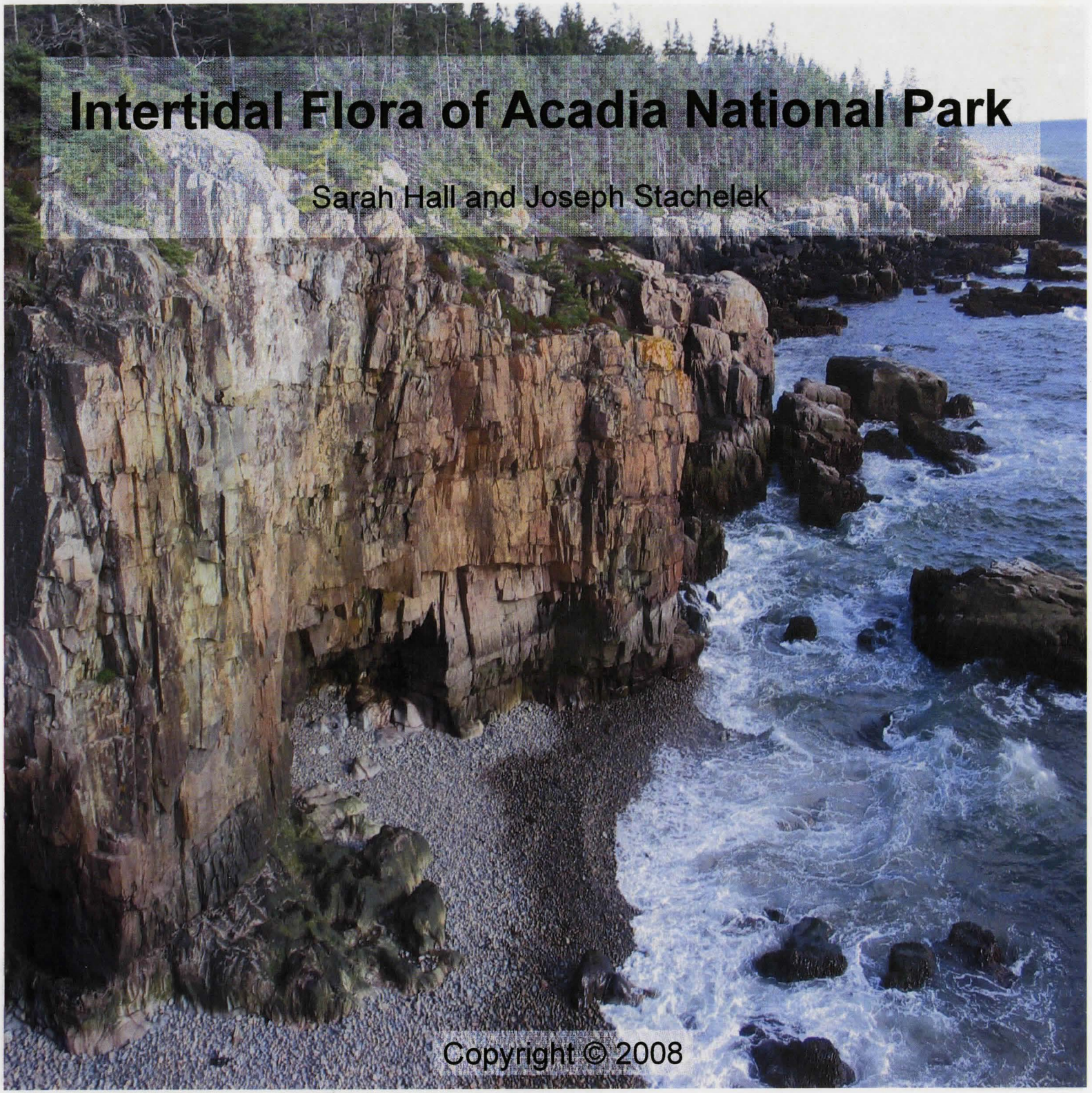
Intertidal Flora of Acadia National Park

Sarah Hall and Joseph Stachelek



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Introduction

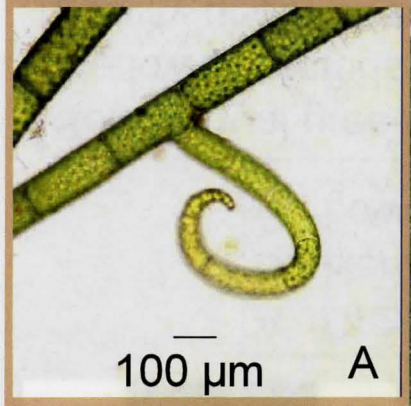
The rocky coast of Acadia National Park contains many kinds of marine algae (seaweeds). These organisms thrive in the dynamic area between the high and low tide marks where the land meets the sea. Algae that grow in the rocky intertidal zone must cope with both aquatic and terrestrial environments in order to survive. Most of these algae are adapted to live in a particular part of the shore that is uncovered at low tide, not the entire shore. For example, many seaweeds in the lowest part of the shore can not survive the long periods of high temperature, drying (or freezing), and high light that occur higher on the shore at low tide. A combination of physical and biological factors determines where each different alga is found. Important physical factors that control distribution include particular levels of light (including UV), drying, temperature, wave action, and ice scour. Biological factors that control distribution include competition for space and resistance to predation; animals that eat algae are called herbivores. These factors all play a part in defining the distinctive zones on the shore, which consist of the splash, high, mid, and lower intertidal zones.

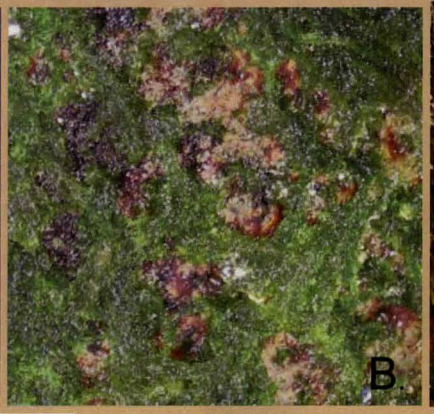
In the splash zone and upper intertidal zone, spray from high tide moistens the algal mats (diatoms, *Ulothrix laetevirins*), which makes footing slippery. The most abundant seaweed is usually the rockweed *Fucus spiralis*. The mid-intertidal zone is typically covered by other rockweeds (*Ascophyllum nodosum*, *Fucus vesiculosus*); whereas, the lower intertidal zone and lower intertidal pools contain many different kinds of seaweeds including sea lettuce (*Ulva lactuca*), kelps (*Alaria esculenta*), and Irish moss (*Chondrus crispus*). This field guide is not a comprehensive guide of all the algae on the shore (e.g. some rarer and winter annual species may not be listed). However, this guide should help you to identify many of the different common algae.

Most of the algae on shores of Acadia National Park belong to one of four groups: the red algae (Rhodophyta), the green algae (Chlorophyta), the brown algae (Phaeophyceae) and the diatoms (Bacillariophyceae). These groupings reflect differences in anatomy, reproduction, life cycles, and types of light-harvesting pigments. As a group, most algae are not closely related to each other, but all algae contain chlorophyll a (a light-harvesting pigment) and need water at some stage in their life cycle. Readers can learn more about the marine algae by consulting the publications listed in the annotated reference section of this guide on page 48.

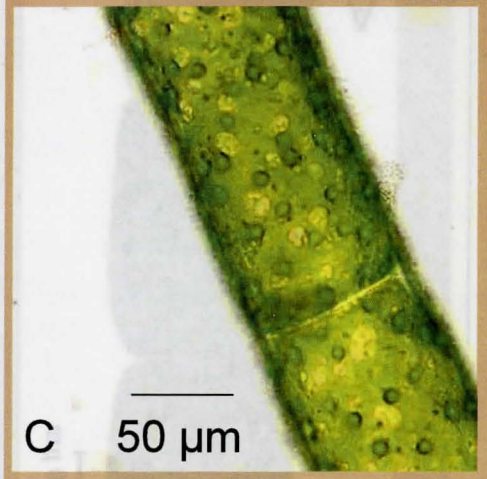
Acrosiphonia arcta (Dillwyn) Gain

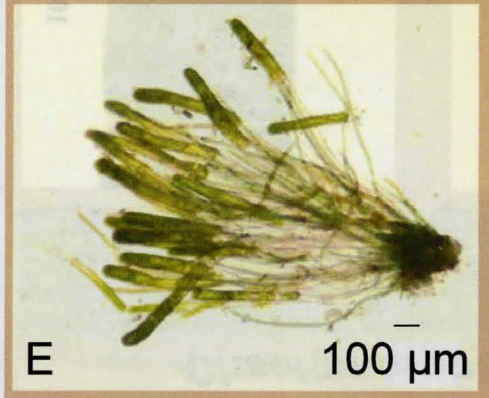
Chlorophyta Ulvophyceae Ulotrichales











A. Characteristic hooked branch
B. Field close up
C. Vegetative filament. Cells with reticulate chloroplast containing many pyrenoids
D. Habitat in the lower intertidal zone
E. "Codiolum" alternate stage of life history

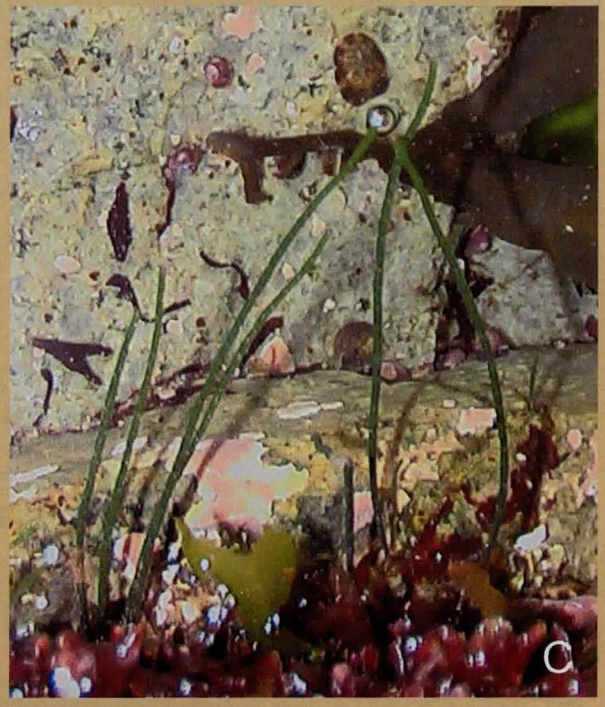
This alga grows as a tufted mat in the lower intertidal zone. It looks unusually fuzzy because it has hooked filaments (see microscopic photograph). This alga is a favorite place for small crustaceans to hide in order to escape drying stress at low tide. Most abundant in late winter to early summer. This is the gametophyte phase of the heteromorphic life history (A - D). The microscopic sporophyte phase is found at other times of the year in the upper intertidal zone and as an algal endophyte.

Chaetomorpha melagonium (F. Weber & D. Mohr) Kützing

Chlorophyta Ulvophyceae Cladophorales







A. Characteristic large cells separated by cell wall
B. Herbarium specimen
C. Lower intertidal pool habitat

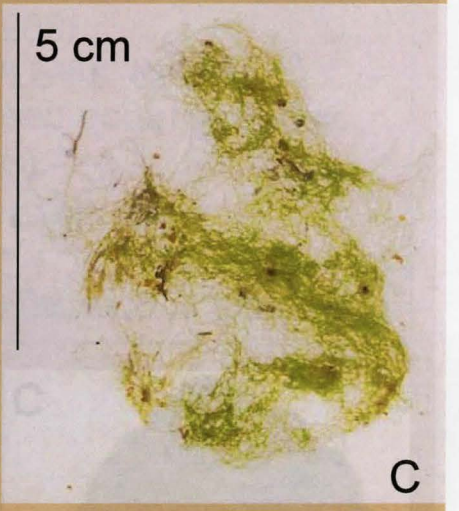
Semiannual green alga found late winter - summer. Present in pools in the lower intertidal zone. This alga shows high levels of photosynthetic activity under stress (Dummermuth et. al 2003). The cells are so large that you can see them with your naked eye. This makes the filament look almost like a beaded tube.

Chaetomorpha minima F.S. Collins & Hervey

Chlorophyta Ulvophyceae Cladophorales







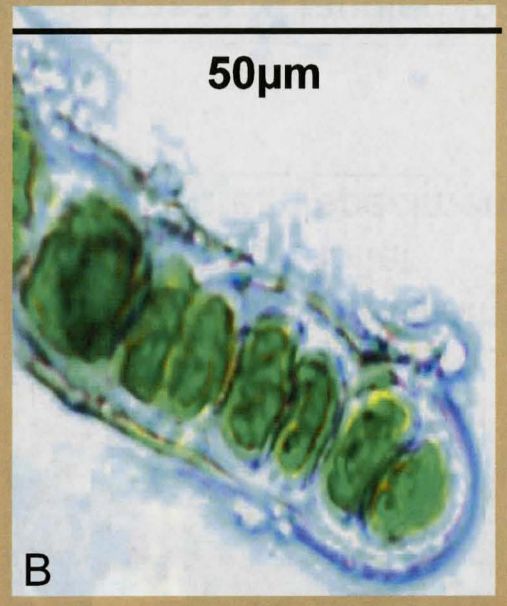
A. Representative filament
B. Intertidal habitat
C. Herbarium specimen

Chaetomorpha minima occurs as a mass of tangled, hair-like filaments. This alga is found in submerged habitats (tide pools) where it is sometimes attached to coarse algae and eelgrass. This alga is not tolerant to drying stress at low tide. Common in spring – summer.

Prasiola stipitata Suhr ex Jess

Chlorophyta Trebouxiophyceae Prasiolales







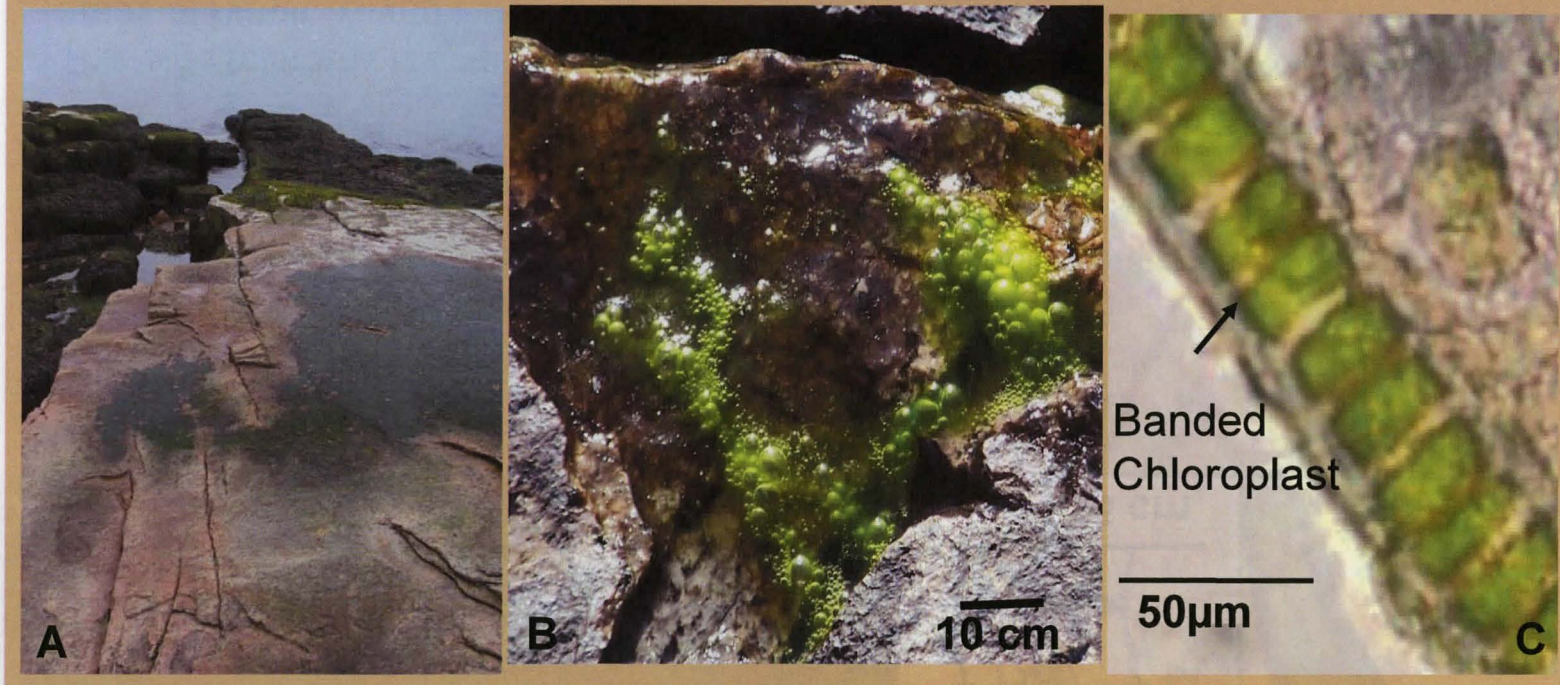


A. Compact turf of *P. stipitata* growing in the splash zone near gull droppings.
B. Cross-section of monostromatic blade
C. *Prasiola stipitata* (Close-up).
D. Herbarium Specimen. Splash Zone, Schoodic Penisula, Acadia National Park, Maine (N 44 21.380, W 068 04.598)

Prasiola stipitata forms a short green turf (< 1 cm) near bird droppings (an excellent source of nutrients) in the upper intertidal zone. When P. stipitata is dried, the blade curves like a mouse ear (Sears 2002).

