

## 6. Seaweed Flora of the European North Atlantic and Mediterranean

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Algae, like most vegetables, have cells with pigments that allow them to perform the photosynthesis. These organisms have a wide geographical distribution, colonizing various sites, but always linked to the presence of water. They can be found floating in the water, on wet rocks, walls, or in association with other organisms, as in the case of lichens, in association with fungi. They are particularly abundant in lakes, rivers, and seas, occupying the euphotic region (or photic), i. e., up to lower penetration of light effective for the realization of photosynthesis of algae (up to 200 m deep). Those that live in water can be planktonic (microalgae) or benthic (macroalgae). The former are small and live suspended in water (microscopic), whereas the latter remain fixed to a substrate (usually rock), are larger in size (macroscopic), and may reach 50 m in length. Seaweeds inhabit the oceans more than 2000 million years and are used as food by people in Asia since the 17th century. Today, seaweed is used in many countries for several purposes: directly as food, phycocolloids extraction (carrageenan, agar, and alginate) used in the pharmaceutical, cosmetic, and food industries. Algae are also used in the extraction of antiviral, antibacterial compounds, and biofertilizers. The larger or macroscopic algae, called macroalgae or seaweed, are mainly found in three of the algal taxonomic groups: Chlorophyta (green algae); Rhodophyta (red algae); and Phaeophyceae (brown algae). In this chapter, the main European seaweed flora and their biotechnological potential are listed.

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### 6.1 Marine Macroalgae (Seaweeds)

Algae, like most vegetables, have cells with pigments that allow them to perform the photosynthesis.

Algae have a wide geographical distribution, colonizing various sites, but always linked to the presence of water. They can be found floating in the water, on

wet rocks, walls, or in association with other organisms, as in the case of lichens, in association with fungi.

They are particularly abundant in lakes, rivers, and seas, occupying the euphotic region (or photic), i. e.,

up to lower penetration of light effective for the realization of photosynthesis of algae (up to 200 m deep). Those that live in water can be planktonic (microalgae) or benthic (macroalgae). The former are small and remain suspended in water (microscopic), whereas the latter remain fixed to a substrate (usually rock), are larger in size (macroscopic), and may reach 50 m in length [6.1].

### 6.1.1 Role of Algae in Nature

Algae are primary producers, i.e., they are able to produce oxygen and organic compounds that serve as food for other living beings, through the process of photosynthesis, using sunlight, atmospheric CO<sub>2</sub>, and inorganic substances present in water. Algae are, in fact, fundamental to food chains of all aquatic ecosystems.

### 6.1.2 Main Taxonomic Groups of Benthic Marine Algae

The coloration of seaweed is the visible expression of the combination of different cellular pigments. Thus, the phyla and classes of macroalgae are essentially defined in practice by their particular pigment composition.

Macroalgae are aquatic photosynthetic organisms belonging to the Domain Eukarya and the Kingdoms Plantae (green and red algae) and Chromista (brown algae). Although classification systems vary over time and according to the authors, it is generally accepted to consider that

1. The green algae are included in the Phylum Chlorophyta; their pigmentation is identical to that of terrestrial plants (chlorophyll a, b, and carotenoids);
2. The red algae belong to the phylum Rhodophyta, their photosynthetic pigments are chlorophyll a, phycobilins (R-phycoyanin and R-phycoerythrin), and carotenoids ( $\beta$ -carotene, lutein, and zeaxanthin);
3. The brown algae are included in the phylum Ochrophyta (or Heterokontophyta), class Phaeophyceae; their pigments are the chlorophylls a, c, and carotenoids, dominated by fucoxanthin, responsible for the brownish color [6.1, 2].

### 6.1.3 Marine Algae Morphology

The diversity of algae is extraordinary; one can find a multitude of morphological types according to their complexity, structure, and environmental adaptations. Macroalgae show a complex degree of morphological organization, with laminar, cylindrical, tubular, or crustose thalli.

### 6.1.4 Importance of Algae for Mankind

Today, seaweed is used in many countries for very different purposes: directly as food, phycocolloids extraction, extraction of compounds with antiviral, antibacterial, or antitumor activity and as biofertilizers.

About four million tonnes of seaweed are harvested annually worldwide. The major producers are China and Japan, followed by America and Norway. France used to import Japanese seaweed in the 1970s but 10 years later it went on to produce algae for food and biological products users. Contrary to what happens in East Asia, the West is more interested in thickeners and gelling properties of hydrocolloids extracted from seaweeds: carrageenan, agar, and alginate (E407, E406, and E400, respectively) [6.3, 4].

### 6.1.5 Historical Overview of Algae Use on Health Treatments

Historically, the algae have been used by coastal communities to prepare home medicines to treat various health problems. Such applications are the product of the empirical knowledge of many generations and, in most cases, their mechanisms are unknown. However, the current research, undertaken in order to analyze the components and causes which affect the proper functioning of our body, are already giving their first fruits. So, we know, for example, that the good results obtained with the use of Kelp (*Laminaria* spp.) in the treatment of goiter are due to the fact that the origin of this disease is a diet low in iodine, chemical element present in significant quantities in brown algae [6.3].

Green algae have been used as anthelmintics, astringent, and to treat gout. Brown algae are used in the treatment of rheumatic processes, arteriosclerosis, menstrual disorders, hypertension, gastric ulcers, goiter, skin diseases, syphilis, and as an anticoagulant. Red algae are used as anticoagulants, anthelmintics, and in treating gastritis and diarrhea [6.3, 5].

## 6.2 The Marine Algae and Their Biotechnological Potential

Over time, the need to find new paths in search of new sources of energy is evident and relevant, especially the methods independent of fossil fuels, because they will run out one day and have an increasingly higher cost of use, both in terms of economic costs but mainly environmental costs.

One way to achieve it is by taking advantage of the biomass from the cultivation of algae in the oceans and seas, which offer large areas available for that purpose, which does not happen on land, where farmland is occupied for the production of food. The algae can produce, for example, biodiesel and ethanol.

On the other hand, in recent years, several marine organisms have been confirmed as an important source of new compounds potentially useful for the development of chemotherapeutic agents. Previous investigations of the production of antibiotic substances by aquatic organisms point to these forms as a rich and varied source of antibacterial and antifungal agents. Over 15 000 novel compounds have been chemically determined. Focusing on bioproducts, recent trends in drug research from natural sources suggest that algae are a promising

group to furnish novel biochemically active substances [6.6].

Seaweeds or marine macroalgae are the renewable living resources which are also used as food and fertilizer in many parts of the world. Seaweeds are of nutritional interest as they contain low calorie food but are rich in vitamins, minerals, and dietary fibers [6.7]. In addition to vitamins and minerals, seaweeds are also potentially good sources of proteins, polysaccharides and fibers [6.8]. The lipids, which are present in very small amounts, are unsaturated and afford protection against cardiovascular pathogens.

Seaweeds are considered as a source of bioactive compounds as they are able to produce a great variety of secondary metabolites characterized by a broad spectrum of biological activities. Compounds with antioxidant, antiviral, antifungal, and antimicrobial activities have been detected in brown, red, and green algae [6.9, 10]. There are numerous reports of compounds derived from macroalgae with a broad range of biological activities, such as antibacterial [6.11], antivirals [6.12], antitumorals [6.13], anticoagulant [6.14], and antifouling [6.15], antihelminthic and antifungal [6.16].

## 6.3 Taxonomy and Description of Marine Algae with Biotechnological Potential

### 6.3.1 Domain/Empire Prokaryota, Kingdom Bacteria, Phylum Cyanobacteria (Blue–Green Algae)

- Class: Cyanophyceae
- Order: **Nostocales**

*Rivularia bullata* (Poir) Berkeley  
ex Bornet & Flahault

**Description.** In general, blue-green algae (Cyanobacteria) are not easy to find on the coastline edge (Fig. 6.1). However, one species may be easily confused with a green seaweed (Chlorophyta), whereby described here. This species forms small globular vesicles, dark green, sometimes bluish, gelatinous, and elastic; adherent to exposed rocks, sometimes on *Chthamalus* spp. (Barnacles), together with *Lichina pygmaea* (Lichens), and may attain 5 mm in diameter [6.2, 17].

**Habitat.** Grows on rocks of the upper littoral zone.

**Distribution.** NE Atlantic (Ireland and Britain to Portugal); Mediterranean; SW Indian Ocean; SW Pacific; Australia.

**Uses and Compounds.** Present antibacterial activity [6.18, 19].

### 6.3.2 Domain/Empire Eukaryota, Kingdom Plantae, Phylum Chlorophyta (Green Algae)

- Class: Bryopsidophyceae
- Order: **Bryopsidales**

*Bryopsis hypnoides* J.V. Lamouroux

**Description.** Plants in filamentous tufts, dull or dark green, 10 cm tall, are branching in an irregular, scattered pattern. Primary axes are highly branched. Fronds decrease in diameter with each successive division;

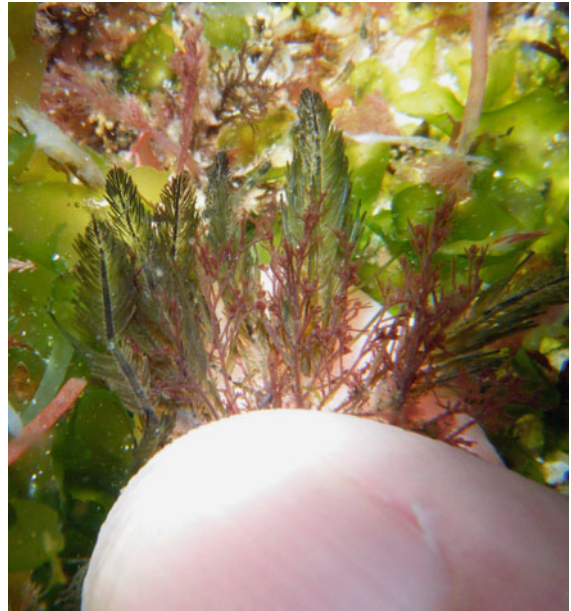


**Fig. 6.1** *R. bullata* specimens on *Chthamalus* spp. (Barnacles)

branchlets form irregularly, undifferentiated from axes, constricted at base. Apices rounded; rhizoidal system fibrous, tightly woven [6.20, 21].

**Habitat.** Common near freshwater and nutrient rich outputs; attaches to hard substrates such as basalt, rocks, or rubble; forms delicate fronds which move with currents.

**Worldwide Distribution.** Atlantic Ocean, Mediterranean, Caribbean, Indian and Pacific Oceans, Australia.



**Fig. 6.2** Underwater photo of *Bryopsis plumosa*

**Uses and Compounds.** The primary structure of bryohealin and of lectin from *Bryopsis hypnoides* had little similarity with any known plant lectin, but rather resembled animal lectins with fucolectin domains [6.20, 22, 23]; Antifouling activity is present [6.24].

***Bryopsis pennata* J.V. Lamouroux**

**Description.** Thallus filamentous, bushy, in tuft-like mats, to 10 cm high. Fronds feather-like, 8–15 mm wide, pinnately branched; lateral branches of uniform length, constricted at base where joined to main axes. Branchlets in two opposite rows on the upper half of branch, the lower half of branch is bare. The rhizoidal system is fibrous, tightly interwoven. Color is glossy dark green, often with light blue iridescence [6.25].

**Habitat.** *B. pennata* forms soft, feathery clumps attached to basalt rocks and rubble on shallow reef flats, in tide pools, and in the lower intertidal habitats of coastlines with low wave action.

**Distribution.** Atlantic Ocean, Mediterranean, Caribbean, Indian and Pacific Oceans, Australia.

**Uses and Compounds.** *Bryopsis* species are potentially invasive. Like the troublesome *Caulerpa taxifolia*, the genus produces chemical defenses that are toxic to most herbivorous organisms and easily reproduces veg-

etatively from the smallest fragments [6.25, 26]. The extracts of this seaweed have antibacterial [6.27–29], antifungal [6.29], anticancer [6.30], and cardiotoxic [6.26] activity.

#### *Bryopsis plumosa* (Hudson) C. Agardh

**Description.** *B. plumosa* is a small, feathery species of green seaweed (Fig. 6.2). The thalli are erect, feather-like, and may reach up to 15 cm in height. It is easily recognized by its delicate branches. All branches are regularly arranged in two rows on opposite sides of the central filament. The lengths of the branches decrease gradually from the base of the plant. It is usually dark to mid-green in color [6.31, 32].

**Common Names.** Evenly branched mossy feather weed; stoneworts.

**Habitat.** Not uncommon; in low littoral rock pools and in the sublittoral. Is an epilithic species that is usually found in a deep lower shore pool or subtidally in both sheltered and well-exposed habitats.

**Distribution.** NE Atlantic (Scandinavia to Mauretania); Mediterranean, Caribbean; SW Atlantic; Indian Ocean; NW Pacific (Japan, China); NE Pacific (Alaska, British Columbia); SE Pacific (Chile); Indo-Pacific (Philippines, Vietnam, Indonesia); Pacific Islands; Australia, New Zealand.

**Uses and Compounds.** Produces lectins with biological activity [6.23]; present antioxidant [6.33] and antimicrobial [6.34] activity, medicinal and, pharmaceutical uses [6.35].

#### *Caulerpa cupressoides* (Vahl) C. Agardh

**Description.** Erect fronds arise from stolons of up to several diameters in length, anchored to the substratum by rhizoidal structures. Fronds are usually rich forked toward the apex, and at base they are naked (usually three) rows of rounded or flattened, ovoidal to conically pointed, short branchlets with a distinctly pointed tip [6.32, 36].

**Habitat.** On rocks in the tidal zone at depths of 40 m depth.

**Distribution.** NE Atlantic (Canary Islands); Caribbean; NW Pacific (Japan, China); West Pacific (Philippines, Indonesia); Pacific Islands; Australia.

**Uses and Compounds.** This seaweed is reported to be edible, to have antibacterial [6.37–40], antifungal, antioxidant [6.41], anticoagulant [6.41, 42], analgesic [6.43, 44] anti-inflammatory [6.43, 44], and antithrombotic [6.45] properties, and used to treat high blood pressure. However, some *Caulerpa* species produce toxins to protect themselves from browsing fish. This also makes them toxic to humans [6.36].

#### *Caulerpa peltata* J.V. Lamouroux

**Common Name.** Big parasol green seaweed.

**Description.** This seaweed has structures that look like fleshy umbrellas, with a thick circular portion (about 1–1.5 cm across) on a little stalk. These little umbrellas emerge along the length of a *stem* that creeps over the surface; bright yellowish-green to bluish-green color [6.32, 46].

**Habitat.** Found on shady rocks or dead corals in infralittoral zones along moderately wave-exposed shorelines. *Caulerpa peltata* grows in tide pools, on lower intertidal coral reefs covered with sand or on soft muddy.

**Distribution.** Widely distributed in tropical seas; Atlantic Islands.

**Uses and Compounds.** This seaweed was reported to be edible and used as medicine for its antifungal properties and has ability to lower blood pressure [6.46–48], it is also reported to have larvicidal [6.49, 50], antiplasmodial [6.51], cytotoxic [6.52], immunomodulatory [6.53], antioxidant [6.52], antimicrobial [6.40, 54], and anticoagulant [6.55] properties. This species was evaluated for producing biodiesel [6.56].

#### *Caulerpa prolifera* (Forsskål) J.V. Lamouroux

**Description.** Fronds leafy, flat, with a distinct slender stipe and entire margins, at times undulating, oval to longitudinal, spatula-shaped or linear oblong, tapering toward the base, at the apex also narrowing but bluntly rounded (Fig. 6.3). Occasionally, more of these dark-green photosynthetic organs emerge from the stipes as well as from the margins or surfaces of the blades. The sparsely branching, relatively thin (1–2 mm) but wiry stolons are widely spread out, often extensive areas colonizing in this way; rhizoids in intervals of 0.5–2 cm [6.32].



**Fig. 6.3** Underwater photo of *Caulerpa prolifera*

**Habitat.** On sandy or muddy bottoms in sheltered lagoons, only slightly below the low water mark, often among Seagrass; but also on little wave-exposed rocks at depths of several meters.

**Distribution.** NE Atlantic (S Spain to Canary Islands), Caribbean, Mediterranean; Indian Ocean, SW Pacific (Philippines).

**Uses and Compounds.** Commonly used in aquaria, to which it is well adapted [6.32, 57], this species produces Caulerpenyne, an acetylenic sesquiterpene, which is specific to *Caulerpa*, as described by Amico et al. [6.58, 59] for *C. prolifera*. This seaweed is reported to have antibacterial [6.40, 60, 61], antialgal [6.61], antifungal [6.62], antifouling [6.63], antiproliferative [6.64], antioxidant [6.64, 65], anticoagulant [6.64], and larvicidal activity [6.66].

#### *Caulerpa racemosa* (Forsskål) J. Agardh

**Common Names.** Sea grape; green caviar; grape caulerpa.

**Description.** It is a bright green seaweed that resembles long skinny vertical bunches of tiny grapes. It can be very similar in appearance to *Caulerpa lentillifera*, though the latter tends to produce denser bunches (though this line can be smudged when *Caulerpa racemosa* grows in wave-exposed waters and develops shorter, stronger branches than normal). *C. racemosa* is quite variable in morphology and has many different growth forms that have been identified and named. A horizontal stolon which is attached to the sediment (usually sand) by descending rhizomes gives rise to

erect branches at every few centimeters. These branches can reach as much as 30 cm in height and produce a large number of stalked branchlets which vary in shape from spherical to ovate to disk-shaped, sometimes flattening on top or forming icecream-cone-type shapes. These plants are coenocytic, which means that the entire plant is made up of one giant cell with many nuclei and no cross-walls. It is mainly due to this characteristic, any part of a *C. racemosa* plant that is fragmented, even tiny bits of tissue, can regenerate to form entirely new plants [6.67, 68].

**Habitat.** Forms intertwined mats in tide pools and on reef flats. Horizontal runners tightly anchor mats to rocks and sand and in calm to moderately heavy surf areas.

**Distribution.** Eastern Mediterranean; Caribbean, Indian Ocean, NW Pacific (Japan, China), Indo-Pacific (Philippines, Vietnam); Pacific Islands; Australia, New Zealand.

**Uses and Compounds.** *C. racemosa* is grown commercially in the South Pacific, and harvested wild in other areas [6.67]; edible seaweed, eaten as salad in Polynesia and the Marquesas [6.32]. *C. racemosa*, like *C. lentillifera*, is used commonly in Asian and Island cuisines. It is often used fresh and raw as a salad vegetable and is desired for its peppery flavor which also makes it ideal for use in sauce making [6.69]. This seaweed is common in the Phuket market of Thailand where 10–20 kg of fresh *C. racemosa* is sold per day [6.67].

*C. racemosa* also contains compounds which function as mild anesthetics, which gives the seaweed clinical value. Traditional medicine of the Philippines uses *C. racemosa* to lower blood pressure and to treat rheumatism [6.67, 68]. This seaweed is reported to have antibacterial [6.39, 60, 70–73], antiviral [6.72, 74, 75], antifungal [6.71], insecticidal [6.76], antioxidant [6.77, 78], anti-inflammatory [6.73, 79], anticoagulant [6.74], analgesic [6.79], hypolipidaemic [6.35, 80], hypoglycemic [6.81] and antitumor [6.77, 82] activity.

#### *Caulerpa taxifolia* (M. Vahl) C. Agardh

**Description.** Plant with widely extending, smooth stolons, about 1 mm in thickness; rhizoid-bearing branches downward and photosynthetic branches growing upward. Erect sections short-stiped and feather-like: the unbranched or sparingly branched axis is covered



**Fig. 6.4** Cushion-shaped, dark green, strongly adhered to the rocky substrate (*Codium adhaerens*)

pinnately with 3–6 mm long and 1 mm wide, flattened and upward-bending branchlets. These are compressed, slightly constricted at the base and narrowing toward the mucronate tip [6.32].

**Common Names.** Killer algae; Aquarium Caulerpa; Folia feathery green seaweed.

**Habitat.** In sunny locations on sheltered shores, most common in shallow water on sand, mud and rocks, but also in up to 30 m depth.

**Distribution.** Widely distributed in warmer seas, NE Atlantic (Canary Islands); W Mediterranean; tropical E Atlantic (Ghana); Caribbean; Indian Ocean; NW Pacific (Japan, China); W Pacific and Indo-Pacific (Philippines, Vietnam, Indonesia); Pacific Islands; Australia.

**Uses and Compounds.** This green seaweed is reported to be edible [6.83], to have antioxidant [6.84], antibacterial [6.83, 85, 86], antiviral [6.87], nematocidal [6.88], and antifungal properties, and used to treat tuberculosis and high blood pressure [6.83]. However, some *Caulerpa* species produce toxins to protect themselves from browsing fish. This also makes them toxic to humans [6.83]; caulerpenyne from *C. taxifolia* which is cytotoxic toward several human cell lines and as such has anticancer, antitumor, and antiproliferative properties [6.35, 89, 90].

### *Codium adhaerens* C. Agardh

**Description.** Spongy thallus, green light, prostrate, irregularly shaped, and presented with the appearance of a plane carpet firmly fixed to the substrate (Fig. 6.4). It consists of entangled coenocytic filaments and a finished surface by narrow and elongated utricles that are difficult to separate. Firm, gelatinous texture, and smooth to the touch [6.91].

**Habitat.** Perennial seaweed that can be found on exposed or protected shores under low light conditions, being located mainly in vertical rock faces and gaps.

**Distribution.** NW Atlantic (common on European bordering countries), Atlantic Islands (Azores, Canary), Africa, Asia, and Australia.

**Uses and Compounds.** Have vermifuge [6.92], antidiabetic [6.93], antibacterial [6.94], and antiviral [6.95] properties.

### *Codium bursa* (Linnaeus) C. Agardh

**Description.** Thallus a spongy sphere with a velvety soft, shiny surface; becomes more flattened when increases in size. The internal branched filamentous network becomes looser with increasing size of the sphere, the space fills with water and the surface becomes indented; anchored to substratum by felted filaments [6.32].

**Habitat.** On rocks, probably prefers sheltered locations; in the infralitoral up to 10 m (–50 m) depth; often in drift.

**Distribution.** NE Atlantic (Ireland to Canary Islands); Mediterranean.

**Uses and Compounds.** Have antifungal [6.62], antibacterial [6.96], and antiplasmodial [6.97] activity.

### *Codium decorticatum* (Woodward) M. Howe

**Description.** Very large, dichotomously branched erect thallus, dark green: from a crustose base rise one to several, up to more than 1 m long ribbons, regularly forking, rounded-flattened (0.5–3 cm wide) and usually visibly compressed at the bifurcations, stretched out like webs, wedge-shaped, and over 6 cm wide at that point [6.32, 98].

**Habitat.** Inhabits shallow muddy bays and harbors, usually during summer months.

**Distribution.** NE and E Atlantic (Spain to tropical W Africa), Mediterranean; Caribbean, SW Atlantic (Brazil, Uruguay); Indian Ocean; Hawaii; Antarctica.

**Uses and Compounds.** Have antibacterial [6.99, 100], antioxidant [6.65, 101, 102], antiviral [6.103], larvicidal [6.104], antifungal [6.105], and antitumor [6.106] activity.

*Codium fragile* (Suringar) Hariot

**Common Names.** Dichotomous sponge tang, Forked felt alga, Sea staghorn.

**Description.** Dark-green alga, ranging from 10 to 40 cm high and consists of repeatedly branching cylindrical segments about 0.5 to 1.0 cm in diameter, and its branches can be as thick as pencil. The segments look like dark green fingers. Its holdfast is a broad, sponge-like cushion of tissue. The tips of segments are blunt and the surface is soft, so it is sometimes mistaken as a sponge. Its body consists of interwoven, filamentous cells with incomplete cross-walls forming the inner part of the branches [6.107, 108].

**Habitat.** On rocky shores from the upper intertidal rock pools down to the lower intertidal.

**Distribution.** *C. fragile* is native to the Pacific Ocean in the Sea of Japan, and from Alaska to Baja California, Mexico. Its range has extended southward to South America, on the coasts of Chile and Argentina. It grows along nearly the whole coastline of the eastern North America, from the Gulf of St. Lawrence in Canada to North Carolina. It can be found in the Mediterranean and Adriatic, including the coasts of France, Spain, and Corsica. *C. fragile* ranges from Scandinavia to the Gulf of Gasconne and to the Canaries Islands. It has also been recorded in the Orkneys, Scotland, Ireland, Wales, and England. It can even be found in Australia, Antarctica, and southern Africa [6.107].

**Uses and Compounds.** *C. fragile* is used for skincare and antiaging products. It is reported to be a regenerating and anti-free radical ingredient, and have rebalancing and energizing properties. Its wealth of macroelements gives it a remineralizing property [6.109]. One seller claims that *C. fragile* is the ideal ingredient to boost tired and mature skin. It is also used as food in eastern Asia and Chile [6.4, 107, 108, 110]. This species have also antioxidant [6.111, 112], antibacterial [6.112–115], anti-inflammatory [6.116]



**Fig. 6.5** Underwater photo of *Codium tomentosum*

immunostimulating [6.117], antitumor [6.118], antiangiogenic [6.119], and antifouling [6.115] properties. The bioremediation potential of *C. fragile* has been tested on integrated multitrophic aquaculture (IMTA) [6.118].

*Codium tomentosum* Stackhouse

**Common Names.** Spongweed, Velvet horn.

**Description.** A small green alga (up to 30 cm long) with a dichotomously branched, cylindrical frond (Fig. 6.5). The frond is solid and spongy with a felt-like touch and has many colorless hairs which can be seen when the plant is immersed in water. The holdfast is disk-like and formed from many fine threads. *C. tomentosum* can be confused with *C. fragile*. However, *C. tomentosum* tends to have a more slender frond with rounded tips whereas *C. fragile* has pointed tips to the frond [6.1, 120, 121].

**Habitat.** Mainly on rock in the lower shore.

**Distribution.** *C. tomentosum* is native to the north-east Atlantic Ocean from the British Isles southward to the Azores and Cape Verde. It has also been recorded around the coasts of Africa and in various other parts of the world.

**Uses and Compounds.** *C. tomentosum* is used in products from the United States, Germany, France, Italy, and the UK. Some of these products are repair and restoration moisturizers, hydration serums, leg and body creams, muds and butters, bath and shower



creams, day creams, night creams, eye creams, anti-aging creams, masks, scrubs, lip balms, and lotions. *C. tomentosum* is a popular food in some parts of Asia [6.120, 122].

This species have antihelminthic and antiprotozoal [6.32, 122, 123], antioxidant [6.124, 125], antigenotoxic [6.124], antitumor [6.126], anticoagulant [6.127–129], antibacterial [6.96, 102, 130, 131] activity.

*Halimeda opuntia* (Linnaeus) J.V. Lamouroux

**Description.** Thick, profusely branched clumps of rounded three-lobed or ribbed leaf-like segments, between 10 and 25 cm in height. The branches are numerous and are in different planes, rather than nearly in a single plane as some other species are. This alga can cover larger areas with a dense mat so that individual plants are indistinguishable [6.32, 132].

**Habitat.** Grow in shallow depressions, cracks and crevices, between hard corals and other somewhat protected areas of the reef, down to 55 m.

**Distribution.** Mediterranean; Caribbean; SW Pacific and Pacific Islands; Japan; Indian Ocean.

**Uses and Compounds.** *H. opuntia* show hair-growth-stimulating [6.133], antimicrobial and cytotoxic [6.134–138], antioxidant and hepatoprotective [6.139–141], larvicidal [6.142], antileishmanial [6.143], and antiviral [6.144] activity.

*Halimeda tuna* (J. Ellis & Solander)

J.V. Lamouroux

**Description.** Thallus calcified, dark green, distinctly segmented with initial branching in one plane; segments disk-like to triangular, up to 2 cm wide. Internodal siphons uncalcified, united in twos or threes, and terminating in pseudodichotomous laterals. Surface cells oppressed to one another in a honeycomb pattern, 25–75 µm in diameter [6.32].

**Habitat.** Found on hard rocky substratum in shallow water, less than 2 m depth.

**Distribution.** Globally in warmer seas: NE Atlantic (Morocco, Azores, Canary Islands); Mediterranean; Caribbean; NW Pacific (Japan); SE Pacific (Chile); SW Pacific; Pacific Islands; Indian Ocean; Australia.

**Uses and Compounds.** This species have antibacterial [6.114, 145, 146], antioxidant [6.65, 147], anticoag-

ulant [6.128], pesticide [6.136, 148], antifungal [6.62], Antitrypanosomal [6.149], cytotoxic and antiproliferative [6.150] activity.

- Class: Dasycladophyceae
- Order: **Dasycladales**

*Acetabularia acetabulum* (Linnaeus) P.C. Silva

**Description.** Thallus with a slender stipe, whitish gray or gray-green, merging into a flattened, funnel-shaped cap at the top; this is divided into 20–80 radial rays, navelled, and annulated around navel and below the cap (Fig. 6.6). During growth, delicate filamentous, forking branchlets arise from the uppermost ring and the stipe. These are discarded soon and are therefore lacking in the mature thallus. Only basal parts perennial, plants with fully developed caps between May and August in the Mediterranean [6.32, 151].

**Habitat.** Mostly forming dense stands on rocks and stones in sheltered bays.

**Distribution.** NE Atlantic; Mediterranean; Indian Ocean.



Fig. 6.6 Underwater photo of *Acetabularia acetabulum*

**Uses and Compounds.** For a time, important researches object in cell biology (cell differentiation, interaction of nucleus and cytoplasm) [6.32].

- Class: Siphonocladophyceae
- Order: **Siphonocladales**

*Valonia utricularis* (Roth) C. Agardh

**Description.** Thallus, translucent light- to dark green, primarily consisting of a large (up to 5 mm thick and 20 mm long) bladder- or club- to hose-like cell, branching at the base rhizoidally (Fig. 6.7). Later due to outgrowths of this cell cylindrical-clavate branches, often contorted and almost gapless densely packed, thus forming intertwined erect stands [6.32, 152].

**Habitat.** Plants sessile; at times forming extensive stands beneath other algae. Mostly on rock and reef edges in sheltered locations and shallow water, in up to 2 m depth.

**Distribution.** Warm NE Atlantic (Portugal to Canary Islands); Mediterranean; Caribbean; Indian Ocean; NW Pacific (Japan, China); Indo-Pacific (Philippines, Vietnam); Pacific Islands; Australia.



Fig. 6.7 *Valonia utricularis* specimen

**Uses and Compounds.** Show antifungal, antiviral, cytotoxic and atimitotic [6.62] activity.

- Class: Ulvophyceae
- Order: **Cladophorales**

*Anadyomene stellata* (Wulfen) C. Agardh

**Description.** *A. stellata* consists of erect, bright green, delicate blades with ruffled edges forming densely packed clumps; blades one cell thick, to 10 cm in height, formed by veins of filaments radiating from base in fan-like branching pattern. Cells between veins arranged in parallel rows. Margins smoothly rounded, formed by small spherical cells; similar to *A. saldanhae* which has cells between veins in random arrangement. Also similar to *A. lacerata* which has lacerated margins formed by elongated vein cells [6.32].

**Habitat.** Commonly found on rocks or other firm surfaces in the lower intertidal zone.

**Distribution.** Warmer parts of the NE Atlantic (Azores, Canary Islands), Mediterranean; Caribbean; Indian Ocean; W Pacific (Philippines, Indonesia); Australia.

**Uses and Compound.** Have anticoagulant [6.153], and antifungal [6.62] activity.

*Chaetomorpha aerea* (Dillwyn) Kützing

**Description.** Light green filaments, 10 cm long, growing attached to the substrate, and mostly grouped in tufts. Filament unbranched, growing in flocks or communities attached to sand covered or bare rocky substratum, 2–3 cm in height, yellowish green in color. Cells cylindrical, apical cells 111.2–111.5  $\mu\text{m}$  in length and 110.5–111.6  $\mu\text{m}$  in breadth, middle cells 54.5–62.2  $\mu\text{m}$  in length and 88.8–89.2  $\mu\text{m}$  in breadth, basal cell much longer than the middle and the upper one, showing its length 133.32–144.5  $\mu\text{m}$  and breadth 55.50–58.8  $\mu\text{m}$ , sheath 17–22.5  $\mu\text{m}$  in thickness, sometimes lamellate in mature portion [6.154].

