

INVESTIGATIONS OF
NEW ENGLAND MARINE ALGAE VII:
SEASONAL OCCURRENCE
AND REPRODUCTION OF MARINE ALGAE
NEAR CAPE COD, MASSACHUSETTS^{1, 2}

DOUGLAS C. COLEMAN AND ARTHUR C. MATHIESON

In an earlier paper (Coleman and Mathieson, 1974) we described the horizontal distribution of seaweeds at seven sites from Scituate to Woods Hole, Massachusetts, including the Cape Cod Canal. In the following account we summarize the seasonal occurrence and reproduction of seaweeds at the same locations. Most previous collections and observations of Cape Cod seaweeds have been restricted to the summer. Conover (1958) and Sears (1971) have conducted the only detailed seasonal investigations of Cape Cod marine algae. Conover described the productivity and seasonal composition of the algae in the Great Pond Estuary of Falmouth in relation to a variety of environmental parameters. Sears described the subtidal benthic algae at several sites in southern Cape Cod. Neither Sears nor Conover gave any consideration to the seaweeds in the Cape Cod Canal, which connects Cape Cod Bay and Buzzards Bay. The Canal is a transitional zone separating two distinctive water masses and marine floras (Coleman and Mathieson, 1974). The temperature discontinuity between the two sides of the Cape may reach 10°C. during the summer; thus, Cape Cod is one of the major phytogeographical boundaries on the Atlantic Coast of North America (Farlow, 1870, 1882; Harvey, 1852-1858; Humm, 1969, Setchell, 1922).

¹Published with the approval of the Director of the University of New Hampshire Agriculture Experiment Station as Scientific Contribution Number 665.

²Jackson Estuarine Laboratory Contribution No. 14.

Monthly collections and observations of marine algae were made at each of the seven sites (Fig. 1) during 1969. Specific details of collections, identifications, and descriptions of stations have been previously summarized (Coleman and Mathieson, 1974), and they will not be repeated in the present paper.

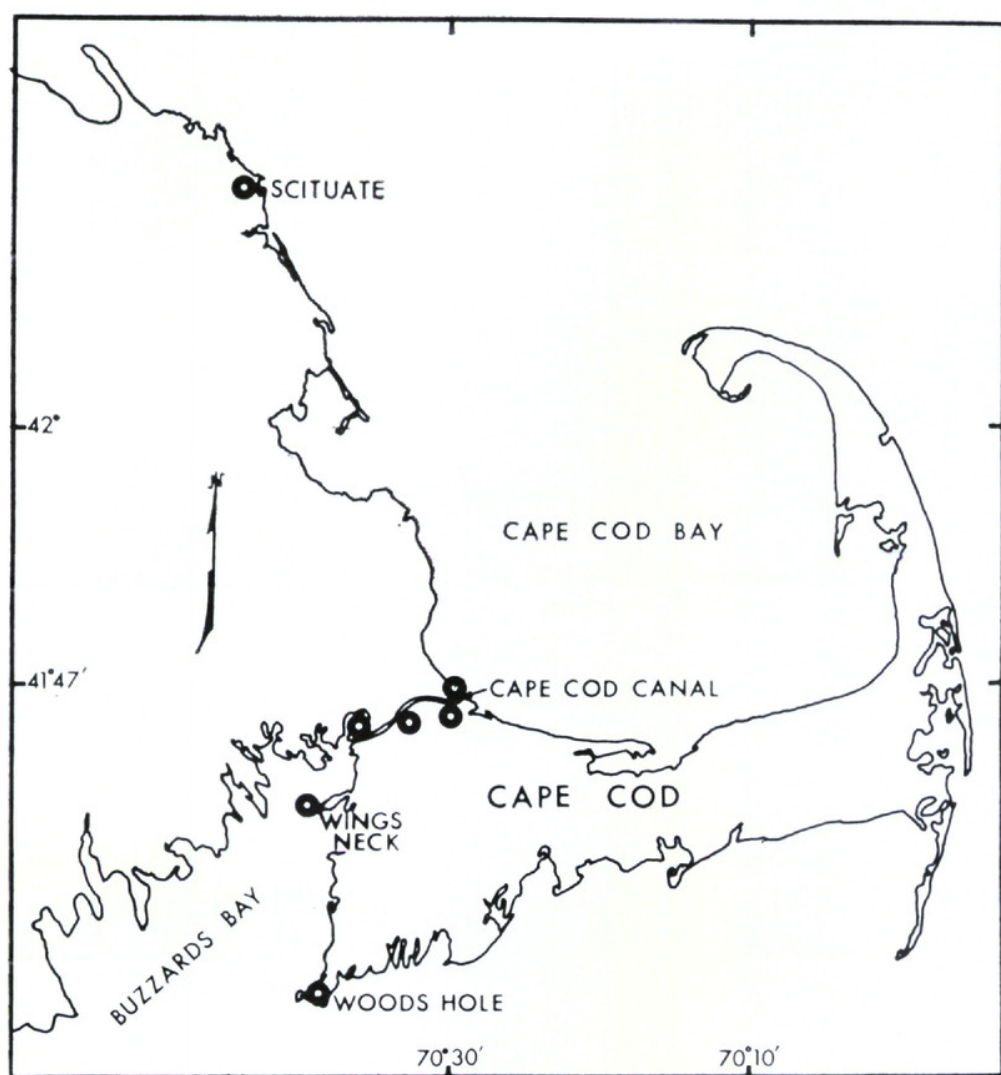


Figure 1. Map of Cape Cod, Massachusetts, showing the seven stations.

SEASONAL OCCURRENCE AND LONGEVITY

Figures 2 and 3 summarize the monthly occurrence of seaweeds at each station. There was a conspicuous increase in the number of species during the spring and summer, except at stations 2, 3, and 4. The time of peak numbers

