

Species composition and distribution of marine algae at Con Co island, Quang Tri province

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Abstract

This paper presents results on species composition and distribution of marine algae at 6 transects of Con Co islands in May 2020. The result of studies shows that 95 species of marine algae are recorded in the study area, belonging to four divisions: Cyanophytes, Rhodophytes, Ochrophytes and Chlorophytes. Among them, five (5) species are classified into Cyanophytes (comprising 5.3% of total species); forty one (41) species into Rhodophytes (43.1%); twenty-nine (29) species into Ochrophytes/Phaeophytes (30.5%) and twenty (20) species into Chlorophytes (21.1%). The species composition of marine algae in Con Co shows significant differences as follows: 48 species (transect number I) to 72 species (transect number IV) and the average value is 60.7 species per transect. Sørensen similarity coefficient fluctuates from 0.56 (transects number I and II) to 0.81 (transects number II and IV, number III and IV) and the average value is 0.70. The current investigations show that twenty-two (22) species are distributed the littoral zone (22.9% of total species) only and thirty-seven (37) species in the sub-littoral zone only. In which there are thirty six (36) species distributed in both littoral zone and sub-littoral zone (44.8%). The algal flora in Con Co is characterized by subtropics.

Keywords: Con Co, composition, distribution, marine algae, species.

INTRODUCTION

Marine macroalgae are not only a crucial and valuable economic component of marine resources that people around the world use in many aspects of life but also a significant object in theoretical research.

In practice, marine macroalga is used as a raw material for many industries as agar, alginate, carrageenan, biological compounds (amino acids, growth hormones,...). These active ingredients have been and will be widely used in various fields (textile fabric, additives for beverage industry, specialized glues, pharmaceutical preparations). In our country today, seaweed has been used in a number of industries (especially extracted glues, compounds) [1, 2].

Con Co is small island, belongs to Quang Tri province and is 13–17 nautical miles from land to the East. The nearest point is from Mui Lay in Vinh Thach commune, Vinh Linh district 13 nautical miles, from Cua Tung 15 nautical miles, Cua Viet 17 nautical miles [3].

Currently, studies on marine macroalgae in Con Co island are few and this is the first complete result on species composition and distribution seaweed in Con Co island.

This paper presents species composition and distribution of marine macroalgae in Con Co, Quang Tri province through the mission: “Supporting scientific research activities for senior researchers in 2019”, code: NCVCC23.5/19–19.

MATERIALS AND METHODS

Materials

The paper is based on the results obtained through the May 2020 survey at 6 cross

sections of Con Co island in the mission: “Supporting scientific research activities for senior researchers in 2019”, code: NCVCC23.5/19–19.

In addition, we also refer to the available research results, including:

1. The results of the project: “Economic evaluation of typical sea-island ecosystems serving the sustainable development of some frontage islands in coastal areas of Vietnam” (KC09.08/11–15);

2. Investigation of special resources in coastal areas from Mong Cai to North Hai Van pass (1992–1993).

Research methods

Sampling method

Vietnam Academy of Science and Technology, 2014. “Investigation Process of Marine Resources and Environment - Section Biology and Environmental Chemistry” [4] (for tidal zone) and the standard method of English et al., (1997) [5] (for subtidal zone) were used in the survey. The specimens in the subtidal zone were collected by SCUBA divers. We used SCUBA diving equipment, underwater digital camera OLYMPUS (Tokyo, Japan) for collecting samples and taking pictures.

The freshly collected marine macroalgal samples were soaked in a solution of formaldehyde 5%, the specimens were then put on Croki paper, compressed into blotting papers, dried naturally and identified.

The survey was conducted at 6 cross sections (symbols CC1, CC2, CC3, CC4, CC5 and CC6) perpendicular to the island shoreline and extended from low tide to the subtidal zone to a depth of 15 m (table 1 and figure 1).