**Habitat.** Ephemeral species, found in intertidal environment, in both exposed and sheltered stations.

**Distribution.** Diffused in Mediterranean, Black Sea, NE Atlantic (from Scandinavia to Portugal) NW Atlantic.

**Uses and Compounds.** Show antibacterial [6.155–157] activity.

*Chaetomorpha capillaris* (Kützting) Børgesen

**Description.** Thallus medium green, loose-lying in shade on tidal flats, forming loose, woolly, entangled masses with few if any attachment cells. Filaments unbranched, of similar diameter throughout. Cells (70–) 85–100 (–105)  $\mu\text{m}$  in diameter and L/B 1–2, not collapsing on drying; walls 8–12  $\mu\text{m}$  thick; chloroplasts densely reticulate with numerous pyrenoids [6.158].

**Habitat.** In shade on mangrove pneumatophores or under Samphires on tidal flats.

**Distribution.** Mediterranean and North Atlantic; Southern Australia and New Zealand.

**Uses and Compounds.** Have antifungal activity [6.62].

*Chaetomorpha linum* (O.F. Müller) Kützting

**Common Name.** Spaghetti algae.

**Description.** Delicate green seaweed, it grows as a filamentous loosely entangled mass (Fig. 6.8). Plants mostly free floating, sometimes attached to rocks and shells; plant body filamentous, less than 20 cm long, bright green to yellowish green in color, filaments wiry and stiff, unbranched; cell walls thick, appear jointed or articulated with dark green bands; cells constricted at the transverse walls [6.159, 160].

**Habitat.** Is an intertidal and supralittoral species that can be found in groups of hundreds or thousands of individuals in sandy areas, on rocks or around tide pools.

**Distribution.** Widespread, including Northern Europe to North Africa Atlantic coasts, North and Baltic; Mediterranean; North American Atlantic Coast (Labrador to Florida); NE Pacific (Alaska to California); SE Pacific (Chile); Indian Ocean, China, Japan, Australia, New Zealand.

**Uses and Compounds.** Spaghetti algae, though not palatable to many herbivorous species, is popular in reef aquariums for its ability to remove nitrates, assist in buffering pH, uptake carbon dioxide producing oxygen, and assist in balancing trace elements. It also provides hiding spaces for small creatures [6.159]. Possible use on biofuel production [6.161–163], liquid fertilizer [6.164], bioremediation in aquaculture [6.165], and animal feed [6.166]. Extracts of this species have



**Fig. 6.8** *Chaetomorpha linum* specimens

insecticidal [6.167], antimicrobial [6.168–171], antioxidant [6.111, 170], larvicidal [6.171], and antiviral [6.172] activity.

*Cladophora coelothrix* Kützting

**Description.** Thallus medium to dark green, drying brownish, forming dense turfs or cushions to several cm across and to 4 cm high, composed of a basal tangle of branched, often curved, stolon-like filaments giving rise to ascending, more-or-less erect, branch-systems. Growth largely by divisions of conspicuous apical cells, but intercalary cells may divide into shorter cells; feebly to distinctly acropetal at the apices, densely and irregularly branched with many cells (especially lower

ones but often also those near the apices) producing a descending rhizoid from their basal poles, and which attach to the substrate or other filaments with a terminal coralloid holdfast; lateral branches mostly wide-angled ( $45^\circ$  or more) arising singly (occasionally two) at or just below a cross wall, with the new wall remaining steeply inclined to the parent cell [6.173].

**Habitat.** Common in shaded areas or pools near low tide level on rough-water coasts but extending into sheltered areas.

**Distribution.** Warm temperate to tropical Atlantic coasts of Europe, Africa and America; probably widespread in tropical and warm temperate waters, and in southern Australia.

**Uses and Compounds.** Have antimicrobial [6.174], and antifungal activity [6.62].

***Cladophora fracta* (O.F. Müller ex Vahl) Kützing**  
**Description.** Filaments branched; attached by rhizoids, pale green, up to 80 cm long, branching irregular or pseudodichotomously divided at wide angles, cells mostly cylindrical; chloroplast parietal net-like with several pyrenoids; main axis up to  $85\ \mu\text{m}$  wide, bearing numerous side branches of different lengths; cells of side branches  $17\text{--}38\ \mu\text{m}$  wide, 5 to 17 times longer than wide, apical cells cylindrical to slightly conical,  $16\text{--}27\ \mu\text{m}$  wide, 3.5 to 25 times longer than wide [6.175].

**Habitat.** Frequent in shallow, nutrient-rich ponds and ditches as well as penetrating slightly brackish-water habitats; mostly free floating or unattached and loose lying.

**Distribution.** NE Atlantic (Sweden to Spain); NW Atlantic; Mediterranean; Australia.

**Uses and Compounds.** Have antihypertensive [6.176], antimycobacterial [6.177], antioxidant [6.178], antibacterial [6.179, 180], antialgal [6.179], piscidal [6.179] activity, and possible use for biodiesel production [6.181, 182].

***Cladophora glomerata* (Linnaeus) Kützing**  
**Description.** Plants were up to 20 cm high and light to dark green in color. The texture of thallus was soft and slightly mucilage. Plants usually formed in dense tufts well branched. Rhizoids were primary and adventitious

and descend from the bases of thallus or from the lower segments of the fronds. Primary branches fused together or not and branched in dichotomous manner. The old branches in the lower portion of the thallus were slight constricted articulations ( $80\text{--}150\ \mu\text{m}$  in width and  $160\text{--}900\ \mu\text{m}$  in length) and usually branched in dichotomous manner. The branches in the upper portion of thallus were cylindrical ( $60\text{--}120\ \mu\text{m}$  in width and  $100\text{--}600\ \mu\text{m}$  in length) and branched in dichotomous or trichotomous manner [6.183].

**Habitat.** Growth of *C. glomerata* usually requires hard substrates for attachment, such as rocks, mussels, and artificial reef structures.

**Distribution.** Distributed widely around world; NE Atlantic (Sweden to Portugal); NW Atlantic (Canada to Cuba and Mexico); SW Atlantic (Brazil); Mediterranean; Indian Ocean, Pacific.

**Uses and Compounds.** Used on the treatment of burns [6.184], biosorption of heavy metals [6.185], animal feed [6.186], biodiesel production [6.187], wastewater treatment [6.188], and as food [6.189]. Have antibacterial [6.190–192], antiprotozoal [6.193], antioxidant [6.190, 194], and antifungal activity [6.192, 195].

***Cladophora pellucida* (Hudson) Kützing**  
**Description.** Filaments rigid, erect, setaceous, full dark green, di-tri-chotomous; the axils very acute, the branches erect; articulations many times longer than broad; dissepiments only at the forking of the branches and ramuli [6.196].

**Habitat.** On the bottoms and sides of deep rock pools, between tide marks, generally near low-water mark.

**Distribution.** NE Atlantic (from Ireland and Britain to Morocco); Mediterranean; SW Atlantic (Brazil); NE Atlantic (South Africa); Indian Ocean (India); Australia.

**Uses and Compounds.** Have antitumor [6.197] activity.

***Cladophora prolifera* (Roth) Kützing**  
**Description.** Unattached or basally attached coarse filaments those are usually less than 0.5 mm wide and 3–5 cm long. The filaments are formed of a single row of often swollen cells; if attached then by a discoid base or by rhizoidal outgrowths [6.198].



**Fig. 6.9** Herbarium specimen of *Cladophora rupestris* (MACOI no. 2419)

**Habitat.** Grow fixed to rocks in the upper sublittoral zone.

**Distribution.** NE and E Atlantic (from Ireland and Britain to Senegal); Mediterranean; NW and SW Atlantic; SE Atlantic; Indo-Pacific Oceans; Australia.

**Uses and Compounds.** Used on experimental coculture [6.199]. Have antimicrobial [6.96, 200–203], antifungal [6.200, 204], antiviral [6.103], antioxidant [6.65, 205], and anticoagulant [6.206] activity.

#### *Cladophora rupestris* (Linnaeus) Kützing

**Description.** *C. rupestris* is a densely tufted plant, darkgreen, which grows up to 20 cm in height, with dark green or bluish colored dull fronds. Typical specimens branch profusely upward from the base, in an irregular, whorled or opposite pattern. The stoutness, density, and arrangement of branches give the seaweed a coarse feel (Fig. 6.9).

The morphology of the species is fairly constant over a wide range of habitat conditions and over a wide geographical area. Its morphology is affected by physical damage due to grazing by animals and loss of the apical region on reproduction; both instances are followed by regeneration and proliferation of branches. *C.*

*rupestris* sometimes forms an almost complete cover of stunted growth at high tide level and occasionally in the splash zone where pools are brackish. Filaments are short and branching dense in the most wave exposed locations [6.1, 32].

**Habitat.** On solid substratum, in all littoral zones, prefers sandy locations in the lower littoral, tolerant to reduced salt content of seawater.

**Distribution.** NE Atlantic (Scandinavia to N Africa), North Sea and Baltic; Mediterranean; NW Atlantic; NW Pacific (Japan) and SW Pacific; Subarctic.

**Uses and Compounds.** Contains arabinose, carotenoids, galactose, glucose, polysaccharides, protein, rhamnose, sulfuric acid, and xylose [6.207, 208]. Used for animal feed [6.209], and CO<sub>2</sub> bioremediation [6.210]. Have antimicrobial [6.130, 211], antimycobacterial [6.212], antiprotozoal [6.212], cytotoxic [6.212], and antifouling [6.213] activity.

#### ● Order: Ulvales

##### *Ulva clathrata* (Roth) C. Agardh

**Synonyms.** *Enteromorpha ramulosa* (Smith) Carmichael, *Enteromorpha clathrata* (Roth) Greville.

**Common Name.** Aonori.

**Description.** Plants less than 30 cm long and soft; thallus repeatedly branched in all directions, cylindrical or compressed with narrow branchlets as much as 40 cm long, light green in color, plants grow first attached to the substratum but later become free floating; cells of the thallus more or less quadrangular in shape with a single cup-shaped chloroplast; pyrenoids 3 to 4.

This species forms tufts, bright green, composed of branched axes, which can reach several centimeters long (20–30 cm). The main axis and branches are covered with conical branchlets very characteristic [6.1].

**Habitat.** In rocks and stones, from mid-littoral to sublittoral.

**Distribution.** Entire Atlantic, Mediterranean, Caribbean (Cuba, Mexico), NE and NW Pacific, Australia and New Zealand.

**Uses and Compounds.** Used as biofilter on shrimp (*Litopenaeus vannamei*) aquaculture [6.214], on shrimp feed [6.215, 216], and for human food [6.4, 217]. Have

antibacterial [6.96, 218–220], anticoagulant [6.221], antifungal [6.217], antiprotozoal [6.123, 218], larvicidal [6.222], analgesic [6.218], anticancer and antiviral [6.217, 218] activity.

#### *Ulva compressa* Linnaeus

**Synonym.** *Enteromorpha compressa* (Linnaeus) Nees.

**Common Names.** Green nori, Plat darmwier.

**Description.** *U. compressa* is a green seaweed that can have one of two different growth forms. The first is a flat, narrow sheet with ruffled edges, and the second form (often referred to as *Enteromorpha compressa*) is a hollow tube of tissue, rounded at the top. In both forms the sheets of tissue are very thin; in fact they are exactly one cell thick. Several blades or tubes arise from a common attachment point and can grow up to 200 mm long. *U. compressa* is a shallow water species and is often found in tide pools or on rocks in the intertidal and shallow infra-littoral up to 3 m deep. As a common tide-pool species, *U. compressa* is able to withstand great swings in salinity, temperature, and pH [6.223, 224].

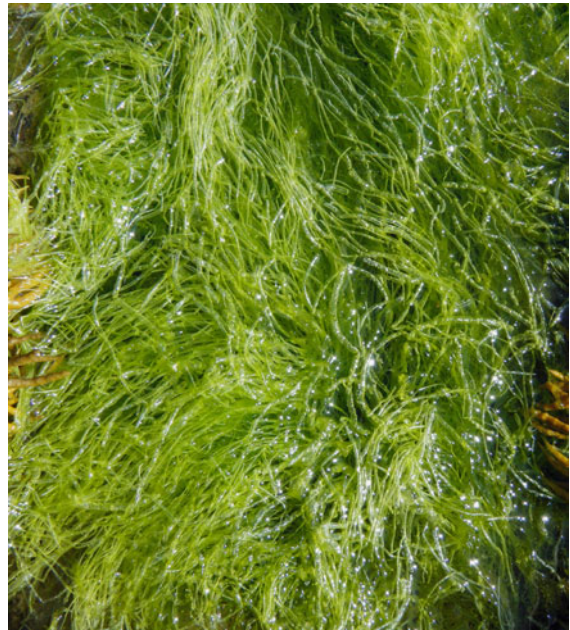
**Habitat.** Marine and estuarine species, rock pools and sandy rocks, particularly in places with widely varying salinities such as upper-shore species.

**Distribution.** *U. compressa* is widely distributed, found commonly on the NE Atlantic coasts, Pacific coast of North America, throughout the Mediterranean, and also in Africa and Australia.

**Uses and Compounds.** *U. compressa*, in the same family as *sea lettuce* is a commonly eaten as a sea vegetable, used fresh or dried for both human and animal consumption for its high nutrient levels and good taste; is used dried in cooking, particularly with eggs [6.109, 223, 224]. This seaweed is also utilized as fertilizer to introduce a wide range of minerals to the soil. Many benefits have been associated with *U. compressa* consumption such as cytotoxic [6.225], antimicrobial [6.96, 171, 224, 226–230], antiviral [6.224], and antioxidant [6.224, 225, 231–234] properties. Extracts of *U. compressa* are also added to cosmetics products for a soothing quality that reduces skin itchiness and tautness [6.224].

#### *Ulva fasciata* Delile

**Description.** Thalli thin, sheet-like, up to 50 cm long, consisting of wide blades, 10 – 15 cm wide at base, tapering upward to less than 2.5 cm wide at tip. Basally broadened, but the upper portions divided deeply into many ribbon like segments; margins smooth, often undulate. Holdfast is small without dark rhizoids. Bright grass-green to dark green, gold at margins when reproductive, may be colorless when stressed [6.32, 235].



**Fig. 6.10** *Ulva intestinalis* specimens

**Habitat.** *U. fasciata* is a common species in the intertidal to shallow infra-littoral, often found in tide pools. This species is a quick colonizer and is able to grow very quickly in the right conditions, often reaching bloom levels in the presence of nutrient run-off and fresh water input [6.236].

**Distribution.** *U. fasciata* has a worldwide distribution in temperate and tropical waters: NE Atlantic; Mediterranean; Caribbean; West coast South Africa; SW Atlantic; entire Pacific; Indian Ocean; Australia, New Zealand.

**Uses and Compounds.** *U. fasciata* is a popular edible seaweed in many areas where it grows, such as Hawaii where it is known as *limu palahalala*. *U. fasciata* has a very fine texture and lovely fresh taste and is often chopped into salads or used as a relish, though it can also be cooked and used in soups [6.236]. Green algae extracts are also very nutrient rich and

are a wonderful addition to natural cosmetic products. Have antiviral [6.237, 238], algicidal [6.239, 240] antifungal [6.241] larvicidal [6.242], cytotoxic [6.242], antifouling [6.243], antibacterial [6.241, 242, 244–247], antioxidant [6.246] activity.

#### *Ulva intestinalis* Linnaeus

**Synonym.** *Enteromorpha intestinalis* (Linnaeus) Nees.

**Common Name.** Gut weed.

**Description.** *U. intestinalis* is a conspicuous bright grass-green seaweed, consisting of inflated irregularly constricted, tubular fronds that grow from a small discoid base (Fig. 6.10). Fronds are typically unbranched. They may be 10–30 cm or more in length and 6–18 mm in diameter, the tips of which are usually rounded. Like other members of the genus, *U. intestinalis* is a summer annual, decaying and forming masses of bleached white fronds toward the end of the season [6.1, 32].

**Habitat.** In sheltered as well as exposed locations, on boulders, breakwaters and piers, in pools, also epiphytically; from the upper littoral (also supra-littoral) pools into the sublittoral.

**Distribution.** More or less globally distributed: entire Atlantic, Mediterranean, Caribbean, NE and NW Pacific, Indian Ocean, Australasia, Antarctica.

**Uses and Compounds.** This species is used as human food [6.4] and animal feed [6.248, 249], for biomonitoring of heavy metals [6.250, 251], have antimicrobial [6.86, 96, 252, 253], antifungal [6.252], antitumor [6.254, 255], antihemolytic [6.253], larvicidal [6.256], antifouling [6.257], antiplasmodial [6.258], antiprotozoal [6.259], algicidal [6.260], and antioxidant [6.261–263] activity.

#### *Ulva lactuca* Linnaeus

**Common Names.** Sea lettuce, Green laver.

**Description.** *U. lactuca* is commonly called sea lettuce. Its color can range from light yellowish green to darker green, but is most commonly a vivid green underwater. When exposed at low tide or when washed up on a beach, it is typically darker green. Out of the water the seaweed looks like a rather slimy lime-green mass but in the water the alga actually does look very

much like young lettuce leaves. *U. lactuca* is vivid green and cellophane thin (only two cell layers thick), and forms light yellowish green to dark-green translucent sheets. The soft frond grows as a single, irregular, but somewhat round-shaped blade with slightly ruffled edges which are often torn. There can be numerous small holes or perforations scattered throughout. The frond is connected to rocks with a small, almost invisible discoid holdfast, and does not have a stipe. *U. lactuca* may grow to a diameter of 20–30 cm, although it is frequently much smaller, with larger sheets feeling slightly thicker than smaller specimens [6.1, 32, 264].

**Habitat.** From the tidal zone to the sublittoral, often free floating in pools.

**Distribution.** *U. lactuca* is ubiquitous, common to most shorelines around the world.

**Uses and Compounds.** *U. lactuca* is available in different forms from companies in countries which include the UK, Ireland, France, Germany, Vietnam, China, Canada, and the United States. It is sold both in fresh and dried form, in flakes, powders, and salad mixes. It is a delicate seaweed with a mild flavor. *U. lactuca* is sometimes eaten as *green laver*, but it is considered inferior to *purple laver*. It is used as a seasoning by itself and in blends, and can be found in soups and salads [6.32]. This species is also used in animal feed [6.265]. It also a key ingredient in many cosmetic and personal care items such as soap, lotion, toner, lifting cream, eye cream, lip cream, makeup remover, body polish, bath soaks, antiaging products, shaving lotion, shampoo, conditioner, and serums [6.264, 266]. It is also a component in gardening and fertilizer products [6.3].

This species have antioxidant [6.267, 268], antibacterial [6.70, 72, 115, 145, 171, 228, 269–271], antitumor [6.72, 126], anti-inflammatory [6.272], antifouling [6.115, 273], antifungal [6.72, 115], antiviral [6.72, 263], antialgal [6.115] activity.

#### *Ulva linza* Linnaeus

**Synonym.** *Enteromorpha linza* (Linnaeus) J. Agardh.

**Common Names.** Breed darmwier, Bright grass kelp, Welded green nori.

**Description.** *U. linza* is a large, ribbon-like species of green seaweed that may reach up to 30 cm in length.

The thalli are unbranched and often have a frilled margin. The thalli taper into a distinct stipe below and are highly compressed. The width of the thallus is greater in the middle than at the base and may reach 5 cm in width. *U. linza* is bright light to dark green in coloration [6.32, 274].

**Habitat.** Usually found on rocks or in rock pools, usually marine but occasionally found under brackish conditions.

**Distribution.** *U. linza* is found worldwide in bays and sheltered coasts.

**Uses and Compounds.** *U. linza* is used as an edible seaweed in many cultures for its high nutrient content and silky texture. Green algae extracts are also very nutrient rich and make a beneficial addition to natural cosmetic products [6.274]. Have antibacterial [6.60, 96, 228, 269, 275, 276], anti-inflammatory [6.277], and antiviral [6.278].

#### *Ulva prolifera* O.F. Müller

**Synonym.** *Enteromorpha prolifera* (O.F. Müller) J. Agardh

**Common Name.** Green ribbon plant.

**Description.** The fronds are tubular, though often more or less flattened, little to much branched. The arrangement of the cells, in longitudinal and transverse rows in the central part of the frond, is characteristic of this species, as are the cylindrical chloroplasts seeming to fill the cell and the usually single, central pyrenoids [6.279].

**Habitat.** A common green alga near the top of the shore, on rocks or other algae, on open coasts or in estuaries and harbors, where it may grow mixed with *U. intestinalis* or other species of the same genus.

**Distribution.** NE Atlantic (Britain to Senegal); Atlantic Islands, Mediterranean; NW and W Atlantic; Caribbean; SE Atlantic; Pacific; China, Australia.

**Uses and Compounds.** Used for food [6.280] and animal feed [6.281, 282]; potential use for the production of biofuels [6.283]. Have also antibacterial [6.171, 284], antifouling [6.285], antioxidant [6.101], antifun-

gal [6.226, 286], antitumor [6.126], immunomodulatory [6.287] activity.

#### *Ulva rigida* C. Agardh

**Common Name.** Green laver.

**Description.** *U. rigida* is a bright green seaweed with a variety of growth forms. The two cell layer thick, sheet-like blades can grow as tiny blades forming carpet-like turfs, or as clumps of several larger blades, or solitarily. In its largest form, *Ulva rigida* can reach up to 10 cm in height, but size and blade shape are both highly variable. Blades may be flat or ruffled, sometimes bearing many small holes (perforations) and sometimes not. However, the defining characteristics of *U. rigida* are common among all its growth forms: the two cell layers of the blades are easily separable, like a deflated balloon, and the holdfasts are composed of many small, tough, dark rhizoids that are absent in other *Ulva* species. *U. rigida* is common in intertidal and shallow sublittoral waters, often found in tidepools. This seaweed is able to withstand high variation in salinity and water chemistry and actually seems to prefer areas with freshwater input [6.32, 288].

**Habitat.** Epilithic, in the entire littoral zone to the sublittoral.

**Distribution.** *U. rigida* has a worldwide distribution in temperate and warm seas.

**Uses and Compounds.** *U. rigida* is often utilized as a fresh sea vegetable by many island cultures for its high nutrient content and fresh taste [6.288, 289]. This species is used to for animal feed [6.290, 291].

Green algae extracts are also very nutrient-rich and make a beneficial addition to natural cosmetic products. The polysaccharide ulvan is easily extracted from *U. rigida*. It is composed of  $\beta$ -(1,4)-xyloglucan, glucuronan, and cellulose in a linear arrangement. It corresponds to a water-soluble dietary fiber and is resistant to both human digestive tract enzymes and degradation by colonic bacteria. This polysaccharide cannot therefore be considered prebiotic; however, it could potentially be hydrolyzed to bioactive oligosaccharides [6.288, 292].

*U. rigida* have antigenotoxicity [6.293, 294], anti-hyperglycemic [6.293], immunomodulating [6.295],



antibacterial [6.201, 296–300], antioxidant [6.300–302], antileishmanial [6.303] activity.

*Ulvaria obscura* (Kützing) Gayral

**Synonym.** *Monostroma obscurum* (Kützing) J. Agardh

**Description.** Thallus widely bladed, similar to that of *Ulva*, turning brown on dying; monostromatic blade; occurring not often; bipolar species [6.304].

**Habitat.** In sublittoral, at 3–17 m depth.

**Distribution.** NE Atlantic (Iceland and Norway to Portugal); Atlantic Islands; NW Atlantic (Alaska and Greenland to Washington); SW Atlantic (Argentina).

**Uses and Compounds.** *Ulvaria obscura* produces a dopamine that functions as antiherbivore defense [6.305, 306], and flavonoids with protective effect action against free radicals, protecting collagen surrounding of blood vessels. This species have antioxidant [6.307] activity.

- Order: **Ulotrichales**

*Gayralia oxysperma* (Kützing) K.L. Vinogradova

**Synonym.** *Monostroma oxyspermum* (Kützing) Doty

**Description.** Thalli forming leafy monostromatic blades from a few centimeter to a meter or more in length. Cells in the upper portion of blade polygonal and isodiametric, becoming more elongate toward base with long rhizoidal projections in holdfast region. In surface view, cells in groups of two or four; cells uninucleate with parietal chloroplast and single prominent pyrenoid traversed by thylakoids [6.32, 308].

**Habitat.** On rocks, boulders or on other seaweeds, older free floating; common through the entire littoral to sublittoral boundary, preferably in sheltered sites; tolerant to changing salinity.

**Distribution.** European coastlines (Atlantic, North Sea and Baltic); Atlantic coasts of North, Central and South America; Caribbean; East Pacific coastlines (Alaska to California), Japan, Mauritius, S Australia.

**Uses and Compounds.** Consumed as green vegetable (SE Asia, China) and used for animal feed [6.32, 109]. Have antiviral activity [6.309].

### 6.3.3 Domain/Empire Eukaryota, Kingdom Plantae, Phylum Rhodophyta (Red Algae)

- Class: Bangiophyceae
- Order: **Bangiiales**

*Bangia fuscopurpurea* (Dillwyn) Lyngbye

**Description.** Gelatinous, unbranched, blackish-purple filaments, at first uniseriate later multiseriate, attached by rhizoidal outgrowths from basal and adjacent cells; cells with central star-shaped rhodoplast with pyrenoid [6.310].

**Habitat.** On rocks, wood, etc., as fleecy mat, especially at high tide level on exposed coasts in autumn and winter, disappearing in spring or early summer, at other times present as sparse filaments.

**Distribution.** NE Atlantic (Iceland to Senegal)); W Atlantic (Brazil and Argentina); Caribbean; W Pacific (Japan, China); NE Pacific (California, Mexico); Indo-Pacific/Indian Ocean; Australia.

**Uses and Compounds.** Consumed as vegetable [6.310]. Have antioxidant, antibacterial, antiviral, cytotoxic [6.205, 311] activity.

*Porphyra leucosticta* Thuret

**Synonym.** *Pyropia leucosticta* (Thuret) Neefus & J. Brodie

**Description.** Delicate membranous monostromatic reddish-brown fronds, becoming pink on drying, to 150 mm long, with very short stipe from basal holdfast [6.1, 2, 312].

**Habitat.** Usually epiphytic on larger algae, littoral to shallow sublittoral, spring to autumn, widely distributed, common.

**Distribution.** NE Atlantic (Norway to Portugal); Mediterranean; NW Atlantic (Canada and USA); SW Atlantic (Brazil); SE Atlantic (Angola).

**Uses and Compounds.** Produces high percentage of vitamin C and natural carotenoids, and therefore *P. leucosticta* could become a valuable source of raw material to obtain such compounds, which have mul-

multiple uses in the pharmaceutical field, cosmetic and food industry [6.313]; used for food [6.3, 314], and for IMTA aquaculture [6.315]. Extracts have high antioxidant [6.316], and low antiprotozoal, antimycobacterial, and cytotoxic [6.317] activity.

#### *Porphyra linearis* Greville

**Description.** Delicate, linear, membranous, purple-brown fronds, 20–40 mm (–200) mm long and 5–10 (–25) mm broad, usually simple with short stipe from basal holdfast; orange patches when reproductive [6.1, 318].

**Habitat.** Marine species, zone forming on rock in the upper intertidal and splash zone of semiexposed and exposed shores, generally distributed; a winter and spring annual appearing on semiexposed and exposed.

**Distribution.** Recorded throughout Northern Europe, from Norway to Portugal, Azores. Canada (Labrador) to USA (at least Connecticut).

**Uses and Compounds.** Used for food [6.3, 4, 319, 320], and for aquaculture [6.321–323]. Extracts have antimicrobial activity [6.130].

#### *Porphyra umbilicalis* (Linnaeus) Kützting

**Common Names.** Purple laver, Pink laver, Laver, Nori.

**Description.** A red alga (up to 40 cm across) with a circular (*P. umbilicalis*) or irregularly shaped (*P. leucosticta*), broad frond that is membranous but tough (Fig. 6.11). The plant attaches to rock via a minute discoid hold-fast, is greenish when young gradually changes into purplish red, and has a polythene-like texture. Another species is the *P. linearis*, with narrow stem that attaches the base and appears mainly in winter [6.1, 324, 325].

**Habitat.** On rocks, mussels, etc., in the littoral to splash zone, generally distributed, abundant, especially on exposed coasts.

**Distribution.** *P. umbilicalis* occurs in the North Atlantic. In the east, it is found in Iceland and has been recorded from Norway to Portugal and in the Western Mediterranean. In the West, *P. umbilicalis* is found from Labrador in Canada to the mid-Atlantic coast of the United States.



**Fig. 6.11** Herbarium specimen of *Porphyra umbilicalis* (MACOI no. 110)

**Uses and Compounds.** *P. umbilicalis* is rich in protein, vitamins A, C, E, and B, and trace minerals, and also rich in omega-3 polyunsaturated fatty acids (EPA and DHA). It contains special compounds named *mycosporine-like amino acids* (MAAs) which are valuable in certain types of personal care products. Some of the favorable properties associated with compounds from *P. umbilicalis* are that it [6.3, 324, 325]: acts as a natural bio-protector against UVA-induced damage; prevents the formation of *sun burn cells* and premature photo-aging; protects cell structures, especially membrane lipids and DNA from damage by UV-induced radicals; helps in the re-equalization of lipid deficient skins; increases epidermal hydration; protects against *Trans Epidermal Water Loss*; improves intercellular cohesion; reinforces the skin barrier function; restores cell membrane structure after irritant damage; has oxygenating properties that helps revitalize stressed and fatigued skin; able to diminish the appearance of fine lines and wrinkles.

As a result, it is used in many different product applications, such as [6.325, 326]: antioxidant; daily UV protective skin care, sun care; anti-photo-aging care; cares for dry, reactive and sensitive skins; lip care; after sun care.

Specific products identified so far from France, Ireland, Italy, Spain, and United States utilizing *P. umbilicalis* include regenerating face creams and antiaging facial creams, facial masks, and aftershave balm. For food, it is sold in flaked and whole leaf form, as a nori substitute, as laver, and is used as an ingredient in several snack mixes and condiments. It is also used as a pet nutrition supplement [6.3, 4, 320, 325].

- Class: Florideophyceae
- Order: **Ahnfeltiales**

*Ahnfeltia plicata* (Hudson) E.M. Fries

**Description.** Perennial red seaweed which forms dense, tangled tufts (Fig. 6.12). The fronds are very fine, tough, and wiry with irregular or dichotomous branching and up to 21 cm in length. The holdfast is disk-like or encrusting, 0.5–2 cm in diameter. The fronds are dark brown when moist and appear almost black when dry. The uppermost branches are often green [6.327].

**Habitat.** On rocks, mid-littoral to sublittoral, especially common on sand-covered rocks, widely distributed, common.

**Distribution.** N and NE Atlantic (Greenland to Azores); SW Atlantic (Uruguay); NE Pacific (Alaska to Mexico); NW Pacific (Russia); SE Pacific (Chile); Indian Ocean; Antarctica and the Sub-Antarctic Islands.

**Uses and Compounds.** A source of so-called *Russian Agar* (agar of high quality and low sulfate content) [6.32, 328, 329]. *A. plicata* is one of the major seaweeds harvested for commercial colloid production as it produces a very high quality, low sulfate and used for many purposes. It forms a major component of Asian cooking, often showing up in soups and jellies.



Fig. 6.12 *Ahnfeltia plicata* specimens

As a nonanimal derived thickening agent, *A. plicata* is also widely used for vegan products (such as marshmallows, gummy bears, cosmetics, etc.) in place of gelatin [6.330].

- Order: **Bonnemaisoniales**

*Asparagopsis armata* Harvey

**Common Names.** Harpoon weed, Harpoon-alga.

**Description.** Thallus of the gametophyte tufted, main axes cylindrical, denuded at the base, densely tufted apically, tufts with pyramidal outline, forming lateral brush-like tassels; some lateral branches develop into unbranched, elongated-pointed harpoon-like anchoring structures covered with barbed hooks (a characteristic feature of the species) which are usually pinnately arranged (Fig. 6.13). The tetrasporophyte (*Falkenbergia*



Fig. 6.13 Underwater photo of *Asparagopsis armata*

phase) is small, almost spherical tufts (similar to cotton balls) of multiseriate branching threads (microscope required) [6.32].

**Habitat.** Both phases readily reproduce vegetatively. Drift specimens of gametophyte readily attach to other algae by barbed branchlets, and produce new shoots; introduced from Southern Hemisphere [6.331].

