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## PHENOLOGY AND FLORISTICS OF SEaweEDS FROM THE OFFSHORE WATERS OF GEORGIA

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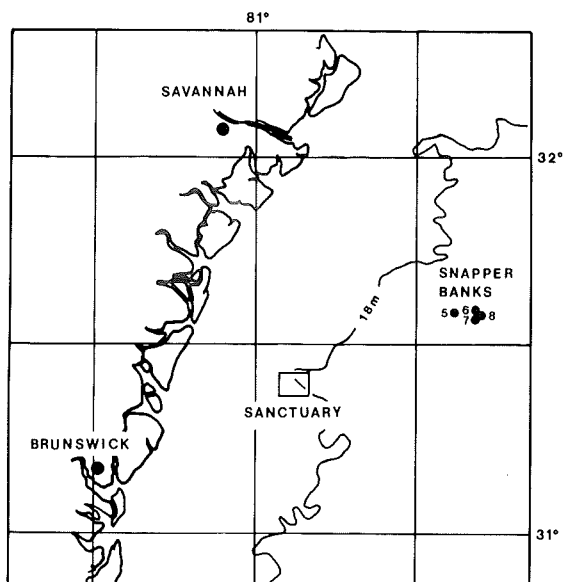
**ABSTRACT:** Seaweeds were studied from rock outcrops in two areas on the Georgia continental shelf, Gray's Reef National Marine Sanctuary on the inner shelf and an area known as the "Snapper Banks" on the outer shelf. The seaweeds observed are seasonal; only a few plants persist through the winter. In this study a gradual increase in number and size of plants and number of species was observed through June; by July-early August, when all 68 species reported were present, the quantity of plants also appeared maximal. Of the 68 species, 43 are species not previously reported from Georgia; eight additional taxa are identified only to genus, but are also new to the region. Sixty-five of the species were collected at Gray' Reef and 22 at the Snapper Banks; three of the latter did not occur at Gray's Reef. In late August and September, when water temperatures were still near the seasonal high, there was a rapid decline in number of species and algal cover.

Establishment of the Gray's Reef National Marine Sanctuary off Sapelo Island, Georgia has been an impetus for investigation of the flora of these offshore waters. For seaweeds, the waters along the southeastern seaboard from Cape Hatteras, North Carolina to Cape Canaveral, Florida appear to constitute a phytogeographically distinct warm-temperate region (Searles, 1984), with Georgia in the least studied, southern half of the region.

Seaweeds are generally restricted to hard, rocky substrates and Gray's Reef is an area of rock outcrops on the inner continental shelf 32 km off the Georgia coast (Fig. 1), which supports an interesting algal flora in depths of 17-22 m. It was the site of most of the collections reported here. A few collections were made further offshore on rock outcrops known locally as the "Snapper Banks" (Fig. 1), in depths of 30-35 m, but those sites have yet to be studied in detail.

Prior to the study reported here, a total of 93 seaweeds identified to species had been reported from Georgia, (Chapman, 1971, 1973; Blair and Hall, 1981; Searles, 1981, 1983; Searles and

Ballantine, 1986; Richardson, 1987); 21 of these were listed from offshore waters. The following account provides seasonal information on the flora and increases the known flora for the offshore waters to 73 taxa including eight currently identified only to genus; many of the eight are probably undescribed, new species. Five species previously reported from Georgia's offshore waters were not observed in this study: *Peyssonnelia rubra* (Grev.) J. Ag. (Blair & Hall, 1981), plus *Chaetomorpha minima* Collins & Harvey, *Pterocladia americana* Taylor, *Gracilaria foliifera* (Forssk.) Boerg. (= *Gracilaria tikvahiae* McLachlan), and *Ceramium leptozonum* Howe (Chapman, 1971). Richardson (1987) has recently enlarged upon the earlier records (Chapman, 1971, 1973) of the seaweed in near-shore, coastal environments; he lists 65 species, not including the 8 Cyanophyta reported by Chapman. Six of the coastal species reported are also reported from offshore waters. The seaweed flora known for the state of Georgia thus total 145 species, including the 8 taxa identified only to genus in this report.