Table 1. Coordinates of survey points at Con Co island

No.	Template notation	Coordinates
1	CC1	17°09'22"N - 107°19'07"E
2	CC2	17°09'41"N - 107°19'86"E
3	CC3	17°10'25"N - 107°20'55"E
4	CC4	17°9'28"N - 107°20'96"E
5	CC5	17°09'56"N - 107°20'64"E
6	CC6	17°09'56"N - 107°20'64"E

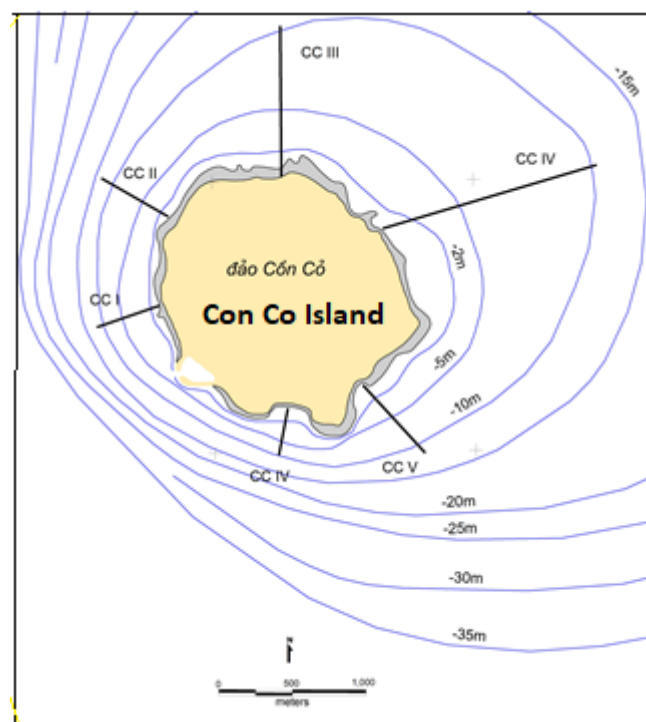


Figure 1. Diagram of seaweed survey on Con Co island

Species identification

The marine macroalgal specimens were analyzed at the laboratory of Marine Botanical Ecology and Resources Department, Institute of Marine Environment and Resources (Vietnam Academy of Science and Technology). Specimens were classified based on criteria relating to the morphology and anatomy of specimens under a LEICA microscope. The scientific names used follow national and international authors.

The classification document is based on the authors such as: Taylor (1960) [6]; Segawa S. (1962) [7]; Pham Hoang Ho (1969) [8]; Tseng et al., (1983) [9]; Nguyen Huu Dinh et al., (1993) [10].

The classification of seaweed follows the general principles of plant classification [11].

The hierarchical order of taxa is arranged according to the system of Golerbackh (1997) [12], the sub-sector taxon is based on Frederik Leliaert et al., [13], Guiry M. D., Guiry G. M. [14]. Names of taxa are used according to the general standard provisions of the Tokyo nomenclature [15]. Some additional

information is searched based on the document of Nguyen Van Tu et al., [16].

The floral characteristic was calculated by the Cheney formula (1977). This method involves calculating the sum of the number of species of Rhodophytes, Chlorophytes and dividing this by the number of species of Phaeophytes. If the ratio is < 3 , then the flora is recognized as subtropical flora. If the ratio is between 3 and 6, the flora is recognized as mixed flora, and if the ratio is > 6 , it is recognized as the tropical flora [17].

Distribution study

Geographical distribution

Geographical distribution in this study referred to the spatial horizontal distribution of marine macroalgae.

To study the geographical distribution of marine macroalgal communities, similarity index (Sorensen similarity index) was calculated according to the formula $S = 2C/A+B$, where A and B are the numbers of species in sample sites A and B , respectively and C is the number of species shared by two sampling sites (A and B) [18].

When the coefficient value approaches 1, these sampling sites show a strong similarity; when coefficient value approaches 0, these sample sites are less similar.