**Distribution.** *A. armata* is native to the Southern Hemisphere (Australia and New Zealand) but has been introduced to the Northern Hemisphere, first recorded in Europe in 1925 and since spreading throughout the Channel Islands and all around Great Britain. *A. armata* is now found globally, from the Canary Islands to Morocco and throughout the Pacific and Indian Oceans [6.32, 331].

**Uses and Compounds.** *A. armata* extract is a powerful antioxidant with antibacterial qualities and is a valued ingredient in many cosmetic products. Present strong cytotoxicity against human cancer cell lines [6.62, 316, 332]. *A. armata* is also harvested or grown for the production of phycocolloid [6.333, 334].

The species has also been examined for its potential as a source of pharmaceutical and bioactive agents since its extracts contain anti-*Leishmania* [6.335], antioxidant [6.336], antiviral [6.337, 338], antifungal [6.62], antimicrobial [6.62, 336, 339, 340] compounds.

### *Asparagopsis taxiformis* (Delile)

Trevisan de Saint-Léon

**Common Name.** Cat's tail red seaweed.

**Description.** Thallus fluffy, fine, filamentous creeping mats or tufts, to 4 cm high, pale red to gray-pink; branching irregular to alternate. Branches cylindrical, occasionally moniliform (with segments swollen or bead-like), 30–80  $\mu\text{m}$  diameter, central axial filament surrounded by 3 pericentral cells; cells commonly pointed at tips, twice as long as broad, each set rotated approximately 60°; apex with single prominent apical cell cutting off lens-shaped cell basally; holdfast initially disk-like, later becoming branched, tangled, creeping, forming filamentous mass. Tetrasporangia solitary on outer filaments, not in groups or series, formed from one pericentral cell of segment. Fluffy appearance and shaped like a Christmas tree. Grows 3–15 cm high [6.32, 341].

**Habitat.** A tropical/subtropical species; thalli are epilithic; in shallow sublittoral habitats with heavy water motion.

**Distribution.** Globally distributed in tropical and subtropical seas: E Atlantic (Azores, Madeira, Canary Islands, W Africa, Cape Verde Islands to Nigeria); W Atlantic (Brazil); Caribbean; W Pacific (Japan, China); NE Pacific (California, Mexico); Pacific Islands (Hawaii); Indo-Pacific/Indian Ocean; Australia, New Zealand.

**Uses and Compounds.** The species has been examined for its potential as a source of pharmaceutical and bioactive agents since its extracts contain antifouling and anticyanobacterial [6.342], antifungal [6.341], anticoagulant [6.343], and antimicrobial [6.341, 344, 345] compounds.

Used fresh in Hawaii as *limu koku* (generic name for seaweed) to flavor meat and fish dishes [6.341, 346].

### *Bonnemaisonia hamifera* Hariot

**Common Names.** Bonnemaison's Hook Weed; Pink cotton wool.

**Description.** Gametophyte plants occurring from March–June, brownish red, fronds feathery, with a slightly flattened axis to 1 mm wide and 350 mm long, attached to *Cystoseira* and other algae by crosier-shaped, hook-like modified branches. Tetrasporophyte (*Trailiella* phase) plants occurring all year round, but most obvious in October–March, brownish red, much branched, filamentous, in dense cotton-wool-like tufts to 25 mm in diameter [6.347].

**Habitat.** Probably introduced from Japan at the end of the last century; gametophyte first found in Europe (Isle of Wight) in 1893, on rocks and other algae, lowest littoral and sublittoral.

**Distribution.** NE Atlantic (Scandinavia to Canary Islands); SE Atlantic (South Africa); Mediterranean; NW Pacific (Russia, Japan); NE Pacific (California, Mexico).

**Uses and Compounds.** Extracts of this species have antibacterial [6.348, 349], antioxidant [6.350], and anti-hypertension [6.351] activity.

- Order: **Ceramiales**

*Alsidium helminthochorton*  
(Schwendimann) Kützing

**Common Name.** Corsican moss.

**Description.** Upright radially organized polysiphonous thalli, up to 15 cm high, with cylindrical axes and progressively narrower distal branches. Branch apices abruptly tapering; trichoblasts spirally arranged on axis, present on every segment but soon deciduous; parenchymatous cortication occurs to near branch apex 6–8 pericentral cells. Lateral polysiphonous branches originate from trichoblast basal cell [6.352].

**Habitat.** Found on calm, shallow, photophilic biotopes.

**Distribution.** Mediterranean.

**Uses and Compounds.** In Mediterranean, the Greek physician, Stephanopoli, discovered in 1775 that the red seaweed *Alsidium helminthochorton*, found on the rocky shores of Corsica, have an efficient anthelmintic action [6.353–355].

*Boergesenella thuyoides* (Harvey) Kylin

**Description.** Cylindrical, cartilaginous, tufted, deep brownish-purple fronds, to 150 mm high, from creeping rhizoidal base; fronds distichously bi-tripinnate, patent, short, of nearly uniform length giving branches a linear appearance; ramuli short, spinelike; polysiphonous, central siphon with 8–12 pericentral siphons and outer cortication of small, colored cells; articulations as broad as long, barely visible [6.356].

**Habitat.** On rock and epiphytic in shallow, wave-exposed pools in lower intertidal.

**Distribution.** NE Atlantic (Ireland and Britain to Morocco).

**Uses and Compounds.** Extracts of this species have antiviral [6.337, 357], and antibacterial [6.358] activity.

*Bornetia secundiflora* (J. Agardh) Thuret

**Description.** *B. secundiflora* is dark red in color, firm and rigid when fresh. The thallus is 5–20 cm high when erect, fan shaped with blunt tips (apices), much branched and tufted, with branches often curved

over. The plant has a jelly-like texture. Branches are sparse at the base becoming denser toward the apices [6.359].

**Habitat.** *B. secundiflora* grows on boulders and bedrock, often under overhangs, from just below extreme low water to 3 m depth. It tolerates sand on rocks and moderately to extreme wave exposure.

**Distribution.** NE Atlantic (England to the Canary Islands, W Africa); Mediterranean.

**Uses and Compounds.** Extracts have antifouling activity [6.360, 361].

*Bostrychia scorpioides*  
(Hudson) Montagne

**Description.** Frond flexuous, dull purple, filiform, much branched, inarticulate, dotted, subdichotomous; the branches three or four times pinnated; pinnae and pinnulee patent; apices strongly rolled inward [6.362].

**Habitat.** On muddy shores near high-water mark, on lower stems of saltmarsh flowering plants, widely distributed, locally abundant.

**Distribution.** Atlantic shores of Europe, from England to Spain.

**Uses and Compounds.** Produces Sorbitol; the polyol sorbitol is known to occur naturally in the Rosaceae family especially in *Sorbus aucupria* and in the algae, e.g., *Bostrychia scorpioides*. It is used in the pharmaceutical industry for the treatment against constipation and it known to stimulate vascular contraction as well. Its use in the cosmetics industry, especially in the manufacture of toothpaste is an example of a well established use of carbohydrate and its derivatives in this sector [6.363].

*Brongniartella byssoides*  
(Goodenough & Woodward) F. Schmitz

**Description.** Soft, tufted, deep purplish red fronds, to 300 mm long; main axis well-defined, bi- or tripinnate, bearing alternate, distichous branches. Branches and branchlets articulated, with central siphon and 5–7 pericentral siphons, clothed with short, slender, repeatedly dichotomously branched, monosiphonous ramuli. Its color is light red brown to almost black when dry [6.32, 364].

**Habitat.** On stones and shells and epiphytic, lower littoral and sublittoral, spring and summer, generally distributed, common in NE Atlantic.

**Distribution.** NE Atlantic (Scandinavia to Portugal, North Sea, E Baltic Sea), Mediterranean Sea.

**Uses and Compounds.** Great antioxidant potential; strong cytotoxicity against human cancer cell lines [6.316].

*Ceramium virgatum* Roth

**Synonym.** *Ceramium rubrum* C. Agardh.

**Common Names.** Hornweed, Red hornweed.

**Description.** Small red seaweed growing up to 30 cm tall. It has a filamentous frond that is irregularly and dichotomously branched, with the branches narrowing toward pincer-like tips. The holdfast is a minute conical disk that extends into a dense mass of rhizoidal filaments. The plant is reddish brown to purple in color and has a banded appearance when viewed closely [6.1, 365].

**Habitat.** *C. virgatum* is both epilithic and epiphytic, often growing on the stipes and fronds of *Fucus* spp., *Mastocarpus stellatus*, and *Laminaria hyperborea* as well as on the leaves of *Zostera marina*.

**Distribution.** *C. virgatum* is common worldwide from the Americas to Europe (Atlantic), through the Mediterranean, down to South Africa, Asia, and Antarctica.

**Uses and Compounds.** *C. virgatum* is used as an extract for cosmetic products [6.313, 366], produces an agar-type polysaccharide [6.367], and have antiviral [6.368], antibacterial [6.276, 369–371], antioxidant [6.372], antialgal [6.373], antiprotozoal, antimycobacterial and cytotoxic activity [6.317].

*Chondria capillaris* (Hudson) M.J. Wynne

**Synonym.** *Chondria tenuissima* (Withering) C. Agardh

**Description.** Thallus bushy, vivid purple to pale yellowish red, upright cylindrical main axes cartilaginous-firm, with numerous long, softer irregularly spirally arranged lateral axes, branching to the fourth degree; the recent branches also stand rather loosely, spindle-shaped tapering at both ends, the apices



**Fig. 6.14** *C. coerulescens* specimen (note the blue iridescence in water)

pointed and crowned by hair-thin filamentous tufts (magnifying glass required); plants with reproductive bodies appear more densely branched peripherally; discoid holdfast, on prostrate axes additional rhizoids [6.32].

**Habitat.** On rocks, pebbles, and shells, in shallow water at wave-protected sites, at depths to about 6 m.

**Distribution.** NE and E Atlantic, Mediterranean, Caribbean, Indian Ocean (India, East Africa, Mauritius).

**Uses and Compounds.** Extracts have antioxidant and vermifuge [6.335] activity.

*Chondria coerulescens* (J. Agardh) Falkenberg

**Description.** *C. coerulescens* has bluish or yellowish fronds with blue iridescence (Fig. 6.14). The fronds are flexible and cartilaginous in texture, turning black when dry. Young axes show a striking turquoise iridescence when alive; the thalli consist of cylindrical erect axes or trailing tufts, and is 3–8 cm high when erect. The distinct main axis is 0.4–0.5 mm in diameter, branching sparsely at irregular intervals in a spiral pattern to 1–3 orders of branching. Branches are linear, often long and curve downward gradually tapering to a slender point, and reattach by secondary holdfast. The morphology shows relatively little variation except that some thalli consist only of inconspicuous isolated erect axes whereas others form dense tufts [6.1, 374].

**Habitat.** *C. coeruleascens* is a sublittoral species, growing on pebbles in mud from extreme low water to 4 m depth.

**Distribution.** NE Atlantic (Ireland and Britain to Senegal); Mediterranean.

**Uses and Compounds.** Produces hemagglutinins [6.375].

*Chondria dasyphylla* (Woodward) C. Agardh

**Description.** The thallus is 10–21 cm high, reddish brown in color, with the primary erect axis initially arising from a discoid holdfast to 4 mm diameter, subsequently further erect axes arising from the same holdfast giving a clumped appearance. Short creeping branchlets are produced from the lowermost parts of erect axes, and become attached to the substrate by small rhizoidal haptera about 0.5 mm diameter. The thallus branching is irregularly radial, erect-patent with 3–4 orders of branching, ultimate branches arising every two to six (eight) axial cells. Ultimate branchlets are 250–500  $\mu\text{m}$  diameter, the variation being a reflection of the robustness of the plant [6.376].

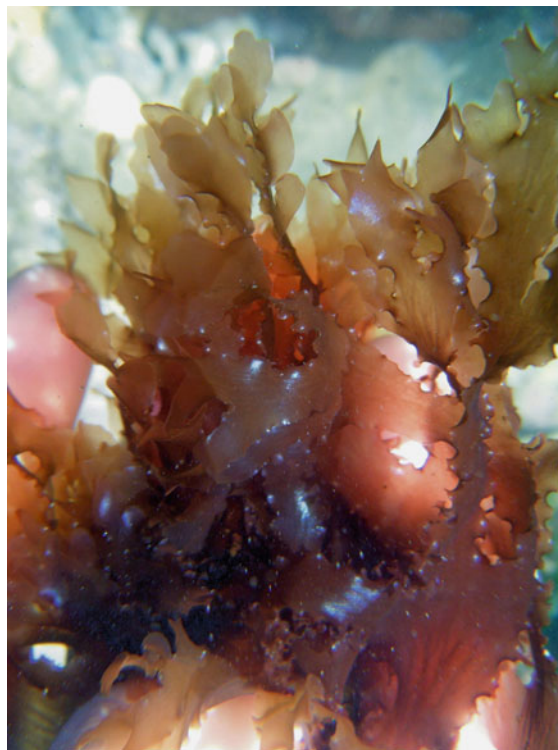
**Habitat.** Usually found in mid-littoral pools.

**Distribution.** NE Atlantic (Ireland to W Africa); Mediterranean, Caribbean, Indian Ocean.

**Uses and Compounds.** According to the results of Khanavi et al. study [6.377], hexane fraction of *Chondria dasyphylla* could contain phytosterols (fucosterol) with cytotoxicity against breast and colon cancer cell line. Extracts of this seaweed have larvicidal [6.378], antibacterial, antifungal, antiprotozoal, antiviral, antifertility, and hypoglycemic [6.218] activity.

*Cryptopleura ramosa* (Hudson) L. Newton

**Description.** A short thallus with a stout midrib arises from a discoid holdfast, widening as it branches into flattened red-brown or red-purple fronds to a height of 20 cm (Fig. 6.15). The fronds are thin and membranous, around 2.5 cm in width and may have a slight blue iridescence under water. Repeated branching gives it a bushy tangled appearance with the branches tapering to rounded tips. Morphology is variable and blades can be either erect or prostrate and broadly wedged or strap shaped. Margins may be smooth, undulating, and den-



**Fig. 6.15** Underwater photo of *C. ramosa*

ticulate or hooked, frequently with a blue iridescence underwater [6.379].

**Habitat.** On rocks and often as epiphyte on stipes of *L. hyperborea*, lower intertidal and sublittoral, generally distributed, common.

**Distribution.** NE Atlantic (Scandinavia to Canary Islands); SW Atlantic (Brazil, Uruguay), Mediterranean Sea.

**Uses and Compounds.** Tested for biodiesel production [6.380]. Have antifouling [6.373], antiviral [6.381], algicidal [6.382], and antifouling [6.361] activity.

*Dasya rigidula* (Kützinger) Ardissonne

**Description.** Present irregular subdichotomous branching; variable cortication among the thallus; ocellate apex; and stichidia with four tetrasporangia per segment. Traditionally, the species of this genus are diagnosed depending on the branching pattern, presence of ocellate apex, and degree of cortication [6.383, 384].

**Habitat.** From the mid-littoral to deep waters.

**Distribution.** NE and E Atlantic (From France to Senegal); Atlantic Islands; West Atlantic; Caribbean; SW Atlantic (Brazil); Mediterranean.

**Uses and Compounds.** Have antibacterial activity [6.60].

*Delesseria sanguinea* (Hudson)

J.V. Lamouroux

**Common Name.** Sea beech

**Description.** Membranous, bright crimson fronds, with cartilaginous, cylindrical, branched stipe, from thickened discoid holdfast, to 300 mm long (Fig. 6.16). Branches bearing spirally arranged, leaflike, ovate-lanceolate blades, each with short stipe and pinnately branched midrib, membranous portion monostromatic, margin undulate (on mature blades), entire; reproductive structures in small oval, stalked blades, borne on midribs in winter [6.385].

**Habitat.** On rocks, in deep shady lower intertidal pools and in the sublittoral.

**Distribution.** NE Atlantic (Scandinavia to Portugal, North Sea, Baltic Sea); Mediterranean (sporadically).

**Uses and Compounds.** *D. sanguinea* is used in the cosmetics industry for its anticoagulant properties and vitamin K content; the active principle being termed



**Fig. 6.16** Herbarium specimen of *Delesseria sanguinea* (MACOI no. 2549)

*Delesseria* [6.386, 387]. Have also anti-inflammatory and antiskin aging [6.387–389] activity.

*Digenea simplex* (Wulfen) C. Agardh

**Description.** Cylindrical axes (1 mm in diameter) rigid, with short secondary branches of the same diameter, carrying dense tufts of thin, straight ramuli; 5–25 cm. Cartilaginous at the apices. Light red (the naked base) to dark red (the branches). The gametophyte and the sporophyte are similar [6.390].

**Habitat.** Found year round in photophyle sheltered biotopes, from surface down to a few meters; frequently covered by epiphytes.

**Distribution.** Worldwide distribution in tropical and temperate waters: Mediterranean (with the exception of the Lion Gulf), tropical Atlantic, Red Sea, and Indo-Pacific.

**Uses and Compounds.** The active agent (Kainic acid), originally isolated in Japan from this species, but now manufactured commercially [6.32], has anti-helminthic activity. The extracts from these red algae have antifungal [6.204] activity.

*Halopithys incurva* (Hudson) Batters

**Description.** Tough, cylindrical, cartilaginous, shaggy, dark red fronds, 250 mm long. Main branches alternate or subdichomous, simple or pectinate in lower parts, much branched above, often curved and hooked. Branches with usually double row of short, pointed ramuli on the upper side, ramuli straight, curved or hooked, slightly narrowed at base; axis of 1 central, 5 pericentral siphons, with several layers of cortical cells, outermost small, colored; articulations visible, shorter than broad [6.32].

**Habitat.** On rocks, mid-littoral pools to subtidal.

**Distribution.** Warmer NE Atlantic (Ireland to Canary Island); Mediterranean.

**Uses and Compounds.** Have antibacterial [6.358, 391, 392], antioxidant [6.393], antitumor [6.394], and antiviral [6.357] activity.

*Heterosiphonia plumosa* (J. Ellis) Batters

**Description.** *H. plumosa* is a red to deep crimson seaweed which appears black when dried. This species has a flattened, fern-like appearance with a hairy thallus



growing from a discoid holdfast. The fronds are flat or slightly cylindrical up to 20 cm in length and 0.5 cm in diameter at the base, tapering toward the apex. The primary branching from the main frond occurs in a single plane, and is alternately, yet irregularly spaced with up to 1 cm between each branch. Each branch is bare at the base, with the rest bearing an irregular and alternately arranged series of smaller secondary branches. The secondary branches are progressively shorter toward the apex, and each branch bears numerous pointed branchlets giving an overall tufted and feather-like appearance [6.395].

**Habitat.** On rocks and epiphytic, low intertidal pools and sublittoral, southern and western shores, common in the south, rare in the north.

**Distribution.** NE Atlantic (Scandinavia to Portugal).

**Uses and Compounds.** Have high antioxidant activity [6.316].

*Hypoglossum hypoglossoides* (Stackhouse)  
F.S. Collins & Hervey

**Description.** Membranous, rose-pink fronds, 20–200 (300) mm long, arising from a discoid base. Frond linear-lanceolate, with well-marked midrib and thin membranous margins, 1–5 (8) mm wide, repeatedly branched irregularly from midrib; fronds with pointed apices, margins without microscopic veins, monostromatic except in midribs [6.396].

**Habitat.** On rocks and epiphytic, lower intertidal and sublittoral to 30 m, most abundant in *L. hyperborea* forests.

**Distribution.** NE and E Atlantic (Scandinavia to Portugal, Azores, Canary Islands, Cap Verde Islands); NW and W Atlantic (North Carolina to West Indies); Mediterranean.

**Uses and Compounds.** Have antimicrobial activity [6.397].

*Laurencia microcladia* Kützing

**Description.** Thallus erect, flexible, soft texture, forming dense tufts up to 15 cm in length. The thallus has greenish-yellow and pinkish apices easily visible. Flaccid consistency does not adhere completely to the herbarium sheet when dry; thalli fully cylindrical with 385–410  $\mu\text{m}$  in diameter; branching irregularly, alter-

nating, dense in the upper two-thirds of the plant, to three branching orders. Adhered to the substrate by rhizoids, from which emerge branches ending in small secondary locking disks [6.398].

**Habitat.** Present in the mid-littoral rock bottom and up to 1–2 feet deep in the sublittoral exposed coasts. Often found in very beaten but has also been collected in puddles of lower mid-littoral and sublittoral.

**Distribution.** NE Atlantic (from France to Mauritania); Atlantic Islands (Azores, Canary Islands); Mediterranean; NW Atlantic (USA); Caribbean; SW Atlantic (Venezuela, Brazil).

**Uses and Compounds.** Have antimitotic and cytotoxic, [6.62, 399–403], antiparasitic [6.402, 404, 405], and antifungal [6.62] activity.

*Laurencia obtusa* (Hudson)  
J.V. Lamouroux

**Description.** Plants 1.5–2.5 cm tall, bushy, with green or yellow axes and rose branchlets, main stems long, which are sparingly alternately branched, 0.75–1.50 cm, but above are increasingly closely paniculately branched and spreading, the smallest branches and the short, truncate, ultimate branchlets opposite or subverticillate, 0.5–0.75 mm diameter; tetrasporangia in a band below the apex of the hardly modified branchlets [6.406].

**Habitat.** On solid substrata, in extremely shallow locations in calm shallow water, also in exposed locations within the intertidal zone.

**Distribution.** Worldwide in warm temperate to tropical seas.

**Uses and Compounds.** Have antibacterial [6.32, 407–410], antimalarial [6.411, 412], antitumor [6.316, 413, 414], antioxidant [6.316, 410, 415], and antifouling [6.416] activity.

*Laurencia pyramidalis*  
Bory de Saint-Vincent ex Kützing

**Description.** Globose tufts of brittle, cartilaginous, narrow, cylindrical, reddish brown to yellowish-red fronds, 150 mm long, from small discoid base (Fig. 6.17). Axis simple, branches patent, often opposite, spirally arranged, shorter toward apex giving regular pyramidal outline [6.417].



Fig. 6.17 Underwater photo of *Laurencia pyramidalis*

**Habitat.** Usually epiphytic, annual, lower intertidal.

**Distribution.** NE Atlantic (From Ireland and Britain to Portugal); NW Mediterranean.

**Uses and Compounds.** Have antioxidant and antimicrobial activity [6.410].

*Laurencia viridis* Gil-Rodríguez & Haroun

**Description.** Thallus annual, cartilaginous, mainly greenish with pink tips, with erect axes averaging 4–8 cm (range 2–15 cm) long, having alternate or helicoid branching only in the upper two-third of the thallus; ovoid spermatangia produced in cup-shaped receptacles; cystocarps urceolate, and sessile; tetrasporangia in parallel abaxial rows [6.418].

**Habitat.** Mainly restricted to exposed low intertidal sites, growing on rocks with strong wave action.

**Distribution.** Macaronesian region (Azores, Madeira, Selvages, Canaries, and Cape Verde).

**Uses and Compounds.** Have cytotoxic and antitumor [6.419–423] activity.

*Nitophyllum punctatum* (Stackhouse)  
Greville

**Description.** Delicately membranous, rose-pink fronds with an elongate fan-shaped outline, margins distinctly frilly, to 40 mm or, exceptionally, to 1 m, sessile or shortly stipitate (< 2 mm long); frond veinless, undivided or deeply subdichotomously divided to the base; apices blunt or rounded, often ribbon-like (Fig. 6.18). Gametophyte plants form rounded spots to 5 mm in diameter whilst tetrasporophyte plants form characteristically elongated spots [6.424].

**Habitat.** In littoral pools in winter and early spring and in the sublittoral (15 m) on cobble or other mobile surfaces and on bedrock in the lower parts of kelp forests from spring to summer.

**Distribution.** NE Atlantic (Norway to Canary Islands); NW Atlantic (N America); Caribbean, Mediterranean and Indian Ocean (India, Egypt); Sub-Antarctic.

**Uses and Compounds.** Potential bio-insecticides against mosquito larvae [6.66].

*Osmundea hybrida* (A.P. de Candolle)  
K.W. Nam

**Description.** Cylindrical, cartilaginous, tufted, dark purple to greenish-yellow fronds, 150 mm long; main axis with repeatedly pinnate branching, branches mostly alternate, shorter toward apex giving pyramidal outline; ultimate ramuli short, patent, truncate; axis monosiphonous with elongated pericentral cells and 1–2 outer layers of rounded colored cells; apex con-

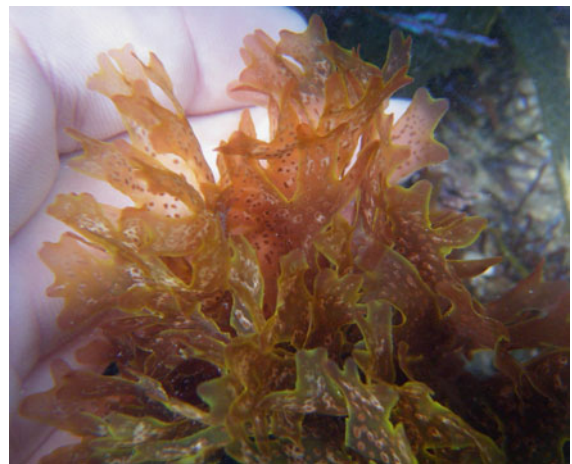


Fig. 6.18 Underwater photo of *N. punctatum*

cave, with ephemerally colorless dichotomous hairs surrounding apical cell [6.425].

**Habitat.** On stones and shells, sometimes epiphytic, upper intertidal, widely distributed, locally common.

**Distribution.** NE Atlantic (Britain to Morocco); SW Atlantic (Brazil).

**Uses and Compounds.** Perform antibacterial activity [6.340, 391].

*Osmundea pinnatifida* (Hudson)

Stackhouse

**Common Name.** Pepper dulse.

**Description.** A small red alga (up to 8 cm in length), it is tough and cartilaginous with flattened fronds (Fig. 6.19). Branching is alternate and occurs in one plane only, with branches becoming shorter toward their apex and broadly rounded. The plant is highly variable in size and coloration depending upon its location on the shore. Higher shore plants are generally dwarfed and yellow green in color, owing to exposure to high levels of sunshine while on the lower shore they are reddish brown [6.1, 426].

**Habitat.** On rocks, perennial, throughout intertidal, often as flattened rosettes covering exposed rocks, also sublittoral, generally distributed, abundant.



Fig. 6.19 *Osmundea pinnatifida* specimen

**Distribution.** NE Atlantic (Ireland and Britain to Senegal); Atlantic Islands; SW Atlantic (Brazil); Mediterranean (Turkey); SW and East Asia, North America, South America, Australia, and New Zealand.

**Uses and Compounds.** The marine polyether triterpenoid dehydrothysiferol 298, originally isolated from the red alga *Laurencia pinnatifida* was shown to induce apoptosis in estrogen-dependent and independent breast cancer cells [6.419, 420]. Have antibacterial [6.27, 358, 427, 428], antioxidant [6.234, 429], antileishmanial [6.430, 431], anticancer [6.225, 432], antifouling [6.257, 275], insecticidal, and antifungal [6.226] activity.

This aromatic seaweed is dried and used as a pepper- or curry-flavored spice in Scotland, Ireland, and Portugal (Azores Islands) [6.3, 426].

*Osmundea truncata* (Kützting)

K.W. Nam & Maggs

**Description.** *O. truncata* is much less common than *O. pinnatifida*, is more pinnately branched, generally grows epiphytically, and rapidly degenerates on collection [6.433].

**Habitat.** On rocks, perennial, throughout intertidal, often as flattened rosettes covering exposed rocks.

**Distribution.** Mediterranean.

**Uses and Compounds.** Extracts have antimicrobial activity [6.130].

*Pterosiphonia complanata* (Clemente)

Falkenberg

**Description.** Thallus with prostrate and erect axes, the erect ones flat-compressed and with distichous, alternate pinnate branching (Fig. 6.20); brownish-red color, flexible, and cartilaginous texture; attached by rhizoids which form discoid adhesive structures [6.434].

**Habitat.** On rocks and as epiphyte on other algae, in the entire intertidal zone and below.

**Distribution.** Warm to tropical regions of the Atlantic and Mediterranean.

**Uses and Compounds.** Extracts have antiviral [6.357], and antibacterial [6.358, 435] activity.



**Fig. 6.20** *Pterosiphonia complanata* specimen

*Ptilota serrata* Kützing

**Synonym.** *Ptilota pectinata* (Gunnerus) Kjellman

**Description.** *P. serrata* is a typically dark red and less than 5 cm tall seaweed. It is branched in opposite pairs, often with wavy spandrels protruding from the ends of the branches. Simple branchelets with serrated margins on one side stand opposite to composite-pinnately divided lateral branches on the other [6.32].

**Habitat.** Understory alga in the shallow sublittoral becoming dominant beyond 10 m.

**Distribution.** North Atlantic (Greenland, Svalbard, Faroe Islands, Norway), and N Pacific (Alaska to Washington).

**Uses and Compounds.** Has hemagglutinating activity [6.375].

*Rhodomela confervoides* (Hudson)

P.C. Silva

**Description.** Cylindrical, cartilaginous, bushy, brownish-red fronds, to 300 mm long. Much branched, repeatedly, irregularly. Branches clothed with small, pinnate branchlets and simple, pointed ramuli. In winter, branchlets are shed and frond appears bare, spiky, and very different from summer appearance. Central siphon surrounded by elongated cells with the outer band of small colored cells, articulations not visible [6.436].

**Habitat.** On rocks and shells, intertidal pools at all levels; widely distributed, common.

**Distribution.** Warmer NE Atlantic (Ireland to Canary Islands); Mediterranean.

**Uses and Compounds.** Extracts have antibacterial [6.437], antifungal [6.438], antihyperglycemic [6.439], cytotoxic [6.440], and antioxidant [6.441–443] activity.

*Rytiphlaea tinctoria* (Clemente) C. Agardh

**Description.** Thallus red, very dark, cartilaginous, abundantly branched, formed on the principal axes, flattened branches alternate provided in turn with short ramuli ends more or less curved. Structure–uniaxial quickly becoming complex by recloisonnement; in cross section showing the axial cell medulla sometimes indistinct, surrounded by 5 pericentral cells; thallus with apical growth [6.444].

**Habitat.** In the upper sublittoral, occasionally in the mid-littoral.

**Distribution.** NE Atlantic (France to Mauritania); Atlantic Islands; Mediterranean.

**Uses and Compounds.** Extracts are used as colorant [6.445]. Extracts have antimicrobial activity [6.130].

*Spyridia filamentosa* (Wulfen) Harvey

**Common name.** Feathery seaweed.

**Description.** Plants, dull brown to pale pink, usually less than 20 cm tall when in low turf mats, up to 18 cm tall in areas of good water motion; fastened by small discoid holdfast, the lower portions of plants and the lower branches tending to entangle; one to several erect axes, branching irregularly dichotomous or completely irregular, at times also alternate or unilateral; axes crisp, brittle, branching to 4–5 or more orders, the last orders short, becoming matted and giving plants fuzzy appearance; plants often look whitish or lightly calcified, but calcification from crustose coralline algae or sediment, not inherent in plants [6.446].

**Habitat.** On solid substrates in calm protected areas or adrift; to 8 m deep; common on eroded coral in sandy areas, but occurring in sandy mud as well, in matted intertidal turfs on coral and basalt.

**Distribution.** NE and E Atlantic (from Ireland and Britain to Sierra Leone); Atlantic Islands; NW and W

Atlantic (USA, Mexico); Caribbean; SW Atlantic; Indian Ocean; SE Pacific; Australia and New Zealand.

**Uses and Compounds.** Extracts have antibacterial [6.60, 421, 447–449], and antitumor [6.421] activity.

**Vertebrata lanosa (Linnaeus) T.A. Christensen**  
**Synonym.** *Polysiphonia lanosa* (Linnaeus) Tandy.

**Common Names.** Wrack siphon weed, Many tubed gable weed.

**Description.** *V. lanosa* is a filamentous red alga that grows as an obligate epiphyte on *Ascophyllum nodosum*. The short, cylindrical, cartilaginous fronds form beautiful dense reddish purple tufts along the ochre colored thalli of their host. Branches of this alga are dichotomous with pointed tips. Formerly classified as *Polysiphonia lanosa*, it lacks the distinctive banded pattern typical of *Polysiphonia* species. As an obligate epiphyte, *V. lanosa* cannot grow except attached to other seaweed species by tiny structures called rhizoids that grow into the tissue of the algal host. *A. nodosum* is the most frequent host, though *V. lanosa* is sometimes found on *Fucus* species such as *F. vesiculosus* as well, so it is abundant where these species thrive [6.450].

