculptured with numerous fine spiral cords (numbering 30 to 40 on body whorl), and the inner edge of the outer lip is finely toothed apart from one or two strong posterior teeth (FAO, 1998).

JAGNA BAY

Fisherfolk preparing to go to sea.

Pisaniidae

Pisaniidae is a marine mollusc family under the superfamily Buccinoidea. The Pisaniinae family is an unaccepted synonym of Pisaniidae (WoRMS Editorial Board, 2022). Cernohorsky (1972) described Pisaniinae shells which are fusiform to ovate, with surface that varies from smooth to sculptured with cords, threads, and granules. The aperture of the shell is narrow, varying in shape from elliptical to fusiform, with thickened lip, and calloused columella.

One of the several genera under the Pisaniidae family is *Engina*, which has broad shape with a low spire, prominent axial ribs, strong sculpture in the aperture with clear knobs in the outer lip and presence of lirae radially situated on the columellar callus (Fraussen and Vermeij, 2021).

In Jagna Bay, this intertidal species was found:

- ***Engina mendicaria*** (Linnaeus, 1758)

Local Name: Not yet identified

Engina mendicaria (Linnaeus,1758)

Distinct characteristics of the sample:
The shell has black and yellowish-white stripes.

Scale bar: 1 cm

Taxonomic Ambiguity

"Some groups remain taxonomically homeless or have been placed in heterogeneous catch-all genera such as *Engina* (Gray, 1839)" (Fraussen and Vermeij, 2021).

Strombidae

Gastropods belonging to this family are characterized by a thick, solid shell with a large body whorl, an elongated aperture with a well-marked siphonal canal, and a distinct notch situated on the anterior margin of the outer lip. In adult species, the outer lip is thick and expanded out. They also have a corneous, claw-like elliptical operculum (FAO, 1998). In general, members of the family Strombidae have varying shell shapes, making it difficult to classify them down to the genus level based on morphological features alone (Poppe, 2008).

Natural Habitat:
Strombidae is present in shallow waters, sandy, muddy bottoms, or marine grass flats in tropical and subtropical areas. They are active and mostly herbivores feeding on algae (FAO, 1998).

In Jagna Bay, this intertidal species was found:

- ***Canarium labiatum*** (Röding, 1798)

Local Name: *Aninikad*

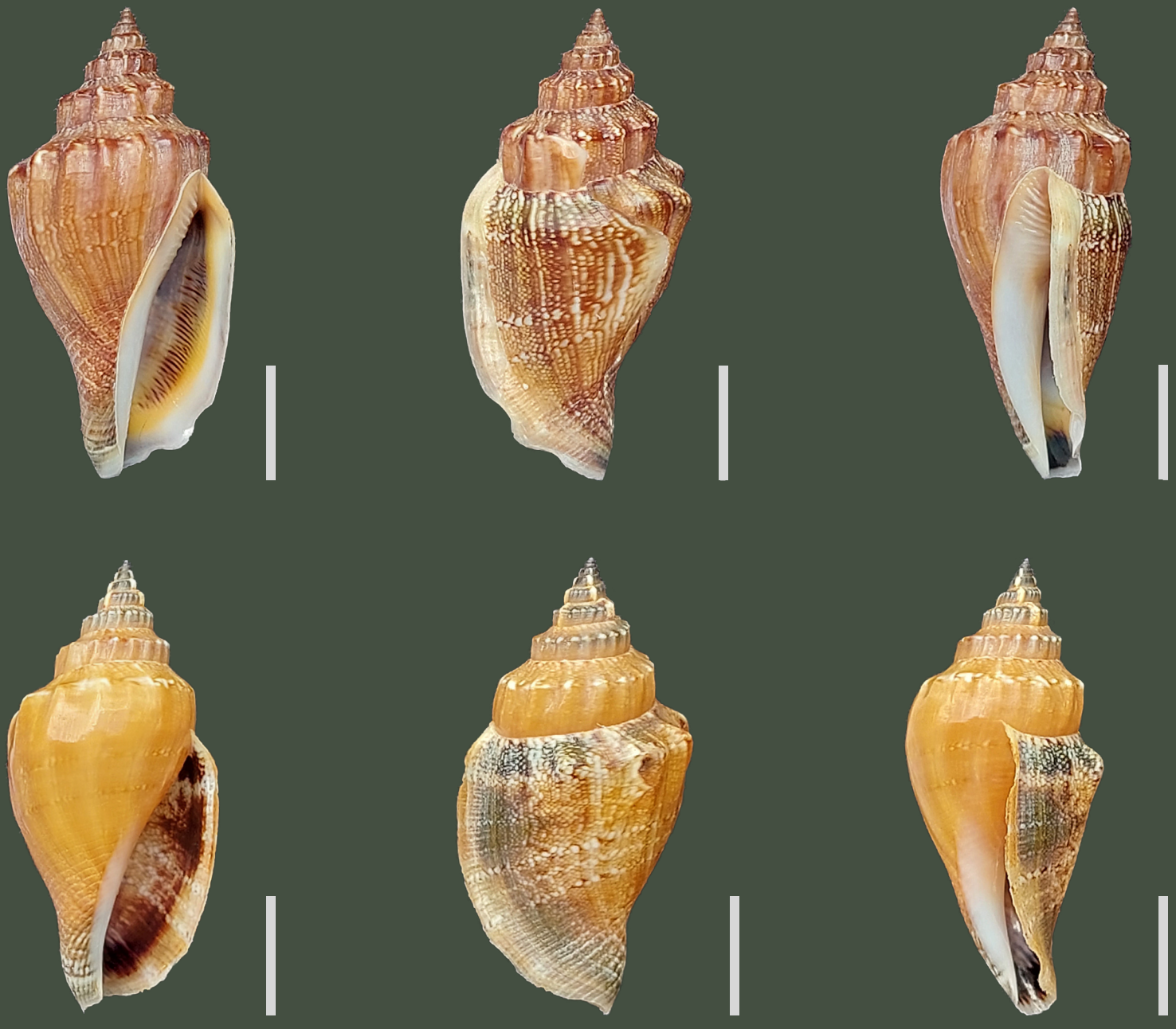
Canarium labiatum (Röding, 1798)

Operculum:

Operculum:

Scale bar: 1 cm

Canarium labiatum (Röding, 1798)



Scale bar: 1 cm

Canarium labiatum (Röding, 1798)

Scale bar: 1 cm

Canarium labiatum (Röding, 1798)

Scale bar: 1 cm

Canarium labiatum (Röding, 1798)

Scale bar: 1 cm

JAGNA BAY

Seagrass bed in Can-upao, Jagna during low tide.

Trochidae

Shells are pyramidal (or trochoid), often with a flattened base. The aperture does not have a siphonal canal and is usually rounded to squarish in shape. They possess a circular corneous operculum (FAO, 1998). Trochoid shells vary from a few millimeters to more than 15 cm for larger species (Poppe, 2008).

Natural Habitat:
Trochidae are grazers living from the intertidal down to several hundred meters deep (Poppe, 2008). In intertidal areas, they can be found in seagrass beds or in rocky substrates usually hiding under rocks or in crevices.

In Jagna Bay, this intertidal species was found:

- ***Tectus fenestratus*** (Gmelin, 1791)

Local Name: *Bulibod*

Tectus fenestratus (Gmelin, 1791)

Distinct characteristics of the sample:
Umbilicus is absent and the base is flat. Shell is thick and strongly structured.
Rounded oblique ribs are present.

General diagnostic characteristics of genus/species:
Thick, oblique ribs are prominent, rounding the outer surface of the body whorl.
The shell is conical in shape, with a flat base and squarish aperture.
Umbilicus is absent (FAO, 1998).