Vertical distribution

Determining the vertical distribution of marine macroalgae was based on the principle of the partitioning (zonation) of the tidal zone as used by Feldmann (1937) [19], Stephenson (1949) [20] and Pham Hoang Ho (1962) [21]. Under this scheme, the coastal zone is arbitrarily partitioned into many different areas depending on the tidal level such as high tide, mid-tide and low tide. Water level and tidal data were derived from the tidal regime measured at Cua Viet in May 2019 [22].

RESULTS AND DISCUSSION

Species composition

Based on the analysis of marine macroalgal samples collected during field surveys in May 2020 at 6 stations and from a review of published data, we identified a total of 95 species of marine algae in the study area, belonging to four divisions: Cyanophytes, Rhodophytes, Ochrophytes and Chlorophytes. Among them, five (5) species are classified into Cyanophytes (comprising 5.3% of total species); forty-one (41) species into Rhodophytes (43.1%); twenty-nine (29) species into Ochrophytes/Phaeophytes (30.5%) and twenty (20) species into Chlorophytes (21.1%) (table 2).

Table 2. Species composition and distribution of marine macroalgae at Con Co island

No.	Taxa	Geographical distribution						Vertical distribution	
		I	II	III	IV	V	VI	a	b
	Cyanophyta								
	Oscillatoriaceae								
1	<i>Lyngbia aestuarii</i> (Mert.) Liebm.	+	+	+	+	+	+	+	
2	<i>L. lutea</i> (C. Ag.) Gom	+			+			+	
3	<i>L. martensiana</i> Menegh.	+						+	
4	<i>Microcoleus chthonoplaste</i> Thur. et Gom	+	+	+	+	+	+	+	
5	<i>Symploca hydroides</i> Kuetz. ex Gom.	+	+	+	+			+	
	Rhodophyta								
	Bangiaceae								
6	<i>Porphyra suborticulata</i> Kjellm.			+	+			+	
	Liagoraceae								
7	<i>Liagora divaricata</i> Tseng	+	+	+	+			+	+
8	<i>L. caenomyce</i> Dcne.		+	+	+		+	+	+
9	<i>L. orientalis</i> J. Ag.	+		+	+		+		+
	Galaxauraceae								
10	<i>Galaxaura fastigiata</i> Decne		+	+	+	+	+		+
11	<i>G. rugosa</i> (J. Ellis et Solander) J. V. Lamouroux		+	+	+	+	+		+
12	<i>G. obtusata</i> (Ell. et Sol.) Lamx.						+		+
13	<i>Actinotrichia fragilis</i> (Forsk.) Boerg.	+						+	+
	Gelidiellaceae								
14	<i>Gelidiella acerosa</i> (Forsk.) Feld. & Ham.	+	+	+	+	+	+	+	
15	<i>G. lubrica</i> (Kuetz.) Feldm. et Ham.	+	+	+	+	+		+	
	Gelidiaceae								
16	<i>Gelidium crinale</i> (Turn.) Lamx.		+			+	+	+	
17	<i>G. lithophila</i> Boerg.	+	+	+	+	+	+	+	
18	<i>G. pulchellum</i> (Turn.) Kuetz.		+	+	+	+	+	+	
	Peyssonneliaceae								
19	<i>Peyssonnelia gunniana</i> J. Ag.			+	+			+	+
	Corallinaceae								
20	<i>Coralina officinalis</i> L.	+		+			+		+
21	<i>Jania capillacea</i> Harv.		+		+	+			+
22	<i>J. pumila</i> Yendo		+	+		+			+
	Lithophyllaceae								

