Nataliya Milchakova

MARINE PLANTS OF THE BLACK SEA

An Illustrated Field Guide

Sevastopol
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DDC 581.9(262.5)

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Marine Plants of the Black Sea. An Illustrated Field Guide
Sevastopol, DigitPrint, 2011. – 144 pp.

ISBN 978-966-02-5801-3
A.O. Kovalevsky Institute of Biology of the Southern Seas
National Academy of Sciences of Ukraine

This Guide has been prepared with the financial assistance of the Commission on the Protection of the Black Sea Against Pollution (BSC).

This book is intended for scientists, teachers, students and the general public interested in flora and bottom vegetation and can be used for species identification of the Black Sea marine plants.

This book may be cited as:
Marine plants of the Black Sea. An illustrated field guide. 2011.
Nataliya Milchakova, Digit Print Press, Sevastopol, 144 pp.

Cover design: Vladykin V., Milchakova N.
Cover images: species, map of the Black Sea

Published by Digit Print Press
Senayvina St. 1, Office 304, Sevastopol 99011
Tel. +38 (095)850-50-28, digitprint@gmail.com

In sweet memory of Alexandra Kalugina-Gutnik and Ronald Phillips

The biology of algae is a duty or a task,
That consumes the better portion of your time
In the sampling of waters from an ocean, or a flask,
Or a snowfield, or a gutter full of slime.
You get cold, and wet, and grubby; you get dusty, hot, and dry;
You get dismal, and dejected, and defied;
But you'll find that, if you are lucky - if you're good - and if you try,
You can do a little science on the side**.**

Ralph Arnold Lewin

Dr. R.A. Lewin (1921–2008) was a famous scientist and world expert in marine algae. He was known as "the father of green algae genetics" and a leading authority in multiple areas of marine biology.

ACKNOWLEDGEMENTS

This book would not have seen the light of day without the enthusiastic efforts of the staff at the Laboratory of Phytoresources, Institute of Biology of the Southern Seas (IBSS), Sevastopol, Ukraine.

I wish to express my gratitude to colleagues – Vladimir Alexandrov, Dr. Liliya Bondareva, Dr. Viktor Dzizurov, Prof. Galina Minicheva, Dr. Nataliya Mironova, Dr. Tatyana Pankeeva, Dr. Fillip Saposhnikov, Dr. Olga Shakhmatova, Dr. Olga Vilkova, and Valentina Ryabogina, for their scientific interest in this project.

My special thanks to Elena Chernyshova, Dr. Pavel Goldin, Vadim Ivanov, Taras Hetman, Andrey Karpov, Alexander Kiryakov, Igor Kolokoltsev, Mikhail Kornilov, Darya Korolesova, Yury Moskalenko, Aleksey Nekrasov, Sergey Petrossian, Ulyana Simakova, Dmitry Shamrey, Viktoria Teyubova, Alexander Zakletsky, Larisa Znamenskaya, Andrey Zubko and other colleaques for land and underwater photographs which they have generously shared.

I am also indebted to Vladimir Alexandrov and Valentina Ryabogina for their cooperation and valuable technical assistance.

My special thanks to Olga Klimentova who translated this book into English, and to Kathleen Parsons and Arthur O' Leary who edited the English text. I also thank Dr. Diane Littler and Prof. Mark Littler for revising the taxonomical parts of the book.

I am deeply grateful to the Black Sea Commission for its support of this Guide and to its Permanent Secretariat Officers, Prof. Ahmet Kideys, Executive Director and Dr. Violeta Velikova, Pollution Monitoring Officer, who enthusiastically accepted this modern tool for identification of the Black Sea marine plants.

PREFACE

The degree of variation of life forms within a given ecosystem is referred to as "biodiversity." For centuries, scientists in many disciplines have engaged in extensive exploration of the biodiversity of the Black Sea. Initially, the Black Sea was considered relatively poor in species richness compared to other seas. Often, the Black Sea was called the 'impoverished pocket' of the Mediterranean Sea.

However, recent investigations had shown that there was a need to seriously revise our perception of Black Sea biodiversity. Why? Many exciting advances in the study of life forms have taken place in the last decade, as new theoretical frameworks have been identified, and new technologies to observe organisms in the field and the laboratory were developed. Hence, new data were analysed leading to the discovery of numerous previously unknown creatures for the Black Sea or correcting the taxonomic descriptions of the familiar species.

The story of the Black Sea macroalgae and high plants was a little bit different. First studies on the species composition and the distribution of Black Sea macroalgae date back to the middle of the 18th century. Initially about 10 different species were described (Gmelin, 1768; Gablicella, 1785). During the 19th century the number of known algal species for the Black Sea grew to 100. S.A. Zernov, and N.V. Morozova-Vodyanizkaya created the Black Sea collections of herbaria in the beginning of the 20th century, and they were widely used by scientists to prepare taxonomic descriptions of algae.

In the 1960s and 1970s, Black Sea benthic communities along the coasts of Ukraine, Russian Federation, Georgia, Bulgaria and Romania had been already thoroughly studied, variability and life cycle of species were well known, their ecological niches and role within ecosystems were identified. The results of numerous taxonomic investigations have been summarized in the famous manual of A. D. Zinova (1967): 'Guideline for identification of green, brown and red algae of the USSR Southern Seas' (in Russian), where 277 different species of macroalgae have been described in detail and presented schematically. In 1975 A.A. Kalugina-Gutnik published her prominent book 'Phytobenthos of the Black Sea' (in Russian), with wide-ranging taxonomic, biological, ecological, phyto-geographical and other characteristics of Black Sea algal communities and included a list of 292 species.

In the period from 2000 to 2010, numerous publications highlighted the species richness along the Ukrainian and Turkish Black Sea coast, and today the Black Sea check-list is comprised of 332 macroalgae and high plants (Milchakova, 2007). In 2006, Daciana Sava published the 'Algele Macrofite' in Romanian, where 35 common Black Sea macroalgae were presented with respective photos. Yet up to the present, there was no comprehensive, modern and well illustrated guide for Black Sea flora and bottom vegetation identification, accompanied with concise and update information on the ecology, distribution and value of the species, which was readable by all nations around the Black Sea or outside of the region.

