

Subtidal marine algae of the Dwaraka coast (Gujarat)*

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A total of 35 marine algal species were recorded during a survey of the subtidal flora of Dwaraka. Maximum number of species were found at 5-8 m depth. Red algal species were dominant (20), followed by green (8) and brown (7). The biomass at 5 m depth was 2.044 kg/m² and comprised of species of *Caulerpa*, *Dictyota* and *Spatoglossum*. The similarity index calculated between intertidal and subtidal species of Dwaraka was 43.40, indicating that the subtidal floral composition is as diversified as that of the intertidal region.

Intertidal survey of marine algal resources along the Gujarat coast of India has revealed great diversity in this region¹⁻³. The algal biomass along this coastline also contributes substantially to the total biomass of Indian coast^{2,4}. Despite being rich in the intertidal algal resources, the subtidal survey of this area is practically ignored for a long time. Present study was undertaken to focus on the algal diversity and availability of harvestable seaweed biomass from the subtidal region of the Dwaraka coast, which is an important archaeological site.

Until recently, knowledge of the subtidal communities of Indian coast was restricted to the information obtained from dredging records or from the algae cast ashore due to the cyclonic weather^{5,6}. This paper documents benthic algal composition and distribution from 3 to 20 m depth by employing SCUBA diving for the first time.

Materials and Methods

The study was undertaken in December 1990, during the archaeological expedition at Dwaraka, Gujarat. The samples were collected at depths of 3, 5, 8, 15 and 20 m in a transect perpendicular to the shore (Fig. 1) using SCUBA diving. All the sampling was done using 0.25 m² quadrant. The algal samples collected were separated species-wise and fresh weight was estimated.

Results and Discussion

Totally 35 marine algal species were recorded up to 20 m depth. Algal distribution was maximum at 5 to 8 m (Table 1), while in deeper waters although the visibility was clear, few species were growing. Maximum number of red algal species (20 i.e. 57.14%) were found followed by green (8 i.e. 22.86%) and brown (7 i.e. 20.00%).

Substratum at the sampling depths showed different composition. At 3 to 5 m depths, mixed substrata of coarse sand and laterite rocks in patches was noticed. Coarse sand had maximum coverage of 70% of the total area. At depths 5 to 8 m rocky substratum, mostly archaeological samples, is present. In these depths, most of the species were found growing luxuriantly. At 15 and 20 m depths, silt deposition was noticed due to which, less algal species, (only 1 at 20 m depth) were found growing.

Among the chlorophycean members, *Ulva fasciata* and *Bryopsis plumosa* were found growing in 3 m depth only, whereas *Caulerpa* spp. and *Halimeda opuntia* were found up to 15 m depth (Table 1). The green algal species were absent in deep waters (20 m). Brown algae showed more restricted distribution, i.e. only up to 8 m level, with maximum distribution at 5 m. Most of the brown algal species belong to order Dictyotales with only two species of *Sargassum*. Rhodophycean members were widely distributed up to 20 m depth. Distribution was maximum at 5 and 8 m depths and decreased as depth increased. The decline was so

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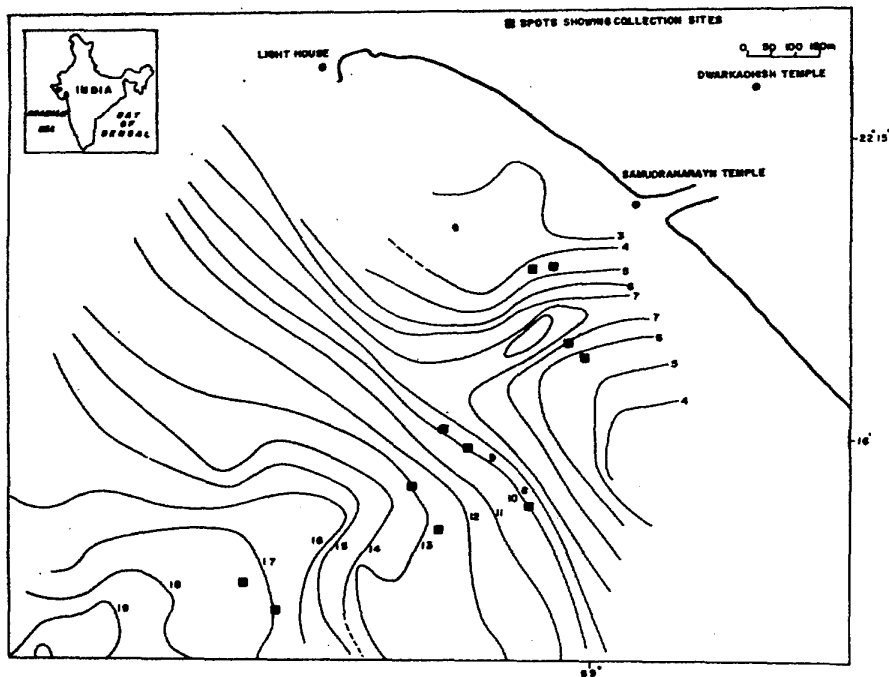


Fig. 1—Sampling stations at various depths (contour lines)

abrupt that only *Polysiphonia* sp. was found at 20 m depth.

