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A comparative study of seaweed flora over a period of time with reference to climate change in Visakhapatnam Coast, Andhra Pradesh, India

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ABSTRACT

A comparative study on present status of marine macro algal flora in relation to their occurrence, distribution and diversity was carried out at along the Visakhapatnam coast intertidal shores areas of Bay of Bengal, East coast of India over a period of five decades with reference to climate change. A total of 48 seaweeds species were recorded, of which 18 species (37%) belong to Chlorophyta, 9 species (19%) belong to Phaeophyta and 21 species (44%) belong to Rhodophyta. A total of 10 macroalgae species were newly recorded, while, 41 species were found to be absent during the present study when compared to 1964 data obtained from this coast. In the present study, the impacts of Hudhud, severe tropical cyclone on intertidal macro algae was observed. Cyclone development in East coast of India was observed in the months of September – November, when prominent growth of macroalgae was recorded. Climate change not only increases the impact of environmental stressors but also intensify their frequency of occurrence.

Keywords: Seaweeds, Visakhapatnam coast, Bay of Bengal, Climate change, Hudhud cyclone.

INTRODUCTION

Seaweeds are macroscopic marine algae that are differentiated into three distinct divisions, Chlorophyta (green algae), Phaeophyta (brown algae) and Rhodophyta (red algae). Seaweeds, known as macroalgae, are among the most important primary producers and act as ecological engineers on rocky coasts of the world's ocean. Most of the seaweeds are growing in the intertidal zone throughout the world although some occupied the supra-littoral and sub-littoral zones of the sea.

In this paper, we consider the vulnerability of intertidal macroalgae to climate change in terms of the vulnerability of species composition and distributions, with reference to five decades data. Climate change refers to the complex environmental changes caused by increasing emissions of CO_2 and other greenhouse gases to the atmosphere, and they have great consequences for marine life forms [3]. Climate change will reduce the resilience of macroalgal habitats to other stressors such as pollution. Extreme events (storms, heat waves, etc) will increase in frequency and magnitude and drive shifts in species' distributions and interactions [8].

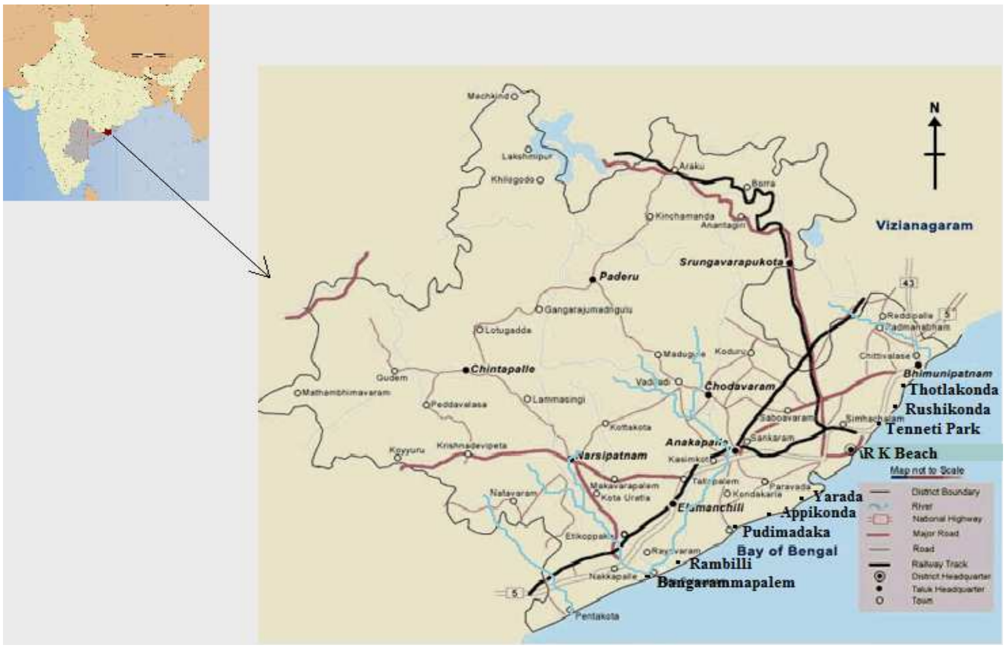
However, it is not only the biodiversity of algae themselves that is under threat; macroalgae are foundation species that facilitate the existence of a myriad of equally unique associated marine life. International studies suggest that climate driven loss of macroalgal canopies to waves may have cascading effects on associated ecosystems and food webs. In the present study, data on macro algae diversity along the Visakhapatnam coast was collected and compared with previous data over a period of five decades to assess the changes in relation to climate change and associated environmental factors.

