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Research Article

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A review on the seaweed resources of Myanmar

Abstract

A total of 261species of marine benthic algae under 121genera,comprising 72 taxa belonging to 26 genera of Chlorophyta, 45 taxa belonging to 18 genera of Phaeophyta and 144 taxa belonging to 77 genera of Rhodophyta growing along the Tanintharyi Coastal Zone, Deltaic Coastal Zone and Rakhine Coastal Zone, were recorded. In general, diversity ratios of seaweeds occur in 3 Coastal Zones is 3:1:4 between the Tanintharyi Coastal Zone (146 taxa), Deltaic Coastal Zone (53 taxa) and Rakhine Coastal Zone (224 taxa).Among these, 89 species of marine benthic algae, including 25 taxa of green, 9 taxa of brown and 55 taxa of red algae, were newly recorded from Myanmar waters. The latitudinal distribution of marine benthic algae along the Myanmar Coastal Zones reveals 25 species of marine benthic algae which uniquely occur in low lattitute in the Tanintharyi Coastal Zone and 111 species which exclusively predominate in high lattitutein the Rakhine Coastal Zone. *Monostroma*, *Ulva*, *Caulerpa* and *Codium* of Chlorophyta, *Dictyota*, *Spatoglossum*, *Hormophysa*, *Turbinaria* and *Sargassum* of Phaeophyta and *Phycocalidia*, *Dermonema*, *Gelidiella*, *Halymenia*, *Solieria*, *Hypnea*, *Gracilaria*,*Gracilariopsis*, *Hydopuntia*, *Catenella* and *Acanthophora* of Rhodophyta could be considered as of dependable natural resources of Myanmar to produce the sea-vegetables and phycocolloids. Mariculture of some economically important marine red algae such as *Gracilaria* spp., *Hydopuntia* spp., *Catenella* spp. And *Kappaphycus alvarezii* was described. Current status and prospects of phycocolloid industries producing alginate, agar-agar and carrageenansfrom raw materials of seaweeds of Myanmar were discussed. Checklist, distribution and conservation of marine benthic algae were briefly presented.

Keywords: checklist, chlorophyta, conservation, macroalgae cultivation, myanmar, phaeophyta, phycocolloids, rhodophyta, sea-vegetables, macroalgae utilization

Volume 10 Issue 4 - 2021

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Received: July 19, 2021 | **Published:** August 16, 2021

Introduction

Myanmar has 2,831km coastal strip in the southon the Bay of Bengal, stretching over 1,900km from 10° to 21° N and 93° to 97°E. The coastline of Myanmar can be subdivided into three coastal zones: 1) the Rakhine Coastal Zone (RCZ, from the mouth of the Naaf River to the Mawtin Point, about 740km in length); 2) the Deltaic Coastal Zone (DCZ, from the Mawtin Point to the Gulf of Mottama, Martaban, about 460km in length); and 3) the Tanintharyi Coastal Zone (TCZ, from the Gulf of Mottama, Martaban) to the mouth of the Pakchan River, about 1631km in length, along with the Mergui (Myeik) Archipelago which comprises a group of more than 800 islands in the southern coastline of Myanmar).[1] The Myanmar continental shelf covers approximately 230,000km^2 and is relatively narrow offshore of the Rakhine coast, widest (and still growing) offshore of the central delta, and with a relatively wide portion offshore of Tanintharyi to the south.

Average monthly surface seawater temperature ranges between 27-32°C in the3Coastal Zones. Salinity varies seasonally, depending on runoff from the rivers and the strength of ocean currents. The salinity ranges of coastal waters of these Coastal Zones are 10-30‰ in DCZ, 20-35‰ in RCZ and 25-35‰ in TCZ, respectively. Due to lower salinity of turbid coastal waters, most coastal areas in DCZ, as well as the northern coastal areas of RCZ and TCZ, support only euryhaline species. On the other hand, the southern coastal areas of RCZ and TCZ display the highest diversity of seaweeds of stenohaline species.

Tides in all 3 Coastal Zones are semi-diurnal with a tidal range of approximately 2.5-4.5m along both RCZ and TCZ, and 4.5-6.5m at spring tides in DCZ. The surface circulation of Myanmar waters generally moves clockwise from January to July and counter-clockwise from August to December in accordance with the monsoons. In general, the oceanographic conditions of Myanmar coastal waters are mainly controlled by the large volumes of freshwater from the Ayeyawady, the Sittaung and the Thanlwin Rivers, the rainfall from the south-west and north-east monsoon, and the North Equatorial Current.

A total of 307 species under 122 genera of seaweeds were previously reported from Myanmar waters.[2,3] Moreover, a total of 221 species under 114 genera were reported from Myanmar.[4,5] Of these marine benthic algae, detailed studies on morphotaxonomy and distribution of the most common genera, namely, *Monostroma*,[6] *Ulva*,[7] *Cladophora*,[8] *Codium* and *Avrainvillea*,[9,10] *Halimeda*,[11] *Caulerpa*,[12] *Dictyota*,[4,13,14] *Canistrocarpus*, *Dictyopteris*, *Stoechospermum* and *Spatoglossum*,[15,16] *Padina*,[17-19] *Colpomenia*,[20] *Sargassum*,[21-25] *Porphyra*,[26,27] *Liagora* and *Izziella*,[28] *Galaxaura* and *Tricleocarpa*,[29-31] *Dichotomaria*,[32] *Amphiroa* and *Jania*,[33,34] *Gelidium*,[35] *Halymenia*,[36] *Titanophora*,[37] *Hypnea*,[38,39,40] *Gracilaria*,[41-46] *Catenella*,[47,51] *Laurencia*,[52-58] *Palisada*,[59]*Caloglossa*,[60] *Polysiphonia*,[61-63] *Bostrichia*,[64,65] *Acanthophora*[66] and *Ceramium*,[67] and floras for Wa Maw,[68] Kampani,[13,14] Kalegauk Island,[71,72] Setse,[73] Kyaikhami,[74,75] Ngwe Saung,[86-80] Magyi,[81] GwaAw,[15,82,83] Mazin (Ngapali)[84] and Sittway,[85] have been done in the Department of Marine Science, Mawlamyine and Pathein Universities.

The purpose of this study is to know the current status of diversity and distribution of the marine benthic algae growing along the 3 Coastal Zones of Myanmar and economic potentials of these algae for sea vegetables, phycocolloids and phycoculture industries in Myanmar.

Materials and methods

Marine algae were collected in the forms of drift and live specimens growing in intertidal and shallow subtidal areas from the following 3 Coastal Zones of Myanmar:

Tanintharyi Coastal Zone (TCZ)**:-**Zar Det Kyee I. (10˚ 01′ 09” N, 98˚ 17′ 22” E), Zar Det Nge I. (10˚ 06′ 58” N, 98˚ 16′ 48” E), St. Luke I. (Pa Law Kar Kyan I.)(10˚ 10′ 02.34” E, 98˚ 14′ 04.88” N), Lampi I. (Kyunn Tann Shey)(10˚ 45′ 06.06” N, 98˚ 16′ 57.68” E), Warr I. (10˚ 55′ 46.02” N, 98˚ 14′ 39.22” E), Pan Daung I. (12˚ 26′ 52.26” N, 98˚ 12′ 02.76” E), Pyin Sa Bu I. (11˚ 42′ 33.43” N, 98˚ 01′ 39.32” E), MeeThway I. (12˚ 02′ 46.64” N, 97˚ 57′ 58.19” E), KyunPon Is. (12˚ 07′ 03.53” N, 97˚ 58′ 13.0” E), Done Pale Aw (12˚ 20′ 21. 39” N, 98˚ 03′ 47.07” E), Kanaung I. (12˚ 20′ 47.23” N, 98˚ 08′ 34.35” E), La Al I. (12˚ 21′ 33.27” N, 98˚ 14′ 06.54” E), KyunHmay Yar I. (12˚ 21′ 44.67” N, 98˚ 13′ 24.03” E), Linn Lunn Aw (12˚ 22′ 51.13” N, 98˚ 01′ 13.90” E), TawpanNge I. (12˚ 23′ 01.55” N, 98˚ 08′ 26.47” E), TawpanGyi I. (12˚ 24′ 28.98” N, 98˚ 08′ 53.76” E), Sharr Aw (12˚ 25′ 03.16” N, 98˚ 06′ 14.90” E), Maw Tone Gyi Aw (12˚ 36′ 44.67” N, 98˚ 23′ 51.33” E), Thamihla I. (12˚ 42′ 52.94” N, 98˚ 21′ 34.89” E), MyinHkwar Aw (13˚ 33′ 07.51” N, 98˚ 08′ 01.89” E), Wa Maw (13˚ 37′ 51” N, 98˚ 08′ 00” E),NyawPyin Aw (13˚ 38′ 26.26” N, 98˚ 08′ 51.68” E), South Moscos I. (13˚ 51′ 15.48” N, 97˚ 55′ 47.48”E), San Hlann (13˚ 54′ 46.48” N, 98˚ 04′ 22.17” E), Kanpani (14˚ 03′ 25.70” N, 98˚ 04′ 36.65” E), Thabawseik (MweTaung)(14˚ 06′ 20.85” N, 98˚ 05′ 40.82” E), Maungmagan (14˚ 07′ 47.05” N, 98˚ 05′ 45.07” E), Kalegauk I. (15˚ 32′ 14” N, 97˚ 39′ 34” E), Setse (15˚ 57′ 06.23” N, 97˚ 36′ 30.48” E), Kyaikkhami (16˚ 05′ 11” N, 97˚ 34′ 58” E).