The 'Marine Plants of the Black Sea' which you hold in your hands is one such manual, prepared in English for wider dissemination and use. We believe this valuable book will be equally attractive and useful both for scientists, experts and decision-makers as well as for children, students and people interested in the Black Sea who will be able to learn and marvel at the beauty of the diverse Black Sea underwater life provided through the rich information and lovely photos.

It is worth mentioning here the serious gap in the communication of scientific achievements to the public which we habitually notice in the Black Sea region. In biodiversity, especially, scientific advances and much current information are not widely known to people outside the professional community who study this field. Besides, scientists outside of the region often have difficulties reading publications written in national languages of the Black Sea states, and they have the wrong impression that the Black Sea region has fallen behind other European seas in science and environment protection. The Black Sea Commission , as the regional Focal Point in environmental protection, works to change this perception and to further develop public awareness.

The Black Sea Commission has supported the publication of 'Marine Plants of the Black Sea' and trust that this book, conveying old and new knowledge, will serve many people. We thank the author and her team for their enthusiastic work, we highly appreciate their cooperation with the Black Sea Commission and their important contribution to communicating the Black Sea scientific achievements in the region and world-wide.

And last but not least, in paraphrase of William Blake , we hope the time spent with this book in the palm of your hand will be the 'eternity in an hour', and beauty discovered in it will be seeing heaven in the Black Sea flowers.

Violeta Velikova & Ahmet Kideys
Permanent Secretariat
Black Sea Commission

[1] The Commission on the Protection of the Black Sea Against Pollution (Black Sea Commission, BSC, www.blacksea-commission.org) is the intergovernmental body established in implementation of the Convention on the Protection of the Black Sea Against Pollution (Bucharest Convention) which was signed in 1992 and later ratified by all Black Sea countries. The basic objective of the Bucharest Convention is to substantiate the general obligation of the Contracting Parties to prevent, reduce and control the pollution in the Black Sea in order to protect and preserve the marine environment and to provide policy and legal frameworks for co-operation and concerted actions to fulfill this obligation. In particular, the BSC works in protection and conservation of biodiversity dealing with pressures causing change and decline of Black Sea ecosystems. One of the BSC actions in pursuing its goals is close cooperation with the regional and international scientific community to assure sound scientific background of decision making in the Black Sea region.

[2] *To see the world in a grain of sand,*
and the heaven in a wild flower.
Hold infinity in the palm of your hand,
and eternity in an hour.

INTRODUCTION

Very delicate and complicated relationships underlie the universe in which marine plants and animals dwell; nowadays inhabitants of the World Ocean too often surrender, being unable to withstand human pressures and consequent impacts.

Everyone who steps from the beach into the sea meets algae and seagrasses, those basic primary producers which account for proper functioning of the coastal marine ecosystem. Seaweeds and seagrasses are coastal resources of inestimable value throughout the world. They create stable habitats for many types of food chains that support the goods and services of marine ecosystems (commercial species, recreation, utilization of land-based and ship-borne pollution, etc.). These marine plants also stabilize bottom sediments thus preventing coastal erosion, and aid in maintaining clear coastal waters since they buffer strong currents and wave action. The extremely high biodiversity of seaweed communities is well known. Besides, a variety of marine plants are used as food and for chemical compounds required in many industries. The first records about using seaweed and seagrass as medicinal agents were made about two thousand years ago.

The greatest risks for disruption and extinction of marine plants are in the shallow coastal zones which, along with estuaries, are the places where most of the high concentrations of population occur in the world. This is where shipping and port activities take place, where large rivers end after draining vast areas of agricultural activities, and where largest tourist resorts are located. The loads resulting from human activities, marine traffic and tourism coupled with the global climate change have disturbed the coastal seaweed and seagrass communities significantly in the long-term run. Regrettably, many countries ignore the ecological importance of the coastal zone and abandon any activity that suggests conservation of the seaweed beds. The recent oil blowout and spill in the Gulf of Mexico has demonstrated how human activity may kill off marine life; the most gravely endangered are semi-enclosed seas, e.g., the Black Sea, which is one of the worst polluted seas in the world. Therefore, preserving and conserving the diversity of the Black Sea life is a challenge of special importance.

Though key species of marine plants and their natural habitats in the Black Sea have been placed under protection of regional and national laws and international conventions, too many underwater communities along the shoreline are still affected by degradation. Marine protected areas (MPAs) have proved efficient in preserving, restoring and maintaining the biological diversity but at present their total area is not large. Their expansion through the Black Sea net of MPAs acquires high priority in nature conservation.

Unacceptably, present legislation level of designation of MPAs fail to adequately preserve the diversity of marine organisms. Besides, the general public awareness is low, people are not well challenged to acquire and enlarge their knowledge of plants and animals inhabiting the sea, their

life cycles and natural habitats. Marine biologists should better communicate their research on underwater life to public – today the number of illustrated manuals describing seaweeds and marine life is insufficient. This Guide was written to bridge this gap and acquaint the reader with common seaweed and seagrasses of the Black Sea.

Chapters of this book describe the Black Sea, marine plants growing on the sea floor, commercial use and protection and techniques which are applied to prepare a seaweed herbarium. The most extensive part of the Guide describes 74 macroscopic marine plants which are widespread along the shorelines of the Black Sea and form extensive beds and communities. They belong to the Kindom Plantae (Phylum Chlorophyta, Rhodophyta and Magnoliophyta) and Kindom Chromista (Phylum Heterokontophyta).

Species names are cited in alphabetic order and in concordance with the recent taxonomic revisions and nomenclature alterations synonyms are also given. The descriptions include details of the taxonomy, morphology, ecology, vegetation, reproduction, distribution and economic use. In compiling this Guide, the author used her own materials and data as well as thematic handbooks, monographs and other references. Almost each species is illustrated with underwater photos that permit identification of the marine plant. Most of the photos are from the archives of the Laboratory of Phytoresources (Institute of Biology of the Southern Seas, IBSS).

Annexes to the Guide include a list of researchers working in different fields of marine biology, an MPAs inventory for the Black Sea, the pertinent international conventions and agreements on preservation of the biological and landscape diversity. The glossary explains special scientific terms. The names and publications of all those who contributed to the general topics of the Guide are included in the references section.

