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Benthic

Algal and Seagrass Communities from Santo Island in Relation to Habitat Diversity

Claude E. Payri

The coral reef communities of Vanuatu have been little studied and nothing has been previously published on the benthic algal flora from Espiritu Santo Island. Some marine algae from Vanuatu have been found in the British Museum collections (BM) and are mainly *Sargassum* species and *Turbinaria ornata*. In their report on Vanuatu's marine resources, Done and Navin (1990) mentioned *Halimeda opuntia* as occurring in most of the sites investigated and noted the high encrustation of coralline algae in exposed sites. More work has been done on seagrass communities; earlier authors reported a total of nine species from Vanuatu including five species from Santo, i.e. *Cymodocea rotundata*, *Halodule uninervis*, *H. pinifolia*, *Halophila ovalis* and *Thalassia hemprechii*.

The present algal flora and seagrass investigation of Santo was conducted during August 2006 as part of the "Santo 2006 expedition". This work is a companion study to that of the Solomons and Fiji and is intended to provide data for ongoing biogeographic work within the West and Central Pacific.

Extensive surveys have been carried out in most of the habitats recognized in the southern part of Santo Island and in the Luganville area, including islands, shorelines, reef flats, channels and deep outer reef slopes.

SAMPLING SITES AND METHODS

The 42 sites investigated are shown in figure 409 and are distributed from Palikolo in the northernmost part of the study area, down to Urepala islet located in the southern part including the Segond Channel, the Malo passage and Abokisa Island on the east coast of Aore Island. Sites were selected to include the largest possible range of environments.

Most of the sites were surveyed by SCUBA divers from the surface down to 60 m deep. The shallow areas, including fringing reef flats, reef channels and rocky shorelines, were sampled by snorkelling and walking on the reef. The sampling effort was standardized and inventory duration at each site was fixed to 80 minutes. A species inventory was compiled in order to create a more comprehensive species list for the southern part of Santo. Specimens were sampled to make a taxonomical collection for the area.

All the collected specimens were pressed and dried for herbaria; fragments of specimens were preserved in a solution of buffered formalin in seawater (5%) for further anatomical studies. Tissues from various taxa were also preserved for further phylogeny and molecular analysis and all the herbarium specimens were air dried (without formalin) which allows for extra DNA analysis if necessary. The collection is currently housed in the phycological herbarium at IRD Nouméa (IRD-NOU) and will be transferred to the *Muséum national d'Histoire naturelle* in Paris (PC). Part of the collection will be deposited at USP in Suva, Fiji.

MARINE MACROPHYTES IN SANTO: GENERAL INSIGHTS

Macrophyte communities on coral reefs are generally distributed in assemblages that more or less reflect reef zonation. The distribution of the marine flora on a coral reef is influenced by various factors including sunlight, salinity, water turbulence and currents, the nature of the substratum, depth, exposure to air, geomorphology, topography, herbivore pressure and biological competition with other benthic organisms.

In addition, Vanuatu's reefs have a complex tectonic history, having experienced several emergence and subsidence events. These have resulted in some features that are typical of many reefs with rocky shorelines, and recent tectonic displacements and uplifts may have affected some of their benthic assemblages. However, we did not observed a recent influence of tectonic displacement on benthic communities in the study areas and the most significant disturbances we

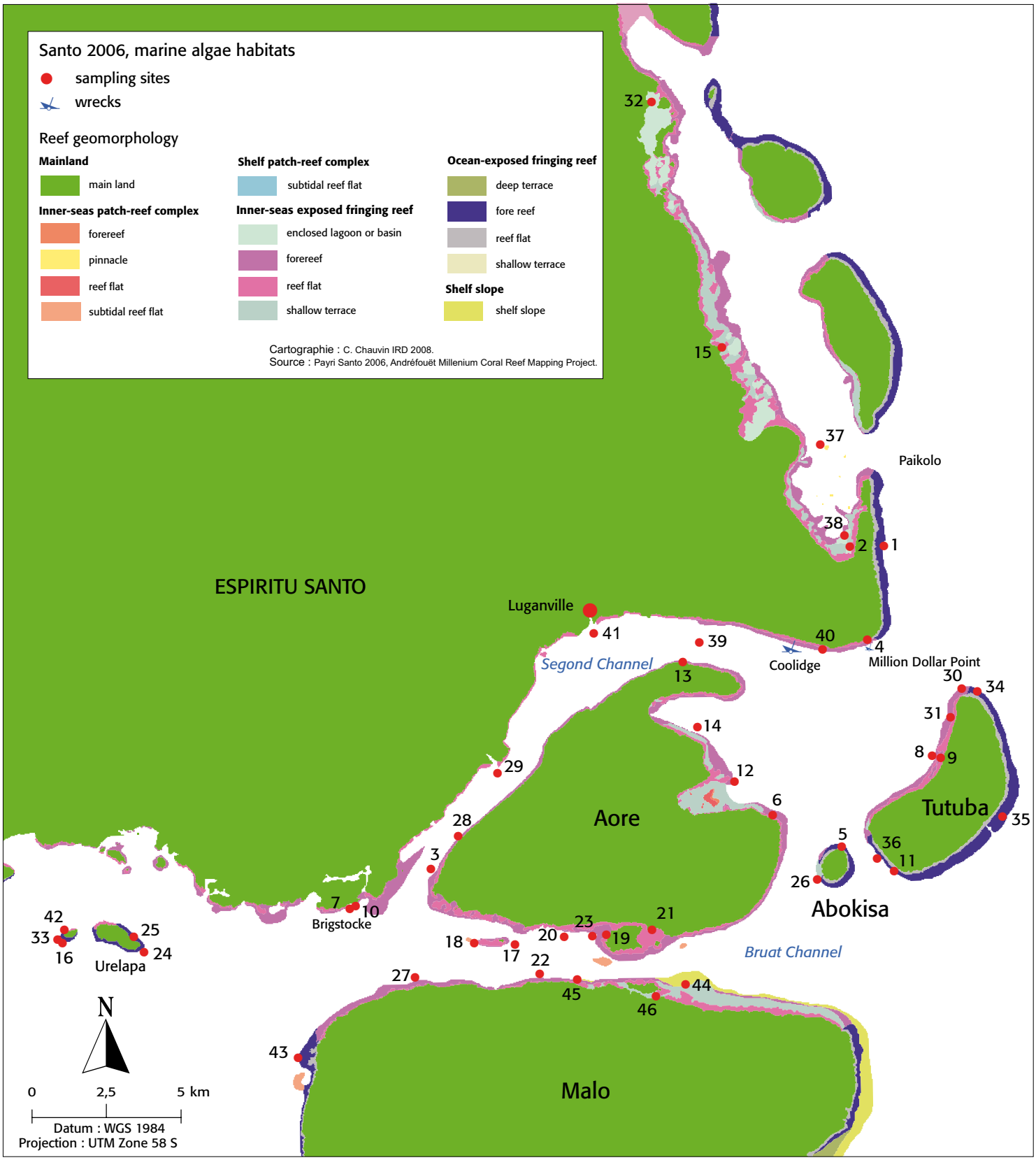

Figure 409: Map of sampling sites in the Luganville area, southern part of Santo Island.

observed were the result of recent cyclone activity and bleaching events over the past few years.

However, environmental factors are not homogeneous across the reefs, and gradually change from the shoreline to outer reef slopes through lagoons and reef flats. The rather patchy zonation patterns are generally distributed parallel to the shorelines and reef margins.

This synthesis comprises an overview of the representative biotopes investigated and describes the different macrophyte (algae and seagrasses) communities associated with the different identified habitats.

REPRESENTATIVE BIOTOPES

The main features of the Santo coral reef complex are the absence of a barrier reef and associated habitats. Most of the structures comprise narrow fringing reefs, outer reefs, patch reefs in shallow water, sheltered and open embayments, deep channels and shallow passes, exposed outer reef slopes and reef walls or drop-offs.

Most of the sites have reef habitats compressed into narrow coastal margins and exposed to ocean influences. On unsheltered coasts the coral reefs are wave-beaten structures that are heavily encrusted by coralline algae as well as by coral species that are well-adapted to strong turbulence.

The great ocean depths, large fetches and the refraction of swells around the small islands adjacent to Santo mean that the open coasts on all sides are subject to strong wave forces, and this limits the types of reefs that can establish. Less robust forms of corals and other benthic communities are however able to develop in more sheltered embayments. The islands around the Segond Channel provide significant shelter from the open ocean, and the channel accumulates siltation originating from the terrestrial erosion of the adjacent island of Santo; the channel supports a range of habitats with conditions ranging from intermediate to abundant shelter, and muddy substrata.

The 42 sites surveyed have been classified into 12 major habitat groups which include geomorphology, topography and major benthic communities. Schematic diagrams (profiles) are given in figures 411-422, the list of the symbols used in the profiles are given figure 410. Descriptions of the profiles are as follows.

Segond Channel (Fig. 411)

This long channel runs between Santo and Aore Island. Around the Luganville area and down to the south there are few reef formations and coral communities and these are mainly developed on sandy slopes and rubble. Narrow reef flats are present, mostly at both entrances to the Channel and along the Aore Island coast. Coral communities are mostly Acroporidae and occasional massive *Porites*. There is also evidence of damaged coral in the high proportion of coral rubble. Large beds of the green macrophyte *Halimeda opuntia* intermixed with sponges colonise the hard substratum. In the northern area, the middle part of the channel is deep (70 m depth) and muddy, marked with ghost shrimp (Calianasseae) hummocks and small benthic communities including some Nephtheidea, *Dophleina* and *Asthenosoma* urchins. The benthic communities of the channel environment are dominated by sponges and octocorallians (soft corals and sea fans). On the shallow muddy flats adjacent to the shore of Santo island seagrasses such as *Halodule* and *Cymodocea* form sparse patches.

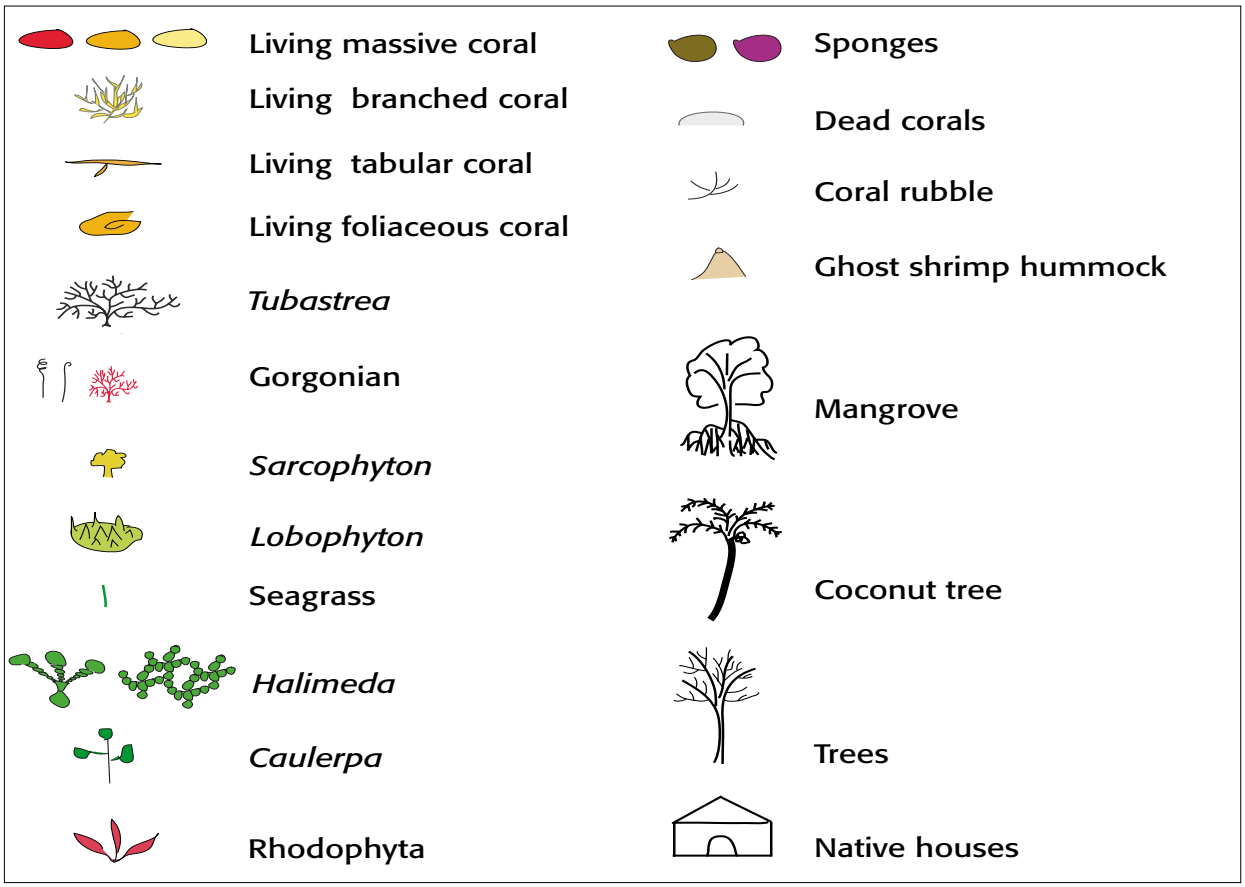

Figure 410: List of symbols used for figures 411-422.

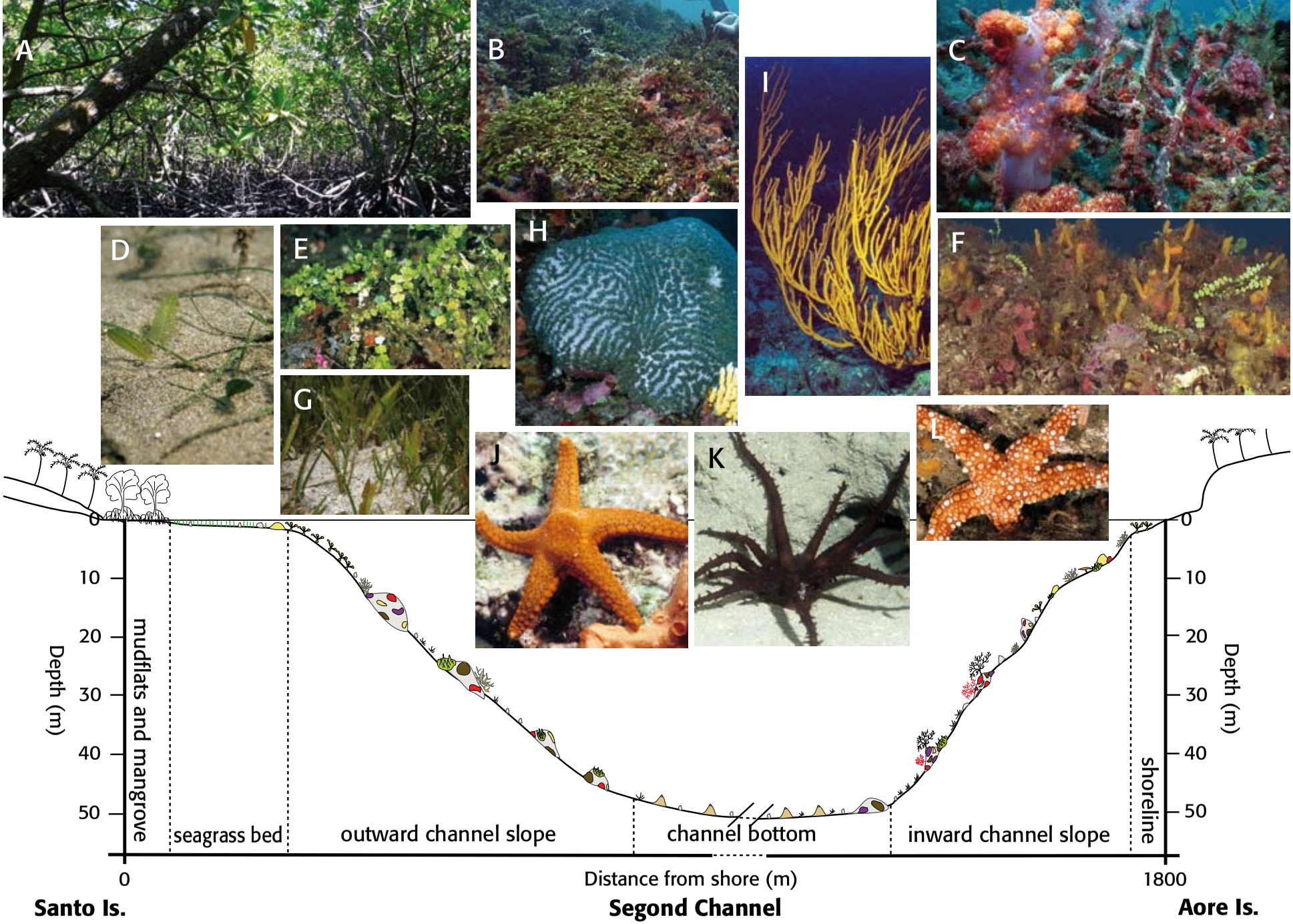

Figure 411: Schematic diagram of the topography and reef communities of the Segond Channel.
A: Mangrove trees on the shoreline. **B**: Typical gentle slope with dense *Halimeda* bed. **C**: Typical mixed community on channel slope dominated by Neiphteidae. **D**: Diffuse seagrass bed of *Halodule pinifolia* and *Halophila ovalis*. **E**: *Halimeda minima* forming thick mats with sponges and other organisms on the channel slope. **F**: Typical community of invertebrates and algae on the deep channel edge. **G**: Mixed seagrass bed of *Halodule uninervis* and *Cymodocea serrulata*. **H**: *Physogyra*. **I**: Gorgonian *Juncella*. **J**: *Fromia milleprorella*. **K**: *Dophleina*. **L**: *Gomophia watsoni*. (Photos J.-L. Menou & J.-M. Boré IRD Nouméa).