Study Area: The study area Visakhapatnam coast was located in North Eastern part of Andhra Pradesh between 17^o - 15' and 18^o-32' Northern latitude and 18^o - 54' and 83^o - 30' in Eastern longitudes. Outcrops of rocky boulders on the Visakhapatnam coastline, extending over 132 km, offer a variety of habitats for the growth of marine algae.

Considering the variations in the nature of the substratum and the associated ecological conditions, ten field stations were selected along the coastline for algal collection and detailed study. There are two river openings into the sea in the vicinity of field station I (Varaha River) and station X (Gosthani River) (Figure 1).

Field Station	Study area/ Site	Substratum available for algal growth
I	Bangarammapalem	Large rocky boulders
II	Rambilli	Rocky boulders
III	Pudimadaka	Rocky platform
IV	Appikonda	Large rocky boulders
V	Yarada	Rocky platform with small basin like pools
VI	Ramakrishna beach	Shingle area
VII	Tenneti Park	Large rocky platform with small basin like pools
VIII	Rushikonda	Shingle area
IX	Thotlakonda	Large rocky platform with tidal pools
X	Bheemunipatnam	Large rocky platform with small basin like pools

Figure 1: Map showing field stations at the Visakhapatnam coast



MATERIALS AND METHODS

Field data was obtained during leap tides (low height tides) from May, 2013 to January, 2015. The whole year is classified into four seasons i.e., May-July, August-October, November-January and February-April for our consideration. Each field site was sampled throughout the year seasonally for species cover and species presence or absence. Species cover is sampled by using quadrat sampling method. Species composition and coverage were obtained from the data collected by using 20 randomly selected quadrat size of 50cmX50cm with 25 subdivisions following the method developed by [9]. Seaweed species, coverage and corresponding indices (referring to Table 1) in each of the 25 subdivisions were recorded. The parameter obtained from each quadrat with respect to coverage (C; expressed as %) was used to compute for the area in the substrate occupied by the species. For convenience, the index numbers: 5, 4, 3, 2, 1 were used for recording data in the field as in the Table 1. Species Richness (SR), Shannon-Weiner Diversity Index (H^1) and Evenness (e) were also calculated.

$$C(`\%)=(qn_5xc_5)+(qn_4xc_4)+(qn_3xc_3)+(qn_2xc_2)+(qn_1xc_1)$$

where, qn_n is the number of subdivisions in which a species appeared to have the corresponding area described in the Table 1.

Table 1. Indices of the degree of macro algae cover and its representative multiplier

Indices	Degree of algal cover on the substratum	Multiplier, C_n
5	Covering 1/2-1 of the substratum surface	3.0
4	Covering 1/4-1/2 of the substratum surface	1.5
3	Covering 1/8-1/4 of the substratum surface	0.75
2	Covering 1/16-1/8 of the substratum surface	0.375
1	Covering less than 1/16 of the substratum surface	0.1875