When the distribution pattern of the algal species was compared on the basis of depth range, it was found that maximum species were present in 0-5 m depth range (Table 2). In all the cases, rhodophycean species were more in number and were present at all the depths. This was followed by Chlorophyta. However, only two green algal species were found at 0-5 m depth range. In case of brown algal species, they were found only up to 6-10 m range and maximum in 0-5 m range. The subtidal flora showed more resemblance to the lower mid or lower intertidal species. Comparison between the two regions is shown in Table 3. The similarity index between total seaweed distribution is 43.40%. Earlier studies² have reported that most of the species were present in the mid littoral zone. The deep water species were recorded either as drifted ashore or in lower mid littoral zone. However, in the present investigations, most of the species were found up to 5 m depth.

The subtidal species from Dwaraka coast have shown little similarity to those of other west coast subtidal flora. Untawale *et al.*⁵ reported 42 species

from a submerged bank off Ratnagiri coast along central west coast of India. Species like *Codium dwarkens*, *Udotea indica* and *Spyridea fusiformis* were some of the common species. Dwaraka subtidal flora is richer and more diversified as compared to that of central west coast of India⁶. From these comparisons among these regions it can be suggested that the number of species in the subtidal zone decreases towards the south. However, recent studies have indicated that benthic algae are capable of growing at much greater depths and their contribution to primary productivity could be significant⁷.

Intertidal seaweed distribution also plays an important role in deciding the subtidal distribution of the region. It is generally found that the rhodophycean and calcareous algae were common in the subtidal zone. This may be the result of survival strategy against more grazing pressure. Another important factor that influences the algal distribution is the substratum. Algae are found growing on different substrata, depending on their respective holdfast nature⁸. In this region the substrata was of laterite rocks in patches and on the submerged archaeological structures. The species

Table 1—List of marine algal species at different depths

Sl no.	Name of species	Depth (m) /Substratum ¹				
		3 (S,P)	5 (S,P)	8 (R)	15 (R,S)	20 (Si,R)
CHLOROPHYTA						
*1.	<i>Ulva fasciata</i> Delile	+	-	-	-	-
2.	<i>Bryopsis plumosa</i> (Huds) Ag.	+	-	-	-	-
3.	<i>Caulerpa scalpelliformis</i> (R. Br.) Web. V. Bosse	-	+	+	-	-
4.	<i>C. sertularioides</i> (Gmel) Howe	-	+	+	-	-
5.	<i>C. taxifolia</i> (Vahl) Ag.	-	+	+	+	-
*6.	<i>Codium dwarkense</i> Boergs.	-	+	-	-	-
7.	<i>Halimeda tuna</i> (Eil et. Sol) Lamour	-	+	+	+	-
*8.	<i>Udotea indica</i> A. & E.S. Gepp	-	-	+	-	-
PHAEOPHYTA						
1.	<i>Pocockiella variegata</i> (Lamour) Papanfuss	-	+	-	-	-
*2.	<i>Dictyopteris australis</i> Sonder	-	+	-	-	-
3.	<i>Stoechospermum marginatum</i> (Ag.) Kuetz.	+	-	-	-	-
4.	<i>Padina tetrastratica</i> Hauck	+	+	+	-	-
*5.	<i>Spatoglossum asperum</i> J. Ag.	+	+	+	-	-
6.	<i>Sargassum tenerrimum</i> J. Ag.	+	+	+	-	-
7.	<i>Sargassum</i> sp.	+	+	-	-	-
RHODOPHYTA						
1.	<i>Pseudogloiophloea fascicularis</i> (Boergs.) Desik.	-	+	-	+	-
2.	<i>Scinia hatei</i> Boergs.	+	+	-	-	-
*3.	<i>Amphiroa fragilissima</i> (L.) Lamour	-	+	-	-	-
*4.	<i>Halymenia Porphyroides</i> Boergs	-	+	+	-	-
5.	<i>H. venusta</i> Boergs.	-	+	-	-	-
*6.	<i>Sebdenia polydactyla</i> (Boergs.) Balak.	-	+	-	-	-
7.	<i>Gracilaria corticata</i> J. Ag.	+	+	-	-	-
*8.	<i>Solieria robusta</i> (Grev.) Kylin	-	+	+	-	-
*9.	<i>Calliblepharis jubata</i> (Good. et. Woodw.) Kuetz.	-	+	+	-	-
10.	<i>Hypnea musciformis</i> (Wulf.) Lamour	+	-	-	-	-
11.	<i>Botryocladia leptopoda</i> (J. Ag.) Kylin	-	+	-	-	-
12.	<i>Coelarthrum muelleri</i> (Sond.) Boergs.	-	-	-	+	-
13.	<i>Champia parvula</i> (Ag.) Harvey	-	+	-	-	-
14.	<i>Haloplegma duperreyi</i> Mont	-	-	-	+	-
15.	<i>Spyridia fusiformis</i> Boergs.	-	+	-	-	-
16.	<i>Acanthophora spicifera</i> (Vahl) Boergs.	-	+	-	-	-
17.	<i>Laurencia cruciata</i> Harvey	-	-	-	+	-
18.	<i>Laurencia obtusa</i> (Huds.) Lamour	-	+	+	+	-
19.	<i>Polysiphonia variegata</i> (Ag.) Zanardini	-	+	-	+	+
20.	<i>Polysiphonia</i> sp.	-	+	+	-	-
TOTAL		10	28	13	8	1

