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# A Baseline Survey of Red Algae (Rhodophyta) at Three Coastal Localities in Northern Luzon, Philippines

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## Abstract

*Rhodophyta are ecologically and economically important components of marine macroalgal assemblages, yet comparable site-level information from geographically separated coastal localities in Northern Luzon remains limited. This study documented Rhodophyta composition, site occurrence, and diversity at Brgy. Daddao, Calayan, Cagayan; Brgy. Canaoay, San Fernando, La Union; and Brgy. Didaddungan, Palanan, Isabela. Each locality was surveyed once during August-September 2025 using three 30-m line transects with fixed observation points at 10, 20, and 30 m. Taxa were identified primarily from macromorphological characters using regional references, with names cross-checked against AlgaeBase and representative vouchers retained. Thirty-one Rhodophyta taxa representing 9 orders and 14 families were recorded. During the survey, Calayan had the highest observed richness (24 taxa) and thallus count (253), followed by Palanan (7 taxa; 104 thalli) and San Fernando (5 taxa; 11 thalli). Shannon diversity index was highest in Calayan (H' = 2.921), Pielou's evenness was highest in San Fernando (J' = 0.961), and Simpson's dominance was highest in Palanan (D = 0.263). Twenty-seven taxa were recorded at only one surveyed locality, three occurred at two localities, and Tricleocarpa cylindrica occurred at all three. The marked site-to-site turnover is consistent with spatial heterogeneity reported in Philippine macroalgal surveys, but the present single-period design does not identify its environmental causes. Physicochemical measurements were therefore treated as contextual observations rather than predictors. The study provides a voucher-backed, Rhodophyta-focused baseline for future seasonal, spatial, habitat-based, and taxonomic monitoring in Northern Luzon.*

**Keywords:** *Rhodophyta; macroalgae; biodiversity baseline; site occurrences; Northern Luzon, Philippines.*

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# INTRODUCTION

Red algae (Rhodophyta) are prominent components of tropical marine floras. They contribute to primary production, nutrient cycling, habitat structure, and benthic community complexity, and several groups are harvested for food, agar, carrageenan, and other products (Cotas et al., 2020; Carpena et al., 2024). Philippine macroalgal diversity is well documented at the national scale, but locality-level records remain uneven, particularly for coastlines in Northern Luzon. Baseline surveys are therefore still needed where comparable field observations and preserved specimens are limited.

National checklists and regional surveys show that the Philippine marine algal flora is taxonomically rich (Trono & Ganzon-Fortes, 1988; Ayson & Encarnacion, 2008; Ganzon-Fortes, 2012; Lastimoso & Santiañez, 2021). They also show that assemblage composition can vary over relatively short distances. Baleta and Nalleb (2016), for example, documented differences among stations in Sta. Ana, Cagayan, while Del Rosario et al. (2016) surveyed the intertidal macroalgae of San Francisco–Canaoay, San Fernando, La Union. More recent Philippine surveys likewise report strong spatial variation in macroalgal composition (Trapa et al., 2024; Elias et al., 2024). Direct numerical comparisons among these studies are limited, however, because they differ in taxonomic scope, sampling design, habitat coverage, and sampling period.

The three localities examined here lie on different Northern Luzon coastlines: Brgy. Daddao in Calayan, Cagayan; Brgy. Canaoay in San Fernando, La Union; and Brgy. Didaddungan in Palanan, Isabela. Their surveyed intertidal settings also differed visibly. Calayan was dominated by sandy coral rubble, San Fernando by coarse sand with rock outcrops, and Palanan by sandy substrate with shell fragments and relatively sheltered conditions. These contrasts provide useful context for comparing the samples, but they were not replicated experimentally and are not treated as tested causes of assemblage differences.

This study used the same Rhodophyta-focused sampling framework at the three localities and retained voucher material for taxonomic re-examination. It addressed three questions: (1) which Rhodophyta taxa were recorded at each locality during the survey; (2) how did observed richness, thallus counts, and sample-level diversity metrics differ among the three sampled assemblages; and (3) which taxa were shared among localities or recorded at only one locality? The aim was to establish a transparent baseline for subsequent seasonal, habitat-based, anatomical, and molecular work, rather than to infer long-term abundance patterns or environmental causes from a single sampling period.

# METHODOLOGY

### Study Area

The study was conducted at three selected coastal sites of Northern Luzon, Philippines, during August - September 2025: Brgy. Daddao, Calayan, Cagayan (19°15′20″ N, 121°30′39″ E); Brgy. Canaoay, San Fernando, La Union (16°34′57″ N, 120°17′59″ E); and Brgy. Didaddungan, Palanan, Isabela (16°58′21″ N, 122°28′01″ E), shown in Figure 1. The sites were purposively selected to represent contrasting coastal settings and substrate characteristics.

Calayan is situated along the northern coast facing the Babuyan Channel and is characterised predominantly by sandy rubble derived from coral fragments, shell debris, and volcanic sediments. Small- to medium-sized seaweeds and seagrasses occur in the intertidal zone, and the area experiences moderate to high wave and wind exposure.

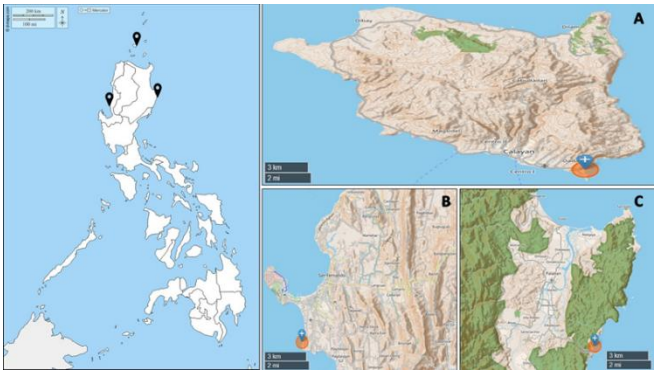



**Figure 1.** Map of the Philippines, showing the three localities in Northern Luzon, Philippines. (A) Calayan, Cagayan, showing the exact sampling location at Brgy. Daddao. (B) San Fernando, La Union, showing the exact sampling location at Brgy. Canaoay. (C) Palanan, Isabela, showing the exact sampling location at Brgy. Didaddungan.