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23	<i>Amphiroa achigoensis</i> Yendo		+			+			+
24	<i>A. zonata</i> Yendo			+		+			+
	Halymeniaceae								
25	<i>Halymenia dilitata</i> Zan.			+	+		+		+
	Acrochaetiaceae								
26	<i>Acrochaetium thuretti</i> (Bornet) F. S. Collins & Hervey			+					+
	Hypneaceae								
27	<i>Hypnea boergesenii</i> Tanaka		+	+	+				+
28	<i>H. esperi</i> Bory		+	+	+				+
29	<i>H. flagelliformis</i> Grev.		+		+		+	+	+
30	<i>H. japonica</i> Tanaka			+			+	+	+
31	<i>H. nidulans</i> Secth			+		+		+	+
	Gracilariaceae								
32	<i>Gracilaria arcuata</i> Zan.	+	+	+	+	+			+
33	<i>G. salicornia</i> (C. Ag.) Daws.	+	+		+	+			+
	Gigartinaeae								
34	<i>Gigartina intermedia</i> Sur.	+	+		+			+	
	Bonnemaisoniaceae								
35	<i>Asparagopsis taxiformis</i> (Del) Coll. et Harv.	+		+	+		+		+
	Phylloporaceae								
36	<i>Ahnfeltiopsis griffithsiae</i> (Turn.) Mart.	+	+	+	+	+	+	+	
	Rhodomelaceae								
37	<i>Polyshipponia nhatrangense</i> Phamhoang H.		+	+	+	+	+	+	+
38	<i>P. sertularioides</i> (Grot.) J. Ag.	+	+	+	+	+	+	+	+
39	<i>P. subtilissima</i> Mont.	+		+				+	+
40	<i>P. sphaerocarpa</i> Boerg.		+		+			+	+
41	<i>Laurencia obtusa</i> (Huds.) Lamx.			+	+		+		+
42	<i>Acanthophora muscoides</i> (L.) Bory	+		+		+	+	+	+
43	<i>A. spicifera</i> (Vahl.) Boerg.			+		+	+	+	+
44	<i>Leveillea jungermanioides</i> (Harv. & Mart.) Harv.		+	+	+	+	+	+	+
45	<i>Acrocystis nana</i> Zan.		+	+	+	+	+	+	+
	Rhodymeniaceae								
46	<i>Ceratodiction spongiosum</i> Zanard.		+	+	+	+	+		+
	Ochrophyta (Phaeophyta)								
	Ectocarpacea								
47	<i>Feldmannia irregularis</i> (Kuetz.) Ham.	+	+	+	+	+	+	+	+
	Scytosiphonaceae								
48	<i>Colpomenia sinuosa</i> (Roth.) Derb. et Sol.	+	+	+	+	+	+	+	+
	Chnoosporaceae								
49	<i>Chnoospora minima</i> (Her.) Papenf.		+	+	+	+			+
50	<i>Ch. implexa</i> (Hering) J. Ag.		+	+	+	+			+
	Ralfsiaceae								
51	<i>Ralfsia verrucosa</i> (Aresch.) J. Ag.		+	+	+	+		+	
	Sphacelariaceae								
52	<i>Sphacelaria variabilis</i> Sauv.		+					+	
53	<i>S. rigidula</i> Kützing		+	+	+	+	+	+	
	Dictyotaceae								
54	<i>Dictyota adnata</i> Zanardini	+		+	+	+	+		+
55	<i>D. divaricata</i> Lamx.		+	+	+	+	+		+
56	<i>D. ceylanica</i> var. <i>anastromosans</i> Ta.		+	+	+	+	+		+
57	<i>D. patens</i> J. Ag.	+	+	+				+	+
58	<i>Padina australis</i> Hauck.	+	+	+	+	+	+	+	+
59	<i>P. boryana</i> Thivy	+	+	+	+				+
60	<i>P. crassa</i> Yam.	+			+	+			+
61	<i>P. tetrastroma</i> Hauck.	+	+	+	+		+	+	+
62	<i>Lobophora variegata</i> (Lamx.) Wom.	+	+	+	+	+	+	+	+