The author was fortunate enough to had been taught by friendly and competent tutors in marine biology and to work in cooperation with colleagues who are as enthusiastic as I am. As a student of Rostov-on-Don State University, I repeatedly went to IBSS, one of the oldest European marine research institutes. Later, in this Institute I have specialized in biology and the ecology of the Black Sea marine plants.

Some of the results obtained are included in this Guide and may be of use to algologists, ecologists, hydrobiologists, specialists in nature protection management, students, and to anyone sincerely interested in marine life.

I would appreciate any comments or suggestions from interested readers.

Nataliya Milchakova

CONTENTS

General Part

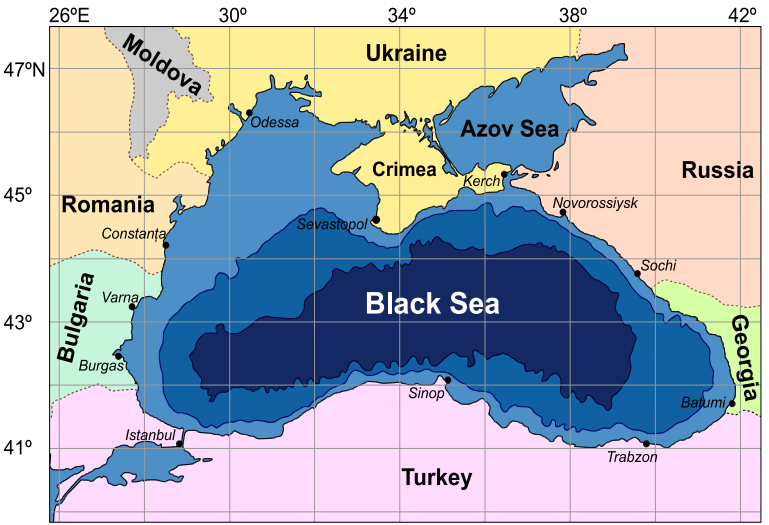
A BRIEF ENVIRONMENTAL SURVEY OF THE BLACK SEA

Morphometry and geomorphology

The Black Sea is a semi-closed sea separating Europe from Asia Minor. The Kerch Strait connects the Black Sea with the Sea of Azov while the Straits of Bosporus and Dardanelles connect to the Mediterranean Sea. The total area of the Black Sea is 423,000 km^2 and the maximum north-to-south distance is approximately 580 km. The greatest depth is 2,245 m and the mean depth is 1,240 m.

The shoreline of the Black Sea is 4,125 km. The longest coasts, 1,450 km and 1,330 km, are in Turkey and in Ukraine, respectively. Others are Russia (410 km), Bulgaria (380 km), Georgia (315 km) and Romania (240 km). The west and north-western of the Black Sea has no mountains and uplifts. There is the Caucasian mountains on the east coast, the Crimean mountain ridge to the north and the mountainous terrain of Asia Minor to the south. The coastline is more or less smooth and indented only in the north and in the northwestern.

The largest gulfs in the Black Sea are Karkinitsky, Kalamitsky, Feodosiysky, Odessa, Varna, Burgas, Sinop and Samsun. The largest bays are of Sevastopol and Novorossiysk. In the north, the Crimean peninsula protrudes far into the sea. The Black Sea is not rich with islands. The largest is Dzarilgatch (62 km^2) and all the rest are small, e.g., Berezan and Zmeiny (Snake) islets are less than 1 km^2 each. The coastal reliefs vary from the prevailing abrasive and accumulative to occasional ria and lagoon-type stretches.



The general map of the Black Sea and regions

Characteristic features of an abrasive coast are a high steep cliff, narrow beach and 150–200 m wide rocky sloping bench. The accumulative submarine terrace of abrasive rock debris often rests against the outward side of the bench.

The submarine bench usually divides into pebble and boulder surf zones, the mid-part where large coarse predominates, and the lower part of broken natural stone and gruss lying from 2 to 20 m deep. Loose silty-sand sediments are found below 20m.

The coastal reliefs vary from the prevailing abrasive and accumulative to occasional ria and lagoon-type stretches. Characteristic features of an abrasive coast are a high steep cliff, narrow beach and 150–200 m wide rocky sloping bench.

The share of abrasive shores aggregates to 60%. Beaches, submarine and coastal banks and coastal sand-bars are most typical of the accumulative coasts at river deltas and coastal salt lake mouths. The ria coasts are rich in numerous sinuous gulfs and bays, e. g. Sevastopol Bay, and the lagoon seashore – in coastal lakes, estuaries, sand spits and earth embankments that is characteristic of Dzharilgatsky and Yagorlitsky gulfs.

Coasts of different types are unevenly distributed along the lithologic contour of the sea. In the northwestern and western parts they are mainly accumulative or abrasive-landslide and lagoon, richly indented with large coastal lakes and lagoons with long sand spits and banks. The sea there is shallow and the submarine relief uniformly flat. The southwestern and southern coasts of Crimea descend steeply into the sea where the underwater relief is surprisingly diverse. The Crimean coast is mainly abrasive, with many rocky capes, small bays, coves and pebble-gravel beaches. Numerous near-shore kekurs are elevated above the sea surface. Accumulative forms are very infrequent and fluvial sediments settle to the sea floor at considerable depths. Only a few small coastal lakes and

The abrasive coast and rocky bench slope (mt Tuapkhat, Caucasus)

lagoons may be found along the coast of the Kerch Strait. In the northeastern part of the Black Sea the coast is usually contour ridge bench built of sedimentary rock in which elevations alternate with crevices and clefts. The long coast of Turkey is abrasive-denudational and abrasive nearly everywhere, with high steep cliffs. The submarine slope harbours numerous rocks and kekurs. The abrasive and landslip coasts are characteristic of the Bulgarian sector of the Black Sea; one-third of the coastal

The abrasive cliffy coast with the ridge bench (Cape Fiolent, SW Crimea).