San Fernando is located along the western coast of Northern Luzon, facing the West Philippine Sea. The site has a coarse sandy substrate with rock outcrops and moderate wave action.

Palanan is located along the eastern coast of Northern Luzon, facing the Philippine Sea. The intertidal zone is characterised by sandy substrate containing shell fragments and relatively sheltered wave conditions.

### Sampling Design and Data Collection

Sampling was conducted once at each locality during August-September 2025, within the Southwest Monsoon period (PAGASA, 2025). A standardized line-transect design adapted from established Philippine macroalgal survey procedures (Ganzon-Fortes, 2012) was used to document Rhodophyta occurrence under the same field framework at all three localities. Three 30-m transects were established per locality, with adjacent transects separated by approximately 50 m and positioned perpendicular to the shoreline. Fixed observation points were located at 10, 20, and 30 m along each transect, yielding nine observation points per locality and 27 observation points across the study.

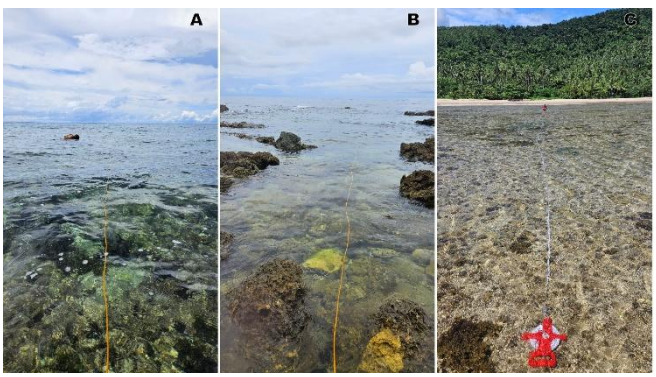



**Figure 2.** Field sampling using the line-transect method at the three study sites. (A) Brgy. Daddao, Calayan, Cagayan. (B) Brgy.

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Canaoay, San Fernando, La Union. (C) Brgy. Didaddungan, Palanan, Isabela.

At each fixed observation point, Rhodophyta thalli intersecting the sampling point were identified, enumerated, and photographed in situ. The observation point, rather than the full transect area, was the sampling unit. Taxon-specific observations were retained by transect and then pooled across the three transects to obtain site-level observed thallus counts used for descriptive comparisons and diversity indices. These counts represent thalli encountered at the standardized sampling points; they are not estimates of population size, density, biomass, or percent cover. Because macroalgae can be clonal or form interconnected mats, the term 'observed thallus count' is used operationally for enumerated thalli encountered during sampling rather than as a claim of genetically distinct individuals.

**Specimen Collection and Taxonomic Identification**

Collected specimens were cleaned and washed with tap water to remove sand, debris, and epiphytes. The specimens were sorted by collection number and placed in a plastic container containing 4% solution (formalin + seawater) for morphological analysis (Trapa et al., 2024). They were then photographed before preservation to document their three-dimensional characteristics and colour for identification.

Representative portions of the collected material were preserved as voucher specimens to permit subsequent taxonomic re-examination. Representative voucher specimens corresponding to recorded taxa were deposited at the Biology Department of Isabela State University–Cabagan Campus under the specimen ID number: MCF-0825-00001, MCF-0825-00002, MCF-0825-00003, MCF-0825-00004, MCF-0825-00005, MCF-0825-00006, MCF-0825-00011, MCF-0825-00017, MCF-0825-00019, MCF-0825-00021, MCF-0825-00022, MCF-0825-00027, MCF-0825-00032, MCF-0825-00035, MCF-0825-00037, MCF-0825-00040, MCF-0825-00042, MCF-0825-00048, MCF-0825-00041, MCF-0825-00053, MCF-0825-00055, MCF-0925-00058, MCF-0925-00059, MCF-0925-00061, MCF-0925-00063, MCF-0925-00065.

**Environmental Parameters**

Temperature, salinity, dissolved oxygen, and pH were measured once at each locality using a Yieri 5-in-1 multiparameter probe. These measurements were recorded to characterize conditions encountered during the field visit. Because no within-site or temporal replication was available, the physicochemical variables were not subjected to inferential statistical testing and were not used to explain or predict differences in Rhodophyta composition, thallus counts, or diversity.

**Morphological Analysis**

ISU) - Cabagan Campus using macromorphological characters. In situ photographs were used together with characters including thallus habit, branching pattern, color, degree of calcification, and attachment structures. Identification followed regional taxonomic references, including Hurtado-Ponce et al. (2006), Trono (1997, 1999, 2007, 2017), Calumpong and Menez (1997), Trono and Ganzon-Fortes (1988), and Lastimoso and Santiañez (2021), with additional taxonomic comparison based on Dumilag et al. (2016). Scientific names were initially cross-checked against AlgaeBase and were re-audited against current AlgaeBase/WoRMS nomenclature prior to submission (Guiry & Guiry, 2026). Where species-level identification could not be supported confidently by macromorphology, the taxon was retained at a higher or unresolved level.

Since identifications were based primarily on macromorphological characters, the taxonomic assignments are regarded as morphology-based identifications. Taxa for which microscopic reproductive characters or molecular markers are known to be important for reliable discrimination should be considered provisional pending anatomical or molecular confirmation.

**Data Analysis**

Field records were organised by locality and transect. Taxon-specific counts from the three transects were pooled to obtain the observed thallus count for each taxon at each locality. Analyses were conducted in Paleontological Statistics (PAST) version 4.03. Descriptive summaries included observed taxon richness (S), total observed thallus count (N), contribution to the pooled count, site occurrence, and diversity indices. Because each locality was surveyed during a single sampling period and the pooled locality values were not independent replicates of broader coastal regions, no inferential tests of differences among localities were performed.