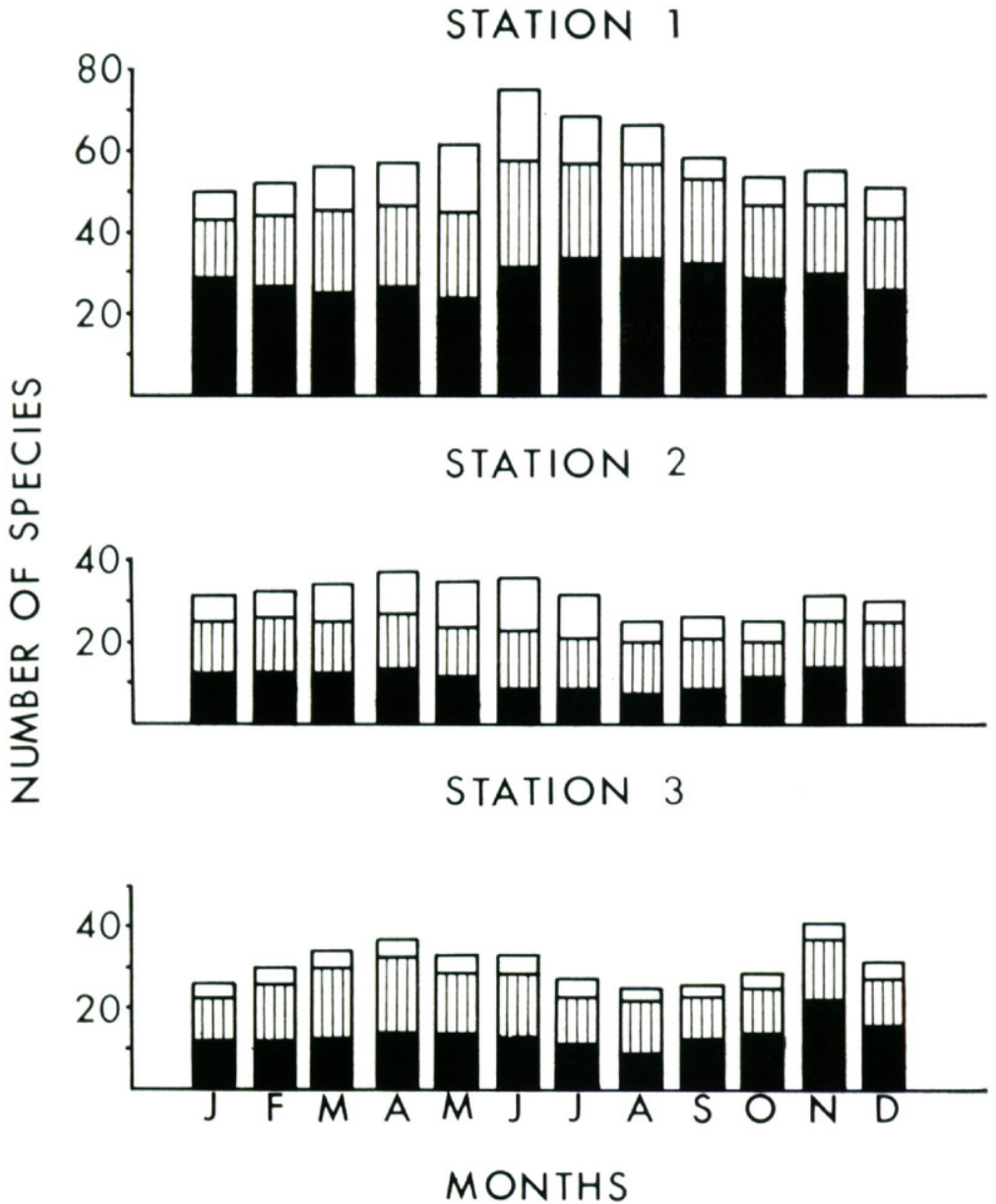


Figure 2. Monthly variation in number of species at stations 1-3. Black = red algae; hatched area = brown algae; white = green algae.

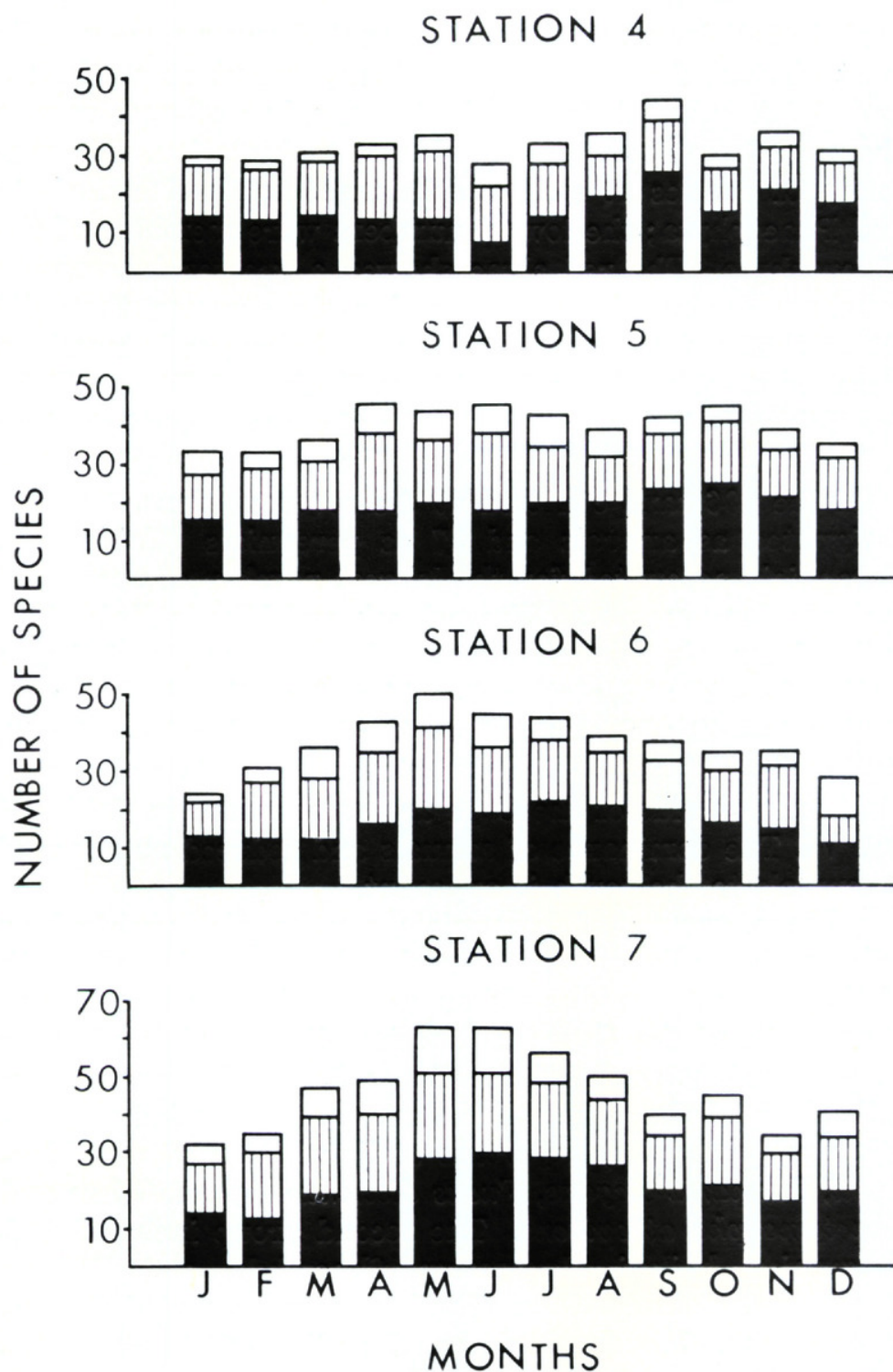


Figure 3. Monthly variation in number of species at stations 4-7. Black = red algae; hatched area = brown algae; white = green algae.

varied at different stations. Seasonal changes were usually most obvious from January to June, except at stations 3 and 4. A gradual decline in the number of species was observed from June to December at each station. The majority of species at each site belonged to the Rhodophyta and Phaeophyta; the lowest numbers were members of the Chlorophyta. The red algae showed a greater increase in numbers during the spring and early summer than did either the browns or greens. Seasonal changes in numbers were greatest at Scituate, Wings Neck and Woods Hole. See Tables I-III for specific details of occurrence at stations 1, 4 and 7 — i.e., a northern, a southern, and a Canal station.

Of the 106 taxa collected at the seven stations, 49 were designated as annuals and 57 as perennials (Table IV). Perennials accounted for the largest number of species at each station, except at Wings Neck and Woods Hole. The ratio of annuals : perennials at each station was as follows: station 1 — 42 : 58, station 2 — 44 : 56, station 3 — 40 : 60, station 4 — 42 : 58, station 5 — 43 : 57, station 6 — 54 : 46, station 7 — 54 : 46. The conspicuous annuals and perennials on each side of the Cape are summarized in Tables V and VI. The dominance of annuals and reduced numbers of perennials to the south is apparent.

Three groups of perennials can be distinguished as follows, depending upon their abundance north and south of the Cape: 1) species either restricted to or more abundant north of the Cape; 2) species either restricted to or more abundant south of the Cape; 3) species common on both sides of the Cape. The first group included *Choreocolax polysiphoniae*, *Gigartina stellata*, *Petrocelis midden-dorfii*, *Plumaria elegans*, *Fucus distichus* ssp. *distichus* and *Chaetomorpha atrovirens*. The second group included *Calithamnion baileyi*, *Sargassum filipendula*, and *Codium fragile* ssp. *tomentosoides*. The last group included *Ceramium rubrum*, *Chondrus crispus*, *Corallina officinalis*, *Sphaecelaria cirrosa* and *Chaetomorpha linum*.