**Habitat.** Hemi-parasitic on *A. nodosum*, more rarely on *F. vesiculosus*, never on rock (appearances can be deceptive as it can grow on old stalks of both species) in the sheltered mid-littoral, generally distributed, usually abundant where *Ascophyllum* occurs. *Vertebrata* is generally infected with a tiny, more or less colorless parasitic red alga called *Choreocolax polysiphoniae*, to which it is closely related [6.451].

**Distribution.** *V. lanosa* is fairly common in the N. Atlantic, along the coasts of North America and Europe.

**Uses and Compounds.** *V. lanosa* is valued for its strong antioxidant and anticancer properties, used in supplements and health and beauty products [6.450]. Extracts of this species have cytotoxic [6.452], antioxidant [6.453], antibacterial [6.454], antifungal [6.455], and antifouling [6.373, 454] activity.

- Order: **Corallinales**

**Amphiroa beauvoisii J.V. Lamouroux**  
**Description.** More or less erect, sometimes bushy. Size: 2–5 cm high. Branching: dichotomous, occasion-

ally irregular. Intergenicula: tapered toward the base and flattened at the apices (up to 3 mm long, the lower diameter 0.6–0.65 mm, the upper diameter 0.4 mm) apices characteristically knife-like and striped. Genicula: with 2 (3–4) rows of cells. Color of living specimen: pink, pink-violet. Color of dried specimen: pink-violet to white [6.456].

**Habitat.** Like that of *A. rigida*, species of sheltered environments, on sublittoral, from surface to 30 m deep.

**Distribution.** Widely distributed in tropical and subtropical seas.

**Uses and Compounds.** Extracts have antibacterial activity [6.457].

**Amphiroa cryptarthrodia Zanardini**  
**Description.** Thallus erect, bushy; endophytic base on other calcareous algae (particularly on *Lithophilum* species). Size: 2–4 cm high. Dichotomous branching, regular and *geometric* (angle of about 90°); branch junctions usually not coinciding with intergenicula. Branches lying on different planes, slightly swollen apices. Intergenicula cylindrical with rare annular swellings, tapered on the upper part of fronds 1–4 (4.5) mm long, 0.25–0.6 mm in the lower diameter, upper diameter 0.15–0.18 mm. Dark red to pink violet (rare), apart from lighter apices due to annular ridges [6.458].

**Habitat.** On the rocks in sheltered waters where they often form large lawns, in the same station of *A. rigida* (but less frequently); also reported in tide pools.

**Distribution.** NE Atlantic (from France to Senegal); Mediterranean.

**Uses and Compounds.** Used on functional foods and pharmaceuticals [6.205]; extracts have antifungal and antimutagenic activity [6.62].

**Amphiroa fragilissima**  
**Description.** Thalli with dense cushion-like tufted growth, very brittle to strong calcification; branches cylindrical, thin, segmented, rather regularly forking, sometimes also trichotomous, the angles between two fork branches usually rather wide (broadly Y-shaped); the segments are slightly swollen at the endings; yellowish red to whitish pink [6.32].

**Habitat.** Common in shallow water, especially in sea-grass meadows and rock hollows; to 10 m depth.

**Distribution.** Widely distributed in tropical and subtropical seas.

**Uses and Compounds.** Used on functional foods [6.109], and the extracts have antiviral [6.237], antibacterial [6.40], cytotoxic and antioxidant [6.459], oxytocic and espermogenic [6.460] activity.

*Amphiroa rigida* J.V. Lamouroux

**Common Name.** Twig algae.

**Description.** Thallus growth lawn-like, segmented branches terete, brittle (calcified), usually forking and simultaneously laterally branching, narrowing toward the tip, segments distally inconspicuous (Fig. 6.21); purple-like conceptacles mostly numerous, especially on peripheral branches [6.32].

**Habitat.** Species recorded in shallow and deep waters in sheltered and shaded sites; sometimes found on rocky pools in exposed areas; mainly on sublittoral.

**Distribution.** Cosmopolitan species, present in warmer and tropical seas.



**Fig. 6.21** *Amphiroa rigida* specimens

**Uses and Compounds.** Extracts have antimicrobial [6.391], antifungal, cytotoxic, and antimitotic [6.62] activity.

*Corallina elongata* J. Ellis & Solander

**Description.** Whitish pink to reddish lilac, calcified, articulated fronds, fish-bone-like arrangement, to 50 mm high, axis compressed, repeatedly pinnate from discoid base, more abundantly and regularly branched than *C. officinalis*; articulations small [6.1].

**Habitat.** On rocks, exposed coasts, lower intertidal, southern and western coasts, occasional.

**Distribution.** NE Atlantic (Ireland and Britain to Senegal); Mediterranean.

**Uses and Compounds.** Used for R-phycoerythrin extraction and for functional foods [6.461]. Extracts have antimicrobial [6.228], antifungal and antiviral [6.62] activity.

*Corallina officinalis* Linnaeus

**Common Name.** Coral weed.

**Description.** Whitish pink to lilac, calcified, articulated fronds, 60–70 (–120) mm high, axis cylindrical to compressed, repeatedly pinnate from and expanded discoid base, branching often irregular (Fig. 6.22). Growth form very variable often stunted. In unfavorable habitats erect system vestigial, but extensive base may be present [6.1].

**Habitat.** On rocks, mid-littoral pools and drainage runnels, lower intertidal and shallow sublittoral, widespread and abundant, especially on exposed coasts.

**Distribution.** *C. officinalis* has been recorded widely in the north Atlantic, from northern Norway to Morocco and from Greenland to Argentina. It is found along the Atlantic coasts of North America from Labrador south to Connecticut and Maryland in the United States. *C. officinalis* has been reported in Japan, China, Australasia, South Africa, and the Arctic Sea.

**Uses and Compounds.** *C. officinalis* is a very popular ingredient among cosmetics and health and personal care companies. There are known sellers of *C. officinalis*-based products in the United States, China, Italy, France, Switzerland, and Ger-



Fig. 6.22 Underwater photo of *C. officinalis*

many. These are products for men and women, and include toners, moisturizers, cleansers, emulsions, essences, astringents, eye creams, wash gels, shower gels, shave balm, hydration sprays and creams, and masks [6.462]. Extracts have antimicrobial [6.201], anthelmintic [6.354], and antioxidant [6.335, 463] activity.

*Halitilon attenuatum* (Kützinger)  
Garbary & H.W. Johansen

**Description.** Thallus habit: erect, bushy with dense not entangled fronds (D). Size: 2–2.5 cm high. Branching: alternate, dichotomic-pinnate (D-A) (whorled); distal dichotomous branchlets. Intergenicula: cylindrical, tapered near apices, 0.2–0.4 (0.5) mm long, 0.07–0.1 mm in diameter. Genicula: 60–200  $\mu\text{m}$  long. Color of living specimen: from red scarlet to purple. Color of dried specimen: from white to ivory yellow [6.464].

**Habitat.** Epiphytic species often on *H. virgatum*; mainly on sublittoral.

**Distribution.** Alboran Sea: Morocco; Middle Western Mediterranean Sea: Italy; North Adriatic Sea: Italy, Croatia.

**Uses and Compounds.** Extract has antibacterial activity [6.60].

*Jania adhaerens* J.V. Lamouroux

**Description.** This species is small (4–5 mm high), heavily calcified, and forms intricately entwined clumps. The branches are pinkish-red color, regularly dichotomous, terete or slightly compressed, and slightly curve downward. Terminal segments are acuminate. This is an epiphytic species, decumbent on other seaweeds such as the species of Sargassaceae, growing in the sublittoral zones along shorelines moderately exposed to water movement [6.465].

**Habitat.** Growing in the sublittoral zones along shorelines moderately exposed to water movement.

**Distribution.** Atlantic Islands; Mediterranean; SW and SE Atlantic; Caribbean; Indo-Pacific Oceans; Australia.

**Uses and Compounds.** Extracts have antigenotoxic [6.466], antifungal, antiviral, and antimicrobial [6.62, 103] activity.

*Jania rubens* (Linnaeus) J.V. Lamouroux

**Description.** Slender, rose-pink, articulated, calcified fronds, to 50 mm high; repeatedly dichotomously branched, luxuriant specimens secondarily pinnate (Fig. 6.23). Segments cylindrical, to 120  $\mu\text{m}$  diameter, those bearing branches somewhat compressed, to 180  $\mu\text{m}$  diameter. Fixed by small conical disk,



Fig. 6.23 *Jania rubens* specimens

but spreading vegetatively by developing attachment disks from branches in contact with solid substratum [6.467].

**Habitat.** Epiphytic, found only growing epiphytically on the brown algae *Cladostephus* and *Cystoseira* lower littoral, often abundant.

**Distribution.** The range of *J. rubens* stretches from the Baltic Sea and Norway in the north to Portugal, Senegal, East Africa, and the Azores in the south; it is also found in the Mediterranean, the Canary Islands, Indian Ocean, Black Sea, and China Sea, as well as around Brazil.

**Uses and Compounds.** *J. rubens* has recently starting to be used by cosmetic companies as an extract in natural beauty products. It is prized for its ultra-moisturizing and protective properties due to the high concentration of minerals and trace elements present in its tissue. One provider notes that *J. rubens* is characterized by a concentration of minerals and trace elements 20 000 to 40 000 times greater than that of seawater, thus giving it re-mineralizing properties. It is also used in skin whitening and hydrating products [6.468].

Extracts of this species have antitumor [6.126], bio-insecticide [6.463], antimicrobial [6.469, 470], antihelminthic and cytotoxic [6.354, 471], antifouling [6.472], and antifungal [6.62] activity.

*Jania rubens* var. *corniculata*  
(Linnaeus) Yendo

**Description.** Thallus erect, bushy, attached by a basal crustose disk. Size: 1–4 cm high; dichotomous branching, abundant, and entangled branches. Intergenicula: cylindrical, slightly compressed, bearing basal, sometimes articulated projections (horn-like); becoming wider at distal apex, 0.40–0.75 mm long (times) 0.10 mm in diameter. Genicula: irregular filaments 90–160  $\mu$ m. Color of living specimen: from violet pink more or less intense. Color of dried specimen: white to yellow ivory [6.473].

**Habitat.** Epilithic or epiphytic on other algae (particularly *Cladostephus* species), in well-lit sites. Bathymetric

**Distribution.** From surface to shallow waters (3 m).

**Distribution.** NE Atlantic (from Ireland and Britain to Morocco); Mediterranean.

**Uses and Compounds.** Extracts have antioxidant and antimicrobial activity [6.474].

*Lithophyllum byssoides* (Lamarck) Foslie  
**Synonym.** *Lithophyllum lichenoides* Philippi

**Description.** *L. byssoides* commonly grows in the intertidal zone. Living specimens, gray–violet in color, form characteristic cushion-like clumps, composed of densely interweaving and anastomosing lamellae which are more or less smooth on the dorsal surface and ridged on the ventral one. Growth form with spiniform lamellae has also been observed. Thalli grow by forming concretions of approximately 10 to 20 cushion-like clumps [6.475].

**Habitat.** It grows on rocky substrata at mid-littoral.

**Distribution.** NE Atlantic (Spain, Portugal to Senegal); Mediterranean (Italy).

**Uses and Compounds.** Extracts have antifungal activity [6.62].

*Lithothamnion corallioides*  
(P.L. Crouan & H.M. Crouan)  
P.L. Crouan & H.M. Crouan

**Common Name.** Maerl.

**Description.** An unattached, fragile, alga with a calcareous skeleton. It is very similar to and often confused with *Phymatolithon calcareum*. Its form is very variable but it commonly occurs as highly branched nodules forming a 3D lattice. Individual plants may reach 4–5 cm across and are bright pink in color when alive but white when dead [6.476].

**Habitat.** Typically found at less than 20 m depth on sand, mud or gravel substrata in areas that are protected from strong wave action but have moderate to high water flow. Usually found as unattached plants.

**Distribution.** NE Atlantic (Norway to Mauritania); Mediterranean.

**Uses and Compounds.** Used as fertilizer and as a constituent of pharmaceutical preparations [6.477, 478]. Extracts have antifungal activity [6.62].

*Lithothamnion glaciale* Kjellman  
**Common name.** Knobby coralline-crust algae.



**Description.** Bright pink to purplish, minutely white-speckled calcareous crust, becoming very thick, usually with abundant regular or irregular branches, free or attached to substratum [6.479].

**Habitat.** On rocks, pebbles, shells or free-living, lower intertidal (north-east coasts) and sublittoral to deeper waters.

**Distribution.** In the NE Atlantic from the British Isles north to Arctic Russia including the Faeroe Isles, Iceland and western Baltic; in the NW Atlantic from Cape Cod north to Arctic Canada and Greenland; also northern Japan and China in the western Pacific.

**Uses and Compounds.** Commercial extraction for use as a soil conditioner on acidic ground, as an animal food additive, for the filtration of acid drinking water and in pharmaceutical and cosmetic products [6.386, 479]. Extracts promote the induction of metamorphosis of the sea urchin larvae (*Strongylocentrotus droebachiensis*) [6.480].

*Mesophyllum lichenoides* (J. Ellis) M. Lemoine

**Description.** Pale to dark purple thin, brittle, leafy calcified fronds, attached at base, margins free, lobed. Fronds semicircular, concentrically banded (Fig. 6.24). Reproduction takes place in winter and spring in small, wart-like conceptacles [6.481].

**Habitat.** Epiphytic on *C. officinalis* in mid-littoral pools.

**Distribution.** NE Atlantic (from Ireland to Mauritania); Mediterranean.

**Uses and Compounds.** Used as a soil conditioner on acidic ground [6.386]. Extracts have antifungal, cytotoxic and antimutagenic activity [6.62].

● Order: **Gelidiales**

*Gelidiella acerosa*

**Description.** *G. acerosa* is a red algae with yellowish brown, tufted, entangled, erect, cylindrical thalli reaching 6 cm tall. The ends of the fronds are pinnately divided, giving it a feathered appearance. Branch tips of *G. acerosa* terminate in a single apical cell. Short, thick branches attached to the substratum by stoloniferous rhizoids form dense mats along shallow reefs. *G. acerosa* is found on surf-exposed and moderately wave-sheltered rocks and reefs in the lower mid-littoral and

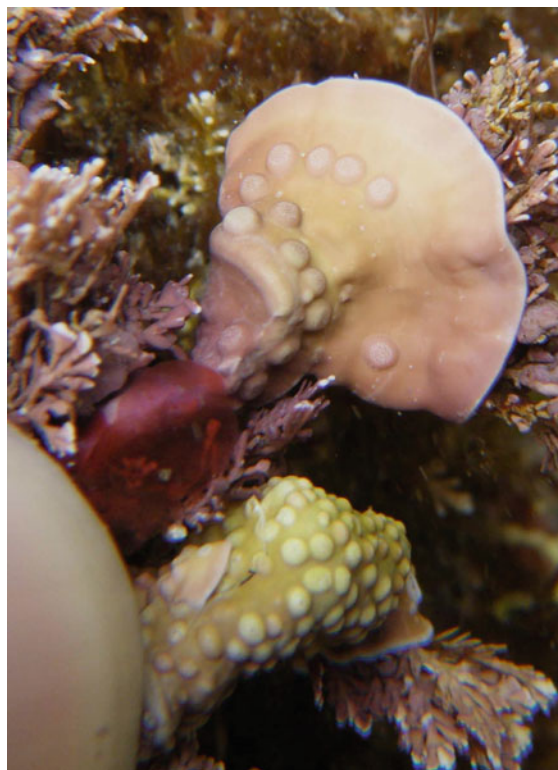


Fig. 6.24 Underwater photo of *Mesophyllum lichenoides*

the sublittoral zone, and in tide pools at higher levels on the shore [6.482, 483].

**Habitat.** In tide pools, attached to rock reefs at depth of 0–1 m; in association with *Gelidiopsis* and *Gelidium* species.

**Distribution.** Atlantic Islands: Azores and Cape Verde Islands.

**Uses and Compounds.** *G. acerosa* is an important commercial species for agar production [6.484–487]. It has also been used traditionally for the preparation of agar-forming hard jellies, or eaten fresh and also prepared as a salad vegetable or cooked and eaten mixed with rice [6.4]. However, over recent years, *G. acerosa* has become a key ingredient in a staggering number of products [6.109]. It is used in nearly 150 hair products, including: hair color and bleaching; shampoos and conditioners; styling mousse, foam, gels, sprays, and lotions; hair relaxers and detanglers; antidandruff hair masks [6.483].

Extracts have antifungal [6.488], contraceptive [6.489], antioxidant [6.490], antifungal, and antibacterial [6.490–493] activity.

*Gelidiella ramellosa* (Kützting)  
Feldmann & G. Hamel

**Description.** Plants occur as turfs to 1–2 cm in height, with prostrate stolons attached by clusters of rhizoids to rock. Erect axes are irregularly pinnately branched and terete to slightly compressed. Structurally, the medulla is pseudoparenchymatous with no discernible central axis, and rhizines are absent. Spermatangia occur in surface sori. Tetrasporangia are borne in irregular whorls in terete, basally constricted stichidia that are lateral on erect axes [6.494].

**Habitat.** Growing as sparse turf amongst coralline algae.

**Distribution.** NE Atlantic (from France to Portugal); Mediterranean; Australia.

**Uses and Compounds.** Extracts have cytotoxic and antimetabolic activity [6.62].

*Gelidium corneum* (Hudson) J.V. Lamouroux  
**Synonym.** *Gelidium sesquipedale* (Clemente) Thuret.

**Common Name.** Kanten.

**Description.** Dark red, hard consistency, cartilaginous, and may reach 30 cm in length thalli. Branches with obtuse apex and attenuated at the base (Fig. 6.25).

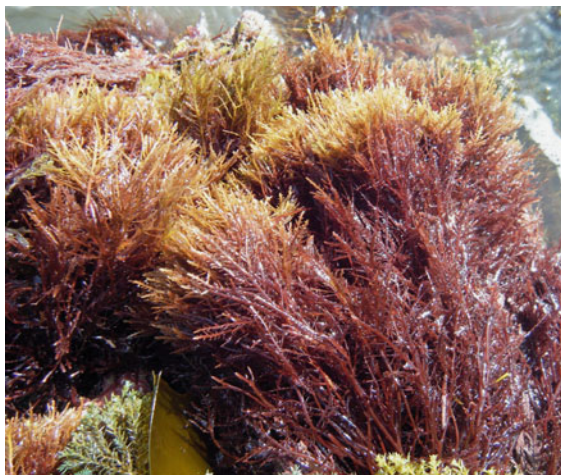


Fig. 6.25 *Gelidium corneum* specimens

This species typically forms dense stands of clumped fronds, often under a kelp canopy [6.1].

**Habitat.** On rocks and tide pools in exposed areas.

**Distribution.** E Atlantic (Britain to South Africa); W Atlantic (USA to Brazil); Mediterranean; Indo-Pacific zone; Australia.

**Uses and Compounds.** One of the main sources of Agar [6.495, 496]. Extracts are used for the production of edible films containing carvacrol for ham packages, and other edible films with antimicrobial effect [6.497–500]. The antimicrobial and antioxidant activity was demonstrated in several studies [6.269, 501, 502].

*Gelidium pulchellum* (Turner) Kützting

**Description.** Cartilaginous, regularly or irregularly bipinnate, dark red-brown fronds, 50–100 mm high, arise from a creeping base. Main axes narrow, cylindrical, somewhat flattened above. Ultimate branches short, pointed at first, later  $\pm$  spatulate, particularly when reproductive; appearance variable with Habitat and time of year [6.503].

**Habitat.** Abundant in and around tidal pools in mid- and lower littoral in high-light situations; generally epiphytic on *C. officinalis*; widely distributed, common.

**Distribution.** NE Atlantic (Ireland and Britain to Portugal and Morocco). Australia.

**Uses and Compounds.** Source of agar [6.3, 503, 504]. Extracts have antibacterial [6.358], and antiviral [6.357] activity.

*Gelidium pusillum* (Stackhouse) Le Jolis

**Description.** Cartilaginous, purplish, or blackish red, turf-forming, 2–10 mm high, arising from extensive creeping base and incorporating shell debris and small mollusks; erect fronds flattened and leaf-like and 0.5–2 mm broad [6.505].

**Habitat.** Marine and estuarine species, on rock pools and sandy rocks, particularly in places with widely varying salinities such as upper shore species.

**Distribution.** NE and E Atlantic (from Norway to Benin); Mediterranean; EW Atlantic; Caribbean; SE Atlantic; SW Atlantic; Indian Ocean; SW Pacific.

**Uses and Compounds.** Source of agar [6.505]. Extracts have antibacterial [6.358], and antifungal [6.62] activity.

*Gelidium spinosum* (S.G. Gmel.)

P.C. Silva

**Description.** Small alga, cartilaginous, crimson to purplish red, 20–60 mm long. Main axes distinctly flattened, often narrower at base, ultimate branches short, often opposite, spine-like or spatulate [6.32].

**Habitat.** In sheltered locations below the tidal mark.

**Distribution.** NE Atlantic (Ireland and Britain to Canary Islands); Mediterranean; Indo-Pacific (Indonesia).

**Uses and Compounds.** Source of Agar [6.506]. Extracts have antiviral, cytotoxic, and antibacterial activity [6.205, 507].

*Pterocladia capillacea* (S.G. Gmelin)

Santelices and Hommersand

**Synonym.** *Pterocladia capillacea* (S.G. Gmelin) Borner.

**Common Name.** Small agar weed.

**Description.** Thallus dark brownish red, commonly grows in dense tufts about 4 cm high, and composed of prostrate axes that give rise to the flat-



Fig. 6.26 *Ahnfeltiopsis devoniensis* specimen

tened erect axes: branching pinnate to irregularly opposite with uniaxial growth from single apical cells; inner structure pseudoparenchymatous, with long, slender, thick-walled rhizine cells filling the spaces between elongated medullary cells that are surrounded by a three-layered cortex of smaller pigmented cells [6.508].

**Habitat.** In large pools and lagoons in the lower littoral and shallow sublittoral, widely distributed, never common.

**Distribution.** Europe, Atlantic Islands, N America, Caribbean Islands, S America, Africa, SW and SE Asia, Australia and New Zealand, Pacific Islands.

**Uses and Compounds.** Source of agar [6.509, 510]. Extracts have antioxidant [6.234], antibacterial [6.470], antinociceptive and anti-inflammatory [6.511], anticoagulant [6.512], and antitumor [6.126] activity.

● Order: **Gigartinales**

*Ahnfeltiopsis devoniensis* (Greville)

P.C. Silva & DeCew

**Synonym.** *Gymnogongrus devoniensis* (Greville) Schotter

**Description.** *A. devoniensis* is a small red marine alga that grows to only several centimeters in length from a disk-like holdfast (Fig. 6.26). It forms a medium-sized flattened frond with regular dichotomous branching. The branches have parallel sides. The reproductive structures (cystocarps) are internal [6.513].

**Habitat.** Generally found in the very lower intertidal or shallow sublittoral, in salty areas protected from strong wave action. As far as it is known, it can be found anytime.

**Distribution.** NE Atlantic (Britain to Portugal).

**Uses and Compounds.** Source of carrageenan [6.514–516]. Extracts have antihypertensive and antioxidant activity [6.501, 517].

*Calliblepharis ciliata* (Hudson) Kützing

**Common Name.** Eyelash weed.

**Description.** *C. ciliata* is bright to dark red in color. The main blade is erect and forms into a wedge shape

or ovate lobe that expands into a dichotomous or irregularly divided blade up to 7 cm broad and 30 cm long and 350–650  $\mu\text{m}$  thick. Small branches arise from the main blade. It can vary considerably in blade width and degree of subdivision. In southeastern England its blades are often only 10–15  $\mu\text{m}$  thick. The branchlets (proliferations) that arise from the margins of the blade are either pointed or rounded. Patches of encrusting bryozoans are very common on old specimens [6.518, 519].

**Habitat.** In larger lower intertidal pools and sublittoral (0–25 m) on stones, maerl, and shells, widely distributed, common in south and west, sometimes frequent in drift.

**Distribution.** NE Atlantic (Ireland and Britain to Mauritania); W Mediterranean.

**Uses and Compounds.** Source of carrageenan [6.520, 521], and hemagglutinins [6.375].

*Calliblepharis jubata*  
(Goodenough & Woodward) Kützing

**Description.** *C. jubata* is brownish red in color. It has a thallus consisting of a branched holdfast that gives rise to an erect frond that expands into a dichotomous or irregularly divided blade (Fig. 6.27). The outline of the frond is variable but it commonly has a cylindrical or very slightly compressed stipe. Its blades are about

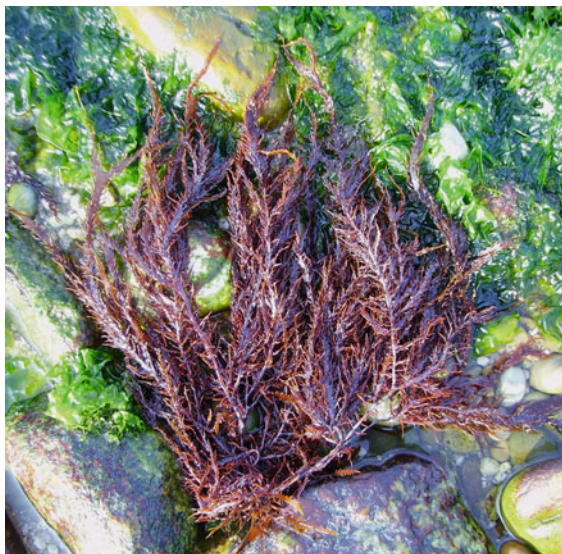


Fig. 6.27 *Calliblepharis jubata* specimen

6 mm broad and 30 cm long with narrow branches. The branches appear long and tendril like. Long branchlets (proliferations) arise from the blade surface and margins of the branches [6.1].

**Habitat.** On rocks and epiphytic, especially on *C. officinalis* in large open pools, mid-littoral to shallow sublittoral (5 m).

**Distribution.** NE Atlantic (Ireland to Mauritania); W Mediterranean.

**Uses and Compounds.** Source of carrageenan [6.514–516, 521–523], and hemagglutinins [6.375]. Extracts have antimycobacterial [6.317], anticoagulant [6.524], antiprotozoal, and cytotoxic [6.525] activity.

*Caulacanthus ustulatus*  
(Mertens ex Turner) Kützing

**Description.** Thalli forming small dense entangled tufts of up to 5 cm, reddish-brown color, which blackens



Fig. 6.28 Underwater photo of *Chondracanthus teedei* var. *lusitanicus*

by desiccation, with rough touch; fixed to the substrate by cylindrical, crawling axes from which derive others, also with circular section, irregularly branched; ramifications with acute apices and behaving small triangular-shaped spines [6.526].

**Habitat.** It lives on rocks and clams in well-lighted areas with little inclination at mid-littoral zones in semiexposed shores.

**Distribution.** NE and E Atlantic (Ireland and Britain to Guinea); Mediterranean; NW Atlantic (Canada to Mexico); SW Atlantic (Brazil); SE Atlantic (Angola to South Africa); Indian and Pacific Oceans; Australia.

**Uses and Compounds.** Produces a kappa/iota-hybrid carrageenan [6.527]. Extracts have antibacterial activity [6.358].

*Chondracanthus acicularis* (Roth)  
Fredericq

**Description.** Cartilaginous, cylindrical, or compressed, purple-red or blackish fronds, sometimes with greenish or whitish spots, to 100 mm long, irregularly bipinnately branched, branches curved, sharply pointed [6.1].

**Habitat.** On rocks, lower intertidal, generally uncommon but may be locally common on sheltered, silty shores in the lower intertidal.

**Distribution.** NE and E Atlantic (Ireland and Britain to Cameroon); Mediterranean; NW and SW Atlantic; Caribbean; Indian Ocean; Pacific (Hawaii); E Australia.

**Uses and Compounds.** Source of carrageenan [6.514–516]. Extracts have antiviral [6.103], antibacterial [6.269, 357], antioxidant [6.429], anti-fungic [6.204], and anticoagulant [6.512] activity.

*Chondracanthus teedei* var. *lusitanicus*  
(Rodrigues) Bárbara & Cremades

**Description.** The fronds of this alga are cartilaginous-membranous, with purple-violet color that darkens by desiccation, becoming greenish yellow with decay (Fig. 6.28). The main axes of the fronds, as their ramifications are wide, reaching 1 cm in the older portions. This species is confused sometimes with *Calliblepharis jubata* [6.1].

**Habitat.** On rocks in mid-littoral zone.

**Distribution.** NE Atlantic (Spain and Portugal).

**Uses and Compounds.** Produces carrageenan [6.514–516, 528]. Extracts have cytotoxic activity [6.529].

*Chondrus crispus* Stackhouse

**Description.** Cartilaginous, dark purplish red, red, yellowish or greenish fronds of 150 mm high, gametophyte plants are often iridescent under water when in good condition; stipe compressed, narrow, expanding gradually to a flat, repeatedly dichotomously branched frond, in tufts from a discoid holdfast. Axils rounded, apices blunt or subacute, frond thicker in center than margins; breadth of segments varies frequently; branching, color, and thickness also vary frequently.

Highly variable (polymorphous) thalli may reach 15 cm long, cartilaginous consistency and reddish-pink or -brown color and iridescent in water. These algae are fixed by a disk whose first unbranched stipe gradually expands into a fan-like blade, repeatedly dichotomously divided, with ends rounded or truncated. Small dilations (2–3 mm in diameter), which are the reproductive structures may appear on the surface of the blades [6.1].

**Common Names.** Irish moss, Carrageen moss, Jelly moss.

**Habitat.** On rocks, lower intertidal and shallow sublittoral, in pools in the mid-littoral in some locations; widely distributed in the northwestern and northeastern Atlantic, often abundant.

**Distribution.** *C. crispus* has a wide distribution. It includes the northwest Atlantic from Labrador and the Maritime Provinces in Canada southward to New Jersey and Delaware in the United States. It can be found to a limited extent in the western Baltic Sea, from northern Russia and Norway to southern Spain, spanning the northeast Atlantic, the North Sea, and the English Channel. It can be found in the Mediterranean, Portugal, the Azores, the Faroes, and West Africa, as well as in the Bering Sea from Russia to Alaska.

**Uses and Compounds.** *C. crispus* is harvested as a common source of the polysaccharide carrageenan, which is extracted from cell walls and forms a gel that is used commercially as a thickener [6.4, 514–516].

The gelling and thickening properties of carrageenan are used widely in the cosmetics, food, and

pharmaceutical industries. Examples of applications include making ice cream and air fresheners, beer clarification, and treatment for coughs and diarrhea [6.109, 530, 531].

Extracts have antifouling and antibacterial [6.61, 532], antioxidant, and antimicrobial [6.205, 373, 533].

#### *Cystoclonium purpureum* (Hudson) Batters

**Description.** Rather soft, cylindrical, dull-purplish pink fronds, 3 mm wide, to 600 mm long. Branches numerous, alternate, branchlets tapered at both ends; branches sometimes drawn out into long twisting tendrils; multiaxial, medulla a cordlike strand of loosely interwoven, narrow filaments, surrounded by large, rounded cells, with outer layer of small, angular, assimilatory cells; said to have an onion-like smell shortly after collection [6.534].

**Habitat.** On rocks and stones in mid-littoral and in shallow sublittoral, generally distributed, abundant.

**Distribution.** North Atlantic (Arctic Canada to Spain); North Sea (Helgoland); Baltic, Mediterranean (Greece), Indian Ocean (Pakistan), Australia (Queensland).

**Uses and Compounds.** Source of carrageenan [6.32, 521, 535]. Extracts have nematicide [6.536], antibacterial [6.86, 358, 537], and anticoagulant [6.375] activity.

#### *Dilsea carnosa* (Schmidel) Kuntze

**Common Name.** Red rags.

**Description.** One of the larger red seaweeds, *D. carnosa* is tough and leathery (Fig. 6.29). Several dark reddish brown, flat, blades gradually expand from a single disk-shaped holdfast, and have short cylindrical stipes. The blades do not have a midrib or veins and are simple wedge or spoon shaped. The blades can be 15–30 cm long and 5–20 cm wide. Older blades may be split from the margin toward the base but the rounded oblong (obovate) shape of the blade is never quite lost [6.1, 538].