Site occurrence was summarized as detection at one locality, two localities, or all three localities. Shannon–Wiener diversity was calculated as $H' = -\Sigma p_i \ln(p_i)$, Simpson's dominance as $D = \Sigma p_i^2$, and Pielou's evenness as $J' = H'/\ln(S)$, where $p_i$ is the proportion of the observed thallus count represented by taxon i and S is observed taxon richness. The indices describe the structure of the samples collected during the survey; they are not estimates of long-term or site-wide diversity.

# RESULTS

### 1. Taxonomic Composition and Classification

A total of 31 Rhodophyta taxa representing 9 orders and 14 families were recorded across the three surveyed coastal sites during August–September 2025. Their taxonomic composition is summarized in Fig. 3, and Table 2 presents the classification, representative morphology, and specimen photographs used in the inventory.

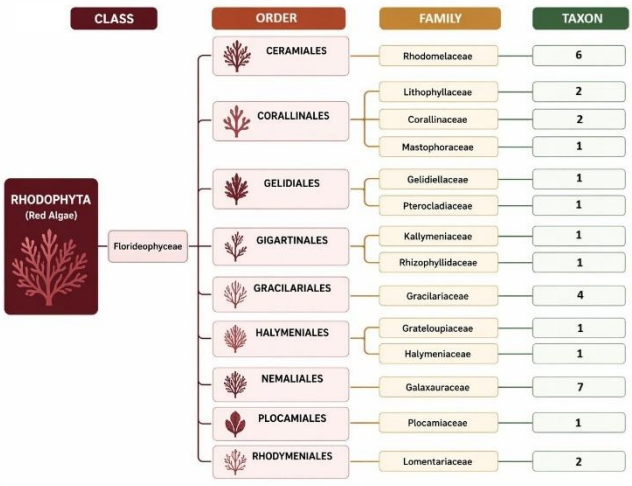



**Figure 3.** Summary of the taxonomic composition of the 31 Rhodophyta taxa recorded at the three selected sites.

Among the recorded orders, Nemaliales had the highest observed richness with seven taxa, followed by Ceramiales with six taxa, Corallinales with five taxa, and Gracilariales with four taxa.

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Gelidiales, Gigartinales, Halymeniales, and Rhodymeniales each contributed two taxa, whereas Plocamiales was represented by one taxon.

Among the recorded orders, Nemaliales had the highest observed richness with seven taxa, followed by Ceramiales with six taxa, Corallinales with five taxa, and Gracilariales with four taxa. Gelidiales, Gigartinales, Halymeniales, and Rhodymeniales each contributed two taxa, whereas Plocamiales was represented by one taxon.

The photographic and morphological documentation for the 31 recorded taxa is presented in Table 1. Species-level names reflect the morphology-based identifications used for this baseline survey; identifications requiring diagnostic anatomy or molecular data should be regarded as provisional, as stated in the Methods.

**Table 1.** Detailed taxonomic classification, morphological descriptions, and representative photographs of Rhodophyta recorded at three surveyed coastal localities in Northern Luzon, Philippines.

| Classification | Morphological Description | Illustration (Habit) |
|---|---|---|
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Ceramiales<br>Family: Rhodomelaceae<br>Tribe: Chondrieae<br>Genus: Acanthophora<br>Species: *Acanthophora spicifera* | Thallus erect, greenish brown to purple in color, with a small discoid holdfast. Branches are terete throughout, slightly attenuated towards the acute tips. Spinous projections are densely borne on spirally arranged determinate branchlets. | <br>Acanthophora spicifera<br>(Vahl) Børgesen |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Ceramiales<br>Family: Rhodomelaceae<br>Tribe: Amansieae<br>Genus: Amansia<br>Species: *Amansia glomerata* | Thallus pink to brownish red, forming thick clumps, attached to the substratum by means of a well-developed holdfast from which arise cylindrical to slightly compressed, irregularly branched axes. The ultimate branches bear crowded linear lanceolate blades forming "rosettes." Blade not corticated, with midrib, simple or decompound branchlets at their margins. | <br>*Amansia glomerata*<br>C. Agardh |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Ceramiales<br>Family: Rhodomelaceae<br>Tribe: Chondrieae<br>Genus: Chondria<br>Species: *Chondria armata* | Thallus small, pinkish red to dark brown in color, attached to substrate by a thick rootlike holdfast; main branches are naked at bases and distal portions densely covered with filiform on determinate rumuli on all sides; ramuli slightly fusiform towards bases and apices. Attached to tubeworm casings. | <br>Chondria armata<br>(Kützing) Okamura |

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|---|---|---|
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Ceramiales<br>Family: Rhodomelaceae<br>Tribe: Alsidieae<br>Genus: Digenea<br>Species: *Digenea simplex* | Thallus erect and tufted, purple to dark brownish-red, stiff and wiry at the base, cartilaginous at the apices, axes with loose repeated irregular dichotomous branching, densely covered with bristly, stiff multicellular unbranched short shoots on all sides except on the often denuded base; crustose holdfast. | <br>*Digenea simplex*<br>*(Wulfen) C.Agardh* |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Ceramiales<br>Family: Rhodomelaceae<br>Tribe: Laurencieae<br>Genus: Ohelopapa<br>Species: *Ohelopapa flexilis* | Thallus forms a dense, bushy clump. Dark reddish-brown to lighter olive green in color. Irregular to sub-dichotomous branching, branches are terete, slender, branchlet short and crowded toward the branch tips. | <br>*Ohelopapa flexilis*<br>(Setchell) F.Rousseau, Martin-Lescanne, Payri & L.Le Gall |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Ceramiales<br>Family: Rhodomelaceae<br>Tribe: Laurencieae<br>Genus: Palisada<br>Species: *Palisada perforata* | Thallus erect, cylindrical and cartilaginous, attached to the substratum by a discoid holdfast, forming low dense clusters, irregularly branched, main axis naked at lower portions. The dense branchlets may retain sand and coral debris, giving the thallus a mottled appearance. | <br>Palisada perforata<br>(Bory) K.W.Nam |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Corallinophycidae<br>Order: Corallinales<br>Family: Lithophyllaceae<br>Tribe: Amphiroeae<br>Genus: Amphiroa<br>Species: *Amphiroa fragilissima f. cyathifera* | Thallus very brittle to strong calcification; branches cylindrical, thin, segmented, regularly forking, sometimes also trichotomous, the angles between two fork branches usually rather wide (broadly Y-shaped); the segments are slightly swollen at the endings; yellowish red to whitish pink. The calcified branches are often prone to cracking and breaking upon collection and handling. | *Amphiroa fragilissima f. cyathifera*<br><br>(J.V. Lamouroux) Weber-van Bosse |