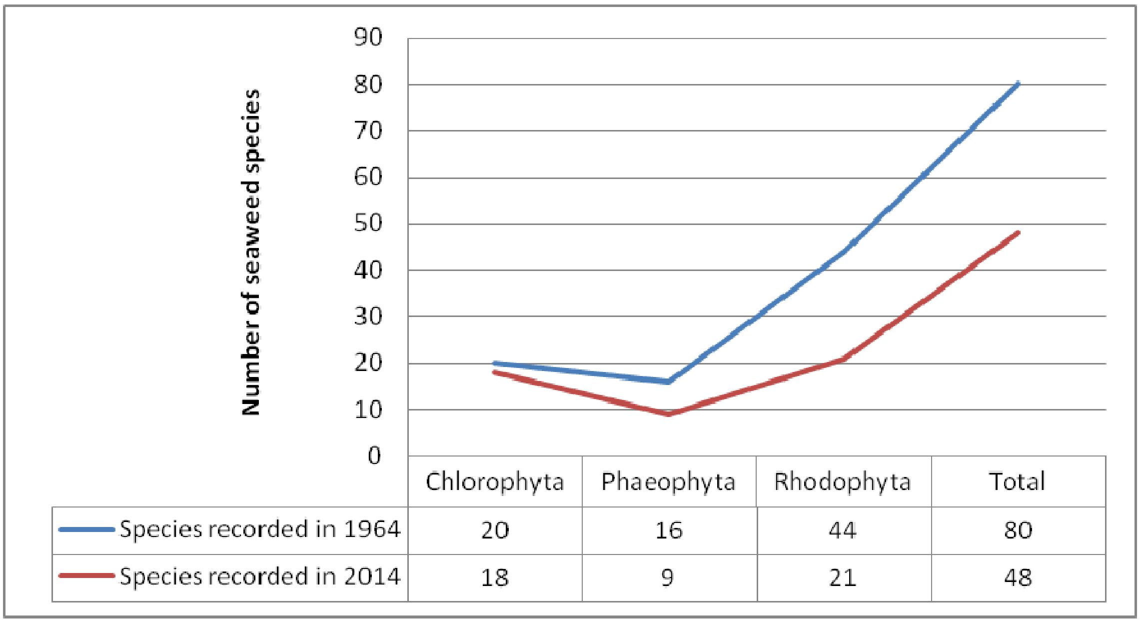
Representative seaweed samples were preserved in 5.0% saline formalin solution and were identified with descriptions and the taxonomic keys provided by Umamaheswara Rao (1964, 1970); Narasimha Rao (1989), Prasanna Lakshmi & Narasimha Rao (2009) and Satya Rao et al., (2011). The observed data from the present study was correlated with pervious data over a period of five decades to notice the changes in diversity and species composition of macro algae at Visakhapatnam coast.

RESULTS AND DISCUSSION

Visakhapatnam coastline provides a good habitat for macroalgae with semidiurnal tides (i.e., two spring tides and two leap tides a day). A total of 48 seaweeds species were recorded in the coast during the study period, of which 18 species (36%) belong to Chlorophyta, 9 species (19%) belong to Phaeophyta and 21 species (45%) belong to Rhodophyta. The species *viz. Ulva fasciata*, *Ulva lactuca*, *Enteromorpha compressa*, *Chaetomorpha antennina*, *Cladophora socialis*, *Spongomorpha indica*, *Amphiroa fragilissima*, *Gracilaria corticata*, *Gracilaria textori*, *Padina tetrastromatica* and *Caulerpa taxifolia* were found to be dominant in rocky shores and other submerged hard surfaces of Visakhapatnam coast (Table 2).

The earlier studies [2], [6], [7] have reported 80 species of marine algae from Visakhapatnam coast, whereas, [4], [5] have recorded 31 and 39 species of macro algae respectively from Visakhapatnam coast. After five decades, the species richness was relatively low when compared to the macroalgae studied at the same coast in 1964 (Figure 2). A total of 10 macroalgae species were newly recorded, while, 41 species were found to be absent in 2014 when compared to 1964 data obtained from this coast (Table 3). The decline percentage was higher in Rhodophyta (23 species; 52.2%), followed by Phaeophyta (7 species; 43.8%) and Chlorophyta (2 species; 10.0%). The lowest decline percentage of Chlorophyta members in course of five decades indicates their resilience capability for environmental stressors.

Figure 2: Graph showing decline of macroalgae species richness at Visakhapatnam coast over five decades



Species richness and percentage cover was observed that highest in Season III (November-January) followed by Season IV (February-April). Low values of percentage cover and species richness was observed in Season II (August-October) and Season I (May-July). In all seasons highest Shannon-Weiner diversity index was observed for Station III with 2.808, 3.078, 3.439 and 3.434. And lowest Shannon-Weiner diversity index was observed for Station

IV with 0.688, 0.591, 0.876 and 0.627. Simpson's evenness index ranges between 0 and 1. Species evenness varied all along the coast from the value 0.571 to 0.992 (Table 4).