E. The accumulative spit and shallow submarine sand slope (Tendrovskaya Spit, W Crimea)

The accumulative pebblestone-and-boulder beach and steep submarine slope covered with pebble and muddy sand (Kazachiya Bay, SW Crimea)

F. The abrasive coast interrupted with few beach patches and the ridge bench (Cape Severnaya Kosa, SW Crimea).

The abrasion-denudation shore
with gravel-boulder beaches and kekurs
(Cape Atlesh, Tarkhankut Peninsula)

The rocky cliff coast
with surrounding bays
(near Cape Fiolent,
SW Crimea)

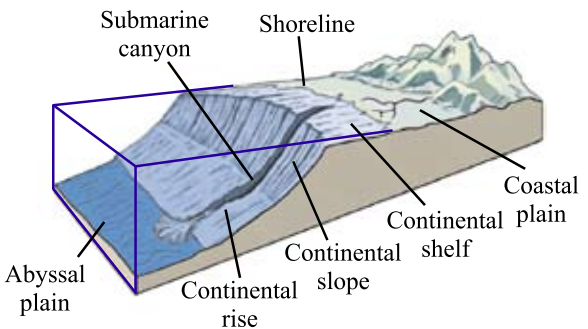
The folded coast destroyed
by erosion and denudation
(Snake Island)

zone are beaches, wide and narrow. Accumulative shores are relatively few, e. g. in the Gulf of Varna. The Romanian sector is remarkable for the Danube's delta, one of the largest in Europe. The strip of lagoons and predominantly abrasive seashore lies southward.

Shelf zone

The shelf occupies 29.9% of the total area of the Black Sea. The shallow (less than 200 m deep) continental shelf in the northwestern part makes up about 25% of the total area of the sea. Coastal zones of Crimea, the Caucasus and the southern part of the Black Sea adjoin very narrow shelf zones often intersected by submarine canyons.

The submarine relief of the Black Sea



The width and structure of the shelf differ depending upon the location. The northwestern shelf is as wide as 190 km. In the steep-coasted southern and eastern parts it narrows to 20 km and is intersected by numerous submarine canyons and depressions. Abrupt continental slope is characteristic of the northeastern Black Sea and the Crimean peninsula, where the sea is 500 m deep a few kilometers of the shore off. Typical features of these areas are boulder-and-block deposits 20-30-m high or shoals situated at a large distance from the shore. There are steep and narrow submarine canyons with the 15–25 m walls.

In the near-shore zone of the Black Sea pebblestone, gravel and sand prevail; farther from the shore coarse deposits give way to fine-grained sand and siltstone. The slopes and sea floor of submarine depressions are covered with pelitic silts, and coquina and shell rock dominate in the northwestern part of the sea.

Water balance

Special hydrological and hydrochemical conditions in the Black Sea are due to river inflow, water exchange with the Sea of Azov and the Mediterranean Sea, air circulation, indented shoreline, special structure of the shelf and other factors. Different experts assess the volume of the Mediterranean seawater inflowing through Bosporus as 123–312 km^3 and the outflow as 227–612 km^3. The influx the Black Sea annually receives through the Kerch Strait is 22–95 km^3 and the outflow 29–70 km^3. The main Black sea current starts from Bosporus and runs along the coast of Turkey in the east and Bulgaria in the west. During the last century sea

level nearly everywhere was rising 0.3 cm a year, and has increased to 15 cm on the average. The resulting coastal flood has ruined vast areas of land.

More than one thousand rivers inflow into the Black Sea. Nine are large – the Danube, Dnieper, Dniester, Kizilirmak, Southern Bug, Sakarya, Yesilirmak, Choruh and Rioni, with the drainage areas over 10,000 km^2. The sea annually receives 52.2 million m^3 of river drift, 20% of which are deposited in terrestrial beds and form beaches. The rest is involved in a continuous sedimentation cycle on the shelf.

Sea depths greater than 150–200 m are saturated with hydrogen sulfide and inhabited only by anaerobic bacteria and poorly known meiobenthic organisms. The upper oxygenated layer constitutes 12–13% to the total volume of the sea. Most recent investigations show that the Black Sea is a giant reservoir of hydrogen sulfide and methane.

Seawater parameters

Annual average temperature in the Black Sea is 8.9°C. In winter the surface of the open sea is usually 6–8°C; the northwestern shallows and the Kerch Strait cool to 0.5°C. In summer, the surface warms up to 25° C and more in many areas of the sea. In 70–100 m-deep zone of cold intermediate sea water the annual temperature is a stable 7–8°C. Average salinity of the Black Sea is about 18‰, and near to the estuaries it is less than 8‰. The sea is usually ice-free. During cold winters some localities on the northwestern and Kerch-Taman shelves may have an ice cover of about 15-cm and during extraordinarily severe winters to 55-cm. Thickest ice is on coastal lakes which completely freeze each year.

Marine plants habitats

The littoral of the Black Sea is not typically oceanic because of the absent tide cycle. Most characteristic are upwelling-downwelling and seiche fluctuations – 0.2–0.3 m and 0.4–0.5 m, respectively. The littoral divides into supralittoral, pseudolittoral and sublittoral zones. Lying above the sea level, the supralittoral or splash zone is washed only from time to time owing to wind or strong gale. Supralittoral macroalgae are not diverse, in winter they are mainly *Nemalion, Bangia and Scytosiphon*, and during spring and summer *Cladophora* and *Ulva* species. In pseudolittoral zone winds may occasionally denude a narrow strip of the sea floor on which *Ceramium, Cladophora, Dictyota, Ulva* and some other alga grow. Next to supralittoral and pseudolittoral is the sublittoral zone which subdivides into upper, medium and lower sections.

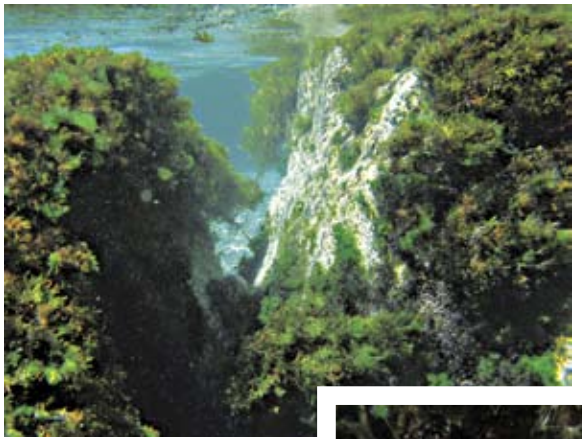
Communities of small filamentous and bushy algae – green, red and brown are characteristic of the upper sublittoral; numerous species of *Ulva, Cladophora, Ceramium, Dictyota* and *Polysiphonia* predominate. Large brown algae like *Cystoseira barbata, C. crinita* and mixed communities which include green *Ulva* spp. and some others prevail in the mid-sublittoral zone. Phytocenoses of the red alga *Phyllophora crispa*, the green *Codium vermilara* and others are commonly found in the lower sublittoral zone. Compared with the shallow near-shore sea, phytodiversity of the sublittoral zone is far richer in the medium part where production, biomass and abundance of macrophytes are also higher. The species composition and structure of seaweed and seagrass communities vary depending upon the underwater relief, e.g., epiphytic algae prevail in depressions and crevices sheltered from the surf, the species composition

resembles that typical of thedeep sea. The relationship between bottom sediments and submarine relief on the one hand and seaweeds specific to locality and population parameters on the other hand is insufficiently understood.