Distinct winter, spring and summer annuals were evident at the seven sites. The first group included *Bangia*

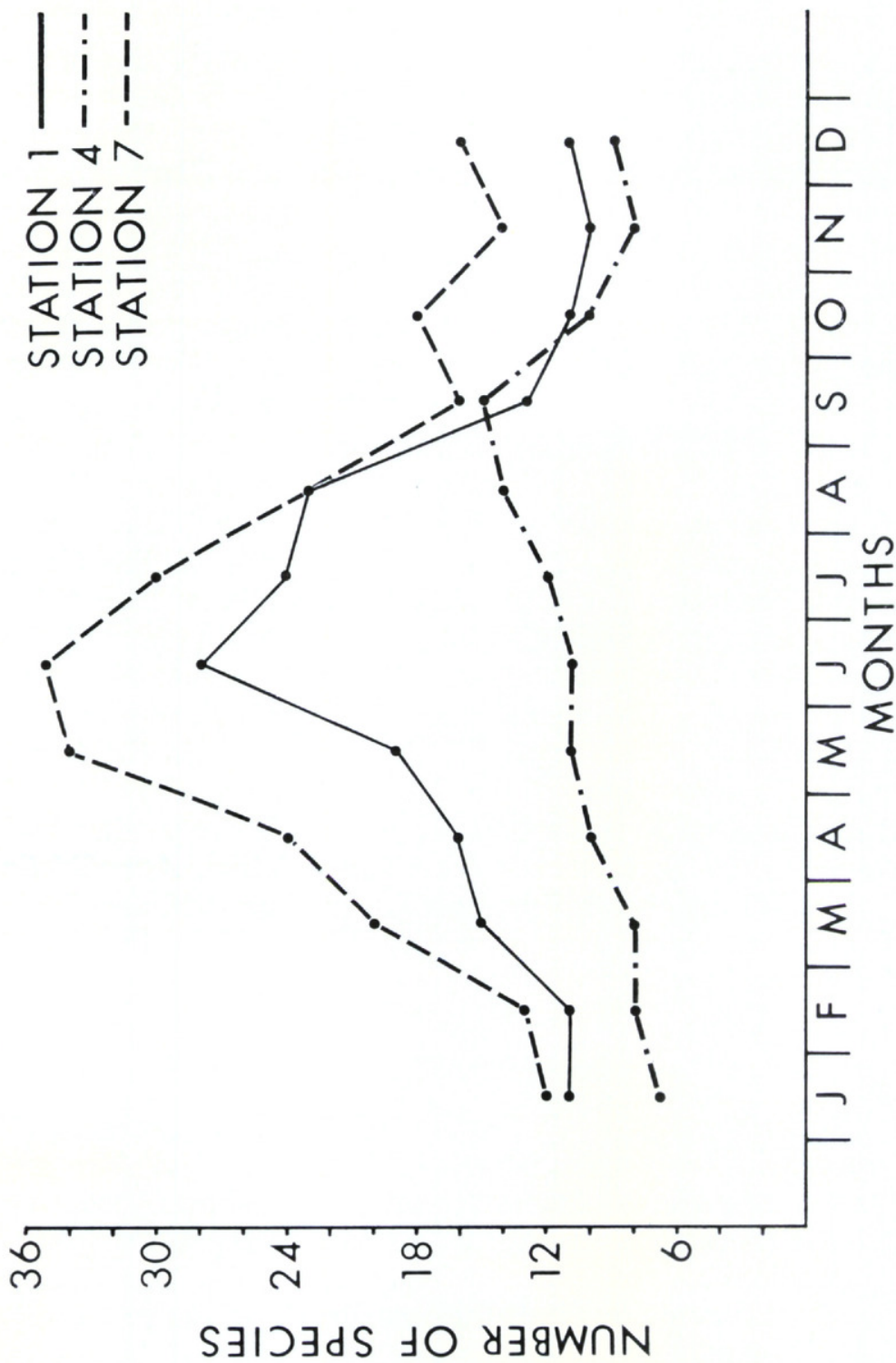


Figure 4. Monthly variation of annuals at stations 1, 4 and 7.

fuscopurpurea, *Petalonia fascia* and *Codiolum gregarium*. The second group included *Desmarestia viridis*, *Desmotrichum balticum*, *Punctaria plantaginea*, *Enteromorpha linza*, *Monostroma grevillei* and *Monostroma pulchrum*. The third group included *Dasya pedicellata*, *Champia parvula*, *Chondria sedifolia*, *Grinnellia americana*, *Hypnea musciformis* and *Seirospora griffithsiana*. Figure 4 illustrates the monthly number of annual species at stations 1, 4 and 7. The largest number of annuals occurred during the spring and summer months, except at station 4, and a decrease was evident during the winter months.

Differential, spatial, and seasonal successions of annuals were recorded north and south of the Cape. Three patterns of seasonal succession were evident (Table VII). Some species occurred earlier south than north of the Cape, others disappeared earlier south than north, while a third group was found throughout the year on both sides of the Cape. Some examples of differential spatial succession may also be noted. The winter annuals *Bangia fuscopurpurea* and *Petalonia fascia* appeared simultaneously in the Canal and on the south shore of the Cape, but they were not found at Scituate until several weeks later. Other spring and summer annuals such as *Ceramium strictum*, *Agardhiella tenera*, *Lomentaria baileyana*, *Chorda filum* and *Leathesia difformis* appeared successively at Woods Hole, the Canal stations and finally at Scituate.

SEASONAL REPRODUCTION

Species common to both sides of the Cape showed differences in reproductive periods (Tables I-III). The annuals can be divided into three groups as follows according to their reproductive patterns: 1) species reproducing earlier south than north of the Cape; 2) species terminating reproduction earlier south than north of the Cape; 3) species reproducing throughout the year north of the Cape, but with limited reproductive periods to the south. Examples of each group are as follows: 1) *Agardhiella tenera*,

Chorda filum, *Leathesia difformis*, *Ceramium strictum*, *Chordaria flagelliformis*, and *Asperococcus echinatus*; 2) *Bangia fuscopurpurea*, *Dumontia incrassata*, *Porphyra umbilicalis*, *Leathesia difformis*, *Petalonia fascia*, and *Monostroma grevillei*; 3) *Porphyra umbilicalis*, *Petalonia fascia*, and *Scytosiphon lomentarius*. Table VIII summarizes all of the species found in each group.

The perennials can also be divided into three groups according to their reproductive patterns: 1) species primarily reproducing during the colder months; 2) species primarily reproducing during the warmer months; 3) species reproducing throughout the year. Examples of each of the groups are as follows: 1) *Chondrus crispus*, *Petrocelis middendorfi*, *Laminaria* spp., and *Polyides rotundus*; 2) *Callithamnion baileyi*, and *Cystoclonium purpureum* var. *cirrhosum*; 3) *Ascophyllum nodosum*, *Fucus* ssp., *Pilayella littoralis*, *Sphacelaria cirrosa*, and *Ahnfeltia plicata*. The generalized groupings of species according to reproductive periods were not always consistent at all stations. For example, *Pilayella littoralis* and *Chondrus crispus* had an extended reproductive period north of the Cape, but exhibited limited periods of reproduction to the south. See Tables I-III for specific details of reproduction at stations 1, 4 and 7.

DISCUSSION

Davis (1913a, b) suggests that the wide range of temperatures near Cape Cod results in distinct annual populations. He distinguishes two groups of annuals as follows: (1) winter-spring, and (2) mid-summer or early autumn. We observed four types of annuals: winter, spring, summer and aseasonal. Sears (1971) also recorded aseasonal annuals during his study of the subtidal marine algae in southern Cape Cod. The latter group showed no seasonal specificity; the plants reproduced throughout the year and they were represented by successive generations of young plants. Among others, Davis (1931a, b), Setchell (1920),

Williams (1948) and Chapman (1964) state that species may survive adverse temperatures in a resting stage. Sears' (1971) observations substantiate the latter suggestion, for he observed germlings of several red algae overwintering in the deep subtidal zone off Martha's Vineyard, Massachusetts.