Table 2: Distribution of seaweeds of different sampling stations in the study area

S.No	Seaweeds	S I	S II	S III	S IV	S V	S VI	S VII	S VIII	S IX	S X
	CHLOROPHYTA										
1	*Ulva fasciata*	√	√	√	√	√	√	√	√	√	√
2	*Ulva lactuca*	-	-	-	-	-	√	√	-	√	-
3	*Enteromorpha compressa*	√	√	√	-	√	√	√	√	√	√
4	*Enteromorpha intestinalis*	-	-	-	-	√	√	-	-	√	-
5	*Chaetomorpha antennina*	√	√	√	-	√	√	√	√	√	√
6	*C. brachygonia*	-	-	√	-	-	-	-	-	√	√
7	*Chaetomorpha torta*	-	-	√	-	√	√	√	√	√	√
8	*Cladophora socialis*	√	√	√	-	√	√	√	√	√	√
9	*Cladophora utriculosa*	-	-	√	-	-	-	-	-	√	-
10	*Cladophora fasicularis*	-	-	√	-	√	√	√	-	√	-
11	*Cladophora patentiramea*	-	-	√	-	√	√	√	-	√	-
12	*Boodlea struveoides*	-	-	√	-	√	-	-	-	√	√
13	*Spongomorpha indica*	-	√	√	-	√	√	√	√	√	√
14	*Bryopsis pennata*	-	√	√	-	√	√	√	√	√	√
15	*Caulerpa fastigiata*	-	√	√	-	√	√	√	√	√	√
16	*Caulerpa racemosa*	-	√	√	-	√	√	√	√	√	√
17	*Caulerpa sertularioides*	-	-	√	-	√	√	√	√	√	√
18	*Caulerpa taxifolia*	-	√	√	-	√	√	√	√	√	√
	PHAEOPHYTA										
19	*Ectocarpus mitchellae*	-	√	√	-	√	√	√	√	√	√
20	*Chnoospora minima*	-	-	√	-	√	√	√	-	√	√
21	*Dictyota dichotoma*	-	-	√	-	√	-	-	-	√	√
22	*Padina tetrastromatica*	-	√	√	-	√	√	√	√	√	√
23	*Sargassum vulgare*	-	√	√	-	√	√	√	√	√	√
24	*Sargassum ilicifolium*	-	√	√	-	√	√	√	√	√	√
25	*Sargassum polycestum*	-	-	√	-	√	-	-	-	√	√
26	*Sargassum tenerrium*	-	-	√	-	√	-	-	-	√	√
27	*Giffordia indica*	-	-	√	-	√	√	√	-	-	-
	RHODOPHYTA										
28	*Porphyra vietnamensis*	-	-	√	-	√	√	√	√	√	√
29	*Bangiopsis subsimplex*	-	√	√	-	√	√	√	√	√	√
30	*Gelidiopsis variabilis*	-	√	√	-	√	√	√	√	√	√
31	*Gelidium pusillum*	-	-	√	-	√	√	√	-	√	√
32	*Pterocladia heteroplatos*	-	√	√	-	√	√	√	√	√	√
33	*Amphiroa fragilissima*	-	√	√	√	√	√	√	√	√	√
34	*Jania rubens*	-	-	√	-	√	√	√	√	√	√
35	*Grateloupia lithophila*	-	√	√	-	√	√	√	√	√	√
36	*Grateloupia filicina*	-	-	√	-	√	√	√	√	√	√
37	*Gracilaria corticata*	-	√	√	√	√	√	√	√	√	√
38	*Gracilaria textori*	-	√	√	-	√	√	√	√	√	√
39	*Gracilaria edulis*	-	-	√	-	√	√	√	√	√	√
40	*Hypnea valentiae*	√	-	√	-	√	√	√	√	√	√
41	*Hypnea musciformis*	-	-	√	-	√	-	-	-	√	√
42	*Gigartina acicularis*	-	√	√	-	√	√	√	√	√	√
43	*Liagora visakhapatnemensis*	-	-	√	-	√	√	√	√	√	√
44	*Liagora erecta*	√	-	√	-	-	-	-	-	√	-
45	*Centroceras clavulatum*	-	√	√	-	√	√	√	√	√	√
46	*Bryocladia thwaitesis*	√	√	√	-	√	√	√	√	√	√
47	*Wrangelia argus*	-	-	√	-	-	-	-	-	√	√
48	*Acanthophora spicifera*	-	-	√	-	-	-	-	-	-	-

'√' Present '-' Absent

S I-Bangarammapalem; S II-Rambilli; S III-Pudimadaka; S IV-Appikonda; S V-Yarada S VI-RK Beach; S VII-Tenneti Park; S VIII-Rushikonda; S IX-Thotlakonda; S X-Bheemunipatnam.