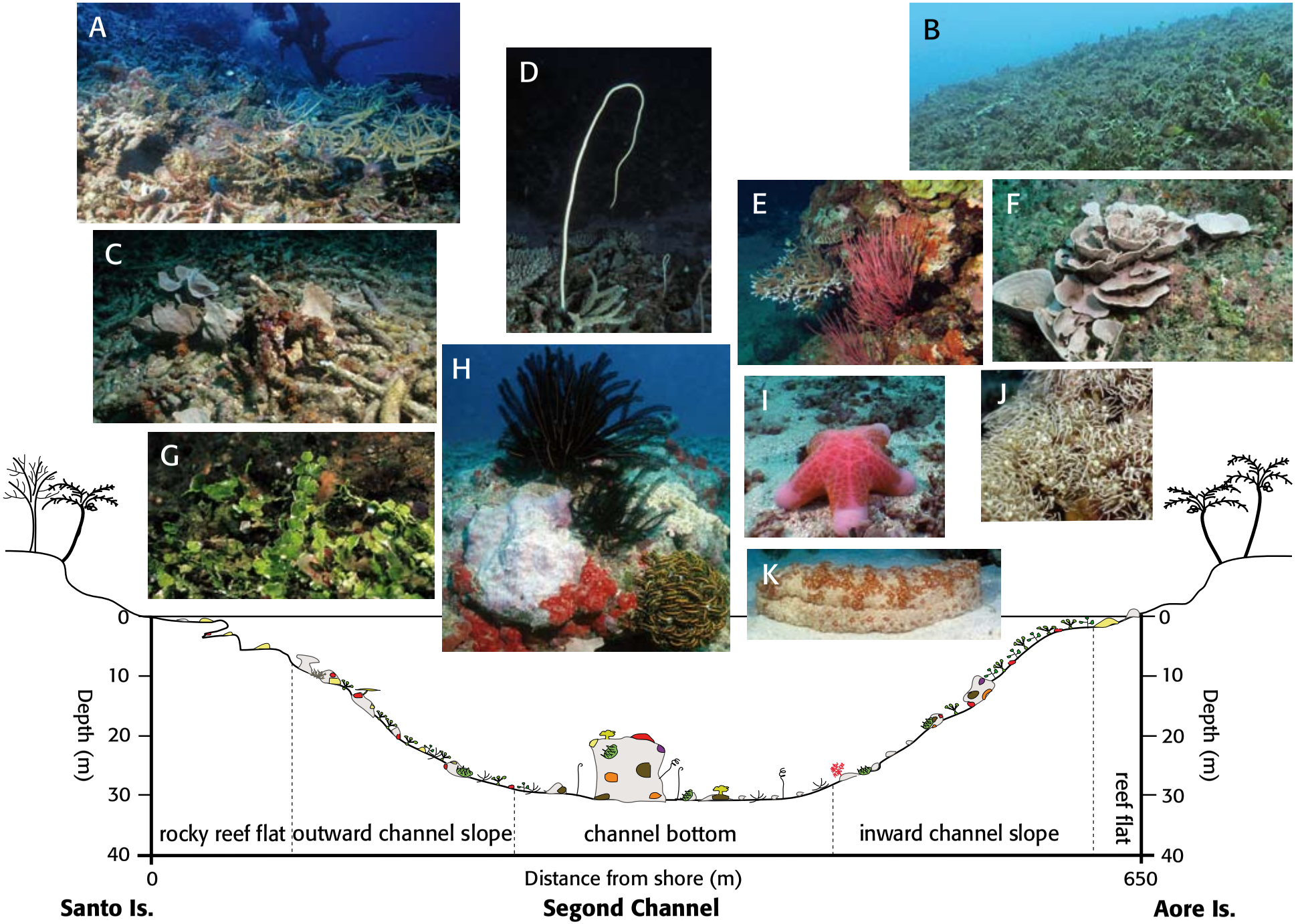

Figure 412: Schematic diagram of the topography and reef communities of Channel Pass (southern entrance of the Segond Channel).
A: Branching *Acropora* community on channel slope. **B**: Typical *Halimeda* beds on the edge of the slope. **C**: Rubble of *Acropora* branches. **D**: Gorgonian. **E**: *Ellisella*. **F**: *Phyllospongia lamelosa* with *Halimeda*. **G**: *Halimeda minima*. **H**: Crinoids *Comantheria briareus* and *Comanthus bennetti*. **I**: *Choriaster granulatus*. **J**: *Tubipora musica*. **K**: *Thelenota anax*. (Photos J.-L. Menou & J.-M. Boré IRD Nouméa).

Channel Pass (southern entrance of Segond Channel) (Fig. 412)

The topography and the environment of the Segond Channel changes from the north to the south with the increasing current. The coral communities are well developed on the slopes with massive corals in the shallow areas while a rich branched coral community is associated with green calcareous algae *Halimeda opuntia* and the coralline algae *Amphiroa* on the gentle sandy slope. The bottom of the channel is a hard substratum supporting large coral patches with flourishing communities of benthic invertebrates including octocorallians and numerous crinoids. This area experiences strong tidal currents. The reef flat on the Aore side is narrow with a steep slope dominated by *Halimeda macroloba* anchored in the muddy sand and various red algae entangled in dead *Acropora* branches.

Sheltered fringing reef (Brigstocke point, SW Luganville) (Fig. 413)

Most of the reefs fringing the southern corner of Santo are characterized by a narrow area of subtidal grooves adjacent to the rocky shoreline, with dense macroalgal vegetation of red algae *Callophycus* spp, *Portieria hornemanii* and *Amphiroa crassa*. The slopes are mostly covered with coral debris with some large blocks of dead *Porites*. The green calcareous alga *Halimeda opuntia* develops spectacular beds from 15-30 m deep, while *Halimeda macroloba* and the red foliaceous algae belonging to the Peyssonneliaceae form aggregations (soft nodules) up to 10 cm in diameter that are locally abundant on the top of the slope.

Malo water passage (between Aore and Malo Islands) (Fig. 414)

The Aore site is fringed by small *Rhizophora* clumps that grow on the beaches along a narrow and shallow depression where *Acroporids* and the seagrass *Enhalus acoroides* are well developed on sand flats with moderate tidal currents. The shallow reef flat on the side of the islet is covered with many massive *Porites*; on the side of Malo Island the reef is deeper and the corals are more massive and have developed into large patches with abundant encrusting coralline algae. The coral cover is high on the reef slope along the water passage. Foliose and branched corals are abundant on the reef slopes while they decrease further down to the bottom of the passage where strong currents limit the development of a benthic community. Large spurs parallel to the sea floor that support octocorallians are the main feature of the base of the slope on the Malo side.

Sheltered sandy slope (Malo passage) (Fig. 415)

The Malo passage has typical sandy slopes with little reef formation along the shores of Aore and Malo islands. Fringing reef flats are narrow, shallow and protected. No seagrass beds were found, only the delicate paddle seagrasses *Halophila* spp. were observed on the sandy slope down to 50 m deep. Sparse coral blocks and rubble are the main features from the top down to the mid-slope while coarse sand and debris are dominant further down beyond 30 m deep. Species diversity is low except for starfish and holothurians with various species such as *Nardoa gomophia*, *Echinaster callosus*, *Choriater granulatus*, *Holothuria* (*Microthele*) *fuscogilva* and *M. fuscopunctata* and the red algae that display several gelatinous species in the deeper part of the slope.

Sheltered embayment (Palikolo Bay) (Fig. 416)

From shore to open ocean, this bay contains several biotopes including:

- Prolific seagrass beds in the fringing muddy flats intermixed with a green macroalgal complex of *Halimeda* and *Caulerpa*;
- Shallow sheltered reefs on sand dominated by acroporids;
- Large areas of coral-construction on deeper (6 m) patch reefs;
- A steep slope from 15 m down to 60 m deep. The patch reefs here support a high diversity of species with a very rich coral community including many fungids and octocorallians. Large mounds of rubble covered by the brown alga *Lobophora variegata* indicate an accumulation of coral skeleton fragments that have broken in recent decades. The diversity decreases down the slope; some holothurians including *Thelenota anax* and *Neoferdina cumingii* (50 m) have been observed along with green algae *Cladophora* and *Halimeda* in the deeper zone.

Open embayment, partially sheltered (east Aore) (Fig. 417)

This habitat occupies the north eastern part of Aore Island. The coral community is developed on a gentle sandy slope down to 25 m deep and looks like the silty bottom of a lagoon. *Porites* with abundant soft corals, sponges and various branching *Acropora* form large beds down to 15 m deep. Various coralline and red fleshy algae were recorded on hard substrata. Corals such as *Polyphyllia*, *Herpolitha limax*, *Sandalolitha robusta* and *Cynarina lacrymalis* were also observed in these sheltered areas. The accumulation of fine carbonate sand in the deeper part is a typical characteristic of lagoons and supports large patches of mixed green algae including *Halimeda*, *Udotea*, *Avrainvillea* and *Caulerpa*. Visibility was reduced in this environment due to the abundance of fine carbonate particles in the water column.

Sheltered fringing reef (West Tutuba Island) (Fig. 418)

On the west side of Tutuba Island adjacent to the beach there is a narrow and patchy fringing reef fronting in some places an enclosed lagoonal gutter (10 m deep) and then a gentle outer slope that nonetheless

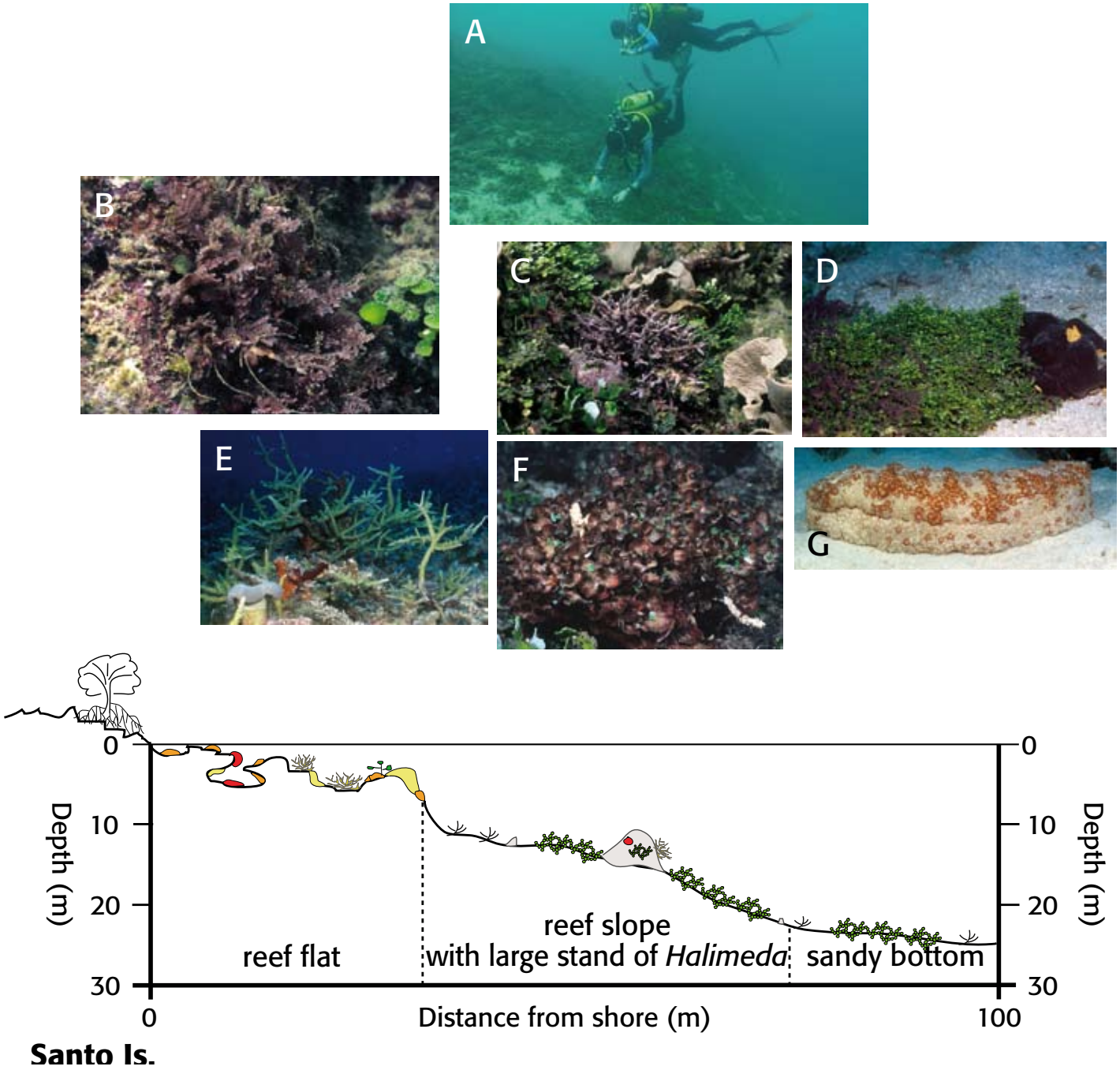

Figure 413: Schematic diagram of the topography and reef communities of a sheltered fringing reef (Brigstocke point, SW Luganville).
A: *Halimeda* beds on the gentle sandy slope. **B**: *Callophycus serratus*. **C**: Branched coralline algae. **D**: *Halimeda distorta* on sandy bottom. **E**: Branching coral community. **F**: Ball-like Peyssonneliaceae. **G**: *Thelenota anax*. (Photos J.-L. Menou & J.-M. Boré IRD Nouméa).

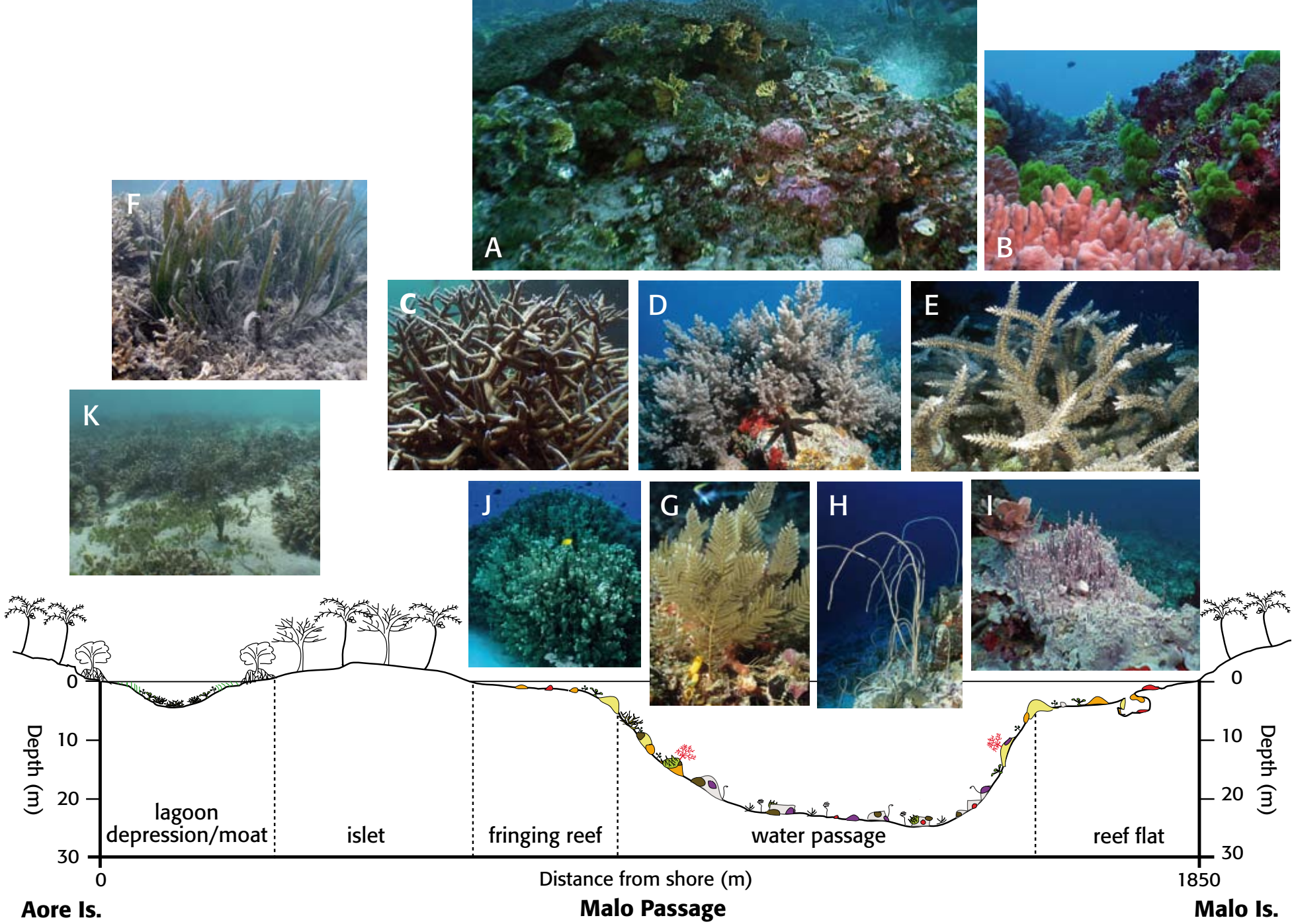

Figure 414: Schematic diagram of the topography and reef communities of the Malo passage (between Aore and Malo Island).
A: Flourishing community on the hard channel bottom. **B**: Spurs at the top of the reef slope. **C**: Branching corals on the reef flat. **D**: *Steronephtya*. **E**: Reef slope community composed of branching and massive corals. **F**: Seagrass *Enhalus acoroides*. **G**: *Aglaophenia*. **H**: Gorgonian community on the bottom of the reef slope. **I**: Candle-like coralline algae on the reef edge. **J**: Massive corals **K**: Branching *Acropora* and seagrass community in the moat. (Photos J.-L. Menou & J.-M. Boré IRD Nouméa).