Cold water perennials might be expected to enter a comparable state during the warmer months. Setchell (1917) states that the northern fucoid alga *Ascophyllum nodosum* enters a heat labor state during the summer south of the Cape. We have observed a similar response for *A. nodosum* south of the Cape, for it becomes bleached and unhealthy looking during the summer.

The ratios of annuals to perennials varied at different stations. North of Cape Cod perennials were dominant, while to the south annuals were more abundant. Intermediate ratios were found in the Canal. The seasonal temperature regimes at the seven sites are correlated with the percentage of annuals and perennials at each site. Thus, the temperature range south of the Cape is about 22°C., while to the north it is about 17°C.; intermediate values are evident in the Canal (Coleman and Mathieson, 1974). The high summer temperatures south of the Cape allow warm temperature annuals to occur in abundance. In contrast the winter flora at the same sites is dominated by northern (boreal) annuals. Williams (1948, 1949) has recorded a similar seasonal variation of annuals at Cape Lookout, North Carolina. He emphasizes that areas with wide temperature fluctuations, such as Cape Lookout, support a wide range of annuals.

Geographical differences of seasonal succession were evident. For example, warm water annuals occurred earlier south of the Cape than north, while many cold water annuals remained longer north than south of the Cape. The early appearance of warm water annuals south of the Cape resulted from higher spring temperatures in Buzzards Bay than Cape Cod Bay. Likewise, some cold water annuals remained longer north of the Cape, because of the lower

spring temperatures in Cape Cod Bay. It is suggested that differences in seasonal successions at the stations are primarily dependent on temperature differentials.

Variable reproductive periodicities were also evident for the same species at different stations. For example, several warm water annuals initiated reproduction earlier south than north of the Cape, while cold water annuals reproduced longer north than south. The reproductive patterns of perennials also showed similar patterns as the annuals, again indicating the importance of temperature differences.

Acknowledgements

We would like to thank Dr. A. Hodgdon for his critical review of the manuscript. In addition we express our gratitude to Dr. R. Fralick, Dr. R. Turner and Mr. John Hansman for their assistance with diving and collection of specimens, and to the Army Corps of Engineers at Cape Cod for diving access to the Cape Cod Canal.

LEGEND: TABLES I-III — a = alpha spore, b = beta spore, C = carpospore, G = gametangia, M = monospore, PS = plurilocular sporangium, R = receptacle, S = spermatium, T = tetraspore, US = unilocular sporangium, Z = zoospore, X = present, — = absent.

TABLE I. SEASONAL OCCURENCE AND REPRODUCTION OF SPECIES AT STATION 1

Rhodophyta

TAXON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
<i>Agardhiella tenera</i>	—	—	—	—	—	X	—	—	—	—	—	—
<i>Ahnfeltia plicata</i>	M	M	M	M	X	M	M	M	M	M	X	M
<i>Bangia fuscopurpurea</i>	M	M	X	X	X	M	X	—	—	—	X	M
<i>Callithamnion baileyi</i>	—	—	—	—	—	—	X	T	—	—	—	—
<i>Callithamnion roseum</i>	—	—	—	—	—	X	X	—	—	—	—	—
<i>Ceramium rubrum</i>	X	X	T	T	X	X	T	T,C	T	T	X	X
<i>Ceramium strictum</i>	—	—	—	—	—	—	X	X	X	—	—	—
<i>Chondrus crispus</i>	X	X	—	—	—	—	X	C	C	C	X	C
<i>Choreocolax polysiphoniae</i>	X	X	X	X	X	C	X	—	X	X	X	X
<i>Clathromorphum circumscriptum</i>	X	X	X	X	X	X	X	—	X	X	X	X
<i>Corallina officinalis</i>	X	X	X	X	X	X	X	X	X	X	X	X
<i>Cystoclonium purpureum</i>	X	X	X	X	X	X	T	T	T	T	T	X
var. <i>cirrhosum</i>	X	X	X	X	X	X	X	X	X	X	X	X
<i>Dermatolithon pustulatum</i>	X	X	X	X	X	X	X	X	X	X	X	X
<i>Dumontia incrassata</i>	X	X	X	T	T	T	X	T	X	X	X	X
<i>Gigartina stellata</i>	C	C	C	C	X	X	C	C	C	C	C	C
<i>Gloiosiphonia capillaris</i>	—	—	—	—	—	—	X	X	—	—	—	—
<i>Hildenbrandia prototypus</i>	X	X	X	T	T	T	X	X	X	X	X	X
<i>Lithophyllum corallinae</i>	X	X	X	X	X	X	X	X	X	X	X	X
<i>Lithothamnium graciale</i>	—	—	—	—	—	—	X	X	X	X	X	X
<i>Lomentaria baileyana</i>	—	—	—	—	—	—	X	X	X	X	X	X
<i>Melobesia lejolissii</i>	—	—	—	—	—	—	X	X	X	X	X	X
<i>Petrocelis middendorffii</i>	T	T	T	T	X	T	X	X	X	X	X	X

TABLE I. — Rhodophyta (continued)

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TAXON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
<i>Phyllophora brodiaei</i>	M	M	X	X	M	M	M	X	X	X	X	M	R
<i>Phyllophora membranifolia</i>	T	T	T	T	X	X	X	X	X	T	X	T	X
<i>Phymatolithon lenormandi</i>	X	X	X	X	X	X	X	X	X	X	X	X	—
<i>Plumaria elegans</i>	X	T	X	X	X	X	X	X	—	X	X	X	—
<i>Polyides rotundus</i>	—	—	—	—	—	—	—	—	X	X	X	T	—
<i>Polysiphonia dunudata</i>	—	—	—	—	—	—	—	—	X	X	X	T	—
<i>Polysiphonia harveyi</i>	—	—	—	—	—	—	—	—	X	X	X	T	—
<i>Polysiphonia lanosa</i>	S	S	S	S	X	C	T,C	T,C	T,C	T,C	T	—	—
<i>Polysiphonia nigrescens</i>	X	—	X	—	—	T	—	—	C	T	T	—	—
<i>Polysiphonia novae-angliae</i>	T	T	—	—	—	—	—	—	X	—	X	—	—
<i>Polysiphonia urceolata</i>	X	X	—	X	—	—	—	—	X	—	X	—	—
<i>Porphyra miniata</i>	—	—	—	—	—	—	—	—	T	—	—	—	—
<i>Porphyra umbilicalis</i>	a	a	a,b	X	a	X	b	a,b	a	—	a,b	—	—
<i>Rhodochorton penicilliforme</i>	X	X	X	X	—	X	X	X	—	X	X	X	—
<i>Rhodomela confervoides</i>	X	X	X	X	T	T,C	X	X	—	X	X	X	—
<i>Rhodymenia palmata</i>	T	T	T	T	—	X	T	T	X	X	X	T	—
<i>Trailliella intricata</i>	—	—	—	—	—	—	—	—	X	—	—	—	—
Phaeophyta													
TAXON													
<i>Ascophyllum nodosum</i>	R	R	R	R	R	R	R	R	R	R	R	R	R
<i>Asperococcus echinatus</i>	—	X	X	US	US	US	X	X	—	X	—	X	—
<i>Chorda filum</i>	—	—	—	—	—	X	US	US	—	—	—	—	—
<i>Chorda tomentosa</i>	X	X	X	US	US	X	X	—	—	—	—	—	—

TABLE I. — Phaeophyta (continued)