Deltaic Coastal Zone (DCZ)**:-**KadonKani (15˚ 47′ 32.213” N, 95˚ 13′ 27.85” E),HaingGyi I. (15˚ 58′ 33.71” N, 94˚18′ 46.09” E), Kyar Kan (15˚ 59′ 13.71” N, 94˚ 13′ 38.77” E), Kha MaukHmaw (15˚ 59′ 28.07” N, 94˚ 16′ 26.03” E), Kyauk Chaung (15˚ 59′ 59.68” N, 94˚ 16′ 48.35” E), Set San (16˚ 03′ 28.62” N, 95˚ 21′ 25.68” E), Pyapon (16˚ 05′ 46.77” N, 95˚ 43′ 51.15” E), Labutta (16˚ 08′ 52.30” N, 94˚ 45′ 30.31” E), Letkokkon (16˚ 19′ 45.75” N, 96˚ 08′ 59.07” E).

Rakhine Coastal Zone (RCZ)**:-** Co CoGyi I. (14˚ 07′ 40.23” N, 93˚ 22′ 00.05” E), Mawtin Point (15˚ 57′ 05.93” N, 94˚ 14′ 42.24” E), Zea Gyaing (16˚ 01′ 06.05” N, 94˚ 12′ 14.79” E), Ngwe Taung Pagoda (16˚ 01′ 09.19” N, 94˚ 12′ 16.61” E), Kyauk Mattup (16˚ 01′ 48.32” N, 94˚ 12′ 04.11” E), Linnoh Gaung (16˚ 02′ 04.30” N, 94˚ 11′ 57.38” E), Pashu Gyaing (16˚ 02′ 23.31” N, 94˚ 11′ 57.14” E), Cape Negrais (16˚ 02′ 31.18” N, 94˚ 11′ 27.62” E), Ohn Kyun I. (16˚ 23′ 22” N, 94˚ 13′ 45” E), Ngayoke Kaung Aw (16˚ 32′ 28” N, 94˚ 17′ 19” E), Thathanar Dauk (16˚ 36′ 29” N, 94˚ 19′ 21” E), Ngwe Saung (16˚ 52′ 20” N, 94˚ 22′ 25” E), Chaung Thar (16˚ 57′ 00” N, 94˚ 25′ 59” E), Thae Phyu Kyun (17˚ 01′ 04” N, 94˚ 18′ 36” E), Inn Din Gyi (17˚ 03′ 32” N, 94˚ 26′ 52” E), Boung Kyun I. (17˚ 04′ 19” N, 94˚ 26′ 39” E), Shwe Thaung Yan (Ma Gyi)(17˚ 04′ 26” N, 94˚ 27′ 16” E), Kyauk Nagar (17˚ 04′ 43” N, 94˚ 27′ 04” E), Wet Thay Gyaing (17˚ 08′ 20” N, 94˚ 27′ 49” E), Phoe Htaung Gyaing (17˚ 10′ 03” N, 94˚ 29′ 41” E), Tapin Maw (17˚ 16′ 09.32” N, 94˚ 29′ 07.14” E), Jade Lett Gyaing (17˚ 17′ 42” N, 94˚ 30′ 57” E), Baw Di Gyaing (17˚ 29′ 43” N, 94˚ 33′ 35” E), Shweya Gyaing (17˚ 35′ 22.79” N, 94˚ 33′ 10.85” E), Makyeengu Gyaing (Gwa Aw)(17˚ 35′ 36.64” N, 94˚ 33′ 39.94” E), Yahaing kutoe (Gwa Aw)(17˚ 38′ 13.94” N, 94˚ 34′ 23.21” E), Chan Pyin Gyaing (17˚ 38′ 59” N, 94˚ 33′ 55” E), Maw Shwe Gyaing (17˚ 41′ 39.50” N, 94˚ 32′ 13.91” E), Yay Myet Taung Gyaing (17˚ 42′ 46” N, 94˚ 31′ 56” E), Hlyaw Gaung Taung Gyaing (17˚ 45′ 46.41” N, 94˚ 30′ 37.55” E), Gyaing Kauk Gyaing (17˚ 47′ 22” N, 94˚ 28′ 52” E), HmawChay Gyaing(18˚ 13′ 50.19” N, 94˚ 25′ 04.41” E), Kwinwaing Gyaing (18˚ 17′ 44.70” N, 94˚ 20′ 47.69” E), Kywe Thauk Gyaing (18˚ 17′ 16” N, 94˚ 22′ 06” E), Maung Shwe Lay Gyaing (18˚ 18′ 16.14” N, 94˚ 19′ 39.36” E), Kyauk Phone Gyi Maw (18˚ 18′ 42.84” N, 94˚ 20′ 38.30” E), Lonetha Gyaing (18˚ 21′ 45.15” N, 94˚ 20′ 19.71” E), Shwewar Gyaing (18˚ 24′ 27"N, 94˚ 19′ 43” E), Ngapali (18˚ 26′ 44.35” N, 94˚ 18′ 39.12” E), Mazin (18˚ 27′ 05.47” N, 94˚ 17′ 44.74”E), Sing aung (18˚ 32′ 48.01” N, 94˚ 14′ 59.66” E), Kyauk Layaine Gyaing (19˚ 50′ 30.13” N, 93˚ 25′ 54.03” E), Kyaukoomaw and U Ba Saw’s Pagoda (Ramree I.)(19˚ 25′ 26.92” N, 93˚ 33′ 33.65” E), Kyauk Phyu (19˚ 25′ 47” N, 93˚ 31′ 17” E), Sittwe Point(20˚ 06′ 51.84” N, 92˚ 53′ 53.57” E)(Figure1) from 1967 to 2021.

Samples were preserved in seawater4 % formalin, and then prepared as herbarium specimens. All voucher specimens were deposited in the Herbarium of the Department of Marine Science, Mawlamyine University (MMB) and then documented in data sheets using a computer for seasonality and distribution range of each taxon. The specimens had been rechecked, verified and updated its taxonomic positions. This study basically followed the classification system used by Guiry *et al*.[86] Economically, important seaweeds have been recorded from the studies on extractions of phycocolloids and phycoculture of seaweeds made by staffs of the Department of Marine Science, Mawlamyine University. Moreover, the recent information on phycological researches in Myanmar has been added to the previous records prepared by Soe-Htun et al.[4,5]

Results and discussion

Diversity and distribution of seaweeds in Myanmar

Studies on the seaweed floras of Myanmar have been made since 1967.[2,3,87,88] The small number of Myanmar phycologists finds it difficult to cope with year round studies of the entire regional floras. Occasional visits are made possible only during the winter and summer months.