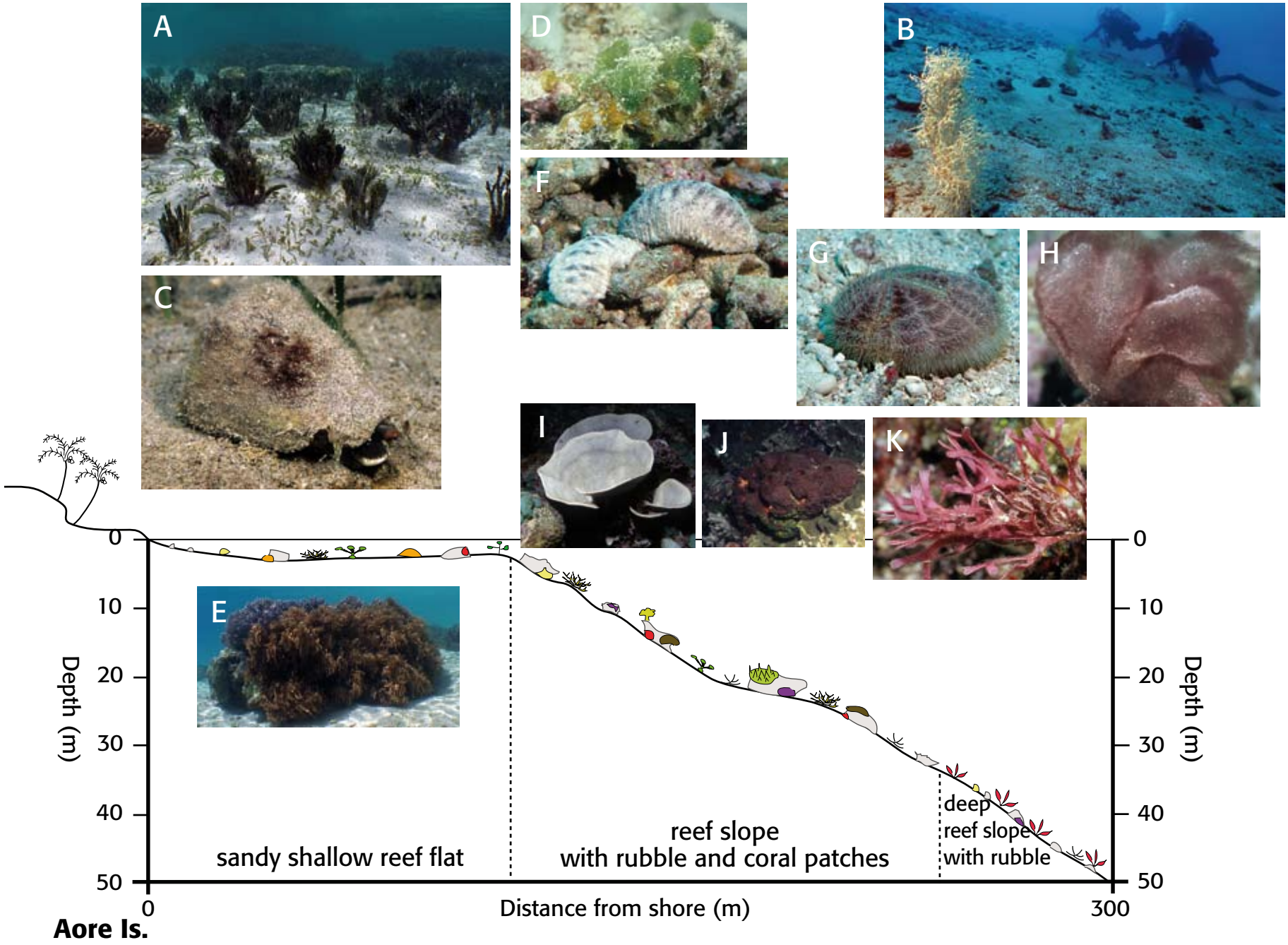

Figure 415: Schematic diagram of the topography and reef communities of a sheltered sandy slope (Malo Passage).
A: Typical mixed beds of *Halimeda cylindracea* and *Halophila ovalis*. **B**: Sandy slope. **C**: *Strombus luhuanus* on shallow sandy bottom. **D**: *Rhipilia crassa* on rubble. **E**: Soft coral on sandy bottom. **F**: Holothurian on rubble on the upper part of the slope. **G**: *Metalia sternalis*. **H**: *Gibsmithia hawaiiensis* on deep rubble. **I**: *Phyllospongia lamelosa*. **J**: Sponge *Melophlus*. **K**: *Dichotomaria marginata*. (Photos J.-L. Menou & J.-M. Boré IRD Nouméa).

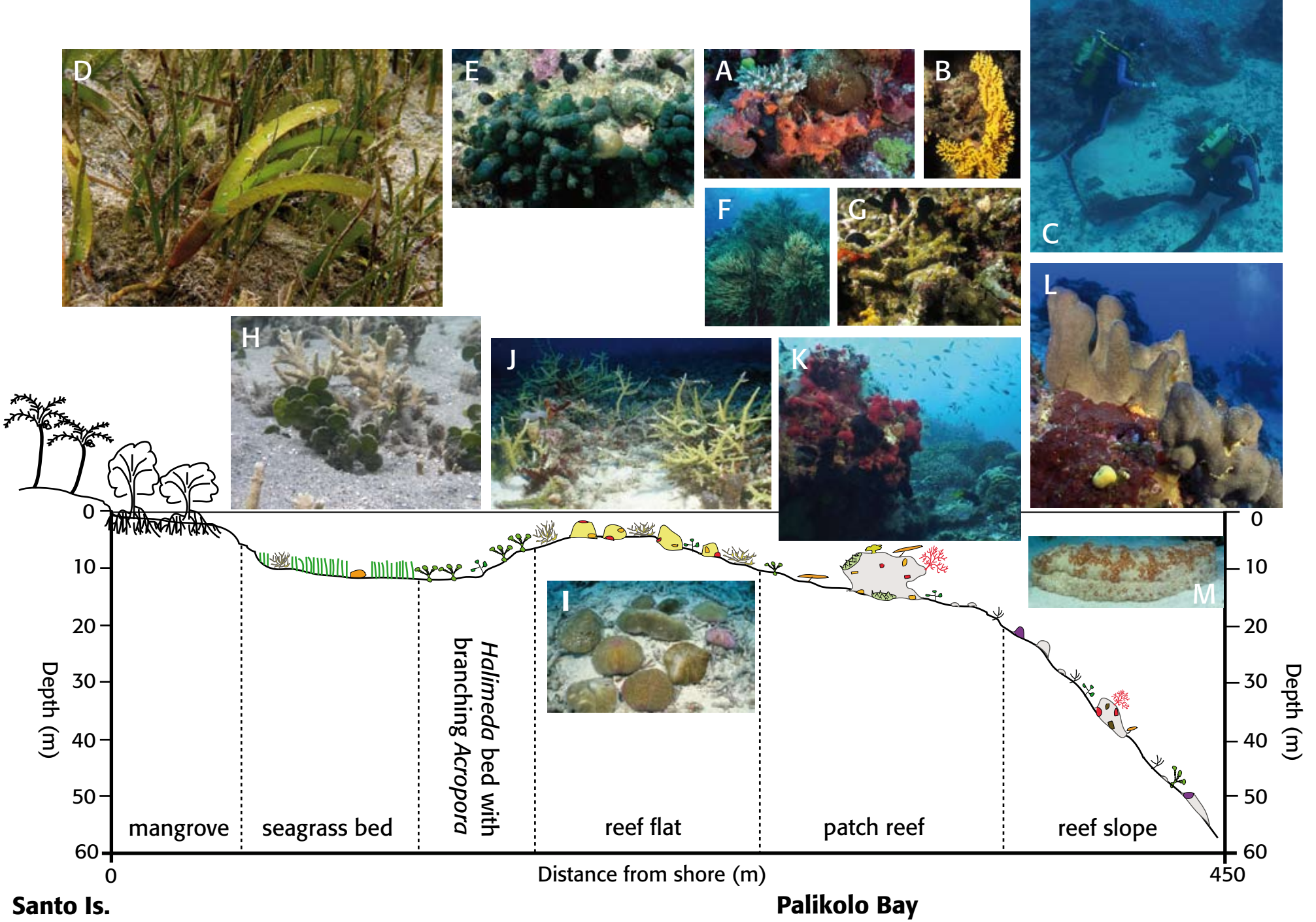

Figure 416: Schematic diagram of the topography and reef communities of a sheltered embayment (Palikolo Bay).
A: Invertebrate assemblage on dead corals. **B**: *Distichopora*. **C**: Deep sandy bottom with massive coral patches. **D**: *Cymodocea serrulata* (large) mixed with *Halodule universis*. **E**: *Tydemania expeditionis*. **F**: Soft coral *Rumphella aggregata*. **G**: Rubble covered by *Lobophora variegata*. **H**: *Halimeda macroloba* growing among corals on sandy bottom. **I**: Fungids growing among rubble. **J**: Branching Acropora community on shallow reef flat. **K**: Massive corals housing luxuriant octocorallian fauna. **L**: Massive coral on the slope. **M**: *Thelenota anax*. (Photos J.-L. Menou & J.-M. Boré IRD Nouméa).

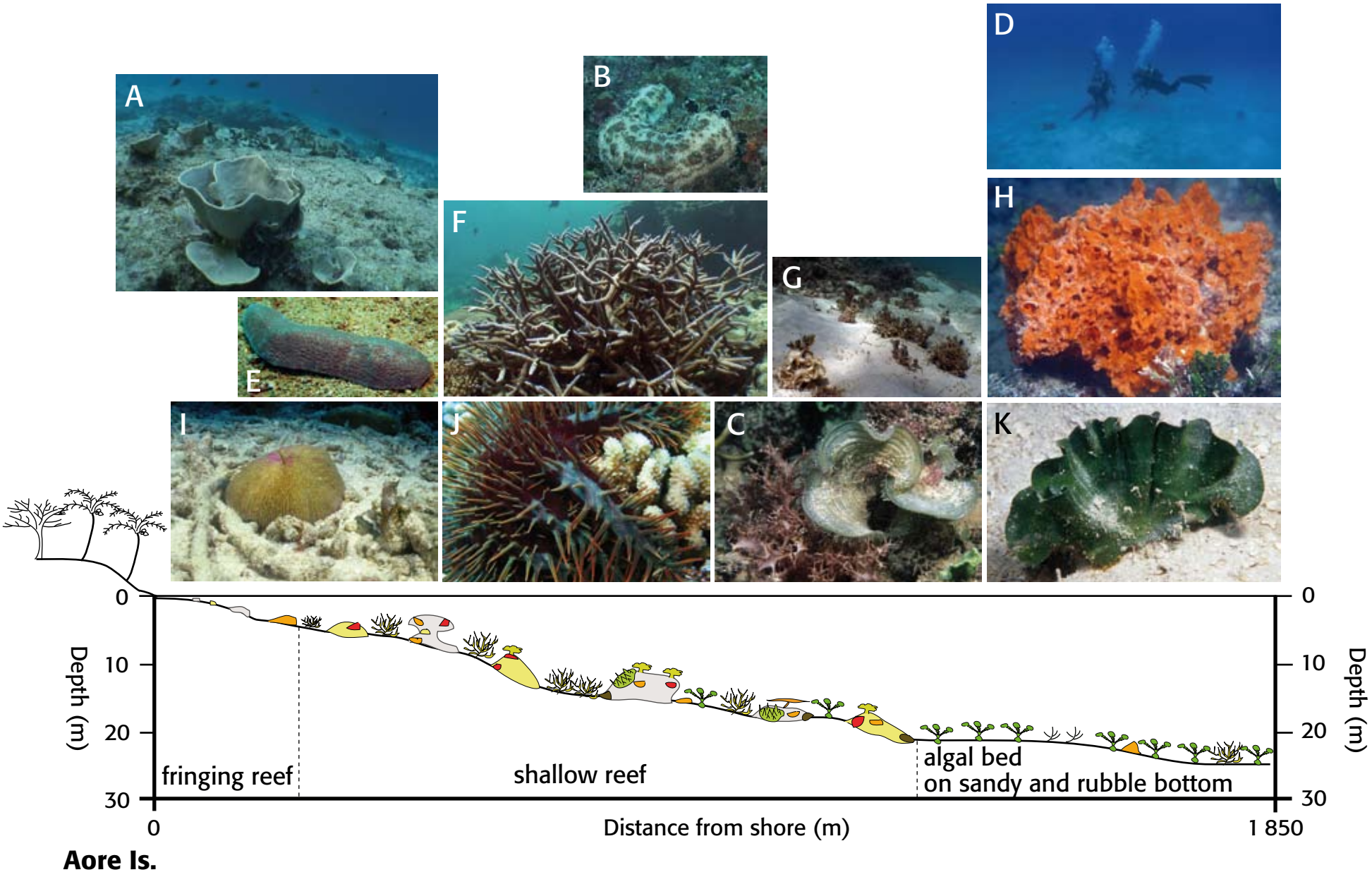

Figure 417: Schematic diagram of the topography and reef communities of an open and partially sheltered embayment (east Aore).
A: Sponges growing among rubble on the upper slope. **B**: Holothurian *Bohadchia graeffei*. **C**: Red algae *Titanophora* and *Padina*. **D**: Sandy lagoon floor. **E**: *Polyphylla*. **F**: Branching *Acropora*. **G**: *Halimeda* and *Padina* on gentle sandy slope. **H**: Sponge *Phakellia cavernosa*. **I**: Fungids growing among rubble. **J**: *Acanthaster plancii* feeding on coral. **K**: Green algae *Udotea argentea*. (Photos J.-L. Menou & J.-M. Boré IRD Nouméa).

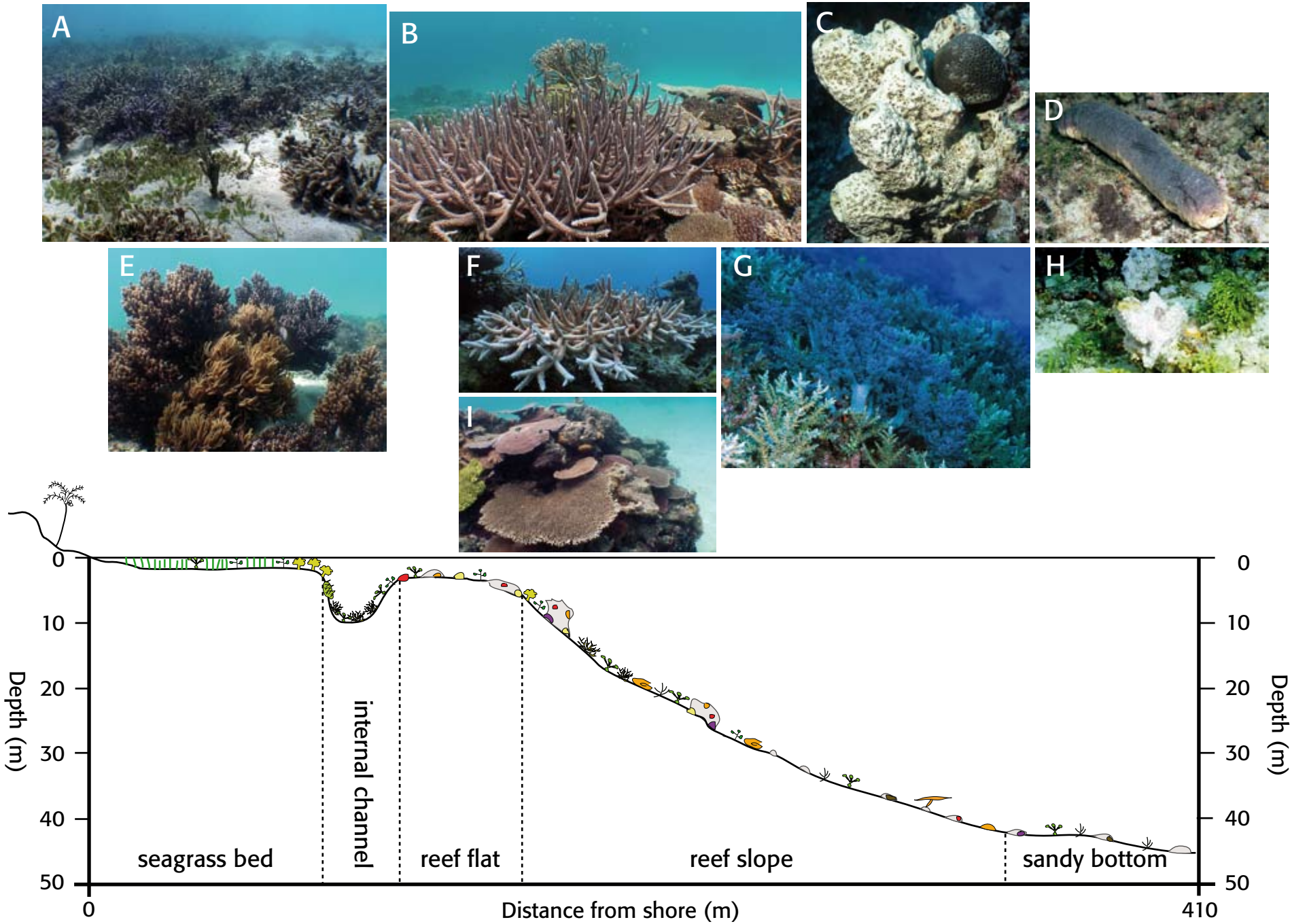

Figure 418: Schematic diagram of the topography and reef communities of a sheltered fringing reef (Tutuba Island W).
A: Mixed *Acropora* and *Halimeda* community. **B**: Attractive coral community. **C**: Sponge *Liosina*, abundant on hard corals. **D**: *Holothuria edulis* on the floor. **E**: Soft corals. **F**: Large branching *Acropora*. **G**: Mixed assemblage of soft and hard corals. **H**: *Halimeda minima* on deep reef slope. **I**: Tabular *Acropora*. (Photos J.-L. Menou & J.-M. Boré IRD Nouméa).