Ulothrix laetevirens (Kütz) Collins

Chlorophyta Ulvophyceae Ulotrichales



A. Mat of *Ulothrix laetevirens* filaments in the upper intertidal zone of Acadia National Park.

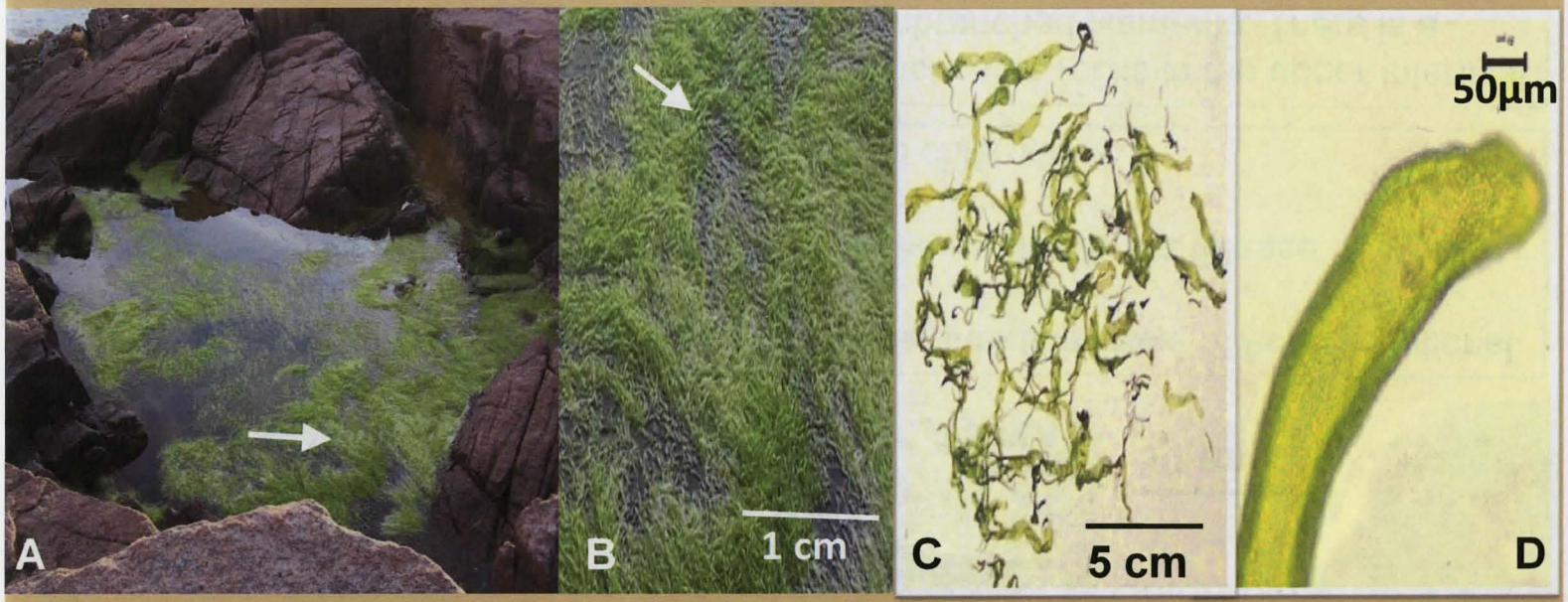
B. Close-up view of *U. laetevirens*. The air bubbles are due to the release of oxygen during photosynthesis.

C. Micrograph of a filament showing band shaped chloroplast.

Ulothrix laetevirens forms slippery, dark-green patches on rocks in the upper intertidal zone. Individuals that make up the patches are unbranched filaments. There is a single, band-shaped chloroplast in each cell (see microscopic photograph). Herds of herbivorous periwinkle snails feed at the edge of patches in spring and work their way inward until the patch disappears.

Ulva intestinalis L.

Chlorophyta Ulvophyceae Ulvales

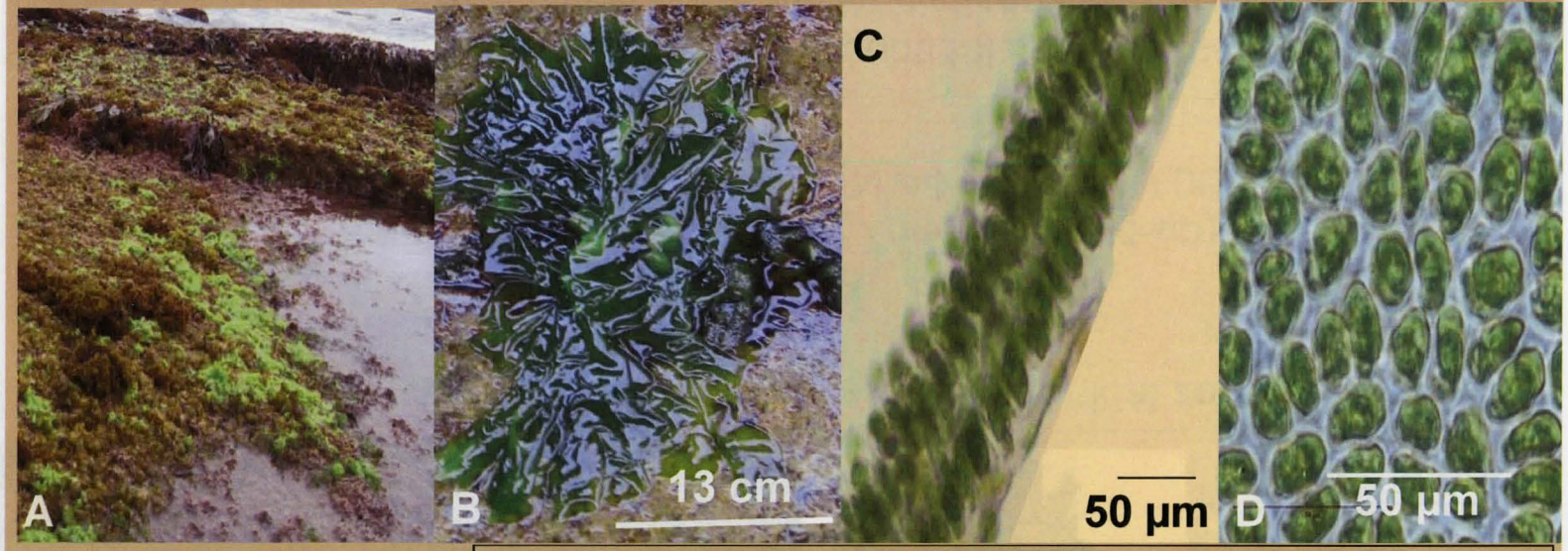


A. Tide pool in upper intertidal zone, Acadia National Park, Schoodic Peninsula, Maine, habitat of *U. intestinalis*.
B. *Ulva intestinalis* (close-up of photo A, see arrow).
C.Herbarium specimen. Splash Zone, Schoodic Peninsula, Acadia National Park, Maine (N 44 21.380, W 068 04.598)
D. Photomicrograph of hollow tip of *U. intestinalis*

This alga tolerates low salinity and is found in the upper intertidal zone in pools and areas of runoff. Young individuals are slender blades whereas older individuals form a tube. Gas bubbles accumulate inside the tube and make it buoyant. Gametes and zoospores are released shortly after dawn near new and full moons. Individuals that have released reproductive cells turn white.

Ulva lactuca L.

Chlorophyta Ulvophyceae Ulvales



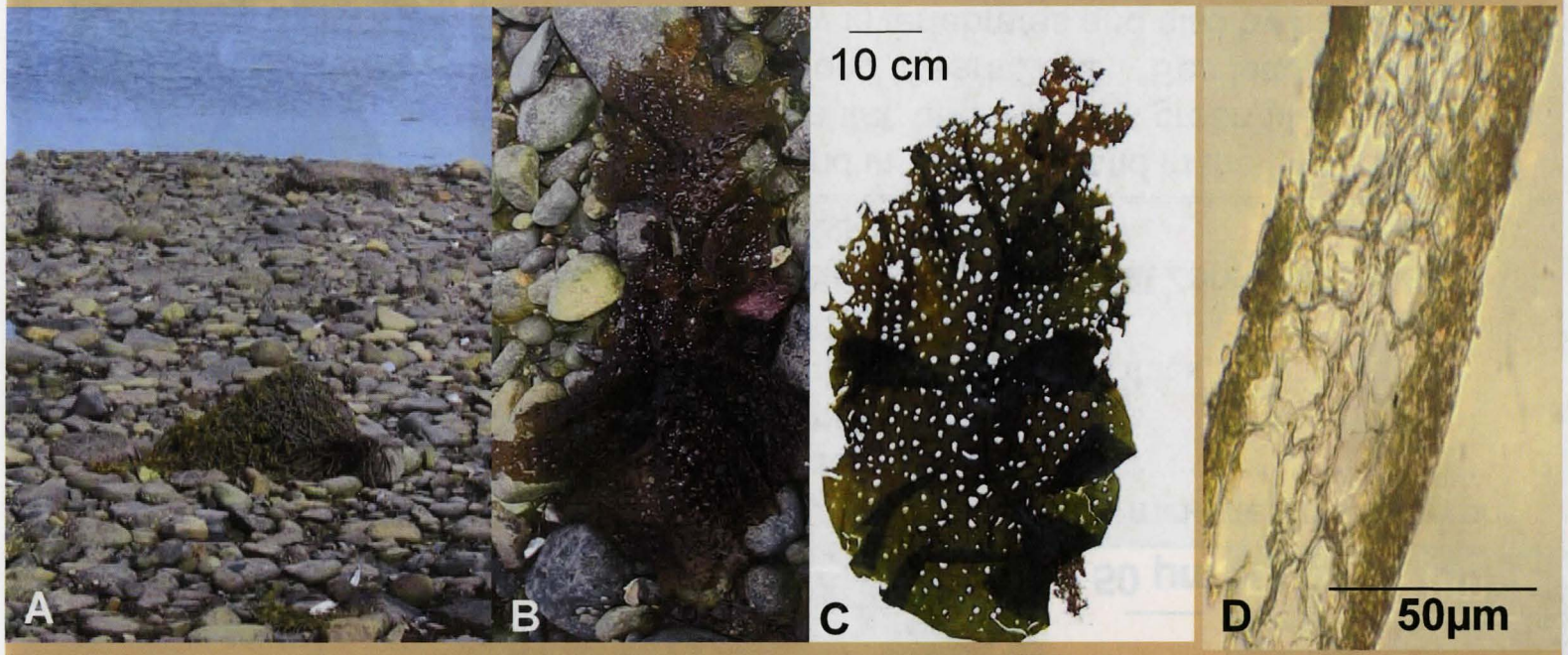


A. The habitat of *Ulva lactuca* in the mid-intertidal zone on the shore of Acadia National Park.
B. Ulva lactuca exposed at low tide.
C. Cross-section of blade (two cells thick).
D. Surface view of blade.
E. Herbarium Specimen. Mid-intertidal Zone, ANP, Maine. (N 44 18.411, W 068 11.590)

Ulva lactuca is found in tide pools and in the lower intertidal zone. This alga is a flat, bright to dark green blade that can grow up to 20 cm long (Sears 2002). “Sea lettuce” is consumed by many invertebrates and also by humans in soups and salads (Erhart and Cerier 2001). *Ulva lactuca* has an isomorphic life history, containing unisexual haploid gametophytes and diploid sporophytes (see example of life history, page 44). Present year round, but most abundant in summer-fall.

Agarum clathratum Dumortier

Ochrophyta Phaeophyceae Laminariales



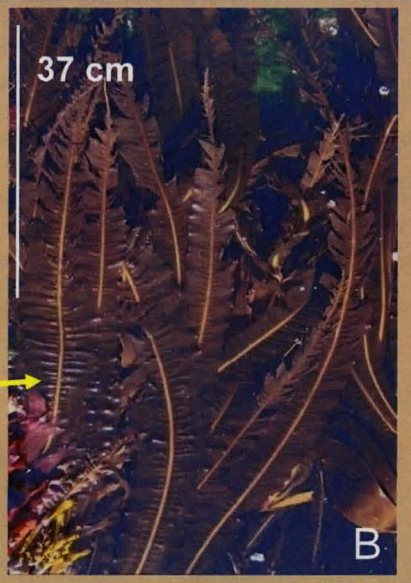
A. *Agarum clathratum* washed up into the lower intertidal zone after a storm.
B. Close up of *A. clathratum* from photo A.
C. Herbarium Specimen. Lower intertidal Zone (washed-up), Schoodic Peninsula, Acadia National Park, Maine (N 44 19.874, W 068 03.007)
D. Cross-section of blade

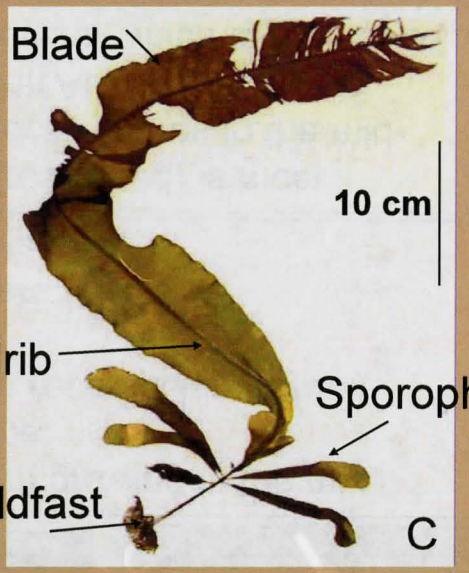
Agarum clathratum ("sea colander") is a subtidal kelp, but can be found washed up after storms. This kelp is easily distinguished from *Alaria esculenta* because *Agarum*'s blade is naturally full of holes in addition to having a thick, central ridge (midrib).

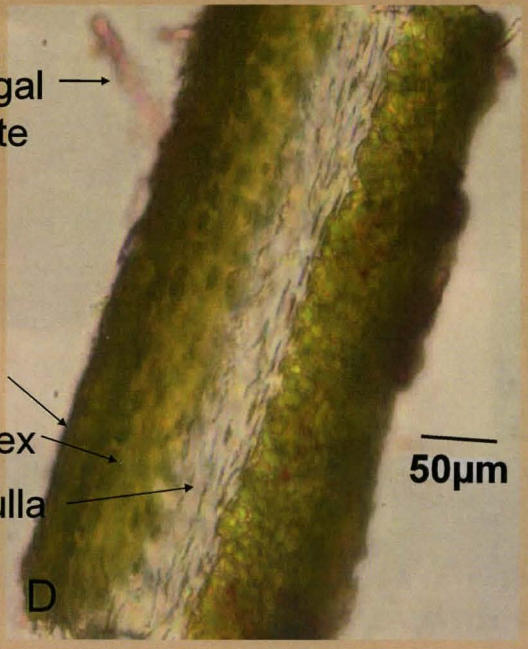
Alaria esculenta (L.) Grev.