**Habitat.** On rocks in shady pools, lower intertidal on rock, and shallow sublittoral to 25 m, usually on rock in kelp forests; widely distributed, common.

**Distribution.** NE Atlantic (Iceland and Spitsbergen to Portugal).



Fig. 6.29 *Dilsea carnosa* specimens

**Uses and Compounds.** Produces carrageenan [6.539, 540], and extracts antisetlement [6.257], antiprotozoal [6.525], antifungal [6.541], and antifouling [6.542] activity.

#### *Dumontia contorta* (S.G.Gmelin) Ruprecht

**Description.** Erect thallus, cylindrical when young, compressed when older, tubular-hollow, brownish red to crimson-purple, often yellow-brown at the tips. Thallus with irregular simple lateral branches, tapering at both ends, sometimes slightly swollen, often twisted around the longitudinal axis; soft, gelatinous. Holdfast a small, persistent disk, expanding with age [6.32].

**Habitat.** On rocks and pebbles, shallow open pools, upper intertidal to shallow sublittoral, common, widely distributed.

**Distribution.** NE Atlantic (Spitsbergen to Portugal, North Sea); NW Atlantic; NW Pacific (Russia, Japan); NE Pacific (Alaska).

**Uses and Compounds.** Extracts have antiviral [6.543], and antioxidant [6.429] activity.

#### *Furcellaria lumbricalis* (Hudson)

J.V. Lamouroux

**Common Names.** Clawed fork weed, black carrageen.

**Description.** Cartilaginous, cylindrical, brownish-black fronds, repeatedly dichotomously branched,

fastigiate, to 2 mm diameter and 300 mm long, with acute apices; attached by much-branched rhizoids. Multiaxial, medulla of cylindrical cells interspersed with rhizoids, cortex of irregular filaments, inner cells elliptical, outer cells narrow, elongated, in radial rows [6.544].

**Habitat.** On rocks, lower intertidal and shallow sublittoral, in pools and runnels, in open situations, often on sandy and muddy shores, tolerating lowered salinities.

**Distribution.** North Atlantic (Nova Scotia, Greenland); NE Atlantic (Faroe Islands, Ireland and Britain to Spain), North Sea (Scandinavia, Hegoland), Baltic; W Mediterranean (Spain, Sardinia, Sicily); Indian Ocean (India, Pakistan).

**Uses and Compounds.** Source of hybrid carrageenan (Furcellaran) [6.32, 545]. The sulfated polysaccharides of this species have immunostimulation activity [6.546].

#### *Gigartina pistillata* (S.G. Gmelin) Stackhouse

**Description.** *G. pistillata* (Fig. 6.30) is the type species of the genus *Gigartina* and their thalli are erect, up to 20 cm tall, dark red or red-brown, cartilaginous, elastic, dichotomously branched, attached to the substrate through a small disk [6.1].

**Habitat.** On firm substrata in the intertidal zone, to 12 m depth.

**Distribution.** NE Atlantic (Ireland and Britain to Senegal); SE Atlantic (South Africa).

**Uses and Compounds.** Source of carrageenan – (female gametophytes) produces a hybrid carrageenan, 48.7 kappa, 44.5 iota (% mol). *G. pistillata* (tetrasporophytes) produces a hybrid carrageenan xi-lambda [6.547]. The sulfated polysaccharides of this species have antitumor [6.548], antiviral [6.549], anti-inflammatory [6.550], and antioxidant [6.429, 551] activity.

#### *Gymnogongrus crenulatus* (Turner) J. Agardh

**Description.** Cartilaginous, fleshy, flattened, dark red fronds, to 100 mm high, with short cylindrical stipe from basal disk; repeatedly dichotomous, branches strap-shaped, apices rounded, often paler than rest of frond. Reproductive structures appear as external, wart-like excrescences [6.552].



**Fig. 6.30** Underwater photo of *Gigartina pistillata*

**Habitat.** Epilithic, lower littoral in pools and emergent, and sublittoral to 13 m, tolerant of sand cover; plants typically encrusted with species of Bryozoa, Foraminifera, and calcareous algae.

**Distribution.** NE Atlantic (Ireland and Britain to Mauritania, Canary Islands, Cap Verde Islands); NW Atlantic (New Brunswick to Massachusetts); Australia.

**Uses and Compounds.** *G. crenulatus* produce a hybrid carrageenan (64.1 kappa, 30.8 iota %mol) [6.547]. The sulfated polysaccharides of this species have antibacterial activity [6.130].

#### *Gymnogongrus griffithsiae* (Turner) Martius

**Description.** Cartilaginous, cylindrical to compressed, brownish red to blackish-purple fronds, to 75 mm high, from an expanded discoid base; repeatedly dichotomous, fastigiate, with rounded, somewhat flattened apices [6.553].

**Habitat.** Epilithic, littoral in pools and emergent, upper sublittoral; tolerant of sand cover. On sand-covered rocks, lower intertidal, rare [6.518].

**Distribution.** NE and E Atlantic (Ireland to W Africa); Mediterranean; NW to SW Atlantic (North and South Carolina, Brazil, Uruguay); Caribbean; Australia.

**Uses and Compounds.** Produces sulfated galactans – carrageenans [6.554] with antioxidant [6.205], and antiviral [6.555–557] activity.

*Hypnea cornuta* (Kützinger) J. Agardh

**Description.** Plants caespitose or loosely intricate-caespitose, up to 30 cm in length, soft in texture and reddish brown in color; axes subterete, up to 1 mm in diameter at the base, pointed at the apex, spirally branched up to the fourth order; branching angle less than 90°; axes and branches loosely clothed with stellate processes; branches up to 550 μm in diameter, and spinous ultimate branchlets, 60–70 μm in diameter, slightly constricted at their base; extensive basal system of prostrate axes attached by secondary discoid holdfasts produced by the cortical cells at any axis level [6.558].

**Habitat.** In mid-littoral rock pools exhibit the habit of free-floating plants, while in the open sea it thrives attached on rocks within –50 cm.

**Distribution.** W Atlantic (USA to Brazil); Mediterranean; Caribbean (Cuba); Indian Ocean; NW Pacific (Japan); Indonesia; Australia.

**Uses and Compounds.** Produces carrageenan [6.559].

*Hypnea musciformis* (Wulfen) J.V. Lamouroux

**Common Names.** Hook weed, Hooked seaweed, Hypnea.

**Description.** *H. musciformis* is a red alga with loosely intertwined cylindrical branches that form clumps or masses up to 20 cm tall, though plants are often broken by wave action before they reach full size (Fig. 6.31). Branches are firm and highly irregularly branched, narrowing to broad, flattened, tendril-like hooks. These hooks make *H. musciformis* easily distinguished from all other *Hypnea* species found in similar Habitats. Holdfasts are small or lacking because the plants usually anchor themselves by attaching to other species such as *Sargassum* (for example, *Sargassum muticum*). The tissue is usually a dark reddish brown, though when growing in nutrient poor water color can pale to yel-



**Fig. 6.31** Herbarium specimen of *Hypnea musciformis* (MACOI no. 3733)

lowish brown. It is found abundantly in shallow coastal waters where it prefers calm, shaded sublittoral reef flats, though it also grows in tide pools and rocky intertidal areas. In bloom stage, it may be found free floating. *H. musciformis* is also a highly opportunistic invader [6.560].

**Habitat.** Common on calm intertidal and shallow sublittoral reef flats, tide pools and on rocky intertidal benches. Most often found low intertidal to shallow sublittoral reef flats, attached to sandy flat rocks.

**Distribution.** NE Atlantic (Spain and Portugal to Canary Islands), E and SE Atlantic (W Africa); NW Atlantic (Georgia, N. Carolina); SW Atlantic (Brazil, Uruguay); Caribbean; Mediterranean; Red Sea, Indian Ocean and Indo-Pacific; Pacific Islands (Hawaii; Fiji); Australia.

**Uses and Compounds.** In some areas, *H. musciformis* is grown for harvest of kappa carrageenan [6.561, 562]. It also contains a high amount of natural occurring antioxidants, and is nourishing to the skin. *H. musciformis* is used in over 100 hair color and hair care products such as shampoos, conditioners, and styling gels, it is used in more than 20 sunless tanning products, and in many antiaging creams and applications. *H. musciformis* is used in facial treatments, toners, and moisturizers, makeup and cosmetics, and eye treatments. *H. musciformis* is also commonly joined by *Gelidiella acerosa* and *Sargassum filipendula* as an effective seaweed ingredient set for personal care products [6.109, 560].



Extracts have antiviral [6.238], antifungal [6.563, 564], antitumoral [6.421, 565], antihelminthic [6.566], psychotropic and anxiolytic [6.567], antibacterial [6.38, 70, 242, 421, 568, 569], cytotoxic, antioxidant, larvicidal, and antifeed [6.242, 570, 571] activity.

#### *Hypnea spinella* (C. Agardh) Kützing

**Description.** Fragile, upright, or in tangled mats, to 15 cm high, light brown-red, rose-red or bleached; branching in all directions; branches 0.4–1.0 mm diameter, cylindrical. Branchlets spine-, spur-, or tendrill-like, numerous, spirally arranged, to 2.5 mm long, occasionally longer; apices tapering, pointed, slightly up-curved. Cortex 1–2 cells thick; cells rounded to irregular, 7.5–25.0  $\mu\text{m}$  diameter, densely pigmented; medullary cells thick-walled, irregular to ovoid, 100–320  $\mu\text{m}$  diameter, surrounding obvious thick-walled central filament (70–80  $\mu\text{m}$  diameter); holdfast initially disk-like. Tetrasporangia ovoid, 10–23  $\mu\text{m}$  diameter, 25–49  $\mu\text{m}$  long, zonately divided, in swollen sori (nemathecia) girdling middle part of lateral branchlet; cystocarps spherical, 100–900  $\mu\text{m}$  diameter, solitary or clustered at base to middle of branchlet [6.572].

**Habitat.** Attached to small shells or rubble, often entangled in seagrass beds; lower intertidal to 7 m (reported to 27 m) deep.

**Distribution.** Warm E Atlantic (Atlantic Islands, W coast of Africa); Mediterranean; Caribbean; NW Pacific (Japan, China); Pacific Islands (Hawaii); Indo-Pacific (Philippines, Vietnam); E Pacific (Mexico, Ecuador); Australia.

**Uses and Compounds.** This is an edible species, being commonly eaten (boiled in coconut milk) in other parts of the Pacific and Asia [6.573]. Extracts have antifungal [6.204], and immunomodulatory [6.394] activity.

#### *Mastocarpus stellatus* (Stackhouse) Guiry

**Common Name.** False Irish moss.

**Description.** A small red alga (up to 17 cm in length), the fronds are channeled with a thickened edge and widen from a narrow stipe with disk-like holdfast (Fig. 6.32). The channeling is often slight and is most noticeable at the base of the frond. Mature plants have conspicuous growths of short, stout papillae (reproductive bodies) on the



**Fig. 6.32** *Mastocarpus stellatus* specimen

fronds. The plant is dark reddish brown to purple in color and may be bleached. The common name false Irish moss is used as it may be confused with *C. crispus* (Irish moss); the main features separating the two species being the channeled frond and appearance of reproductive bodies on mature plants [6.1].

**Habitat.** This alga is found on rocky shores, particularly in very exposed areas where it grows among barnacles and mussels, on less exposed shores it is often abundant under fucoids.

**Distribution.** NE Atlantic (Scandinavia to Mauritania, North Sea); NW Atlantic (Newfoundland and Nova Scotia to Rhode Island).

**Uses and Compounds.** Source of carrageenan [6.514–516]. Extracts have antioxidant activity [6.205, 373, 429, 574].

#### *Phyllophora crispa* (Hudson) P.S. Dixon

**Description.** Bright red or pink seaweed. Each plant has a small disk-shaped base and erect fronds. The fronds consist of short cylindrical stipes (stalks) rarely longer than 1 cm long and blades which may be up to 15 cm long and 10 mm wide. The fronds are dichotomously branched, with undulating margins and an indistinct midrib. The tip of each frond is distinctly rounded. The fronds are perennial and in some case five or six new periods of growth can be identified. Regeneration occurs following erosion or animal

grazing. Continual regeneration leads to great variation in the appearance of individual plants as each new growth could come from the end, margin or surface of the blade. Fronds are frequently encrusted with the spiral tube worm *Spirorbis spirorbis* or bryozoans [6.575].

**Habitat.** Frequent in shady pools in lower intertidal and on rock subtidally to 30 m.

**Distribution.** NE Atlantic (Scandinavia to Canary Islands, North Sea); W Mediterranean; Black Sea; Free-floating forms in the Baltic Sea.

**Uses and Compounds.** Raw material for the agar production on the Black Sea [6.32]. Extracts have antifungal activity [6.62].

#### *Polyides rotundus* (Hudson) Gaillon

**Common Names.** Discoid forked weed, Goat tang.

**Description.** Dark red or blackish seaweed with smooth, cartilaginous, cylindrical fronds, branching dichotomously in roughly the same plane. The fronds rise from a fleshy, discoid holdfast up to 2 cm in diameter. The reproductive bodies occur as oval-shaped swellings along the sides of the branches or occasionally encircling them. The seaweed grows up to 20 cm in length [6.576].

**Habitat.** On rocks and stones in open sandy pools and runnels, lower intertidal and shallow sublittoral.

**Distribution.** N and NE Atlantic (Arctic Ocean to Iberian Peninsula, Baltic); NW Atlantic (Arctic Canada to New York).

**Uses and Compounds.** Extracts have antifouling activity [6.532].

#### *Solieria chordalis* (C. Agardh) J. Agardh

**Description.** Thallus tufted, vividly red, axes cylindrical, thin, only sparsely branching at first, later characteristically with relatively long, unilaterally inserted appendices, height to 20 cm [6.577].

**Habitat.** In sheltered localities below the mid-littoral zone on rocks.

**Distribution.** NE Atlantic (from N France to S Morocco), Mediterranean.

**Uses and Compounds.** Source of carrageenan [6.521, 578–581]. Extracts have hemagglutinating [6.375], and Immunostimulation [6.581] activity.

#### *Sphaerococcus coronopifolius* Stackhouse

**Common Name.** Berry wart.

**Description.** Narrow, compressed, two-edged, cartilaginous, scarlet fronds, main axes dark brownish red, to 300 mm long; branching abundant, distichous, subdichotomous or alternate, terminal branchlets acute, fringed with short marginal proliferations. Tetrasporophyte is *Haematocelis fissurata*, a thick crust with oily fissures, with which it is sometimes found [6.582].

**Habitat.** Rarely on rocks in lower littoral, often common in the shallow sublittoral to 15 m.

**Distribution.** E Atlantic (Ireland and Britain to Canary Islands); Mediterranean, the Black Sea.

**Uses and Compounds.** Extracts have antifouling [6.583], cytotoxic and antimetabolic [6.62, 332, 584, 585], antiviral [6.586], antibacterial and antifungal [6.62, 275], activity.

#### *Stenogramma interruptum* (C. Agardh) Montagne

**Description.** Cartilaginous, flattened, bright-red fronds, to 70 mm high, shortly stipitate from the discoid base. Lamina fan-shaped,  $\pm$ dichotomously divided, segments about 10 mm wide, with rounded apices, margin usually smooth, rarely proliferous; reproductive structures often occurring in a clearly visible, often discontinuous, *midrib* over the surface of the fronds [6.587].

**Habitat.** Epilithic, sublittoral to 13 m, in sheltered areas on small stones among gravel and mud [6.518]. On rocks, stones, etc., sublittoral, southern and western coasts, occasional.

**Distribution.** NE Atlantic (Ireland and Britain to Morocco); West of Atlantic (Canada to Brazil); E and W Pacific (Japan, Mexico, Ecuador, Chile, Peru); Australia and New Zealand.

**Uses and Compounds.** Produces carrageenan – polysaccharides from tetrasporic plants (lambda-carrageenan) of *S. interruptum* showed higher anticoagulant activity than those isolated from cystocarpic



**Fig. 6.33** Underwater photo of *Gracilaria gracilis*

(kappa/iota-carrageenan) plants [6.512, 588]. Extracts have also antiviral activity [6.35, 549].

- Order: **Gracilariales**

*Gracilaria bursa-pastoris* (S.G. Gmelin)  
P.C. Silva

**Description.** Growing in tufts to 30 cm long, much branched usually simply forked or alternate rarely opposite; somewhat compressed, but not flat. Thallus greenish red, yellow greenish to dark brownish red, with cylindrical axes, forking and with lateral branching, tufted, erect, branches gradually tapering off, not narrowing at their origins, the cystocarp-bearing plants are densely covered with hemispherical reproductive structures (cystocarps); texture cartilaginous-meaty, stiff, bristly; discoid holdfast [6.32].

**Habitat.** Epilithic, on calmer water of the upper sublittoral.

**Distribution.** NE Atlantic (Ireland to Cape Verde Islands, Kenya); Mediterranean, Indo-Pacific Oceans (In-

dia, Sri Lanka, Philippines, Singapore, Japan, China, Hawaiian Islands, Florida, Mexico); Caribbean (Cuba) and SW Atlantic (Brazil).

**Uses and Compounds.** Source of agar [6.589] and used directly as food and for animal feed [6.32, 290]. Extracts have antibacterial [6.171], anticoagulant [6.375] activity.

*Gracilaria gracilis* (Stackhouse) Steentoft,  
L.M. Irvine & Farnham

**Common Name.** False Ceylon moss.

**Description.** Cartilaginous, cylindrical, dull-purple fronds, to 500 mm long, one or several are arising from small, fleshy, perennial discoid holdfast (Fig. 6.33). Branching very irregular, sparse or profuse, branches to 2 mm diameter, apices pointed; intertidal tissue of large thin-walled cells with narrow outer cortical zone of small colorless cells [6.2, 590].

**Habitat.** On rocks and stones, intertidal and sublittoral, especially on sandy shores, generally distributed, common.

**Distribution.** Temperate-warm to warm NE and E Atlantic (Ireland to Canary Islands, W Africa); SE Atlantic (South Africa); Mediterranean; Caribbean; W Atlantic (Brazil); NW Pacific (Russia, Japan); NE Pacific (Alaska to California, Mexico); Pacific Islands; Indo-Pacific Ocean; Australia; Antarctica.

**Uses and Compounds.** Source of agar [6.32, 523, 591–593] and used directly for animal feed [6.594]. Extracts have antimicrobial [6.276, 569], and antioxidant [6.350, 595] activity.

*Gracilaria multipartita* (Clemente) Harvey

**Description.** *G. multipartita* is a translucent, dull purple or reddish-brown alga which has fronds that measure up to 25 cm long. It is cartilaginous, very brittle, and has a compressed stipe [6.1].

**Habitat.** Grows on rocks or other hard substrata, tolerating a wide degree of wave exposure. Recorded from the upper sublittoral to a depth of 15 m. *G. multipartita* is also tolerant of sand.

**Distribution.** NE Atlantic (Britain to Senegal); Atlantic Islands; Mediterranean (Italy, Spain).

**Uses and Compounds.** Source of agar [6.596]. Extracts have antibacterial [6.269, 358, 597, 598], and antifungal [6.284, 286] activity.

*Gracilaria vermiculophylla* (Ohmi) Papenfuss  
**Common Name.** Komulkosiraegi.

**Description.** *G. vermiculophylla* is a red macroalga that is cartilaginous, cylindrical, and up to 50 cm long. It is coarsely branched, often profusely so. It can be found as loose-lying thalli or attached to small stones or shells. Red algae are often found in the vegetative state, and the characterization of reproductive structures is often necessary for correct identification of *Gracilaria* species [6.599–601].

**Habitat.** Estuarine habitats, marine habitats, mainly in salinity lagoons. It is well adapted to low energy, shallow-bottom bays, lagoons, estuaries, harbors, and inlets [6.602].

**Distribution.** Native range – NW Pacific ocean including Japan and E Asia [6.601]; Introduced range – N American E and W coasts, Europe, NE Atlantic coast extending from Morocco to SW Sweden, E Pacific [6.603, 604].

**Uses and Compounds.** *G. vermiculophylla* is widely collected for the production of Agar, which is used extensively in the pharmaceutical and food industries [6.592, 605–607]. Extracts have antibacterial [6.449], and antioxidant [6.335, 608] activity.

*Gracilariopsis longissima* (S.G. Gmelin)  
M. Steentoft, L.M. Irvine & W.F. Farnham

**Description.** Thalli are from almost simple to profuse and irregularly branched, with the slender cylindrical axis throughout the plant. Cystocarps are scattered throughout the thallus, protruding from the thallus surface. Spermatia are formed in near the surface of the thallus. Tetrasporangia are cruciate and are scattered in the cortex [6.609].

**Habitat.** Usually lives in the sublittoral environment, on loamy or sandy funds shells or gravel.

**Distribution.** NE Atlantic (Britain to Portugal); SE Atlantic (Namibia, South Africa).

**Uses and Compounds.** Source of agar [6.592, 605]. Extracts have antibacterial [6.569, 610, 611] activity.

- Order: **Halimeneales**

*Grateloupia filicina* (J.V. Lamouroux)  
C. Agardh

**Description.** Compressed, tufted, dark purplish brown fronds, to 120 mm high, main axis 1–4 mm broad. Once or twice pinnate, axes and branchlets tapered at base and apex. This is a soft limp and slippery smooth seaweed with somewhat flattened branches that can be red green brown or almost black. Size and shape vary greatly from 0.5–5 mm wide to 2–30 cm long, with either few or many branches [6.612].

**Habitat.** On rocks in pools; mid-littoral to shallow sublittoral, sporadic, often locally common.

**Distribution.** Worldwide in warm and temperate-warm seas.

**Uses and Compounds.** Used as food and source of Carrageenan [6.613–615]. Extracts have antioxidant [6.350, 595, 615–617], antimicrobial [6.34], antiviral [6.615, 618, 619], anticoagulation [6.615, 620, 621] activity.

*Grateloupia turuturu* Yamada

**Description.** Thallus flat, membranous, with short stipe, the single fronds linear to broad-lanceolate, undivided or irregularly dividing from the base, narrowing toward the base as well as the tip (Fig. 6.34); sometimes proliferating on the margins and the surface; consistency gelatinous-slippery but firm; discoid holdfast; violet- to crimson-red, often greenish at the top thallus [6.32].

**Habitat.** Epilithic in shallow tide pools and on sand-covered rocks near coast.

**Distribution.** SE Pacific (Chile), SW Atlantic (Peru), *G. turuturu* is considered native to Japan, China, and Korea, but has spread to the NE Atlantic, the Mediterranean, South America, Australia, and New Zealand.

**Uses and Compounds.** In Japan, this seaweed is commonly used as a sea vegetable [6.622]. *G. turuturu* is characterized by its richness in dietary fiber (nearly 60% DW) and therefore appears to be a good source of food fiber for human consumption. This is very interesting because the beneficial effect of fiber on health is already well known [6.623, 624]. This seaweed is also rich in proteins, like *Palmaria palmata*, another red alga



**Fig. 6.34** Underwater photo of *Grateloupia turuturu*

now authorized in France as a sea vegetable. Its lipid content is low, like all red seaweeds used in human nutrition, and its eicosapentaenoic acid content is similar to those reported for edible red seaweeds such as *Chondrus crispus* or *Gracilaria verrucosa* [6.625].

Extracts have antifouling [6.586], antibacterial [6.626], anticoagulant [6.512], antioxidant [6.627], and antiviral [6.278] activity.

- Order: **Nemaliales**

*Galaxaura rugosa* (J. Ellis & Solander)  
J.V. Lamouroux

**Synonym.** *Galaxaura elongata* J. Agardh.

**Description.** Thallus bushy, stiff, compact, forming hemispherical mounds, 5–7 (–12) cm high, dark red-brown; branching irregularly dichotomous; calcification moderate. Branches cylindrical, 0.5–1.5 (–3) mm diameter, densely but evenly covered by stiff hair-like filaments; holdfast inconspicuous. Tetrasporangia at apex of surface filaments, occasionally lateral near tip, spherical to oval, to 32 μm diameter, cruciately divided [6.628].

**Habitat.** On firm substrata in calmer shallow water; found in up to 18 m depth.

**Distribution.** E Atlantic (Madeira, Canary Islands, Cap Verde to Gabon); W Atlantic (Brazil); Caribbean; Indian Ocean; NW Pacific (Japan, Philippines, Indonesia); Pacific Islands; Australia, New Zealand.

**Uses and Compounds.** Extracts have anti-inflammatory [6.629], antimicrobial [6.72, 391], antifungal, cytotoxic, and antiviral [6.72] activity.

*Ganonema farinosum* (J.V. Lamouroux)  
K.C. Fan & Yung C. Wang

**Synonym.** *Liagora farinosa* J.V. Lamouroux

**Description.** This alga is soft, smooth and about 13 cm tall. It is pinkish, lightly calcified, farinose and attached by small discoid holdfasts. The branching pattern is basically dichotomous, with interdichotomal lengths decreasing toward terminal portions of the thallus. The branches are numerous, cylindrical, measuring about 1.5 mm in diameter, with forking apices into very short, acute and terminal branchlets [6.630].

**Habitat.** *G. farinosum* is found attached to rocky substrate among other algae in the sublittoral and intertidal areas exposed to air during low tides.

**Distribution.** *G. farinosum* is widely distributed in the tropical waters of the Atlantic, Pacific, and Indian Oceans; Mediterranean; In SE Asia, it has been recorded from Thailand, Vietnam, Malaysia, Indonesia (Irian Jaya) and the Philippines.

**Uses and Compounds.** Extracts have antibacterial [6.449], antifungal [6.204], cytotoxic, and antiviral [6.72] activity.

*Liagora ceranoides* J.V. Lamouroux

**Description.** Thallus to 11 cm high, pale pink to gray, lightly calcified, mucilaginous, irregularly or dichotomously branched every 2–20 mm, with many proliferous lateral branches to 10 mm long; pressed specimens strongly adherent. Main axes to 2.5 mm in diameter basally, tapering to 0.2 mm near apices [6.631].

**Habitat.** From intertidal pools to 27 m depth, epilithic on *Lobophora variegata*; widespread in tropical seas.

**Distribution.** NE Atlantic (from France, Spain); Atlantic Islands; Mediterranean; NW Atlantic; Caribbean; SW and SE Atlantic; Indo-Pacific Oceans; Australia.

**Uses and Compounds.** Extracts have anticoagulant [6.206], and antioxidant [6.65] activity.

*Liagora viscida* (Forsskål) C. Agardh

**Description.** Thallus tufted, gray-purple to greenish white or pink, repeated dense branching at almost the same length, branches terete, tapering toward the top (Fig. 6.35); terminal branches usually spreading as wide-angled bifurcations, moderately calcified, texture flexible-firm [6.32].

**Habitat.** On firm substrata in shallow water to 5 m depth.

**Distribution.** NE and North Atlantic (France to Cap Verde Islands); Mediterranean; Indian Ocean (India, Sri Lanka); Pacific Islands (Fiji).

**Uses and Compounds.** Their endophytic fungi have antitumor and antimicrobial activity [6.632, 633].

*Nemalion helminthoides* (Velley) Batters

**Description.** Thallus cylindrical, reddish to purple brown, softly gelatinous, simple or sparingly dichotomously branched, to 2 mm wide, to 250 mm long, with discoid holdfast [6.634].

**Habitat.** On exposed rocky shores, generally growing on barnacles and limpets.

**Distribution.** NE Atlantic (Scandinavia to Canary Islands, W Africa); SW Atlantic (Brazil, Uruguay); Mediterranean; NW Pacific (Japan); NE Pacific (Alaska to Mexico); Australia, New Zealand.

**Uses and Compounds.** Used as food [6.634] and with dietary antioxidants [6.65, 205, 429]. *N. helminthoides* showed appreciable antiherpetic activity [6.635].

*Scinaia furcellata* (Turner) J. Agardh

**Common Name.** Southern scinà's weed.

**Description.** Cylindrical, gelatinous but firm, clear pink to purplish-red fronds, 10 mm wide, 250 mm long, dichotomously branched from small discoid base (Fig. 6.36); constrictions at irregular intervals in mature plants [6.32].



Fig. 6.35 *Liagora viscida* specimen



Fig. 6.36 *Scinaia furcellata* specimen

**Habitat.** On stones, shells, and mal in the sublittoral (30 m), mainly in clear, unpolluted water; not common.

**Distribution.** NE and E Atlantic (S Norway to Morocco, Canary Islands to Congo); NW Atlantic; Mediterranean; Indian Ocean.

**Uses and Compounds.** Extracts have cytotoxic [6.636], antibacterial [6.130], and anticoagulant [6.637] activity.

- Order: **Neamatomales**

*Schizymenia dubyi* (Chauvin ex Duby)  
J. Agardh

**Description.** Erect leaf-like flat fronds, brow-red (liver-colored), translucent, gradually widening from the base, simple or irregularly split or lobed, then at a narrow angle, overlapping; often noticeably sickle-shaped, with smooth margin, not proliferating texture soft-slippery; cystocarps very small and sunken; very short stunted stipe, small discoid holdfast [6.32].

**Habitat.** Pools and on rock mid lower intertidal zone.

**Distribution.** NE Atlantic (Iceland to Morocco); Mediterranean; NW Pacific (Japan, China, Korea); Australia.

**Uses and Compounds.** Extracts have antioxidant [6.350], antitumor [6.638], antiviral, and anticoagulant [6.205, 546, 639, 640] activity.

- Order: **Palmariales**

*Palmaria palmata* (Linnaeus) Weber & Mohr

**Common Name.** Dulse, Grannogh, Dillisk, Handed focus.

**Description.** Reddish brown, membranous or leathery, flattened fronds, 50–300 (–1000) mm long, arising from a discoid base, usually with a small stipe expanding gradually to form simple or dichotomously and palmately divided fronds, often with characteristic marginal leaflets (Fig. 6.37); blade very variable in shape, having broadly ovate to narrowly linear segments [6.641].

**Habitat.** On rocks, mussels, and epiphytic on several algae, intertidal (at all levels but particularly near low water) and shallow sublittoral, especially on the upper part of *L. hyperborea* stipe.

**Distribution.** *P. palmata* grows along the northern coasts of the Atlantic and Pacific oceans, as far north as Arctic Canada and Russia, and as far south as Portugal in Europe, and New Jersey and California in the United States. In the western Pacific, the southern range of *P. palmata* includes Japan and Korea.

**Uses and Compounds.** Dulse is good to eat, but only after being dried. In a fresh state it is leathery



**Fig. 6.37** *Palmaria palmata* specimen

and unpalatable. After sun drying and proper storage, it is a very pleasant plant to chew. It has very little fat and only a small amount of proteins and cellulose, but is very rich in trace elements and vitamins, particularly vitamin A. Dulse contains large amount of several unusual carbohydrates including an unusual short-chained one, floridoside, and this can form up to 30% of the dry weight. This may account for its palatability [6.642].

*P. palmata* is a good source of dietary requirements; it is rich in potassium, iron, iodine and trace elements, and relatively low in sodium. A small amount can provide more than 100% of the daily amount of Vitamin B<sub>6</sub>, 66% of Vitamin B<sub>12</sub>, iron, and fluoride. It has a slight nutty flavor, and has a long tradition in the cuisines of many Northern European cultures. *P. palmata* is also a traditional food in maritime North America, used in condiments, soups, and appetizers. Younger parts of the fronds are considered the most tender and edible. It can be eaten raw. *P. palmata* is also used as fodder for a variety of animals in many countries, as pet supplements, and sometimes as an agricultural fertilizer [6.4, 642, 643].

Extracts of this species have antioxidant [6.533, 644–647], and antitumor [6.432, 644, 645] activity.

*Rhodothamniella floridula* (Dillwyn)  
Feldmann

**Description.** *R. floridula* is perennial brownish-red seaweed found on the lower shore. It usually covers large areas of rock in sandy habitats. At the base of the seaweed, filaments bind with sand to form a spongy, carpet like mass. The filaments are well-spaced and branch out up to 3 cm in length. Upright filaments of the seaweed uncovered by the ebbing tide appear as tufts of hair; when plants dry out they have a purplish tinge [6.648].

**Habitat.** Turf-forming on sand-covered rocks, mid- and lower intertidal, often under *Fucus serratus*; widely distributed, very common.

**Distribution.** NE Atlantic (Ireland and Britain to Portugal); SE Atlantic (Namibia, South Africa); SW Atlantic (Argentina).