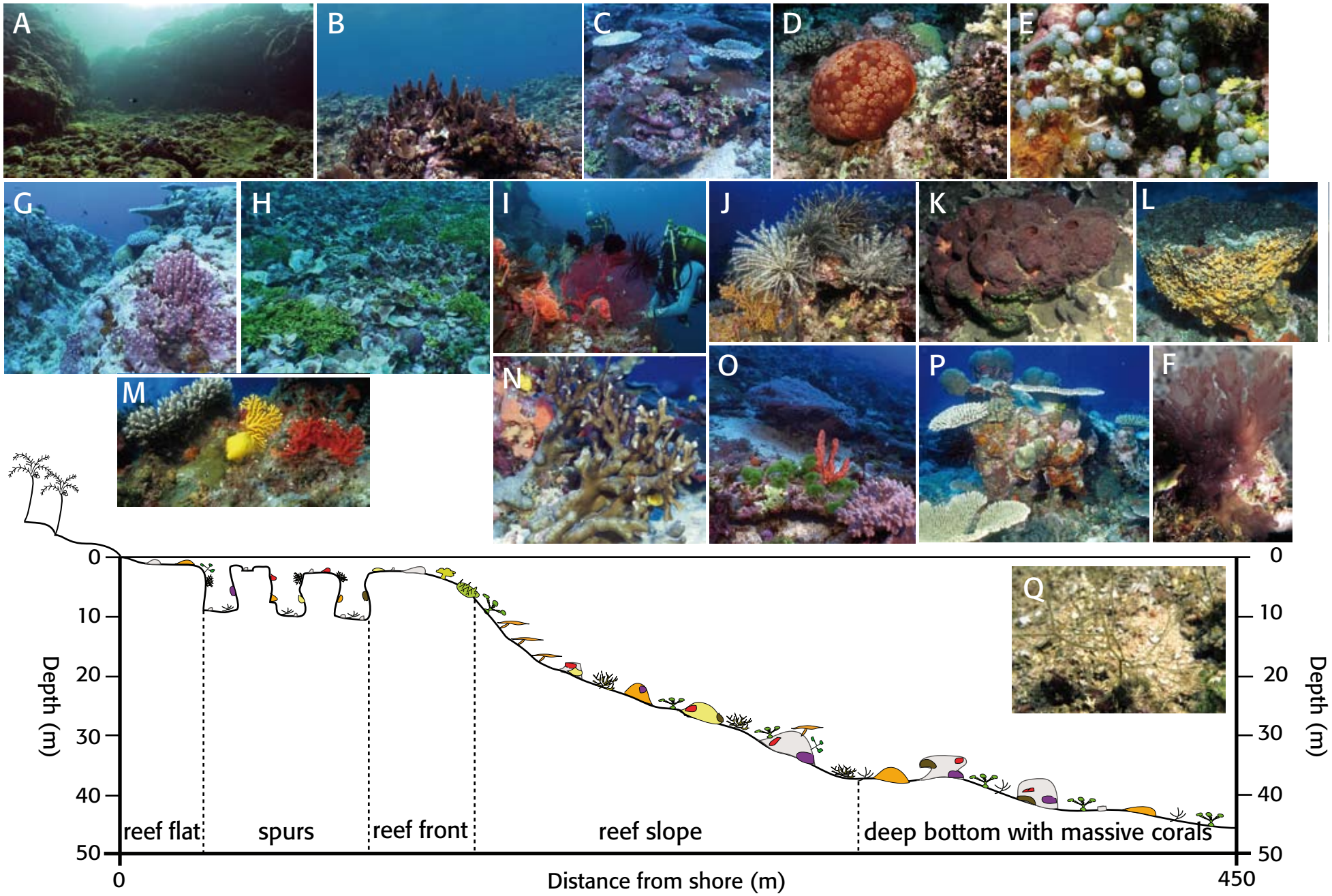

Figure 419: Schematic diagram of the topography and reef communities of a windward fringing reef and exposed outer reef slope (Tutuba Is. N & E).
A: Spurs. **B**: Top of reef. **C**: Typical reef edge community composed of massive and tabular corals. **D**: *Culcita novaeguinea*. **E**: *Caulerpa fergusoni*. **F**: Red algae *Predaea laciniosa*. **G**: Coralline algae. **H**. *Halimeda* on rubble. **I**: Octocorallian community on spur edges. **J**: Crinoid assemblage. **K**: Sponge *Melophlus*. **L**: Abundant large sponges. **M**: Octocorallian community on the reef edge. **N**: *Heliopora* on slope. **O**: Luxuriant coral community on mid slope. **P**: Massive corals on slope in deep water. **Q**: Green alga *Cladophora obukhoana* on coarse sand. (Photos J.-L. Menou & J.-M. Boré IRD Nouméa).

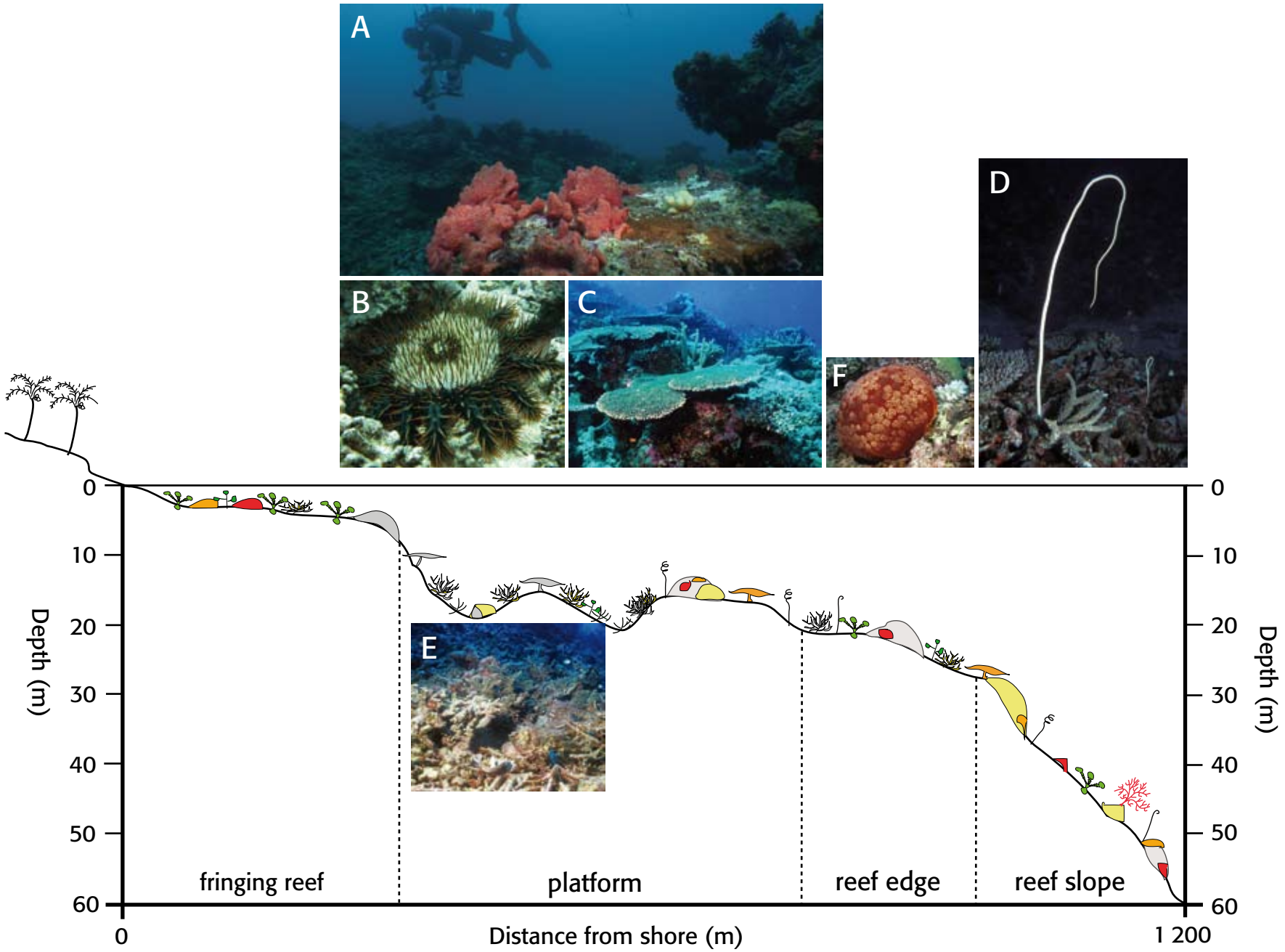

Figure 420: Schematic diagram of the topography and reef communities of an outer reef platform (Malo Is. W coast).
A: Reef platform. **B**: *Acanthaster plancii*. **C**: Large tabular *Acropora*. **D**: Gorgonian. **E**: Rubble. **F**: *Culcita noveaguinea*. (Photos J.-L. Menou & J.-M. Boré IRD Nouméa).

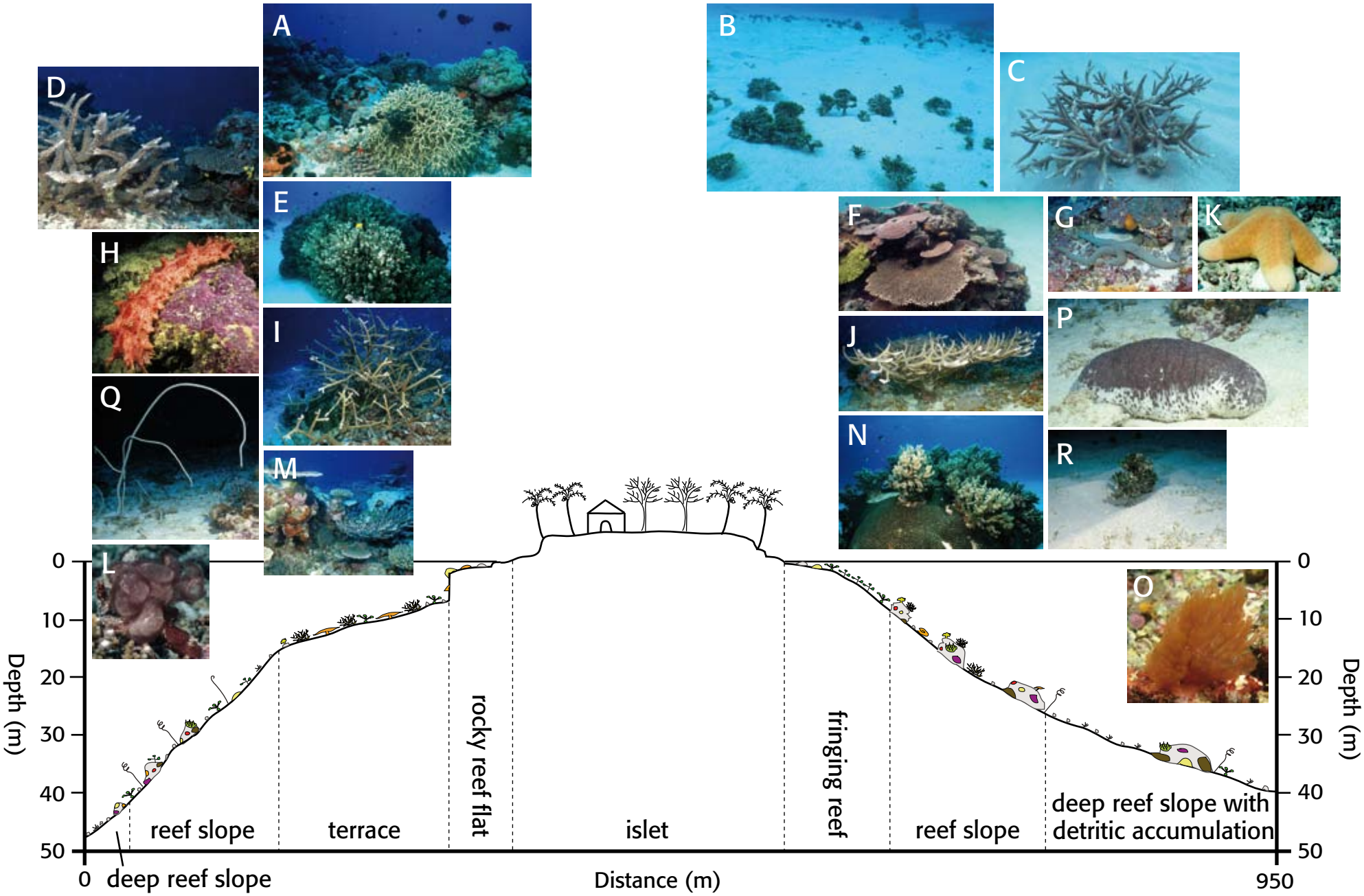

Figure 421: Schematic diagram of the topography and reef communities of a patch reef and outer slope adjacent to a limestone island (Abokisa Island).
A: Attractive coral community on the reef flat. **B**: *Halimeda cylindracea* on shallow sandy bottom. **C**: Branching *Acropora* on shallow sandy bottom. **D**: Massive tabular and branching corals. **E**: Massive coral heads on sandy bottom. **F**: Tabular *Acropora* community on patch reef. **G**: *Linckia* guild. **H**: *Thelenota rubrolineata*. **I**: Branching *Acropora* on sandy slope. **J**: Branching *Acropora* on slope. **K**: *Choriaster granulatus*. **L**: *Gibsmithia hawaiiensis*. **M**: Massive coral community on the terrace. **N**: Soft corals on massive coral head. **O**: *Predaea weldii*. **P**: *Holothuria* (*Microthele*) *fuscogilva*. **Q**: Gorgonian on the bottom of the outer slope. **R**: *Halimeda cylindracea* and *Halophila ovalis* on deep sandy bottom. (Photos J.-L. Menou & J.-M. Boré IRD Nouméa).

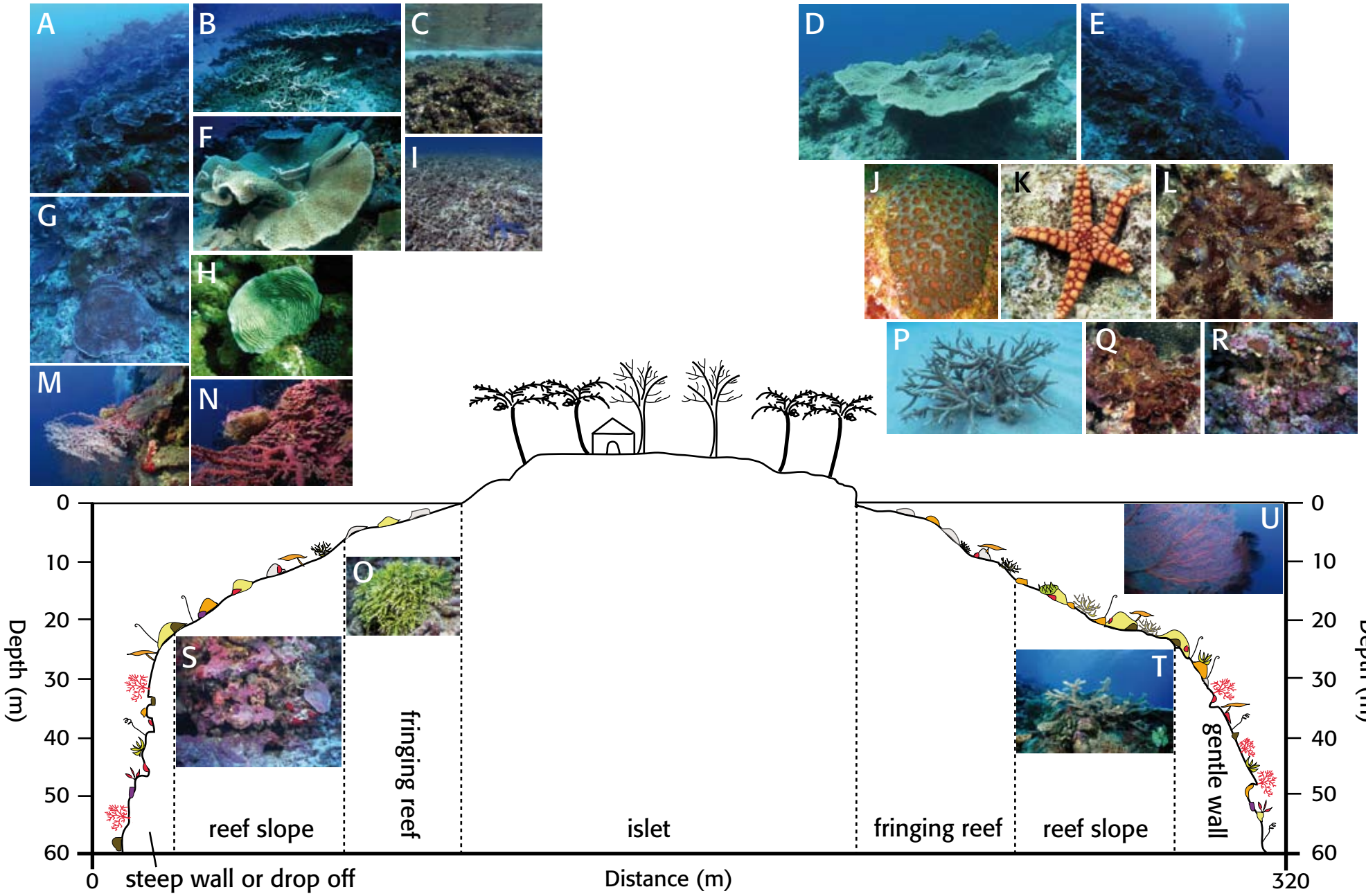

Figure 422: Schematic diagram of the topography and reef communities of reef wall (Urelapa Island).
A: Typical outer slope at 30 m depth. **B**: Branching *Acropora* community on the sandy terrace. **C**: Top of the reef. **D**: *Diploastrea heliopora*. **E**: Reef slope and wall. **F**: *Foliacea coral* cf. *Turbinaria*. **G**: Foliaceous corals on the wall. **H**: *Pachysiris speciosa*. **I**: *Acropora* rubble on the reef crest. **J**: *Montastrea annuligera*. **K**: *Celerina*. **L**: *Asteronemia anastomosans*. **M**: Gorgonian and crinoids on the drop-off. **N**: Coralline algae and octocorallian on the wall 2. **O**: *Halimeda minima* on rubble. **P**: *Acropora* on sandy bottom with ripple marks. **Q**: *Peyssonnelia*. **R**: Cryptic community of coralline algae on the outer slope. **S**: Coralgal (coral-algal) assemblage on the reef slope. **T**: Massive branching *Acropora* on the reef flat. **U**: Gorgonian on the drop-off (wall). (Photos J.-L. Menou & J.-M. Boré IRD Nouméa).

goes down to 50 m in depth. The reef flat area is very shallow and supports a diffuse seagrass bed composed mainly of *Cymodocea serrulata*, intermingling with algae and small coral colonies. The front of the stretches of reef and edges of the lagoon are overgrown by a dense covering of erect soft corals such as *Sinularia* and *Sarcophyton*, while the narrow silty lagoon contains isolated massive *Porites*. The steep internal slope and the outer reef flat are covered by thick swathes of rubble without coral communities. This entire zone is exposed at low tide. The outer reef slope is similar to other sheltered slopes with large areas of broken *Acropora* branches and plates on white coral sand down to 8 m deep; further down there is an accumulation of coral branches and other carbonate debris with few coral colonies and occasional fleshy algae.