Scale bar: 1 cm

Turbinidae

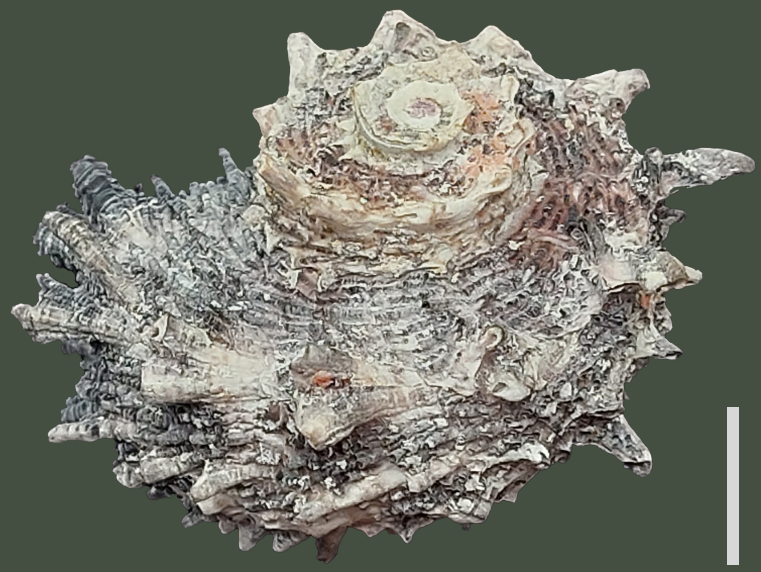
Known as “Turban Shells”, this family has heavy, thick shells that are turbinate to conical in shape. Sculpture in the outer surface varies but is often spiral to nodular. The aperture is rounded and is nacreous on the inside. There is no siphonal canal, and the operculum is strongly calcified (FAO, 1998).

Natural Habitat:
Turbans are commonly found in shallow marine environments of warm temperate and tropical regions, mostly in rocky areas and coral reefs. They are herbivores; they feed on small epibenthic algae and vegetable detritus (FAO, 1998).

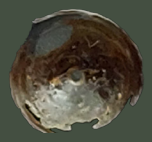
In Jagna Bay, this intertidal species was found:

- ***Angaria delphinus*** (Linnaeus, 1758)

Local Name: *Lumban-lumban*



Operculum:



Scale bar: 1 cm

Angaria delphinus (Linnaeus, 1758)

Distinct characteristics of the sample:
The shell has rounded operculum and is nacreous inside. Its inner lip is smooth and pinkish; umbilicus is present. The spiral spines of the shell have secondary fine spikes in between them.

Jagnaanons gleaning molluscs and sea urchin *(tojum)* at low tide in Jagna Bay.


LITE FERRIES

Bivalves

Bivalves belong to Class Bivalvia, the second largest group in the Phylum Mollusca next to gastropods. They are composed of two (2) calcified valves that are either equal in size and shape (equivalve shells) or not (inequivalve shells).

JAGNA BAY

Fisherfolks in Jagna Bay.

Arcidae

Also known as the "Ark Clams", family Arcidae can be found in varying water depths (Poppe, 2010). Solid shell of this family is equivalve. Umbone is curving towards the anterior on top of a wide cardinal region. Shell has an elongated and almost straight to slightly arched hinge, with many small transverse teeth. The ligaments on the cardinal region are often with V-shaped grooves. It has two (2) adductor muscle scars that are almost equal in size (FAO, 1998).

Natural Habitat:
Ark Clams are sedentary animals, attached to the substrate through their fringe-like byssus and sometimes nestling in rock cracks. They can also be unattached and often more or less buried in soft bottoms (FAO, 1998).

In Jagna Bay, the following intertidal species were found:

- ***Barbatia decussata*** (G. B. Sowerby I, 1833)
- ***Barbatia foliata*** (Forsskål in Niebuhr, 1775)

Local Name: *Kay-kay/ Litub*

Barbatia decussata (G. B. Sowerby I, 1833)

Distinct characteristics of the sample:
The shell has numerous small teeth that can be seen transverse to dorsal margin near the umbo then transitioning to partly transverse to lateral margin. It has white outer surface, fine radial ribs, thin coating at the lateral and ventral margin, and nearly straight dorsal margin.

Scale bar: 1 cm

Scale bar: 1 cm

Barbatia foliata (Forsskål in Niebuhr, 1775)

Distinct characteristics of the sample:
The shell has a white and reddish dark brown outer surface, narrow and slanting ligamentation and hinge teeth.

General diagnostic characteristics of genus/species:
The shell has a white outer surface and a distinct narrow ligament area.

JAGNA BAY

Sunrise view from Can-upao, Jagna Bay.

Chamidae

Bivalves belonging to family Chamidae are commonly referred to as "Jewel Box Shells". Shell is thick and markedly unequal. The lower valve is large and deep, whereas the upper valve is small and flat. Lower valve is partly to completely cemented on reef platforms or rocky substrate. Umbones on both valves are low and recurved. Inside of the shell looks porcelaneous. Both anterior and posterior adductor muscle scars are present. Hinge is thick and has a pair of large teeth and socket, oriented parallel to the dorsal margin (FAO, 1998).

Natural Habitat:
They are sedentary, suspension filter feeders on coral reefs and rocky shores (FAO, 1998).

In Jagna Bay, this intertidal species was found:

- ***Chama limbula*** (Lamarck, 1819)

Local Name: Not yet identified

Shells joined together *(top view)*

Scale bar: 1 cm

Scale bar: 1 cm

Chama limbula (Lamarck, 1819)

Distinct characteristics of the sample:
Thick shell is with unequal valves. Outer shell is somewhat spinose. The smaller, upper valve has two (2) radial rows separated by a furrow, and two short leaf-like extensions on the anterior margin.

General diagnostic characteristics of genus/species:
Outer shell has concentrically stacked thin layers with crenulated margins and sometimes looking like short spines. The smaller, upper valve has two (2) radial rows separated by a furrow.

Isognomonidae

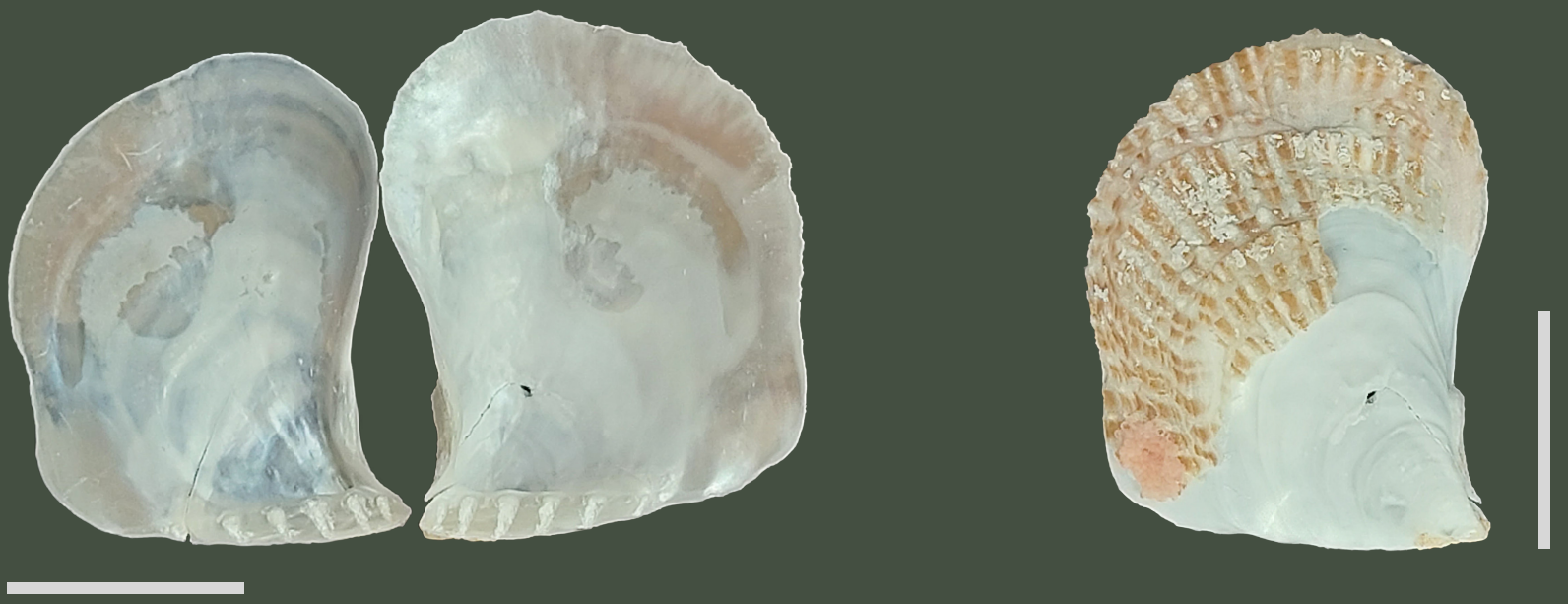
Family Isognomonidae are also known as "Tree Oysters". The shells have a characteristically straight dorsal margin. The ligament also found on the dorsal margin is etched with perpendicular grooves. Internal shell is nacreous with only one large adductor muscle scar (FAO, 1998).