**Figure 1.** Location of Gray's Reef National Marine Sanctuary and the Snapper Banks dive sites off the Georgia coast. Numbers at the Snapper Banks correspond to the sites listed in Table 1.

**MATERIALS AND METHODS**

All collections were made by diving, either by SCUBA or surface-supplied, hose divers. Collections were made mainly during summers from 1983 to 1986. Plants were fixed in formalin-seawater in a ratio of 1:9. Specimens were prepared for microscopic study by staining with 1% aqueous aniline blue dye, fixing the stain with 1% HC and mounting in corn syrup. Voucher specimens have been deposited in the Duke University Herbarium, Durham, North Carolina and the National Herbarium at the Smithsonian Institution, Washington, D.C.

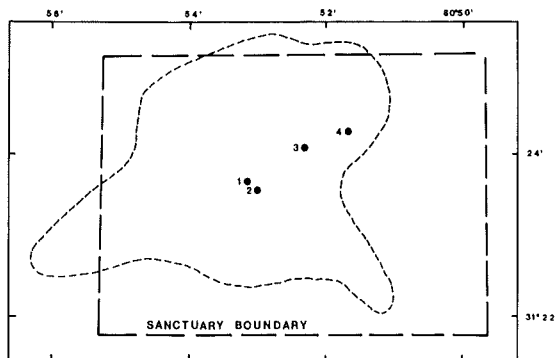
**COLLECTION SITES**

Four sites (1-4) were visited in Gray's Reef National Marine Sanctuary (Fig. 2) throughout the study. The four sites (5-8) on the Snapper Banks (Fig. 1) were only visited in July and August of 1985. The

precise locations and collection dates are given in Table 1.

The Gray's Reef sites are ledges of sedimentary rock with relief of less than 2 m. The rock at the ledges is bare of sediment; behind the ledges there are extensive areas of flat rock covered with a thin veneer of sand through which seaweeds and attached marine invertebrates emerge. Information on the extent of the rocky bottom areas and their geology is given in a report by Hunt (1974). Water temperatures observed during the study ranged from 13°C in March to 30°C in August. No data are available on light transmission in the water column, but visibility during dives varied from 2-3 to 20 m on dives made during this study and Hunt (1974) reported visibility of 1.5-9 m in his study.

The Snapper Banks region has not been studied with the same intensity as Gray's Reef. The topography of the seafloor based on diver observations is, however, comparable. There are small rock ledges of less than 2 m relief and extensive areas of flat rock covered by a thin layer of sand through which sessile plants and animals emerge.



**Figure 2.** Location of collecting sites in Gray's Reef National Marine Sanctuary. Numbers correspond to the sites listed in Table 1. The irregular shaped area set off by broken lines is the general area of rocky outcrops and live bottom as suggested by Hunt (1974).

**RESULTS**

**General Observations**

A total of 68 taxa were identified in this study. Forty-three of these are new records in Georgia, two of those are clarifications of previously misidentified species. Eight other taxa are identified

only to genus and many of these are probably undescribed species. Two of the remaining 17 species had previously been reported only from shallow-water, coastal sites and 15 were already known from offshore locations. The Georgia records reported are the southern limits of distribution in the North Atlantic for 6 species, two of which reappear off

**Table 1.** Latitude, longitude, and depth of collection sites at Gray's Reef National Marine Sanctuary and Snapper Banks with dates collections were made.