Ochrophyta Phaeophyceae Laminariales









A. The lower intertidal zone habitat of *A. esculenta* in ANP.

B. Alaria esculenta (close-up of photo A, arrow).

C. Herbarium Specimen. (N 44 19.874, W 068 03.007)

D. Cross-section of blade.

Alaria esculenta has a holdfast, a relatively short stipe and a long, undivided blade that has a distinct midrib. The sporophylls of *A. esculenta* are reproductive tissues that release zoospores. This sea vegetable is economically important as human food. *Alaria esculenta* is found in the lower intertidal and shallow subtidal zones.

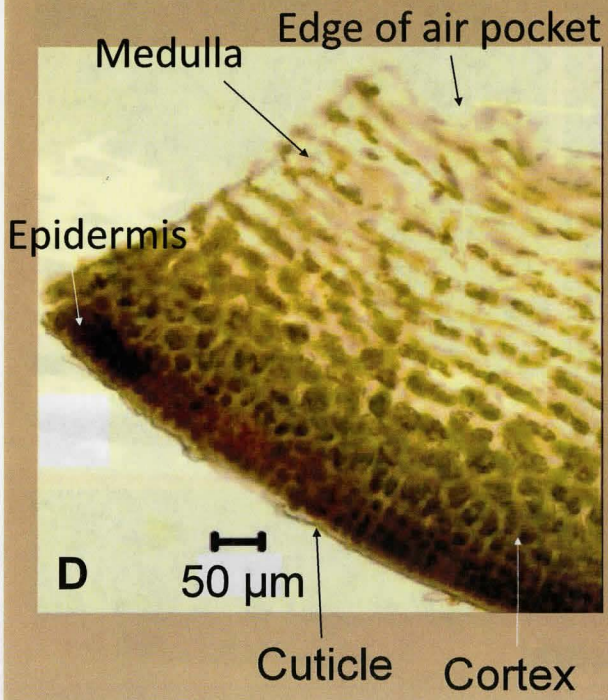
Ascophyllum nodosum (L.) Le Jolis

Ochrophyta Phaeophyceae Fucales







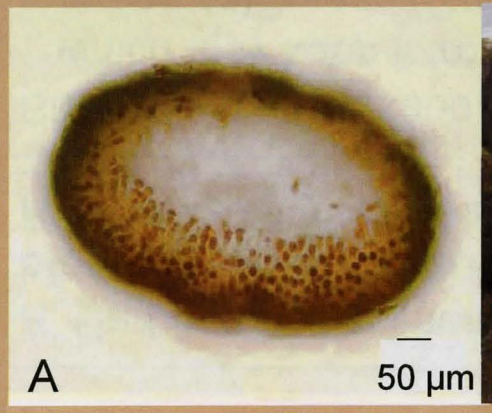


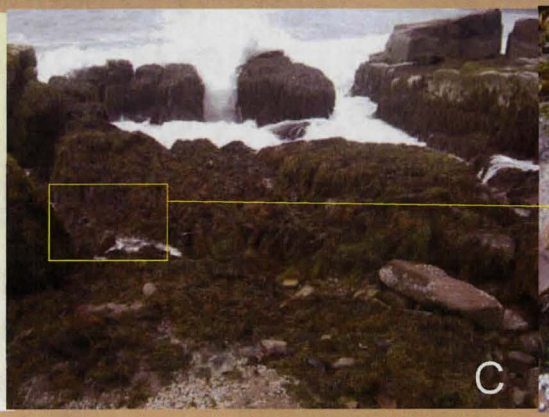
A. *Ascophyllum nodosum* growing in the mid-intertidal zone ANP, Maine.
B. Male *A. nodosum* with receptacles (arrow) containing sperm.
C. Close up of air bladders (arrow).
D. Cross-section of air bladder.

Ascophyllum nodosum (rockweed) is most abundant on sheltered rocky shores in the mid-intertidal zone of the North Atlantic. This alga makes one air bladder a year, which can be used to determine the age of the alga. Orange receptacles (males) and green receptacles (females) release sperm and eggs on 1-2 spring tides in late May and early June, sometimes causing the water to turn orange.

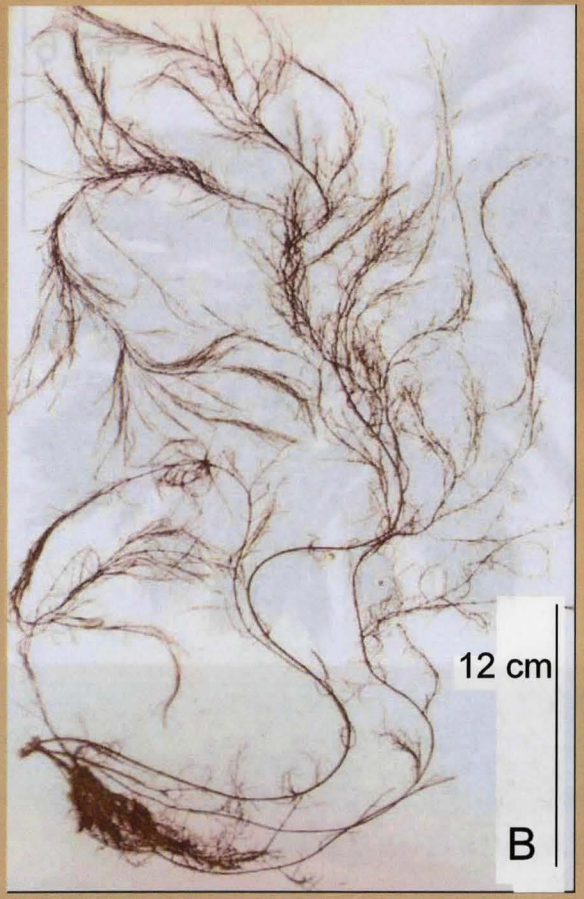
Desmarestia aculeata (L.) J.V. Lamouroux

Ochrophyta Phaeophyceae Desmarestiales









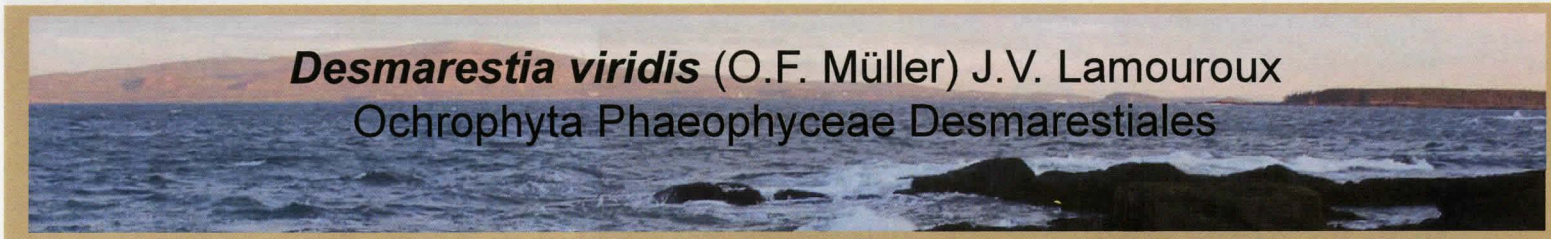
A. Cross section showing photosynthetic epidermis and unpigmented, filamentous medulla

B. Alternately branched sporophyte, herbarium specimen

C. Storm-cast specimens in intertidal zone

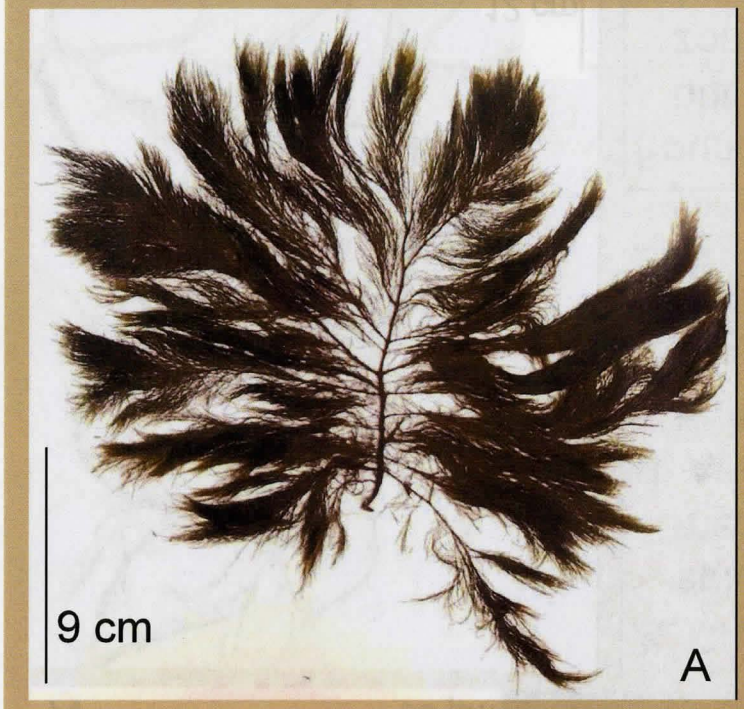
D. Close up (boxed area)

Found in the shallow to deep subtidal zone but collected after storms in the intertidal zone. The sporophyte is shown (microscopic, filamentous gametophyte generation not shown).



Desmarestia viridis (O.F. Müller) J.V. Lamouroux

Ochrophyta Phaeophyceae Desmarestiales





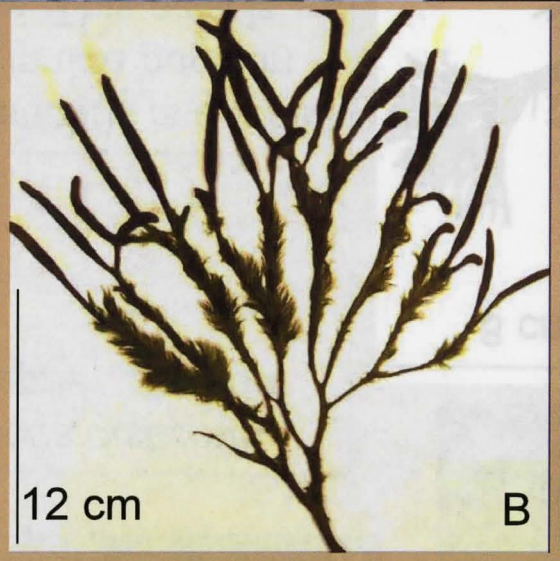
A. Herbarium specimen with alternate branching on main axis
B. Stressed individual in the lower intertidal zone

Sometimes called “sourweed”, *D. viridis* stores sulfuric acid within its cells, which may keep it from being eaten. However, sea urchins feed on it during calm seas (Gagnon et al. 2006). *Desmarestia viridis* is a subtidal alga that is also found in the lowest part of the intertidal zone. If exposed too long during a hot, dry low tide, its cells leak sulfuric acid and turn this brown seaweed into a limp, green mess.

Elachista fuciola (Velley) J.E. Areschoug

Ochrophyta Phaeophyceae Ectocarpales





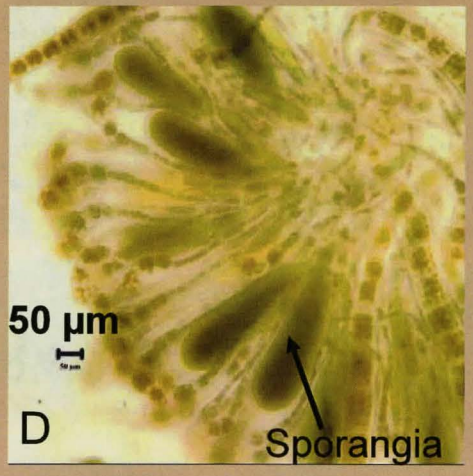


A. Representative filament

B. Epiphyte on *Fucus distichus* ssp. *edentatus*

C. Intertidal habitat

D. Micrograph of sporangia

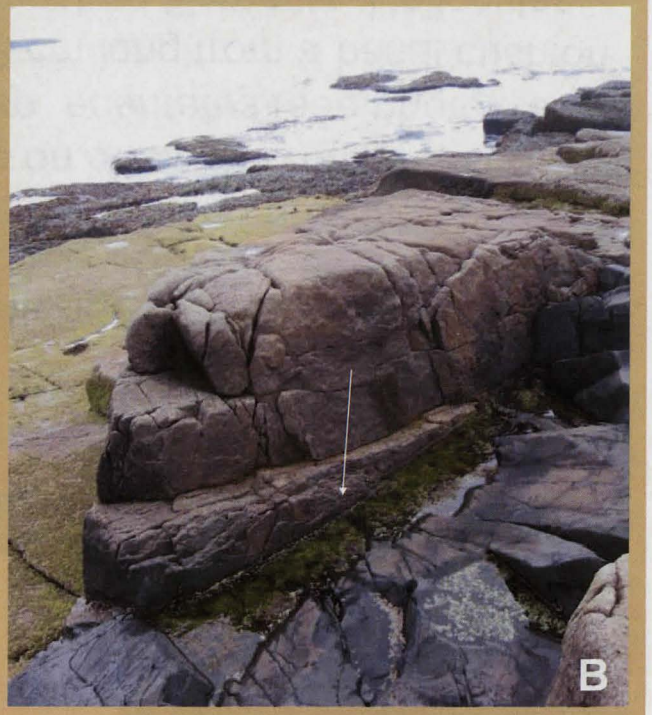


This brown alga is often found growing in the mid-intertidal zone on other macroalgae, such as *Fucus distichus* ssp. *edentatus* (see photo). This alga grows up to 2 cm long from a basal cushion as a mass of unbranched filaments. Unilocular sporangia form at the base of erect filaments (Sears 2002).

Fucus distichus* ssp. *distichus L. emend. H.T. Powell

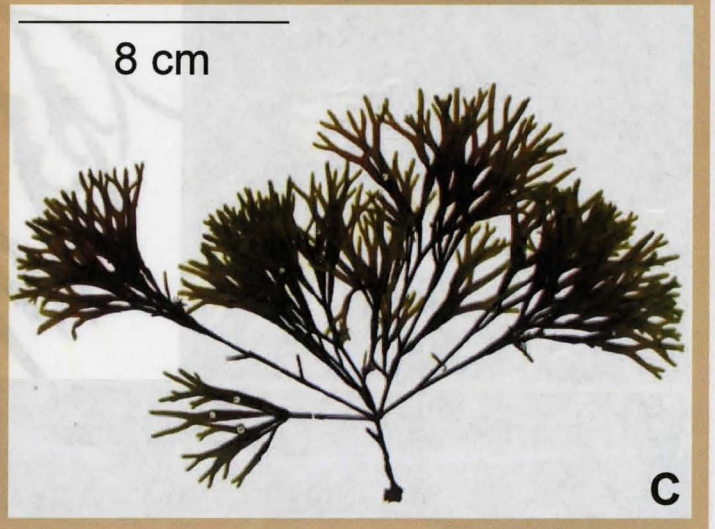
Ochrophyta Phaeophyceae Fucales





A., B. The habitat of *Fucus distichus* ssp. *distichus* in an upper intertidal pool

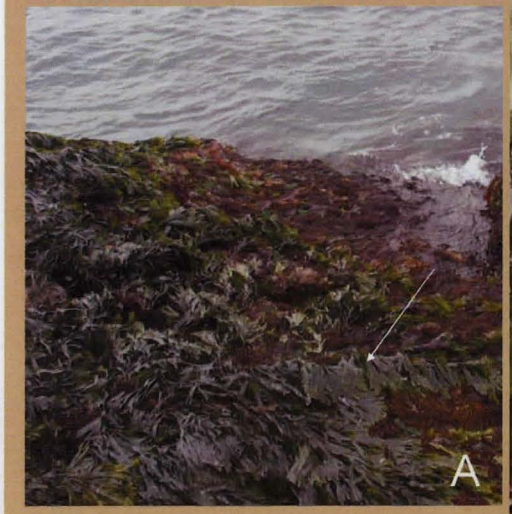
C. Herbarium specimen



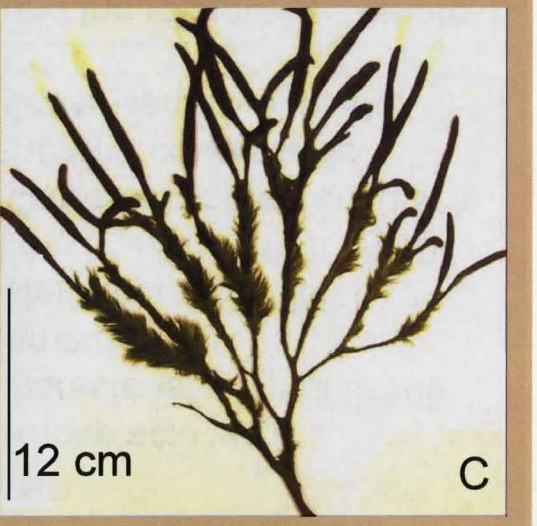
Fucus distichus ssp. *distichus* is a small rockweed that is found in tide pools in the upper intertidal zone. This alga is reproductive in winter and spring (Coleman and Brawley 2005).