Natural Habitat:
Isognomonidae are sedentary bivalves, commonly attached to various hard substrates and forming dense colonies in tropical shallow waters. They are commonly found from the intertidal to water depths of 20 m (FAO, 1998).

In Jagna Bay, this intertidal species was found:

- ***Isognomon perna*** (Linnaeus, 1767)

Local Name: Not yet identified



Scale bar: 1 cm

Isognomon perna (Linnaeus, 1767)

Distinct characteristics of the sample:
Rounded shell with short, straight dorsal margin. Perpendicular grooves etched on the ligament. Radial ribs are present. Internal shell is nacreous with only one adductor muscle scar.

General diagnostic characteristics of genus/species:
Shells have a generally rounded outline except for the short, straight dorsal margin. Radial ribs are present (FAO, 1998).

Mytilidae

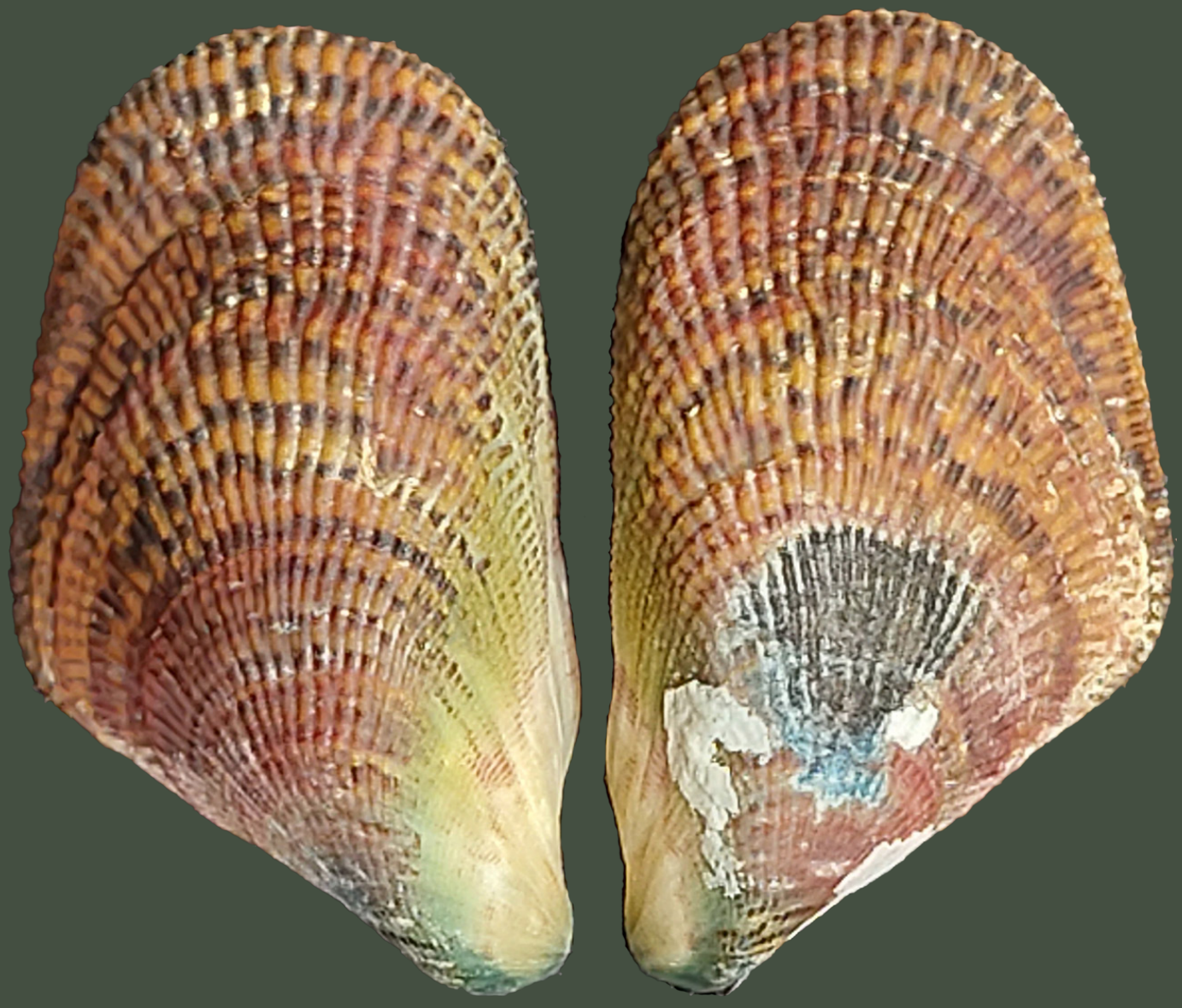
Mytilids are famously known as the Sea Mussels that cover shallow water areas and intertidal rocks (Poppe, 2010). Most of the species of family Mytilidae are collected largely for food. The shell is equivalve, generally with a narrow byssal gape at the ventral margin. It has an inequilateral shape that ranges from elongate-ovate to partially trigonal. Umbones are situated at or near the anterior end of the shell. It has a prominent periostracum that varies in sculpture. External ligaments are often embedded along the posterior dorsal margin. Hinge teeth are reduced or absent. It has very unequal adductor muscle scars, the anterior scar is small, sometimes absent in the adult while the posterior scar is large. An expansive nacreous layer is substantially present at the inner side of the shell (FAO, 1998).

Natural Habitat:
Sea Mussels primarily attach to hard substrates by their well-developed byssus. They occasionally thrive as nestlers, coral and rock borers, or they sometimes associate with the filter feeders ascidians.

In Jagna Bay, this intertidal species was found:

- ***Septifer bilocularis*** (Linnaeus, 1758)

Local Name: Not yet identified



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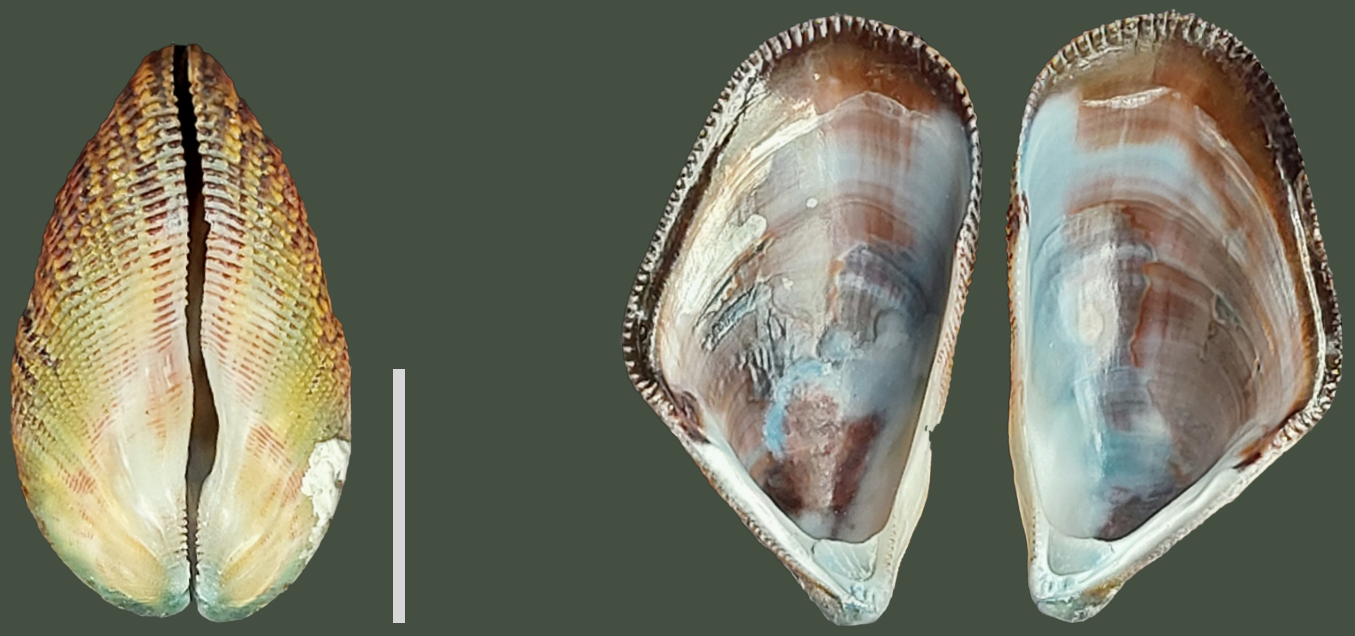


Scale bar: 1 cm

Septifer bilocularis (Linnaeus, 1758)

Distinct characteristics of the sample:
Shell has very unequal anterior and posterior adductor muscle scars and umbones near the anterior end. Anterior adductor scar is above the umbonal cavity; radial riblets are present.