Site number	Latitude and longitude	Depth	Collection dates
Gray's Reef National Marine Sanctuary			
1	31°23.82' N 80°53.15' W	19-21 m	27 Jun 1983 6 Aug 1984 15 Jul 1985
2	31°23.60' N 80°53.00' W	18-19 m	27 Jun 1983 12 Jul 1984 6 Aug 1984 22 Sep 1984 16 Jul 1985 23 Aug 1985 4 Mar 1986
3	31°24.09' N 80°52.32' W	17-21 m	27 Jun 1983 11 Jul 1984 7 Aug 1984 15 July 1985 27 Aug 1985 4 Mar 1986
4	31°24.30' N 80°51.70' W	17-19 m	12 Jul 1984 7 Aug 1984 22 Sep 1984 17 Jul 1985 23 Aug 1985
Snapper Banks			
5	31°35.00' N 80°23.0'	30 m	15 Jul 1985 24 Aug 1985
6	31°35.5' N 80°19.00' W	31-32 m	13 Jul 1985
7	31°34.00' N 80°19.00' W	34-35 m	24 Aug 1985
8	31°34.07' N 80°17.09' W	35 m	14 Jul 1985

South America. Four species are at their northern limits of distribution and there is one range extension from the eastern Atlantic and one from the Pacific. Of the taxa identified to species, only *Dudresnaya georgiana* is currently recognized as endemic to Georgia.

The vegetation at Gray's Reef is very seasonal (Table 2). The March collection yielded only 7 species, three of which (*Codium isthmocladum*, *Sargassum filipendula* and *Botryocladia occidentalis*) appeared to be regenerating from the tattered remains from the previous season. June collections increased the number of species to 23. The seasonal seaweed peak, both in number of species and in the apparent richness of the algal cover, is in July and early August, during which all 68 species were collected. The decline in the flora after early August is abrupt. After finding an abundance of plants, 51 species, in early August of 1984, only 10 species were collected in late September of that year. A hurricane had passed by the sanctuary in the intervening weeks, which could possibly have accounted for the removal of plants. However, the presence in that September of plants of *Botryocladia occidentalis* of maximum size, which would appear to be as susceptible to removal by bottom surge as many other species, suggested that the hurricane was not the primary cause. Collections on August 22nd in 1985 demonstrated a similar decline with only 17 species present. This decline occurred in calm weather, in the absence of any marked change in the physical environment.

The Snapper Banks sites were not visited with the same regularity as Gray's Reef and appeared to support a much more limited flora. This is reflected in the species list and in the observed algal cover, which was very sparse; the rocks in most cases appeared to lack any

seaweeds or supported only a few isolated plants. Twenty-two species were collected on the Snapper Banks versus 65 at Gray's Reef. Only three species were collected on the Snapper Banks which were not also collected at Gray's Reef.

Two of the species occurring on Gray's Reef have been the total or partial basis for the description of the new species, *Dudresnaya georgiana* (Searles, 1983) and *Dudresnaya puertoricensis* (Searles and Ballantine, 1986). Collections of plants in the genera *Cladophora*, *Derbesia*, *Leptophytum*, *Pneophyllum*, *Callithamnion*, *Callithamniella*, *Ptilothamnion* and *Lejolesia*, which were not identified to species, may be the basis for description of new species with further study and additional collections.

### List of Species

All taxa reported from Georgia's offshore waters in this study are listed in Table 2. Comments on species of special interest with respect to their biogeography or taxonomy are given separately.

### CYANOPHYTA

*Schizothrix mexicana*. This is, surprisingly, the only blue-green alga collected. It formed red mats on rocks and was also epiphytic.

### CHLOROPHYTA

*Cladophora* sp. These plants are similar to *Cladophora bainesii* van den Hoek, from South Australia. The species has also been noted in collections from the offshore waters of North Carolina. A species description is in preparation.