A total of 261 marine benthic algae with 121 genera, including 72 taxa, belonging to 26 genera of Chlorophyta (Table 1), 45 taxa, belonging to 18 genera of Phaeophyta (Table 2) and 144 taxa, belonging to 77 genera (Table 3) of Rhodophyta growing alongTCZ, DCZ and RCZ, have been recorded in the present study. In general, seaweed diversity ratio in the 3 Coastal Zones was3:1:4 (TCZ with 146 taxa, DCZ with 53 taxa and RCZ with 224 taxa) (Tables 1-3). A total of 89 species of marine benthic algae, including 25 taxa of green, 9 taxa of brown and 55 taxa of red algae, were newly recorded for Myanmar waters.

Table 1 Checklist and distribution of marine green algae of Myanmar

Sr. No.	Scientific Name	Coastal Zone		
		TCZ	DCZ	RCZ
1	*Ulothrix sp. 1*	+	-	+
2	*Monostroma sp.1*	+	-	-
3	*Monostroma sp. 2*	+	-	+
4	†*Ulva lactuca* C.Agardh	-	+	+
5	*U. reticulata* Forsskal	+	-	-
6	*U. flexuosa* Wulfen	-	-	+
7	†*U. intestinalis* Linnaeus	+	+	+
8	*U. compressa* Linnaeus	+	+	+

Citation: Soe-Htun U, Kyaw SPP, Wai MK, et al. A review on the seaweed resources of Myanmar. *J Aquac Mar Biol.* 2021;10(4):152–166.
DOI: 10.15406/jamb.2021.10.00317

Table Continued...

Sr. No.	Scientific Name	Coastal Zone		
		TCZ	DCZ	RCZ
9	†*U. linza* Linnaeus	+	+	+
10	*U. clathrata* (Roth) C.Agardh	+	+	+
11	†*U. rigida* C.Agardh	-	-	+
12	†*U. prolifera* O.F.Muller	-	+	+
13	†*Cladophora prolifera* (Roth) Kützing	+	-	+
14	*C. rupestris* (Linnaeus) Kützing	+	+	+
15	*C. vagabunda* (Linnaeus) Hoek	+	+	+
16	†*C. saracenica* Boergesen	+	+	+
17	†*C. sibogae* Reinbold	+	+	+
18	†*C. flexuosa* (O.F.Muller) Kutzing	+	+	+
19	†*Cladophora sp. 1*	+	-	-
20	*Chaetomorpha antennina* (Bory) Kützing	-	-	+
21	*C. linum* (Müller) Kützing	+	+	+
22	*C. gracilis* Kuetzing	+	+	+
23	†*C. aerea* (Dillwyn) Kutzing	+	+	+
24	†*C. spiralis* Okamura	+	+	+
25	*Rhizoclonium africanum* Kützing	+	+	+
26	†*R. riparium* (Roth) Harvey	+	+	+
27	†*R. grande* Boergesen	+	+	+
28	†*R. curvatum* Chapman	+	-	+
29	†*Rhizoclonium sp. 1*	+	+	-
30	*Anadyomene stellata* (Wulfen) C.Agardh	+	-	+
31	†*Phyllodictyon anastomosan* (Harvey) Kraft & Wynne	+	-	+
32	*Valonia aegagropila* C.Agardh	-	-	+
33	*V. macrophysa* Kützing	-	-	+
34	*V. utricularis* (Roth) C.Agardh	+	+	+
35	*Ventricaria ventricosa* (J.Agardh) Olsen & West	+	-	+
36	*Valoniopsis pachynema* (Martins) Boergesen	-	-	+
37	*Dictyosphaeria cavernosa* (Forsskal) Boergesen	-	-	+
38	†*Dictyosphaeria sp. 1*	-	-	+
39	†*Struvea elegans* Børgesen	-	-	+
40	*Cladophoropsis membranacea* (Hofman Bang ex C.Agardh) Børgesen	+	+	+
41	†*Boodlea composita* (Harvey) F.Brand	-	-	+
42	*Boergesenia forbesii* (Hervey) Feldmann	-	-	+
43	*Acetabularia calyculus* Lamouroux	-	-	+
44	*Neomeris annulata* Dickie	-	-	+
45	*Bryopsis plumosa* (Hudson) C.Agardh	-	-	+
46	*B. pennata* Lamouroux	-	-	+
47	*B. hypnoides* Lamouroux	+	+	-
48	*Trichosolen mucronatus* (Børgesen) Taylor	-	-	+
49	*T. gracilis* (Womersley & Bailey) John	-	-	+
50	†*Dichotomosiphon sp. 1*	+	-	-
51	*Caulerpa racemosa* (Forsskal) J.Agardh	+	-	+
52	*C. serrulata* (Forsskal) J.Agardh	+	-	-
53	*C. verticillata* J.Agardh	-	-	+
54	*C. taxifolia* (Vahl) C.Agardh	+	-	+
55	*C. sertulariodes* (Gmelin) Howe	+	-	+
56	*C. fergusonii* Murray	-	-	+
57	*C. microphysa* (Weber-van Bosse) Feldmann	+	-	+
58	†*C. lentillifera* J.Agardh	+	-	+
59	†*C. cylindracea* Sonder	+	-	+
60	†*C. chemnitzia* (Esper) Lamouroux	+	-	+
61	*Caulerpa sp. 1*	-	-	+
62	*Halimeda macroloba* Decaisne	+	-	+
63	*H. discoidea* Decaisne	+	-	+
64	*H. opuntia* (Linnaeus) Lamouroux	+	-	+
65	*Codium fragile* (Suringar) Hariot	+	-	+
66	*C. adhaerens* C.Agardh	+	-	+
67	*C. edule* Silva	-	-	+
68	*C. arabicum* Kutzing	+	-	-
69	*Udotea sp. 1*	+	-	+
70	*Avrainvillea erecta* (Berkeley) A.Gepp et E.S.Gepp	+	-	+
71	*A. lacerata* J.Agardh	-	-	+
72	†*A. obscura* (C.Agardh) J.Agardh	-	-	+
	Total	47	22	64

TCZ , tanintharyi coastal zone; DCZ, deltaic coastal zone; RCZ, rakhine coastal zone; + = Present; - = Absent; Distribution, , TCZ only; RCZ only; , All Coastal Zones; †, New record after Soe-Htun *et al.* (2009a).

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Table 2 Checklist and distribution of marine brown algae of Myanmar

Sr. No.	Scientific Name	Coastal Zone		
		TCZ	DCZ	RCZ
1	*Sphacelaria sp. 1*	-	-	+
2	*Sphacelaria sp. 2*	+	-	+
3	*Ectocarpus sp. 1*	+	-	+
4	†*Chnoospora minima* (Hering)Papenfuss	-	-	+
5	†*Psudochnoospora implexa* (J.Agardh) Santiañez, G.Y.Cho & Kogame	-	-	+
6	*Colpomenia sinuosa* (Mertens ex Roth) Derbès & Solier	+	+	+
7	*Hydroclathrus clathratus* (C.Agardh) Howe	-	-	+
8	*Rosenvingea orientalis* (J.Agardh) Boergesen	-	-	+
9	†*R.endiviifolia* (Martius) M.J.Wynne	+	-	+
10	†Neoralfsia expansa (J.Agardh) P.-E.Lim & H.Kawai ex Cormaci & G.Furnari	-	-	+
11	Dictyota bartayresiana Lamouroux	-	-	+
12	*D. dichotoma* (Hudson) Lamouroux	-	-	+
13	*D. adnata* Zanardini	+	+	+
14	*D. hauckiana* Nizamuddin	+	-	+
15	*D. indica* Anand	+	+	+
16	†*D. implexa* (Desfontaines) Lamouroux	+	-	+
17	*Dictyota sp. 1*	-	-	+
18	*Canistrocarpus cervicornis* (Kützing) De Paula et De Clerck	+	-	+
19	*Spathoglossum asperum* J.Agardh	-	-	+
20	*Dictyopteris woodwardia* (Brown ex Turner) C.Agardh	+	-	+
21	*Lobophora variegata* (Lamouroux) Womersley ex Oliveira	+	-	+
22	*Padina antillarum* (Kützing) Piccone	+	-	+
23	*P. boryana* Thivy	+	+	+
24	*P. minor* Yamada	+	-	+
25	*P. australis* Hauck	+	-	+
26	*P. japonica* Yamada	+	-	+
27	†*P. usoehtunii* Ni-Ni-Win et H.Kawai	+	-	+
28	*Stoechospermum polypodioides* (Lamouroux) J.Agardh	+	-	+
29	*Hormophysa cuneiformis* (Gmelin) Silva	-	-	+
30	*Turbinaria ornata* (Turner) J.Agardh	+	-	+
31	*Sargassum sp. 1*	-	-	+
32	*Sargassum sp. 2*	+	-	-
33	*Sargassum sp. 3*	-	-	+
34	*Sargassum aff. trichophyllum* (Kützing) Kuntze	-	-	+
35	*S. aff. kasyotense* Yamada	-	-	+
36	*S. aff. salicifoloides* Yamada	-	-	+
37	*S. carpophyllum* J.Agardh	-	-	+
38	*S. tenerrimum* J.Agardh	-	-	+
39	*S. illicifolium* (Turner) C.Agardh	-	-	+
40	*S. plagiophyllum* C.Agardh	+	-	+
41	*S. swartzii* C.Agardh	+	-	+
42	*S. polycystum* C.Agardh	-	-	+
43	†*S. cervicorne* Greville	+	-	+
44	†*S. paniculatum* J.Agardh	+	-	-
45	†*S. aquifolium* Turner (C.Agardh)	-	-	+
	Total	24	4	42