General diagnostic characteristics of genus/species:
Shell is more or less triangular in outline. Outer surface has dense radial riblets, marginally diverging on the posterior dorsal region. A shelly overhang above the umbonal cavity is present where the anterior adductor scar is positioned (FAO, 1998).

Spondylidae

This family is also known as "Thorny Oysters" or "Spiny Oysters" (Poppe, 2011) because of the spines extending along the radial ribs on the surface of the shells. The hinge line is straight and has two strong teeth and two deep sockets (FAO, 1998). Internal shell characteristics such as the size and color of the hinge teeth in the left valve (upper valve) and the marginal color band around the circumference of the inner margin of the shell are useful in distinguishing different species (Lodeiros et al., 2016). In some species, the amount of shell attachment of the right valve (lower valve) to the substrate can be a good diagnostic feature (Lodeiros et al., 2016). The right valve may be attached extensively, only on a small area, or not attached at all.

Natural Habitat:
Spondylidae are suspension filter-feeders living in relatively shallow waters in coralline areas. The right valve is strongly cemented to hard coral substrates.

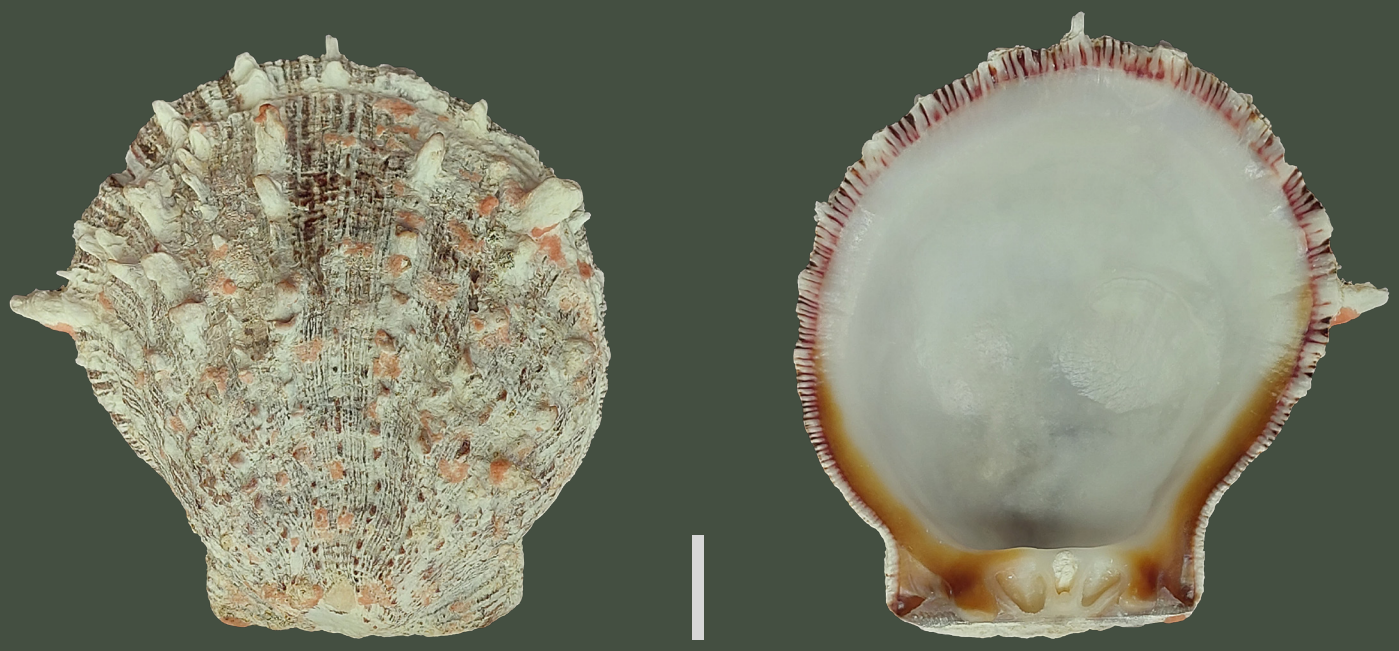
In Jagna Bay, this intertidal species was found:

- ***Spondylus asiaticus*** (Chenu, 1844)
- ***Spondylus variegatus*** (Schreibers, 1793)

Local Name: Not yet identified

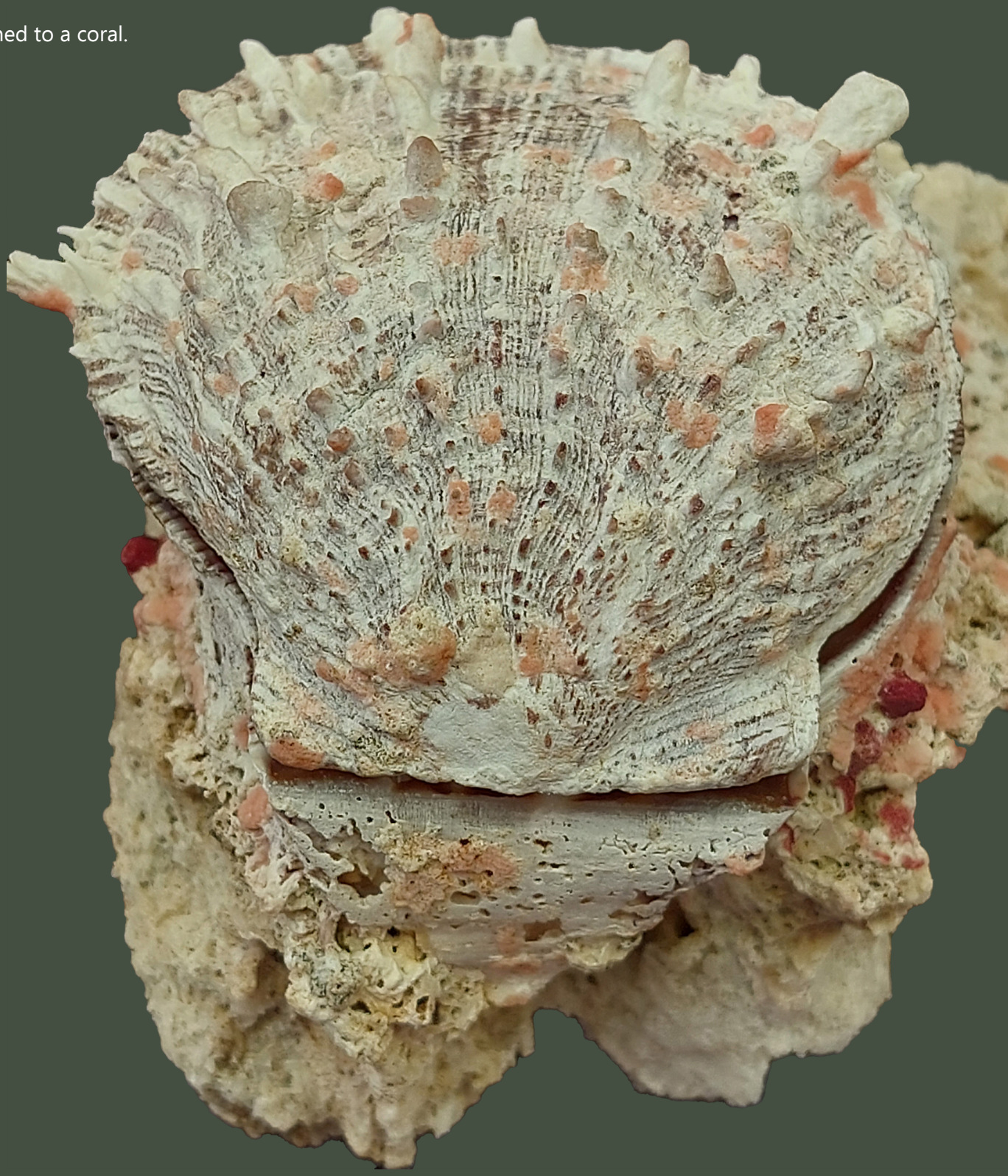
Spondylus asiaticus (Chenu, 1844)

Distinct characteristics of the sample:
Shell is ovate and inequivalve. Right valve is partly attached to a hard coralline substrate.