*Cladophora pellucidoidea*. This species

**Table 2.** List of species, months and sites of collections, frequency observed, and records of previous collections.

Species	Months and sites of collections			Frequency observed	Previous records			
<b>CYANOPHYTA</b>								
<b>HORMOGONALES</b>								
<i>Schizothrix mexicana</i> Gomont	Jul	Aug		O	N			
<b>CLADOPHORALES</b>								
<i>Cladophora</i> sp.	Jul*	Aug		R	U			
<i>Cladophora dalmatica</i> Kuetz.		Aug		R	N			
<i>Cladophora laetevirens</i> (Dillw.) Kuetz.		Aug		R	N			
<i>Cladophora pellucidoidea</i> Hoek	Jun	Jul	Aug	O	M			
<b>CAULERPALES</b>								
<i>Bryopsis pennata</i> Lamour.	Jul#	Aug		O	N			
<i>Derbesia marina</i> (Lyngb.) Solier		Aug		R	N			
<i>Derbesia turbinata</i> Howe & Hoyt	Jul*	Aug		R	N			
<i>Derbesia</i> sp.	Jul*			R	U			
<i>Boodleopsis pusilla</i> (Coll.) Tayl., Joly & Bernat.	Jun	Jul#	Aug#	C	N			
<i>Codium isthmocladum</i> Vickers	Mar	Jun	Jul#	Aug	Sep	C	C	
<i>Caulerpa mexicana</i> Sond. in Kuetz.			Jul	Aug		R	N	
<b>PHAEOPHYTA</b>								
<b>ECTOCARPALES</b>								
<i>Giffordia mitchellae</i> (Harv.) Hamel	Jul					R	N	
<i>Giffordia onslowensis</i> Amsl. & Kapr.	Jul					R	N	
<b>SPHACELARIALES</b>								
<i>Onslowia endophytica</i> Searl.	Jul	Aug				C	N	
<b>DICTYOTALES</b>								
<i>Dictyota dichotoma</i> var. <i>mentrualis</i> Hoyt	Jul	Aug				C	N	
<i>Spatoglossum schroederi</i> (C. Ag.) Kuetz.	Jul	Aug	Sep			C	N	
<i>Dictyopteris hoytii</i> Tayl.	Jul	Aug				O	N	
<b>DICTYOSIPHONALES</b>								
<i>Rosenvingia intricata</i> (J.Ag.) Boerg.	Jul					R	N	
<b>SCYTOSIPHONALES</b>								
<i>Colpomenia sinuosa</i> (Roth) Derb. & Sol.	Jul					O	N	
<b>FUCALES</b>								
<i>Sargassum filipendula</i> C.Ag.	Mar	Jun	Jul	Aug	Sep		C	N
<b>RHODOPHYTA</b>								
<b>PORPHYRIDIALES</b>								
<i>Stylonema alsidii</i> (Zanard.) Drew.	Jul	Aug				O	N	
<i>Erythrocladia irregularis</i> f. <i>subintegra</i> (Rosenv.) Garb., Hans. Scag.	Jul	Aug				R	N	
<i>Erythrotrichia carnea</i> (Dillw.) J.Ag.	Jul	Aug				R	Cs	
<b>NEMALIALES</b>								
<i>Audouinella bispora</i> (Boerg.) Garb.	Jul	Aug				O	N	
<i>Audouinella hoytii</i> (Coll.)	Jul	Aug				O	N	
<i>Audouinella hoytii</i> (Coll.) Schneid.	Jul					O	N	
<i>Audouinella ophioglossa</i> Schneid.	Jul	Aug				C	N	
<i>Scinaia complanata</i> (Coll.) Cotton	Jun	Jul	Aug	Sep		C	S	
<i>Falkenbergia hillebrandii</i> (Born.) Falk.		Jul#	Aug*			R	N	
<b>GIGARTINALES</b>								
<i>Dudresnaya crassa</i> Howe		Jul	Aug			C	N	
<i>Dudresnaya georgiana</i> Searl.	Jun	Jul	Aug			O	S	