In the area outside the lagoonal depression the sandy bottom supports a mosaic of patch reefs dominated by robust massive corals that are highly dissected with spectacular communities of green and red algae. Several *Holothuria edulis* have been observed on the shallow sandy bottom.

Windward fringing reef and exposed outer reef slope (north and east Tutuba Island) (Fig. 419)

On the windward side, fringing reefs are deeply dissected with massive spurs and narrow grooves from 3 to 12 m deep that are littered with coarse sand and coral rubble. Heavy crusts and candle-like coralline algae are well developed in this exposed area along with numerous small species in the overhangs and reef interstices. Corals are sparse on the reef top and mostly consist of massive *Pocillopora*, *Acropora* and *Millepora*. The outer slope is steep from 15 to 30 m in depth, with scattered low spurs and large patches of coarse sand with abundant *Halimeda* segments. Beautiful sea fans and other octocorallian fauna are present on the top of the reef with numerous crinoids making this a very attractive area. From 30-60 m deep the slope is less steep and comprises rubble and scattered coral heads. The deeper part of this seaward slope is typical of many deep slopes, especially with respect to the associated red gelatinous algae (*Predaea*, *Dudresnaya* and *Gibsmithia*), green algae *Caulerpa fergusonii* and *Cladophora ohkuboana* and *C. dotyana*.

The reef slopes facing the open sea are less steep from 30 m down to at least 50 m deep. Coral cover is reduced; *Halimeda minima* coverage is high and contributes to sand accumulation from their calcified segments. *Seriatopora* cf *histrix*, and black coral *Cirrhipathes anguineus* have been observed at 45 m deep.

Outer reef platform (west coast of Malo Island) (Fig. 420)

Reef formation on the northwest coast of Malo Island provides an example of a platform that was not seen elsewhere during the survey. This reef is totally subtidal with broad, irregular and meandering spurs and grooves. The site has a high proportion of rubble and corals that have been dead for several years. The coral communities were dominated by plate and branching forms. At the time of the survey coral recovery was observed with several living colonies of the same size (20-30 cm in diameter). The inshore reef and outer slopes were not studied.

Numerous *Culcita novaeguineae* were observed, along with one specimen of *Acanthaster planci*.

Patch reef and outer slope adjacent to limestone island (Abokisa Island) (Fig. 421)

The small limestone islet located between the larger Tutuba Island and Aore is surrounded by an intermittent fringing reef developed on coral sand to about 6 m in depth with an attractive coral community. Structurally they are dominated by stands of *Acropora* in plate (*A. danai*) and branched forms, both living and dead. The dead skeletons provide the substrata for a complex and beautiful coral community in shallow sandy water and include coralline algae. The adjacent slope is dominated by massive *Porites* down to 15 m deep with numerous *Halimeda* and encrusted rubble as well as rare echinoderms such as *Holothuria* (*Microthele*) *fuscogilva* and *Linckia guildingi*. Further down the slope drops off to 40 m deep in the north and more than 60 m on the southwestern side with a steeper declination. The coral community is replaced by rubble and a few small colonies (< 1 m high). In deep water, species diversity is low with some red gelatinous algae (*Predaea* and *Gibsmithia*), the green algae *Caulerpa* and *Cladophora ohkuboana* and the echinoderms *Choriaster granulatus* and *Thelenota rubrolineata*.

Reef wall (Urelapa Island) (Fig. 422)

Fringing reefs on limestone islands adjacent to deep water such as Urelapa and Tuvana islets located off the southern part of Santo have vertical underwater cliffs. These reef walls are distinct features that represent one of the more spectacular biotopes for species diversity. Stretches of fringing reef are found adjacent to limestone and coral sand beaches, which change gradually to a reef slope dominated by a mixture of massive corals such as *Diploastrea*, *Goniastrea* and *Montastrea magnistellata* and branching Acroporidae down to the cliff precipice. The coral walls start beyond 20 to 25 m deep down at least 60 m deep and are present around the islets where the coast is neither sheltered nor exposed. Coralline algae in association with numerous fleshy red algae (large patches of *Halichrysis irregularis* and *Asteromenia anastomosans*) are dominant components with octocorallians. Corals are encrusting or foliaceous such as *Pachyseris speciosa*.

REPRESENTATIVE MACROPHYTES COMMUNITIES

Algal vegetation

The species list of the benthic marine algae and seagrasses collected from Santo is shown in tables 37 & 38. The classification follows *The catalogue of the benthic marine algae of the Indian Ocean* by Silva and coauthors (1996). The 271 listed species of algae consist of 163 Rhodophyta (red algae), 83 Chlorophyta (green algae) and 25 Pheaophyceae (brown algae). A selection of species is illustrated in figures 423-428. About 150 specimens of coralline algae are under study and are not included in this work; only the most common encrusting coralline algae are considered here. The species belong to 12 orders and 45 families (Figs 429 & 430). Most of the specimens have been identified to species level and these represent 90% of the collection; the 10% remaining unidentified species comprise taxa that could be new to science. Among the identified species, three of them are newly described from Solomon Islands, Fiji and New Caledonia; while at least five taxa including four species of *Martensia*, *Rhizophyllis*, *Rhodymenia*, *Hypoglossum* and *Dudresnaya* and one new genus belonging to the Dumontiaceae are being studied to describe new taxa or establish them as belonging to existing species. The study of the coralline algae will probably reveal new taxa as well.

The algal flora is typically tropical and most of the species belong to the Indo-Pacific biogeographic province. Comparison with flora from adjacent archipelagos is limited due to the difference in sampling effort in the various regions. However, 55% and 53% of the species of Santo are present in Solomons and Fiji respectively.

The Rhodymeniaceae *Asteronemia pseudocoalescens* described from Lord Howe Island was observed for the first time outside of its type locality, suggesting that its geographic distribution is broader than originally thought; this discovery enhances the known biogeographic affinities of the Santo marine flora with the tropical west Pacific.

Algal assemblages are characterized within the biotopes as shown in the following sections.

Table 37: List of Rhodophyta, Chlorophyta and Phaeophyceae species from Santo waters.

Class Rhodophyta	
Order Bonnemaisoniales	
Family Bonnemaisoniaceae	*Asparagopsis taxiformis* (Delile) Trevisan
Order Ceramiales	
Family Ceramiaceae	*Aglaothamnion boergesenii* (Aponte & D.L. Ballantine) L'Hardy-Halos & Rueness
	Anotrichum tenue (C. Agardh) Nägeli
	Antithamnionella elegans (Berthold) J.H. Price & D.M. John
	Balliella repens Huisman & Kraft
	Centroceras clavulatum (C. Agardh) Montagne
	Centroceras minutum Yamada
	Ceramium flaccidum (H.E. Petersen) Furnari & Seiro
	Ceramium marshallense Dawson
	Ceramium upolense South & Skelton
	Corallophila apiculata (Yamada) R. Norris
	Griffithsia heteromorpha Kützing
	Haloplegma duperreyi Montagne
	Monosporus indicus Børgesen
	Spyridia hypnoides (Bory de Saint-Vincent) Papenfuss
	Tiffaniella saccorhiza (Setchell & Gardner) Doty & Menez
	Wrangelia argus Montagne
	Wrangelia elegantissima R.E. Norris
Family Dasyaceae	*Dasya anastomosans* Weber-van Bosse
	Dasya baillouviana (S.G. Gmelin) Montagne
	Dasyphila plumarioides Yendo
	Heterosiphonia crispella (C. Agardh) M.J. Wynne
	Thuretia sp. nov.
Family Delesseriaceae	*Frikkiella searlesii* M.J. Wynne & C.W. Schneider
	Haraldia lenormandii (Derbès & Solier) Feldmann
	Hypoglossum simulans M.J. Wynne, Price & Ballantine
	Martensia cf. *australis* Harvey
	Martensia elegans Hering
	Martensia flabelliforme Harvey ex J. Agardh
	Martensia fragilis Harvey
	Martensia sp. nov.
	Myriogramme melanesiensis N'Yeurt, Wynne & Payri
	Nitophyllum adhaerens M.J. Wynne
	Vanvoorstia spectabilis Harvey
Family Rhodomelaceae	*Acanthophora pacifica* (Setchell) Kraft

	Acanthophora spicifera (Vahl) Børgesen
	Amansia rhodantha (Harvey) J. Agardh
	Bostrychia tenella (J.V. Lamouroux) J. Agardh
	Chondria armata (Kützing) Okamura
	Chondria dangeardii Dawson
	Chondria minutula Weber-van Bosse
	Chondria ryukyuensis Yamada
	Chondria simpliciuscula Weber-van Bosse
	Chondria bullata N'Yeurt & Payri
	Chondria sp.
	Chondrophycus parvipapillatus (C.K. Tseng) Garbary & Harper
	Chondrophycus succisus (A.B. Cribb) K.W. Nam
	Exophyllum wentii Weber-van Bosse
	Herposiphonia nuda Hollenberg
	Herposiphonia tenella (C. Agardh) Ambronn
	Laurencia brachyclados Pilger
	Laurencia cf. *distichophylla* J. Agardh
	Laurencia decumbens Kützing
	Laurencia sp. 1
	Laurencia sp. 2
	Neosiphonia apiculata (Hollenberg) Masuda & Kogame
	Polysiphonia scopulorum Harvey
	Polysiphonia sertularioides (Grateloup) J. Agardh
	Polysiphonia sp
	Polysiphonia triton P.C. Silva
	Spirocladia barodensis Børgesen
	Tolypiocladia glomerulata (C. Agardh) F. Schmitz
Order Corallinales	
Family Corallinaceae	*Amphiroa anceps* (Lamarck) Decaisne
	Amphiroa crassa Lamouroux in Quoy & Gaimard
	Amphiroa foliacea Lamouroux in Quoy & Gaimard
	Amphiroa fragilissima (Linnaeus) Lamouroux
	Amphiroa sp. nov.
	Amphiroa tribulus (Ellis & Solander) Lamouroux
	Amphiroa valonioides Yendo
	Cheilosporum acutilobum (Decaisne) Piccone
	Cheilosporum spectabile Harvey ex Grunow
	Hydrolithon onkodes (Heydrich) D. Penrose & Woelkerling
	Hydrolithon orthoblastum
	Hydrolithon reinboldii (Weber-van Bosse & Foslie) Foslie
	Jania adhaerens Lamouroux
	Jania rubens (Linnaeus) Lamouroux
	Lithophyllum pygmaeum (Heydrich) Heydrich
	Lithothamnion proliferum Foslie
	Neogoniolithon fosliei (Heydrich) Setchell & mason
Order Gelidiales	
Family Gelidiaceae	*Gelidiella acerosa* (Forsskål) Feldmann & G. Hamel
	Gelidium cf. *crinale* (Turner) Gaillon
	Gelidium isabelae W.R. Taylor
	Pterocladiella sp.
Order Gigartinales	
Family Caulacanthaceae	*Caulacanthus ustulatus* (Turner) Kützing
Family Corynocystaceaea	*Corynocystis prostrata* G.T. Kraft
Family Dicranemataceae	*Pinnatiphycus menouana* N'Yeurt, Payri & Gabrielson
Family Dumontiaceae	*Dudresnaya capricornica* Robins & Kraft
	Dudresnaya hawaiiensis R.K.S. Lee
	Dudresnaya sp. nov.
	Dumontiaceae gen. nov.
	Gibsmithia dotyi Hoyle
	Gibsmithia hawaiiensis Doty
	Gibsmithia larkumii Kraft
Family Hypneaceae	*Hypnea cervicornis* J. Agardh
	Hypnea nidulans Setchell
	Hypnea pannosa J. Agardh
	Hypnea saidana Holmes

	Hypnea spinella (C. Agardh) Kützing
	Hypnea valentiae (Turner) Montagne
Family Nemastomataceae	*Predaea laciniosa* Kraft
	Predaea weldii Kraft & I.A. Abbott
Family Peyssonneliaceae	*Peyssonnelia* cf. *boergesenii* Weber-van Bosse
	Peyssonnelia inamoena Pilger
	Peyssonnelia sp. 1
	Peyssonnelia sp. 2
Family Rhizophyllidacea	*Portieria hornemannii* (Lyngbye) P.C. Silva
	Rhizophyllis sp. nov.
Family Schizymeniaceae	*Titanophora weberae* Børgesen
Family Solieriaceae	*Callophycus densus* (Sonder) G.T. Kraft
	Callophycus serratus (Harvey ex Kützing) P.C. Silva
	Eucheuma horizontale Weber-van Bosse
	Eucheuma sp.
	Meristotheca procumbens P. Gabrielson & Kraft
	Wurdemannia miniata (Sprengel) Feldmann & G. Hamel
Order Gracilariales	
Family Gracilariaceae	*Gracilaria dotyi* Hoyle
	Gracilaria sp.
Order Halymeniales	
Family Halymeniaceae	*Cryptonemia* cf. *lomation* (Bertoloni) Agardh
	Cryptonemia cf. *umbraticola* Dawson
	Cryptonemia crenulata (J. Agardh) J. Agardh
	Cryptonemia umbraticola Dawson
	Grateloupia ovata Womersley & J.A. Lewis
	Halymenia maculata J. Agardh
	Halymenia porphyraeformis Parkinson
	Halymenia stipitata I.A. Abbott
	Prionitis angusta (Okamura) Okamura
Order Halymeniales	
Family Sebdeniaceae	*Sebdenia cerebriformis* N'Yeurt & Payri
	Sebdenia flabellata Zablackis
Order Nemaliales	
Family Galaxauraceae	*Actinotrichia fragilis* (Forsskål) Børgesen
	Dichotomaria australis (Sonder) Huisman, J.T. Harper & G.W. Saunders
	Dichotomaria marginata (Ellis & Solander) Lamarck
	Dichotomaria obtusata (Ellis & Solander) Lamarck
	Galaxaura divaricata (Linnaeus) Huisman & Townsend
	Galaxaura filamentosa R. Chou
	Galaxaura obtusata (Ellis & Solander) Lamouroux
	Galaxaura rugosa (Ellis & Solander) Lamouroux
	Tricleocarpa fragilis (Linnaeus) Huisman & Townsend
Order Nemaliales	
Family Liagoraceae	*Liagora* sp.
	Yamadaella caenomyce (Decaisne) I.A. Abbott
Order Nemaliales	
Family Scinaiaceae	*Scinaia furcata* Zablackis
Order Plocamiales	
Family Plocamiaceae	*Plocamium sandvicense* J. Agardh
	Plocamium sp.
Order Rhodymeniales	
Family Champiaceae	*Champia compressa* Harvey
	Champia parvula (C. Agardh) Harvey
	Champia vieillardii Kützing
Order Rhodymeniales	
Family Faucheaceae	*Gloiocladia iyoensis* (Okamura) R. Norris
Order Rhodymeniales	
Family Lomentariaceae	*Lomentaria corallicola* Børgesen
Order Rhodymeniales	
Family Rhodymeniaceae	*Asteromenia anastomosans* (Weber-van Bosse) G.W. Saunders, C.E. Lane, C.W. Schneider & Kraft
	Asteromenia pseudocoalescens G.W. Saunders, C.E. Lane, C.W. Schneider & Kraft
	Botryocladia kuckuckii (Weber-van Bosse) Yamada & Tanaka
	Botryocladia skottsbergii (Børgesen) Levring
	Botryocladia spinulifera W.R. Taylor & I.A. Abbott
	Chamaebotrys boergesenii (Weber-van Bosse) Huisman
	Chrysymenia procumbens Weber-van Bosse

	Coelothrix irregularis (Harvey) Børgesen
	Gelidiopsis intricata (C. Agardh) Vickers
	Gelidiopsis repens (Kützing) Weber-van Bosse
	Gelidiopsis scoparia (Montagne & Millardet) De Toni
	Halichrysis irregularis (Kützing) A.J.K. Millar
	Leptofauchea sp.
	Rhodymenia intricata (Okamura) Okamura
	Rhodymenia pacifica Kylin
	Rhodymenia sp. 1
	Rhodymenia sp. 2
Class Chlorophyta	
Order Bryopsidales	
Family Bryopsidaceae	*Bryopsis pennata* J.V. Lamouroux var. *secunda* (Harvey) Collins & Hervey
Order Bryopsidales	
Family Caulerpaceae	*Caulerpa biserrulata* Sonder
	Caulerpa brachypus Harvey
	Caulerpa cupressoides (Vahl) C. Agardh
	Caulerpa fastigiata Montagne
	Caulerpa fergusonii Murray
	Caulerpa manorensis Nizamuddin
	Caulerpa microphysa (Weber-van Bosse) Feldmann
	Caulerpa nummularia Harvey ex J. Agardh
	Caulerpa racemosa (Forsskål) J. Agardh var. *clavifera* Turner (Weber-van Bosse)
	Caulerpa racemosa (Forsskål) J. Agardh var. *lamourouxii* (Turner) Weber-van Bosse
	Caulerpa racemosa (Forsskål) J. Agardh var. *peltata* (Lamouroux) Eubank
	Caulerpa sedoides C. Agardh
	Caulerpa serrulata (Forsskål) J. Agardh
	Caulerpa sertularioides (S. Gmelin) M. Howe
	Caulerpa taxifolia (Vahl) C. Agardh
	Caulerpa verticillata J. Agardh
	Caulerpa webbiana Montagne