Scale bar: 1 cm

Spondylus asiaticus attached to a coral.



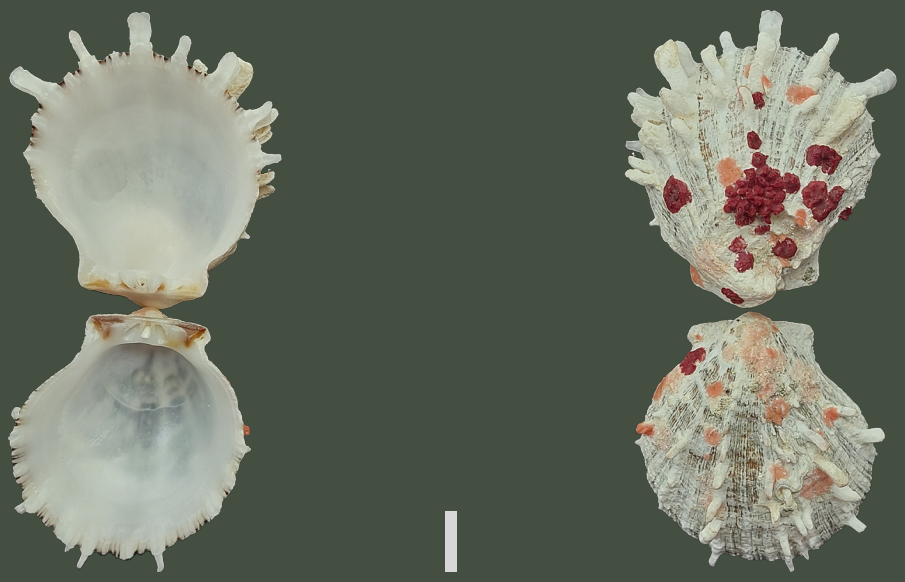
Scale bar: 1 cm

Scale bar: 1 cm

Spondylus asiaticus (Chenu, 1844)

Distinct characteristics of the sample:
Shell is ovate and inequivalve. Right valve is partly attached to a hard coralline substrate.

Scale bar: 1 cm



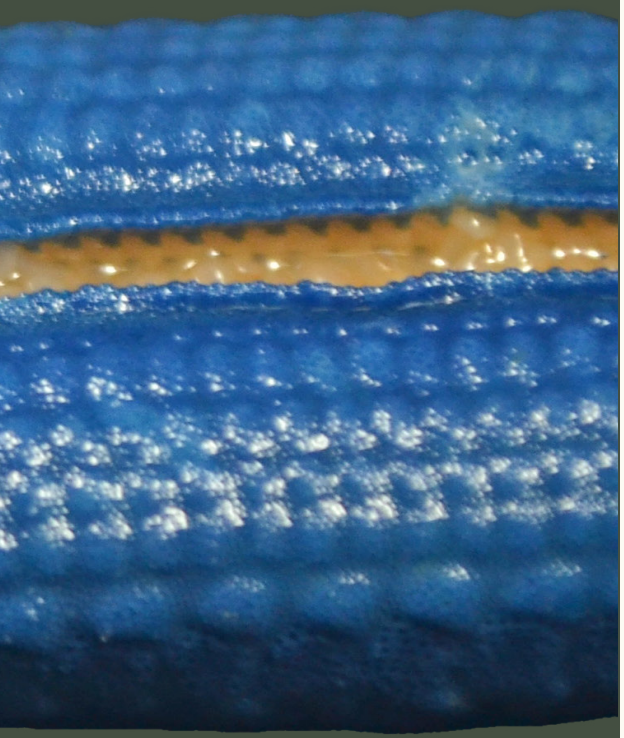
Scale bar: 1 cm

Spondylus variegatus (Schreibers, 1793)

Distinct characteristics of the sample:
Shell is ovate and inequivalve. Right valve is partly or fully attached to a hard coralline substrate. Main radial ribs are armed with short, angular spines. Spineless smaller ribs separate each of the main radial ribs. Outer shell color is reddish brown with white spines. Hinge is straight with two large, brown teeth. The shell interior is white and porcelaneous with alternating reddish brown and white crenulated margin; the margin of the hinge is brown.

Jagnaanons gleaning molluscs and sea urchin *(tojum)* at low tide in Pangdan, Jagna Bay.

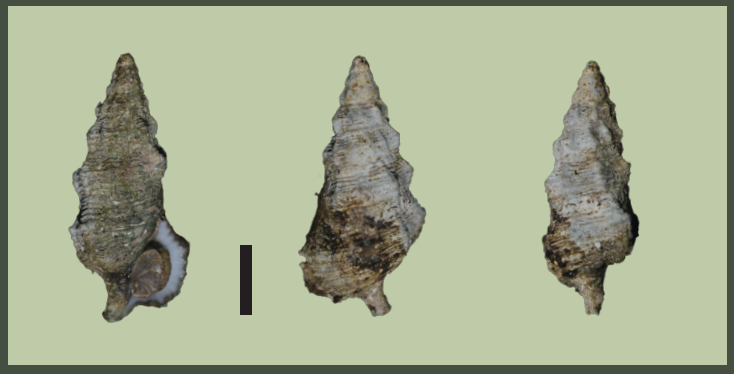
Afrocardium richardi attached to a sea star.



2016

Mollusc Collection

Cerithiidae



Cerithium citrinum (G. B. Sowerby, 1855)

Clypeomorus moniliferus (Kiener, 1841)

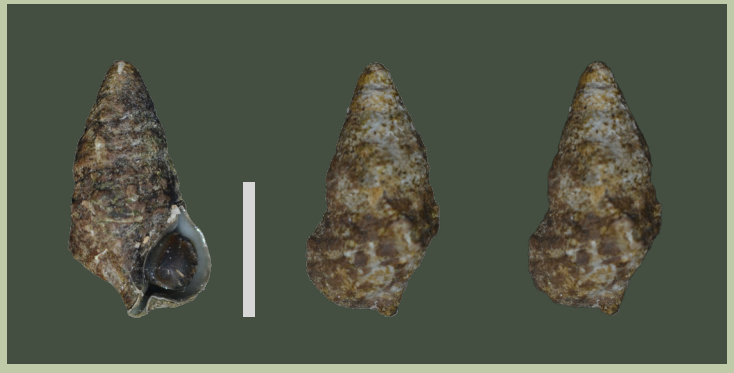
Clypeomorus moniliferus (Kiener, 1841)

Clypeomorus moniliferus (Kiener, 1841)

Scale bar: 1 mm

Cerithiidae

Clypeomorus petrosus (Wood, 1828)

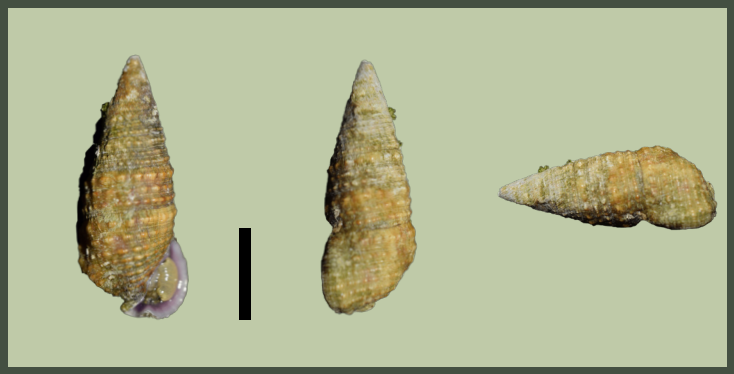


Clypeomorus petrosus (Wood, 1828)