Table 2 continued

<i>Dudresnaya puertoricensis</i> Searl. & Ballan.		Jul	Aug			C	SB
<i>Halymenia agardhii</i> De Toni	Jun	Jul	Aug	Sep		C	S
<i>Halymenia floridana</i> J.Ag.	Jun	Jul	Aug			C	CS
<i>Halymenia hancockii</i> Tayl.			Aug			R	N
<i>Predaea feldmanii</i> Boerg.		Jul	Aug			R	N
<i>Soliera filiformis</i> (Kuetz.) Garb.		Jul	Aug			R	N
<i>Sebdenia polydactyla</i> (Boerg.) Balakr.	Jun	Jul	Aug			C	S
<i>Gracilaria blodgettii</i> Harv.		Jul	Aug			R	N
<i>Gracilaria mamillaris</i> (Mont.) Howe		Jul				R	N
CORALLINALES							
<i>Leptophytum</i> sp.			Aug			R	U
<i>Pneophyllum</i> sp.		Jul	Aug			C	U
<i>Fosliella farinosa</i> (Lamour.) Howe			Aug			C	N
RHODYMENIALES							
<i>Botryocladia occidentalis</i> (Boerg.) Kylin	Mar	Jun	Jul	Aug	Sep	C	CS
<i>Botryocladia wynnei</i> Ballan.		Jun	Jul	Aug		R	N
<i>Rhodymenia pseudopalmata</i> (Lamour.) Silva	Mar	Jun	Jul	Aug	Sep	C	CS
<i>Champia parvula</i> var. <i>prostrata</i> Williams in Pearse & Williams		Jun	Jul	Aug		C	CS
<i>Lomentaria baileyana</i> (Harv.) Farl.		Jun	Jul#	Aug		C	CS
CERAMIALES							
<i>Callithamnion</i> sp.		Jun	Jul#	Aug#	Sep	O	U
<i>Antithamnionella breviformis</i> (Daws.) Woll. in Womers. & Bail.			Jul*			R	N
<i>Antithamnionella spirographidis</i> (Schiff.) Woll.			Jul	Aug		R	N
<i>Ceramium fastigiatum</i> f. <i>flaccidum</i> H. Peterson in Boerg.		Jun	Jul#	Aug	Sep	C	CS
<i>Spyridea hypnoides</i> (Bory in Balan.) Papenf.			Jul	Aug		R	N
<i>Callithamniella</i> sp.			Jul			R	U
<i>Plenosporium boergesonii</i> (Joly) R. Norris				Aug	Sep	R	N
<i>Anotrichium tenue</i> (C.Ag.) Naeg.			Jul	Aug		R	N
<i>Griffithsia gobulifera</i> Harv. ex Kuetz.		Jun	Jul#	Aug#		C	N
<i>Ptilothamnion</i> sp.			Jul	Aug*		R	U
<i>Lejolesia</i> sp.	Mar	Jun	Jul			R	U
<i>Branchioglossum minutum</i> Schneid. in Schneid. & Searl.		Jun	Jul#	Aug#		O	S
<i>Hypoglossum hypoglossoides</i> (Stackh.) Coll. & Herv.	Mar	Jun	Jul#	Aug	Sep	C	M
<i>Grinnellia americana</i> (C.Ag.) Harv.	Mar	Jun	Jul#	Aug		O	CS
<i>Haraldia prostrata</i> Daws., Neush. & Wildm.			Jul*	Aug*		R	N
<i>Dasya baillouviana</i> (Gmel.) Mont.			Jul#	Aug		O	C
<i>Dipterosiphonia reversa</i> Schneid.			Jul#	Aug		R	N
<i>Polysiphonia denudata</i> (Dillw.) Grev. ex Harv. in Hook.			Jul*	Aug	R	Cs	
<i>Polysiphonia atlantica</i> Kapr. & J. Norris		Jun	Jul#	Aug		C	N
<i>Chondria polyrhiza</i> Coll. & Herv.		Jun	Jul*	Aug		R	N

## Key to symbols:

Collection sites: \* = Collected only in the Snapper Banks area; # = Collected in both the Sanctuary and the Snapper Banks area.