TCZ, tanintharyi coastal zone; DCZ , deltaic coastal zone; RCZ, rakhine coastal zone; + , Present; - ,Absent; Distribution, , TCZ only; , RCZ only; , All Coastal Zones; †, New record after Soe-Htun *et al.* (2009a).

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Table 3 Checklist and distribution of marine red algae of Myanmar

Sr. No.	Scientific Name	Coastal Zone		
		TCZ	DCZ	RCZ
1	*Stylonema cornu-cervi* Reinsch	-	-	+
2	*Erythrotrichia carnea* (Dillwyn) J.Agardh	-	-	+
3	†*Bangia atropurpurea* (Mertens ex Roth) C.Agardh	-	-	+
4	†Phycocalidia suborbiculata (Kjellman) Santiañez & M.J.Wynne	+	-	+
5	†Colaconema robustum (Børgesen) Huisman & Woelkerling	+	+	+
6	*Asparagopsis taxiformis* (Delile) Trevisan de Saint-Leon	-	-	+
7	*Liagora boergesenii* Yamada	-	-	+
8	*L. ceranoides* Lamouroux	-	-	+
9	†Yamadaella caenomyce (Decaisne) I.A.Abbott	-	-	+
10	*Izziella orientalis* (J.Agardh) Huisman & Schils	-	-	+
11	*Ganonema farinosum* (Lamouroux) Fan & Wang	-	-	+
12	*Trichogloea requienii* (Montagne) Kuetzing	-	-	+
13	*Dermonema virens* (J.Agardh) Pedroche & Avila Ortiz	-	-	+
14	*Dichotomaria spathulata* (Kjellman) Kurihara & Huisman	-	-	+
15	*D. falcata* (Kjellman) Kurihara & Masuda	-	-	+
16	*D. obtusata* (Ellis et Solander) Lamarck	+	-	-
17	*D. marginata* (Ellis et Solander) Lamarck	+	-	+
18	*Galaxaura rugosa* (Ellis & Solander) Lamouroux	+	-	+
19	*G. filamentosa* Chou	+	-	-
20	*Tricleocarpa fragilis* (Linnaeus) Huisman & Townsend	+	-	+
21	*Actinotrichia fragilis* (Forsskal) Boergesen	-	-	+
22	*Scinaia furcellata* (Turner) J.Agardh	-	-	+
23	†*Melyvonnea erubescens* (Foslie) Athanasiadis & D.L.Ballantine	-	-	+
24	*Lithophyllum okamurae* Foslie	-	-	+
25	*Hydrolithon reinboldii* (Weber-van Bosse & Foslie) Foslie	-	-	+
26	*Amphiroa fragilissima* (Linnaeus) Lamouroux	+	+	+
27	*A. foliacea* Lamouroux	-	-	+
28	*A. anceps* (Lamarck) Decaisne	-	-	+
29	†*A. gracilis* Harvey	-	-	+
30	†*A. beauvoisii* Lamouroux	-	-	+
31	*Jania spectabile* (Harvey ex Grunow) Kim, Guiry & Choi	+	-	-
32	†*J. adhaerens* Lamouroux	+	-	+
33	†*J. ungulata* (Yendo) Yendo	+	-	+
34	†*J. rubens* (Linnaeus) Lamouroux	+	-	+
35	†*J. capillacea* Harvey	+	-	+
36	*J. pumila* Lamouroux	-	-	+
37	*J. radiata* Yendo	+	-	+
38	†Hydrolithon farinosum (J.V.Lamouroux) Penrose & Y.M.Chamberlain	+	-	+
39	*Metagoniolithon stelliferum* (Lamarck) Ducker	-	-	+
40	*Gelidium pusillum* (Stackhouse) Le Jolis	+	-	+
41	†*G. arenarium* Kylin	+	+	+
42	*G. crinale* (Hare ex Turner) Gaillon	+	+	+
43	*Pterocladiella capillacea* (Gmelin) Santelices & Hommersand	-	-	+
44	*Gelidiella acerosa* (Forsskal) Feldmann and Hamel	+	-	+
45	*Grateloupia filicina* (Lamouroux) C.Agardh	-	-	+
46	*G. ramosissima* Okamura	-	-	+
47	*Corynomorpha prismatica* (J.Agardh) J.Agardh	-	-	+
48	*Halymenia dilatata* Zanardini	+	-	+
49	*H. durvillaei* Bory	+	-	+
50	†Yonagunia maillardii (Montagne & Maillardet) Showe M.Lin, Y.-C.Chuang & De Cleck	-	-	+
51	*Kallymenia perforata* J.Agardh	-	-	+
52	*Sarcodia montagneana* (Hooker & Hervey) J.Agardh	-	-	+

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Table Continued...

Sr. No.	Scientific Name	Coastal Zone		
		TCZ	DCZ	RCZ
53	†*Ahnfeltiopsis flabelliformis* (Harvey) Masuda	+	-	+
54	†*Ahnfeltiopsis sp. 1*	+	-	-
55	*Titanophora pikeana* (Dickie) Feldmann	-	-	+
56	Peyssonelia rubra (Greville) J.Agardh	+	+	+
57	†*Peyssonelia sp. 1*	+	-	-
58	*Chondracanthus acicularis* (Roth) Fredericq	+	+	+
59	†*C. intermedius* (Suringar) Hommersand	-	-	+
60	*Catenella nipae* Zanardini	+	+	+
61	*C. impudica* (Montagne) J.Agardh	+	+	-
62	†*C. caespitosa (Withering)* Irvine	+	-	-
63	*Hypnea chordacea* Kützing	-	-	+
64	*H. valentiae* (Turner) Montagne	+	-	+
65	*H. flagelliformis* Greville ex J.Agardh	-	-	+
66	†*H. cervicornis* J.Agardh	-	-	+
67	*H. charoides* Lamouroux	-	-	+
68	†*H. musciformis* (Wulfen) Lamouroux	+	-	-
69	*H. spinella* (C.Agardh) Kützing	-	-	+
70	*H. hamulosa* (Esper) Lamouroux	+	-	+
71	†*H. pannosa* J.Agardh	+	-	+
72	†*H. anastomosans* Papenfuss, Lipkin & Silva, q.v.	+	+	+
73	*H. cenomyce* J.Agardh	-	-	+
74	*H. japonica* Tanaka	-	-	+
75	*Plocamium cartilagineum* (Linnaeus) Dixon	-	-	+
76	*Portieria hornemanii* (Lyngbye) Silva	+	-	+
77	*Solieria robusta* (Greville) Kylin	-	-	+
78	†*Gracilariopsis longissima* (S.G.Gmelin) Steemtoft, L.M.Irvine & Farnham	+	+	+
79	*Gracilaria canaliculata* Sonder	+	+	+
80	*G. foliifera* (Forsskal) Boergesen	+	-	+
81	*G. textorii* (Suringar) Hariot	+	-	+
82	†*G. salicornia* (C.Agrdh) Dawson	-	-	+
83	†Hydropuntia millardetii (Montagne) Gurgel, J.N.Norris & Fredericq	+	-	+
84	†H. edulis (S.G.Gmelin) Gurgel & Fredericq	+	+	+
85	†*H. eucheumoides* (Harvey) Gurgel & Fredsricq	+	-	+
86	†*Ceratodictyon repens* (Kutzing) R.E.Norris	+	+	+
87	†C. variabile (J.Agardh) R.E.Norris	-	-	+
88	*Champia parvula* (C.Agardh) Harvey	-	-	+
89	*Botryocladia botryoides* (Wulfen) Feldmann	-	-	+
90	*B. leptopoda* (J.Agardh) Kylin	-	-	+
91	†*Coelarthrum opuntia* (Endlicher) Børgesen	-	-	+
92	*Calliblepharis ciliata* (Hudson) Kützing	+	-	-
93	†C. saidana (Holmes) M.Y.Yang & M.S.Kim	-	-	+
94	†*Taenioma perpusillum* (J.Agardh)J.Agardh	+	-	-
95	*Antithamnion antillanum* Boergesen	-	-	+
96	†*Ceramium aduncum* Nakamura	+	-	-
97	*Ceramium sp. 1*	+	+	+
98	*Ceramium sp. 2*	+	-	+
99	*Crouania attenuata* (C.Agardh) J.Agardh	-	-	+
100	*Centroceras clavulatum* (C.Agardh) Montagne	+	-	+
101	*Ptilota gunneri* Silva, Maggs & Irvine	-	-	+
102	*Spyridia filamentosa* (Wulfen) Harvey	-	-	+
103	*Plumariella sp. 1*	-	-	+
104	†*Acrothamnion butlerae* (Collins) Kylin	+	-	-
105	*Dasya flagellifera* Boergesen	-	-	+
106	†*Heterosiphonia muelleri* (Sonder) De Toni	-	-	+