Table 3: Shown the newly recorded and absent species of marine macro algae in the study area of Visakhapatnam coast

Newly recorded species	Species Absent*
1.*Ulva lactuca,* 2.*Enteromorpha intestinalis,* 3.*Cladophora socialis,* 4.*Cladophora fasicularis,* 5.*Ectocarpus mitchellae,* 6.*Sargassum polycestum,* 7.*Gelidiopsis variabilis,* 8.*Pterocladia heteroplatos,* 9.*Gracilaria edulis* and 10.*Hypnea valentiae*	1.*Chondria cornuta,* 2.*Herposiphonia tenella,* 3. *Herposiphonia secunda,* 4.*Polysiphonia platycarpa,* 5.*Polysiphonia ferulacea,* 6.*Ceramium fimbriatum,* 7.*Ceramium gracillimum,* 8.*Ceramium cruciatum,* 9.*Spermothamnion speluncarum,* 10.*Aglaothamnion cordatum,* 11.*Gracilariopsis sjoestedtii,* 12.*Dermatolithon ascripticium,* 13.*Fosliella minutula,* 14.*Fosliella farinose,* 15.*Peyssonnelia obscura,* 16.*Peyssonnelia conchicola,* 17.*Hildenbrandia prototypes,* 18.*Gelidium heteroplatos,* 19.*Gelidiella myriocladia,* 20.*Scinaia bengalica,* 21.*Acrochaetium iyengarii,* 22.*Acrochaetium krusadii,* 23.*Acrochaetium sargassicola,* 24.*Erythrotrichia obscura,* 25.*Erythrocladia subintegra,* 26.*Rosenvingea nhatrangensis,* 27.*Ralfsia expansa,* 28.*Pocockiella variegate,* 29.*Sphacelaria tribuloides,* 30.*Sphacelaria furcigera,* 31.*Streblonema turmale,* 32.*Giffordia mitchellae,* 33.*Feldmannia irregularis,* 34.*Bachelotia antillarum, 35.Codium iyengarii,* 36.*Pseudobryopsis mucronata,* 37.*Derbesis turbinate,* 38.*Cladophora colabense,* 39.*Myrionema sp.*, 40.*Spermothamnion sp.*, and 41.*Chaetomorpha linoides*

* *As the species were reported by earlier studies and have been not observed during the present study.*

Table 4: Total percentage cover, Species Richness, Shannon-Weiner Diversity Index and Evenness of seaweeds at studied sample stations

Field Stations/ Diversity Indices	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
SEASON I : May-July										
Percentage Cover (%)	16.56	32.18	70.50	2.38	69.56	51.80	68.11	36.11	68.25	60.05
Species Richness(SR)	7	13	25	2	25	23	22	17	23	22
Shannon-Weiner Diversity Index(H^1)	1.790	2.298	2.808	0.688	2.780	2.775	2.663	2.563	2.766	2.647
Evenness(e)	0.92	0.896	0.873	0.992	0.864	0.885	0.862	0.905	0.882	0.856
SEASON II : August-October										
Percentage Cover (%)	14.28	39.02	82.72	3.37	81.65	65.49	77.31	45.99	80.99	63.40
Species Richness(SR)	7	16	28	2	27	24	26	21	27	26
Shannon-Weiner Diversity Index(H^1)	1.799	2.438	3.078	0.591	3.040	2.929	2.928	2.628	2.923	2.874
Evenness(e)	0.925	0.879	0.924	0.852	0.923	0.922	0.898	0.863	0.887	0.882
SEASON III: November-January										
Percentage Cover (%)	23.81	59.07	95.30	6.5	88.01	88.52	91.17	66.87	93.36	90.78
Species Richness(SR)	7	23	44	3	39	34	34	31	42	40
Shannon-Weiner Diversity Index(H^1)	1.769	2.824	3.439	0.876	3.375	3.270	3.216	3.042	3.418	3.334
Evenness(e)	0.909	0.901	0.909	0.798	0.921	0.927	0.912	0.886	0.915	0.904
SEASON IV : February-April										
Percentage Cover (%)	21.31	56.99	93.37	6.13	82.43	87.17	90.96	64.09	91.59	87.13
Species Richness(SR)	7	23	45	3	39	35	35	31	43	37
Shannon-Weiner Diversity Index(H^1)	1.872	2.882	3.434	0.627	3.344	3.267	3.198	3.095	3.339	3.268
Evenness(e)	0.962	0.919	0.902	0.571	0.913	0.919	0.899	0.901	0.892	0.905