**Uses and Compounds.** Used for the production of pharmaceuticals and functional foods [6.205]. Extracts have antioxidant activity [6.205].

- Order: **Plocamiales**

*Plocamium cartilagineum* (Linnaeus)  
P.S. Dixon

**Common Names.** Cock's comb, Kammtang, Kamwier, Red comb weed.

**Description.** Bright scarlet seaweed up to 30 cm in length with branching fronds (Fig. 6.38). The branching occurs alternately along the fronds and becomes more frequent toward the tips. The general appearance of these seaweeds can greatly vary from very compact and closely branched to a much broader appearance with widely separated branching. The tips are incurving and ultimate branching occurs only to one side, giving a distinctive feathery or comb-like appearance [6.649].

**Habitat.** Temperate seas throughout the world; found on coasts of strong to moderate wave action and known from depths of 2–26 m. Growing on *L. hyperborea* stipes and on other algae.

**Distribution.** NE Atlantic (Scandinavia to Senegal, North Sea), SE Atlantic (Namibia); Mediterranean; Indian Ocean (Pakistan, Mauritius); NW Pacific (Japan); Pacific Islands; NE Pacific (Alaska to California); SE-Pacific (Chile); Australia, New Zealand; Antarctica.



**Fig. 6.38** Underwater photo of *Plocamium cartilagineum*

**Uses and Compounds.** Extracts with a red color are said to have been used for cosmetic purposes in ancient Rome [6.32].

*P. cartilagineum* is harvested commercially as the main raw material for the agar production on the Pacific coast of North America. Agar is widely used not only in laboratories as a growth medium for bacteria and other cultures, but in food and cosmetics as a gelling agent and stabilizer. It is a very pure, natural, firm gel. *P. cartilagineum* extracts are also high in lypholitic (lipid-digesting) sterols and as such is useful as an additive in slimming applications such as creams and massage products where it is able to provoke the release of fatty acids and eliminate surface fat, acting as a skin-firmer [6.650].

Extracts have antimicrobial [6.651], insecticidal [6.652], cytotoxic and antitumor [6.653], antioxidant [6.125], and antiviral [6.357, 549] activity.

- Order: **Rhodymeniales**

*Botryocladia botryoides* (Wulfen) Feldmann

**Description.** Plants rose-red to honey pink, erect, up to 11 cm in length, with irregular pseudodichotomous branching. Main axis and branches terete, 9–2.5 mm in diameter, of solid construction, composed of small pigmented, round to oval, cortical cells (5 μm diameter) that gradually increase in size thallus inward; medullary cells larger, hyaline, and ovoid, up to 50 μm. Axis and branches bearing pyriform vesicles [6.654, 655].

**Habitat.** Epilithic in depths up to 7 m.

**Distribution.** NE Atlantic (Atlantic Islands), Western Atlantic [6.654].



**Uses and Compounds.** Extracts have antifungal activity [6.62].

*Champia parvula* (C. Agardh) Harvey

**Description.** Soft, gelatinous, pinkish red, much-branched fronds, densely matted, with blunt apices, to 100 mm high. Axes segmented, with nodal diaphragms, segments about as broad as long, filled with watery mucilage [6.656].

**Habitat.** Epiphytic on smaller algae in lower intertidal pools and sublittoral, South West England and Ireland, Channel Islands, locally common.

**Distribution.** Worldwide in tropical to subtropical and warmer seas with bordering warm-temperate zones.

**Uses and Compounds.** Extracts have anticoagulant [6.637], and antiherpetic [6.657] activity.

*Chylocladia verticillata* (Lightfoot) Bliding

**Description.** Soft, gelatinous, cylindrical, pinkish to brown-red fronds (often bleached yellow or almost

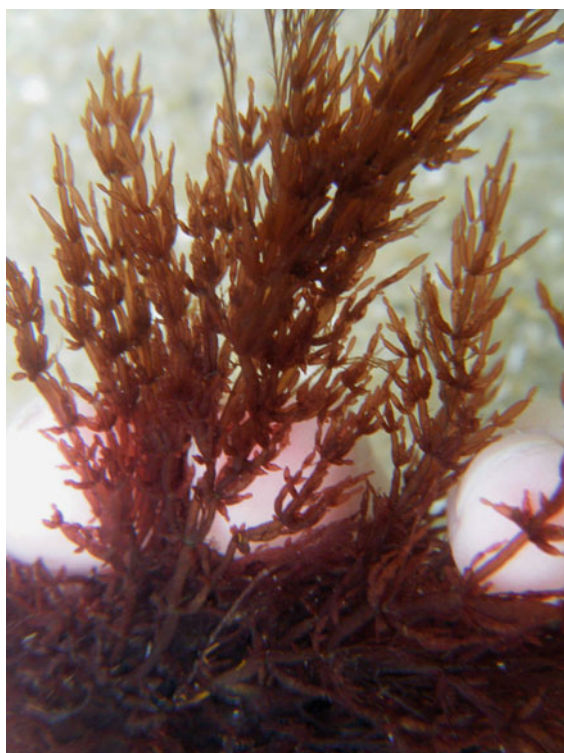


Fig. 6.39 Underwater photo of *Lomentaria articulata*

white in sunny Habitats), to 300 mm high, filled with a watery mucilage. Main axis simple, jointed, with nodal diaphragms, very slightly constricted at nodes, 2-several branches per node, themselves often branched, with small beaded ultimate ramuli. Very variable in branching pattern, plants of exposed coasts often simple with small terminal tufts of ramuli [6.658].

**Habitat.** On rocks and stones and epiphytic, lower intertidal and sublittoral, generally distributed, common.

**Distribution.** NE Atlantic (Norway to Sierra Leone); Mediterranean.

**Uses and Compounds.** Extracts have cytotoxic activity [6.659].

*Lomentaria articulata* (Hudson) Lyngbye

**Description.** A small (up to 20 cm tall, but usually much shorter) dark brown to red alga (Fig. 6.39). The thallus is conspicuously constricted giving a segmented appearance. Starting almost at the base, many branches grow out of each constriction, the bead-like segments becoming gradually smaller toward the tip of the branch. The plant is very shiny and the tips of branches may be bleached pink or orange [6.1].

**Habitat.** On rocks and stones in pools, lower intertidal and sublittoral, generally distributed, frequent.

**Distribution.** NE and E Atlantic (Scandinavia to Cameroon), Mediterranean, Black Sea, Indian Ocean (India), W Pacific (Philippines).

**Uses and Compounds.** Extracts have antioxidant [6.316], and antimicrobial [6.660] activity.

*Rhodymenia pseudoplamata* (J.V. Lamouroux)  
P.C. Silva

**Description.** Flattened, fan shaped, rather stiff, rose-red fronds, to 100 mm high, with long or short stipes arising from a discoidal base. Fronds repeatedly dichotomously lobed, axils wide, apices rounded, margin smooth [6.32].

**Habitat.** On rocks, shady pools lower intertidal and sublittoral, also epiphytic on *L. hyperborea* stipes.

**Distribution.** NE Atlantic (Scandinavia to Cap Verde Islands), E Atlantic (W Africa), SE Atlantic

(Namibia, South Africa); NW Atlantic (N and S Carolina), Caribbean, SW Atlantic (Brazil, Uruguay); Mediterranean.

**Uses and Compounds.** Extracts have antibacterial activity [6.358].

### 6.3.4 Domain/Empire Eukaryota, Kingdom Chromista, Phylum Ochrophyta; Class Phaeophyceae (Brown Algae)

- Order: **Cutleriales**

*Cutleria multifida* (Turner) Greville

**Description.** Only the morphologically more conspicuous *Cutleria*-phase is described: thallus erect, light to yellow-brown, also olive-brown, flattened, membranous, with smooth margins, deeply incised and repeatedly irregular forking, with linear to wedge-shaped sections, gradually narrowing toward the tip and dissected apices, fringed by a tuft of hair-like filaments; without stipe, rhizoidal discoid holdfast [6.32].

**Habitat.** On rocks, usually isolated, sublittoral to 10 m.

**Distribution.** NE Atlantic (Scandinavia to Canary Islands); Mediterranean; Indian Ocean; NW Pacific (Japan); SE Pacific (Chile); Pacific Islands; Australia.

**Uses and Compounds.** Extracts have anticoagulant activity [6.661].

*Zanardinia typus* (Nardo) P.C. Silva

**Common Name.** Penny weed.

**Description.** *Z. typus* is a fairly small brown seaweed with flat fronds that may be either round or fan-like and possibly irregular in shape. The appearance may change with age, varying in color from olive to dark brown or black and in texture from smooth to leathery. The edge of the fronds may be smooth or ruffled, and has a distinct fringe of hairs [6.662].

**Habitat.** Found mainly on silty boulders or bedrock, rarely on living substrata, on sublittoral from shallow water to about 20 m depth.

**Distribution.** NE Atlantic (SW Ireland and SW Britain, Canary Islands); Mediterranean (Italy).

**Uses and Compounds.** Extracts have antifouling [6.663], antioxidant [6.664], antibacterial and antifungal [6.62, 311, 665], antiviral cytotoxic, and antimutagenic [6.62, 507].

- Order: **Desmarestiales**

*Desmarestia aculeata* (Linnaeus)

J.V. Lamouroux

**Description.** This species of brown seaweed looks like a flattened cactus; a flat main axis approximately 2 cm wide with obvious midrib arises from a discoid holdfast. Numerous thinner opposite growing flat side branches are attached to the main axis. *D. ligulata* grows low to sublittoral and reaches 80 cm in length. Other species of flattened *Desmarestia* have been described for our area and there is ongoing discussion about the relationships of these species and their exact number. *D. munda* is described as growing to over 120 cm with side branches as wide as the main axis (4–10 cm), but strictly sublittoral. Beach Watchers have observed individuals that match both descriptions and a combination of the two [6.1].

**Habitat.** On rocks in pools in the lower intertidal; however, mostly sublittoral, to 15 m depth often abundant.

**Distribution.** NE Atlantic (Iceland to Morocco); NW Pacific (Japan); NE Pacific (Alaska to California); SE Pacific (Chile); Pacific Islands (Hawaii); Australia, New Zealand.

**Uses and Compounds.** Source of Laminaran and Alginate [6.666].

*Desmarestia ligulata* (Stackhouse)

J.V. Lamouroux

**Description.** This species of brown seaweed looks like a flattened cactus (Fig. 6.40); a flat main axis approximately 2 cm wide with obvious midrib arises from a discoid holdfast. Numerous thinner opposite growing flat side branches are attached to the main axis. *D. ligulata* grows low to sublittoral and reaches 80 cm in length. Other species of flattened *Desmarestia* have been described for our area and there is ongoing discussion about the relationships of these species and their exact number. *D. munda* is described as growing to over 120 cm with side branches as wide as the main axis



**Fig. 6.40** Underwater photo of *Desmarestia ligulata*

(4–10 cm), but strictly sublittoral. Beach Watchers have observed individuals that match both descriptions and a combination of the two [6.1].

**Habitat.** On rocks in pools in the lower intertidal; however, mostly sublittoral, to 15 m depth often abundant.

**Distribution.** NE Atlantic (Iceland to Morocco); NW Pacific (Japan); NE Pacific (Alaska to California); SE Pacific (Chile); Pacific Islands (Hawaii); Australia, New Zealand.

**Uses and Compounds.** The brown algae *D. ligulata* and *D. viridis* accumulate sulfuric acid until their average internal pH is 0.5 – 0.8. A related species, *D. aculeata*, does not accumulate acid [6.667]. Extracts have antimicrobial [6.668], antioxidant, and antitumor [6.316, 421] activity.

- Order: **Dictyotales**

*Canistrocarpus cervicornis* (Kützting)  
De Paula & De Clerck

**Synonym.** *Dictyota cervicornis* Kützting

**Description.** Thallus tufted, yellow-brown, erect, somewhat intertwined; branches screw-like twisted, narrow ribbons, mostly forking, but asymmetrically branching (one fork longer than the other), widening at the fork-base (to 4 mm), the upper thallus parts narrow (1–2 mm wide), slightly tapering upward, tips acute, margins smooth; anchored to right substrata by a discoidal holdfast [6.669].

**Habitat.** Grows on rocks and epiphytically in shallow water of warmer seas, but also in up to 20 m depth.

**Distribution.** Warm E Atlantic; Caribbean; SW Atlantic (Brazil); NW Pacific (Japan, China); Indian Ocean.

**Uses and Compounds.** Extracts have antinociceptive [6.670], antifouling [6.671], antifungal [6.204], antiproliferative [6.672], antiviral [6.673], antioxidant and anticoagulant [6.64, 674] activity.

*Dictiopteris polypodioides* (A.P. De Candolle)  
J.V. Lamouroux

**Synonym.** *Dictyopteris membranacea* (Stackhouse) Batters

**Description.** Thallus flat and leaf-like, to 300 mm long and 20–30 mm broad; fronds olive to yellow-brown, translucent, and ± regularly dichotomously forked with a prominent midrib extending to the apices (Fig. 6.41). Margins sometimes split to the midrib. Initially with an unpleasant smell shortly after collection, and degenerating quickly [6.1].

**Habitat.** In low-light calm water, to 40 m depth.

**Distribution.** Cold temperate to warm NE Atlantic (Ireland to Canary Islands); Mediterranean; W Pacific (Philippines); NW Pacific (Japan); Caribbean; Indian Ocean.

**Uses and Compounds.** Extracts have anti-inflammatory [6.675], antibacterial [6.276, 675], antitumor [6.676], antioxidant [6.675], and cytotoxic [6.62] activity.



**Fig. 6.41** Herbarium specimen of *Dictiopteris polypodioides* (MACOI no. 260)

### *Dictiopteris delicatula*

J.V. Lamouroux

**Description.** *D. delicatula* has erect, light-brown, strap-shaped blades attaching to substratum at basal holdfast or to adjacent branches, creating a tangled mass 2–8 cm in height. Dichotomous to irregularly branched bilayered blades, 0.5–5.0 mm wide, have a distinctly raised midrib that may be several cells thick. Cells of blades are arranged in parallel rows at acute angles to midrib. Scattered clusters of hyaline hairs in dense tufts arise along midrib on only one surface of midrib [6.677].

**Habitat.** Attached to rock-sand coral fragments, also as an epiphyte on larger seaweeds; from the lower sublittoral to  $\approx$  10–30 m depth.

**Distribution.** Tropical and Sub-tropical Atlantic (Canary Islands), Gulf of Mexico, Caribbean, Indian Ocean, Red Sea, Central Pacific, Costa Rica; Pacific.

**Uses and Compounds.** Extracts have antifungal [6.204], cytotoxic [6.459], antibacterial [6.449], anti-proliferative and antitumor [6.672], antioxidant and anticoagulant [6.459, 678, 679] activity.

### *Dictiopteris plagiogramma* (Montagne)

Vickers

**Common Name.** Limu lipoa

**Description.** Thalli dark olivaceous green to light tan or almost yellowish, occurring as dense often intertwined tufts of multiple axes arising from a common matted holdfast; fronds 2–8 cm long, 1–8 mm wide, usually crisp in texture and pungently aromatic when fresh; branching of juvenile thalli basically dichotomous, becoming pseudomonopodial at maturity and then highly irregular as wing tissue wears away to leave midribs as several orders of stalks. Blades from apex to base traversed from midrib to margin by regularly spaced microscopic to faintly visible veins that arise at angles of 10–20° and form broad arches bending away from the apices [6.680].

**Habitat.** Uncommon, on hard substrates, often attached to coral fragments or scattered rocks on deep sand plains; 9–55 m deep.

**Distribution.** Widespread in the subtropical to tropical waters of the Atlantic, Caribbean, Mediterranean, Indian Oceans, and in the Pacific Ocean.

**Uses and Compounds.** Produces Laminaran and Alginate and is used as food [6.681]. Extracts have antioxidant activity [6.682].

### *Dictyota ciliolata* Sonder ex Kützing

**Description.** Thallus erect, light brown with yellow green iridescence, sometimes with dark brown striations; branching irregular to dichotomous; branches strap-shaped, margin with teeth, often spirally twisted; medullary cells one layer thick, rectangular [6.683].

**Habitat.** Attached to rock in seagrass bed, and in intertidal pools in moderately high energy Habitats.

**Distribution.** Warm E Atlantic (Madeira, Canary Islands, W Africa); Caribbean; SW Atlantic (Brazil); SW Pacific; Indian Ocean; Australia.

**Uses and Compounds.** Extracts have antifungal [6.204], and antioxidant [6.65] activity.

### *Dictyota dichotoma* (Hudson)

J.V. Lamouroux

**Description.** Thallus flat, homogenous yellow-brown to darker brown, with fairly regular dichotomous branches (Fig. 6.42) with parallel sides to 30 cm long, the tips usually bifid; branches 3 to 12 mm wide, membranous, without a mid-rib [6.1].



Fig. 6.42 Underwater photo of *Dictyota dichotoma*

**Habitat.** In shallow water on firm substrata, found in >50 m depth.

**Distribution.** Common and globally distributed.

**Uses and Compounds.** A chlorine-containing perhydroazulene diterpene, dictyol J 146, was isolated from the brown alga *D. dichotoma* along with two known diterpenes, dictyolactone and sanadaol [6.684, 685]. All three metabolites were algicidal [6.686] to the bloom-forming species *Heterosigma akashiwo* and *Karenia mikimotoi*. Dictyolactone also displayed a moderate activity against the dinoflagellate *Alexandrium catenella*.

Extracts of this seaweed have also anticoagulant [6.512, 637, 687], cytotoxic [6.62, 688, 689], antitumor [6.126, 690], anti-inflammatory [6.691], antifungal [6.62], larvicidal [6.51], antimicrobial [6.18, 40, 692], and antifouling [6.693, 694] activity. Extracts have also used for a liquid fertilizer [6.695].

#### *Dictyota fascida* (Roth)

J.V. Lamouroux

**Synonym.** *Dilophus fasciola* (Roth) M.A. Howe

**Description.** *D. fasciola* has a ribbon-like opaque thallus with a height of 100–150 mm, and width of 1–6 mm. The thalli are flattened, and highly branched in a dichotomous pattern; it is three cells thick and without midrib. The branches are attenuated with forked tips; it has a yellowish-brown coloration [6.696].

**Habitat.** On firm substrata in the intertidal.

**Distribution.** Warmer E Atlantic (Madeira, Canary Islands); E Africa; Mediterranean; Indian Ocean.

**Uses and Compounds.** Extracts have antimicrobial [6.130], antioxidant [6.664], and antifouling [6.697] activity.

#### *Dictyota implexa* (Desfontaines)

J.V. Lamouroux

**Synonyms:** *Dictyota dichotoma* var. *implexa* (Desfontaines) S.F. Gray; *Dictyota linearis* (C. Agardh) Greville

**Description.** Thallus bushy, brown, consisting of intertwined, erect fascicles; thallus regularly forking, width at the base 2–3 mm, abruptly narrowing toward the tip, then filamentous (< 0.5 mm) [6.32].

**Habitat.** From 0 to 10 m depth.

**Distribution.** Atlantic Islands (Azores and Canary Islands); Mediterranean.

**Uses and Compounds.** Extracts have antibacterial [6.40, 276, 698], antifungal [6.276], and antioxidant [6.112] activity.

#### *Dictyota mertensii* (Martius) Kützing

**Description.** Thallus bushy, brown, often iridescent blue-green under water, erect, robust and stately; the flattened fronds show a branching pattern atypical for the genus: distinct main axes branch repeated-alternating, terminal forkings of the latitudinal axes turn into spur-like, 1–2 mm long, pointed or rounded tips [6.32].

**Habitat.** On rocks in shallow (about 2 m deep) water, in moderately wave-exposed sites in the intertidal, also in up to approx. 15 m depth.

**Distribution.** Warm E Atlantic (Canary Islands to Gabon); Caribbean; SW Pacific and Pacific Islands.

**Uses and Compounds.** Extracts have antibacterial [6.699] and feeding-deterrent [6.700, 701] activity.

#### *Dictyota spiralis* Montagne

**Synonym.** *Dilophus spiralis* (Montagne) G. Hamel

**Description.** Thallus bushy, erect; lamina segments ribbon-like, regular forking, spiralling around the longitudinal axis, tips straight, pointed. 10–20 cm long, brown, tips a lighter shade [6.702].

**Habitat.** Near the surface on rocks, also as an epiphyte.

**Distribution.** NE Atlantic (W Ireland and SW Britain to Mauretania); Mediterranean.

**Uses and Compounds.** Extracts have antimicrobial activity [6.18, 130, 703].

*Lobophora variegata* (J.V. Lamouroux)  
Womersley ex E.C. Oliveira

**Description.** These algae occur in orange brown to dark brown in colour and bear a leathery feel. The blades may appear as fan shaped, flabellate or as crusts. They are often tightly adhered to the substrate [6.704].

**Habitat.** Grow in most reef environments, encrusting great areas of shaded, rocky substrates. Especially abundant on undercut wall faces along deep drop-offs.

**Distribution.** Warm E Atlantic (Madeira, Canary Islands, W Africa); Caribbean (Trinidad); Hawaii; Indian Ocean, Australia.

**Uses and Compounds.** Lobophorolide was isolated from the common brown alga *L. variegata* and displayed a potent and highly specific activity against the marine filamentous fungi *Dendrophiella salina* and *Lindra thalassiae* and a potent activity against *C. albicans* and antineoplastic [6.705]. Extracts have also antiprotozoal [6.706, 707], antimicrobial [6.65, 260, 707], anti-inflammatory [6.708], hypoglycemic [6.81], antifungal [6.61, 62], antifouling [6.260], anti-inflammatory, antioxidant, and anticoagulant [6.65, 709, 710] activity.

*Padina gymnospora* (Kützing) Sonder

**Description.** Usually the blades are 10–12 cm long and broad, but plants with 15 cm long and to 20 cm broad blades may be found; the frond has three layers of cells except near the enrolled edge where two cell layers occur; the hair lines alternate on both sides of the blade and the dark lines of sporangia are found just above every second hair-line; plants tufted, 5–10 cm tall, the blades 5–20 cm broad rounded or split into narrower portions, the lower parts stalk like and stupose, usually rather moderately calcified on the upper surface [6.711, 712].

**Habitat.** On rocks and other firm substrata (mangrove-roots), in calm or only moderately wave-exposed locations in the intertidal, found in up to 14 m depth.

**Distribution.** Warm E and SE Atlantic (Canary Islands to Angola); SW Atlantic (Brazil); Caribbean; W Pacific and Indo-Pacific (Philippines, Vietnam); Pacific Islands; Indian Ocean; Australia.

**Uses and Compounds.** Extracts have anti-inflammatory [6.713], antibacterial [6.114, 493, 714, 715], antifungal [6.715], anticoagulant [6.716], antioxidant [6.717], neuroprotective [6.718], antiviral [6.172, 719] activity.

*Padina pavonica* (Linnaeus) Thivy  
Common Name. Peacock's tail

**Description.** The fronds are thin and leafy, flattish and entire when young, but often concave, or almost funnel shaped in mature specimens, with a lactinate or irregularly lobed margin (Fig. 6.43). The inner (or upper) surface is covered in a thin coating of slime, and the outer (or lower) surface is banded with zones of light brown, dark brown, and olive green. Small, fine hairs form concentric lines, 3–5 mm apart, from the outer margin continuing down the outer (colored) surface of the fronds [6.32].

**Habitat.** On rocks in sheltered locations near the surface, to 20 m depth.

**Distribution.** NE Atlantic (S Britain to Canary Islands, W Africa); Mediterranean; Caribbean; W Pacific (Philippines), Pacific Islands; Indian Ocean.

**Uses and Compounds.** Cosmetic uses for skin anti-aging [6.720]. High anticoagulant activity has been reported for purified fucan sulphates from *P. pavonica* (xylofucanmannoglucuronan) [6.721]. Extracts have also allelopathic [6.722], antifungal [6.204, 286, 438, 722], antibacterial [6.72, 284, 421, 723, 724], anticoagulant [6.512], antitumor [6.126, 421], antiviral [6.72], cytotoxic, and antimetabolic [6.62, 72, 725] activity.

*Taonia atomaria* (Woodward) J. Agardh

**Description.** Thallus erect, flat ribbon-shaped, paper-like thin, irregularly branching into wedge-shaped segments and/or deeply dividing into narrower, almost linear bands, the upper margin appearing frayed; without midrib; dark, slightly undulating zones of transverse stripes on both sides (hairs and reproductive structures). Stipe-like at the bottom anchored by a dense rhizoidal felt [6.32].



Fig. 6.43 *Padina pavonica* specimens

**Habitat.** In pools on rocky and sandy substrata in semiwave-exposed situations up to 10 m depth.

**Distribution.** NE Atlantic (Britain to Mauretania), Mediterranean.

**Uses and Compounds.** Used as functional foods ingredient [6.205, 726, 727].

*T. atomaria* was a source of meroditerpenes atomarianones A 123 and B 124, the cytotoxic agents against the NSCLC-N6 and A-549 cell lines [6.728]. The brown alga *T. atomaria* was also a source of meroditerpenes atomarianones, the cytotoxic agents against some cell lines [6.728].

Sargaquinone were isolated from the brown alga *T. atomaria* and were anti-inflammatory agents by inhibition of leukotriene biosynthesis [6.729].

Extracts have also antioxidant [6.102, 205, 685], antitumor [6.730], and antimicrobial [6.130] activity.

***Zonaria tournefortii* (J.V. Lamouroux)**  
Montagne

**Description.** Thallus erect, with flat lobed sections divided into. Wedge-shaped segments, often incised and proliferating; lamina inconspicuously banded by distant, concentric rows of hairs which are parallel to the distal margin; additionally, delicate lines which run radially from the base to the upper margin; margins not enrolled, lamina not calcified; basally thickened, stipe-like, branching, stipe extending like a midrib into the segments; cushion-like rhizoidal network [6.32].

**Habitat.** In shady locations, from the surface to 40 m depth.

**Distribution.** Warm NE Atlantic (Madeira, Canary Islands, W Africa); Mediterranean; Caribbean; SW Atlantic (Brazil); SW Indian Ocean (South Africa).

**Uses and Compounds.** Extracts have antibacterial activity [6.391].

● Order: **Ectocarpales**

***Asperococcus bullosus***  
J.V. Lamouroux

**Description:** Thallus simple, membranous, hollow and irregularly bladder-like bloated; with short stipe which abruptly widens into the hollow inflated thallus body; reproductive structures on the surface are visible as dark dots; discoid holdfast [6.32].

**Habitat.** Lower intertidal and shallow sublittoral; mainly epiphytic.

**Distribution.** Widely distributed in temperate seas.

**Uses and Compounds.** Extracts have antioxidant and antitumor activity [6.205, 731].

***Chordaria flagelliformis* (O.F. Müller)**  
C. Agardh

**Common Name.** Black whip weed.

**Description.** Thallus string-like, with divaricated branches, slippery, solid, dark brown to black, 10–30 cm high; branching irregular, alternate from all sides; branches cylindrical, or slightly compressed, to 3 mm wide, slightly tapering toward the base. Branch apices blunt. Medulla composed of longitudinal filaments of long cylindrical cells to 50–600 μm decreasing toward periphery to 16–18 μm. A layer of assimilative unbranched filaments (of 4–9 cell rows) develop from the peripheral cells [6.732].

**Habitat.** Growing on stony bottom, in low intertidal to sublittoral, in calm shores and exposed to wave action.

**Distribution.** NE Atlantic (from Greenland, Scandinavia to Britain, North Sea and Baltic)); NW Atlantic; SE Atlantic; NE Pacific; Antarctica and Sub-Antarctic Islands.

**Uses and Compounds.** Used as food [6.546, 732], and extracts have antitumor [6.733], anticoagulant and

antithrombotic [6.732, 734], and antioxidant [6.546] activity.

*Colpomenia peregrina* Sauvageau

**Common Name.** Oyster thief.

**Description.** Sometimes regularly spherical (*C. peregrina*) or more or less irregular outline (*C. sinuosa*), yellowish-brown color, fixed to the substrate by filamentous rhizoids. Internally, the thallus is characterized by an outer cortex composed of small colored cells and inner pith composed of large pigmented cells [6.1].

**Habitat.** On moderately wave-exposed rocks and (mostly) on other algae in the lower intertidal.

**Distribution.** NE Atlantic (Norway to Canary Islands); W Mediterranean; NW Pacific (Japan); NE Pacific (Alaska to California); Australia, New Zealand.

**Uses and Compounds.** Extracts have cytotoxic and antibacterial activity [6.735].

*Colpomenia sinuosa* (Mertens ex Roth)  
Derbès & Solier

**Description.** Thallus bladder-like, smooth, slick, hollow, crisp, spherical to sac-like, irregularly expanded or somewhat lobed, to 30 cm diameter, 10 cm high, golden-brown (Fig. 6.44); often covered with fine colorless hairs; reproductive sori as dark raised patches on surface. Membrane 300–500  $\mu\text{m}$  thick, of 4–6 cell layers; medullary cells to 240  $\mu\text{m}$  diameter; cortex 1–2 cells thick; surface cells 3.7–8.0 (–16)  $\mu\text{m}$  diameter, darkly pigmented; surface-phaeophycean-hairs transparent, in scattered clusters; holdfast not apparent, attachment at many points [6.1].

**Habitat.** Firmly attached to hard surfaces or epiphytic on other organisms; lower intertidal to 15 m deep.

**Distribution.** NE Atlantic (Portugal to Canary Islands); Mediterranean; E and SE Atlantic (W to South Africa); Caribbean; SW Atlantic (Brazil, Uruguay); Indian Ocean; NW Pacific (Japan, China) NE Pacific (California); SE Pacific (Galapagos, Chile); W Pacific and Indo-Pacific (Vietnam, Malaysia, Philippines); Pacific Islands (Hawaii, Polynesia); Australia, New Zealand.

**Uses and Compounds.** Edible, used as food [6.32], fertilizer, and source of alginic acid [6.109]. Ex-



**Fig. 6.44** Underwater photo of *Colpomenia sinuosa*

tracts have antibacterial [6.86, 228, 692], antifungal [6.204], antioxidant [6.736, 737], antitumor [6.126], antileukemic, antiprotozoan, and hypolipidemic [6.698] activity.

*Ectocarpus siliculosus* (Dillwyn)  
Lyngbye

**Description.** Plants tufted, often only one to a few cm tall, but in exceptional cases up to 20 cm. Axes freely branched, main axis not distinguishable; filaments up to 30  $\mu\text{m}$  in diameter, tapering toward the apices. Sometimes forming terminal pseudohairs, forms soft beards on larger plants or other firm substrata, and grows up to 2 feet long [6.738].

**Habitat.** On various firm substrata near the low-tide mark or below, later often free floating; also epiphytic.

**Distribution.** Almost globally distributed: NE Atlantic (Greenland to Canary Islands; North Sea; Baltic); Mediterranean; NW Atlantic (Canada, USA); SE and SW Atlantic; Caribbean; NW Pacific (Japan, China); NE Pacific, Australia and New Zealand; Sub-Antarctica.

**Uses and Compounds.** Extracts have antibacterial [6.248, 276, 454], and antioxidant [6.595] activity.

*Hydroclathrus clathratus* (C. Agardh)  
M.A. Howe

**Common Name.** Perforated brown seaweed.

**Description.** *H. clathratus* is a very interesting brown seaweed, appearing as a 6 – 10 cm yellow-brown clump of very porous, chain-like tissue. The plant



has a very open, sponge-like structure with a complex series of holes perforating narrow, fleshy strips. Its name, *clathratus*, means *latticed*, an apt description. *H. clathratus* is found worldwide in warm seas but is an uncommon species on hard reefs. *H. clathratus* is more often found on in calm, shallow areas where it is anchored in bare sand [6.32, 739].

**Habitat.** In mid-littoral, often on wave-exposed rocks, more rarely in depths of apertures 1–3 cm, of the bridges 1–3 mm.

**Distribution.** The worldwide distribution of *H. clathratus* includes Europe, both coasts of Africa, the Pacific Islands, Asia, Australia, North and South America from California through Chile and the Gulf of Mexico.

**Uses and Compounds.** *H. clathratus* has been used for centuries in traditional cuisine and medicine of island cultures, such as Hawaii. *Hydroclathrus clathratus* is known to possess anticancer, anti-herpetic, anti-inflammatory, and anticoagulant properties and is now used as a mineral supplement in cosmetics and as a soil-additive (fertilizer) for its high concentration of micronutrients [6.32, 739].