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Table Continued...

Sr. No.	Scientific Name	Coastal Zone		
		TCZ	DCZ	RCZ
107	*Caloglossa leprieurii* (Montagne) Martens	+	+	-
108	*C. bengalensis* (Martens) King & Puttock	+	+	+
109	†*C. adhaerens* King & Puttock	+	+	-
110	†*C. stipitata* E.Post	+	+	-
111	†*C. beccarii* (Zanardini) De Toni	+	+	-
112	†*C. continua* (Okamura) King & Puttuck	+	+	-
113	†*C. vieillardii* (Kutzing) Setchell	+	+	-
114	*Vanvoorstia spectabilis* Harvey	-	-	+
115	*Martensia fragilis* Harvey	-	-	+
116	*Acanthophora spicifera* (Vahl) Boergesen	+	+	+
117	*A. muscoides* (Linnaeus) Bory	+	-	+
118	*Lophocladia lallemandii* (Montagne) Schmitz	-	-	+
119	*Acrocystis nana* Zanardini	+	-	-
120	*Laurencia composita* Yamada	-	-	+
121	*L. pinnata* Yamada	-	-	+
122	†*Laurencia sp.1* (= *Laurencia intricata* Lamouroux)	+	+	+
123	†*Laurencia sp.2* (= *Chondrophycus ceylanicus* (J.Agardh) Wynne, Serio, Cormaci & Furnari)	-	-	+
124	†*Palisada perforata* (Bory) K.W.Nam	+	-	+
125	†*P. intermedia* (Yamada) K.W.Nam	-	-	+
126	†*P. parvipapillata* (C.K.Tesng) K.W.Nam	+	-	-
127	*Polysiphonia subtilissima* Montagne	+	-	+
128	†*P. atlantica* Kapraun & Norris	+	-	-
129	*Polysiphonia sp.1*	+	+	+
130	†*Polysiphonia sp.2*	+	-	-
131	†Wilsonosiphonia howei (Hollenberg) D.Bustamante, Won & T.O.Cho	+	-	-
132	*Herposiphonia secunda* (C.Agardh) Ambronn	-	-	+
133	†*H. tenella* (C.Agardh) Ambronn	+	-	-
134	*Leveillea jungermannoides* (Hering & Martens) Harvey	-	-	+
135	*Neurymenia fraxinifolia* (Mertense ex Turner) J.Agardh	-	-	+
136	*Tolypiocladia glomerulata* (C.Agardh) Schmitz	+	-	+
137	†*T. calodictyon* (Harvey ex Kutzing) Silva	-	-	+
138	*Bostrychia tenella* (Lamouroux) J.Agardh	+	+	+
139	*B. binderii* Harvey	+	+	+
140	†*B. radicans* (Montagne) Montagne	+	+	+
141	†*B. calliptera* (Montagne) Montagne	+	+	+
142	†*Bostrychia sp. 1*	+	+	-
143	†*Amansia glomerata* C.Agardh)	-	-	+
	Total	75	27	118

TCZ, tanintharyi coastal zone; DCZ, deltaic coastal zone; RCZ, rakhine coastal zone; +, Present; - ,Absent; Distribution , , TCZ only; , RCZ only; , All Coastal Zones; †, New record after Soe-Htun *et al.* (2009a).

With regard to the distribution of marine benthic algae, 25 species wereuniquely found in TCZ which is facing the inner maginal sea of the Andaman Sea, whereas 111 species are exclusively encountered in RCZ which is facing directly the open sea of the Bay of Bengal, showing the latitudinal distribution of marine benthic algae along the long scretching distance of 2831 km from 10° to 21° N of Myanmar Coastal Zones. However, between these lattitutes, 43 species, including 18 taxa of green algae, 4 taxa of brown algae and 21 taxa of red algae, ubiquitously occurred along the 3Coastal Zones.

Along the southern parts in both TCZ and RCZ, the most commonly encountered taxa werethe stenohaline species of marine algae, namely, *Anadyomene*, *Caulerpa*, *Codium*, *Halimeda*, *Stoechospermum*, *Dictyopteris*, *Canistrocarpus*, *Lobophora*, *Turbinaria*, *Sargassum*, *Phycocalidia*, *Gelidiella* and *Tolypiocladia*. In the northern parts of the two same and in DCZ were estuarine areas prevailed, a few numbers of marine algal taxa such as *Ulva*, *Colpomenia*, *Amphiroa*, *Gracilaria*, *Catenella, Laurencia*, *Acanthophora* and *Bostrichia* were commonly encountered.

Economic seaweeds of Myanmar

Sargassum and *Hypnea*natural beds can be considered as sustainable resources of Myanmar if they were properly exploited (Kyaw Soe, 1970). However, systematic estimates on the quantities of seaweeds that can be exploitedfrom the natural beds have not been made in Myanmar's coastal areas. From visual observations and transect data, the following seaweed genera may be of economic potential used as sea-vegetables (Figure 2-11), alginophytes ((Figure 12-22), agarophytes ((Figure 23-32)and carrageenophytes