	Caulerpella ambigua (Okamura) Prud'homme van Reine & Lokhorst
Order Bryopsidales	
Family Codiaceae	*Codium arabicum* Kützing
	Codium geppiorum O.C. Schmidt
	Codium mamillosum Harvey
	Codium ovale Zanardini
Order Bryopsidales	
Family Halimedaceae	*Halimeda borneensis* W.R. Taylor
	Halimeda cuneata K. Hering
	Halimeda cylindracea Decaisne
	Halimeda discoidea Decaisne
	Halimeda distorta (Yamada) Hillis-Colinvaux
	Halimeda gigas W.R. Taylor
	Halimeda heteromorpha N'Yeurt
	Halimeda lacunalis (W.R. Taylor) Hillis
	Halimeda macroloba Decaisne
	Halimeda macrophysa Askenasy
	Halimeda micronesica Yamada
	Halimeda minima (W.R. Taylor) Colinvaux
	Halimeda opuntia (Linnaeus) Lamouroux
	Halimeda taenicola W.R. Taylor
Order Bryopsidales	
Family Pseudocodiaceae	*Pseudocodium floridanum* Dawes & Mathieson
Order Bryopsidales	
Family Udoteaceae	*Avrainvillea erecta* (Berkeley) A. Gepp & E. Gepp
	Avrainvillea lacerata Harvey ex J. Agardh
	Boodleopsis pusilla (Collins) W. Taylor, Joly & Bernatowicz
	Chlorodesmis fastigiata (C. Agardh) Ducker
	Chlorodesmis hildebrandtii A. Gepp & E. Gepp
	Rhipidosiphon javensis Montagne
	Rhipilia crassa A.J.K. Millar & G.T. Kraft
	Rhipilia penicilloides N'Yeurt & Keats
	Rhipilia sinuosa Gilbert
	Rhipilia sp. nov.
	Rhipiliopsis carolyniae Kraft
	Rhipiliopsis echinocaulos (A.B. Cribb) Farghaly

	Rhipiliopsis howensis Kraft
	Siphonogramen sp.
	Tydemania expeditionis Weber-van Bosse
	Udotea argentea Zanardini
Order Cladophorales	
Family Anadyomenaceaea	*Anadyomene wrightii* Harvey ex J. Gray
	Microdictyon umbilicatum (Velley) Zanardini
Order Siphonocladales	
Family Boodleaceae	*Phyllodictyon anastomosans* (Harvey) Kraft & M.J. Wynne
Order Cladophorales	
Family Cladophoraceae	*Chaetomorpha antennina* (Bory de Saint-Vincent) Kützing
	Cladophora dotyana Gilbert
	Cladophora glomerata (L.) Kutzing
	Cladophora liebetruthii Grunow
	Cladophora ohkuboana Holmes
	Cladophora prehendens Kraft & Millar
	Cladophora sp.
Order Siphonocladales	
Family Siphonocladaceae	*Boergesenia forbesii* (Harvey) J. Feldmann
Order Dasycladales	
Family Dasycladaceae	*Bornetella nitida* Sonder
	Bornetella sphaerica (Zanardini) Solms-Laubach
	Neomeris vanbosseae Howe
Order Siphonocladales	
Family Boodleaceae	*Boodlea composita* (Harvey) F. Brand
	Cladophoropsis herpestica (Montagne) M.A. Howe
	Cladophoropsis vaucheriaeformis (J.E Areschoug) Papenfuss
	Struvea elegans Børgesen
Order Siphonocladales	
Family Siphonocladaceae	*Dictyosphaeria cavernosa* (Forsskål) Børgesen
	Dictyosphaeria intermedia Weber-van Bosse
	Dictyosphaeria versluysii Weber-van Bosse
	Siphonocladus sp.
Order Siphonocladales	
Family Valoniaceae	*Valonia aegagropila* C. Agardh
	Valonia fastigiata Harvey ex J. Agardh
	Valonia macrophysa Kützing
	Valonia ventricosa J. Agardh
	Valoniopsis pachynema (G. Martens) Børgesen
Order Ulvales	
Family Ulvaceae	*Ulva intestinalis* (Linnaeus) Nees
	Ulva lactuca Linnaeus
Class Phaeophyceae	
Order Dictyotales	
Family Dictyotaceae	*Dictyopteris repens* (Okamura) Børgesen
	Dictyopteris sp.
	Dictyota bartayresiana Lamouroux
	Dictyota ceylanica Kützing
	Dictyota cf. *canaliculata* O. De Clerck & E. Coppejans
	Dictyota cf. *friabilis* Setchell
	Dictyota cf. *pfaffii* Schnetter
	Dictyota divaricata Lamouroux
	Dictyota friabilis Setchell
	Dictyota grossedentata De Clerck & Coppejans
	Dictyota hamifera Setchell
	Dictyota sp.
	Distromium sp.
	Lobophora papenfussii (W.R. Taylor) Farghaly
	Lobophora variegata (Lamouroux) Womersley ex Oliveira
	Padina boryana Thyvi
	Padina melemele Abbott & Magruder in Abbott
	Padina sp.
	Padina sp. nov.
	Stypopodium flabelliforme Weber-van Bosse
Order Ectocarpales	
Family Acinetosporaceae	*Hincksia indica* (Sonder) J. Tanaka
Order Fucales	
Family Sargassaceae	*Sargassum aquifolium* (Turner) C. Agardh
	Spatoglossum asperum J. Agardh
	Turbinaria ornata (Turner) J. Agardh
Order Sphacelariales	
Family Sphacelariaceae	*Sphacelaria tribuloides* Meneghini

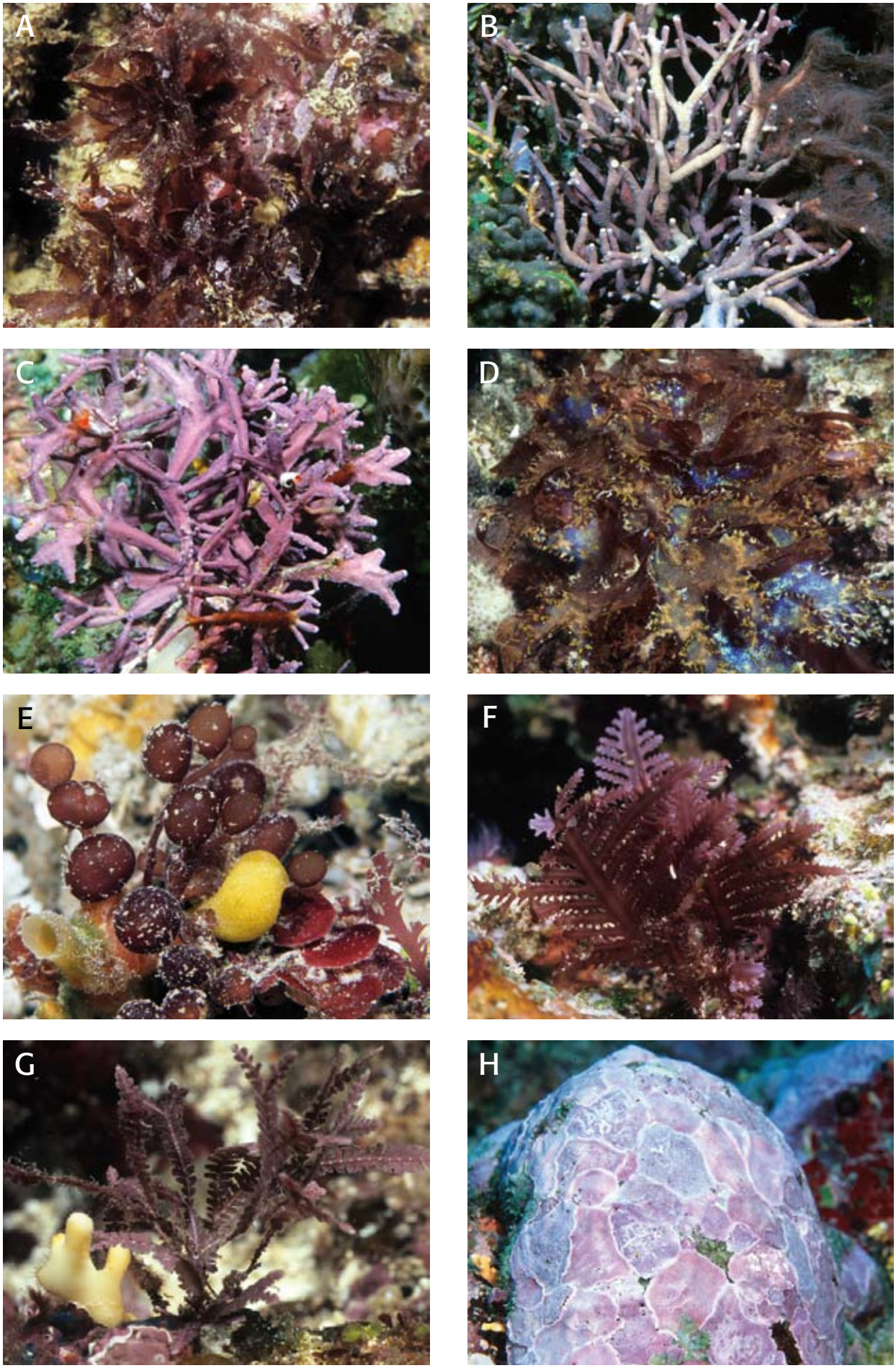

Figure 423: Rhodophyta. **A**: *Amansia rhodantha*. **B**: *Amphiroa crassa*. **C**: *Amphiroa foliacea*. **D**: *Asteronemia anastomosans*. **E**: *Botryocladia spinuligera*. **F**: *Callophycus serratus*. **G**: *Cheilosporum spectabile*. **H**: Corallinales complex. (Photos J.-L. Menou IRD Nouméa).

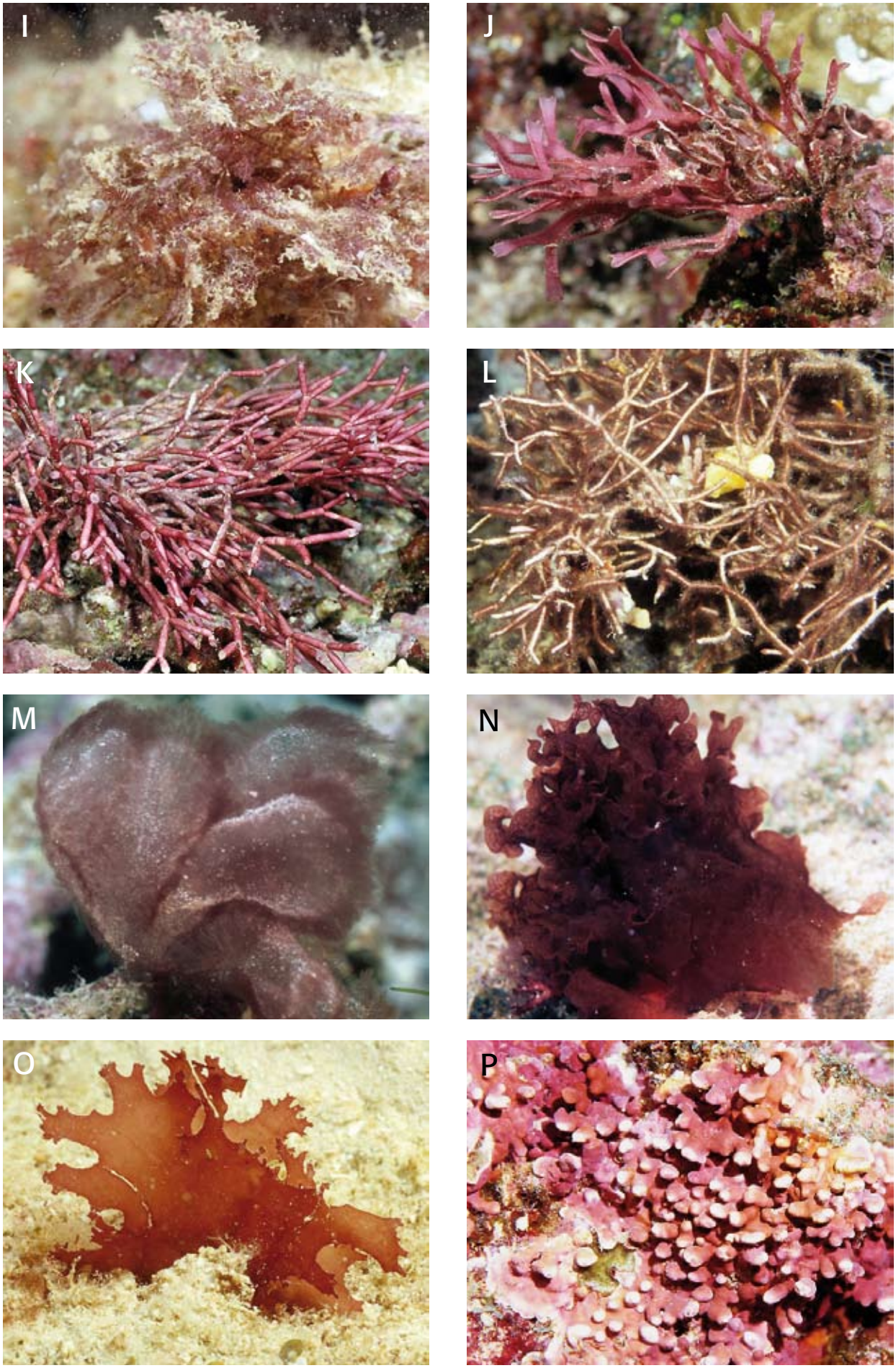

Figure 424: Rhodophyta. **I**: *Dasyphila plumarioides*. **J**: *Dichotomaria marginata*. **K**: *Dichotomaria obtusata*. **L**: *Galaxaura divaricata*. **M**: *Gibsmithia hawaiiensis*. **N**: *Halymenia porphyraeformis*. **O**: *Halymenia stipitata*. **P**: *Lithothamnion proliferum*. (Photos J.-L. Menou IRD Nouméa).

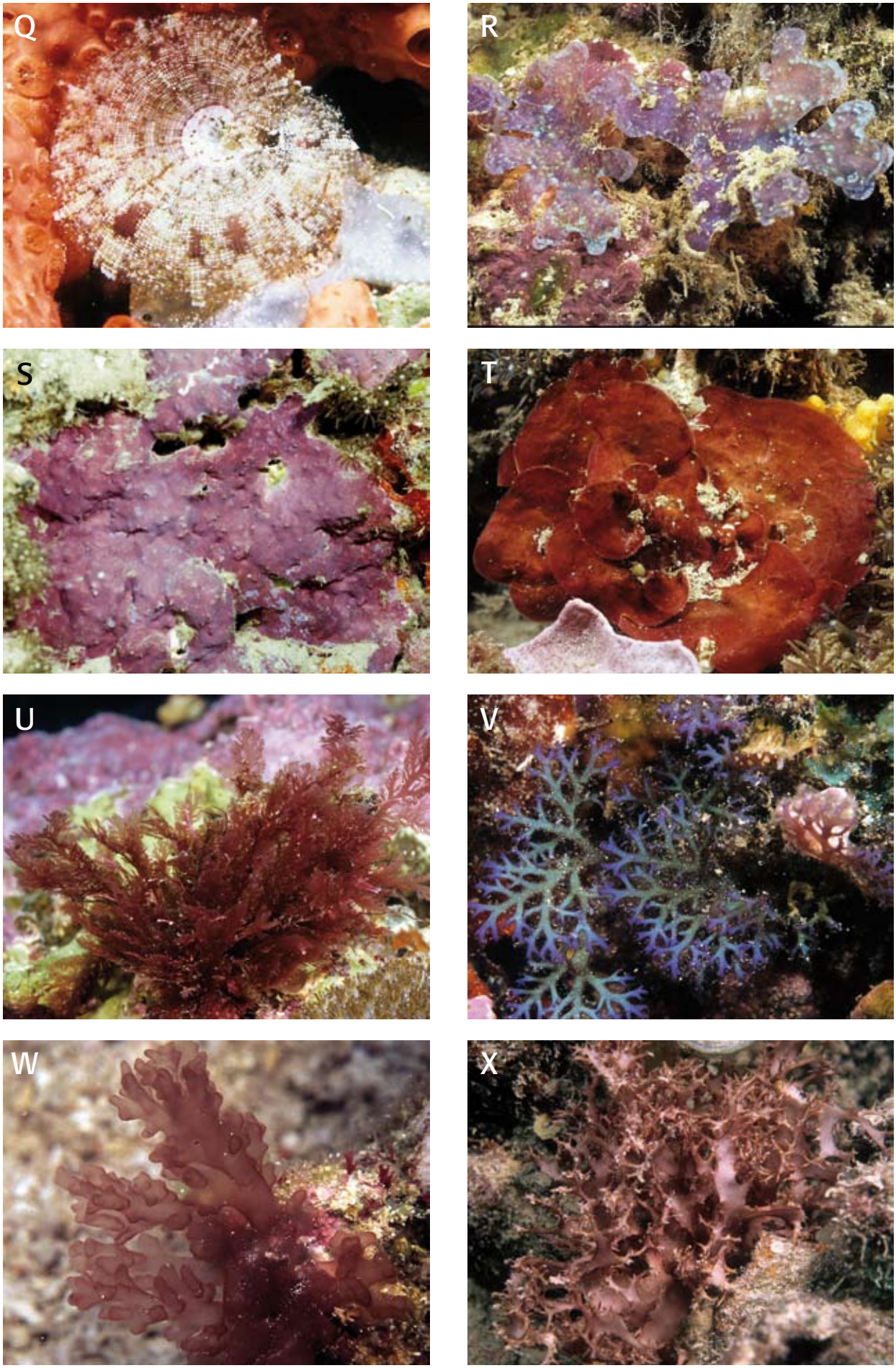

Figure 425: Rhodophyta. **Q**: *Martensia flabellata*. **R**: *Martensia* sp. nov. **S**: *Neogoniolithon fosliei*. **T**: *Peyssonnelia inamoena*. **U**: *Plocamium sandvicense*. **V**: *Portieria hornemanii*. **W**: *Predaea laciniosa*. **X**: *Titanophora weberae*. (Photos J.-L. Menou IRD Nouméa).