The most extensive marine plants assemblages in the coastal zone of the Black Sea are:

- Belt of *Cystoseira* – the communities of *Cystoseira* spp. on hard substrates, along the rocky bench, from 0.5 to 10 m deep
- Belt of *Phyllophora* – the communities of *Phyllophora* spp. on hard and soft substrates, at 10 to 20 m depths
- Zernov *Phyllophora* field – the communities of *Phyllophora* spp. on soft substrates from 14 to 45 m deep, the northwestern part of the Black Sea
- Minor *Phyllophora* field – the communities of *Phyllophora* spp. on soft substrates from 7 to 16 m deep, the Karkinitsky Gulf
- Seagrass communities – on soft substrates in shallow gulfs, bays, coves and coastal salt lakes, from 0.5 to 10 m depths

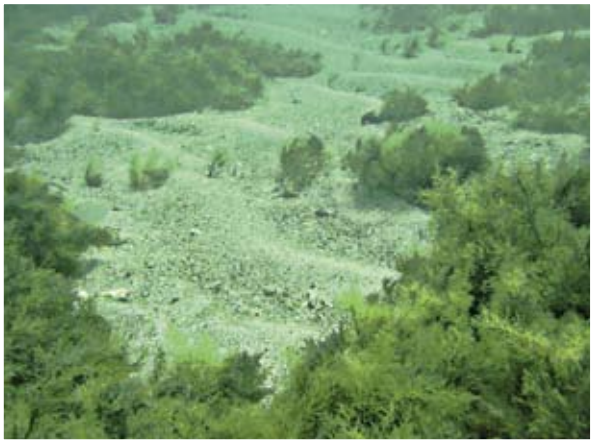
Generally, the geomorphological features specific to the coastal zone, the submarine slope relief, and the local hydrological and hydrochemical regimes set conditions for high species diversity of macroalgae and seagrasses. The species richness of the Black Sea is four times less than the Mediterranean, however productivity and biomass of Black sea seaweeds are far greater.



Cystoseira spp. habitat

Phyllophora crispa habitat

Seaweed and seagrass habitats



THE MARINE FLORA AND BOTTOM VEGETATION OF THE BLACK SEA

Seaweeds and seagrasses of the Black Sea have been investigated for more than a century. A recent inventory of Black Sea flora identified 332 species among them are 75 brown (Heterokontophyta), 80 green (Chlorophyta), 169 red algae (Rhodophyta) and 7 species of higher plants (Magnoliophyta) including seagrasses. However, taxonomic revisions, nomenclature changes and accidental introduction of exotic species make the number of species fluid rather than constant.

Marine flora of the Black Sea originates mostly from the northern Atlantic and the Mediterranean Sea. Species diversity is nearly 4 times less than in the Mediterranean due to environmental factors unique to the Black Sea: low salinity, high eutrophication and cold winters during which the sea surface in the north-western part and in some other areas is ice-covered. Some indigenous species have been inhabitants of the Black Sea since the Ice Age. The share of autochthonous species is in the minority and the flora is only feebly endemic.

The portion of species which are common for regional floras is small because of different regional environmental conditions. Besides, relevant knowledge about the regional floras is insufficient. The number of species found in the eastern part of the sea is at least twice as large as the number in the west. Species diversity is richest along the Ukrainian and Turkish coasts since their shorelines are twice as long as those of other Black Sea countries. The majority of red algae grow near the Turkish coast while green algae are most common near the Romanian shore and brown algae are mostly found along the coastal zones of Russia and Ukraine. The largest number of species are red algae of the genus *Polysiphonia*, green algae of the genus *Cladophora* and *Ulva*. The distribution of marine plants by depth and along the shores depends upon many environmental factors.

Forty associations are represented in the bottom vegetation of the Black Sea. Communities of brown algae *Cystoseira crinita* and *C. barbata* and of red algae *Phyllophora* spp. are the keystones of the coastal ecosystem. These communities form two belts with patch-distributed marginal associations. Seagrasses *Zostera marina* and *Z. notii* occupy vast areas of shallow bays, gulfs and coastal salt lakes.

The largest assemblage of unattached *Phyllophora* spp. concentrates on the central north-western shelf of the Black Sea and is known as the Zernov *Phyllophora* field. S.A. Zernov, the prominent Russian scientist, first discovered this phenomenon about a century ago. This field is vanishing and needs urgent protection.

Factors identified as most seriously endangering seaweeds are increased anthropogenic load on the coastal zone, e.g., intensive recreation-related development of land, vanishing of typical biotopes, rapidly increasing municipal and industrial sewage, overregulated river run-off, dumping of soil, conspicuous silting of bottom sediments, overexploitation of biological and mineral resources and the global climate changes coupled with the

rising sea level. Others adverse factors are erosion and intensive abrasive activity of the sea, especially in loose rock localities. These factors have disturbed the seaweed belts in many parts of the coastal zone. The cover of dominant species has been conspicuously reduced while micro-groups of algae with short life cycle have become more numerous in the bottom vegetation.

This background has reduced the richness and biomass of the *Phyllophora* and *Cystoseira* communities as well as the number of perennial species, and stimulated an increase of ephemeroids with short life cycles. In many localities the dominant perennial species have decreased in weight and size, so that young plants have been the prevailing fraction while the number of full-grown individuals dramatically decreased which secured the reproduction success. Epiphytic synusiae and companion species have acquired greater importance as the main element of community. Along the 10–15 m deep belts' border, perennial species have been replaced by algae with short life cycles and ephemeroids, which have a large specific surface. Some opportunistic species expand to strange localities; for instance, free-floating *Cladophora* spp. are found now in 30–40 m depths where they have never before been registered.