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|---|---|---|
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Corallinophycidae<br>Order: Corallinales<br>Family: Lithophyllaceae<br>Tribe: Amphiroeae<br>Genus: Amphiroa<br>Species: *Amphiroa foliacea* | Thallus forms a decumbent clump, highly calcified, pinkish to cream in color. The branch segments have distinct central midribs flanked on both sides by flattened extensions, or "wings." Basal segments with undulate lateral margins. Branching of the thallus is sub-dichotomous to trichotomous. | *Amphiroa foliacea*<br><br>J.V.Lamouroux |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Corallinophycidae<br>Order: Corallinales<br>Family: Corallinaceae<br>Tribe: Janieae<br>Genus: Jania<br>Species: Jania cultrata | Thallus highly calcified, pinkish to reddish in color, composed of decumbent branches. The branches are made up of distinctly flat, somewhat sagittate segments with a prominent midrib. The wing-like lateral extensions of the segments are mostly wide, flat, with parallel edges, and with truncate, undulate, gnawed, dentate, or incised outer tips. The other segments have broadly spinose lateral wings. | <br>*Jania cultrata*<br>(Harvey) J.H. Kim, Guiry & H.-G. Choi |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Corallinophycidae<br>Order: Corallinales<br>Family: Corallinaceae<br>Tribe: Janieae<br>Genus: Jania<br>Species: *Jania sp.* | Thallus small, calcified, brownish-red in color; branches calcified, branching repeatedly dichotomous with acute angles; interdichotomal segments cylindrical, longer than thick. Apical segment shorter. Characterized by the presence of light conceptacles at the distal end of the segments. | <br>*Jania sp.*<br>J.V. Lamouroux |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Corallinophycidae<br>Order: Corallinales<br>Family: Mastophoraceae<br>Genus: Mastophora<br>Species: *Mastophora rosea* | Thallus divaricate, decumbent, forming clumps, closely attached to Sargassum, pinkish to purplish on dorsal surface, grayish to whitish on ventral surface, thin, papery, irregularly dichotomously branched, forming ribbon-like branches. Branches complanate, cuneate, striations distinct; margins folded on the ventral surface; tips rounded, regularly forked. Conceptacles are numerous, scattered, and limited on the dorsal surface, with a pore at the center. | <br>*Mastophora rosea*<br>(C. Agardh) Setchell |

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| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Gelidiales<br>Family: Gelidiellaceae<br>Genus: Gelidiella<br>Species: *Gelidiella acerosa* | Thallus greenish-brown to reddish-purple in color. Creeping stolons form mats on hard substrates. Branches are pinnately arranged, erect, and decumbent with a terete to compressed central axis. Branchlets are upcurved and generally decreasing in length towards the apex. | <br>*Gelidiella acerosa*<br>(Forsskål) Feldmann & Hamel |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Gelidiales<br>Family: Pterocladiaceae<br>Genus: Pterocladiella<br>Species: *Pterocladiella capillacea* | Thallus dark purplish-red in color; flat and branches out regularly in a pinnate pattern. The bases of the branches are thin, and the tips are rounded, often tapering at both ends; The regularly pinnate branching produces a characteristic pyramidal outline. Margins are flattened, and determinate branches have coarse, serrated teeth. Several individuals grow in clumps, entangled with attached roots, but they tend to come apart when removed from rocks. | <br>*Pterocladiella capillacea*<br>(S.G.Gmelin) Santelices & Hommersand |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Gigartinales<br>Family: Kallymeniaceae<br>Genus: Callophyllis<br>Species: *Callophyllis fastigiata* | Thallus terete to slightly compressed and bushy, arising from a discoid holdfast or creeping multicellular haptera. Branches are cylindrical and constricted at the base. Branching irregular to alternate, usually becoming finer and fastigiate toward the distal portions of the thallus. Brownish-green or dark brown to purple when dry. | <br>Callophyllis fastigiata<br>(J.Agardh) J.Agardh |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Gigartinales<br>Family: Rhizophyllidaceae<br>Genus: Portieria<br>Species: *Portieria hornemannii* | Thallus has small, bright orange to red in color, composed of erect, overlapping, flattened branches with a small discoid holdfast. Has curved, or claw-like tips at the terminal branches. Branching is irregularly pinnate-alternate branching in one plane. Slightly gelatinous when fresh and adheres to paper when dried. | <br>*Portieria hornemannii*<br>(Lyngbye) P.C.Silva |

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| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Gracilariales<br>Family: Gracilariaceae<br>Genus: Gracilaria<br>Species: *Gracilaria arcuata* | Thallus erect, greenish-brown to reddish-purple in color, with cylindrical branches with numerous uneven protrusions. Primary and secondary branches prominent, mostly arcuate, terete throughout, slightly constricted at the base. Branching of the main axes generally secund; the terminal branch gives rise to two to three short, stubby, spinose branchlets at their distal portions. | <br>*Gracilaria arcuata*<br>Zardini |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Gracilariales<br>Family: Gracilariaceae<br>Genus: Gracilaria<br>Species: *Gracilaria salicornia* | Thallus bright orange to light green in habitat, branches distinctly divided into terete, sub-clavate to clavate segments, swollen at the distal end and constricted at the base, branching irregularly, subdichotomous to trichotomous to alternate. | <br>*Gracilaria salicornia*<br>(C. Agardh) E.Y. Dawson |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Gracilariales<br>Family: Gracilariaceae<br>Genus: Gracilaria<br>Species: Gracilaria textorii | Thallus flat, branch irregularly into a forked or palmate shape, spreading out like a fan. Greenish purple to light red orange, flabellate blade. Some individuals are twisted or have wavy edges. The thallus is firm and leathery, with small blackish, spherical reproductive structures distributed over the surface. | <br>*Gracilaria textorii*<br>(Suringar) Hariot |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Gracilariales<br>Family: Gracilariaceae<br>Genus: Gracilaria<br>Species: *Gracilaria tenuistipitata var. liui* | Thallus slender, bearing numerous, delicate, short to long lateral branchlets, branching mostly from the percurrent axes. Main axes cylindrical | <br>*Gracilaria tenuistipitata var. liui*<br>Zhang & Xia |