	Scytosiphonaceae								
63	<i>Hydroclathrus clathratus</i> (Bory) Howe.		+	+			+	+	+
	Chordariaceae								
64	<i>Nemacystus decipiens</i> (Sun.) Kack.	+		+				+	+
	Sargassaceae								
65	<i>Sargassum aquifolium</i> (Turner) C. Agardh						+		+
66	<i>S. duplicatum</i> J. Ag.						+		+
67	<i>S. echinocarpum</i> I. Ag.	+			+	+		+	+
68	<i>S. glaucescens</i> J. Ag.	+			+	+	+	+	+
69	<i>S. gracillimum</i> Rbd.				+	+		+	+
70	<i>S. kuetzingii</i> Setch.			+	+	+		+	+
71	<i>S. paniculatum</i> J. Ag.	+			+	+	+	+	+
72	<i>S. polycystum</i> C. Ag.	+			+	+		+	+
73	<i>S. polyporum</i> Mont.	+		+	+	+		+	+
74	<i>Sargassum siliquosum</i> J. Ag.	+			+		+		+
75	<i>Turbinaria gracilis</i> Sond.	+	+	+	+	+	+		+
	Chlorophyta								
	Ulveaceae								
76	<i>Ulva clathrata</i> (Roth.) Grev.	+	+	+	+	+	+	+	
77	<i>Ulva flexuosa</i> (Wult.) J.	+	+	+	+	+	+	+	
	Anadyomenaceae								
78	<i>Anadymene wrightii</i> Harv.			+	+	+			+
	Boodleaceae								
79	<i>Boodlea siamensis</i> Reinb		+	+	+	+	+	+	+
	Cladophoraceae								
80	<i>Chaetomorpha antennina</i> (Boerg.) Kuetz.			+					+
81	<i>Chaetomorpha crassa</i> (C. Ag.) Kuetz.		+		+				+
82	<i>Rhizoclonium riparium</i> (Roth.) Harv.	+	+			+		+	+
	Bryopsidaceae								
83	<i>Bryopsis pennata</i> Lamx.	+	+	+	+	+	+		+
	Caulerpaceae								
84	<i>Caulerpa lentilifera</i> J. Ag.			+	+	+			+
85	<i>Caulerpa peltata</i> Lamx. var. <i>Typica</i> W. V. Bosse	+	+	+	+	+	+		+
86	<i>Caulerpa serrulata</i> (Forsk.) J. Ag.	+	+	+	+	+	+		+
87	<i>Caulerpa racemosa</i> (Forsk.) J. Ag.	+	+	+	+	+	+		+
88	<i>Caulerpa taxifolia</i> (Vahl.) C. Ag.		+	+	+		+		+
	Codiaceae								
89	<i>Codium arabicum</i> Kuetz.		+	+	+	+	+	+	+
90	<i>Codium tenue</i> Kuetz.		+	+	+	+	+		+
	Halimedaceae								
91	<i>Halimeda macroloba</i> Decn.	+	+	+	+	+	+		+
	Udoteaceae								
92	<i>Chlorodesmis hildebrandtii</i> A. et E. S. Gepp				+		+	+	
	Dasiacaladaceae								
93	<i>Neomeris annunata</i> Dich.	+	+	+	+		+	+	+
94	<i>Neomeris Vanbosseae</i> Howe	+		+		+		+	+
	Polyphysaceae								
95	<i>Acetabularia parvula</i> Solms-Laubach	+	+	+	+	+	+	+	+
	Total: 95 species	48	60	71	72	58	55	58	73

Notes: I, II, III, IV, V and VI are sampling sites; "a" as intertidal zone, "b" as subtidal zone.

The algal flora

Based on Cheney's method and results obtained from table 2, we determine that the

index $C = (41 + 20)/29 = 2.10$. This value is between 0 and 3. Thus, the algal flora in Co To and Thanh Lan is characterized by subtropics.

Distribution

Geographical distribution

Table 2 shows that the number of species at different sites ranges from 48 species (site I) to 72 species (site IV) with the average value of 60.7 species/site.