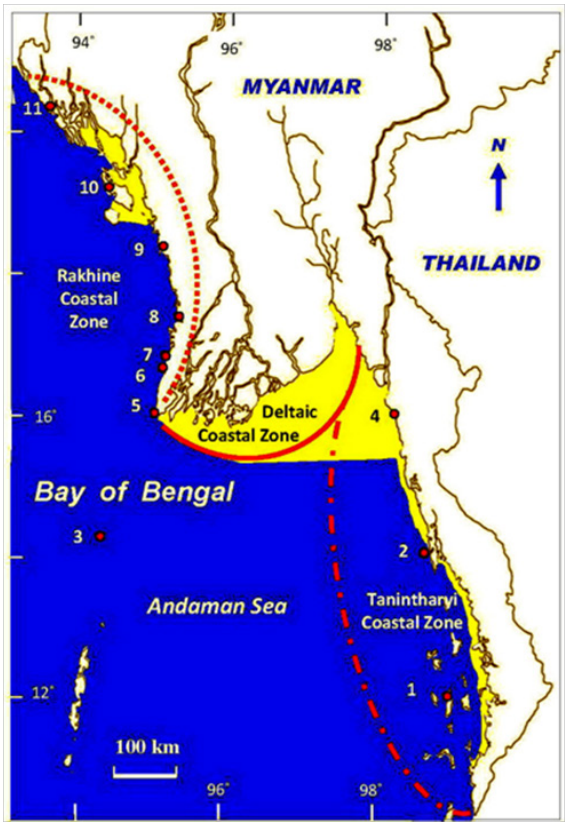
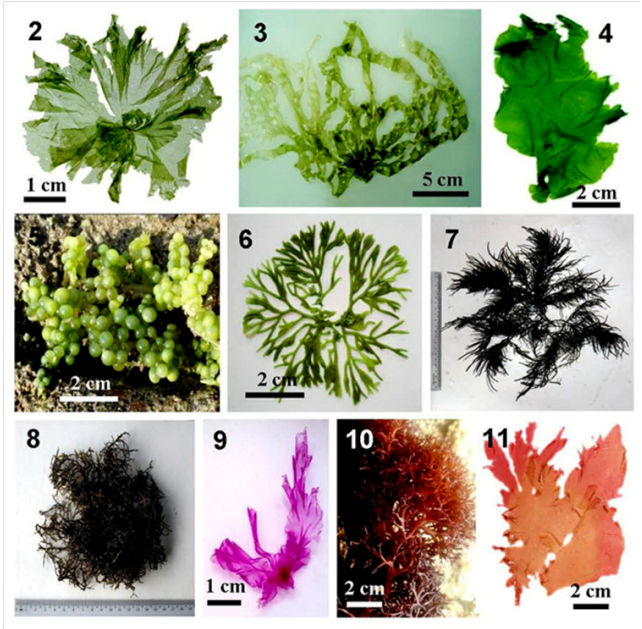
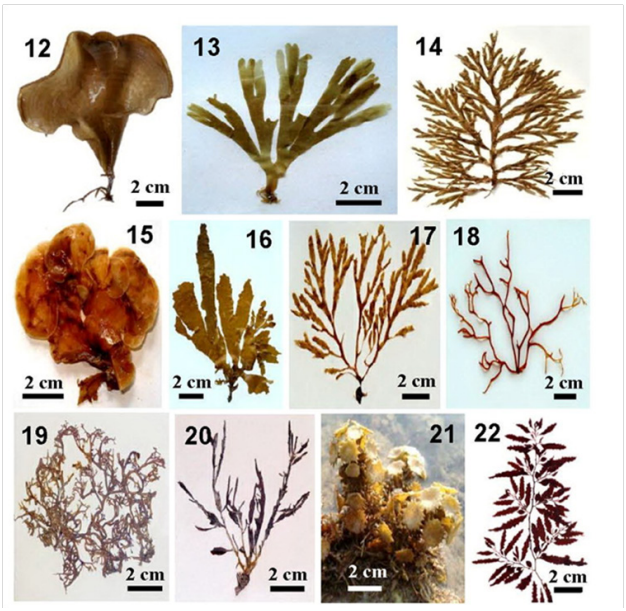


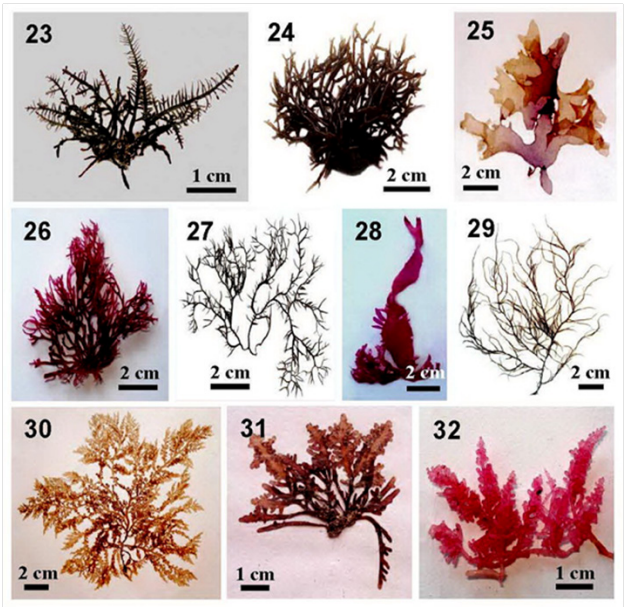
Figure 1. Map of seaweeds collection sites in Myanmar- 1. Myeik (Mergui) Archipelago; 2. Maungmagan (Dawei, Tavoy); 3. Co Co Gyi I.; 4. Setse; 5. Mawtin Point; 6. Ngwe Saung; 7. Chaung Thar; 8. Gwa Aw; 9. Mazin-Ngapali (Sandoway); 10. Kyauk Phyu (Ramree Is.);11. Sittwe (Akyab). = Marine = Estuarine; = Tanintharyi Coastal Zone; = Deltaic Coastal Zone; = Rakhine Coastal Zone.



Figures 2-11 Edible seaweeds. 2. *Monostroma sp*. 3. *Ulva reticulata*. 4. *U. linza*. 5. *Caulerparacemosa*. 6.*Codium fragile*. 7. *Hydropuntia edulis*. 8.*Catenellanipae*. 9. *Phycocalidiasuborbiculata*. 10. *Dermonema virens*. 11. *Halymenia dilatata*.



Figures 12-22 Alginophytes. 12. *Padina boryana*.13.*Dictyotadichotoma*. 14. *Dictyopteris woodwardia*.15. *Lobophora variegata*. 16. *Spatoglossum asperum*. 17. *Stoechospermum polypodioides*.18.*Chnoospora minima*.19.*Rosenvingea orientalis*.20. *Hormophysa cuneiformis*. 21.*Turbinaria ornata*.22.*Sargassum swartzii*.



Figures 23-32 Agarophytes. 23. *Gelidiella acerosa*. 24. *Gracilariacanaliculata*. 25. *G.textorii*.26. *G. foliifera*.27. *Hydropuntiaedulis*.28. *H. millardetii*. 29. *Gracilariopsis longissima*. 30.*Laurencia composita*.31.*L. pinnata*.32. *Palisida intermeda*.

((Figure 33-41) for production of relevant phycocolloids such as alginates, agar-agar and carrageenans. Chlorophyta: *Monostroma, Ulva, Caulerpa* and *Codium*; Phaeophyta- *Padina, Dictyota, Dictyopteris*, *Spatoglossum, Stoechospemum, Chnoospora, Rosenvingea, Hormophysa, Turbinaria* and *Sargassum*; Rhodophyta: *Phycocalidia*, *Dermonema, Gelidiella, Halymenia, Solieria, Catenella, Gracilaria, Hydropuntia*, *Gracilariopsis*, *Hypnea, Laurencia* and *Acanthophora.* Among these, *Sargassum* and *Hypnea* are the most abundant genera of seaweeds. The standing stocks of *Sargassum* and *Hypnea* were estimated at 1000 tonnes (dry wt.) per year and 500tonnes (dry wt.) per year, respectively.[87]

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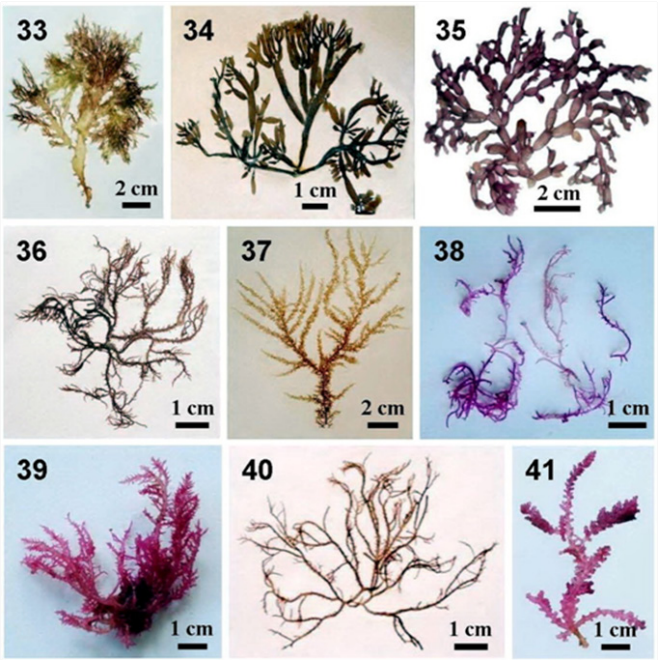

Figures 33-41 Carrageenophytes. 33. *Halymenia durvillaei*. 34. *Solieria robusta*.35.*Catenella impudica*.36. *Hypnea valentiae*. 37. *H. charoides*. 38. *H. spinella*.39.*H. hamulosa*. 40. *H. musciformis var. hippuriodes*. 41. *Acanthophora spicifera*.