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|---|---|---|
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Halymeniales<br>Family: Grateloupiaceae<br>Genus: Grateloupia<br>Species: *Grateloupia crispata* | The body is flat and slightly twisted in the upper part, spreading three-dimensionally with repeated forked branches, forming a hemispherical mass. The branches are somewhat more numerous in the upper part, but are slightly wider in width. The tips of the branches are bluntly rounded and may be loosely bifurcated. The texture is hard and celluloid-like. The living specimen is red to dark red. | <br>*Grateloupia crispata*<br>(Okamura) Y.-P.Lee |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Halymeniales<br>Family: Halymeniaceae<br>Genus: Halymenia<br>Species: Halymenia sp. | The plant is red to purplish, soft-cartilaginous, slimy when fresh, shortly stipulated, and attached to the substrate by a discoid holdfast. Stipe short, flat, and expanded at its distal end supporting several narrow primary branches. Branching irregular, the lesser branches are also very narrow, with the ultimate branchlets irregularly linear and much twisted. | <br>*Halymenia sp.*<br>Bory de Saint-Vincent |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Nemaliophycidae<br>Order: Nemaliales<br>Family: Galaxauraceae<br>Genus: Actinotrichia<br>Species: *Actinotrichia fragilis* | Thallus form red to orange clumps, attached to rocky substrates on the reef flat and shallow subtidal areas. The branches are terete, regularly and repeatedly dichotomously branched, forming acute angles. The terminal branched-segments with truncate to rounded apices. All the branches are distinctly clothed with closely and regularly arranged bands or whorls of extended assimilatory filaments. | <br>*Actinotrichia fragilis*<br>(Forsskål) Børgesen |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Nemaliophycidae<br>Order: Nemaliales<br>Suborder: Galaxaurineae<br>Family: Galaxauraceae<br>Genus: Dichotomaria<br>Species: *Dichotomaria falcata (Galaxaura falcata)* | The body is cylindrical at the base, with a flat, linear body emerging from the top of the stalk. The thallus has a disc-shaped appressorium and densely covered with short hairs up to the base. Branching only seen occasionally at the base, flattened upper part branches multiple times into regular, forked shapes. The axils at the branching points are narrow. The branches are slightly calcified. They have a textured, somewhat firm feel. The living plant is brownish-red in color. When dried, they do not adhere to the mount and become harder and bulkier to the touch. | <br>*Dichotomaria falcata*<br>*(Kjellman) Kurihara & Masuda* |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Nemaliophycidae<br>Order: Nemaliales<br>Suborder: Galaxaurineae<br>Family: Galaxauraceae<br>Genus: Dichotomaria<br>Species: *Dichotomaria marginata (Galaxaura marginata)* | Thallus slightly calcified, bushy, solitary or gregarious, forming clumps, cream-red to brownish-red, with smooth surface. At the base, the main axes are terete, but above, they become flattened. Branching dichotomous. Thallus flat with margins slightly thickened, and with faint visible cross banding towards the apices. Thick-walled, sometimes with pointed white-tipped apices. | <br>*Dichotomaria marginata*<br>(J. Ellis & Solander) J.V. Lamouroux |

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|---|---|---|
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Nemaliophycidae<br>Order: Nemaliales<br>Suborder: Galaxaurineae<br>Family: Galaxauraceae<br>Genus: Dichotomaria<br>Species: *Dichotomaria obtusata (Galaxaura obtusata)* | Thallus brownish red to chalky grey-red, subdichotomously branched and clearly segmented, segments ovoid to elongate, rounded at both ends; found attached to the substratum by a holdfast, branching dichotomously. | <br>*Dichotomaria obtusata*<br>(J. Ellis & Solander) Lamarck |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Nemaliophycidae<br>Order: Nemaliales<br>Suborder: Galaxaurineae<br>Family: Galaxauraceae<br>Genus: Galaxaura<br>Species: Galaxaura rugosa | Thallus dimorphic, pinkish red to reddish-brown clumps on sandy, corally, and rocky substrates, composed of slightly calcified, terete branches that are regularly dichotomous, lightly constricted at both ends, and have annulate surfaces. The upper portion of the thallus is very smooth (glabrous) and lacks assimilatory filaments, while the lower portion is hairy. | <br>*Galaxaura rugosa*<br>*(J.Ellis & Solander) J.V.Lamouroux* |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Nemaliophycidae<br>Order: Nemaliales<br>Suborder: Galaxaurineae<br>Family: Galaxauraceae<br>Genus: Tricleocarpa<br>Species: *Tricleocarpa cylindrica* | Thallus forms erect, bushy, cylindrical, pinkish-red clumps on sandy-coralline or rocky substrates. There are nodes at regular intervals, and each node branches into a fork. The surface is generally smooth, but on closer inspection, ring-shaped wrinkles can be seen. The tips of the branches are flattened, as if they had been cut. The body contains a lot of lime. The thallus is firm when fresh and becomes harder after drying, consistent with its high degree of calcification. The living plant is pink to pale pink in color. Pressed leaf specimens do not stick to the mount. | <br>*Tricleocarpa cylindrica*<br>(J.Ellis & Solander) Huisman & Borowitzka |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Nemaliophycidae<br>Order: Nemaliales<br>Suborder: Galaxaurineae<br>Family: Galaxauraceae<br>Genus: Tricleocarpa<br>Species: *Tricleocarpa fragilis* | Thallus fragile, bushy, pinkish-red to brownish-white, forming hemispherical clumps. Regularly dichotomous branches consist of lightly calcified, smooth segments. Branch segments cylindrical, slightly constricted at both ends, sometimes broader near apices, with faint annulations and with obvious depressions at the truncate tips. Joints are flexible, noncalcified. Holdfast small, discoid, inconspicuous. Growing on rocks, dead coral fragments, and shells. | <br>*Tricleocarpa fragilis*<br>(Linnaeus) Huisman & R.A. Townsend |