Fucus distichus ssp. *edentatus* (De la Pylaie) Powell

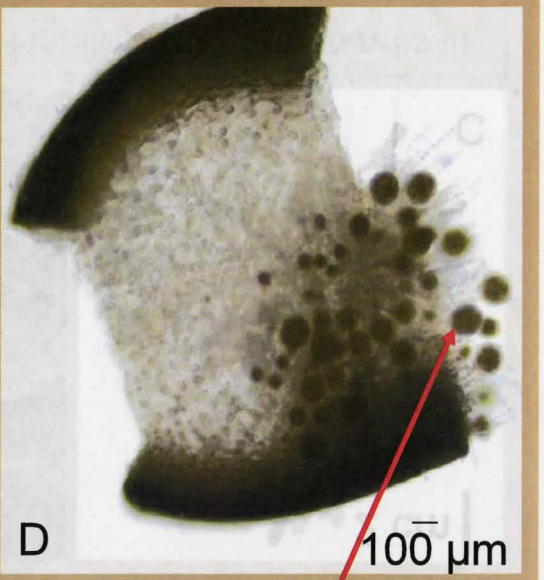
Ochrophyta Phaeophyceae Fucales







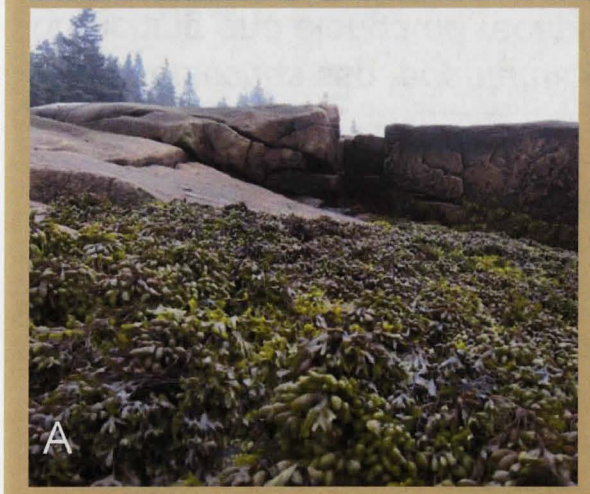
A. The habitat of *Fucus distichus* ssp. *edentatus* (arrow) in the lower intertidal zone in Acadia National Park at Bass Harbor lighthouse.
B. A close-up of the long receptacles of *Fucus distichus* ssp. *edentatus,* which contain eggs and sperm.
C. Herbarium Specimen. Lower intertidal zone, ANP (N 44 21.380, W 068 04.598)
D. Cross-section of receptacle showing conceptacle with gametes.



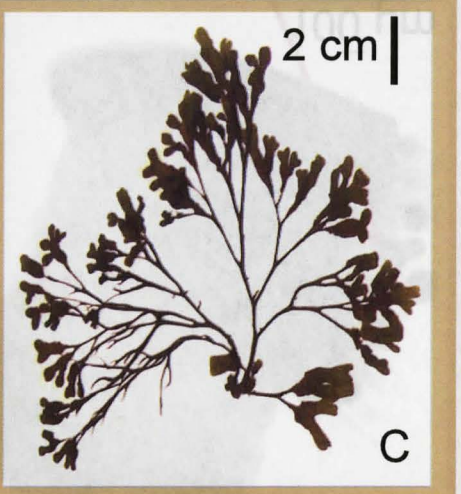
Fucus distichus ssp. *edentatus* has regular dichotomous branching and elongated receptacles containing eggs and sperm. This alga is found in the lower intertidal zone of rocky shores. All rockweeds contain high concentrations of phenolics, which makes them taste bad to herbivores.

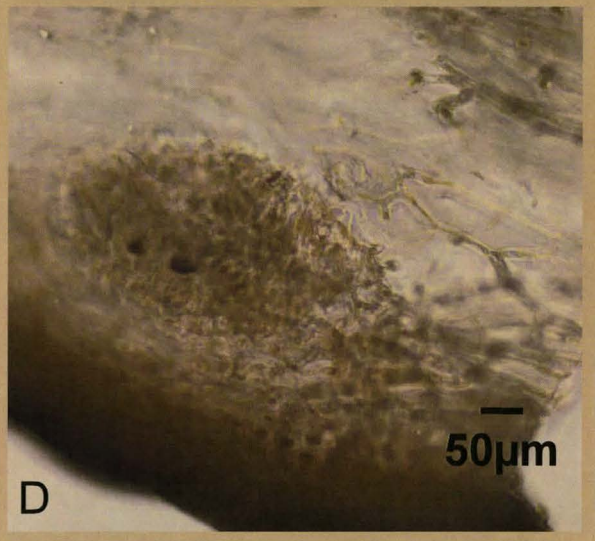
Fucus spiralis L.

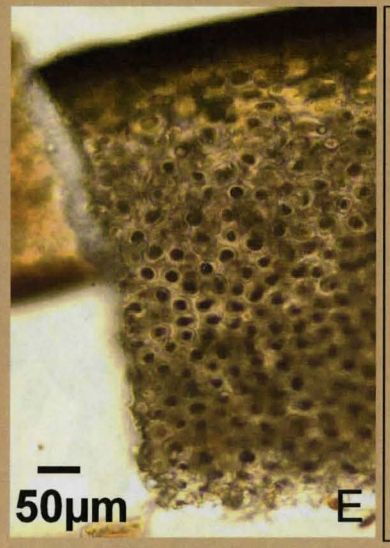
Ochrophyta Phaeophyceae Fucales











A. Habitat of *Fucus spiralis* in the high intertidal zone of ANP

B. Receptacle with characteristic rim of tissue (arrow).

C. Herbarium Specimen. (N 44 21.380, W 068 04.598)

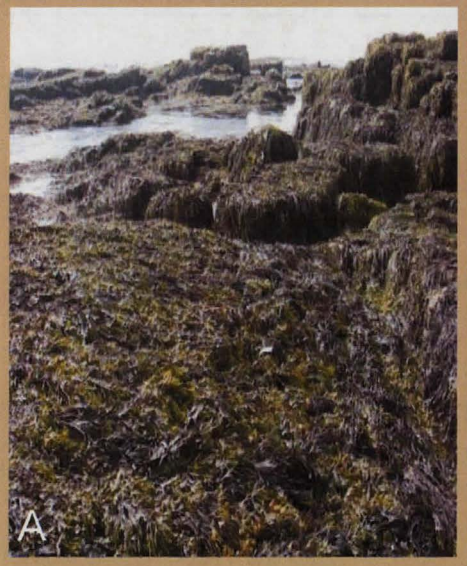
D. Cross-section of receptacle showing conceptacle.

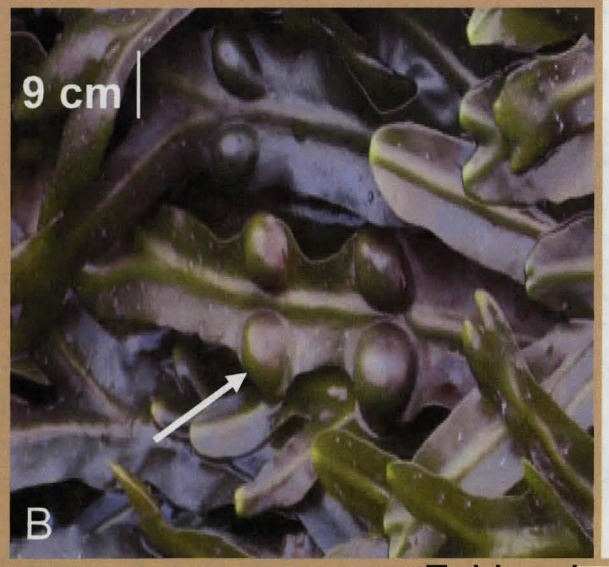
E. Cross-section of blade.

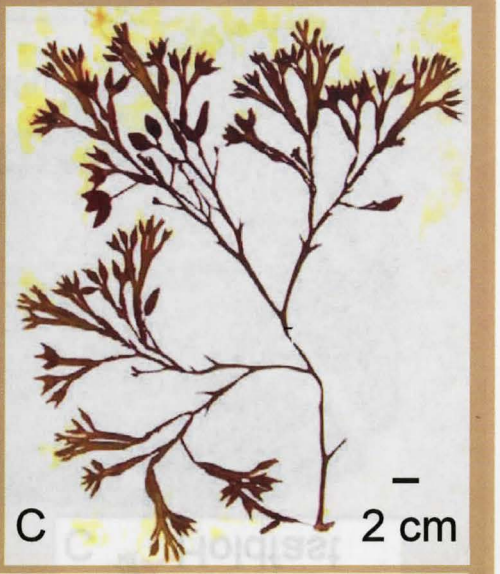
This species of *Fucus* develops a distinct rim of tissue around the receptacles (photo B) and lacks the paired air bladders found in *F. vesiculosus. Fucus spiralis* is found in the high intertidal zone of rocky shores in the North Atlantic and is reproductive during summer and fall.

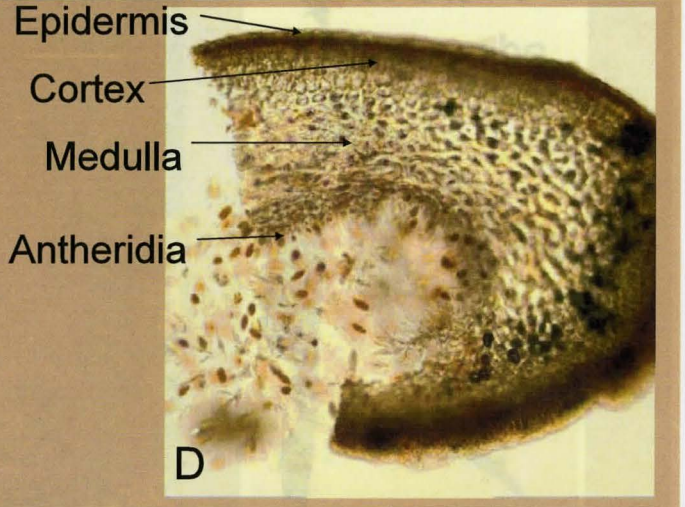
Fucus vesiculosus L.

Ochrophyta Phaeophyceae Fucales









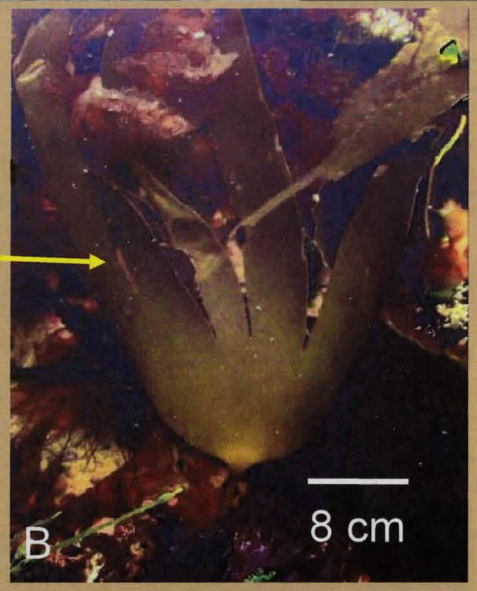
A. Broad zone of *Fucus vesiculosus*.
B. *Fucus vesiculosus* with paired air bladders (arrow).
C. Herbarium specimen. Acadia National Park, Maine (N 44 20.309, W 068 04.023)
D. Cross-section of male receptacle showing cavity (conceptacle) where sperm develop inside antheridia.

This rockweed dominates the mid-intertidal zone of moderately wave-exposed, rocky shores. *Fucus vesiculosus* often has paired air bladders, and individuals are dichotomously branched. However, individuals in the most exposed habitats sometimes lack paired air bladders. Rockweeds release gametes under calm, sunny conditions at high tide. Present year round.

Laminaria digitata (Hudson) J.V. Lamouroux

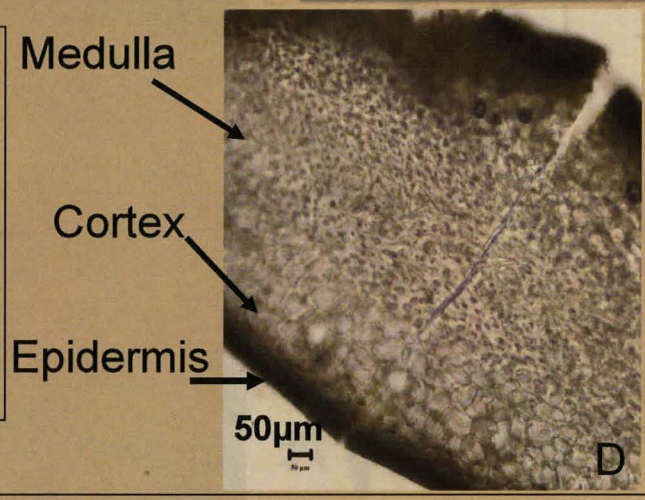
Ochrophyta Phaeophyceae Laminariales







A. *Laminaria digitata* in the lower intertidal zone.
B. *Laminaria digitata* in a tide pool in the lower intertidal zone (close-up, see arrow in photo A-B).
C. Herbarium Specimen. Lower Intertidal Zone, ANP, Maine (N 44 21.380, W 068 04.598). The brown pigment fucoxanthin was lost in places due to heat stress exposing green chlorophylls.
D. Cross-section of blade.