Extracts have antiviral [6.740, 741], antitumor [6.742–747], cytotoxic and antiviral [6.72], and antimicrobial [6.72, 230, 248, 692, 715] activity.

### *Leathesia marina* (Lyngbye)

Decaisne

**Synonym.** *Leathesia difformis*

**Common Names.** Sea cauliflower, Sea balls.

**Description.** Thallus round in young stages, light brown, firm-fleshy and slimy-smooth, later hollow, and with an irregularly convoluted surface [6.32].

**Habitat.** Mostly epiphytically on larger algae or sessile on rocks.

**Distribution.** Nearly worldwide; NE Atlantic (Iceland to Canary Islands); Mediterranean; NW Atlantic; SE Atlantic (Namibia, South Africa); Indian Ocean (South Africa); NW Pacific (Japan, China); NE Pacific (Alaska to California); SW Pacific (Philippines); Australia; New Zealand, Antarctica and Sub-Antarctica.

**Uses and Compounds.** Extracts have agricultural bio-control and bio-stimulating [6.748], antifouling [6.749], antiviral [6.750], antioxidant [6.111], and antitumor [6.751] activity.

### *Petalonia fascia* (O.F. Müller) Kuntze

**Description.** Thallus consists of erect, light to dark brown, dorsoventrally flattened lamina, arising from a holdfast singly or in clusters; linear or broadly lanceolate to almost elliptical, abruptly or gradually narrowing toward the base and merging into a elliptical, abruptly or gradually narrowing toward the base and merging into a short stipe, only slightly narrowing at the tip, rounded and often frayed; thallus undivided, membranous and thin when young, later leathery-tough with smooth, sometimes undulating, margins (Fig. 6.45). The species is very polymorphic especially in relation to thallus width [6.752].

**Habitat.** Found growing on rock in the mid intertidal to shallow sublittoral from protected to semiexposed Habitats.

**Distribution.** N NE Atlantic (Greenland to Canary Islands); Mediterranean; NW Atlantic (Arctic to New Jersey); SE Atlantic (Senegal, Namibia, South Africa); SW Atlantic (Brazil, Uruguay); Indian Ocean (Pakistan, South Africa); NW Pacific (Japan, China); NE Pacific (Alaska to California); SE Pacific (Chile); Australia, New Zealand; Antarctica, and Sub-Antarctica.



**Fig. 6.45** Herbarium specimen of *Petalonia fascia* (MA-COI no. 292)

**Uses and Compounds.** Used as directly food, and the extracts have antimicrobial and antioxidant [6.203, 698] activity.

#### *Punctaria latifolia* Greville

**Description.** Frond oblong or obovate, medium brown, complanate, simple, ovate to ligulate, thickish, gelatinous and tender, usually 5–20 (–30) cm long and (1–) 2–6 cm broad, margin smooth to undulate, with a short, slender, stipe and cuneate base, arising from a small, discoid, rhizoidal holdfast (0.5–) 1–2 (–3) mm across; epiphytic (usually on *Posidonia* or *Heterozostera*) or epilithic; growth diffuse. Structure (2–) 4–6 cells and 80–120  $\mu\text{m}$  thick, with a medulla 2–4 cells thick with few phaeoplasts, and a monostromatic cortex of isodiametric cells mostly of similar size to the medullary cells, 15–25  $\mu\text{m}$  across in surface view, each with several discoid to irregularly shaped phaeoplasts each with a pyrenoid; phaeophyceean hairs scattered, single or in small groups, 7–10  $\mu\text{m}$  in diameter [6.753].

**Habitat.** On rocks in the upper intertidal down to several meters depth.

**Distribution.** Widely distributed in cooler temperate waters.

**Uses and Compounds.** Extracts have antibacterial [6.735], antiviral [6.735], cytotoxic, and antitumor [6.102, 735, 751, 754] activity.

#### *Scytosiphon lomentaria* (Lyngbye) Link

**Common Name.** Sausage weed

**Description.** *S. lomentaria* has cylindrical, shiny, olive brown, unbranched fronds up to 400 mm long. They have short stalks and a large number may arise from a single discoid holdfast. They widen to 3–10 mm and narrow again near the tip. They are hollow and often have irregular constrictions [6.755].

**Habitat.** It occurs in the littoral zone on wave-exposed shores and rock pools. Small plants are often found growing on limpets and pebbles.

**Distribution.** Cosmopolitan in temperate and cold seas.

**Uses and Compounds.** Used directly as food, and the extracts have antioxidant [6.111, 112, 335, 756, 757],

antiviral [6.278], antimicrobial [6.421, 698], antitumor [6.421, 758], and antifouling [6.759] activity.

● Order: **Fucales**

#### *Ascophyllum nodosum* (Linnaeus) Le Jolis

**Common Names.** Knotted wrack, Asco, Sea Whistle, Bladderwrack, Egg wrack.

**Description.** *A. nodosum* is a perennial brown intertidal seaweed species most abundant on sheltered rocky shores in the mid-intertidal zone of the North Atlantic. Olive green in color, *A. nodosum* generally grows upward in the water column anchoring to hard substrates using a disk-shaped holdfast (Fig. 6.46). A single specimen resembles an intertwined mass of shoots and branches. Incoming tides gradually refloat vast stands of *A. nodosum*, until it becomes an expansive swaying undersea forest. Its thallus can measure from 30 to 60 cm, and is flexible to decrease breakage that may result from strong wave action. Its long, thick, leathery, branching strap-like fronds are typically between 0.5 and 2 m in length, and have large egg-shaped air bladders (*pneumatocysts*) at regular intervals along their length which keep the plant floating upright when submerged at high tide, and hang downward, draping over intertidal rocks in a thick, tangled, and glistening mat at low tide. The large air bladders take it toward the light for maximum photosynthesis. The fronds have no midrib.

It is present and grows all year round, and has no resting period. The species grows slowly and can live to be several decades old in wave-sheltered locations of temperate waters, and it has the capability to survive low temperatures. It can eventually grow to three and four meters; individual fronds can become up to 15 years old before breakage. The holdfasts of *A. nodosum* are thought to persist for several decades from which new fronds regenerate. Another interesting attribute of *A. nodosum* is that it repeatedly sloughs its entire outer epidermis, a phenomenon not exhibited by other related seaweeds.

*A. nodosum* attaches to rocks and boulders on the middle shore in a range of habitats, from estuaries to relatively exposed coasts. These sites can have low, moderate, and high wave action across low-, mid- and upper littoral heights, although some sublittoral populations have been reported. The upper limits of *A. nodosum* distribution are controlled by its ability to resist desiccation and high temperatures [6.1, 760].



**Fig. 6.46** *A. nodosum* specimen

**Habitat.** On rocks in sheltered locations of the mid- to the lower littoral zone.

**Distribution.** Distribution is confined to the North Atlantic basin, found in the Arctic Ocean, Baltic Sea, Belt Sea, Northern Europe, Gulf of Maine, North Sea, and Northwest Atlantic. Its northern limits are northern Norway and the White Sea in the east, and Baffin Island in the west. Southern distributions extend to northern Portugal and New Jersey.

**Uses and Compounds.** *A. nodosum* is very effective at accumulating nutrients and minerals from the surrounding seawater, and this is what makes them a valuable resource for human enterprise. This species is harvested for use in items such as food, fertilizer, soil conditioners, animal feed, skin and hair care products, cleaners, degreasers, equestrian products, and nutritional supplements. It is also popular in cosmetology and thalassotherapy. The Industry has more than 200 product types from over 100 compa-

nies which include *A. nodosum* as an ingredient [6.3, 4, 760].

Extracts of this species have anticoagulant [6.761], antiviral, and anti-inflammatory [6.762, 763], antibacterial [6.764, 765], antioxidant [6.763, 766], nematocidal [6.767], agricultural biostimulant [6.768], antitumor [6.432], antifouling [6.61], and phytoantic activity.

*Bifurcaria bifurcata* R. Ross

**Common Names.** Brown tuning fork weed, Brown forking weed

**Description.** Up to 30 cm in length; olive-yellow in color, but much darker when dry (Fig. 6.47); holdfast expanded and knobby; frond cylindrical, unbranched near base then branching dichotomously. Elongate reproductive bodies present at ends of branches. Rounded air bladders sometimes present [6.1].

**Habitat.** Epilithic in intertidal tide pools, occasionally exposed at low tide and extending into the shallow sublittoral.

**Distribution.** Temperate NE Atlantic (from W Ireland to Morocco).

**Uses and Compounds.** A linear cytotoxic diterpene bifurcadiol was isolated from the brown alga *B. bifurcata* by Di Guardia et al. [6.770] which exhibit cytotoxicity against cultured human tumor



**Fig. 6.47** *Bifurcaria bifurcata* specimen

cell lines. Extracts have also antifouling [6.771, 772], antibacterial [6.96, 269, 773], antiprotozoal [6.525], antioxidant [6.429, 731], and antitumoral [6.774] activity.

*Cystoseira abies-marina* (S.G. Gmelin)

**Description.** At the base a branching, gnarled stem with teeth-like appendages. Upper thallus tufted, forking or lateral branching at more or less the same length, single branches thin, covered with scattered dark dots, and conspicuous bilateral saw-teeth-like; conceptacles as wart-like swellings in the upper parts of the thallus; without swim bladders [6.32].

**Habitat.** It is mostly present in the Macronesian islands. Widely spread out in the sublittoral zone, in places subject to wave action.

**Distribution.** E Atlantic (Azores, Madeira, Canary Islands, Cap Verde Islands); Mediterranean (Spain, Sardinia, Libya, Italy).

**Uses and Compounds.** This species is used directly for food and as fertilizer [6.775]. Extracts have antioxidant [6.225, 776, 777], antimicrobial [6.778], and cytotoxic [6.225] activity.

*Cystoseira baccata* (S.G. Gmelin) P.C. Silva

**Common Name.** Bushy berry wrack

**Description.** Fronds usually solitary, 1 m or more in length, attached by a thick, conical attaching disk (Fig. 6.48). Axis simple or branched, up to 1 m in length, flattened, about 1 × 0.4 cm in transverse section; apex smooth and surrounded during periods of active growth by incurred young laterals. Lateral branch systems distichous, alternate, radially symmetrical, and profusely branched in a repeatedly pinnate fashion and bearing sparse, filiform, occasionally bifurcate appendages on the branches of higher orders; deciduous, leaving decurrent bases which give an irregular, zigzag outline to the axis. Aerocysts present in axes of branches of higher order, sometimes in chains; seasonal, particularly numerous in Autumn. Receptacles 1–5 cm long, formed from axes of ultimate ramuli, irregularly nodose and bearing simple, filiform appendages [6.779].

**Habitat.** Lower intertidal in large sandy pools or lagoons, mostly in persistent stands.



Fig. 6.48 Underwater photo of *Cystoseira baccata*

**Distribution.** Widely distributed in the NE Atlantic (Baltic, Netherlands, Belgium, Ireland, Britain, N France, N Spain, Portugal, Mauretania, and Canary Islands).

**Uses and Compounds.** Extracts have antifouling [6.780], antibiotic [6.781, 782], antiplasmodial, and cytotoxic [6.783] activity.

*Cystoseira barbata* (Stackhouse) C. Agardh

**Description.** The thallus is 15–20 cm tall—each branch ends with a conic foot (sole); in most cases the basement branches are joined together in a common base. The stem is narrow enough, 3–5 mm thick, cylindrical, the final side is smooth and unequal. The main branches are alternatively or chaotically branched from the stem, very long, cylindrical shape, plenty of small branches whose number gradually decreases, leaving a few singular cylindrical small branches, much shorter than the initial ones; the small branches are uni-

formly distributed along the main branches or come together as brooms nearest their tops. In winter and spring, there are many (air) bladders on branches. Cryptostoma are numerous on the surface of the branches and (air) bladders. The receptacles are sparse shaded or cylindrical 0.2–1 cm long, strongly stressed on the scaphidia surface and with thready sterile tops; gathered in dense installments on the lateral surface of the branches: often in the receptacles the (air) bladders are metamorphosed and are distributed close the top branches [6.784].

**Habitat.** Rocky bottoms on pebbly grounds in sublittoral areas at 0.5–10 m depths.

**Distribution.** NE Atlantic (France to Portugal); Mediterranean, India and Russia.

**Uses and Compounds.** Source of alginic acid and the extracts have antioxidant, antibacterial, antifungal, anti-HIV, and hypoglycemic activity [6.130, 192, 201, 784–788].

*Cystoseira brachycarpa* J. Agardh

**Synonym.** *Cystoseira balearica* Sauvageau

**Description.** Plant caespitose, to 20–25 cm in height, attached to the substratum by a more or less compact discoid base formed of haptera; axes numerous, 2–6 with 8 cm high; apices of the axes not very prominent, flattened and smooth; tophules absent. Primary branches cylindrical, seasonally either with smooth bases or covered with small spinose; conical appendages, some of which can give rise to smaller branches; secondary and tertiary branches also cylindrical and covered with spinose appendages [6.789].

**Habitat.** Occurs in the upper sublittoral zone, from the surface to several meters depth, in moderately exposed and high light-intensity places.

**Distribution.** Mediterranean.

**Uses and Compounds.** The linear diterpenes eleganolone and elegandiol, isolated from *C. brachycarpa*, inhibit contractile activities of acetylcholine and histamine on ileum musculature of guinea pigs [6.790, 791]. Extracts have antimicrobial and antiviral [6.62, 136, 792, 793], antifungal, cytotoxic, and antimitotic [6.62] activity.

*Cystoseira compressa* (Esper)

Gerloff & Nizamuddin

**Description.** *C. compressa* has a discoid base with several spined axes; the axes have denticulate margins. It is irregularly branched with compressed primary ramifications, and compact crawling receptacles; the axes have a height of 10–100 mm, and a thickness of 2–5 mm. This alga lacks any leaves, tophules, and air vesicles; *C. compressa* has an olive-brown coloration [6.794].

**Habitat.** On rocky substrata, especially in the shallow sublittoral of light exposed, sheltered locations, to 30 m depth.

**Distribution.** NE Atlantic (Azores, Canary Islands); Mediterranean.

**Uses and Compounds.** Extracts have anti-inflammatory and antiproliferative [6.795], antimicrobial [6.72, 248], antiviral, and cytotoxic [6.72] activity.

*Cystoseira crinita* Duby

**Description.** *C. crinita* has an upright, bushy thallus with smooth axes; it reaches a height of 50–350 mm, and a width of 200–500 mm. The main branches are rough, thin, and alternate; the upper section is particularly densely branched. The secondary ramifications are lacking spines, and the terminal receptacles are long, and compact. This alga lacks tophules and the gas vacuoles are either missing or few. *C. crinita* has a light-brown to blackish coloration [6.796].

**Habitat.** Rocky bottoms on pebbly grounds in sublittoral areas.

**Distribution.** Mediterranean.

**Uses and Compounds.** Extracts have antibacterial [6.114, 474, 735], antioxidant [6.717, 797, 798], antiviral and cytotoxic [6.735], anti-inflammatory, and antiproliferative [6.798] activity.

*Cystoseira foeniculacea* (Linnaeus) Greville

**Description.** Plant caespitose, to 30 cm, attached to the substratum by a wide and irregular basal disk. Axes to 10 cm high, with a circular cross-section (to 5 mm), normally spinose and with small scars from dehiscent primary branches; apices of the axes not very prominent, with small spines [6.799].

**Habitat.** Occurs in mid-littoral pools and sheltered places.

**Distribution.** NE Atlantic (Scotland and Ireland to Senegal, Cap Verde Islands); Mediterranean.

**Uses and Compounds.** Extracts have antibacterial activity [6.60].

#### *Cystoseira humilis* Schousboe ex Kützing

**Description.** Characterized by highly differentiated basal and apical regions and the presence of catenate pneumatocysts (air vesicles). In old plants they have an elongated main axis, and in time the primary laterals become proportionally elongated. Their lower parts are strongly flattened into *foliar expansions* or basal leaves. Fertile regions which bear conceptacles are known as receptacles. These are normally found at the tips of the branches. Their basal and apical regions are highly differentiated. They have catenated pneumatocysts (air vesicles). The aerocyst or air vesicles keep the organism erect, by causing it to float in strong currents [6.800].

**Habitat.** Occurs in mid-littoral pools and sheltered places.

**Distribution.** One of the most widely distributed genera of the Fucales order and provides an essential habitat for many epiphytes, invertebrates, and fish. Found mostly in temperate regions of the Northern Hemisphere, such as the Atlantic, Mediterranean, Indian, and Pacific Oceans.

**Uses and Compounds.** Extracts have antibacterial activity [6.96, 171, 269].

#### *Cystoseira mediterranea* Sauvageau

**Description.** *C. mediterranea* has an upright thallus, with a single cylindrical main axis; irregular ramifications are present with the alga reaching a height of 400 mm. The receptacles are short and cylindrical, and whilst it has gas-filled vesicles, it is lacking in tophules. The main axis has a relatively soft texture, whilst the outer extremities are rough, almost spiny. It is a brown to olive green color and displays a bluish green iridescence when submerged [6.801].

**Habitat.** Grows in wave-exposed or moderately exposed places, in the upper sublittoral zone, always near the surface.

**Distribution.** Mediterranean.

**Uses and Compounds.** Extracts have antitumor [6.62, 421], antimicrobial [6.96, 276, 284, 421], and antifungal [6.62, 276] activity.

#### *Cystoseira nodicaulis* (Withering) M. Roberts

**Common Name.** Bushy noduled wrack.

**Description.** Thallus to 1 m long, usually solitary, attached by a irregular conical disk. Axis cylindrical usually branched, with smooth, rounded apex immersed between bases or tophules of developing laterals. Lateral branch systems (below) radial or distichous, with greenish-blue iridescence when first formed, about 50 cm long, repeatedly branched in a pinnate manner, either regularly or irregularly, with infrequent cryptostomata and bearing spine-like appendages; deciduous in summer; first-formed laterals of the season with tophules, later without; tophules ovoid, to 15 mm long, smooth or covered with small tubercles, persistent on axis after rest of lateral has been shed. Receptacles formed in the ultimate branchlets, simple or branched, nodose, usually bearing spine-like appendages; air vesicles inconspicuous, dilations of ultimate branchlets, solitary, in series or confluent; sometimes absent [6.802].

**Habitat.** Found in large intertidal rock pools and lagoons, often with *C. tamariscifolia* and *C. baccata*.

**Distribution.** Southern and western shores of Britain and Ireland, north to the Argyll in Scotland; Atlantic France and Spain, Portugal, Canary Islands, Morocco, south to Mauritania.

**Uses and Compounds.** Extracts have antileukemia activity [6.803].

#### *Cystoseira spinosa* Sauvageau

**Description.** Plant with a single axis, to 30–40 cm in height. Axis simple, to 20–30 cm high: Apex of the axis not prominent and with spines; tophules spinose and oblong; branches both cylindrical and completely flattened, the latter with a pronounced midrib. Spinose appendages more abundantly present in the cylindrical than in the flattened branches; aerocysts absent [6.799].

**Habitat.** Occurs in the lower sublittoral zone.

**Distribution.** Mediterranean.

**Uses and Compounds.** Extracts have antifungal and antimicrobial activity [6.62, 804].

*Cystoseira tamariscifolia* (Hudson) Papenfuss  
**Common Name.** Rainbow wrack

**Description.** *C. tamariscifolia* is a bushy seaweed, up to 60 cm in length but usually 30–45 cm. It has a cylindrical frond and branches irregularly (Fig. 6.49). The reproductive bodies on the end of branches are long, oval and spiny. Small air bladders are usually found below the reproductive bodies. *C. tamariscifolia* is olive green in color, almost black when dry. When the plant is seen underwater it has a blue-green iridescence [6.805].

**Habitat.** Found in rock pools and on the lower shore; grows on both rocky shores and gravelly flats.

**Distribution.** NE Atlantic (United Kingdom to Mauritania); Mediterranean (France to Turkey).

**Uses and Compounds.** Extracts have antibacterial and antifungal [6.269, 438, 806–808], antioxidant and antitumor [6.731], and cytotoxic [6.317] activity.

*Cystoseira usneoides* (Linnaeus) M. Roberts

**Description.** Large sized thallus, formed by a central axis and lateral branches with secondary branches – the ones which are closer from basis are flattened and have a foliaceous aspect (Fig. 6.50); presents numerous vesicles [6.809].

**Habitat.** Is present in relatively deep rocky areas crossed by currents.

**Distribution.** NE and E Atlantic (France, Spain, Portugal, Morocco, Senegal); Mediterranean (France, Spain, Algeria, Italy).

**Uses and Compounds.** Extracts have hypoglycemic and hypocholesterolemic [6.810], neuropharmacological [6.811, 812], anticancer, antioxidant, and anti-inflammatory [6.813] activity.

*Cystoseira zosteroides* C. Agardh

**Description.** Plant with a single axis, to 30 cm in height, attached to the substratum by simple or branched unfused haptera; axis branched or simple, to 10 cm high; apex of axis smooth and prominent; tophules cylindrical or ovoid, completely smooth, blackish or yellowish brown, sessile or with a sort pe-



Fig. 6.49 Underwater photo of *C. tamariscifolia*

duncle; primary branches cylindrical or slightly flattened; secondary and tertiary branches foliaceous, several centimeters long and 1–1.5 mm wide, with an unpronounced midrib and with flattened and triangular spinose appendages, 1 mm long; aerocysts absent [6.799].



Fig. 6.50 *Cystoseira usneoides* specimen

**Habitat.** Occurs in the lower sublittoral zone.

**Distribution.** Mediterranean.

**Uses and Compounds.** Extracts have antifungal and antimutagenic activity [6.62].

*Fucus ceranoides* Linnaeus

**Common Name.** Horned wrack

**Description.** Large brown intertidal seaweed, restricted to growing in estuaries or near freshwater streams on the shore. *F. ceranoides* does not have airbladders, but the side of the fronds is often inflated. Frond thin with smooth margin, fan shaped with prominent midrib, without air bladders but frond on either side may be inflated, reproductive bodies' narrow, pointed fronds at ends of branches [6.814].

**Habitat.** On estuaries or near freshwater streams on the shore, it attaches to stones, rocks, or gravel.

**Distribution.** *F. ceranoides* is widely distributed in NE Europe but is only common in brackish water. It is characteristic of estuaries and is often abundant where freshwater streams run onto the shore.

**Uses and Compounds.** Extracts have antioxidant and antitumor activity [6.205].

*Fucus distichus* Linnaeus

**Common Name.** Rock weeds

**Description.** A small tufted brown alga. It has narrow fronds without airbladders and short receptacles. The species has a life span of 3 years and grows up to 30 cm long [6.815].

**Habitat.** Occurs in rock pools and on rock faces in the upper mid-littoral at wave exposed locations.

**Distribution.** NE Atlantic (Arctic to Britain and Ireland); NE Pacific (Alaska); Japan.

**Uses and Compounds.** Extracts have antimicrobial activity [6.816].

*Fucus evanescens* C. Agardh

**Common Name.** Arctic wrack

**Description.** Brown to olive green in color, broad blades, obvious midrib, with Y-shaped forks. Can

grow up to 3–90 cm and can be difficult or to distinguish from *F. vesiculosus*, sometimes indistinguishable [6.817].

**Habitat.** Occurs in rock pools and on rock faces in the upper mid-littoral at wave exposed locations.

**Distribution.** NE Atlantic (Arctic to Britain and Ireland); NE Pacific (Alaska); Japan.

**Uses and Compounds.** Source of alginic acid, fucoidan, and used for animal feed [6.817, 818]. Extracts have antiviral [6.819, 820], antibacterial [6.821], antitrypanosomal [6.822], anti-inflammatory, antiangiogenic and antiadhesive [6.823], antithrombotic and hemorrhagic [6.824], anticoagulant [6.823, 825], antitumor [6.826–828], and immunostimulating [6.829–831] activity.

*Fucus serratus* Linnaeus

**Common Names.** Toothed wrack, Black wrack, Blackweed

**Description.** *F. serratus* is a robust, olive-brown shrubby seaweed. It can grow in high densities low on the shore, forming dense mats of long ribbons up to 1 meter long and 2–5 cm across. It attaches to rocks via a discoid holdfast about 3 cm in diameter. Though technically a brown alga, it can vary in color from olive green through reddish brown (though it often has a greenish tint). It typically grows up to 70 cm but has been recorded at over 2 m in length in very sheltered environments. The flat, strap-like fronds have a forward-pointing serrated edge, a distinct midrib, and grow from a short stipe. The fronds are bifurcating (splitting in two repeatedly) [6.832].

**Habitat.** On firm substrata in the lower mid-littoral; often zone forming.

**Distribution.** *F. serratus* is a seaweed of the North Atlantic Ocean. It extends from the Canary Islands and northern Portugal along the Atlantic coast of France, into the British Isles and North Sea coasts, and into the W Baltic. It is found in Scandinavia up to Novaya Zemlya, around Iceland, and over to the Gulf of St. Lawrence in the NW Atlantic, ranging from Chaleur Bay and the tip of Cape Breton to Bar Harbor, Maine.

**Uses and Compounds.** *F. serratus* survives by filtering the ocean for nutrients and as a result, amasses



a huge amount of minerals and vitamins. Used for hundreds of years in seaweed baths, the oils from this seaweed have positive effects on skin, hair and body. The antioxidant [6.766] compounds found naturally in this seaweed have long been known to have pronounced antiaging, skin conditioning, and repair and hydrating effects. This seaweed is used as a food, and is harvested for cosmetics, and it is harvested to make fertilizer. Its edible properties are very similar to that of bladderwrack and interest in this plant is growing, as, being a thyroid stimulant it might counter obesity by increasing the metabolic rate. It is also known to help women with abnormal menstrual cycling patterns and/or menstrual-related disease histories. It can be stored dried to make a nutritious tea as well as for use in soups and stews as a flavoring [6.833].

This species is collected, dried, and used as a soil additive as well. *F. serratus* is used by over a dozen businesses across the United States, Australia, France, Italy, Ireland, and the United Kingdom in a wide variety of products, such as: antiaging and eye serums, facial moisturizers and sunscreens, dental care compound, revitalizing compound used in skin and hair products, hair shampoos and conditioners, bath soak products, cleansing lotions, body buffs and gels, hand creams, facial, washes, cleansers, and toners, and fertilizers [6.833].

#### *Fucus spiralis* Linnaeus

**Common Name.** Spiral wrack

**Description.** Well-grown fronds are usually easily recognizable by the flattened, twisted, dichotomously branched thallus, lacking bladders, and the large, oval receptacles at the frond tips, each receptacle being surrounded by a narrow rim of vegetative frond. Nevertheless, younger plants are not always so easy to identify, and even mature plants can be confused with *F. ceranoides* or with bladderless forms of *F. vesiculosus*. Both of these species, however, have narrower, more pointed, rimless receptacles [6.834].

**Habitat.** Attaches to rocky substrata on sheltered to moderately exposed shores.

**Distribution.** *F. spiralis* is common on the coasts all around the British Isles, Iceland, W coasts of Europe, Canary Islands, Azores and Northeast North America from New Jersey to Nova Scotia. There are also isolated reports in the N Pacific.

**Uses and Compounds.** *F. spiralis* has been used historically for treatment of obesity, gout, goiter, and corns, and also in weight reducing and revitalizing bath treatments. It has been used for cattle feed, and as an organic manure. This alga, regularly exposed to sun radiation and its oxidative consequences, has developed optimal bioelectronics characters. It has a high concentration of phloroglucinol derivatives, including phenol acid, and in turn has been used in products from companies in France and the UK such as nutritional supplements, skin serum, body lotion, and compounds and extracts used as ingredients in other skin and hair products [6.835].

Extracts of this species have also antifouling [6.275], antimicrobial [6.269], antioxidant [6.225, 836, 837], anticoagulant [6.55], and antiproliferative [6.225] activity.

#### *Fucus vesiculosus* Linnaeus

**Common name.** Bladder wrack

**Description.** *F. vesiculosus* varies in color from olive green to olive brown to reddish brown to almost black and is typically about 40 cm in length (although fronds can grow longer). It attaches to rocky substrates by means of a small disk-shaped holdfast. *F. vesiculosus* is characterized by the small nearly spherical gas-filled vesicles (bladders) which look like bubblewrap and occur in pairs one on either side of an obvious central midrib running along the center of the strap-like frond (Fig. 6.51). The flattened, branching fronds can grow from one to two meters in length, and the air-filled bladders which keep the seaweed floating upright in its rocky anchorages increase its ability to photosynthesize. Typically it grows gregariously, forming dense mats of long ribbons up to one meter long and five centimeters across. The appearance of *F. vesiculosus* varies depending on the environmental conditions in which it occurs; in more sheltered areas there are many air bladders, whereas there are fewer in more exposed conditions. Also, in small plants, air bladders may be entirely absent. In exposed areas, it is beneficial for *F. vesiculosus* to lack bladders, as this decreases the potential for severe damage, and minimizes the risk of it being detached and swept away [6.1, 838].

**Habitat.** On rocks and stones in the mid-littoral; often zone forming.

**Distribution.** *F. vesiculosus* is found on the coasts of the North Sea, the western Baltic Sea, and the Atlantic



Fig. 6.51 *F. vesiculosus* specimens

and Pacific Oceans. It occurs around the coastline of Greenland, Britain, Ireland, Norway, the Atlantic coast of France, Spain and Morocco, and the Atlantic coasts of Canada and the United States from Hudson Bay to North Carolina.

**Uses and Compounds.** Primary chemical constituents of *F. vesiculosus* include mucilage, alginic acid, mannitol, beta-carotene, zeaxanthin, iodine and iodine salts, bromine, potassium, volatile oils, and many other minerals, as well as polysaccharides. When used in hot seawater baths or steamed the plants are said to release certain substances that promote good skin, the lower blood pressure and ease arthritic and rheumatic pains. *F. vesiculosus* has been shown to help women with abnormal menstrual cycling patterns and menstrual-related disease histories. A popular use of *F. vesiculosus* in herbal medicine is as a source of iodine (it was the original source of iodine, discovered in 1811), an essential nutrient for the thyroid gland; it can be used in the treatment of underactive thyroid glands (hypothyroidism) and goiter, a swelling of the thyroid gland related to iodine deficiency [6.3, 4, 838].

Extracts of this species have genotoxic and antigenotoxic [6.839], antioxidant [6.717, 766, 840, 841], antithrombotic [6.842], antibacterial and antifouling [6.275], antiviral [6.843], antitumor [6.844, 845], and anticoagulant [6.512] activity.

*Halidrys siliquosa* (Linnaeus) Lyngbye  
**Common Name.** Sea oak, Pod weed

**Description.** A large sturdy brown alga 0.3–1 m in length (occasionally up to 2 m) rising from a strong, flattened cone shaped holdfast. The main stem is flattened and branches alternately to give a distinctly zigzag appearance. The stem bears a few, flattened ribbon-like leafy fronds. The ends of some branches bear characteristic pod-shaped air bladders (about 0.5 cm wide by 1–4 cm long) that are divided by transverse septa into 10 or 12 compartments. The branches also bear reproductive bodies that appear similar to the bladders but lack the septa. Young plants are olive-green in color while older specimens are dark brown and leathery. This species is perennial [6.846].

**Habitat.** Distinctive and common rock pool seaweed from the middle to the lower shore (may be found in the upper mid-littoral but only in rock pools). It may also form a zone in the sublittoral below the lower limit.

**Distribution.** NE Atlantic (from Faroe Islands to Portugal, North Sea, Baltic).

**Uses and Compounds.** Source of alginic acid. Extracts have antibiotic [6.847, 848], antifouling [6.849], antioxidant, and antitumor [6.421, 731] activity.

*Himanthalia elongata* (Linnaeus) S.F. Gray  
**Common Names.** Sea spaghetti, Sea thong

**Description.** Common brown seaweed, which has a two stage morphology. Small button-like thalli are first produced, from which long strap-like reproductive fronds (receptacles) are formed in autumn (Fig. 6.52). The strap-like reproductive fronds grow quickly between February and May, reaching a length of up to 3 m. The plant releases gametes from June until the winter when it starts to decay. Plants commonly live for 2–3 years and reproduce once before dying [6.1].

**Habitat.** *H. elongata* is common on gently shelving rocky shores attached to hard substrata such as bedrock, or large to very large boulders. It is found on the lower



**Fig. 6.52** *Himanthalia elongata* specimen

shore flourishing at the low tide limit with moderate wave exposure where its thallus is typically always submerged, and is considered a sublittoral species.