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|---|---|---|
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Plocamiales<br>Family: Plocamiaceae<br>Genus: Plocamium<br>Species: *Plocamium telfairiae* | Thallus forms small clumps on substrate; slightly gelatinous when fresh, dark red in color, branches are membranous and thin; lateral branches are distichous, up to four times decompound, pinnate-alternate. The lower branches are usually simple and longer than those at the distal portions, which may give rise to small determinate branchlets at their tips, determinate branchlets, upcurved, sickle-shaped, broad with acute tips. | <br>*Plocamium telfairiae*<br>(W.J.Hooker & Harvey) Harvey ex Kützing |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Rhodymeniales<br>Family: Lomentariaceae<br>Genus: Ceratodictyon<br>Species: *Ceratodictyon repens* | Thallus reddish-brown in color, consists of a short branching basal stem (stipe) that gives rise to three to four dichotomously branched foliar segments arranged in one plane to form a fan-shaped tuft. Branchlets are fine, somewhat wiry. The base shows slight encrustation or attachment residues. | <br>*Ceratodictyon repens*<br>(Kützing) R.E. Norris |
| Phylum: Rhodophyta<br>Subphylum: Eurhodophytina<br>Class: Florideophyceae<br>Subclass: Rhodymeniophycidae<br>Order: Rhodymeniales<br>Family: Lomentariaceae<br>Genus: Ceratodictyon<br>Species: Ceratodictyon spongiosum | Thallus greenish brown to purple in color, distinctly sponge-like in appearance, hard and tough. Branching irregular, anastomosing in many parts. The branches have holes resembling the ostioles of true sponges. A branch is made up of terete filaments from which arise numerous short, attenuated, and intertwining branchlets. | <br>*Ceratodictyon spongiosum*<br>Zanardini |

*Note. Representative voucher specimens corresponding to the recorded taxa were deposited at the Biology Department of Isabela State University–Cabagan Campus. Nomenclature was re-audited before submission; Galaxaura pacifica Tanaka is treated under the currently accepted name Galaxaura rugosa (J.Ellis & Solander) J.V.Lamouroux.*

**Table. 2.** Observed taxon richness (S), total observed thallus count (N), and site contribution to pooled observed thallus count (%) of Rhodophyta across the three study sites in Northern Luzon, Philippines. Percentages are based on the observed thallus counts recorded at nine observation points per site.

| ***Study Sites*** | ***Taxon Richness (S)*** | ***Observed Thallus Count (N)*** | ***Pooled observed thallus count (%)*** |
|---|---|---|---|
| *Calayan, Cagayan* | **24** | **253** | **68.75%** |
| *Palanan, Isabela* | **7** | **104** | **28.26%** |
| *San Fernando, La Union* | **5** | **11** | **2.99%** |

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The three sampled assemblages differed markedly in observed richness and thallus counts (Table 2). Calayan yielded 24 taxa and 253 observed thalli, Palanan seven taxa and 104 thalli, and San Fernando five taxa and 11 thalli. Of the 368 thalli recorded at the fixed observation points, 68.75% were from Calayan, 28.26% from Palanan, and 2.99% from San Fernando. The percentages described are contributions to the pooled sample and are not estimates of percent cover or total locality-wide abundance.

**2. Site Occurrence/Distribution**

**Table 3.** Occurrence of Rhodophyta taxa recorded at Calayan, Cagayan; San Fernando, La Union; and Palanan, Isabela.

| Taxon | Authority | Site Occurrence | Sampling Sites | | |
|---|---|---|---|---|---|
| | | | Calayan, Cagayan | San Fernando, La Union | Palanan, Isabela |
| *Acanthophora spicifera* | (Vahl) Børgesen | Once | + | - | - |
| *Actinotrichia fragilis* | (Forsskål) Børgesen | Twice | + | - | + |
| *Amansia glomerata* | C. Agardh | Once | + | - | - |
| *Amphiroa fragilissima f. cyathifera* | (J.V. Lamouroux) Weber-van Bosse | Once | - | + | - |
| *Amphiroa foliacea* | J.V.Lamouroux | Once | - | - | + |
| *Callophyllis fastigiata* | (J.Agardh) J.Agardh | Once | + | - | - |
| *Ceratodictyon repens* | (Kützing) R.E. Norris | Once | + | - | - |
| *Ceratodictyon spongiosum* | Zanardini | Once | + | - | - |
| *Chondria armata* | (Kützing) Okamura | Once | + | - | - |
| *Dichotomaria falcata* | (Kjellman) Kurihara & Masuda | Once | + | - | - |
| *Dichotomaria marginata* | (J. Ellis & Solander) J.V. Lamouroux | Once | + | - | - |
| *Dichotomaria obtusata* | (J. Ellis & Solander) Lamarck | Once | + | - | - |
| *Digenea simplex* | (Wulfen) C.Agardh | Once | - | - | + |
| *Galaxaura rugosa* | (J.Ellis & Solander) J.V.Lamouroux | Once | + | - | - |
| *Gelidiella acerosa* | (Forsskål) Feldmann & Hamel | Twice | - | + | + |
| *Gracilaria arcuata* | Zanardini | Once | + | - | - |
| *Gracilaria salicornia* | (C. Agardh) E.Y. Dawson | Once | + | - | - |
| *Gracilaria textorii* | (Suringar) Hariot | Once | + | - | - |
| *Gracilaria tenuistipitata var. liui* | Zhang & Xia | Once | - | + | - |
| *Grateloupia crispata* | (Okamura) Y.-P.Lee | Once | + | - | - |
| *Halymenia sp.* | Bory de Saint-Vincent | Once | - | + | - |
| *Jania cultrata* | (Harvey) J.H. Kim, Guiry & H.-G. Choi | Once | + | - | - |
| *Jania sp.* | J.V. Lamouroux | Once | + | - | - |
| *Mastophora rosea* | (C. Agardh) Setchell | Twice | + | - | + |
| *Ohelopapa flexilis* | (Setchell) F.Rousseau, Martin-Lescanne, Payri & L.Le Gall | Once | + | - | - |
| *Palisada perforata* | (Bory) K.W.Nam | Once | + | - | - |
| *Plocamium telfairiae* | (W.J.Hooker & Harvey) Harvey ex Kützing | Once | - | - | + |