A good sign is that observations made during recent decades in different localities of the Black Sea show the rehabilitation succession of phytocenoses of *Cystoseira* characteristic of the 0.5 – 3 m deep upper littoral zone develops little by little, particularly in marine protected areas (MPAs). The biomass of communities and the density of dominant species in them increased while the share contributed by epiphytic synusiae decreased. However, the degradation of the *Phyllophora* communities goes on in the lower sublittoral zone from 10 to 20 m deep. Seagrass communities growing in the bays and gulfs have not undergone such dramatic changes; in fact, the abundance and biomass of the dominant species of *Zostera* have even increased in some seawater areas. This is possibly in response to global warming or to as yet unknown environmental and non-environmental factors. Analysis of long-term dynamics of the structure of key Black sea phytocenoses shows that *Cystoseira* and *Zostera* have adapted to the environmental changes better than *Phyllophora*.

The present stock of *Cystoseira, Phyllophora* and seagrasses in the Black Sea is evaluated at 1.5 million tons wet weight, while three decades ago it was greater than 8 million tons. Additionally, in some areas of the Black Sea shelf the width of algae distribution has narrowed 3 to 6 fold and the lower depth of algal growth has risen to 20–25 m while thirty years ago it lay at a depth of 40–50 m.

Generally, in recent decades the flora of the Black Sea has been changing in response to global climate change as well as anthropogenic impacts and other stresses. These factors are responsible for the disturbed floristic diversity and the accidental introduction of invasive exotic species. These changes have introduced thermophilic organisms formerly unknown in the Black Sea basin. The comparative floristic analysis has shown that the number of *Cladophora, Cystoseira, Gelidiella, Polysiphonia* and *Sargassum* species in the Black Sea have nearly doubled; these genera are common for the Mediterranean Sea.

Based on the author's own data, 15 macroalgae and 1 seagrass species have been classified as exotic species. In fact, seagrass species

Cymodocea nodosa was only recently found near the Turkish coast. Most of the aliens are warm-water and tropical, originated from the area lying between the boreal and tropical zone. However, the question of when exotic species were first found in algal flora of the Black Sea remains unanswered. Assuming that the Mediterranean 'migrants' enter the Black Sea not only due to increased anthropogenic load but also through general seawater exchange, it is reasonable to expect further introduction with the eastern and western streams of the Bosphorus current interacting with regional alongshore currents. Most probably, new findings will be made near the shores of Turkey, Bulgaria and Romania. In addition to the Mediterranean, Caspian species have added to seaweeds flora of the Black Sea. For instance, *Ectocarpus caspicus* and *Laurencia caspica* have been reported along the northern and western coasts of the sea.

Presently the diversity of the Black Sea flora enlarges either through mediterranization (tropicalization) or through accidental introduction of Caspian species. It is noteworthy that, while environmental factors favoring the invasion are mostly known, we still don't have enough data about biological factors. Probably the diversity of life strategies, the special morphostructure, abilities for thallus fragmentation and for secretion of grazing-inhibiting substances characteristic of macroalgae in general, and of the warm-water complex in particular, will further the invasion of new species into the Black Sea.

Conservation

40 marine protected areas have been legally established in the coastal zone of the Black Sea. The key species of *Cystoseira, Phyllophora* and *Zostera* are included in the Red Book of the Black Sea (1999). Many Black Sea countries have taken an inventory of endangered and vanishing marine plants. More as 30 macroalgae species which urgently need protection have been included in the Red Book of Ukraine (2009).

Recognizing the very important role which bottom vegetation and its key elements play in the sustaining ecosystem of the coastal sea, the protection and conservation of marine plants is a top priority for regional and national ecological management. To this end, trawling of seaweeds is prohibited in the Black Sea.

Of prime importance for the protection of Black Sea flora and bottom vegetation is enlarging the MPAs and creating the MPAs network. This includes upgrading the status of the existing nature reservations, especially those rich in floristic and landscape diversity.

Validation of the national and European status of such preserves and long-term monitoring of the biota allow working out proposals for optimization of loads on the coastal zones and ecosystems. These activities are provided by the strategy of creation of a European coastal and marine protected areas network (ECMEN - European Coastal and Marine Ecological Network, Sofia, 1995; Natura 2000), and the Declaration of the World Summit on Sustainable Development (Johannesburg, 2002), that suggest the global expansion of the MPA network by 2012. In recent years the number of MPAs has doubled and they occupy now about 2.35 million km^2, or 0.65% of the total area of the World Ocean.

Danube Delta
Biosphere Reserve

Swan Isles,
a part of Crimean
National Reserve

Chernomorskiy
Biosphere
Reserve

Aerial view of Karadag Nature Reserve

Mys Aya Nature Preserve

Aerial view of Fiolent Nature Preserve

Aerial view of Opuk Nature Reserve

Aerial view
of Isle Zmeinyi
Zoological Preserve

View of the Karansk plateau,
reserved for Nature Preserve
(Crimea, near Sevastopol)

Aerial view of Kazachiya Bay
Zoological Preserve

MARINE PLANTS: AN OUTLINE

Macroscopic marine plants or macrophytes are the algae and seagrasses which are visible either to the naked eye or under an ordinary magnifying glass. The words *algae* and *seagrasses* refer to biology rather than to taxonomy. Algae are lower plants, of which the body is an undifferentiated thallus and not partitioned to organs; these marine plants are attached to substrate by an individual cell or a holdfast or a rhizome, and often have unattached, free-floating forms. Algae may be epiphytic, i.e., growing on other plants. Seagrasses are higher plants, they have a stem or a shoot, blades, and are attached to the sea floor by rhizomes and roots. Algae reproduce by spores, and seagrasses by seeds. Sharing the same habitats, algae and seagrasses grow under the equivalent environmental conditions. All seagrasses and the majority of algae have underwater life cycles, and some species grow close to the water edge which is only periodically covered with water.