Seaweed processing and industry

Sea vegetables

Sea-vegetables have commercial importance as a dietary supplement to combat goiter, inhibit the progress of hypertension, ease insomnia, prevent stomach diseases, constipation and internal parasites in the digestive tract, stimulate greater activity and promote longevity for the presence of natural vitamins, minerals and trace elements.[88-93] *Catenella nipae* collected from the mangrove-covered areas of Myeik is sold in Kyaikkhami and Yangon Market and eaten raw or boiled, with sesame oil and spices.[94] Min-Thein and Soe-Htun[21] made edible seaweed sheets from a combination of *Ulva* (ex *Enteromorpha*) and *Catenella.* Likewise, Soe-Htun et al. [95] produced papery seaweed sheets very similar to Japanese "Nori" sheets using *Catenella* (Figure 42). Some local people produced seaweed sheets using *Hypnea*or *Catenella,* known as "Kyaukpwint" in Myanmar (Figure 43) for sale in the domestic markets.

People living in the coastal areas also eat *Ulva*, *Caulerpa*, *Codium*, *Sargassum, Halymenia*, *Hypnea*, *Solieria*, *Sarcodia*,*Gracilaria*, *Gracilariopsis* and *Catenella* in salads. The coastal people of Zea Gyaing Village, situated between the Mortin Point and the Cape Negrais, traditionally collected *Dermonema virens* which are called "Kyauk Kyar" in Myanmar, in the rainy season to be used as seaweed salad. Those people did not collect *Phycocalidiasub orbiculata* which grow abundantly together with *Dermonema virens* because they did not know the nutritional values. In general, *P.suborbiculata* and *D.virens* could be used as sea-vegetables for the people living in inland areas of Myanmar.

Now, the papery seaweed sheets imported from Thailand and China were very popular among the Myanmar people. Likewise, *Sparassis crispa*, the cauliflower mushroom which was imported from China, under the fake name "Kyauk Pwint" in Myanmar, meaning seaweed, is greatly preferred by Myanmar people. The salad of that fungus known as the salad of seaweed is available in every restaurant. Fortunately, it is needed to conduct mass production of the genuine Myanmar edible seaweeds, namely *Monostroma*, *Ulva*, *Caulerpa*, *Dermonema*, *Phycocalidia*, *Halymenia*, *Sarcodia*, *Solieria*, *Hypnea*, *Gracilaria*, *Hydopuntia*, *Gracilariopsis* and *Catenella* from the natural beds or cultivation grounds to compete the original local market demands of that mushroom from China.

Moreover, it is necessary to inform the benefits of eating seaweeds with higher contents of vital vitamins, proteins, antibiotics, antivirus, antitumours, antioxidants, and essential trace elements and minerals in the edible seaweeds of Myanmar to the people of Myanmar by the public media such as radios and television programs.

About 1000 tonnes of brown algae with a high concentration of iodine are washed ashore, in every year, forming an extensive brown band on the beaches, especially along RCZ. If these algae could be transformed into foods, sea-vegetables or seaweed tablets (Figure 44) for consumption, it could be of great economic resource and to the people living in the highlands along the northeast and northwest frontiers of Myanmar, helping for reducing goiter incidences associated with iodine deficiency that cause a large numbers of cretins and deaf mutes.[96] Researchers in various departments and organizations have the responsibility of providing seaweed resources for inland needs.

The production of alginate

Sodium alginate can be extracted from *Sargassum* spp., *Padina, Stoechospermum* and *Turbinaria* growing along the Myanmar coastal areas[97,98] (Figure 45-46). At the moment, local demands for sodium alginate in confectionery, pharmaceuticals, and textile and rubber industries are gradually increasing. It is expected that the ever increasing local demands of alginates will lend support to the development of the modern alginate factories, using raw materials of *Sargassum* spp. collected from the natural beds and artificial cultivation of *Sargassum* along TCZ and RCZ, in Myanmar.

The production of agar-agar

Biochemists in the Department of Marine Science, Mawlamyine University, had made a number of intensive studies dealing with the extraction of agar-agar from *Gracilaria* spp.[99-101] To fulfill the domestic demands for agar-agar, either in powder form or in stripe form (Figure 47), collaboration works between scientists and potential investors are required to establish a viable agar-agar industry in Myanmar.

The production of carrageenan

Although carrageenan can be extracted from *Catenella*,[102] this phycocolloid is mainly obtained from *Hypnea* spp. collected in large quantities from natural beds.[103,104] About 25 small factories are now producing stripes (Figure 48) and flakes (Figure 49) of carrageenan for the domestic markets. However, the general public in Myanmar does not know whether it is carrageenan or agar-agar, and refers to both under the same name, "Kyaukkyaw" in Myanmar. Modern factories are needed to produce high quality carrageenan products from the raw materials of the local species of *Hypnea*, *Catenella* and *Solieria*, and the foreign species, *Kappaphycus alvarezii* cultivated in Myanmar.

Cultivation of seaweeds

The only seaweed pilot farm of *Gracilaria edulis*(=*Hydropuntia edulis*)(Figure 50) in Maung Shwe Lay Gyaing (18˚ 17´N, 94˚20´E), Thandwe, in the Rakhine State,[105,106] stopped its production in 1987, due to lack of demand for agar industry by local users. The experimental

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cultivation of *Gracilaria* and *Catenella* had been undertaken at Setse Aquaculture Research Center (SARC) on a small-scale to produce sea-vegetables and agar-agar and carrageenan.[48,107-19] In addition, Hla Tint[110] showed that *Gracilaria edulis* and *G. Crassa* grew well in the reservoir ponds used for salt production. Nets (3mx1m) with seedlings were fixed with four bamboo poles in these ponds. After 3 months, the plants were harvested and a yield of 15-20kg (wet wt.) per net was recorded. This method can be used together with the shrimp *Penaeus monodon* in a polyculture system.

Recently, some local fishers living in coastal areas of RCZ try to cultivate *Hydropuntia edulis*(ex *Gracilaria edulis*) collected from Yay Myet Taung Gyaing, in Chan Pyin and Gyaing Kauk Gyaing. They had good results to produce raw materials of *H. edulis*. However, there are no local market demands of these raw materials. Many calm bays and inlets along RCZ are suitable for the cultivation of *Gracilaria* spp. and *Hydropuntia* spp.

Figures 42-49 Experimental products of seaweeds. 42. Papery *Catenella* sheets. 43. A pack of instant noodle-like *Catenella* sheets. 44. *Sargassum* tablets (500mg). 45. Sodium alginate fibre. 46. Sodium alginate powder. 47. Strips of agar-agar. 48. Strips of carrageenan. 49. Flakes of carrageenan.

Soe-Htun *et al.*[49] used bamboo sticks (5cmx45cm) as spore collectors for cultivation of *Catenella*. One third of the total length of the bamboo stakes were inserted into the mudflats of the mangrove swamps between the *Caloglossa* and *Crassostrea* zonesto collect *Catenella* spores during winter and summer. Luxuriant growth of *Catenella* was observed on both sides of the bamboo stakes after the rainy season (Figure 51). The yield of *Catenella* was about 40-50gm (wet wt.) per bamboo stake. It is expected that thousands of hectares of mudflats in the mangrove swamps will be potentially used for *Catenella* cultivation farms in coastal areas of Myanmar.