Clypeomorus tuberculatus (Linne, 1758)

Scale bar: 1 mm

Cerithiidae



Clypeomorus tuberculatus (Linne, 1758)

Clypeomorus tuberculatus (Linne, 1758)

Clypeomorus tuberculatus (Linne, 1758)

Clypeomorus tuberculatus (Linne, 1758)

Scale bar: 1 mm

Cerithiidae

Clypeomorus tuberculatus (Linne, 1758)

Clypeomorus tuberculatus (Linne, 1758)

Clypeomorus tuberculatus (Linne, 1758)

Scale bar: 1 mm

Columbellidae

Pictocolumbella ocellata (Link, 1807)

Pictocolumbella ocellata (Link, 1807)

Scale bar: 1 mm

Costellariidae

Vexillum infaustum (Reeve, 1845)

Scale bar: 1 mm

Cypraeidae

Monetaria moneta (Linnaeus, 1758)

Scale bar: 1 mm

Marginellidae

Volvarina hirasei (Bavay, 1917)

Scale bar: 1 mm

Muricidae

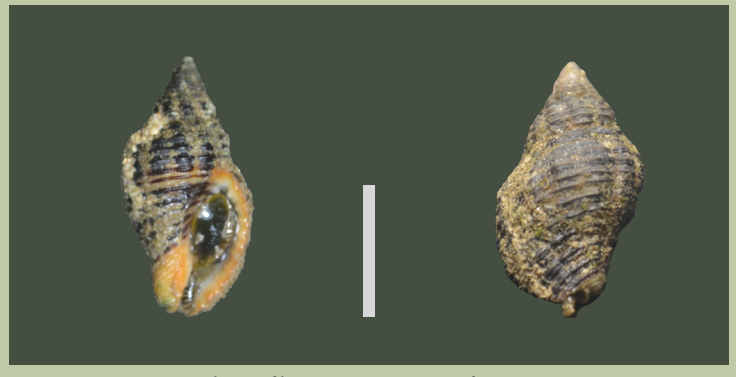
Haustellum haustellum (Linnaeus, 1758)

Scale bar: 1 mm

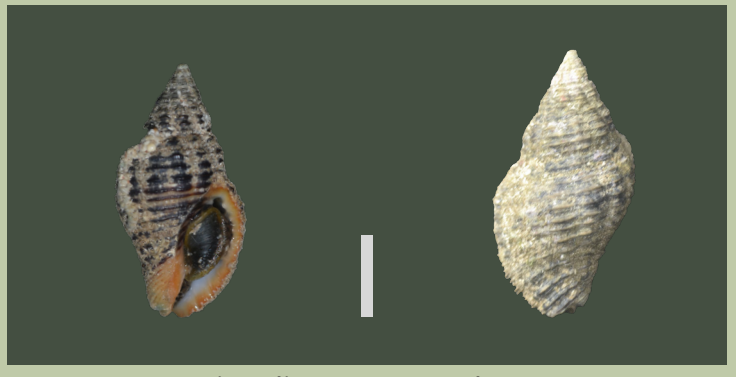
Nassariidae

Nassarius distortus (A. Adams, 1852)

Nassarius distortus (A. Adams, 1852)



Nassarius distortus (A. Adams, 1852)



Nassarius distortus (A. Adams, 1852)

Scale bar: 1 mm

Pisaniidae

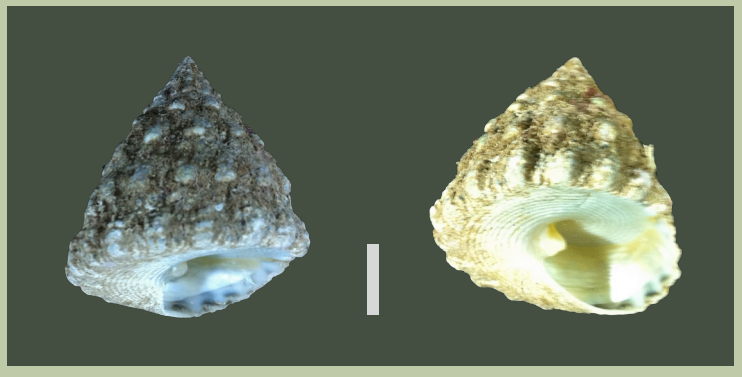
Engina mendicaria (Linne, 1758)

Engina mendicaria (Linne, 1758)

Engina mendicaria (Linne, 1758)

Scale bar: 1 mm

Trochidae

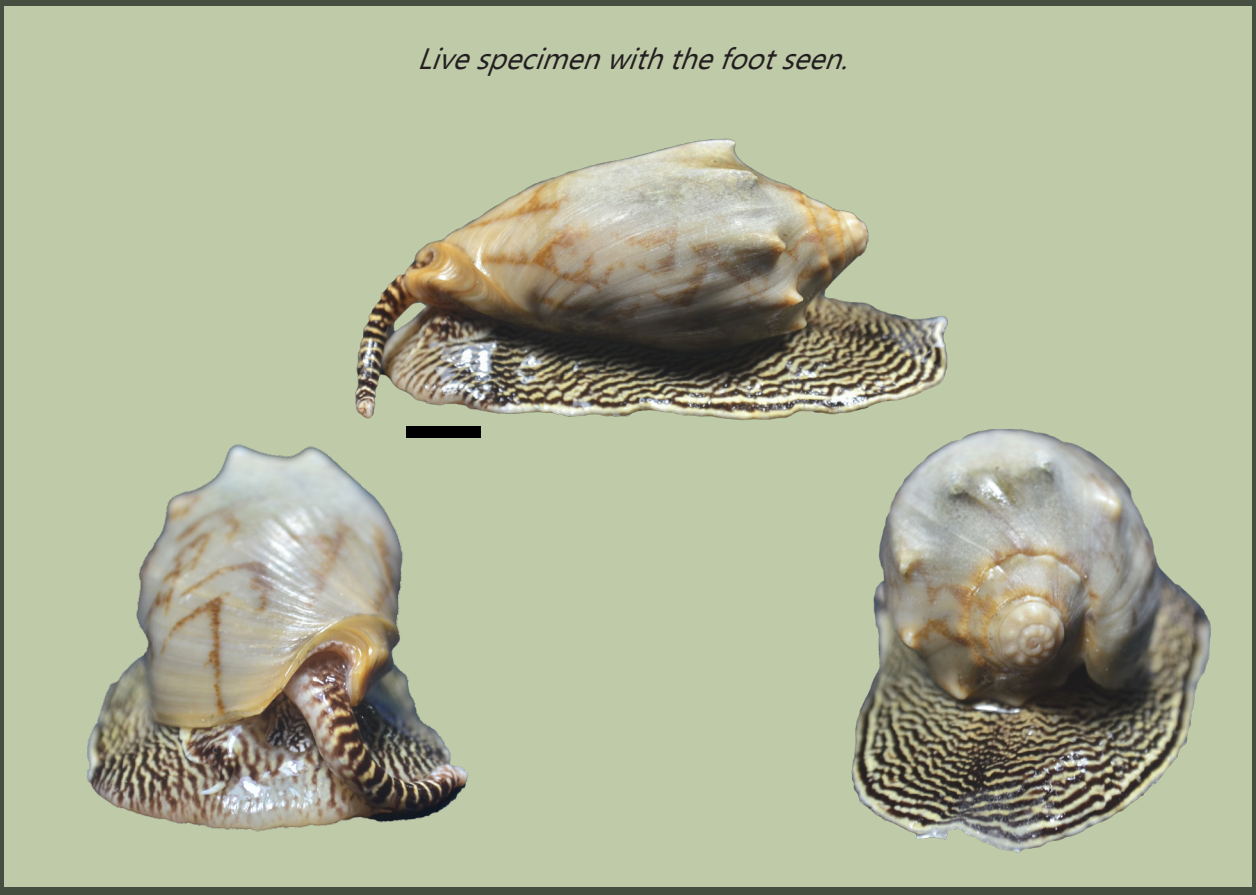


Trochus maculatus (Linnaeus, 1758)

Trochus niloticus (Linnaeus, 1758)