TAXON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
<i>Chordaria flagelliformis</i>	X	X	X	X	X	US	US	X	US	X	US	X
<i>Desmarestia aculeata</i>	X	X	X	X	X	X	X	—	X	US	X	X
<i>Desmarestia viridis</i>	—	—	—	—	X	X	X	X	—	—	—	—
<i>Desmotrichum balticum</i>	—	—	—	—	—	PS	—	X	—	—	—	—
<i>Dictyosiphon foeniculaceus</i>	X	X	X	X	X	X	X	X	X	X	X	—
<i>Ectocarpus siliculosus</i>	X	—	—	—	—	PS	X	X	X	X	X	—
<i>Elachista fucicola</i>	X	X	X	X	X	X	US	US	X	US	US	US
<i>Fucus distichus</i> ssp. <i>distichus</i>	—	—	R	R	R	X	X	X	X	X	X	X
<i>Fucus distichus</i> ssp. <i>edentatus</i>	R	R	R	X	X	R	R	—	R	R	R	R
<i>Fucus distichus</i> ssp. <i>evanescens</i>	—	—	—	—	—	R	R	X	X	X	—	—
<i>Fucus spiralis</i>	R	X	X	R	R	R	R	X	R	R	R	X
<i>Fucus vesiculosus</i>	R	R	R	R	R	R	R	X	X	X	R	R
<i>Laminaria digitata</i>	US	US	US	US	X	X	X	X	X	X	X	US
<i>Laminaria saccharina</i>	US	US	US	X	X	X	X	X	X	X	US	US
<i>Leathesia difformis</i>	—	—	—	—	—	X	US	US	—	—	—	—
<i>Myrionema strangulans</i>	X	X	X	X	X	X	—	—	X	—	X	X
<i>Petalonia fascia</i>	PS	PS	PS	PS	PS	X	X	X	PS	PS	PS	X
<i>Punctaria latifolia</i>	—	—	—	—	—	X	—	—	—	—	—	—
<i>Pilayella littoralis</i>	US,PS	US,PS	US,PS	US,PS	US,PS	US,PS	US,PS	US,PS	US,PS	X	X	X
<i>Ralfsia fungiformis</i>	—	X	X	X	X	X	X	X	X	X	—	—
<i>Ralfsia verrucosa</i>	—	—	US	US	US	US	US	US	US	US	US	—
<i>Scytosiphon lomentarius</i>	PS	PS	PS	PS	PS	PS	—	PS	PS	X	X	PS

TABLE I. — Phaeophyta (continued)

TAXON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
<i>Sphacelaria cirrosa</i>	X	X	X	X	X	P	P	P	P	P	P	X
Chlorophyta												
TAXON												
<i>Chaetomorpha atrovirens</i>	X	X	X	—	X	X	X	X	X	X	X	X
<i>Chaetomorpha linum</i>	X	X	X	X	X	X	X	X	X	X	X	X
<i>Chaetomorpha melagonium</i>	—	—	—	—	X	X	X	X	—	—	—	—
<i>Cladophora flexuosa</i>	—	—	—	—	X	X	X	X	X	—	—	—
<i>Cladophora gracilis</i>	—	—	—	—	X	X	X	X	—	—	—	—
<i>Codiolum petrocelidis</i>	—	—	—	—	—	X	X	X	—	—	—	—
<i>Codiolum gregarium</i>	—	—	—	—	—	X	X	X	—	—	—	—
<i>Enteromorpha intestinalis</i>	X	X	X	X	X	X	X	X	X	X	X	X
<i>Enteromorpha linza</i>	—	—	—	—	X	X	X	—	—	—	—	—
<i>Monostroma grevillei</i>	—	—	—	—	X	X	X	—	—	—	—	—
<i>Monostroma pulchrum</i>	—	—	—	—	X	X	X	—	—	—	—	—
<i>Rhizoclonium tortuosum</i>	X	X	X	X	X	X	X	X	X	X	X	X
<i>Spongomorpha arcta</i>	—	—	—	—	X	X	X	—	—	—	—	—
<i>Spongomorpha spinescens</i>	—	—	—	—	X	X	X	—	—	—	—	—
<i>Ulothrix flacca</i>	X	X	X	Z	X	X	X	—	—	—	—	—
<i>Ulva lactuca</i>	X	X	X	X	X	X	X	X	X	X	X	X
<i>Urospora collabens</i>	—	—	—	X	X	X	X	—	—	—	—	—
<i>Urospora penicilliformis</i>	—	—	Z	Z	X	Z	X	X	—	—	—	—

TABLE II. SEASONAL OCCURRENCE AND REPRODUCTION OF SPECIES AT STATION 4 90

Rhodophyta

TAXON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
<i>Agardhiella tenera</i>	-	-	-	-	-	X	X	C	C	C	-	-
<i>Ahnfeltia plicata</i>	M	M	M	X	M	-	X	X	-	X	X	M
<i>Bonnemaïsonia hamifera</i>	-	-	-	-	-	-	-	-	-	-	-	X
<i>Callithamnion roseum</i>	-	-	-	-	-	-	X	X	T	T	-	-
<i>Ceramium rubrum</i>	X	X	T	T	X	X	T	X	X	-	-	X
<i>Ceramium strictum</i>	-	-	-	-	-	-	T	T	T	-	-	-
<i>Champia parvula</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Chondrus crispus</i>	C	C	X	C	C	C	X	X	C	C	C	C
<i>Choreocolax polysiphoniae</i>	X	X	X	X	X	X	-	-	X	X	X	-
<i>Corallina officinalis</i>	X	X	X	X	X	-	-	-	-	-	-	-
<i>Cystoclonium purpureum</i>	X	X	X	X	X	X	-	-	-	-	-	-
var. <i>cirrhosum</i>	X	X	X	X	X	-	-	-	-	-	-	-
<i>Dumontia incrassata</i>	X	X	X	X	X	-	-	-	-	-	-	-
<i>Goniotrichum alsidii</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Grinnellia americana</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Lomentaria orcadensis</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Melobesia lejolisi</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Phyllophora brodiaei</i>	M	M	M	X	M	X	X	X	X	X	X	M
<i>Phyllophora membranifolia</i>	T	T	T	X	X	X	X	X	X	X	X	T
<i>Polyides rotundus</i>	T	T	T	-	X	-	-	-	-	-	-	T
<i>Polysiphonia denudata</i>	-	-	-	-	-	-	-	-	-	-	-	-
<i>Polysiphonia elongata</i>	X	-	X	-	-	-	-	-	T,C	T	X	-
<i>Polysiphonia harveyi</i>	-	-	-	-	-	-	X	T,C	T,C	C	X	-

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TABLE II. — Rhodophyta (continued)

TAXON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
<i>Polysiphonia lanosa</i>	X	X	—	X	X	—	—	T,C	T,C	T	T,C	X
<i>Polysiphonia nigrescens</i>	—	—	X	—	—	—	T	T	X	—	X	X
<i>Polysiphonia novae-angliae</i>	—	—	—	—	—	—	—	—	T,C	—	—	—
<i>Polysiphonia urceolata</i>	—	—	—	—	X	T	T,C	—	X	—	X	X
<i>Porphyra leucosticta</i>	—	—	—	—	—	—	—	—	—	—	X	—
<i>Porphyra umbilicalis</i>	—	—	X	X	X	—	—	—	—	—	—	—
<i>Rhodomela confervoides</i>	X	X	X	—	—	—	—	T	T	—	X	X
<i>Rhodymenia palmata</i>	T	T	T	T	T	T	X	T	T	T	T	X
<i>Trailliella intricata</i>	—	—	—	—	—	—	—	—	X	—	—	—
Phaeophyta												
TAXON												
<i>Ascophyllum nodosum</i>	R	R	R	R	R	X	X	R	X	R	R	R
<i>Asperococcus echinatus</i>	—	X	X	US	—	—	—	X	—	—	—	X
<i>Chorda filum</i>	—	—	—	—	X	US	US	US	US	—	—	—
<i>Chorda tomentosa</i>	X	X	US	US	US	—	—	—	—	—	—	—
<i>Chordaria flagelliformis</i>	—	—	—	X	X	X	X	US	US	US	US	—
<i>Desmarestia aculeata</i>	X	X	X	X	X	X	X	—	X	X	X	—
<i>Desmarestia viridis</i>	—	—	—	X	X	X	X	—	—	—	—	—
<i>Desmotrichum undulatum</i>	—	—	—	US	—	—	—	—	—	—	—	—
<i>Ectocarpus siliculosus</i>	X	X	X	X	X	US	X	X	PS	PS	—	PS
<i>Elachista fucicola</i>	US	US	X	X	X	X	X	US	US	X	US	US
<i>Fucus distichus</i>	—	—	X	R	R	—	—	—	—	—	—	—
ssp. <i>evanescens</i>	—	—	R	R	R	—	—	—	X	—	—	—