There are about 10,000 species of marine macroalgae and 60 species of seagrasses. The species diversity is largest in red, green and brown algae; in the tropical zone the diversity of seaweeds is far richer than in other latitudes. Marine macroalgae and seagrasses have been inhabitants of the ocean for a few million years, and red algae are the oldest.

The morphology, growth, reproduction and life cycle of macroalgae

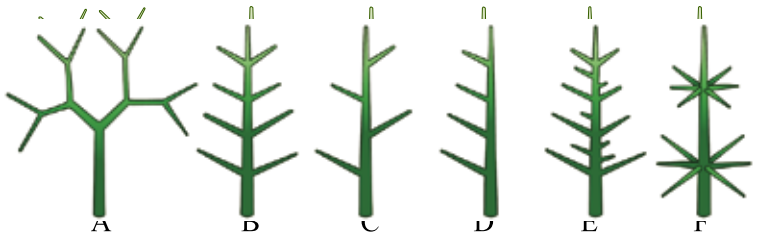
The form and size of thalli vary from simple to intricately complex, and the length spans from a few micrometers to 50–70 m. Each of the three phyla named according to the thalli color. The different parts of the thalli may vary in color and shade, depending upon pigments and their content. The brown colour of algae results from the dominance of the pigment fucoxanthin, which masks the other pigments, and green colour connects with chlorophyll *a* and *b* (in the same proportions as the higher plants), beta-carotene (a yellow pigment) and xanthophylls (yellowish or brownish pigments). The red colour is formed from the pigments phycoerythrin and phycocyanin, beta-carotene and a number of unique xanthophylls.

In taxonomy, morphological structure is the crucial systematic criterion and evidence of species ecological variation. Approximately 10 types of morphostructure of thallus have been identified (see table below); each is characteristic of the morphological differentiation attained during evolution. Describing the type of structure, a researcher should use only full-grown plants, discarding any young individuals.

The functional-form groups of marine macroalgae (by Littler et al., 1980)

Group	External morphology	Internal anatomy	Texture	Genera
Sheet group	Thin, tubular and sheet-like (foliose)	Uncorticated, one to several cells thick	Soft	*Ulva, Porphyra, Dictyota*
Filamentous group	Delicately branched (filamentous)	Uniseriate, multiseriate, or lightly corticated	Soft	*Chaetomorpha, Cladophora, Polysiphonia*
Coarsely branched group	Coarsely branched upright	Corticated	Fleshy-wiry	*Laurencia, Cladostephus, Gracilaria*
Thick, leathery group	Thick blades and branches	Differentiated, heavily corticated, thick-walled	Leather, rubbery	*Cystoseira*
Jointed calcareous group	Articulated, calcareous, upright	Calcified genicula, flexible intergenicula with parallel cells rows	Stony	*Corallina, Jania*
Crustose group	Prostrate, encrusting	Calcified or uncalcified parallel rows of cells	Stony or tough	*Lithothamnion, Peyssonnelia*

Algae display a diversity of branching patterns: dichotomous, opposite, alternate, irregular and whorls (see fig. below). Besides, a thallus may often give rise to processes called prolifications, papillae or galls.



The main types of branching in marine algae.
A – dichotomous, B – opposite,
C – alternate, D – unilateral, E – irregular, F – whorled

The thallus increases in size through division of all its cells (diffusive growth) or of meristematic apical or marginal cells (apical and marginal growth, respectively), that depends upon the species. There are three type of reproduction: vegetative, asexual and sexual. The vegetative reproduction entails thallus fragmentation, vegetative buds – propagules, or vegetative cells – akinetes, or prostrate filament and rhizoid sprouting or secondary shoots emerging in the basal part of thallus. Asexual reproduction occurs through special spores or zoospores (flagellate spores), usually formed in sporangia, these special cells which differ from a common cell by size, shape and origin. Sporangia may develop inside the thallus or on its surface, singularly or in groups called soruses; as a rule they are small in size, but their number in different species varies from one to a few hundred. The structure of spores and the types of spore bearing are essential systematic features.

Germinated spores give rise to a plant-gametophyte on which antheridia and oogonia (male and female reproductive organs) develop; inside them gametes(specialized sex cells) can mature. Gametes can be motile (flagellate) or non-motile (without flagella). Having fused, the male and female gametes give rise to a zygote with diploid chromosome set which later forms to sporophyte. Algae have evolved several types of sexual reproduction – isogamy, anisogamy and oogamy, or through conjugation. Sexual reproduction ensures digenesis, or the alternation of generations, and the diploid chromosome set that makes the plants better adapted to aquatic environment. Primitive sexual reproduction is typical of many algae, while it assumes the most complicated form in red algae.

Algal life cycles are diverse and complicated; usually sporophyte and gametophyte stages will alternate. The alternation is of several types: under the prevailing isomorphic alternation, the involved sporophyte and gametophyte formally resemble each other, while they differ considerably under heteromorphic alternation, being a few cells or a few meters long. Generation sequences are absent in some algae. Under certain conditions, particularly under environmental stress, only one generation – either sporophyte or gametophyte – prevails. The most complicated life cycles

have been described for red algae; the elicited details are of special worth for taxonomic investigations.

By duration of their life cycle, algae are divided into perennial, annual, seasonal and ephemeroidal. Some perennial algae, particularly brown, have thalli which live for several decades; annual species grow for one year during which several generations develop. Life time of ephemeroids is indeed ephemeral; usually these plants may be found during only one season, in winter or in summer. More details about algae, their growth, reproduction and life cycles can be found in numerous articles and books on the subject.

The ecology of macroalgae

As autotrophic photosynthetic organisms, algae have special preferences for sunlight, illumination, seawater temperature, salinity, transparency, dissolved oxygen, nutrient content, substrate, wave activity and the velocity of currents. A number of abiotic factors inhibit algal growth and development; the phylum of green algae is remarkably tolerant to a variety of aquatic and land environments.

Macroalgae are attributed to benthic organisms adapted to marine and freshwater environmental conditions. Most of them are attached forms, and the unattached are in minority. Algae are also typical representatives of periphyton, frequently found on diverse underwater constructions and objects. Marine benthic macroalgae grow on rocks, stones and shell rock, other hard substrates are known as epilithic; on soft ground, sand and silt, as epipelithic; on larger marine plants, as epiphytes, and in the body of other plant, as endophytes.