Table 3. Sorensen index values between sites at Con Co island

	I	II	III	IV	V	VI
VI	0.57	0.68	0.74	0.74	0.68	
V	0.60	0.73	0.73	0.76		
IV	0.66	0.81	0.81			
III	0.61	0.77				
II	0.56					
I						

Notes: I, II, III, IV, V and VI are sampling sites.

The average number of species reaching 60.7 species/site is relatively high. This result is completely consistent because Con Co is an offshore island, less affected by fresh water from the continent, the amount of alluvium and sediment almost does not affect the clarity of seawater, so the transparency is usually high with stable salinity. These are very favorable conditions for the survival and development of marine macroalgae, making the average number of species at the cross section relatively high. However, at a few points on the sections (the bottom structure is dead coral interbedded with light sand), it is

difficult for seaweed to survive and develop, which is the reason for the difference in the number of species between the sections.

The Sorensen index of marine macroalgae at different sites ranged from 0.56 (between sites I and II) to 0.81 (between sites II and IV) and the average value was 0.70 (table 3).

Although the distance between sections I and II is not far and the base is mainly coral reefs, the similarity coefficient is the lowest (0.56), because the construction of the wharf (section I) has changed the basal structure and impacted on seaweed survival. The average value between sites II and IV reached the highest (0.81) because the bottom structure and other conditions (salinity, light intensity, flow,...) were relatively similar.

The mean value for the six cross sections reaching 0.70 is relatively high. The reason is that the survey sites are relatively close together because Con Co is an island with a small area, the natural conditions are quite similar, so there is no big difference in species composition (table 3).

Vertical distribution

Based on tidal level data in May 2020 at Cua Viet, among 95 species in Con Co island, there were 22 species (occupying 23.1% of total species) distributed in intertidal zone only and 37 species (38.9%) in subtidal zone only (in which 36 species (38.0%) were distributed in both intertidal and subtidal zones).

Table 4. The distribution of marine macroalgae by depth in Con Co island (Based on tide level in Cua Viet, May 2020)

Region	Tidal belt	Featured species
On the tide		There is no seaweed The average value of the tropical spring tide 0.8 m
Tidal area	High tide belt	<i>Chaetomorpha antennina</i> , <i>Ulva clathrata</i> , <i>Ulva flexuosa</i> ,... The average value of the equator spring tide 0.7 m
	Middle tide belt	<i>Porphyra suborticulata</i> , <i>Gelidium crinale</i> , <i>Gelidiella acerosa</i> ,... The average value of the equator neap tide 0.3 m
	Low tide belt	<i>Gelidiella lubrica</i> , <i>Colpomenia sinuosa</i> , <i>Feldmannia irregularis</i> ,... The average value of the tropical neap tide 0 m
Subtidal area	High belt	<i>Hypnea boergesenii</i> , <i>Chnoospora implexa</i> , <i>Bryopsis pennata</i> , ... -10 m
	Low belt	<i>Galaxaura fastigiata</i> , <i>Peyssonnelia calcea</i> , <i>Jania capillacea</i> ,...

The results in table 4 show that in the intertidal area, the high tide belt usually has the

following species: *Chaetomorpha antennina*, *Ulva clathrata*, *Ulva flexuosa*,...; middle tide

belt: *Porphyra suborticulata*, *Gelidium crinale*, *Gelidiella acerosa*,...; low tide belt: *Gelidiella lubrica*, *Colpomenia sinuosa*, *Feldmannia irregularis*,...; in the subtidal tide area, the high belt usually has the following species: *Hypnea boergesenii*, *Chnoospora implexa*, *Bryopsis pennata*,... and low belt: *Galaxaura fastigiata*, *Peyssonnelia calcea*, *Jania capillacea*,...