Rhodophyta

[illegible]

TABLE III. — Rhodophyta (continued)

TAXON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
<i>Phyllophora brodiaei</i>	—	—	—	—	—	—	—	X	—	—	—	—
<i>Phyllophora membranifolia</i>	X	C	C	X	X	X	X	X	X	X	X	X
<i>Polyides rotundus</i>	—	—	X	—	X	—	—	—	—	—	—	—
<i>Polysiphonia denudata</i>	—	—	—	—	—	—	—	T	T	T	T,C	C
<i>Polysiphonia harveyi</i>	—	—	—	X	—	X	X	T,C	—	—	—	—
<i>Polysiphonia lanosa</i>	X	—	—	—	—	—	—	X	—	—	—	—
<i>Polysiphonia nigrescens</i>	—	—	X	—	X	T	X	X	X	T	T	X
<i>Polysiphonia novae-angliae</i>	—	—	—	—	—	X	—	—	—	—	—	—
<i>Polysiphonia urceolata</i>	C	—	C	X	T,C	X	T,C	T,C	C	X	—	X
<i>Porphyra leucosticta</i>	—	—	—	—	X	X	—	—	—	—	—	—
<i>Porphyra miniata</i>	—	X	X	—	—	—	—	—	—	—	—	—
<i>Porphyra umbilicalis</i>	—	—	—	—	X	X	a	X	a,b	X	a	X
<i>Rhodomela confervoides</i>	—	—	—	X	X	X	X	—	—	—	—	—
<i>Rhodomenia palmata</i>	—	—	X	X	X	X	X	—	—	—	—	—
<i>Seirospora griffithsiana</i>	—	—	—	—	—	X	X	—	—	—	—	—
<i>Trailliella intricata</i>	—	—	—	—	X	X	X	X	—	—	—	—
Phaeophyta												
TAXON												
<i>Ascophyllum nodosum</i>	R	R	R	R	R	R	R	R	R	R	R	R
<i>Asperococcus echinatus</i>	—	US	US	X	US	X	X	X	—	—	—	X
<i>Chorda filum</i>	X	—	—	—	US	US	US	US	US	US	—	—
<i>Chorda tomentosa</i>	X	X	US	US	US	US	—	—	—	—	—	—
<i>Chordaria flagelliformis</i>	—	—	—	X	US	US	X	US	X	US	—	—

TABLE III. — Phaeophyta (continued)

TAXON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
<i>Desmarestia viridis</i>	—	—	—	—	X	X	X	—	—	—	—	—
<i>Desmotrichum balticum</i>	—	—	US	—	—	—	—	US	—	—	—	—
<i>Desmotrichum undulatum</i>	—	—	US	US	US	X	X	X	X	—	—	—
<i>Dictyosiphon foeniculaceus</i>	X	X	X	X	X	X	X	X	X	X	—	—
<i>Ectocarpus siliculosus</i>	US, PS	X	X	US, PS	PS	PS	PS	X	X	PS	PS	PS
<i>Elachista fucicola</i>	X	X	X	X	US	US	US	US	X	US	US	X
<i>Fucus spiralis</i>	X	X	X	—	—	—	—	—	—	R	X	—
<i>Fucus vesiculosus</i> var. <i>sphaerocarpus</i>	R	X	R	R	R	X	X	R	R	R	R	R
<i>Fucus vesiculosus</i> var. <i>spiralis</i>	—	—	—	—	—	—	—	—	—	—	—	R
<i>Giffordia granulosa</i>	—	R	—	—	—	—	—	—	—	—	—	—
<i>Giffordia secunda</i>	—	—	—	—	X	—	PG	—	—	X	—	—
<i>Laminaria saccharina</i>	US	US	X	X	X	X	X	X	X	R	X	R
<i>Leathesia difformis</i>	—	—	—	X	US	US	US	—	—	—	—	—
<i>Myrionema strangulans</i>	—	—	X	X	X	—	—	X	—	X	—	—
<i>Petalonia fascia</i>	PS	PS	PS	X	PS	—	—	—	—	X	X	X
<i>Punctaria latifolia</i>	—	—	—	US	X	X	—	—	—	—	—	—
<i>Punctaria plantaginea</i>	—	—	X	US	X	US	X	X	—	—	—	—
<i>Pilayella littoralis</i>	US	US	US	US	US	X	X	X	X	X	X	US
<i>Ralfsia fungiformis</i>	—	X	X	—	—	—	—	—	—	—	—	X
<i>Ralfsia verrucosa</i>	—	X	X	X	X	X	US	US	X	X	—	—
<i>Sargassum filipendula</i>	X	X	R	X	R	X	R	R	R	R	X	X
<i>Scytosiphon lomentarius</i>	PS	PS	PS	PS	PS	PS	X	—	—	X	PS	PS
<i>Sphacelaria cirrosa</i>	X	X	P	P	P	P	P	X	P	P	P	X

TABLE III. — Phaeophyta (continued)

TAXON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
<i>Sphaerotrichia divaricata</i>	—	—	—	—	—	X	X	US	US	US	—	—
Chlorophyta												
TAXON												
<i>Chaetomorpha linum</i>	—	—	—	—	X	X	X	X	X	X	X	X
<i>Chaetomorpha melagonium</i>	—	—	—	X	—	—	—	—	—	—	—	—
<i>Cladophora flexuosa</i>	—	—	—	—	X	X	X	X	X	X	X	X
<i>Cladophora gracilis</i>	—	—	—	—	—	—	X	X	X	X	X	X
<i>Codium fragile</i>	—	—	—	—	—	—	—	—	—	—	—	—
<i>ssp. tomentosoides</i>	X	G	G	G	G	G	G	G	G	G	G	G
<i>Enteromorpha intestinalis</i>	X	X	X	X	X	X	X	X	X	X	X	X
<i>Enteromorpha linza</i>	—	—	—	—	X	X	X	—	—	—	—	—
<i>Monostroma grevillei</i>	—	—	X	Z	Z	X	X	—	—	—	—	—
<i>Monostroma pulchrum</i>	—	X	X	Z	Z	X	—	—	—	—	—	—
<i>Spongomorpha arcta</i>	—	X	X	X	X	—	—	—	—	—	—	—
<i>Ulothrix flacca</i>	X	X	Z	Z	Z	X	—	—	—	—	—	—
<i>Ulva lactuca</i>	X	—	X	X	X	X	X	X	X	X	X	X
<i>Urospora penicilliformis</i>	X	X	Z	Z	Z	X	—	—	—	—	—	—