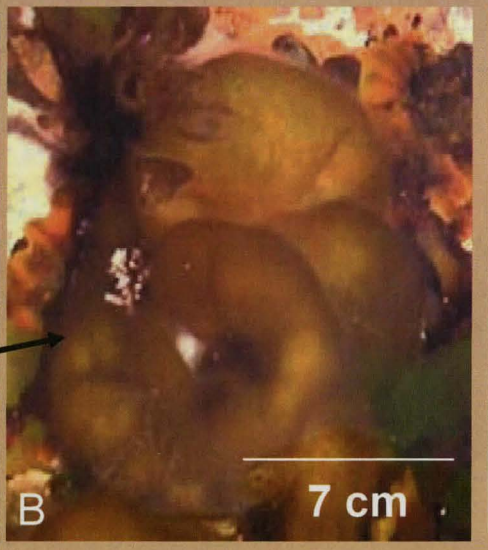


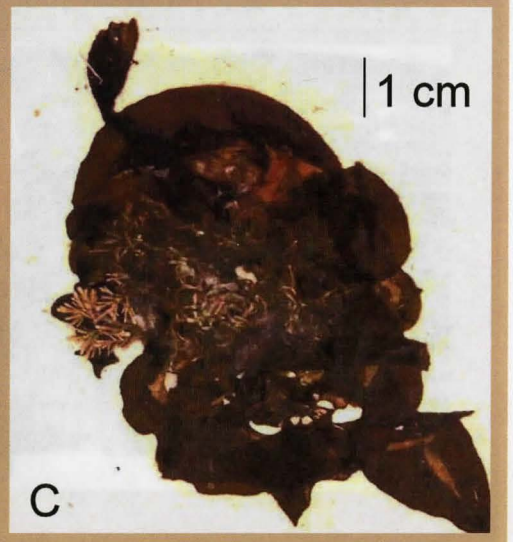
This kelp is found in subtidal beds, but can be observed in tide pools in the lower intertidal zone. Dark stripes on *Laminaria digitata* are patches of sori, which contain specialized reproductive cells called zoospores. All kelps have a heteromorphic life history. The bladed form (sporophyte) is only half of the kelp life history, and the other half is the filamentous, microscopic gametophyte, which produces eggs and sperm. Kelps are economically valuable as food and sources of alginate. The kelp zone is an important habitat for many animals.

Leathesia difformis (L.) Aresch.

Ochrophyta Phaeophyceae Chordariales





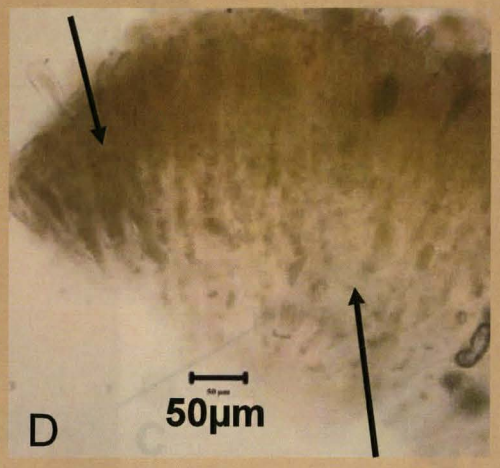


A. *Leathesia difformis* growing in the lower intertidal zone of Bass Harbor Lighthouse, Acadia National Park.

B. Leathesia difformis in a tide pool in the lower intertidal zone (close-up, see arrow), Note that this alga is a hollow ball when mature.

C. Herbarium Specimen. Lower Intertidal Zone, Mount Desert Island, Acadia National Park, Maine (N 44 13.329, W 068 20.035)

D. Cross-section of young individual.



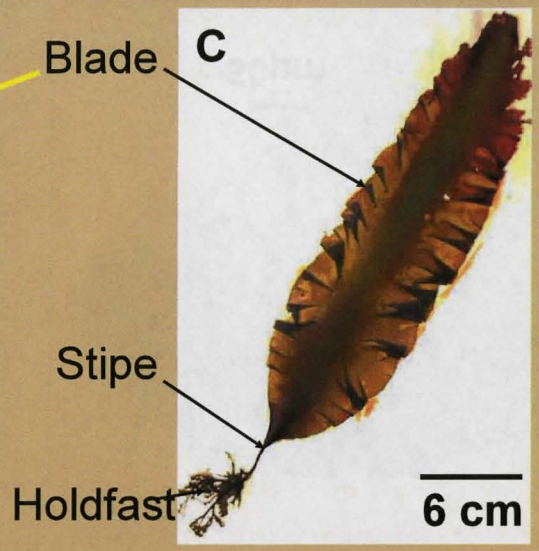
Leathesia difformis ("rat brains") is common in the lower intertidal zone in late spring to summer. This brown alga is a hollow ball.

Saccharina latissima (L.) C.E Lane, C. Mayes, Druehl *et* G.W. Saunders

Ochrophyta Phaeophyceae Laminariales





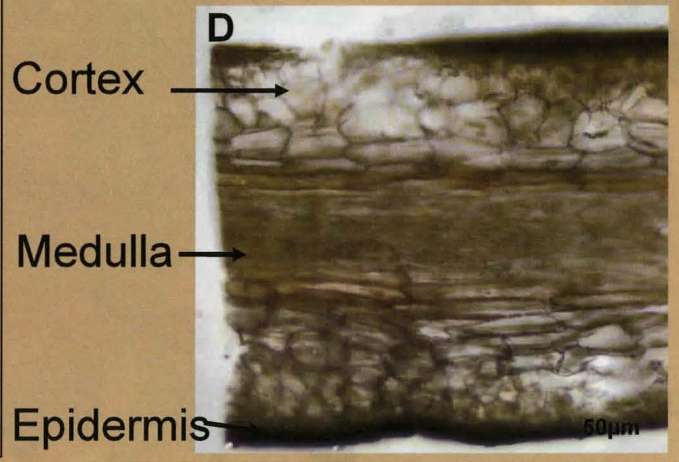


A. *Saccharina latissima,* an abundant subtidal kelp, growing in two large tide pools on Mount Desert Island.

B. Saccharina latissima from a tide pool

C. Herbarium Specimen. Lower Intertidal Zone, Mount Desert Island (Tide Pool), Acadia National Park, Maine (N 44 18.411, W 068 11.590). Reproductive (note dark sorus).

D. Longitudinal cross-section of blade of sporophyte.



Saccharina latissima ("sugar kelp") has a leathery, undivided blade that is about 2 to 5 meters long. This kelp forms a substantial belt below the intertidal zone and is an important habitat and food source for animals such as sea urchins. *Saccharina* can be found in lower intertidal pools and on extremely low tides. Kelps are economically valuable as food and sources of alginate (a thickener in many foods, toothpaste etc.). Recent molecular studies resulted in reclassification of *Laminaria saccharina* to *Saccharina latissima* (Lane et al. 2006).

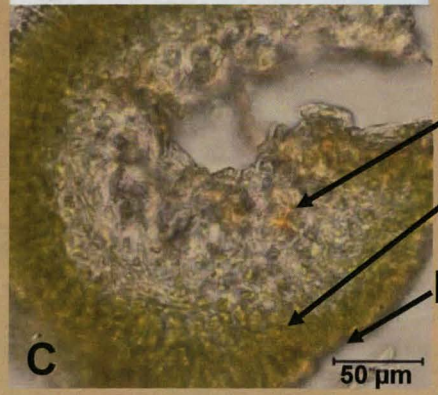
Scytosiphon lomentaria (Lyngbye) Link

Ochrophyta Phaeophyceae Scytosiphonales





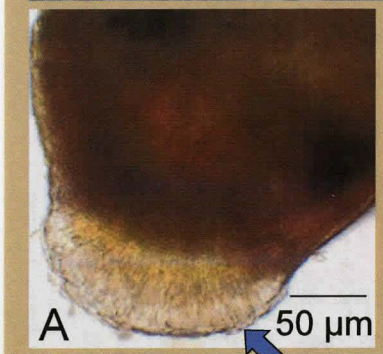
A. The lower intertidal habitat of *S. lomentaria*.
B. Herbarium Specimen. High Intertidal Zone (In a tide pool), Schoodic Peninsula, Acadia National Park, Maine (N 44 21.380, W 068 04.598)
C. Cross-section of hollow thallus.

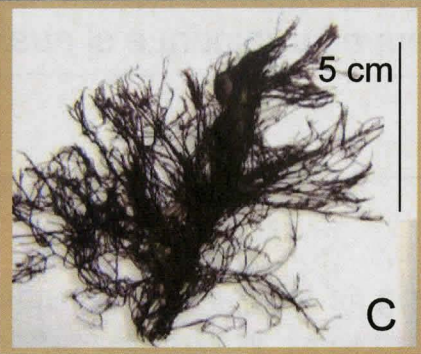


Scytosiphon lomentaria is a tubular alga that is constricted at intervals (Graham & Wilcox 2000). Gas accumulates within the tubular thalli of the gametophytic phase and makes it buoyant. This enables the alga to harvest more light when underwater. This brown alga occurs as a crust during the sporophytic phase of its life cycle, which is more resistant to grazers.

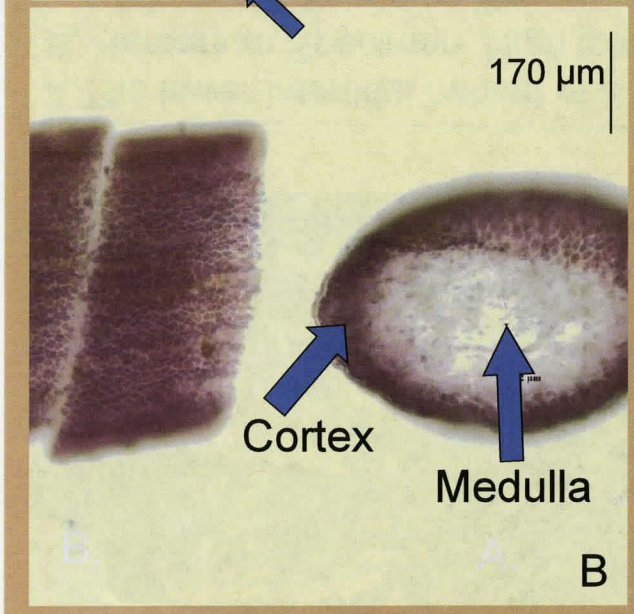
Ahnfeltia plicata (Hudson) Fries

Rhodophyta Florideophyceae Ahnfeltiales







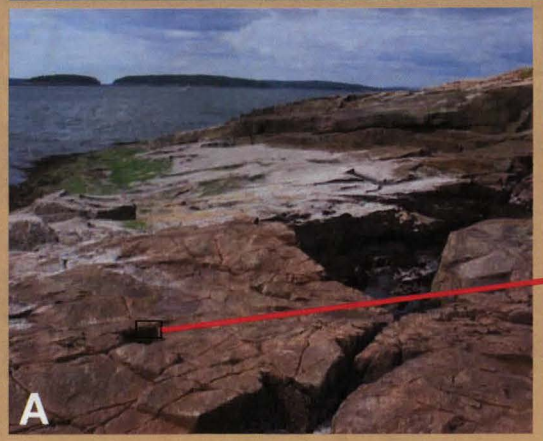


A. Developing reproductive tissue (arrow)
B. Cross section: pigmented cortex and medulla consisting of longitudinal filaments
C. Herbarium specimen
D. Individual alga in the lower intertidal zone

. This lower intertidal alga has stiff and wiry branches. A few red algae are the sole source of agar, a gel-like polysaccharide that is widely used in hospitals and research laboratories to grow bacteria. Although not a commercial source, *Ahnfeltia plicata* contains agar in its cell walls, giving it a characteristic texture. The gametophytic phase of the life history is a wiry, stiff thallus (algal body); crustose sporophyte not shown.

Bangia fuscopurpurea (Dillwyn) Lyngbye

Rhodophyta Bangiophyceae Bangiales





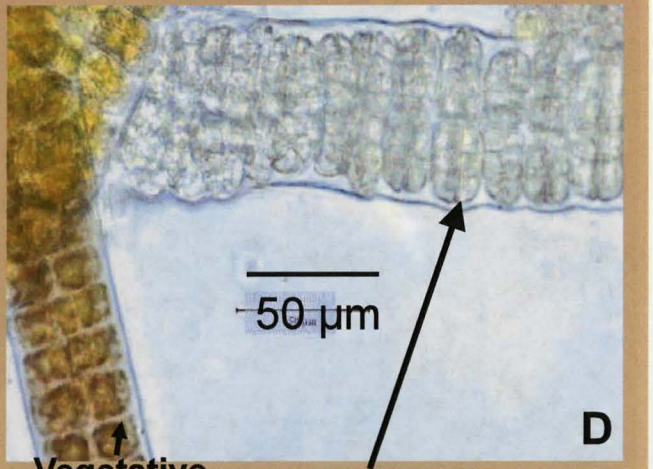


A. Upper intertidal zone habitat of *B. fuscopurpurea*.

B. Close-up of *B. fuscopurpurea*

C. Herbarium Specimen. High Intertidal Zone, Acadia National Park, Maine (N 44 21.380, W 068 04.598) Reproductive

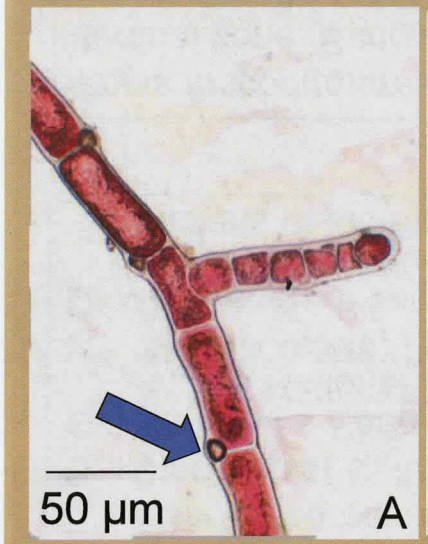
D. Micrograph of vegetative and male filaments of *B. fuscopurpurea* (Note spermatangial packets of the male filament).

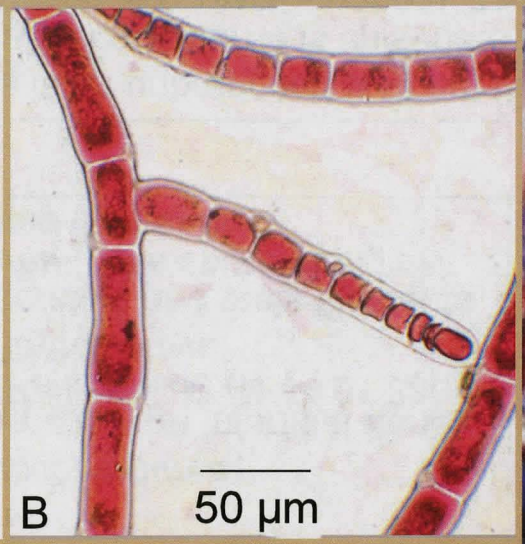


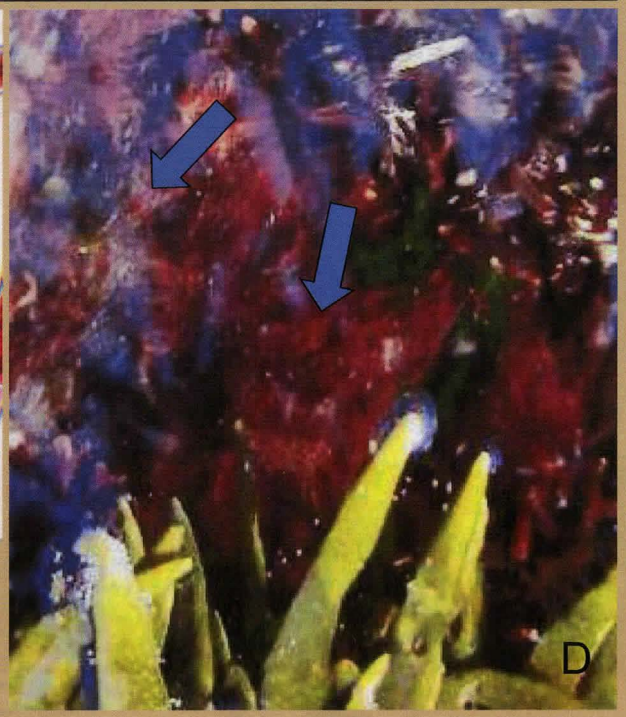
Bangia fuscopurpurea is an unbranched filament that is found in masses high in the intertidal zone. *Bangia fuscopurpurea* is uniseriate in early development and later becomes multiseriate (Graham & Wilcox 2000). These red algae have fossils that date to 1.2 billion years old, and are among the oldest known fossils of advanced (eukaryotic), multicellular organisms (Butterfield et al. 1988). The *Bangia* clade contains species that inhabit both fresh and marine water; *B. fuscopurpurea* is a marine species (Nelson et al. 2006).