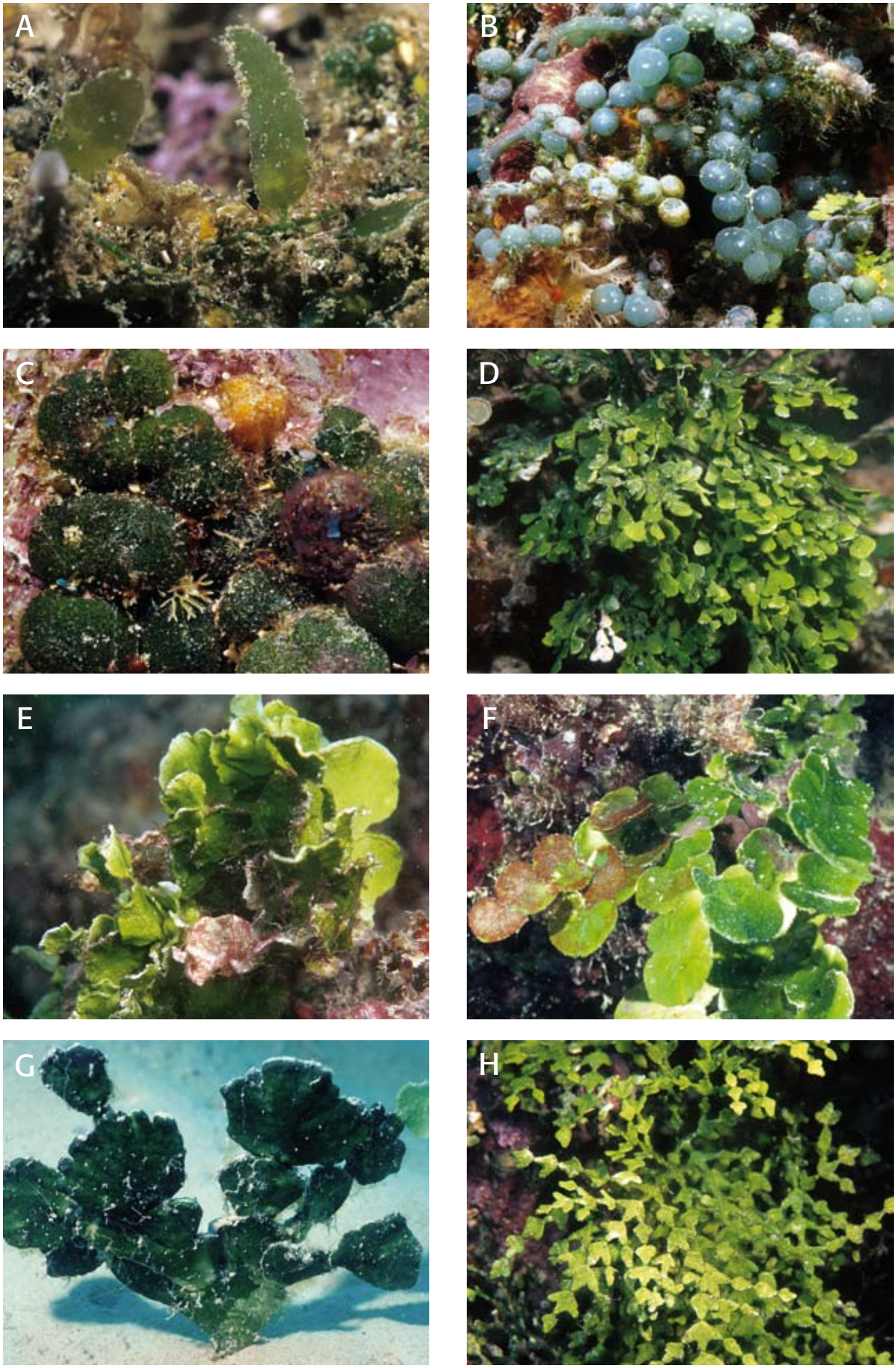

Figure 426: Chlorophyta. **A**: *Caulerpa bisserulata*. **B**: *Caulerpa fergusoni*. **C**: *Codium mamillosum*. **D**: *Halimeda cuneata*. **E**: *Halimeda discoidea*. **F**: *Halimeda lacunalis*. **G**: *Halimeda macroloba*. **H**: *Halimeda minima*. (Photos J.-L. Menou IRD Nouméa).

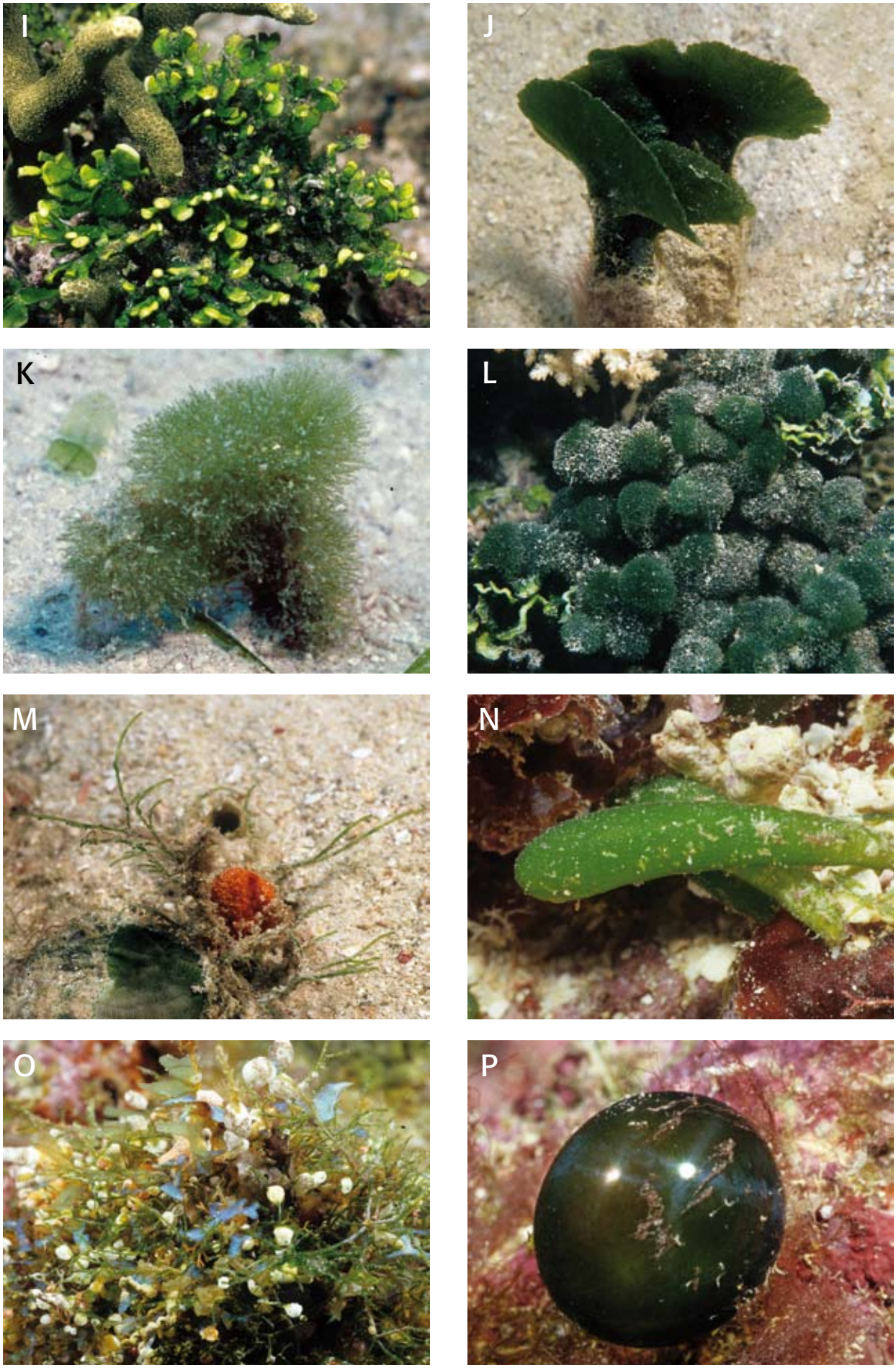

Figure 427: Chlorophyta. **I**: *Halimeda taenicola*. **J**: *Avrainvillea erecta*. **K**: *Rhipilia* sp. **L**: *Tydemania expeditionis*. **M**: *Cladophora ohkuboana*. **N**: *Bornetella nitida*. **O**: *Cladophorospsis herpestica*. **P**: *Valonia ventricosa*. (Photos J.-L. Menou IRD Nouméa).

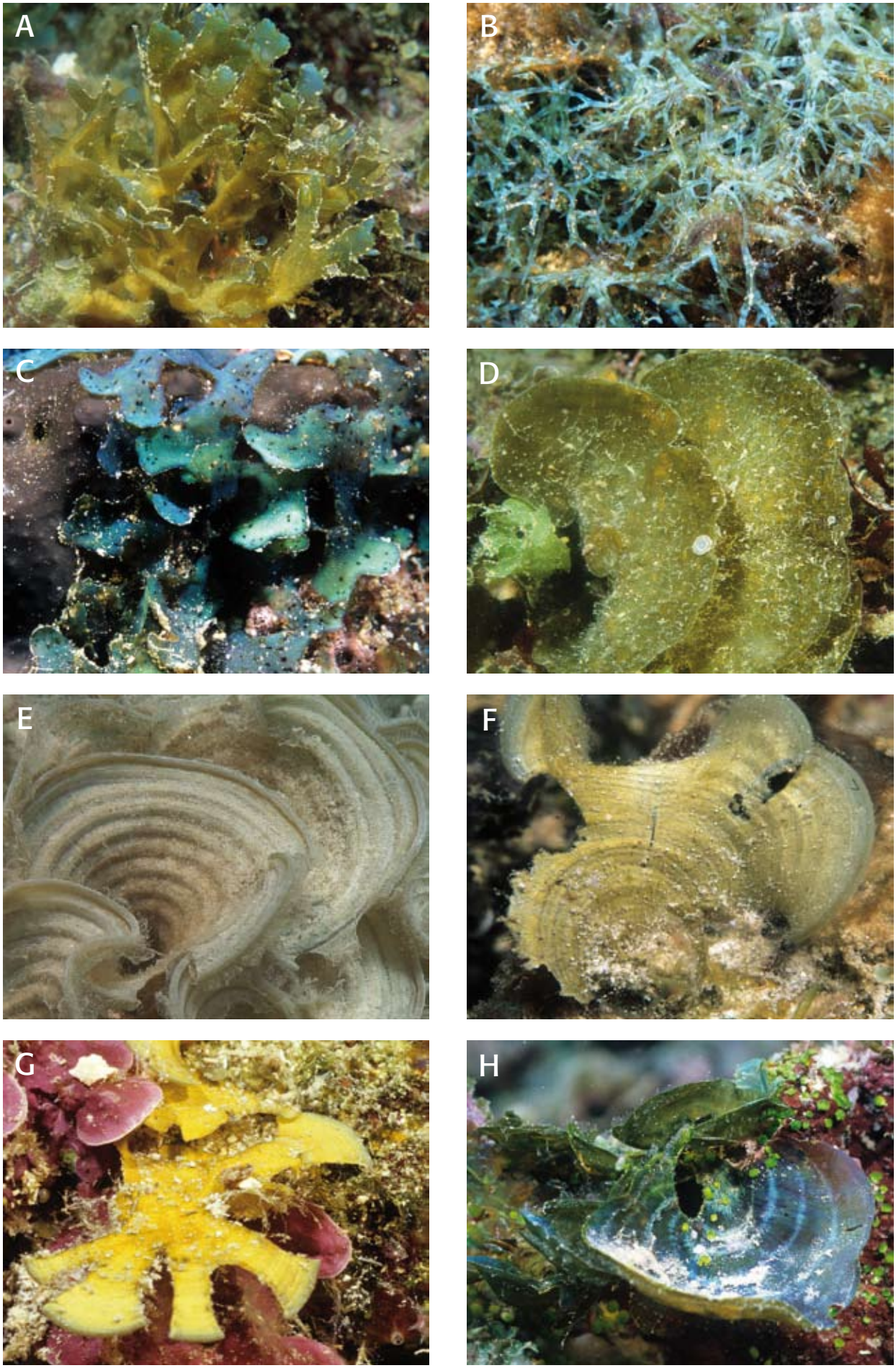

Figure 428: Phaeophyceae. **A**: *Dictyota barteyresiana*. **B**: *Dictyota ceylanica*. **C**: *Dictyota friabilis*. **D**: *Distromium* sp. **E**: *Padina boryana*. **F**: *Padina melemele*. **G**: *Padina* sp. **H**: *Stypopodium*. (Photos J.-L. Menou IRD Nouméa).

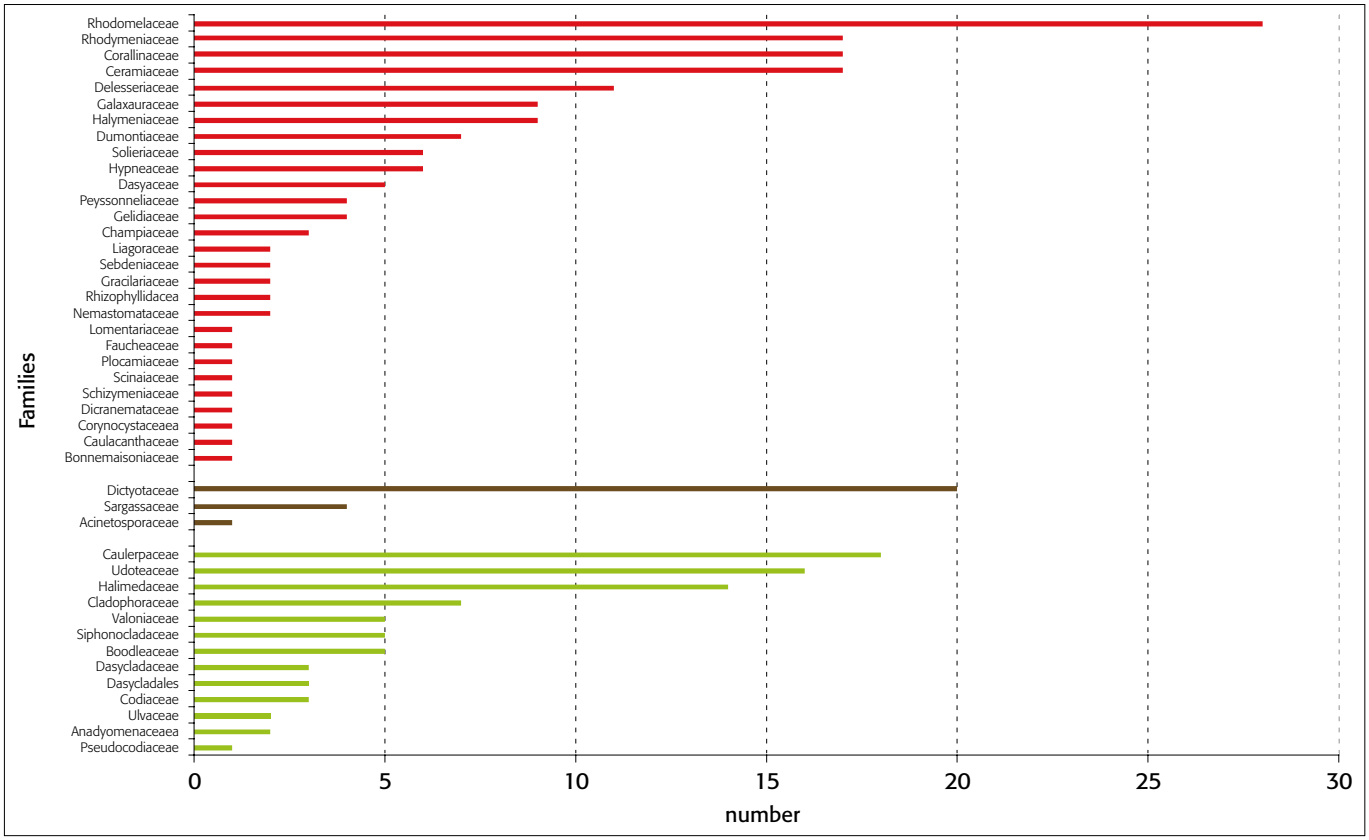

Figure 429: Species richness of the families of Rhodophyta (red), Phaeophyceae (brown) and Chlorophyta (green).