TABLE IV. LONGEVITY OF SPECIES

Chlorophyta

TAXON	Longevity
<i>Chaetomorpha atrovirens</i> Taylor	P
<i>Chaetomorpha linum</i> (Muller) Kützing	P
<i>Chaetomorpha melagonium</i> (Weber et Mohr) Kützing	P
<i>Cladophora flexuosa</i> (Muller) Harvey	P?
<i>Cladophora gracilis</i> (Griffiths ex Harvey) Kützing	P?
<i>Codium gregarium</i> A. Braun	A
<i>Codium petrocelidis</i> Kuckuck	A
<i>Codium fragile</i> (Sur.) Hariot ssp. <i>tomentosoides</i> (van Goor) Silva	P
<i>Enteromorpha intestinalis</i> (L.) Link	A
<i>Enteromorpha linza</i> (L.) J. Agardh	A
<i>Monostroma grevillei</i> (Thuret) Whittrock	A
<i>Monostroma pulchrum</i> Farlow	A
<i>Rhizoclonium tortuosum</i> Kützing	P
<i>Spongomorpha arcta</i> (Dillwyn) Kützing	A
<i>Spongomorpha spinescens</i> Kützing	A
<i>Ulothrix flacca</i> (Dillwyn) Thuret	A
<i>Ulva lactuca</i> L.	A
<i>Urospora collabens</i> (C. Agardh) Homes et Batters	A
<i>Urospora penicilliformis</i> (Roth) Areschoug	A

Phaeophyta

TAXON	Longevity
<i>Ascophyllum nodosum</i> (L.) Le Jolis	P
<i>Asperococcus echinatus</i> (Mertens) Greville	A
<i>Chorda filum</i> (L.) Stackhouse	A
<i>Chorda tomentosa</i> Lyngbye	A
<i>Chordaria flagelliformis</i> (Muller) C. Agardh	A
<i>Desmarestia aculeata</i> (L.) Lamouroux	P
<i>Desmarestia viridis</i> (Muller) Lamouroux	A
<i>Desmotrichum balticum</i> Kützing	A
<i>Desmotrichum undulatum</i> (J. Agardh) Reinke	A
<i>Dictyosiphon foeniculaceus</i> (Hudson) Greville	P
<i>Ectocarpus siliculosus</i> (Dillwyn) Lyngbye	A
<i>Elachista fucicola</i> (Vellay) Areschoug	P
<i>Fucus distichus</i> L. emend. ssp. <i>distichus</i> (C. Agardh) Powell	P
<i>Fucus distichus</i> L. emend. ssp. <i>edentatus</i> (C. Agardh) Powell	P
<i>Fucus distichus</i> L. emend. ssp. <i>evanescens</i> (C. Agardh) Powell	P

Phaeophyta

TAXON	Longevity
<i>Fucus spiralis</i> L.	P
<i>Fucus vesiculosus</i> L.	P
<i>Fucus vesiculosus</i> var. <i>sphaerocarpus</i> J. Agardh	P
<i>Fucus vesiculosus</i> var. <i>spiralis</i> Farlow	P
<i>Giffordia granulosa</i> (Smith) Hamel	A
<i>Giffordia secunda</i> (Kützinger) Batters	A
<i>Laminaria digitata</i> (Hudson) Lamouroux	P
<i>Laminaria saccharina</i> (L.) Lamouroux	P
<i>Leathesia difformis</i> (L.) Areschoug	A
<i>Myrionema strangulans</i> Greville	P?
<i>Petalonia fascia</i> (Muller) Kuntze	A
<i>Pilayella littoralis</i> (L.) Kjellman	P
<i>Punctaria latifolia</i> Greville	A
<i>Punctaria plantaginea</i> (Roth) Greville	A
<i>Ralfsia fungiformis</i> (Gunner) Setchell et Gardner	P
<i>Ralfsia verrucosa</i> (Areschoug) J. Agardh	P
<i>Sargassum filipendula</i> C. Agardh	P
<i>Scytosiphon lomentarius</i> (Lyngbye) Link	A
<i>Sphacelaria cirrosa</i> (Roth) C. Agardh	P
<i>Sphaerotrichia divaricata</i> (C. Agardh) Kylin	A

Rhodophyceae

TAXON	Longevity
<i>Agardhiella tenera</i> (J. Agardh) Schmitz	A?
<i>Ahnfeltia plicata</i> (Hudson) Fries	P
<i>Antithamnion americanum</i> (Harvey) Farlow	A
<i>Bangia fuscopurpurea</i> (Dillwyn) Lyngbye	A
<i>Bonnemaisonia hamifera</i> Hariot	P
<i>Callithamnion baileyi</i> Harvey	P?
<i>Callithamnion roseum</i> (Roth) Lyngbye	A?
<i>Ceramium rubrum</i> (Hudson) C. Agardh	P
<i>Ceramium strictum</i> Harvey	A
<i>Champia parvula</i> (C. Agardh) Harvey	A
<i>Chondria sedifolia</i> Harvey	A
<i>Chondrus crispus</i> Stackhouse	P
<i>Choreocolax polysiphoniae</i> Reinsch.	P
<i>Clathromorphum circumscriptum</i> (Strømfelt) Foslie	P
<i>Corallina officinalis</i> L.	P
<i>Cystoclonium purpureum</i> (Hudson) Batters var. <i>cirrhosum</i> Harvey	P

Rhodophyceae (Continued)

TAXON	Longevity
<i>Dasya pedicellata</i> (C. Agardh) C. Agardh	A
<i>Dermatolithon pustulatum</i> (Lamouroux) Foslie	P
<i>Dumontia incrassata</i> (Muller) Lamouroux	A
<i>Gigartina stellata</i> (Stackhouse) Batters	P
<i>Gloiosiphonia capillaris</i> (Hudson) Carmichael ex Berkeley	A
<i>Goniotrichum alsidii</i> (Zanardini) Howe	A
<i>Griffithsia tenuis</i> C. Agardh	A
<i>Grinnellia americana</i> (C. Agardh) Harvey	A
<i>Hildenbrandia prototypus</i> Nardo	P
<i>Hypha musciformis</i> (Wulfen) Lamouroux	A
<i>Lithophyllum corallinae</i> (Crouan) Heydrich	P
<i>Lithothamnium glaciale</i> Kjellman	P
<i>Lomentaria baileyana</i> (Harvey) Farlow	A
<i>Lomentaria orcadensis</i> (Harvey) Collins ex Taylor	P?
<i>Melobesia lejolisi</i> Rosanoff	P
<i>Petrocelis middendorfi</i> (Ruprecht) Kjellman	P
<i>Phyllophora brodiaei</i> (Turner) Endlick	P
<i>Phyllophora membranifolia</i> (Goodenough ex Woodward) J. Agardh	P
<i>Phymatolithon lenormandi</i> (Areschoug) Adey	P
<i>Plumaria elegans</i> (Bonnemaison) Schmitz	P
<i>Polyides rotundus</i> (Hudson) Greville	P
<i>Polysiphonia denudata</i> (Dillwyn) Greville ex Harvey in Hooker	A
<i>Polysiphonia elongata</i> (Hudson) Sprengel	P
<i>Polysiphonia harveyi</i> Bailey	A
<i>Polysiphonia lanosa</i> (L.) Tandy	P
<i>Polysiphonia nigrescens</i> (Hudson) Greville	P
<i>Polysiphonia novae-angliae</i> Taylor	P
<i>Polysiphonia urceolata</i> (Lightfoot ex Dillwyn) Greville	P
<i>Porphyra leucosticta</i> Thuret	A
<i>Porphyra miniata</i> (C. Agardh) C. Agardh	A
<i>Porphyra umbilicalis</i> (L.) J. Agardh	A
<i>Rhodochorton penicilliforme</i> (Lightfoot) Rosenvinge	P
<i>Rhodomela confervoides</i> (Hudson) Silva	P
<i>Rhodymenia palmata</i> (L.) Greville	P
<i>Seirospora griffithsiana</i> (Harvey) Dixon	A
<i>Trailliella intricata</i> (J. Agardh) Batters	P

TABLE V. DOMINANT ANNUALS NORTH AND SOUTH OF THE CANAL

ANNUALS

NORTH

Bangia fuscopurpurea
Dumontia incrassata
Lomentaria baileyana
Polysiphonia harveyi
Porphyra umbilicalis

Asperococcus echinatus
Chorda filum
Chorda tomentosa
Chordaria flagelliformis
Ectocarpus confervoides
Leathesia difformis
Petalonia fascia
Scytosiphon lomentaria