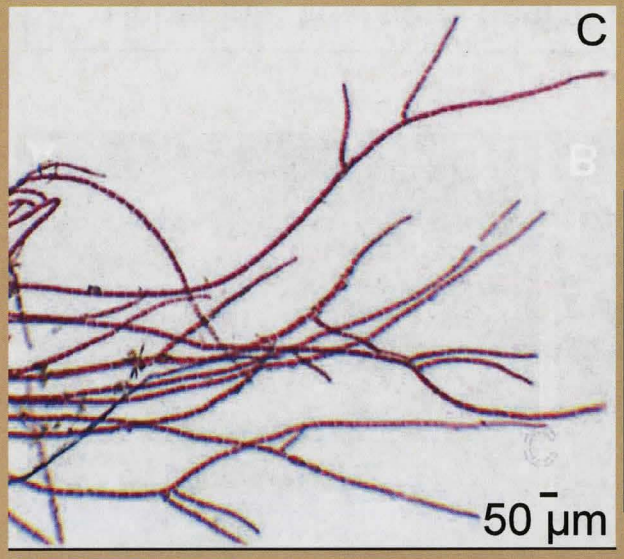
Bonnemaisonia hamifera Hariot

Rhodophyta Florideophyceae Bonnemaisoniales









A., B. Filament with gland cells (arrow), cells having a single chloroplast

C. Infrequent branching pattern of filaments

D. Individual growing in lower intertidal pool

Generally found as tufts growing epiphytic on other algae. The tetrasporophytic phase of the life history is shown. The gametophytic phase of the heteromorphic life history is more conspicuous and found in the subtidal zone (Bird and McLachlan 1992).

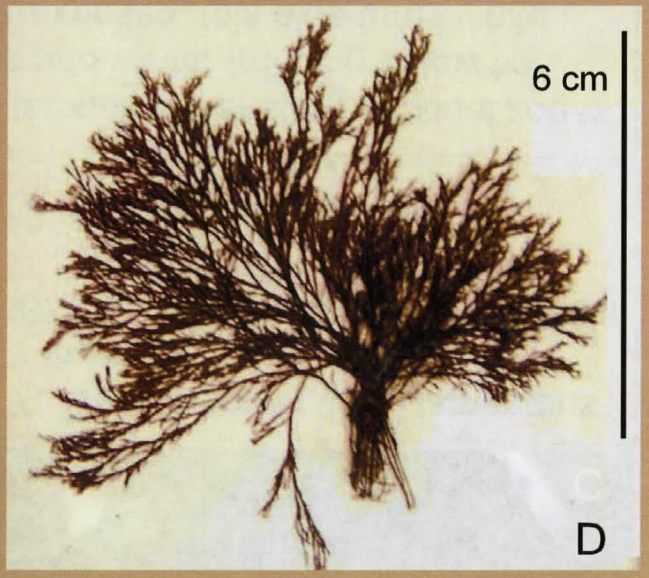
Ceramium rubrum C. Agardh

Rhodophyta Florideophyceae Ceramiales









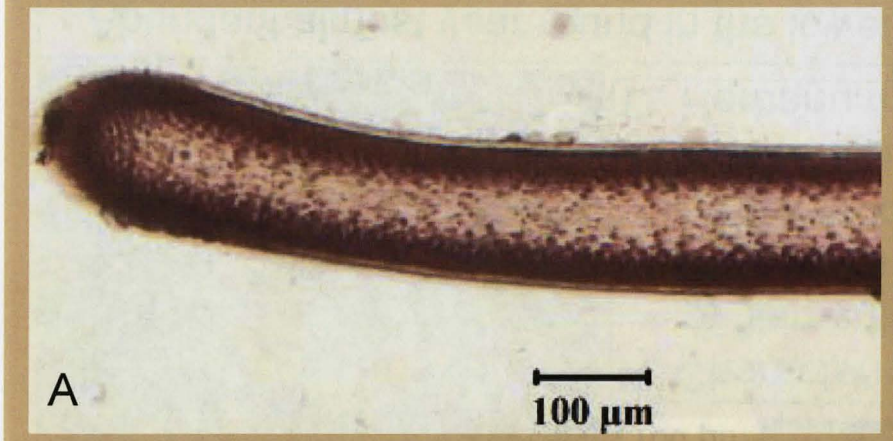


A. Characteristic pincers at end of filaments
B. Older area of plant showing continuous cortication of main axis
C. Habitat in the lower intertidal zone (arrow)
D. Herbarium specimen

Abundant almost year round in the lower intertidal zone. The amount of cortication in a given individual is a function of day length, but older parts of the plant are fully corticated (Bird and McLachlan 1992). *Ceramium rubrum* has pincers on the ends of its filamentous branches that are visible to the naked eye.

Chondrus crispus Stackhouse

Rhodophyta Florideophyceae Gigartinales







A. Cross-section with filamentous medulla

B. Chondrus belt in lower intertidal zone

C. Close-up of individual

This red alga ("Irish Moss") is found in the lower intertidal and shallow subtidal zones. *Chondrus* is more sensitive to high temperatures and winter freezing at low tide than the closely related *Mastocarpus*. When overexposed, this alga turns white. *Chondrus crispus* is a common source of carrageenan, a commercial thickener. The polysaccharide carrageenan is extracted from cell walls, and forms a gel that is used commercially as a thickener (e.g. in ice cream). *Chondrus* has an isomorphic alternation of generations.

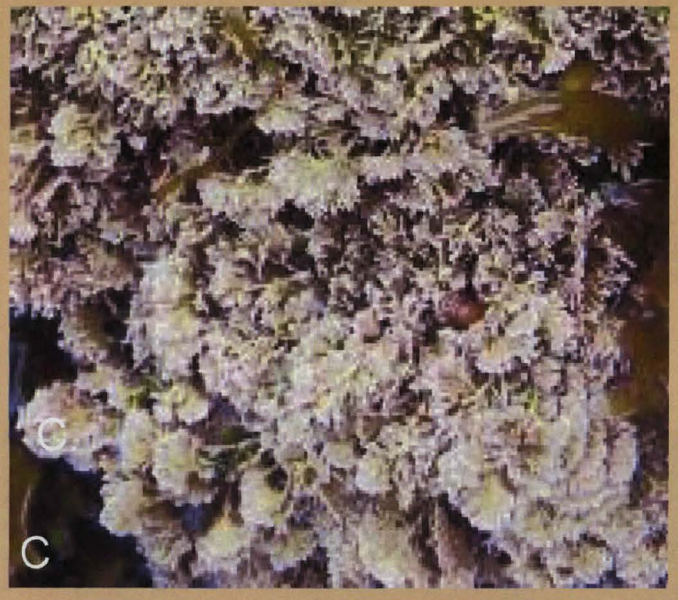
Corallina officinalis Linnaeus

Rhodophyta Florideophyceae Corallinales





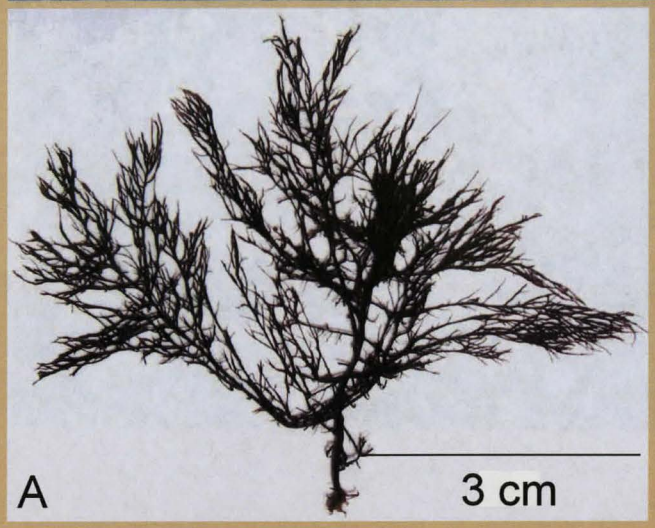
A., B., C. tide pool habitat

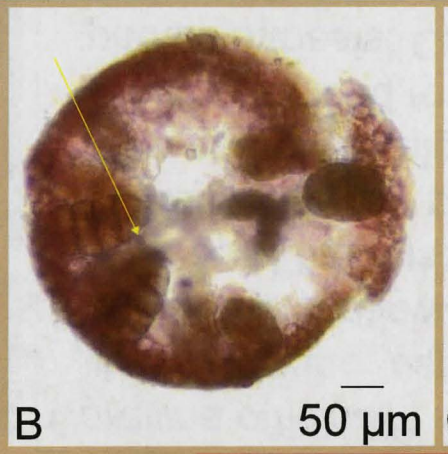


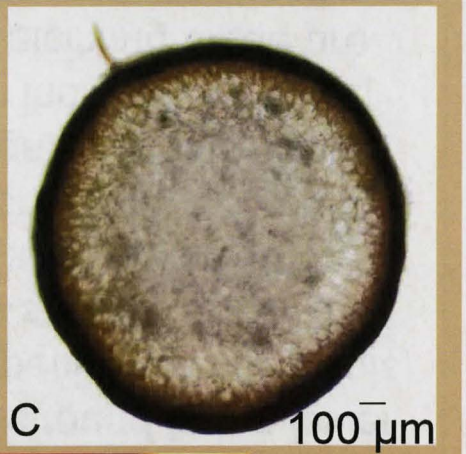
Corallina officinalis is found in the lower intertidal zone, especially in tide pools, and in the shallow subtidal zone. It feels hard because it is calcified; calcification may prevent herbivores from eating the alga, and calcification is hypothesized to increase photosynthesis. Calcifying algae are under threat from ocean acidification due to carbon emissions from cars and factories. Present year round.

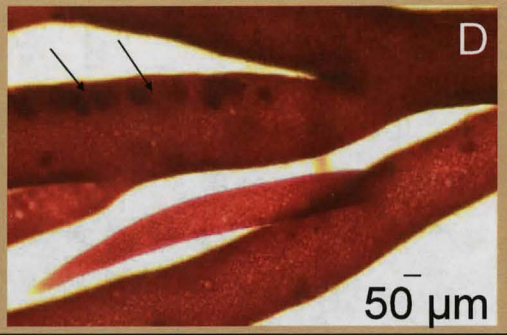
Cystoclonium purpureum (Hudson) Batters

Rhodophyta Florideophyceae Gigartinales











A. Herbarium specimen
B. Cross-section showing zonate tetrasporangia (arrow).
C. Cross-section of main axis showing filamentous medulla.
D. Branch showing tetrasporangia.
E. Lower intertidal zone habitat

This red alga is found in the lower intertidal and shallow subtidal zones and is most abundant in summer. *Cystoclonium purpureum* sometimes grows on other coarse algae such as *Corallina officinalis.*

Devaleraea ramentacea (L.) Guiry

Rhodophyta Florideophyceae Palmariales







A. *Devaleraea ramentacea* growing in the lower intertidal zone in Acadia National Park.
B. Close up
C. Herbarium Specimen. (N 44 19.874, W 068 03.007)

This red alga is only able to survive in waters that are colder than 15 ˚C (Bird and McLachlan 1992). *Devalerea ramentacea* branches into radiating clusters when older. Similar in appearance to *Dumontia* but hollow when mature. *Devaleraea ramentacea* is abundant in the lower intertidal (including tide pools) and shallow subtidal zones. Common in winter-late spring.

Dumontia contorta (S.G. Gmelin) Ruprecht

Rhodophyta Florideophyceae Gigartinales





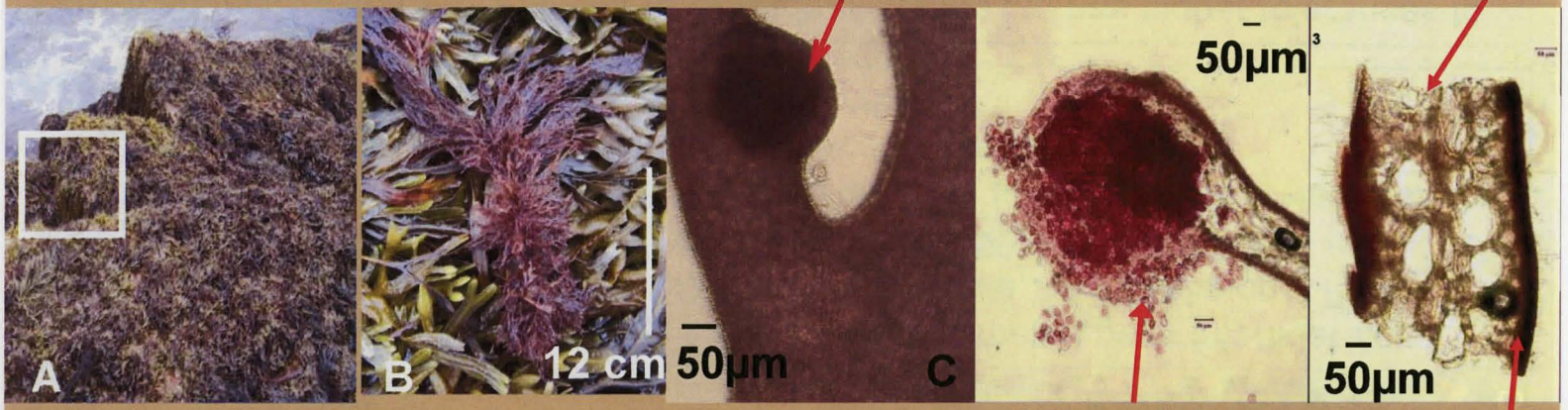


A. Herbarium specimen
B. Cross section showing cortex and filamentous medulla.
C. Early spring/late winter tide pool habitat

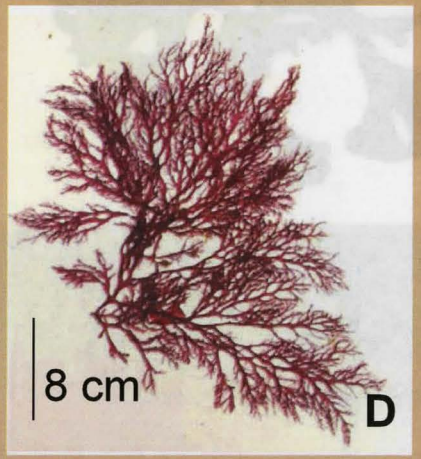
This alga can be identified by its overall twisted structure. Perennial macrothalli sprout from a substrate-anchored basal disc. The life history of *Dumontia* is isomorphic (all adults look the same). This alga is most abundant in tide pools and in the lower intertidal zone.