Scale bar: 1 mm

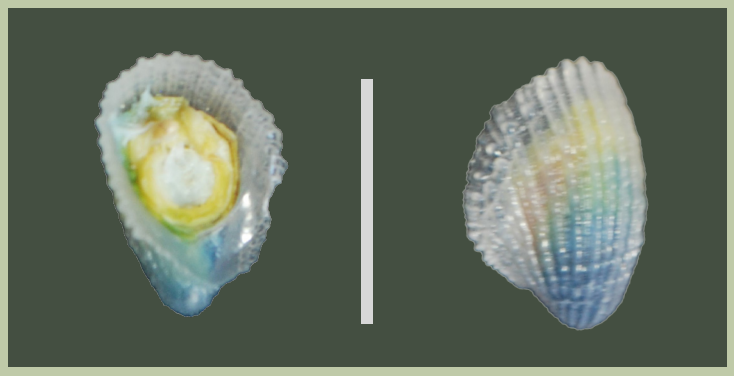
Volutidae



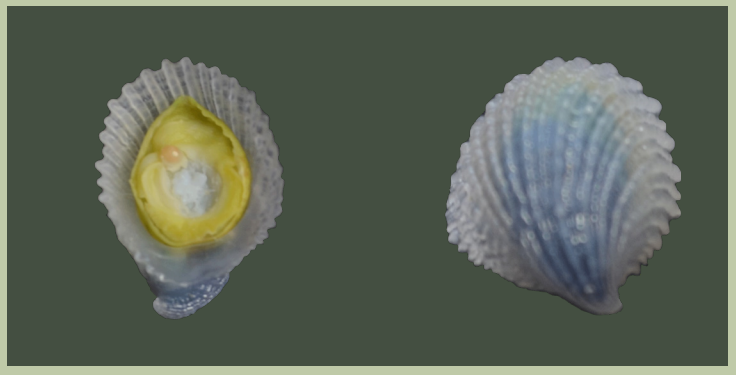
Cymbiola vespertilio (Linnaeus, 1758)

Scale bar: 1 mm

Cardiidae



Afrocardium richardi (Audouin, 1826)



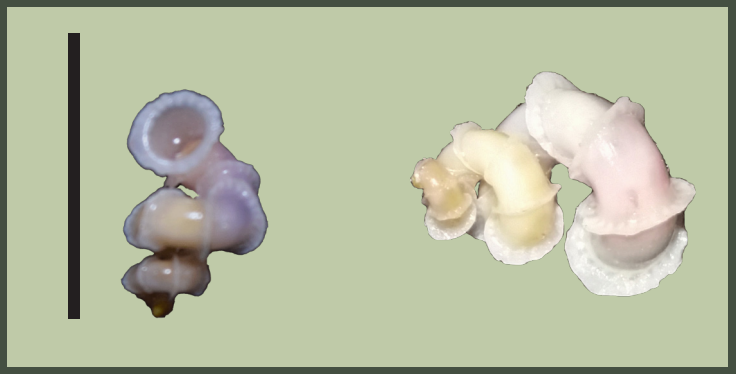
Afrocardium richardi (Audouin, 1826)

Scale bar: 1 mm

2016 Lumun-Lumun Net Collection

The first documented sighting of *Cycloscala* off the southern part of Bohol Island, retrieved using lumun-lumun net in March 2016 (Bernido et al., 2017).

Epitoniidae



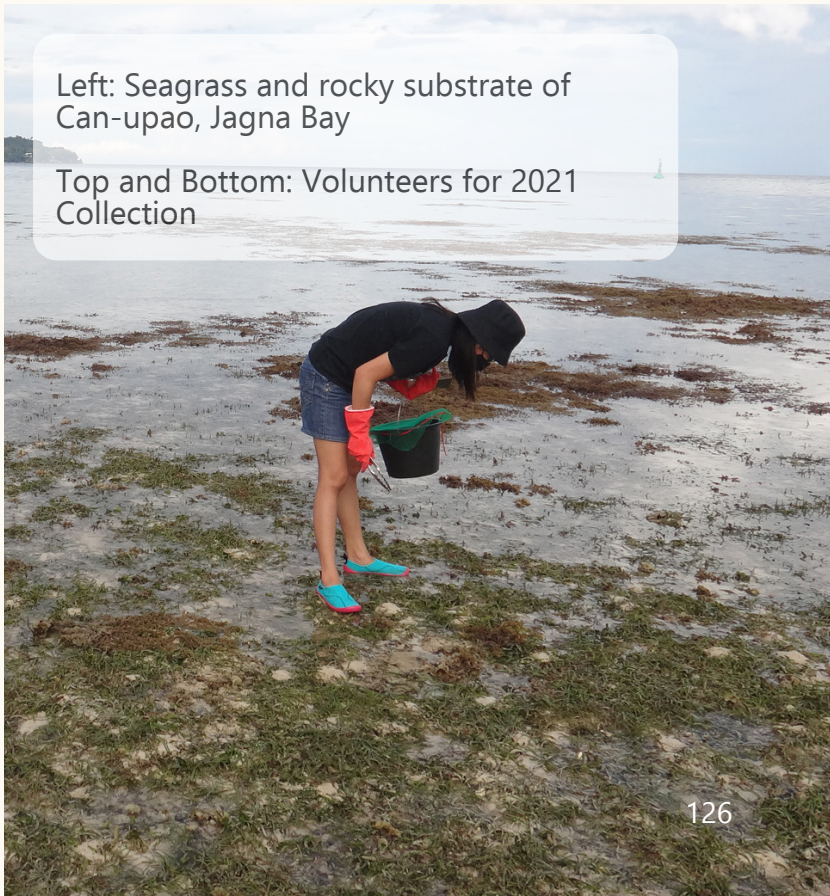
Cycloscala revoluta (Hedley, 1899)
Cycloscala cvifensis (Bernido et al., 2017)

Scale bar: 1 mm

Gallery

Volunteers for the 2021 mollusc collection.

Left & Top: Volunteers handpicking live molluscs.
Bottom: *Vexillum plicarium* grazing on seagrass.



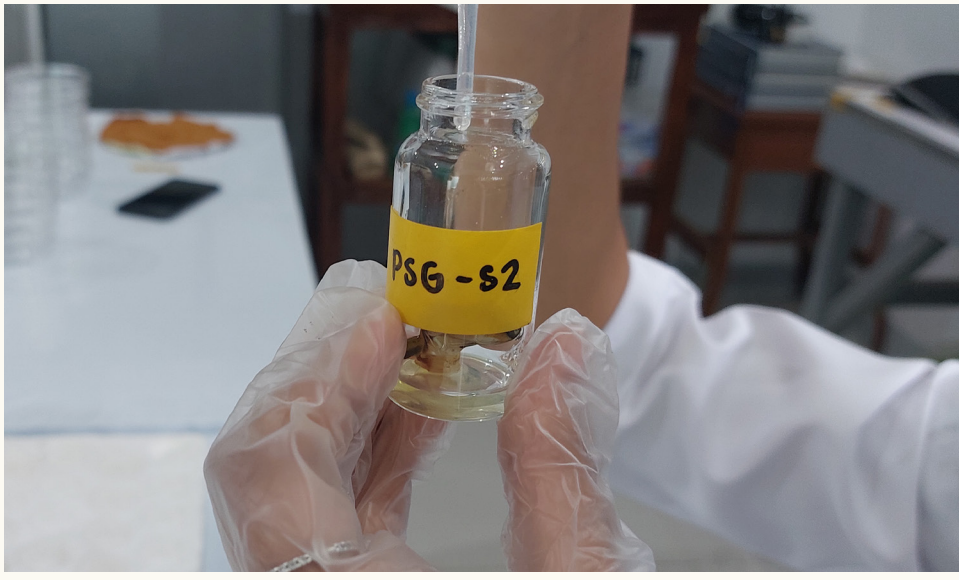
Left: Seagrass and rocky substrate of Can-upao, Jagna Bay

Top and Bottom: Volunteers for 2021 Collection

Transect layout for sampling.

Volunteers and Researchers for the 2021 mollusc collection.
Standing (left to right): Christiane Joy Gulles, Gio Bernaldez, Jazzy Jeff Montañez, Lester Everson Bolaer, Justin Ericson Mangyao, Lovella Joy Abcede, Rey Aceron, Floramil Claire Udtuhan, Sherry Rose Indino
Sitting (left to right): Mary Dored Ann Cadeliña, Janneli Lea Soria, Kimverly Ranoco, Jodivine Navarosa, Dale Niño Lagare, Edna Aceron, Queenie Joy Abcede

Processing of mollusc samples in the laboratory.