Subjective estimate of frequency of observation: R = rare, O = occasional, C = common.

Previous records: C = Collected by Chapman (1971) in offshore waters; Cs = Collected by Chapman (1971) in shallow, coastal waters; M = New record, previously identified as a different species; N = New record; S = Previously reported by Searles (1981, 1983); SB = Previously reported by Searles and Ballantine (1986); U = Identified only to genus; possibly a new species.

was reported by Searles (1981) as *Cladophora pseudopellucida* van den Hoek.

*Bryopsis pennata*. Very abundant along the edges of some ledges where it may be the dominant alga.

*Derbesia marina*. Species of this genus may be more common than the seasonal listings suggest, for sterile plants not identified to species were collected in June and July.

*Derbesia turbinata*. This species was originally described from the offshore waters of North Carolina early in the century (Howe and Hoyt, 1916) and had not been reported again until this study. These collections appear to constitute the southern limit of a narrow endemic limited in distribution to the warm-temperate southeastern coast of the United States.

*Derbesia* sp. Fertile plants were collected from the Snapper Banks, which have obconical or subspherical sporangia, broader than long and unlike those of any of the species of the genus from the North Atlantic.

*Codium isthmocladum*. This is the commonest, most conspicuous green alga at Gray's Reef and is perennial.

*Caulerpa mexicana*. This is the northern limit of distribution of this species on the east coast of the United States.

## PHAEOPHYTA

*Giffordia onslowensis*. Previously reported only from North Carolina, this is the southern limit of distribution.

*Dictyota dichotoma* var. *menstrualis*.

This variety, found only in the western Atlantic and Caribbean, has been reported by Schnetter *et al* (1986) to be a separate species from *Dictyota dichotoma* (Huds.) Lamour. and they plan to recognize the variety as a species.

*Spatoglossum schroederi*. Taylor (1960) indicates that this warm-temperate and tropical western Atlantic endemic is uncommon, but it is one of the larger and more conspicuous plants at Gray's Reef.

*Dictyopteris hoytii*. This species is restricted in its distribution to Venezuela and the United States. Gray's Reef is the southern limit of the species in the United States.

*Rosenvingia intricata*. Only a single, immature plant was collected and identification is tentative.

*Sargassum filipendula*. A perennial, this was the only brown alga collected in March, when tattered stubs of plants were producing fresh new growth.

## RHODOPHYTA

*Audouinella bispora*. Previously reported only from North Carolina and the Virgin Islands.

*Audouinella hoytii*. Previously reported from North and South Carolina; Gray's Reef is a slight southern extension of the range of this species.

*Audouinella ophioglossa*. Previously reported only from North Carolina, but also occurring in Puerto Rico (personal observation). It is a common epiphyte in *Dudresnaya crassa*.

*Falkenbergia hillebrandii*. Rare, intermingled with other small, filamentous

algae. Northern limit of reported distribution.

*Dudresnaya georgiana*. Endemic to Gray's Reef.

*Dudresnaya puertoricensis*. Known only from Puerto Rico and Georgia.

*Gracilaria mammillaris*. Apparently rare, but easily confused with *Rhodymenia pseudopalmata* when sterile.

*Leptophytum* sp. This report is based on a single collection. The plants appear to belong to *Leptophytum*, which is characterized as a genus of cold waters. The vegetative characteristics of the specimens lie within the parameters of the description of *Leptophytum foecundum* (Kjellm.) Adey as given by Adey (1966), but cavities of the tetrasporangial conceptacles are not nearly as tall (80  $\mu$ m as those described (125-170  $\mu$ m) for that primarily arctic species. The plants appear therefore to be a species unknown in the North Atlantic.

*Pneophyllum* sp. The conceptacles of these plants are similar to those of *P. confervicolus* (Kuetzing) Y. Chamberlain. The hypothallial cells are, however, mostly 1.5-2 x longer than broad, whereas those described by Chamberlain (1983) are square.