Euthora cristata (C. Agardh) J. Agardh

Rhodophyta Florideophyceae Gigartinales



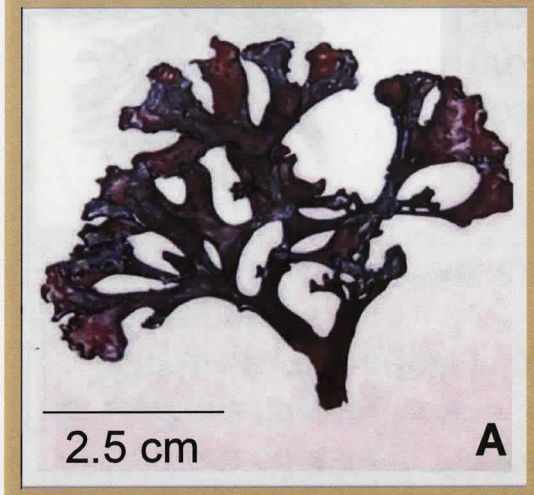
A. *Euthora cristata* in the lower intertidal zone on the ANP shoreline.
B. Euthora cristata washed-up into the lower intertidal zone from the sublittoral zone (Close-up, see arrow in photo A).
C. Micrographs
D. Herbarium Specimen. Lower Intertidal Zone, ANP (N 44 13.329, W 068 20.035)

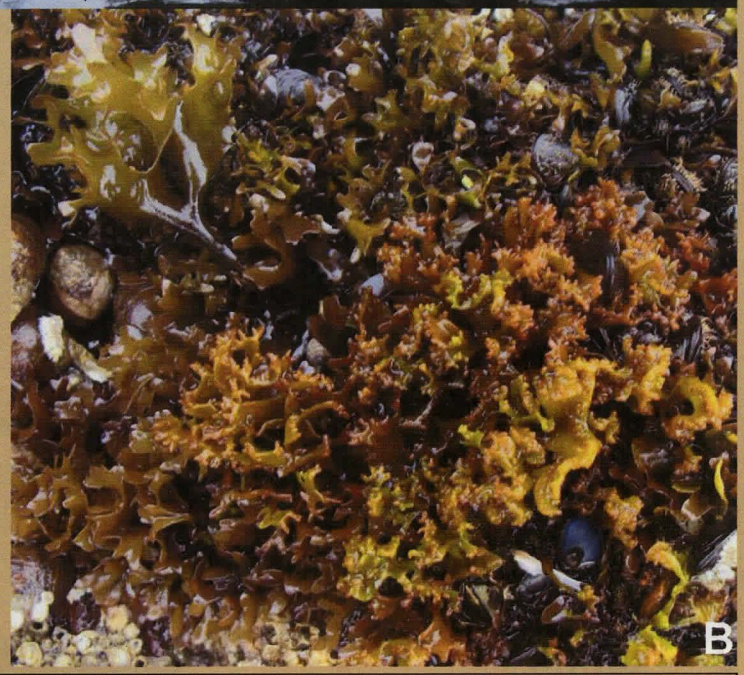


Euthora cristata has dichotomously branched thalli that posses a multicellular apical meristem. *Euthora cristata* can grow up to 13 cm tall, and has 1 to several erect fronds that grow from a discoidal holdfast (Bird & McLachlan 1992). This red alga has compact branching in shallow, protected habitats, whereas in turbulent habitats, branching is loose. (Bird & McLachlan 1992).

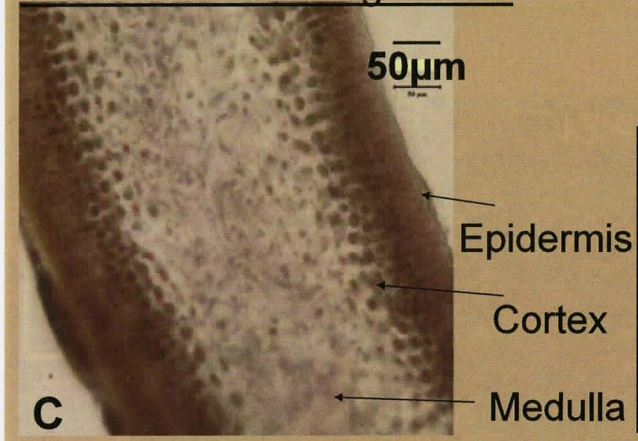
Mastocarpus stellatus (Stackhouse) Guiry

Rhodophyta Florideophyceae Gigartinales





Cross-section through blade



A. Herbarium Specimen. Lower intertidal Zone, Schoodic Peninsula, Acadia National Park, Maine (N 44 20.309, W 068 04.023

B. The habitat of *M. stellatus* in the lower intertidal zone of Acadia National Park.

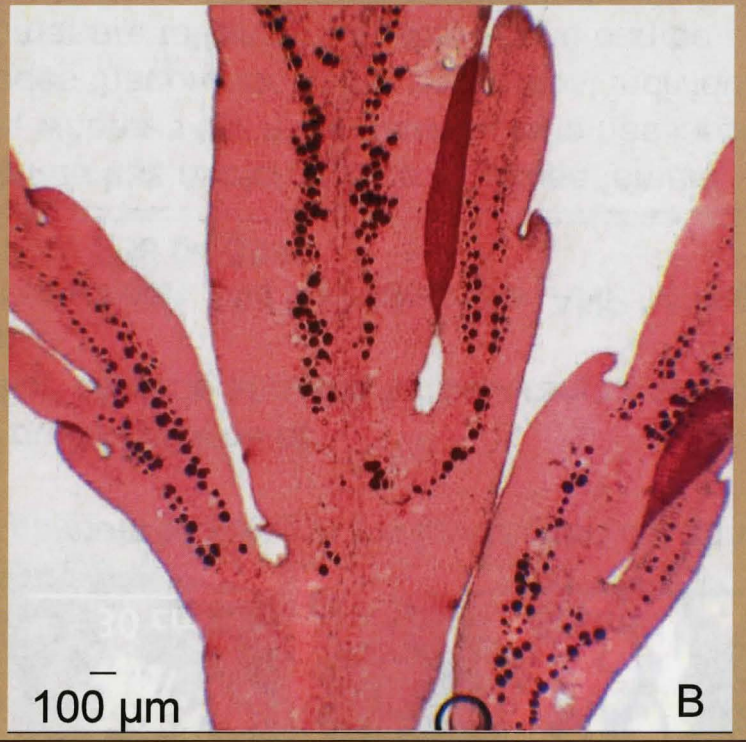
C. Cross section

Mastocarpus stellatus looks similar to *Chondrus crispus* but has higher tolerances to physical stresses including freezing and desiccation (Dudgeon et al.1995). Consequently, it is most abundant near the borders of the mid and low intertidal zones. Females of *Mastocarpus stellatus* are typically covered with distinctive bumps (papillae), giving the blades a rough texture. *Mastocarpus stellatus* has an isomorphic alternation of generations (see page 45).

Membranoptera alata (Hudson) Stackhouse

Rhodophyta Florideophyceae Ceramiales





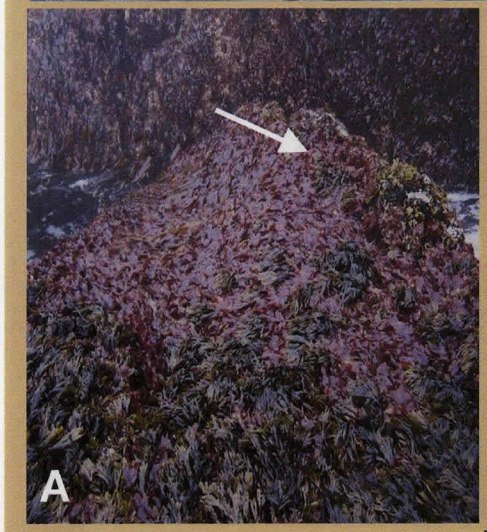


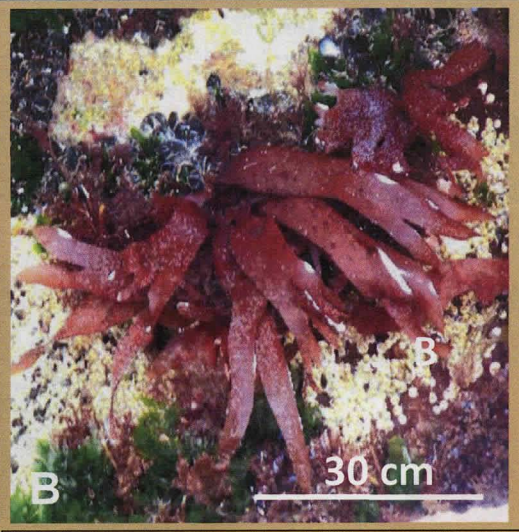
A. Reproductive cells (tetrasporangia) adjacent to distinctive multiseriate midrib
B. Blade showing tetrasporangial sori
C. *M. alata* growing in tide pool habitat

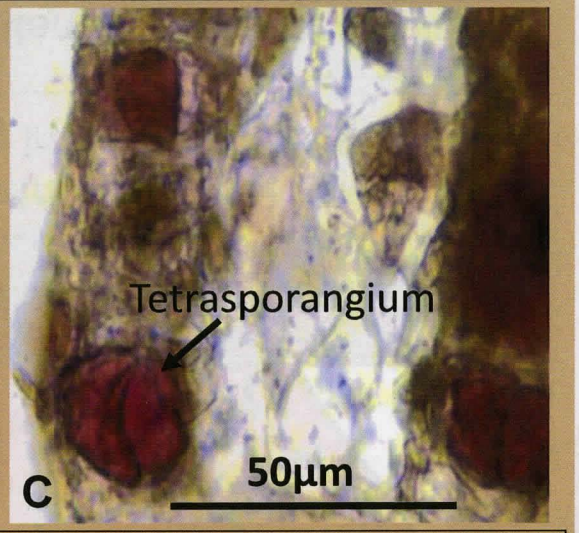
This alga is a made up of small, flattened, and alternately branched blades with distinctive midribs. Reproductive in winter, this alga can be found growing in tide pools and the shallow subtidal zone.

Palmaria palmata (L.) Kuntze

Rhodophyta Florideophyceae Palmariales







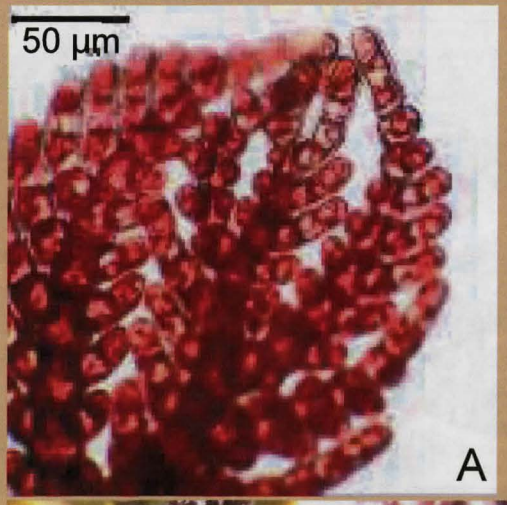


A. *Palmaria palmata* growing in the lower intertidal zone (arrow).
B. *Palmaria palmata* (close up)
C. Cross-section of blade showing tetrasporangia developing in the cortex.
D. Herbarium specimen. Mid intertidal zone. ANP, Maine (N 44 21.380, W 068 04.598)

Palmaria palmata has a microscopic, crustose female gametophyte, whereas the male gametophyte has large, branched blades that produce spermatia. Most individuals found in summer are tetrasporophytes. These can be recognized by their uneven coloring in which the dark patches (sori) contain tetraspores. Dulse (*P. palmata*) is a traditional food in Maine, and is often sold in condiments, soups, dietary supplements and appetizers (Erhart and Cerier 2001).

Plumaria plumosa (Hudson) Kuntze

Rhodophyta Florideophyceae Ceramiales





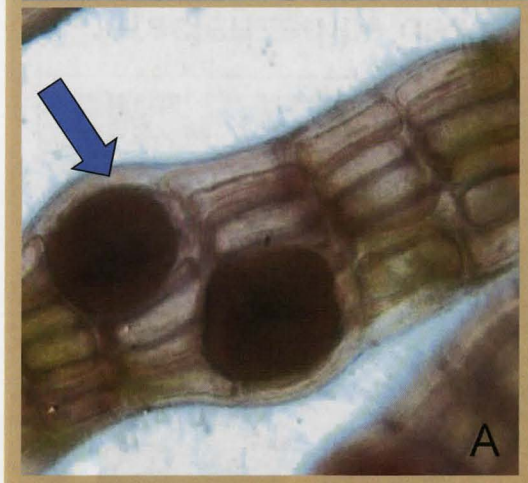


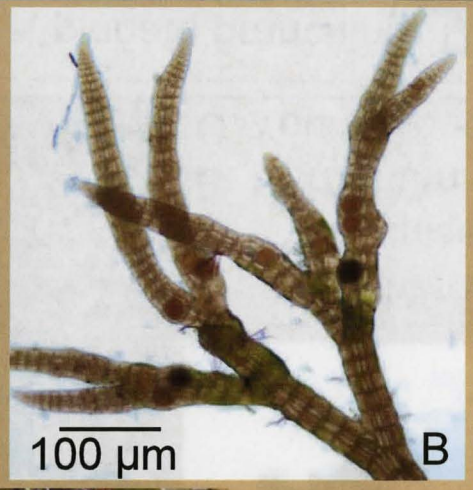
A. Characteristic ecorticate, uniseriate, rounded branch tips
B. Herbarium specimen
C. Young specimen in tide pool habitat

Characterized by delicate, pinnate branching. The Latin, "*plumosa*" describes this species as feathery. This red alga is found year round in the lower intertidal zone and tide pools.

Polysiphonia lanosa (L.) Tandy

Rhodophyta Florideophyceae Ceramiales







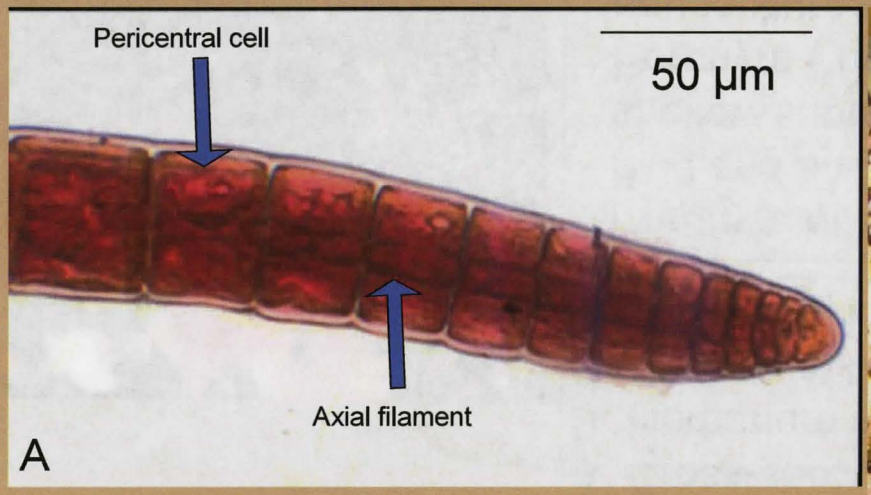


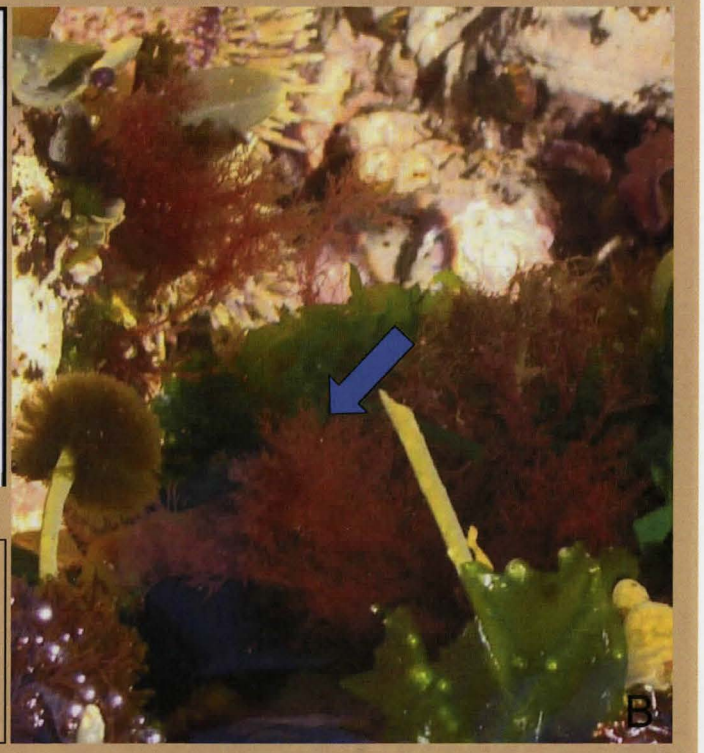
A. Reproductive material containing tetrasporangia
B. Ultimate branching pattern of tetrasporophyte
C. Female gametophyte with developing carposporangia
D. Epiphyte on *Ascophyllum nodosum*

Polysiphonia lanosa is a branched, filamentous alga that is very common in the mid-intertidal zone growing on *Ascophyllum nodosum*.