Algal assemblages

Algal vegetation on outer reefs and slopes down to 20 m

The algal community on the outer reef and slope down to 20 m in depth comprises a large number of encrusting coralline algae mixed with several dozen species growing among corals. Near the top of the reef, many species — mainly red algae — grow within the interstices of corals, and include *Chondrophycus parvipapillatus*, *Avrainvillea lacerata*, *Martensia flabelliformis*, *Halymenia porphyraeformis*, *Meristotheca procumbens*, *Champia vieillardii*, *Caulerpa nummularia*, *C. biserrulata* and *Halimeda micronesica*. In the breakwater area coralline algae *Hydrolithon onkodes* and *Neogoniolithon fosliei* develop thick candle-like crusts, with *Hydrolithon orthoblatum* or branched clumps of *Lithophyllum pygmaeum*. The vegetation can vary according to the topography and the presence of gutters and grooves is often associated with large clumps of *Callophycus serratus*, *Cheilosporum spectabile*, *Asparagopsis taxiformis*, *Dasyphila plumarioides*, *Tricleocarpa fragilis*, *Caulerpa* spp. and *Halimeda* spp. and small species such as *Chondria armata*, *Botryocladia* spp., *Chamaebotrys boergesenii* and *Portieria hornemanii*. The pinkish colours of coralline algae contrast with the very bright green pompom-like morphology of *Chlorodesmis hildenbrandtii* and *Rhipilia penicilloides*. Further down the reef slope, from 8-20 m deep, the motion of the water is reduced and the reefs support a higher coral cover and articulated calcareous algae such as *Amphiroa crassa*, *A. tribulus* and *A. foliacea*, and the green *Halimeda cuneata*, *H. gigas*, *H. minima* and *H. taenicola* dominate some reef slopes. Fleshy algae are less abundant and mostly comprise *Gibsmitha hawaiiensis*, *Amansia rhodanta* and *Valonia*

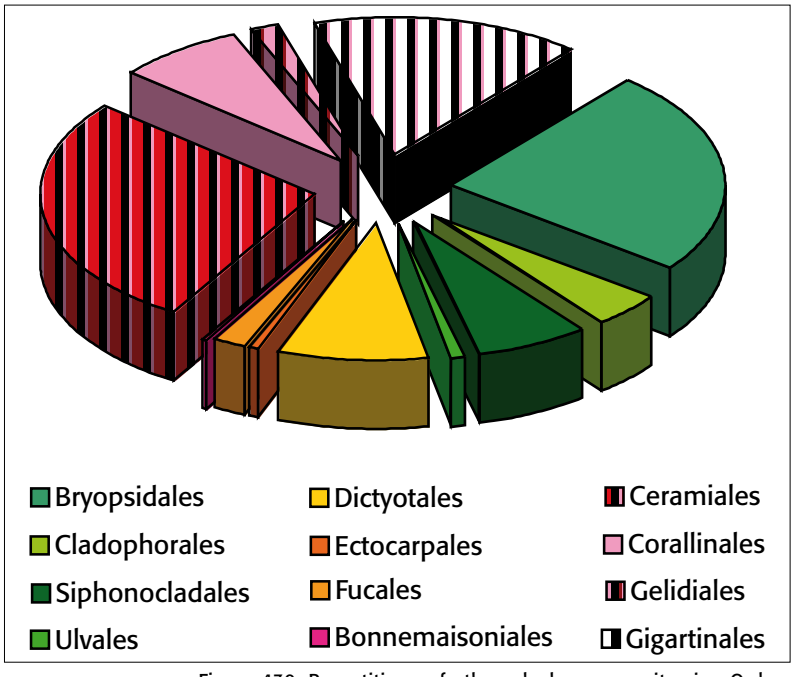

Figure 430: Repartition of the algal community in Orders Rhodophyta (red), Phaephyceae (brown), Chlorophyta (green).

fastigiata. Rubble is often found at the bottom of the slope rupture, at ~ 15 m deep and *Caulerpa serrulata*, *C. sedoides*, *Microdictyon umbilicatum*, *Neomeris van-bossea*, *Halimeda distorta*, *Valonia aegagropila*, *Myriogramme melanesiensis*, *Stypopodium flabelliforme* and *Padina* spp. grow among the coral debris. Various thin and small fronds of dark green *Rhipilia* spp. and *Rhipiliopsis* spp., *Anadyomene wrightii* form small associations in the shady areas with *Corynocystis protrata* and *Cryptonemia crenulata*.

••• Algal vegetation on deep outer slopes

In the outer slope from 40 m to at least 60 m deep, coral debris and coarse sand dominate the substratum. At the first glance fleshy algae are relatively few in species number and the vegetation is not luxuriant. Most of the gelatinous red algae such as *Dudresnaya capricornica*, *Predaea weldii*, *P. laciniosa*, *Gibsmithia hawaiiensis*, *G. larkumii*, and the green algae *Caulerpa fergusonii*, *C. sedoides*, *C. microphysa*, *Codium mamillosum*, *Rhipilia* sp. nov. grow in this environment on and among the coral debris, while the delicate green *Cladophora ohkuboana*, *C. dotyana* are found on sand. Brown algae are very few and *Dictyota bartayresiana* and *Padina* groupe *melemele* can be observed in this deep habitat.

••• Algal vegetation on coral walls

Coral walls usually start deeper than 30 m on the edge of limestone islands located in deep open water. This environment is often dark due to a heavily variegated surface with numerous interstices, overhangs and small caves. Coral walls are of great beauty with spectacular encrustations by coralline algae and *Peyssonnelia* spp. giving an attractive mosaic of forms and colours. The dominant *Lithothamnion prolifer* is easily recognisable by its pink crust and numerous short knobs. Numerous Rhodymeniales including several species of *Leptofauchea* and *Rhodymenia* live in the caves and interstices with *Cryptonemia crenulata*, *C. umbraticola*, *Corynocystis prostrata* and *Callophycus serratus*, while the iridescent *Halichrysis irregularis* and the star-like *Asteromenia anastomosans* grow luxuriantly on the walls with the large foliose *Peyssonnelia inamoena* and *P. capensis*. The golden-yellow *Padina melemele* and the green ball-like *Codium mamillosum* are present in discrete clumps among coral debris with very occasional *Sebdenia flabellata* and *S. cerebriformis*.

All these species can be found in other deep areas but in less abundance. The shady environment and open ocean influences enhance this algal community that is generally sheltered in the reef interstices.

••• Algal vegetation on the sandy bottom of deep lagoons

Various green algae grow together and develop meadows between coral colonies located on the coral sandy bottom at 25-30 m deep in the embayments. This sheltered and silty environment supports luxuriant vegetation including: *Udotea argentea*, *Avrainvillea erecta*, *Halimeda borneensis*, *H. distorta*, *Caulerpa verticilata*, *C. cupressoides*, *C. racemosa*, *C. sedoides*, *C. serrulata*, *C. taxifolia* as well as some red algae such as *Martensia*, *Titanophora webera* and the brown alga *Stypopodium flabelliforme* with its fan-like shape and iridescent blue on the thallus surface.

••• Algal vegetation on shallow reef flats

The shallow fringing reef flat along the shoreline to the north of Luganville supports many algae from the beach to the reef front. The flats are exposed at low tide and corals are therefore reduced in abundance, except at the outer part of the reef flat where large stands of staghorn *Acropora* grow in the gutters perpendicular to the reef front. Adjacent to the beach, the reef is covered with a green underwater "turf" mainly composed of *Cladophora glomerata*, *Boodlea composita* and *Boergesenia forbesii* that is partially buried in the sand. Several *Caulerpa*, *C. fastigiata*, *C. racemosa*, *C. serrulata* along with light green *Chlorodesmis fastigiata*, *Halimeda opuntia* and the red pompom-like algae *Galaxaura filamentosa* and *G. rugosa* grow on the inner part of the reef. Among the coral branches there are numerous green algae *Dictyosphaeria cavernosa* and *H. micronesica*. The edible red seaweed *Meristotheca procumbens* was abundant within the coral branches and in the interstices on the reef margin. The vegetation on the front part is dominated by nongeniculated coralline algae including crusts of *Hydrolithon onkodes* and the candle-like thallus of *H. orthoblastum*. Various articulated coralline algae such as *Amphiroa* spp. form clumps on the reef top. Surprisingly, no stands of *Sargassum* were observed except occasional young stages of *Sargassum aquifolium*.

••• Algal vegetation in shallow sandy coral communities

The algal vegetation associated with the coral community in shallow sandy environments is mainly represented by patches of the fan-like brown alga *Padina boryana* mixed with another brown alga *Turbinaria ornata* and various species of green algae such as *Caulerpa cupressoides*, *C. racemosa*, *C. racemosa* var *lamourouxii*, *C. fergusonii*, *Boodlea composita* and *Udotea argentea* and the red algae *Galaxaura rugosa*, *Hypnea* spp. and *Tolypiocladia glomerata*. *Microdictyon umbilicatum*, *Halimeda discoidea* and *Myriogramme melanesiensis* grow among the branches of staghorn *Acropora*. Moreover, the delicate red algae *Martensia fragilis*, *Neomartensia flabelliforme*, *Haloplegma duppereyi*, along with *Laurencia* spp., *Exophyllym wentii* and several Rhodymeniales form small associations of a rich algal flora in the interstices of submassive corals *Porites rus* and *Montipora*.

••• Algal vegetation in channel environments

In general, the algal vegetation of the channels is not very rich due to the silty and muddy environment that

limits algal diversity. There is no typical association of algae from this environment except the brown alga *Spatoglossum asperum* which has only been recorded in the Segond Channel and Malo passage. The algal flora has characteristics that are typical of sheltered areas; *Halimeda* spp. and *Caulerpa* spp. can locally cover the substratum and most of the investigated sites showed coral damage. The algal vegetation associated with dead coral communities is described in the next section.

Algal vegetation on dead coral communities

Santo coral reefs have experienced heavy damage from successive cyclones, bleaching events and crown-of-thorns starfish (*Acanthaster*) outbreaks in the past decades. Thus on the outer reefs and slopes along the channel, the dead corals are colonized by small prostate algae such as the brown *Dictyota friabilis*, *Lobophora variegata* and large green calcareous *Halimeda distorta* and *H. minima*. In more exposed locations, dead and collapsing branches are overgrown by coralline algae, turfs of filamentous red algae and cyanobacteria assemblages. Depending on the local environmental and reef condition, this pioneer stage of colonization will evolve into a secondary succession of algal-dominated communities or revert to coral recolonization.

Remarks on the absence of *Sargassum* beds

Sargassum species are common features of the algal vegetation of tropical islands in the Pacific. However, around Santo this genus is restricted to limited germlings and the reduced thalli of *Sargassum aquifolium* on reef flats, while personal observations in Efate at the same period have shown the presence of large beds of *Sargassum* including several common tropical species such as *S. polycystum*. The lack of suitable habitats such as sheltered shallow lagoons could explain the absence of the species in these biotopes around Santo.

Seagrass communities

Seagrasses are flowering plants belonging to the Cymodoceaceae and the Hydrocharitaceae families which are placed in the Alismatales order (nomenclature based on molecular analysis). In tropical regions they are mostly permanently submerged in marine and estuarine biotopes that are generally sheltered from wave action and offer a suitable substratum for rooting in mud, sand or coarse rubble. In many places they can also develop into large meadows or beds in deeper lagoon zones down to 40 m deep, on barrier reefs or surrounding lagoon islands. They are remarkable habitats in tropical shallow waters and they often form a key functioning system on sandy bottoms along shorelines between mangroves and coral reefs.

Most coastal areas around Santo do not have these typical seagrass habitats and only the fringing sandy flats adjacent to estuarine and river catchments, sheltered embayments and inner reef sandy flats provide the necessary conditions for seagrass development. However, deep sandy slopes, sandy channel slopes and bottoms also support the paddle-like *Halophila* seagrasses.

Eight species of seagrass were reported from our survey (Table 38), four of these are new records for Santo: *Cymodocea serrulata*, *Enhalus acoroides*, *Halophila capricorni* and *H. decipiens*, and the two species of *Halophila* had not been previously recorded for the Vanuatu archipelago.

Seagrass diversity and abundance were relatively low in the investigated areas. Plants never form large meadows; they mostly developed in scattered patches except in Palikolo bay where they form dense mats (>75 % coverage) in 70 m wide zones that represent the most extensive bed surveyed. The seagrass communities generally comprised few species; most of the sites had just one to three species growing together. The inner sandy areas such as Palikolo bay, the Aore shoreline in the Malo passage and the estuarine zone adjacent to Luganville showed the highest species diversity with four species growing together. However, most of the time one species was dominant in the bed, i.e. *Halodule uninervis* in Luganville, *Cymodocea rotundata* in Palikolo. In some localities seagrasses form mixed communities with marine algae such as *Halimeda macroloba*, *H. cylindracea*, *H. borneensis*, *Caulerpa serrulata*, *Padina boryana* and *Acanthophora spicifera*.

Table 38: List of seagrass species from Santo waters.

Class	Order	Family	Genus	Species	Authority
Anthophyta	Alismatales	Cymodoceacea	*Cymodocea*	*rotundata*	(Hemprich & Ehrenberg) Aschers & Schweinf
			Cymodocea	*serrulata*	(R. Brown) Aschers & Magnus
			Halodule	*uninervis*	(Forsskål) Ascherson in Boissier
		Hydrocharitacea	*Enhalus*	*acoroides*	(Linnaeus) Royle
			Halophila	*capricorni*	Larkum
			Halophila	*decipiens*	Ostenfed
			Halophila	*ovalis*	(R. Brown) J.D. Hooker
			Thalassia	*hemprichii*	(Ehrenberg) Ascherson

Except for the species of *Halophila*, all the other taxa were confined to very shallow waters although they are known to grow in deeper habitats elsewhere.

It is clear that the coastal physiography of Santo does not provide ideal habitats for seagrass meadows, but it is not clear why seagrasses are so restricted in shallow waters and are not well developed in other areas that appear to be suitable. Part of the explanation could be due to climatic conditions. The high occurrence of cyclones and rough seas can provoke sediment movements and salinity changes, which may have prevented the establishment of seagrasses or removed beds which would both have limited the development or the absence of this key functioning habitat. This situation could turn critical with the predicted increase of threats as a result of human activities and climate change. Seagrass habitats must be considered as associated ecosystems to coral reefs just like mangroves. All these habitats are important and integral components of the natural environment of Santo and they must be considered as priorities in conservation efforts. This study provides information that could aid coastal zone planning and development.

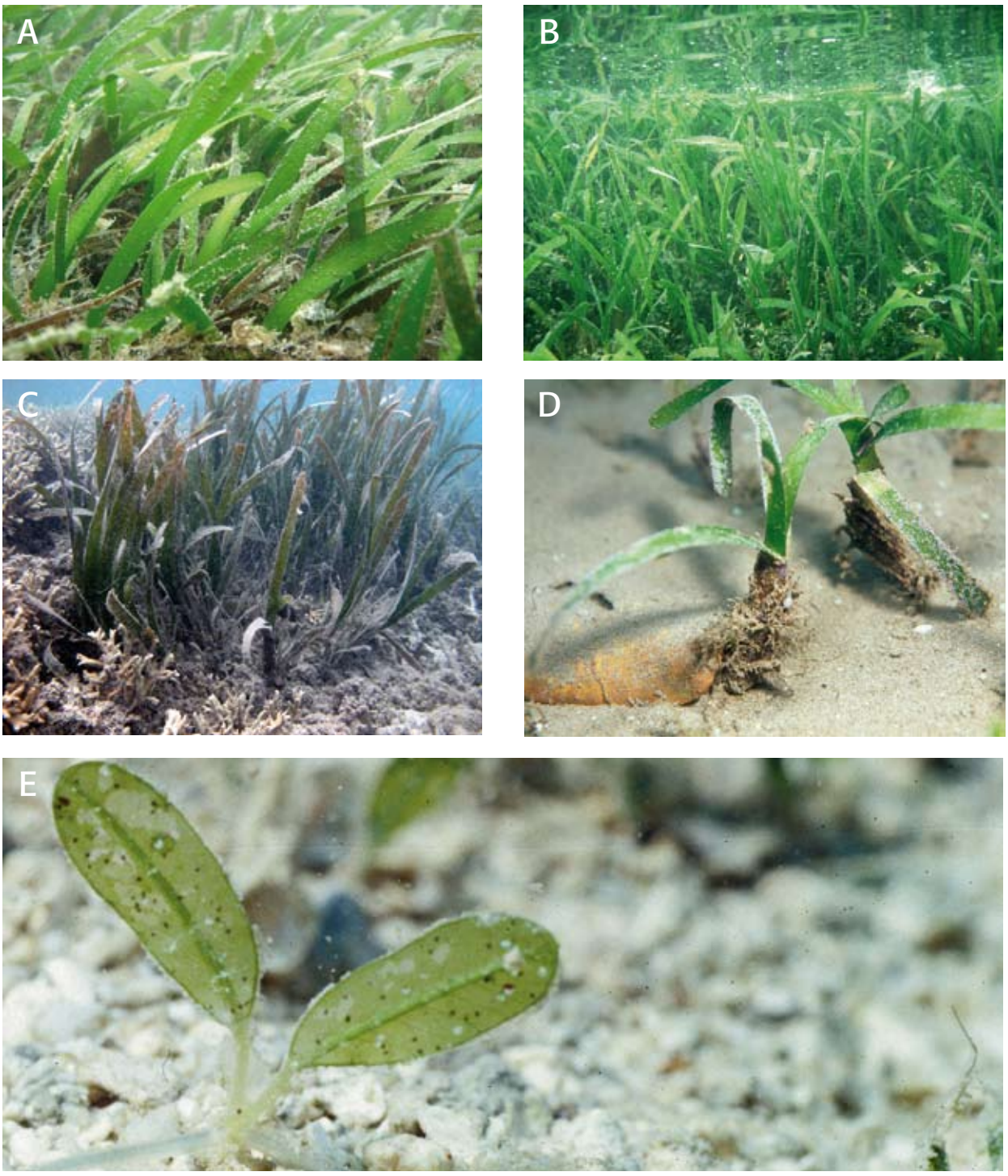

Figure 431: Seagrass species. **A**: *Cymodocea serrulata*. **B**: *Halodule uninervis*. **C**: *Enhalus acoroides*. **D**: *Thalassia hemprechii*. **E**: *Halophila capricorni*. (Photos J.-L. Menou IRD Nouméa).