Conclusion

Con Co island is located in the mouth of the Tonkin Gulf. This is the midpoint between the sub-tropical zone (in the North) and the mixed zone (in the South). Survey results in May 2020 found 95 species of marine macroalgae. This number is much higher than the survey results in 2014 by Dam Duc Tien (71 species) [20] and in 2013 by Do Anh Duy and Do Van Khuong (52 species) [22]. Thus, in this study, 25 species have been added to the list of Con Co seaweed.

Since most surveys on Con Co island were only conducted in the summer (usually high temperatures), a complete winter species

group was not collected (genera *Porphyra*, *Bangia*, *Grateloupia*,...). If the surveys are carried out in winter, the number of species here may be even higher.

The survey trip in May 2020 was also not favorable due to the weather conditions and leap year, so the seaweed crop was also changed. An additional survey is expected in the months to come, but due to disease and weather, it cannot be implemented. This also affects the number of seaweed species that can be recorded at Con Co.

Compared to other islands in the Tonkin Gulf, the number of species detected in Con Co island is the highest (95 species), those in other islands are lower: Bach Long Vi (46 species), Ba Mun (11), Vinh Thuc island (68), Ha Mai island (19). The highest number of species on Con Co island is in compliance with the law since Con Co island has a base of mostly dead rocks or corals. In addition, the number of species also follows the distribution of aquatic organisms (table 5).

Table 5. The number of the marine algae species in Con Co in 2020 compared with previous studies in the Tonkin Gulf area

Study area	Species number	Reference
Bach Long Vi island	46	Dam Duc Tien (1997) [23]
Tran island	34	Dam Duc Tien (2004) [24]
Ha Mai island	19	Dam Duc Tien (2004) [24]
Co To island	53	Do Anh Duy, Do Van Khuong (2013) [26]
Ba Mun island	11	Do Anh Duy, Do Van Khuong (2013) [26]
Vinh Thuc island	68	Do Anh Duy et al., (2019) [25]
Co To and Thanh Lan island	76	Dam Duc Tien et al., (2020) [28]
Con Co island	52	Do Anh Duy, Do Van Khuong (2013) [26]
Con Co island	71	Dam Duc Tien (2014) [27]
Con Co island	95	This study

At present, because the renovation and construction of coastal structures happen frequently and in a long time, at many points it will certainly affect the wide distribution of seaweed. The number of species at different cross sections can have more variation.

Due to the fact that most of the surveyed sections at Con Co island have a hard bottom structure, great slope, narrow tidal area and low tidal range, the daytime exposure does not have a large effect on the distribution of seaweed.

Natural conditions such as clear water, little influence of fresh water from the continent, hard bottom, narrow tidal area, low tidal fluctuations are very favorable for seaweed to survive. In the summer period, the water temperature is usually high, the water drains mainly during the day, so it is not favorable for the existence and development of seaweed in the tidal area. However, some other conditions are very favorable for the distribution in the subtidal area, so the season of seaweed tends to

be longer, and they are distributed deeper in the subtidal area.

CONCLUSION

At Con Co island, we have identified 95 species of marine macroalgae. They belong to 4 phyla of marine macroalgae consisting of 5 species of Cyanobacteria, representing 5.3% of the total number of species, 41 species of Rhodophytes (43.1%), 29 species of Phaeophytes (30.5%) and 20 species of Chlorophytes (21.1%). The algal flora in Con Co is characterized by subtropics.

The geographical distribution of marine macroalgae at Con Co is not similar; they ranged from 48 species (site number I) to 72 species (site number IV) and the average value is 60.7 species/site. Sorensen index of marine macroalgae at six (6) sites ranged from 0.56 (between sites I and II) to 0.81 (between sites II and IV) and the average value was 0.70.

Among 95 species of marine macroalgae at Con Co island, there are 22 species (occupying 22.9% of total species) distributed in intertidal area only and 37 species (32.3%) in subtidal area (in which 36 species - 44.8% were distributed in both intertidal and subtidal areas).

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