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|---|---|---|---|---|---|
| *Portieria hornemannii* | (Lyngbye) P.C.Silva | Once | + | - | - |
| *Pterocladiella capillacea* | (S.G.Gmelin) Santelices & Hommersand | Once | + | - | - |
| *Tricleocarpa cylindrica* | (J.Ellis & Solander) Huisman & Borowitzka | All sites | + | + | + |
| *Tricleocarpa fragilis* | (Linnaeus) Huisman & R.A. Townsend | Once | + | - | - |

***Note: (+) present; (−) not detected during survey.***

Table 3 shows taxon occurrence across the three sampled localities. Because each locality was sampled once, the categories describe detection during this survey rather than persistent geographic restriction.

Twenty-seven of the 31 taxa (87.1%) were detected at only one locality, three taxa (9.7%) at two localities, and one taxon (3.2%), *Tricleocarpa cylindrica*, at all three. Of the 27 single-locality records, 21 were from Calayan, three from Palanan, and three from San Fernando.

The three taxa detected at two localities were *A. fragilis, G. acerosa,* and *M. rosea. T. cylindrica* was the only taxon detected at all three. Non-detection at a locality is not treated as evidence of true absence because the survey represents one sampling period and a point-based sampling design.

### 3. Physicochemical Characteristics

The physicochemical measurements describe conditions encountered during the field visits. Salinity, for example, ranged from 14.86 to 29.21 ppt. Temperature, salinity, dissolved oxygen, and pH were each measured once per locality, so these observations were not used to explain differences in taxon richness, thallus counts, or diversity. Potential influences such as rainfall, freshwater input, tidal state, water movement, substrate, nutrients, and irradiance were not measured with sufficient replication for causal analysis. For the documentation of data, measurements were presented in Figure 4.

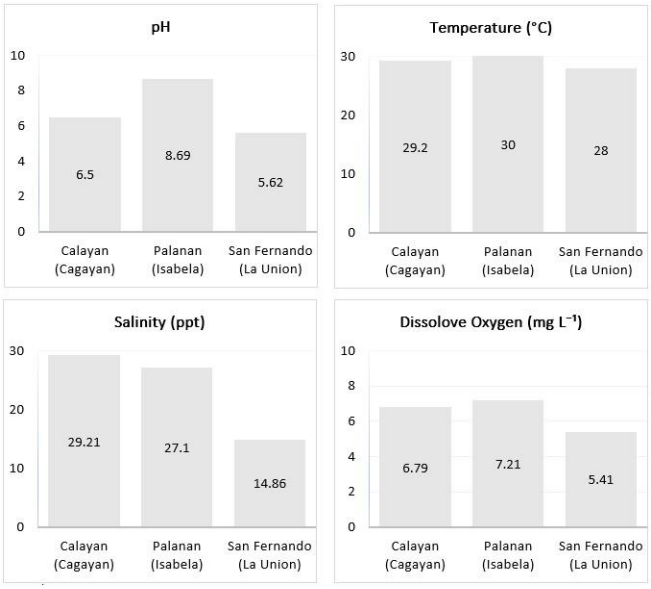



**Figure 4.** Physicochemical parameters recorded at the three sampling sites. One site-level measurement was obtained per locality (n = 1 per site). Values are therefore presented descriptively and do not represent replicated site means.

The measured environmental variables differed among the three sites during the respective sampling visits, such as, salinity, were as it ranged from 14.86 to 29.21 ppt. The lower salinity recorded at some sites may reflect freshwater inputs or rainfall during the sampling period, but these potential sources were not directly quantified because environmental measurements were obtained during a single field visit per locality. Thus, they are best treated as contextual descriptors rather than explanatory variables.

### 4. Diversity indices

Sample-level assemblage structure was summarized with Shannon–Wiener diversity (H′), Simpson's dominance (D), and Pielou's evenness (J′) (Table 4).

**Table 4.** Shannon–Wiener diversity (H′), Simpson's dominance (D), and Pielou's evenness index (J′) of Rhodophyta at the three study sites. Diversity indices were calculated from pooled observed thallus counts at the three study sites.

| ***Study Sites*** | ***Taxon Richness*** | ***Shannon–Wiener Diversity Index (H')*** | ***Simpson's Dominance Index (D)*** | ***Pielou's Evenness Index (J')*** |
|---|---|---|---|---|
| Calayan, Cagayan | **24** | **2.921** | **0.070** | **0.919** |
| Palanan, Isabela | **7** | **1.557** | **0.263** | **0.800** |
| San Fernando, La Union | **5** | **1.547** | **0.223** | **0.961** |

Calayan had the highest Shannon–Wiener diversity (H′ = 2.921) and observed richness (S = 24), with low Simpson's dominance (D = 0.070) and high evenness (J′ = 0.919). San Fernando had the lowest richness (S = 5) and thallus count (N = 11) but the highest evenness (J′ = 0.961). Palanan had the highest dominance (D = 0.263) and lowest evenness (J′ = 0.800). These values characterize the pooled samples collected during the survey and are not long-term estimates for the three localities.

## DISCUSSION

### 1. Taxonomic composition and identification

The 31 recorded taxa span nine orders and 14 families, showing that the survey captured a taxonomically broad set of red algae rather than a small number of closely related groups. For Northern Luzon, the value of this result is primarily documentary: the records were generated under one field framework and are linked to preserved voucher material that can be re-examined as Philippine red-algal taxonomy is refined. Richness values should

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not be compared directly with whole-macroalgal surveys because those studies differ in taxonomic coverage and sampling effort.