Mollusc shells cleaned for archive.

Examination of mollusc morphology and anatomy.

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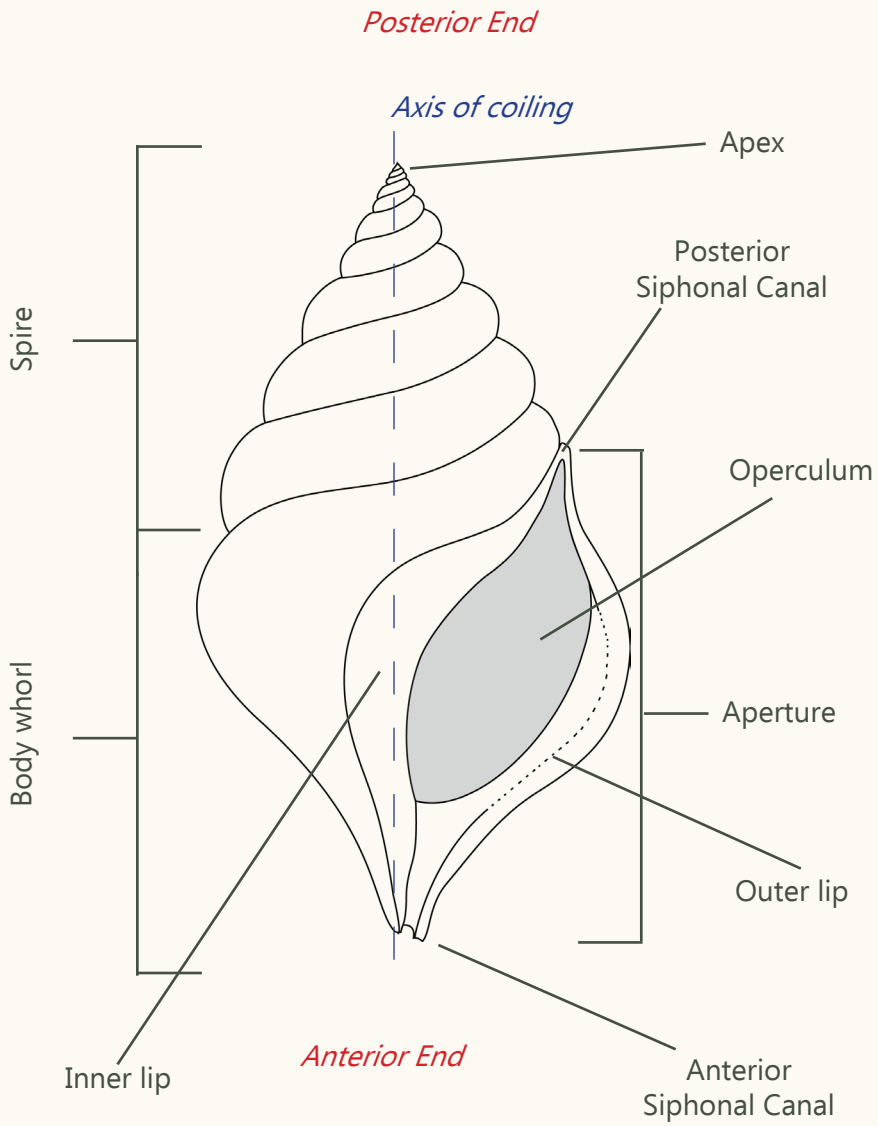
Mollusc Morphology

Gastropods



Anterior Siphonal Canal - tubular extension of the aperture at the anterior end.

Aperture - the opening of the shell.

Apex - the tip or summit of the shell.

Body whorl - last and largest spiral turn.

Inner lip - the margin of the aperture closer to the axis of coiling.

Operculum - covering or seal of the the shell's opening that is attached to the foot of the animal.

Outer lip - the margin of the aperture opposite to the inner lip.

Posterior Siphonal Canal - tubular extension of the aperture at the posterior end.

Spire - all the whorls of the shell not including the body whorl.

Reference: FAO (1998)

Mollusc Morphology

Bivalves

Adductor Scar - imprints of the adductor muscle.

Cardinal tooth - the hinge teeth close to the umbo.

Lateral tooth - the hinge teeth set apart from the cardinal teeth.

Ligament - elastic structure connecting the hinge.

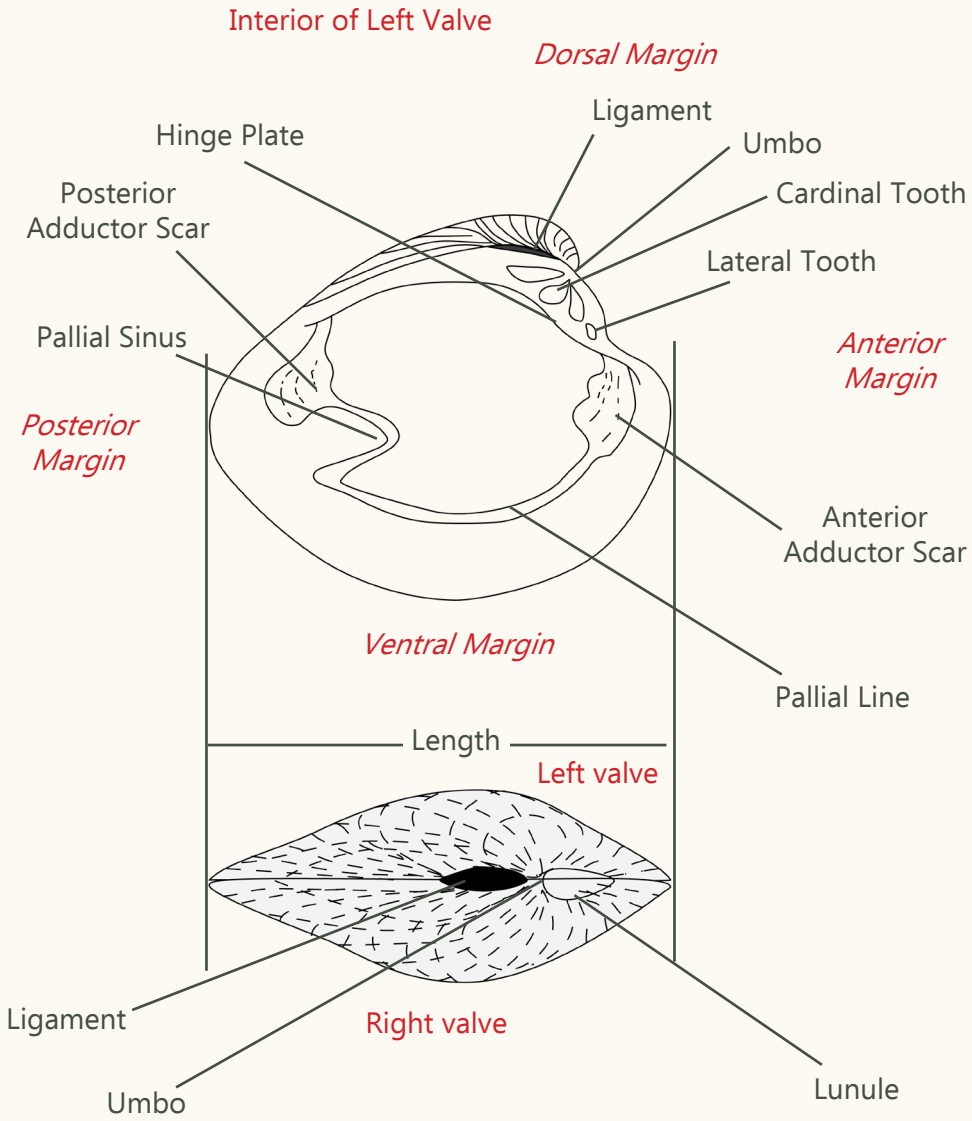
Hinge plate - contains the hinge teeth and sockets that join the valves together.

Pallial line - marks where the animal's mantle is attached.

Pallial sinus - indentation of the pallial line in the posterior end. It is the mark of the site of attachment of the muscles that allow retraction of siphons within the shell.

Umbo - the part of the valve that is formed first.

Reference: FAO (1998)



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To God be the glory.

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