Hudhud cyclone affect on intertidal seaweeds: Intertidal algae are more likely to be exposed to the physical forces and wave energy of cyclones. It has been observed from previous data that the conditions are mostly suitable for cyclone development in Visakhapatnam coast mostly occur from September to December and sometimes in the months of May and June. Algal growth was found prominent in these seasons at Visakhapatnam coast are likely to be exposed to increased nutrients, re-suspension of sediments and increased water flow associated with cyclones, but the most important effect is likely to result from increased substrate (sediment deposition).

Hudhud, a severe tropical cyclonic storm, that caused extensive damage and loss of life in eastern India and Nepal during October, 2014. Physical wave energy had reduce abundance by dislodging and removing shallow water species, particularly of delicate forms but would increase propagation and dispersal for some species (eg. *Sargassum,* re-grow from minute fragments of holdfast tissue). After a week, of the disaster, the status survey of macroalgae revealed that hardly species were found on the rocky substratum and fragments of many species were washed on to shoreline (Figure 3). In January, the growth of some macro algal species like *Ulva fasciata, Enteromorpha compressa* and *Amphiroa fragilissima* were observed. Some slow growing macro algae may not recover quickly, but at larger spatial scales, are likely to derive some protection from their morphology. Such impacts may produce shifts in species composition, with some macroalgae becoming rare while others bloom.

Climate change not only causes changes to the mean conditions, but also the magnitude of variation around the mean: the frequency of extreme climatic events (droughts, floods, heat waves, etc.) has been increasing globally as a consequence of climate change, and this trend is expected to continue and intensify.

Figure 3: Hudhud impact on intertidal macroalgae at Visakhapatnam coast

CONCLUSION

The present quantitative study on frequency and biomass of Marine algae, when compared to previous quantitative findings at Visakhapatnam coast reveals that the gradual depletion of marine algal species from the intertidal rocky surfaces. This may be due to the changes in the ecological and environmental conditions in intertidal zone and dynamic changes in coastal geomorphology over a long period of time due to erosion, sedimentation marine water pollution and climate change.

Seaweeds serve as early warning indicators for the impacts of climate change, species can either move or change their phenotypes to match with the new environment, or adapt through genetic changes to the new conditions [3]. Large-scale substitution of dominant native seaweeds with alien species will consequently alter coastal productivity and food web structure, and therefore impact ecosystem services. Disturbances of these very important components of the ecosystem are likely to lead to serious cascading effects such as loss of unique habitats and decreased primary production. Studies on the global response of a wide variety of marine and terrestrial species to climate change conclude that the planet is facing drastic ecosystem shifts and numerous extinctions due to climate change impacts [1].

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REFERENCES

[1] Alexander Jueterbock, Lennert Tyberghein, Heroen Verbruggen, A. James Coyer, L. Jeanine Olsen and Galice Hoarau, *Ecology and Evolution*, **2013**, 3(5), 1356–1373.
[2] G. M. Narsimha Rao, *PhD thesis*, **1989,** Department of Botany, Andhra University, Visakhapatnam.
[3] Gihan Ahmed El Shoubaky, *Oceanologia*, **2013**, 55(3), 663-685.
[4] K. Prasanna Lakshmi and G. M. Narasimha Rao, *Journal of Algal Biomass Utilization*, **2009** 1 (1), 60-85.
[5] K. Satya Rao, K. Prayaga Murty and G. M. Narasimha Rao, *Journal of Algal Biomass Utilization* **2011**, 2(2), 69-82.
[6] M. Umamaheswara Rao and T. Sreeramulu, F.L.S, *Botanical Journal Linnean Society*, **1970**, 63, 23-45.
[7] M. Umamaheswara Rao and T. Sreeramulu, *Journal of Ecology*,**1964**, 52(3), 595-603.

[8] Thomas Wernberg, D. Bayden Russell, S. Mads Thomsen, C. D. Frederico Gurgel, J. A. Corey Bradshaw, S. Elvira Poloczanska, and D. Sean Connell, *Current Biology*, **2001**, 21, 1828–1832.
[9] Y. Saito and S. Atobe, *Bulletin of Faculty of Fisheries*, **1970**, Hokkaido University 21(2), 37-69.