Several records overlap with earlier Philippine inventories. Baleta and Nalleb (2016), for example, reported *Actinotrichia fragilis*, *Gelidiella acerosa*, *Mastophora rosea*, and *Ceratodictyon spongiosum* from Cagayan. Their occurrence in the present survey places the new locality records within a better-documented Philippine flora, while the many taxa detected at only one of the three localities add finer-scale occurrence information for Northern Luzon.

Taxonomic certainty is not uniform across the inventory. Most identifications were based on macromorphology, which is suitable for a baseline survey but can be insufficient where diagnostic anatomy or molecular characters separate similar taxa. This limitation is especially relevant to groups known to contain cryptic or morphologically overlapping lineages. Philippine verification studies likewise emphasize the need to reassess historical records as nomenclature and species concepts change (Ang et al., 2013). The specimen IDs reported in the Methods are therefore important: they provide material that can be checked anatomically or molecularly without treating every present species-level assignment as irreversible.

Gracilaria was among the genera recorded in the survey and includes economically important agarophytes in the Philippines (Hurtado-Ponce et al., 2006). No biomass, agar yield, harvesting intensity, or productivity measurements were made here. These records therefore have taxonomic and biodiversity value but do not demonstrate commercial resource potential at any of the three localities.

### 2. Differences among localities and site occurrence

The clearest spatial result is the contrast among the three sampled assemblages. With the same observation-point framework, Calayan yielded 24 taxa and 253 of the 368 observed thalli, Palanan seven taxa and 104 thalli, and San Fernando five taxa and 11 thalli. Spatial heterogeneity is also reported in Philippine macroalgal surveys, including work from Cagayan and other island localities (Baleta & Nalleb, 2016; Trapa et al., 2024). The present figures, however, describe the August–September 2025 samples and should not be read as a ranking of the long-term biodiversity of the three coastlines.

Locality turnover was pronounced: 27 of 31 taxa (87.1%) were detected at only one locality, three at two localities, and only T. cylindrica at all three. For baseline monitoring, this matters because no single locality contained the full set of taxa recorded across the survey. Substrate, exposure, tidal position, season, water movement, and other habitat features could contribute to such turnover, but the study did not measure these factors with the replication needed to test their effects. The supported result is therefore the occurrence pattern itself, not a causal explanation for it.

*Tricleocarpa cylindrica* was the only taxon detected at all three localities. This repeated record is useful, but it does not by itself demonstrate broad ecological tolerance. Molecular studies of Tricleocarpa have reported complex species boundaries and geographic patterns (Wiriyadamrikul et al., 2013; Liu et al., 2015). Anatomical or molecular examination of the deposited vouchers would therefore be a useful next step for confirming the cross-locality records.

The occurrence matrix should also be read as a record of detection, not permanent distribution. A taxon not encountered at one locality may have been absent from the sampled points or may simply have gone undetected during the single survey. Repeated sampling across seasons and tidal zones would be needed to distinguish persistent locality differences from short-term variation.

### 3. Environmental context

Environmental conditions offer possible lines of enquiry rather than explanations for the present pattern. Macroalgal assemblages can respond to substrate, wave exposure, tidal elevation, turbidity, nutrients, irradiance, and season (Baleta & Nalleb, 2016; Trapa et al., 2024; Elias et al., 2024), but the four physicochemical variables in this study were measured only once per locality. Their values are therefore useful field context only. Testing environmental associations would require repeated measurements together with replicated biological observations at matching spatial and temporal scales.

### 4. Diversity patterns

The three indices describe different features of the samples. Calayan combined the greatest observed richness with the highest Shannon diversity. San Fernando, despite having only five recorded taxa and 11 thalli, had the highest evenness because its counts were comparatively balanced among the taxa present. Palanan showed the highest dominance and lowest evenness, reflecting greater concentration of its observed counts in a smaller number of taxa. The small difference in Shannon diversity between San Fernando and Palanan should not be overinterpreted.

These diversity values support a descriptive comparison of the sampled assemblages, not an inferential comparison of the localities as ecological populations. Seasonal replication, transect-level analyses, and repeated habitat measurements would be needed to test whether the same patterns persist and to evaluate the processes that might produce them.

## CONCLUSION

This study recorded 31 Rhodophyta taxa representing 9 orders and 14 families across three selected coastal sites in Northern Luzon. Calayan had the highest observed taxon richness, total observed thallus count, contribution to the pooled observed count, and Shannon diversity, while Palanan showed the highest Pielou's evenness and San Fernando had the highest Simpson's dominance. Twenty-seven taxa (84%) occurred at only one surveyed site, four occurred at two sites, and Tricleocarpa cylindrica occurred at all three sites.

The ecological patterns, taxonomic richness, and diversity indices reported in this study provide valuable baseline information on the intertidal Rhodophyta communities of Northern Luzon. However, several spatial and temporal sampling constraints must be contextualized when interpreting these findings. First, the line-transect point-intercept configuration (sampling at fixed 10 m intervals) was designed as a rapid assessment technique to characterize macroalgal species presence and relative spatial occurrence. While effective for baseline taxonomic inventory, point-intercept sampling may underestimate small, epiphytic, or patchily distributed micro-thalli compared to continuous line-intercept or dense quadrat grid surveys. Second, sampling was conducted during a single period (August–September 2025), representing the monsoonal/wet season dynamics. Intertidal

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macroalgal assemblages in tropical marine ecosystems undergo pronounced seasonal shifts driven by monsoonal regimes, wave exposure, light availability, and nutrient runoff. Consequently, the reported community structures reflect seasonal baseline snapshot conditions rather than full annual successional trends. Similarly, localized physicochemical measurements capture the immediate micro-environmental state at the time of collection; therefore, the data cannot be used to infer causal relationships with community structure. The findings should also be regarded as a baseline assessment of the surveyed localities rather than a definitive characterization of regional biodiversity patterns.

Future monitoring should expand across seasons and additional coastal localities, quantify substrate characteristics, replicate environmental measurements, and incorporate anatomical and/or molecular identification where necessary.

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