*Fosliella farinosa*. Germlings with the characteristic pattern of germination known for this genus were observed. They were not linked to mature, reproductive crusts, but are assumed to belong to this species, which occurs from Canada to Brazil.

*Botryocladia occidentalis*. A perennial; one of the commonest species in the sanctuary.

*Botryocladia wynnei*. Previously reported by Searles (1981) as *Chrysomenia enteromorpha* Harv. This is the only record of this species outside the type locality in Puerto Rico (Ballantine, 1985).

*Callithamnion* sp. Reported by Searles (1981) as *Callithamnion halliae* Collins (1906). Plants are similar to that species, but are at most only 2.5 mm tall rather than 5 cm and have slender axes (to 60  $\mu$ m diam.) rather than axes of 200  $\mu$ m diam. These small plants were thought to be immature in the early season, June collections reported in 1981, but they become fertile without becoming larger.

*Antithamnionella spirographidis*. Determination of this single collection is provisional. It differs from the species as described by Wollaston (1968) in having three rather than two determinate branchlets per axial cell and having gland cells produced on the 4th as well as the 2nd and 3rd cell of the determinate branchlets. Originally described from the Adriatic Sea and subsequently from Britain, France and Australia, this is the first Western Atlantic record of the species.

*Ceramium fastigiatum* f. *flaccidum*. Though very small, the plants are common and are seen as a reddish fuzz on the surface of other algae and on sessile invertebrate colonies.

*Callithamniella* sp. A single collection, tentatively assigned to this genus.

*Plenosporium boergesenii*. Previously reported only from the type locality in Brasil and from North Carolina.

*Ptilothamnion* sp. This genus has not been reported from the east coast of North America. Other species of the genus occur in the seas of Europe,

Japan, New Zealand, and in fresh-water in South America (Kylin, 1956). Plants in the Georgia collections are immature. The erect branches arise from prostrate axes and end in procarpis subtended by rudimentary involucre.

*Lejolesia* sp. These plants are similar to *Lejolesia pacifica* Itono (1977), described only from Japan. The dimensions of the vegetative structures, the tetrasporangia and the spermatangial heads agree with those of *L. pacifica*. Difference in the origin of the pericarp and a larger size cystocarp in the Georgia plants, together with the geographic separation of the populations, indicate that this is an undescribed species.

*Hypoglossum hypoglossoides*. Reported earlier by Searles (1981) as *H. tenuifolium* (Harv.) J. Ag.

*Grinnellia americana*. Plants in the sanctuary are small, up to 3-4 cm tall, and were rare on the rock substrate, but were common as tiny epiphytes.

*Haraldia prostrata*. Originally described from the Pacific by Dawson *et al.* (1960), who suggested that plants from Barbados may also belong to this species. The collections from the Snapper Banks correspond to their description except for lacking undulating blades and in having tetrasporangial sori scattered on the blade rather than confined to ends of ultimate branches.

*Dipterosiphonia reversa*. This is the first record of the species outside of the type locality in North Carolina's offshore waters.

## DISCUSSION

The present study is the first at-

tempt to systematically survey the seaweed flora from Georgia's offshore rock outcrops. The 73 species now reported from this study and earlier, single sample reports (Chapman, 1971; Blair and Hall, 1981; Searles, 1981) indicate a moderately rich assemblage of algae, but not as diverse a flora as that of the more extensive and well studied flora of North Carolina (Schneider, 1976; Searles and Schneider, 1980).

One of the more interesting observations made is the rapid decline in both the number of species and the abundance of plants after early August even though there appears to be no marked change in the physical environment. Furthermore, many of the same warm water species persist later into the year in the more northern waters off the North Carolina coast (Schneider, 1976). It remains to be seen whether the August-September decline involves senescence of the plants mediated by the physical and/or chemical environment or, whether it is due to some biological interactions such as grazing by migrating herbivorous fish.

## ACKNOWLEDGMENTS

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of the species of *Cladophora*.

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