Commercial mariculture industries of seaweed, using *Kappaphycus alvarezii*(Doty) Doty (Figure 52) transplanted from the Philippines, had been successfully established in shallow and sheltered subtidal zones of the Myeik Archipelago coastal waters in the TCZ since 2004 by a group of Koreans from MSC Co. Ltd., under the supervision of Prof. Dr. Masao Ohno(Kochi University, Japan), creating new livelihoods as seaweed farmers.[111] During that time, a total of ca. 500 acres of *Kappaphycus* firms in various coastal islands, namely, Mali I. (5 acres), Pyin Sa Bu I. (50 acres), Done Pale Aw (100 acres), Sharr Aw (15 acres), Kyun Hmay Yar I. (10 acres), La El (20 acres),Tawpan Gyi I. (30 acres), Tawpan Nyge I. (15 acres), Daung Kyun I.(40 acres), Kanaung I. (50 acres), Linn Lunn Village (35 acres), Kyunpon Is. (20 acres), Pan Daung I. (10 acres), Thamihla I. (7 acres), Maw Tone Gyi Aw (Padaw Aw)(47 acres), Warr KyunI. (5 acres), Mee Thway I. (10 acres) and Zar Det Gyi I. (30 acres)were launched to produce the raw matetials of *Kappaphycus alvarezii*. Although a total production of ca. 2000 tonnes (dry wt.) per year will be expected, a total of 1000 tonnes (dry wt.) were produced during the culture periods of 7 years from 2005-2006 to 2011-2012 from these seaweed firms. In 2012, the local seaweed firmers stopped its operations for culture of *Kappaphycus alvarezii* due to ice-ice disease occurred in all seaweed firms along the Myeik Archipelago coastal waters. Recently, some of the seaweed firmers living in Ma Aai Village, Kyaweku-Kyaukphya Village, Pann Zin Village, Min Gaung Sae Village, Pal Taing Village andLutlut Village try to cultivate the estuarine species, *Hydropuntia edulis*.

Figures 50–52 Marine red algae cultured in various coastal areas. 50. *Gracilaria edulis*(= *Hydropuntia edulis*) cultured in Maung Shwe Lay Gyaing of Rakhine State. 51. Cultivation of *Catenellanipae* in mangrove swamps atSetse. 52. *Kappaphycus alvarezii* harvested from cultivation grounds in the Myeik (Mergui)Archipelago.

Conservation of natural seaweed beds

Marine algal beds in 3 Myanmar Coastal Zones serve as natural habitats as well as feeding, spawning and nursery grounds for the economically important marine living resources such as shrimps,

clams, oysters and fishes. Within five decades, natural marine algal beds are remarkably degrading in all Coastal Zones. For example, 50 years ago, there were many *Sargassum* beds large enough for the *Hypnea* spp. growing as of epiphytes on top of the leaves and branches of *Sargassum*. Every year, seaweed dealers bought about 400-500 tonnes of this dried *Hypnea* spp. from the local fishers of Zea Gyaing Village coastal areas, located between the Mortin Point and the Cape Negrais in the southernmost RCZ, to produce the products of carrageenan. Now, there are no *Sargassum* beds and no *Hypnea* as well in ZeaGyaing Village coastal areas. Similarly, the same conditions occur in the collections of *Hypnea* spp. growing along Ramree I. and Mun Aung I. which are situated in the northern RCZ.

It is needed to know which factors cause that kind of total depleting of all those natural seaweed beds that directly support economically important marine living resources and indirectly provided the livelihoods of the coastal people and seaweed dealers and phycocoloid producers. For this reason, the conservation of natural beds of marine algae is vital for the sustainable development of other marine living resources in the future. Likewise, rigorous floristic studies on tropical marine benthic algae of Myanmar are still needed to be worked out to understand the present status of diversity of seaweeds which in turn paves the way to compare the phyto sociological changes of these floras due to the impacts of global warming and climate change in the future. The processes of management for the conservation of these tropical marine algal floras against over-harvesting and domestic municipal wastes and land-based industrial pollutants are underway to preserve natural diversity of marine algae by the Ministry of Environmental Conservation and Forestry (MOECAF).

Conclusions

The present study recorded a total of 261 taxa of marine benthic algae growing in 3 Coastal Zones of Myanmar. In general, diversity ratio of marine benthic algae is 3:1:4 between the Tanintharyi Coastal Zone (146 taxa), the Deltaic Coastal Zone (53 taxa) and Rakhine Coastal Zone (224 taxa). Although the studies on morphotaxomy of the most common matrine algae have been mainly done well during a half of century, it is still necessited to the study molecular taxonomy of marine algae to confirm the nomenclature of it in Myanmar. In addition, the ecological studies on marine algae of Myanmar are also extremely needed to be done to know the impacts of controlling factors such as the climate change and land-based pollution which severely impact on the phenology of marine algae growing along 3 Coastal Zones in Myanmar.

Although coastal people directly used *Ulva*, *Caulerpa*, *Codium*, *Sargassum*, *Dermonema*, *Halymenia*, *Hypnea*, *Gracilaria*, *Hydropuntia*, *Gracilariopsis*, *Catenella* and *Solieria* as sea-vegetables in salads, there were still no firms to produce mass production of sea-vegetables for the people living in inland and highland of Myanmar. Recently, there are no phycocolloid industries due to lack of relevant raw materials of seaweeds in Myanmar. However, phycocolloid industries in small scale can be established using the materials from culture grounds in various coastal areas of Myanmar Coastal Zones using *Gracilaria* spp., *Hydropuntia* spp., *Gracilariopsis longissima* and *Catenella nipae*. In general, mariculture of seaweeds such as *Ulva*, *Phycocalidia*, *Hydropuntia edulis* and *Kappaphycus alvarezii* in Myanmar faces many challenges to establish seaweed industries or phycocolloid industries in Myanmar. During a half century, seaweed beds are gradually depleteing in all 3 Coastal Zones in Myanmar due perhaps to lack proper management on the industrial and municipal wastes from inland areas. The managemaent plans for conservation of seaweed beds that support the economically important fishery resources and provide the livelihoods of the coastal people, are still needed.

In short, mariculture industries of economically important red seaweeds such as *Hydropuntia edulis* and *Gracilariopsis longissima* luxuriantly grown in the estuarine areas of Rakhine and Tanintharyi Coastal Zones, *Catenella nipae* commonly found in the DeltaicCoastal Zone and *Kappaphycus alvarezii* in the Myeik (Mergui) Archipelago of the Tanintharyi Coastal Zone, can also be established to create the new livelihoods for the people living in coastal areas.

Acknowledgements

We are indebted to Dr. Aung Myat Kyaw Sein, Rector of Mawlamyine University, for his encouragement and supports in this work. We are very grateful to the late Dr. Min-Thein, Director (Retd), Ministry of Industry (1), Myanmar Pharmaceutical Factory (MPF), Sagaing, Myanmar for his valuable suggestions and supports in this work. We express our gratitude towards U Aung Myint, Director of *Renewable Energy* Association *Myanmar (REAM)* for sharing his knowledge on the cultivation of *Gracilaria* in Maung Shwe Lay Gyaing, Thandwe District, Rakhine State. We are thankful to Prof. Dr. Myint Myint Cho(Retd), Department of Marine Science, Mawlamyine University,for her expert information on the extraction of phycocolloids from the marine algae of Myanmar. We would like to thank Dr. Ni Ni Win, Assistant Professor, Kyushu University, Japan, for providing literature on Phycology. Special thanks go to U Aye Thwin, Deputy Director (Retd.), Department of Fishery (DoF) and U Kyaw Zay Ya (FFI), for providing with a lot of valuable information based ontheir experience in the cultivation of *Kappaphycus* and *Gracilaria* in the Myeik Archipelago waters. Many thanks go to the local people who kindly help us in many ways during our field trips. We would like to express our sincere thanks to Dr.Thida Nyunt, Dr.Khin Khin Gyi, Dr. Myo Min Tun, Dr. Aung Aye Latt, Dr. Aung Myo Hsanand U Thet Htwe Aung, Department of Marine Science, Mawlamyine University, and Prof. Dr. Yin Yin Htay, Department of Marine Science, Pathein University, for their helpful assistance in the preparations of the manuscript. We would like to extend our sincere thanks to the members of Marine Science Association, Myanmar (MSAM) for their interest and supports in this work.

Funding

None.

Conflicts of interest

The authors have no conflict of interest.

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Citation: Soe-Htun U, Kyaw SPP, Wai MK, et al. A review on the seaweed resources of Myanmar. *J Aquac Mar Biol.* 2021;10(4):152–166.
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Citation: Soe-Htun U, Kyaw SPP, Wai MK, et al. A review on the seaweed resources of Myanmar. *J Aquac Mar Biol.* 2021;10(4):152–166.
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