**Distribution.** *H. elongata* can be found from the Arctic Ocean south to the Iberian Peninsula, in the waters of the Baltic Sea, the North Sea and the northeast Atlantic Ocean. It is seen on the shores of Norway, the Faroes, Britain, Ireland, the western coast of France, northern Spain, and Portugal.

**Uses and Compounds.** *H. elongata* is known to provide high levels of Vitamins A, C, and E along with essential amino acids and other natural minerals. It has several properties which make it attractive as an ingredient in personal care and cosmetic products, such as that it is absorbent, viscosity controlling, skin protecting, and can be used as a binding agent. It has a natural ability to help restore balance to skin's mois-

ture levels. It is used in dozens of products made in Ireland, France, Spain, Italy, Canada, and the United States [6.3, 4, 850].

*H. elongata* is used in shampoos and hair treatments, facial cleansers and skin care products, and also as a fertilizer. It can be sold and eaten fresh when in season, but it is typically sold dried or pickled, and is eaten most commonly in France and Ireland. It is used as an alternative to both traditional semolina spaghetti and green beans. It is found in popular tartar (sauce), *tahini*, *pâté* and cream products, and also in sea vegetable mixes [6.3, 4, 850].

Extracts of this species have hypoglycemic [6.851], antibiotic [6.852, 853], neuropharmacological [6.854, 855], antimicrobial, and antioxidant [6.429, 533, 765, 766, 856, 857] activity.

*Pelvetia canaliculata* (Linnaeus)  
Decaisne & Thuret

**Description.** *P. canaliculata*, often called channelled wrack, is a very common brown alga (Phaeophyceae) of Europe. It is the only species remaining in the monotypic genus *Pelvetia*. It is relatively small, not growing longer than 15 cm. When viewed underwater, its color can be light olive green, and sometimes yellowish brown (Fig. 6.53). *P. canaliculata*'s color can range from dark brown to dark olive to very dark or blackish green when dried. Its extremities can appear swollen and with orange during spring and summer. These bumpy, irregularly v-shaped swellings with forked tips at the ends of the fronds are its reproductive structures. It appears bushy and grows in dense tufts. Each frond is curled longitudinally (rolled lengthwise) to form a distinct channel. It is irregularly dichotomously branched; each tough and thick branch is of uniform width up to 1 cm, lacks a midrib, and lacks air vesicles or bladders. *P. canaliculata* is a perennial species; it is at least two years old before it reaches maturity, and has a life span of up to 4 or 5 years, growing 3 – 4 cm per year [6.1, 858].

**Habitat.** *P. canaliculata* grows attached to hard substrata with a small basal disk on the upper shore, and forms the uppermost zone of algae growing at or above high water mark. It needs periods of exposure to the air, and sometimes grows so high up a beach that coarse grass and other long-shore angiosperms grow among it. *P. canaliculata* is found right at the top of the beach in sheltered to moderately exposed areas where it can dry out completely to become black and crispy.



**Fig. 6.53** *Pelvetia canaliculata* specimens

**Distribution.** One can find *P. canaliculata* in the northeast Atlantic, from the Arctic Ocean to the Iberian Peninsula, in the English Channel, and in the North Sea. It is common on the Atlantic shores of Europe from Iceland to Spain, including Norway, Ireland, the UK, the Netherlands, France, and Portugal (southern limit of this species).

**Uses and Compounds.** *P. canaliculata* was historically harvested for use as animal fodder, and in certain areas there are still animals which graze on the growing plants. It has also been collected historically as a source of food for people. It is included in dozens of products from Italy, France, United Kingdom, and the United States. According to one leading cosmetics producer, *P. canaliculata* stimulates the synthesis of collagens and proteoglycans, which are responsible for giving connective tissue its elastic properties. Using it as a compound can increase the skin's firmness and reduce the appearance of lines and wrinkles. It is reported from another leading cosmetics company that it increases microcirculation and can help reduce fat and cellulite. *P. canalicu-*

*lata* can be found on ingredient labels for moisturizing lotions, masks and creams, and in body creams, day creams, and night creams. It is found in quality restorative and hydrating serums, and in compounds and extracts used in different products. For food, it is sold in different dried forms, and as a seasoning mix [6.858].

Source of alginic acid and fucoidan [6.859], and the extracts of this species have antioxidant [6.860, 861], anticoagulant [6.862], antifungal [6.863], antifouling [6.275], and antibiotic [6.864] activity.

#### *Sargassum filipendula* C. Agardh

**Description.** The habit of *S. filipendula* is so like that of other species which have been described that it needs but slight attention. This species grows attached to rocks below low water mark, and therefore, unlike *Fucus* and *Ascophyllum*, is never exposed to the air. Vegetative plants and reproductive plants bearing all stages of conceptacles are plentiful in summer. Sporelings are abundant also and easily collected, for the discharged eggs and their products, the sporelings, remain attached for some time by mucilage to the surface of reproductive branches near the parent conceptacles. The stem arises from a small disk-shaped holdfast and passes into long cylindrical branches which bear spirally arranged leaves, berry-like floats, which seem to be modified portions of leaves, as generally stated, and short reproductive branches. This form may attain a height of 60 cm, but is commonly shorter [6.865].

**Habitat.** On firm substrata in the shallow sublittoral, to 6 (–30) m depth.

**Distribution.** NE Atlantic (Spain and Portugal to Gabon), Caribbean (Cuba), SW Atlantic (Mexico to Brazil).

**Uses and Compounds.** Extracts have antitumor [6.866–869], antioxidant [6.679, 866, 868, 869], and antifungal [6.863, 870] activity.

#### *Sargassum hornschurchii* C. Agardh

**Description.** Differs from the *S. vulgare* for the shape of the leaves: laminated in *S. vulgare* and triangular section in *S. hornschurchii* [6.871].

**Habitat.** On firm substrata in the shallow sublittoral, to 6 (–30) m depth.

**Distribution.** Mediterranean.

**Uses and Compounds.** Extracts have antifungal [6.62], cytotoxic, and antitumor [6.197] activity.

*S. muticum* (Yendo) Fensholt

**Common Names.** Japanese seaweed, Japanese brown alga, Japweed, Wire weed, Strangle weed.

**Description.** *S. muticum* is a large brown seaweed, varying in color from dark brown to pale, yellowish brown depending on the season and the growing conditions. *S. muticum* has regularly alternating lateral shoots or branches, on a central perennial stem (Fig. 6.54). It attaches to the substrate with a disk-shaped holdfast. It has numerous small 2–3 mm round or pear-shaped air-bladders which sit on small stems and cause the alga to stand upright in the water or float if parts of the alga are detached from the basal stem. *S. muticum* has a frond which may be 75–120 cm long in its native range, but normally reaches a length of 1.5–2 m in Swedish waters, 6–7 m in French waters, and up to 8.5 m in Norwegian waters. Lateral branches detach in the summer or autumn, leaving a short perennial basal stem to overwinter [6.872]. During the summer, cigar-shaped reproductive receptacles develop in the areas where the annual shoot or branch attaches to the stem, but may also sit on top of the branch [6.1, 873].

**Habitat.** In the mid-littoral and to below the tidal mark (3–5 m).

**Distribution.** Highly invasive: originally from Japan, it now colonizes large parts of the NE Atlantic (Norway to Portugal, North Sea), the W Mediterranean, and the N Pacific: NW Pacific (Japan), NE Pacific (Alaska to Mexico).

**Uses and Compounds.** Source of Laminaran [6.873], and extracts have antitumor and antibacterial [6.113], antioxidant [6.874], antialgal [6.257], antifungal [6.863], antibiotic [6.875], and antifouling [6.876–880] activity.

*Sargassum natans* (Linnaeus) Gaillon

**Description.** *S. natans*, unlike the many benthic *Sargassum* species (i.e., those that live attached to the sea bottom), is a pelagic (free-floating) brown seaweed that occurs mainly far out in the North Central Atlantic Ocean, but washes ashore regularly. It is often associated with the Sargasso Sea, a very large region situated offshore from the southeastern United States,



Fig. 6.54 Underwater photo of *S. muticum*

approximately south and east of Bermuda and seaward from the Gulf Stream. The Sargasso Sea, which accumulates large masses of *Sargassum*, results from a ring of prevailing ocean currents that enclose an enormous eddy (about 5.2 million km<sup>2</sup>) which rotates clockwise as a result of the Earth's eastward rotation. *S. natans* apparently reproduces only asexually, by fragmentation. Gower and King [6.881, 882] used satellite imagery to track the origin, distribution, and fate of floating *Sargassum*. Using this approach, they analyzed data from 2002 to 2008 and were able to present the first mapping of the full distribution and movement of pelagic *Sargassum* in the Gulf of Mexico and western Atlantic. Their results revealed a seasonal pattern in which *Sargassum* typically shows strong growth in the northwest Gulf of Mexico in the spring of each year, is transported into the Atlantic in about July, appearing east of Cape Hatteras as a *Sargassum jet*, and ends up northeast of the Bahamas in February of the following year.

**Habitat.** On firm substrata in the shallow sublittoral, to 6 (–30) m depth.

**Distribution.** NE Atlantic (Spain); Atlantic Islands; NW Atlantic; Caribbean; SW Atlantic; Pacific Ocean (Indonesia); Australia.

**Uses and Compounds.** Source of alginic acid [6.883] and extracts of this species have antimicrobial [6.136, 884, 885], antifouling [6.275], and antitrypanosomal [6.822] activity.

*Sargassum vulgare* C. Agardh

**Description.** *S. vulgare* has a bush-like thalli reaching 15–70 cm high; the fronds are oval, flattened, olive-green to brown and possess a central rib and undulated edge. The base of the fronds has hollow, spherical vesicles, of 5–8 mm, and clusters of reproductive bodies; these are held in place by a pedicle. The alga is attached to the substrate with irregular rhizoidal branches. *S. vulgare* has an olive brown to dark brown coloration [6.886].

**Habitat.** On firm substrata in the shallow sublittoral, to 6 (–30)m depth.

**Distribution.** NE Atlantic (Portugal, S Spain to Canary Islands); Mediterranean; Caribbean; SE Atlantic (W Africa); W Pacific (Philippines); Indian Ocean.

**Uses and Compounds.** Source of alginic acid [6.765, 886, 887] and extracts of this species have anti-helminthic [6.886], antioxidant, antimicrobial and antifungal [6.336, 888, 889], antitumor [6.765, 890, 891], antilipemic [6.892], antifouling [6.893, 894], antimicrobial [6.228], anticoagulant, antithrombotic, and anti-inflammatory [6.889] activity.

- Order: **Laminariales**

*Alaria esculenta* (Linnaeus) Greville

**Common Name.** Dabberlocks.

**Description.** Fronds with olive or yellow-brown fronds to 4 m long and 25 cm wide. Attached by a root-like holdfast at the base from which a narrow flexible stipe arises which continues into the leafy part of the plant as a distinct mid-rib (Fig. 6.55). The reproductive structures, apparent as dark-brown areas, are confined to unbranched leafy appendages borne on the stipe, usually in two rows. This is the only kelp-like plant in Ireland and Britain with a distinct midrib and is the only one with sporangia borne at the base of the frond in special leaflets called sporophylls [6.895, 896].



**Fig. 6.55** Herbarium specimen of *Alaria esculenta* (MA-COI no. 2664)

**Habitat.** Generally grows on rock in very exposed places, often forming a band at low water and in the shallow sublittoral, but also occurs in tidal pools in the lower shore.

**Distribution.** Coasts of the North Atlantic (France, Scotland, Ireland, Greenland, Iceland, northeastern United States, northeastern Canada), the N Sea (England, Norway, Netherlands), Novaya Zemlya to the N Pacific (Bering Sea and Sea of Japan).

**Uses and Compounds.** *A. esculenta* can be used for a variety of purposes from human consumption and alginate production to fodder and body-care products. It is rapidly gaining popularity in the natural foods market. It can be ordered from many sellers as whole, flaked, milled, or powdered. It is used

for antiaging body creams, foot creams, bath soaks, body and face masks, body polish, UV-protecting facial moisturizers, self-tanning lotions, lip balm, day- and night-creams, and nutritional supplements to name a few. In Canada and the United States, this seaweed is sometimes sold as *Atlantic Wakame* and is presented as an alternative to traditional Japanese Wakame (*Undaria pinnatifida*). *A. esculenta* also has potential as a foodstuff in aquaculture for herbivorous molluscs such as abalone. Over 20 sellers with over 70 *A. esculenta*-based products have been identified. These sellers are from Germany, Italy, France, Ireland, United Kingdom, Canada, and the United States [6.4, 896, 897].

#### *Chorda filum* (Linnaeus) Stackhouse

**Common Names.** Sea lace; dead man's rope; mermaid's tresses; Cat gut.

**Description.** *C. filum* is a brown seaweed with long cord-like fronds, only 5 mm thick in diameter. The fronds are hollow, slippery, unbranched, and grow up to 8 m long. The species is attached to the substratum using a small discoid holdfast. It is an annual species, disappearing in winter [6.898, 899].

**Habitat.** It is found in rock pools on the low shore and in the sublittoral down to 5 m. It is most commonly found in the sheltered bay.

**Distribution.** Abundant throughout the North Atlantic, on the shores of Europe and America, coast of Brazil, and also in the North Pacific, at Sitka, Unalaska, and Kamtschatka.

**Uses and Compounds.** *C. filum* is used fresh as a foodstuff, and for animal feed [6.898]. This species produces alginate and fucoidan, and have antimicrobial [6.474, 546, 844, 898, 900], algicidal [6.257], anti-coagulant [6.524], and antioxidant [6.474] activity.

#### *Laminaria digitata* (Hudson) J.V. Lamouroux

**Description.** A large conspicuous kelp growing up to 2 m in length commonly found at low water during spring tides on rocky shores. The frond is broad and digitate, glossy and dark brown in color and lacks a midrib. The stipe is oval in cross section, smooth and flexible and is usually free of epiphytes, although old stipes which has become slightly roughened may support a few epiphytes, notably *Palmaria palmata*. The kelp is attached to freely branched haptera, which spread out to

form a shallow dome-shaped holdfast. *L. digitata* may be confused with young *L. hyperborea* plants. However, the stipe of *L. hyperborea* is circular in cross section, is stiff, and snaps easily when bent (although you would not see that in younger fronds) [6.901, 902].

**Habitat.** On rocks from the low water spring tide level to the shallow sublittoral. In some locations, *L. digitata* may be found in deeper water.

**Distribution.** *L. digitata* is a North Atlantic Arctic-cold-temperate species which does not occur in the North Pacific. It is found along both coasts of the English Channel; the southernmost occurrence of this species in European waters is on the southern coasts of Brittany. It grows along most coasts of Britain and Ireland, and along the North Sea coasts of Scandinavia. Its northerly range includes into the Barents Sea and the western shores of Novaya Zemlya, and has been reported to occur in the Svalbard Archipelago. *L. digitata* also grows in Iceland, the Faeroes, southern Greenland, and the eastern coasts of North America, as far south as Cape Cod.

**Uses and Compounds.** *L. digitata* plants contain minerals, vitamins, and trace elements. These include iodine, calcium, potassium, iron, carotene, alginic acid, laminaran, fucoidan, mannitol, protein, carotene, niacin, phosphorus, the B complex vitamins, vitamin C, and many other trace elements. This species stores flavor-enhancing glutamic acid, or sodium glutamate, which imparts a mellow, silky taste to dishes. The slight sweet background is mannitol, a natural sugar. In terms of relatives, *L. digitata* is closely related to the five species (*Saccharina latissima*, *S. japonica*, *L. angustata*, *L. longissima*, and *L. ochotensis*) typically harvested as *Kombu* in Japan, and is frequently harvested and sold as *Kombu* in North America. Many recipes calling for *Kombu* could be made with this form of kelp [6.901–906].

Extracts of this species have antibacterial [6.371], and antioxidant [6.766] activity.

#### *L. hyperborea* (Gunnerus) Foslie

**Common Name.** Oarweed.

**Description.** *L. hyperborea* is often difficult to distinguish from *L. digitata*, particularly when plants are young (Fig. 6.56). However, the stipe of *L. digitata* is darker and usually oval in cross section instead of cylindrical, is not thicker at the base, does not snap easily,



**Fig. 6.56** *Saccorhiza polyschides* (left) and *L. hyperborea* (right)

and does not have epiphytes on the stipe. Also, the belt of *L. hyperborea* is nearly always below (in deeper water) any belt of *L. digitata*. *L. ochroleuca* is a similar species, but has a smooth stipe (not rough like *L. hyperborea*), and its fronds are typically more golden or yellow. *Saccorhiza polyschides*, another commercially utilized kelp, appears similar to *L. hyperborea* from the frond, but has a twisted stipe near a bulbous holdfast, which is very different from *L. hyperborea*'s bird claw holdfast [6.1, 907].

**Habitat.** Found on bedrock or other stable substrata from extreme low water to depths dependent on light penetration and sea urchin grazing (typically about 8 m depth in coastal waters to 30 m in clear coastal).

**Distribution.** *L. hyperborea* is a European North Atlantic cold-temperate species which does not extend into areas influenced by Arctic waters; its range is the NE Atlantic Ocean, from Scandinavia south to Spain and the Canary Islands, the Baltic Sea, and the North Sea.

**Uses and Compounds.** In Europe, *L. hyperborea* is one of the two kelp species commercially exploited by the hydrocolloid industry, the other being *L. digi-*

*tata*. *L. hyperborea* is also utilized by the cosmetic and agrochemical industries and for biotechnological applications, and by the food industry for emulsifiers and gelling agents. Drift kelp has long been collected as an agricultural fertilizer and soil conditioner. *L. hyperborea* is still harvested and used in popular kelp meal fertilizer products. *L. hyperborea* is a source of laminarin and mannitol, which are used in industrial and other applications. Because of its ability to absorb and retain water, it has been used in wound dressings to prevent adhesions, and has also been used to help dilate the cervix during childbirth [6.3, 907].

Extracts have antifungal [6.863], anticoagulant [6.512], antibacterial [6.765], antioxidant [6.860], and anticoagulant [6.524] activity.

*Laminaria ochroleuca* Bachelot de la Pylaie  
**Common Names.** Kelp, Kombu.

**Description.** *L. ochroleuca* is a glossy, yellow-brown kelp that is prevalent along the intertidal zones. This kelp is quite conspicuous as it grows quite large under the right conditions. The maximum length recorded is 4 m long, but this length is rarely attained and occurs only in specific areas. Under normal conditions *L. ochroleuca* is more likely to reach a maximum length of about 2 m. It has a large heavy holdfast made up of thick haptera (up to 18 cm in diameter) that support the plant and anchor it to rock. This holdfast gives rise to a fairly long, rigid, round, epiphyte-free stipe that tapers somewhat as it approaches the blade. This stipe is so strong and stiff that it stands erect when the plant is out of the water. The blade of this kelp is large, flat, and leathery, and is divided into 5–20 strap-like digits. This kelp is easily distinguished by the distinct yellow area at the junction of the stipe and the blade. The entire plant actually has a very lovely yellowish hue to its smooth, bright, glossy tissue. *L. ochroleuca* is a perennial kelp that retains its stipe and holdfast year long but regenerates a new blade each year [6.1, 908].

**Habitat.** This species is found on rocks from the low water spring tide level to the shallow sublittoral. In some locations *L. ochroleuca* may be found in deeper water.

**Distribution.** *L. ochroleuca* is a warm-temperate species of kelp, and is most common in the NE Atlantic from the British Isles to the Sahara and the Atlantic zones of the Mediterranean.



**Uses and Compounds.** Extracts of *L. ochroleuca* have been found to act as a central nervous system depressant with a slight analgesic activity. It is also able to effectively guard DNA against UV rays and premature aging. With these properties, it is becoming more widely used in cosmetics and in natural therapeutic medicine. Applied topically, *L. ochroleuca* helps reduce inflammation and, like many forms of seaweed, has some amount of moisture-binding properties due to its sterol content. It is used in products from Spain, Germany, France, and the United Kingdom; these include rescue balms, repairing and anti-aging moisturizers, as well as dried and packaged foods [6.3, 4, 908, 909].

Extracts have also antimicrobial [6.224, 269, 910–913], antifungal [6.913], and anti-algal [6.257] activity.

*Saccharina latissima* (Linnaeus) C.E. Lane,  
C. Mayes, Druehl & G.W. Saunders

**Synonym.** *Laminaria saccharina* (Linnaeus) J.V. Lamouroux

**Common Names.** Sugar kelp, Sea belt, Sugar wrack.

**Description.** Just like most kelps, *S. latissima* has blades (lamina), stipes, and holdfasts, which is attached to substrates. The sporophytes of *S. latissima* have a rich medium brown color, a long undivided frond without a midrib and a profusely branched holdfast (Fig. 6.57). Mucilage ducts are absent from stipe; the blade often has two rows of bullations formed in two longitudinal rows parallel to the central axis. The frond of *S. latissima* has a distinctive frilly undulating margin. The stipe of *S. latissima* may be up to 50 cm long [6.1, 914].

**Habitat.** *S. latissima* is usually found from the sublittoral fringe down to a depth of 30 m. More rarely, it occurs in rock pools. The species usually occurs in sheltered conditions and may be attached to unstable substrata such as boulders and cobbles.

**Distribution.** N and NE Atlantic (Greenland to Portugal, North Sea, Baltic); NW Atlantic (Canadian Arctic to Massachusetts); NE Pacific (Alaska to California).

**Uses and Compounds.** Kelp harvesting is also an important industry around the world. Kelp products, alginic acid and fucoidan, are used for different purposes [6.915]. Alginic acid is a common polysaccharide constituent of kelp cell walls and it



Fig. 6.57 *Saccharina latissima* specimen

can be used to form gels. Alginic acid is used as a stabilizer in the food, cosmetic, and pharmaceutical industries: yogurts, shampoos, skin creams, lotions as well as ice creams. Alginic acid is also being used in many dietary products because human body cannot absorb it. In lots of biotechnological research experiments, alginic acid is used to separate substances [6.3, 4].

People eat Sugar kelp (also called Kombu in Japanese dishes), which contains appreciable amount of vitamin C and is high in iodine, protein, and calcium. The blade is usually chopped and cooked as a savory garnish (Tororo Konbu) for rice and other dishes, as a vegetable, and as snacks (such

as Tsukudani). Kombu is also used to add flavor to broths (Dashi stock) and stews but it removes itself removed from the liquid at the end of cooking and discarded. It can be used to soften beans during cooking, and to help convert indigestible sugars [6.4].

Extracts of this species have anticoagulant [6.512, 524], antifouling [6.916], antimicrobial [6.533, 816, 917], and antioxidant [6.429, 533, 860] activity.

*Saccharina longicuris* (Bachelot de la Pylaie)  
Kuntze

**Description.** *S. longicuris* is a particularly tall species of kelp. The hollow, cylindrical stipe itself can reach up to 10 m long, plus the frond which adds another 1–2 m. The large branched holdfast grips firmly to the rocky substrate allowing a single long, thin, olive-brown, leafy blade to float near the surface. The midsection of these blades is somewhat thicker, but the edges spread and thin and become wide and ruffled. *S. longicuris* is limited to the sublittoral zone, but can be found either in shallow or in much deeper waters, often preferring areas with a strong flow. In this environment, it is a dominant part of the seaweed community and forms dense multistory forests with older plants forming a canopy of fronds floating on the surface and younger plants protected underneath [6.918].

**Habitat.** Horizontal distribution is determined to a large extent by substratum type and salinity. In very sheltered sites the species can occur on an unstable substratum of gravel and small stones.

**Distribution.** The species occurs widely throughout the NW Atlantic and eastern Arctic Oceans, mostly within Canadian territorial waters, and along the west coast of Greenland north of 62° N. The species is rare on the east coast of Greenland, but has been recorded from Iceland, the Faeroes and as far south as Long Sound on the Shetland Islands at the latitude of 60° N. *S. longicuris* has not been recorded from the European mainland.

**Uses and Compounds.** *S. longicuris* is an edible species of kelp that is related to traditional Japanese Kombu, but is thinner, tenderer, and cooked faster. It is high in minerals and micronutrients and is particularly delicious as it contains naturally occurring monosodium glutamate – a little known feature of many kelp species [6.918, 919].

Extracts have immunostimulatory [6.920], and skin antiaging [6.921] activity.

*Saccorhiza polyschides* (Lightfoot) Batters  
**Common Name.** Furbelows.

**Description.** *S. polyschides* is kelp species with a distinctive large warty holdfast and a flattened stipe with a frilly margin (Fig. 6.56). The stipe is twisted at the base and widens to form a large flat lamina, which is divided into ribbon-like sections. The species is an annual, and very fast growing. It is opportunistic and colonizes available hard substrata in the sublittoral [6.1, 922].

**Habitat.** In the lower littoral, in calm shallow water to 19 m.

**Distribution.** NE Atlantic (Norway to Morocco), W Mediterranean.

**Uses and Compounds.** Source of alginic acid, and possible source of biofuel [6.380]. Extracts of this species have hypoglycemic [6.923], antisetlement [6.360], cytotoxic, and antiplasmodial [6.924] activity.

*U. pinnatifida* (Harvey) Suringar  
**Common Name.** Wakame.

**Description.** *U. pinnatifida* belongs to the order Laminariales, with three clearly recognizable parts comprising its visible thallus: blade, stipe, and holdfast. The thallus can reach 1–3 m in length. The blade is lanceolate and broad with a prominent midrib, and translucent with color ranging from green to yellowish brown to dark brown. The blade could also be described as triangular and lobed (Fig. 6.58). The appearance of the blade evolves and changes over time; it is initially simple, flattened, and broad with a pronounced or distinct midrib; older plants have thicker blade tissue which splits horizontally down to the midrib to form fingers or straps, becoming more transversally lobed, and becomes pinnate with age. The margins of the blade can also be described as wavy. The distal portion of the blade and the straps eventually become tattered. The stipe of *U. pinnatifida* is wavy or corrugated above the holdfast. The stipe is also usually short (10–30 cm) in length and up to 1 cm in diameter) and in mature plants bears convoluted wing-like reproductive outgrowths or frills (sporophylls). The stipe is



Fig. 6.58 *U. pinnatifida* specimen

also flattened, and transitions into the midrib which extends through the middle of the length of the blade. *U. pinnatifida* is attached to its substrate by a branched holdfast comprised of haptera. It may be confused with *A. esculenta*, as it also has a prominent midrib, but the corrugated stipe of *U. pinnatifida* (which contains its sporophylls) is distinctive. Also, *A. esculenta* grows in more exposed and wave-battered locations than *U. pinnatifida* [6.1, 4, 925].

**Habitat.** Wakame is economically important as a food crop but is also a fouling organism. It is able to compete with native Kelp species in the shallow sublittoral zone.

**Distribution.** Worldwide distribution.

**Uses and Compounds.** *U. pinnatifida* is economically important as a food crop, next to Nori, on the Japanese menu, and is eaten both dried and fresh. In East Asian countries the seaweed is known as Wakame and is treated as a delicacy, often added to miso soup. It can be considered a sea vegetable, or edible seaweed. *Wakame* fronds are green and have a subtly sweet flavor and slippery texture. In Asia and Eu-



Fig. 6.59 Herbarium specimen of *Cladostephus spongiosus* (MACOI no. 3509)

rope, Wakame is distributed either dried or salted, and used in soups (particularly miso soup), and salads (such as tofu salad), or often as a side dish to tofu and a salad vegetable like cucumber. Goma wakame, also known as seaweed salad, is a popular side dish at some sushi restaurants; literally translated, it means *sesame seaweed*. In Korea, *U. pinnatifida* is used in salads or soup such as Miyeokguk. Many women consume *U. pinnatifida* during pregnancy, and *Miyeokguk* is popularly consumed by women after giving birth as Miyeok contains a high content of calcium and iodine, nutrients that are important for nursing new mothers. It is also traditionally eaten on birthdays for this reason, a reminder of the first food that the mother has eaten and passed on to her newborn through her milk, thus bringing good fortune for the rest of the year. After the species was accidentally introduced in 1971 in the Mediterranean via farming of Japanese oysters (*Crassostrea gigas*), *U. pinnatifida* was grown in the French Bretagne as food, which increased exposure of this seaweed to Europeans. *U. pinnatifida* is also used in a wide variety of topical beauty treatments and personal care products, due to its high polysaccharide content and ability to provide moisture [6.3, 4, 925].

Extracts of this species have antihypertensive [6.926], immunomodulating [6.927], antidiabetic [6.928], antiviral [6.929, 930], cytotoxic [6.931], antioxidant [6.932], antitumor [6.933, 934], antiedema

[6.935], antiplasmodial [6.936], anti-osteoporotic [6.937], anti-inflammatory [6.938], antiobesity [6.939, 940], antihypertensive [6.941], and antithrombotic [6.942] activity.

- Order: **Ralfsiales**

*Ralfsia verrucosa* (J.E. Areschoug)

J.E. Areschoug

**Description.** *R. verrucosa* is an olive brown to khaki encrusting brown seaweed that occurs abundantly in low shore tide pools. Here it often forms large, flat, smooth expanses giving the impression that someone had accidentally dropped khaki paint into the tide pools. *R. verrucosa* can occur in high abundance because of its relatively fast growth rate and also because it produces a chemical which seems to deter most grazers [6.943].

**Habitat.** Saxicolous, mid-littoral.

**Distribution.** NE Atlantic (Ireland and Britain to Morocco); SE Atlantic (South Africa); NW Atlantic (Canada, USA); SW Atlantic (Argentina); Mediterranean; Indo-Pacific; Australia.

**Uses and Compounds.** Extracts have antibacterial and antifouling activity [6.944].

- Order: **Sphacelariales**

*Cladostephus spongiosus* (Hudson)

C. Agardh

**Description.** Fairly stiffly branched fronds growing from a crust-like discoid holdfast, covered with small branchlets arranged in whorls (Fig. 6.59); maximum length is usually about 15 cm [6.945].

**Habitat.** On firm substrata in the intertidal zone.

**Distribution.** NE Atlantic (Iceland to Morocco); Mediterranean, Indian Ocean; Australasia; Antarctica, Sub-Antarctic Islands.

**Uses and Compounds.** Extracts have antibacterial activity [6.171, 201].

*Halopteris filicina* (Grateloup) Kützing

**Description.** Compressed, tufted, dark purplish brown fronds, to 120 mm high, main axis 1–4 mm broad. Once or twice pinnate, axes and branchlets tapered at base and apex [6.946].

**Habitat.** On rocks in pools, mid-littoral to shallow sublittoral, sporadic, often locally common.

**Distribution.** NE Atlantic (Ireland and Britain to Morocco); Mediterranean; NW Atlantic (USA); SW Atlantic (Brazil); NE Pacific (South Korea, Japan).

**Uses and Compounds.** Extracts have anti-helminthic [6.946], antimicrobial [6.40, 130, 201, 203], antifouling [6.947], antifungal and antimitotic [6.62] activity.

*Stypocaulon scoparium* (Linnaeus) Kützing

**Synonym.** *Halopteris scoparia* (Linnaeus) Sauvageau.

**Common Name.** Sea broom.

**Description.** *S. scoparium*, previously known as *H. scoparia*, is a dark brown algae that forms beautiful fluffy clumps in shallow rocky-bottomed water. Growing only up to 15 cm in length, *S. scoparium* has a main axis with alternate plumed branches which are more or less fan shaped when flat, though when buoyed up by water they form inverted cone-shaped tufts with a very delicate appearance due to the many filamentous branches. Plants are usually attached to rocks with small to extensive disks often obscured by many matted rhizoids; though these are lacking in free-living plants. These plants are characterized by pure, sheltered waters with high light levels. *S. scoparium* often forms clumps on cobble in the shallow sublittoral zone, though they are just as likely to be found in shallow tide pools or sandy-bottomed areas [6.32, 948].

**Habitat.** On rocks and epiphytically on other seaweeds; in sheltered zones of the upper littoral and in up to 5 m depth.

**Distribution.** NE and E Atlantic (Scandinavia to Cap Verde Islands); Mediterranean.

**Uses and Compounds.** *S. scoparium* is known to be an ingredient in compounds used in personal care products; it contains growth substances (phytohormones) that include auxins, gibberellins, cytokinins, abscissic acid, and betaines [6.948].

Extracts of this species have antiprotozoal [6.193], antifungal and antimitotic [6.62], antioxidant [6.949], antileukemia [6.950], and antimicrobial [6.296] activity.

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