Polysiphonia stricta (Dillwyn) Greville

Rhodophyta Florideophyceae Ceramiales



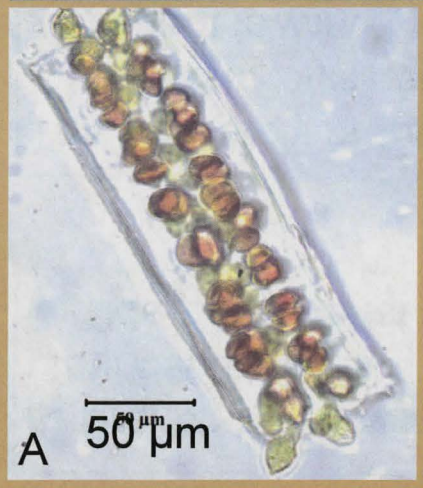


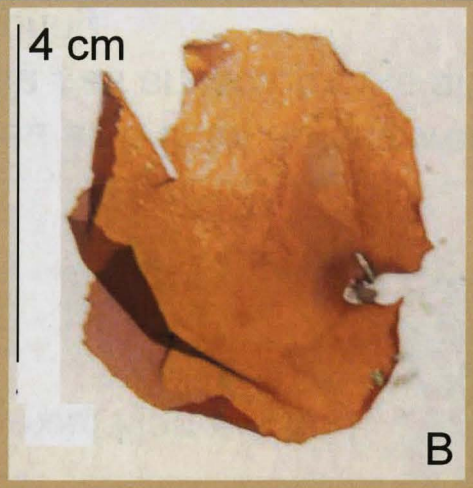
A. Branch tip showing axial filament and pericentral cells
B. Tide pool habitat

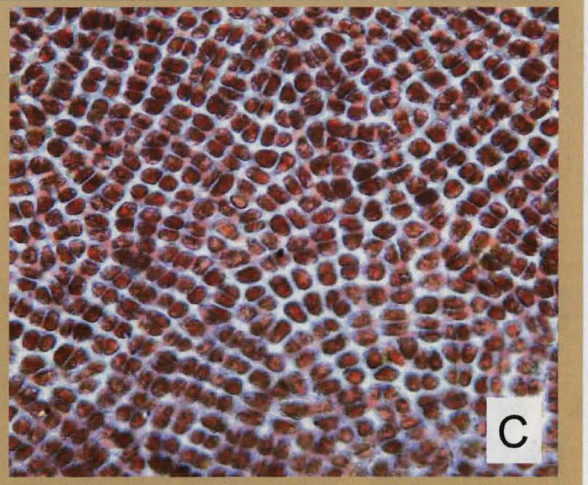
This delicately branched alga is found in lower intertidal zone and tide pool habitats. *Polysiphonia* has an isomorphic alternation of generations. Present in winter - spring.

Porphyra amplissima (Kjellman) Setchell & Hus ex Hus

Rhodophyta Bangiophyceae Bangiales









A. Cross-section of blade (two cells thick)
B. Herbarium specimen
C. Surface of blade
D. Small individual in lower intertidal zone

Porphyra amplissima grows up to a meter long and and is found in the low intertidal and shallow subtidal zones. In Asia, other Porphyra ("nori") species are important aquaculture crops; experts estimate that *nori* production and associated industry represent the most valuable sector of algal aquaculture worldwide (1.2 billion dollars a year, FAO). Present spring - early summer.

Porphyra umbilicalis (L.) Kütz.

Rhodophyta Bangiophyceae Bangiales



A. Mid-intertidal habitat of *Porphyra umbilicalis.*

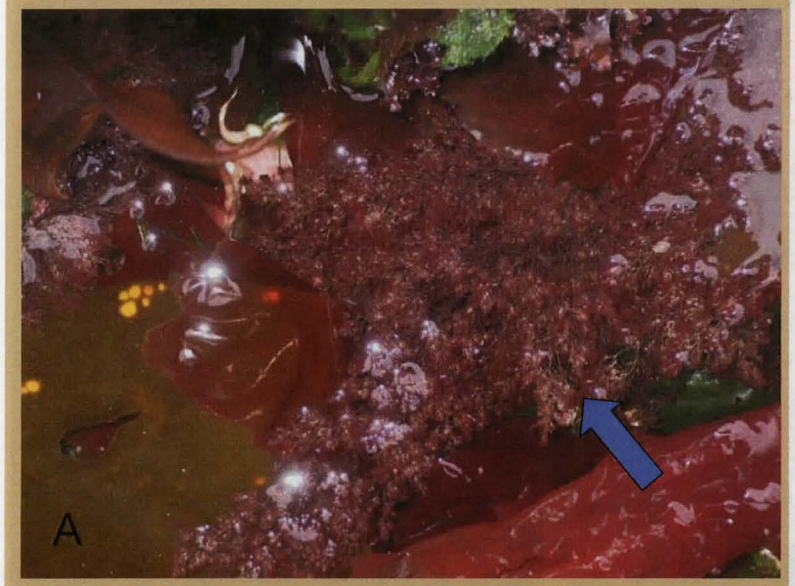
B., C. Close-up of *P. umbilicalis* in the mid-intertidal zone.

D. Cross-section of blade, single layer of cells.

Porphyra umbilicalis ("purple laver", "nori") is most common in the mid intertidal zone. Its irregularly-shaped, reddish brown blade is edible. *Porphyra umbilicalis* is very resistant to drying during low tide and contains natural UV sunscreens. This red alga turns green in summer because of low nutrients and exposure to temperatures above its tolerance level at low tide. The genome of *P. umbilicalis* is currently being sequenced by the Joint Genome Institute (US Department of Energy).

Rhodomela confervoides C. Agardh

Rhodophyta Florideophyceae Ceramiales



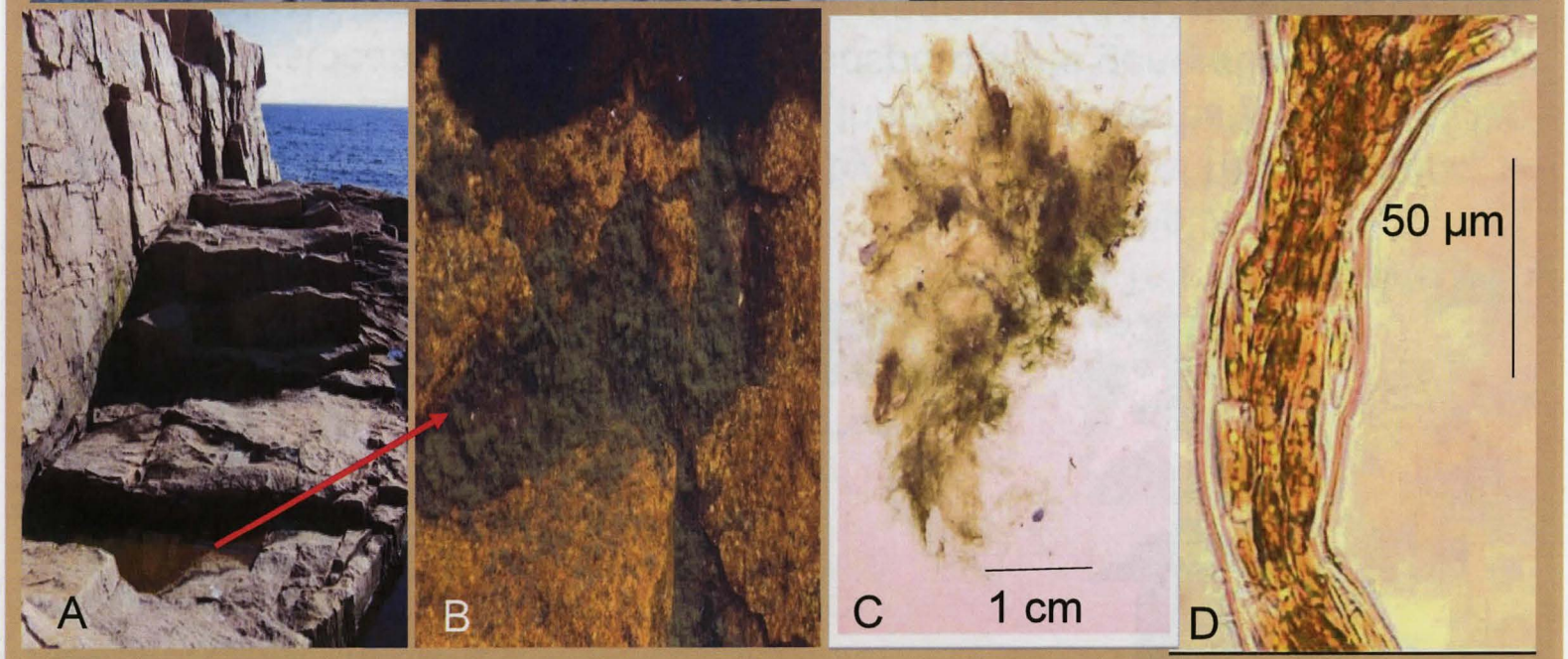


A. Individual in tide pool

B. Herbarium specimen with reduced branching of main axis and dense branching at tips.

The upper portions of *Rhodomela confervoides* are densely branched. When present, this red alga is common in tide pools. It contains bromophenols, which are compounds that have antibacterial properties (Fan et al. 2003). Present late winter – mid summer.

Navicula sp. (Tube-Dwelling Diatom)



A. Navicula sp. in the intertidal zone on Schoodic Peninsula, ANP.
B. *Navicula* sp. close-up, see arrow in photo A).
C. Herbarium Specimen. Mid-Intertidal Zone, Schoodic Peninsula, Acadia National Park, Maine (N 44 20.309, W 068 04.023)
D. Photomicrograph of diatoms in tube.

Navicula sp. is a tube-dwelling diatom that is particularly abundant in spring from the high to the lower intertidal zone. *Navicula sp*. is a pennate diatom (bilaterally symmetric). The outer covering of diatom cells is made of two silica valves that fit together like a hat box; diatoms live in “glass houses”. *Navicula sp*. is particularly abundant in spring from the high to the lower intertidal zone. This diatom often fools experts, because it can look like a filamentous brown alga.

Mastocarpus stellatus (Stackhouse) Guiry

(Triphasic Life History)



Female Gametophyte ♀
(Haploid)



Male Gametophyte ♂
(Haploid)

Gametes
(spermatia)
(carpogonia)

Carposporophyte Generation
(Diploid)

Carpospores



Crustose Tetrasporophyte
(Diploid)

Tetraspores

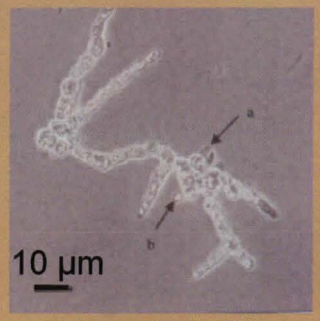
Female gametophytes can be identified by the presence of raised bumps called papillae. Male gametophytes lack these distinctive markings. Papillae represent cystocarps containing the carposporophyte generation. Cystocarps are formed as a result of a carpogonium (egg) produced by the female gametophyte being fertilized by a spermatium from the male gametophyte. Carpospores are released by the carposporophyte and form the crustose tetrasporophyte generation. Released tetraspores go on to form both male and female gametophytes.

Alaria esculenta (L.) Grev.

(Heteromorphic alternation of generations)



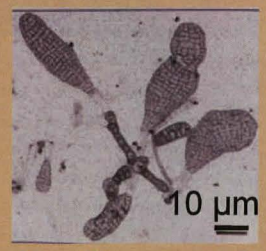
Sporophyte (Diploid)



Gordon and Brawley 2004

♀

Filamentous Gametophyte (Haploid)



Gordon and Brawley 2004

Juvenile Sporophytes

Alaria esculenta has alternating diploid sporophytic and gametophytic stages. The zoospores mature within sporangia located on small blades called sporophylls. Sporophylls can be found attached to the stipe at the base of the adult sporophyte blade. After the zoospores are released into the water column, they settle and become male and female gametophytes. The ripe egg on the female gametophyte stimulates nearby male gametophytes to release sperm by secreting a small hydrocarbon pheromone (oogamous reproduction). The fertilized egg germinates from the female gametophyte into a juvenile sporophyte. Thus, underneath every huge kelp are the remains of a female gametophyte.

Ulva lactuca L.

(Isomorphic alternation of generations)



♂

Gametophyte (Haploid)



Adult Sporophyte (Diploid)



♀

Gametophyte (Haploid)

The mature sporophyte, female gametophyte, and male gametophyte are identical in appearance. The mature sporophyte produces flagellated "zoospores" by meiosis. These germinate into female and male gametophytes, which each produce flagellated gametes when mature. The fertilized egg germinates and grows into the sporophyte.

Glossary

- Apical - the single cell or group of cells that occur at the tip of the thallus
- Alginate - gelatinous cell wall polysaccharide obtained from some brown algae; used as a thickening agent
- Antheridium (antheridia) - cell where sperm develop
- Aquaculture - the process of growing aquatic animals or plants
- Blade - flat leaf-like structure of the alga
- Carrageenan - a gel-forming polysaccharide found in cell walls of some red algae
- Cross-section - created by making thin slices of algae. Many distinguishing characteristics of algae can only be investigated by studying cross-sections.
- Carposporophyte - a diploid phase in the life history of many red algae, which develops on the female gametophyte after fertilization of the egg (=carpogonium).
- Chloroplast – photosynthetic structure (organelle) in plants.
- Conceptacle – spherical area of receptacle where eggs and sperm develop in fucoid algae.
- Cortication - a small, compact, outer layer of cells.
- Crustose – when algae are present as thin crusts, usually attached directly to rock but sometimes growing on other algae or invertebrates.
- Cystocarp - structure containing the carposporophyte generation of red algae.
- Desiccation - the process of drying out.
- Diatom - microscopic algae with cell walls made of silicon and having two separate halves.
- Dichotomous - branching into two equal parts (Y)
- Discoidal - has a flat, circular shape.
- Endophyte - An alga that grows inside another alga.
- Filamentous - composed of thread-like cells.

- Flagellated – having flagella. Allows movement of cell in water.
- Fucoid - a reference to algae such as those of the genus *Fucus.*
- Gametophyte - the gamete-producing stage of the life cycle
- Herbivores – animals that eat plants.
- Holdfast - part of the alga that fastens the alga to substrate
- Macrothallus - the larger of two alternating phases in a heteromorophic life history
- Medulla – describes the interior tissue of large macroalgae.
- Multiseriate - many rows of cells
- Perennial - alga that lives for many years
- Plastid – cellular structure containing light harvesting compounds
- Pheromone – compound that causes directed movements (taxis).
- Pyrenoids – spherical or disc shaped structure(s) inside chloroplast where ribulose biphosphate carboxylase (rubisco) is concentrated; this enzyme is required for the first step of sugar synthesis in photosynthesis.
- Receptacles – In fucoid algae, modified branch tips containing conceptacles where eggs and sperm form.
- Sporophyte - the spore-producing stage of the life cycle
- Stipe – the tube-like piece of alga between the holdfast and blade (e.g., in kelps such as genus *Saccharina*).
- Tetrasporophyte - diploid generation in Rhodophyta derived from carpospores; it reproduces by releasing tetraspores.
- Unicellular – made of one cell
- Uniseriate – filament made up of one row of cells
- Unilocular - consisting of one cavity
- Zoospores - asexual, flagellated spores (=reproductive cells)

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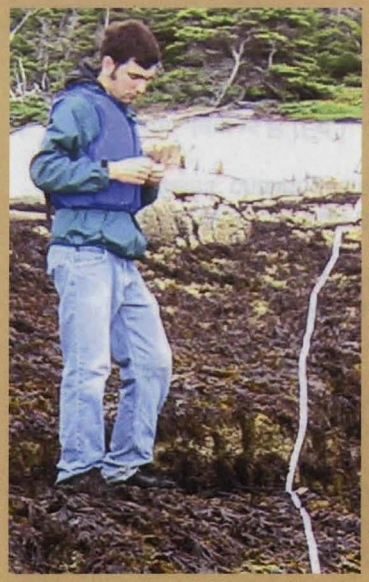
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