† P=Patchy rocks, R=rocky, S=sandy, Si=silty.

*Species not found in the intertidal zone.

Table 2—Distribution of algal species at different depths

Depth range (m)	Chlorophyta		Phaeophyta		Rhodophyta		Total
	n	% total	n	% total	n	% total	
0-5	2	7.41	7	25.92	18	66.67	27
6-10	6	42.86	3	21.43	5	35.71	14
11-15	3	37.50	0	0	5	62.50	8
16-20	0	0	0	0	1	100	1

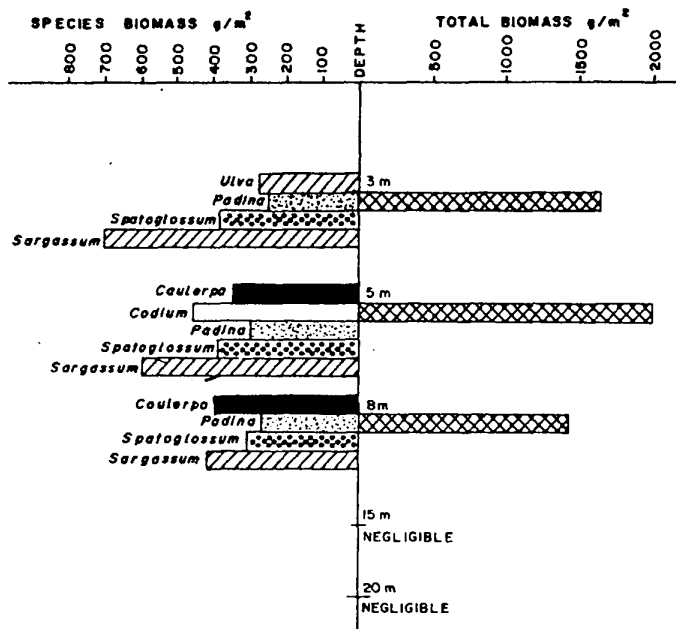


Fig. 2—Species-wise and total biomass distribution at different depths

Table 3—Comparison between intertidal and subtidal marine algal distribution

Division	Intertidal (0-2 m)	Subtidal (2-20m)	Common species	Similarity index (%)
Chlorophyta	12	8	6	42.86
Phaeophyta	11	7	5	38.46
Rhodophyta	19	19	12	46.15

growing on sandy substratum have loose filamentous holdfast that can hold on to the fine sand particles and thus species like *Polysiphonia*, *Coelarthrum* are found in deeper waters and more on sandy substratum. Species found in the archaeological samples were with discoid holdfast such as *Padina*, *Codium* and *Sargassum*.

The maximum biomass of 2.088 kg/m² was recorded at 5 m depth (Fig. 2). *Caulerpa* spp., Dictyotaceae species and *Sargassum* spp. were found to be the major species contributing to the biomass. The dominance of these species suggests that they were less vulnerable to the grazing pressures. Species belonging to Dictyotaceae produce some phenolic compounds that protect the thalli from grazing. In *Caulerpa* spp., a substance called caulerpicin, a toxic substance acts as a

repellent for grazing organisms⁸. This may also be the reason why these species were dominating in the subtidal region.

Associated fauna collected from the sites were mainly sponges, brittle stars, polychaetes, gorgonians and several crustaceans. Negligible algal species distribution, associated with dominance of gorgonians was recorded at Karwar⁶. In sandy or muddy substratum less or no algal growth was observed. Similarly, at the depth of 20 m, where maximum faunal species were found, only one red algal species was found.

Another reason could be that the penetration of the diffused light, of certain wavelength, to the deeper region. The physical factors such as light penetration at the study area was quite good and without turbulence. High yield of the biomass and maximum diversified flora at 5 m depth suggests that this area can be utilized for deep water seaweed cultivation.

Benthic algal collection by dredging has its limitations. Dredging harvests large sized plants and is more likely to provide a fragmented and poorly qualified subtidal communities than systematic surveys done using SCUBA diving

techniques. More studies are needed on the exploration of various areas and to enhance our knowledge of subtidal algal biodiversity. Therefore an integrated discipline and experimental approach will result in deeper understanding the distributional pattern of subtidal benthic algae.

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