Codiolum petrocelidis
Enteromorpha intestinalis
Monostroma grevillei
Monostroma pulchrum
Spongomorpha arcta
Spongomorpha spinescens
Ulothrix flacca
Ulva lactuca
Urospora collabens
Urospora penicilliformis

SOUTH

Agardhiella tenera
Antithamnion americanum
Bangia fuscopurpurea
Cailithamnion roseum
Ceramium strictum
Champia parvula
Chondria sedifolia
Dasya pedicellata
Dumontia incrassata
Grinnellia americana
Hypnea musciformis
Lomentaria baileyana
Polysiphonia harveyi
Porphyra umbilicalis
Seirospora griffithsiana
Trailliella intricata

Asperococcus echinatus
Chorda filum
Chorda tomentosa
Chordaria flagelliformis
Desmotrichum undulatum
Ectocarpus confervoides
Leathesia difformis
Petalonia fascia
Punctaria latifolia
Punctaria plantaginea
Scytosiphon lomentaria
Sphaerotrichia divaricata

Enteromorpha intestinalis
Monostroma grevillei
Monostroma pulchrum
Spongomorpha arcta
Ulothrix flacca
Urospora penicilliformis

TABLE VI. DOMINANT PERENNIALS NORTH AND SOUTH OF THE CANAL

PERENNIALS

NORTH	SOUTH
<i>Ahnfeltia plicata</i>	<i>Callithamnion baileyi</i>
<i>Ceramium rubrum</i>	<i>Ceramium rubrum</i>
<i>Chondrus crispus</i>	<i>Chondrus crispus</i>
<i>Choreocolax polysiphoniae</i>	<i>Corallina officinalis</i>
<i>Clathromorphum circumscriptum</i>	<i>Cystoclonium purpureum</i>
<i>Corallina officinalis</i>	var. <i>cirrhosum</i>
<i>Cystoclonium purpureum</i> var. <i>cirrhosum</i>	<i>Fosliella lejolisii</i>
<i>Gigartina stellata</i>	<i>Lithophyllum macrocarpum</i>
<i>Hildenbrandia prototypus</i>	<i>Phyllophora membranifolia</i>
<i>Lithophyllum corallinae</i>	<i>Polysiphonia nigrescens</i>
<i>Lithophyllum macrocarpum</i>	<i>Polysiphonia urceolata</i>
<i>Petrocelis middendorfi</i>	
<i>Phyllophora membranifolia</i>	
<i>Phymatolithon lenormandi</i>	
<i>Plumaria elegans</i>	
<i>Polyides carpinus</i>	
<i>Polysiphonia lanosa</i>	
<i>Polysiphonia nigrescens</i>	
<i>Polysiphonia urceolata</i>	
<i>Rhodochorton penicilliforme</i>	
<i>Rhodomela confervoides</i>	
<i>Rhodymenia palmata</i>	
<i>Ascophyllum nodosum</i>	<i>Ascophyllum nodosum</i>
<i>Desmarestia aculeata</i>	<i>Dictyosiphon foeniculaceus</i>
<i>Elachista fucicola</i>	<i>Elachista fucicola</i>
<i>Fucus distichus</i> ssp. <i>distichus</i>	<i>Fucus vesiculosus</i>
<i>Fucus distichus</i> ssp. <i>edentatus</i>	var. <i>sphaerocarpus</i>
<i>Fucus spiralis</i>	<i>Pilaiella littoralis</i>
<i>Fucus vesiculosus</i>	<i>Sargassum filipendula</i>
<i>Laminaria digitata</i>	<i>Sphacelaria cirrosa</i>
<i>Laminaria saccharina</i>	
<i>Pilaiella littoralis</i>	
<i>Ralfsia fungiformis</i>	
<i>Ralfsia verrucosa</i>	
<i>Sphacelaria cirrosa</i>	
<i>Chaetomorpha atrovirens</i>	<i>Chaetomorpha linum</i>
<i>Chaetomorpha linum</i>	<i>Cladophora flexuosa</i>
<i>Chaetomorpha melagonium</i>	<i>Cladophora gracilis</i>
<i>Rhizoclonium tortosum</i>	<i>Codium fragile</i> ssp. <i>tomentosoides</i>

TABLE VII. PATTERNS OF SEASONAL OCCURRENCE OF ANNUALS

ANNUALS OCCURRING EARLIER SOUTH THAN NORTH OF CAPE		
<i>Agardhiella tenera</i>	<i>Chorda filum</i>	<i>Monostroma pulchrum</i>
<i>Ceramium strictum</i>	<i>Desmotrichum balticum</i>	<i>Urospora penicilliformis</i>
<i>Gloiosiphonia capillaris</i>	<i>Ectocarpus siliculosus</i>	<i>Monostroma grevillei</i>
<i>Lomentaria baileyana</i>	<i>Leathesia difformis</i>	
<i>Polysiphonia denudata</i>	<i>Punctaria latifolia</i>	
<i>Polysiphonia harveyi</i>		
<i>Porphyra miniata</i>		
ANNUALS DISAPPEARING EARLIER SOUTH THAN NORTH		
<i>Bangia fuscopurpurea</i>	<i>Chorda tomentosa</i>	<i>Urospora penicilliformis</i>
<i>Ceramium strictum</i>	<i>Chordaria flagelliformis</i>	
<i>Dumontia incrassata</i>	<i>Desmarestia viridis</i>	
<i>Gloiosiphonia capillaris</i>	<i>Leathesia difformis</i>	
<i>Lomentaria baileyana</i>	<i>Petalonia fascia</i>	
<i>Porphyra miniata</i>	<i>Scytosiphon lomentarius</i>	
<i>Porphyra umbilicalis</i>		
ANNUALS FOUND ALL YEAR ON BOTH SIDES		
	<i>Asperococcus echinatus</i>	<i>Enteromorpha intestinalis</i>
	<i>Scytosiphon lomentarius</i>	<i>Ulva lactuca</i>

TABLE VIII. PATTERNS OF REPRODUCTIVE PERIODICITIES OF ANNUALS
ANNUALS REPRODUCING EARLIER SOUTH THAN NORTH

<i>Agardhiella tenera</i>	<i>Asperococcus echinatus</i>
<i>Ceramium strictum</i>	<i>Chorda flum</i>
<i>Dumontia incrassata</i>	<i>Chorda tomentosa</i>
<i>Lomentaria baileyana</i>	<i>Chordaria flagelliformis</i>
<i>Polysiphonia harveyi</i>	<i>Desmothrichum balticum</i>
	<i>Ectocarpus siliculosus</i>
	<i>Elachista fucicola</i>
	<i>Lethesia difformis</i>

ANNUALS TERMINATING REPRODUCTION EARLIER SOUTH THAN NORTH

<i>Bangia fuscopurpurea</i>	<i>Asperococcus echinatus</i>	<i>Monostroma grevillei</i>
<i>Dumontia incrassata</i>	<i>Leathesia difformis</i>	
<i>Lomentaria baileyana</i>	<i>Petalonia fascia</i>	
<i>Porphyra umbilicalis</i>		

ANNUALS REPRODUCING THROUGHOUT THE YEAR NORTH OF THE CAPE
WITH LIMITED REPRODUCTIVE PERIODS SOUTH OF THE CAPE

<i>Porphyra umbilicalis</i>	<i>Petalonia fascia</i>
	<i>Scytosiphon lomentarius</i>

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UNIVERSITY OF NEW HAMPSHIRE
DURHAM, N.H. 03824



Coleman, Douglas C. and Mathieson, Arthur C. 1975. "INVESTIGATIONS OF NEW-ENGLAND MARINE ALGAE PART 7 SEASONAL OCCURRENCE AND REPRODUCTION OF MARINE ALGAE NEAR CAPE COD MASSACHUSETTS USA." *Rhodora* 77, 76–104.

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