Marine algae grow from the seawater edge to 250-m depth. Their extensive beds concentrate in the coastal zone of the seas and oceans on hard substrates lying to 30 m deep where the coverage, biomass and density are highest.

Services to the environment

Marine plants perform a function of utmost importance by releasing oxygen during their photosynthesis. Nearly 90% primary production is due to seaweeds and seagrasses in the coastal zone. They have high reproduction rates and are almost exclusively oxygen producers; their significance to the coastal ecosystems can hardly be overestimated. They are a key element in many food chains; in coastal areas marine plants are reliable indicators of environmental quality and an essential component of environmental monitoring. Computations suggest that the cumulative benefits that seagrass and algae beds supply to coastal ecosystems approximate almost US$ 20,000 per hectare per year.

Protection

With an ever-growing load upon coastal ecosystems, environmental degradation and destruction of natural biotopes, the number of algae and seagrasses which need placing under protection is increasing. Many species have been entered in international and national nature protection lists and Red Books, and seagrass and coralline algae communities are acknowledged as global critical ecotopes. Nowadays the protection of seaweeds and seagrasses is given special concern and has become the subject of a series of special national and international agreements and conventions.

COMMERCIAL USE OF SEAWEED AND SEAGRASSES

More than 30 countries have developed commercial algal farming and harvesting from cold, temperate and tropical waters of the World Ocean. Half of the consumed harvest is from the ocean and half is from the mariculture farms. Annually, the total algal crop amounts more than 2 million tons dry weight in which 90% are consumed in China, Japan, Korea, Chile and France. The four most popular genera are *Saccharina* (= *Laminaria*), *Porphyra*, *Undaria* and *Gracilaria*. The farming of seaweed has expanded rapidly as demand has outstripped the supply available from natural resources.

Of at least 221 commercial seaweeds, 155 are used as food and about 100 are for phycocolloid production. In Asia, where seaweeds are traditional food, they are successfully farmed for the food industry. The annual seaweed harvest is estimated at US$ 6.2 billion, of which food products for human consumption contribute about US$ 5 billion. The most eagerly eaten seaweed is *Porphyra*, or "nori" (which is used in sushi). Seaweeds are eaten raw, fresh, dried or cooked like spinach, and are added to soups and salads. The largest producer of edible seaweeds is China.

Most known seaweed phycocolloids are water-soluble carbohydrates – alginate, agar and carrageenan. Their manufacture consumes nearly one million wet tonnes. The food industry uses seaweed phycocolloids as additives in food products and as a stiffening agent to form gels, water-soluble films and to stabilise some products. Other consumers are the medicine and the cosmetic industry.

The brown alga *Saccharina latissima* farmed in the Japan Sea (Russia, permission of TINRO)

Alginate production (US$ 213 million) is by extraction from brown algae, all of which are harvested from the wild since the cultivation of brown algae is too expensive to provide raw material for industrial uses. Agar and carrageenan production (US$ 132 million and 240 million, respectively) are mostly from red algae, usually *Gelidium* and *Gracilaria* harvested from coastal seawater areas and lagoons.

The growth of seaweed hydrocolloid sales (US$ million) from 1999 to 2009 (from Bixler, Porse, 2010)

Seaweed hydrocolloid	1999	2009
Agar	128	173
Alginates	225	318
Carrageenans	291	527
Total	644	1,018

Similar to terrestrial plant, seaweed extracts have shown a wide range of biological activities. 83 species of seaweeds are pharmacologically effective, among them 49 Rhodophyta, 20 Heterokontophyta and 14 Chlorophyta. In clinical applications the drugs from marine algae can be divided into major groups: antifungal; anticoagulant and antihemorrhagic; antiviral; antihypertensive; antitumor; cardio- and cerebrovascular; and supporting resistance to acquired immunodeficiency syndrome. Many claims have been made for the effectiveness of seaweeds in the treatment of tuberculosis, arthritis, colds and influenza. They are also prescribed to lower cholesterol activity, lipid effects and blood pressure. This treatment provides relief for rheumatism and osteoporosis when combined with seawater hydrotherapy.

Washed ashore by storms (storm casts), seaweeds are the source of the popular fertilizer potassium nitrate. In organic farming they are especially effective in growing fruit and vegetables; seaweeds are also added to fodder. Macroalgae could be use in the treatment of industrial and agriculture wastewater to reduce the nitrogen- and phosphorus-containing compounds and remove toxic metals.

Though not used as widely as seaweeds, seagrasses have been known for their special properties since ancient times. A possible explanation is their flame-retardant, heat-insulating and decay-resistant properties. Dry blades of *Zostera marina* carpeted many burial chambers in of the Bosphorus Kingdom (Kerch Peninsula, Crimea, 6th century BC). Chinese manuscripts of the 2nd century AD mention the powder from *Zostera* as a medicine. Being extremely strong and durable, seagrass leaves are used in the manufacture of furniture (e.g., armchairs, bed headboards, display shelves, bookcases) and decorative items such as rugs, baskets, and mats which are usually completely hand-woven. Even today seagrasses provide heat-insulating, fire-resistant and noise-proof materials. In southern Ukraine seagrass blades are used for insulating barns during winter.

Interest in utilizing seagrasses for agriculture, industries and medicine is growing everywhere. Today, with their unique chemical composition, seagrasses provide humanity with food, fodder and medicines. The polysaccharide zosterin from *Zostera marina* is a natural organic sorbent producing versatile cleansing effect on the gastrointestinal tract and blood. It has high immunomodulating activity and improves epithelial regeneration and resistance to some cancers and minor diseases. *Z. marina* provides a valuable component of fodder and fertilizer. Having a high moisture capacity towards 3,000%, the leaves of eelgrass can form moisture-proof film, thereby retaining the fertilizer in the soil and maintaining its efficiency.

Expanding commercial exploitation of marine plants is impossible without the development of new biotechnologies of their cultivation. This is especially important because the habitats of many species of marine macroalgae and seagrasses belong to the critical zones of the World Ocean and have been placed under legal protection in the World. The meadows of seagrasses are strongly protected in Europe (Bern Convention, 1976; Nature, 2000).

NOTE: do not use macroalgae and seagrasses described in this book for self-treatment!

The storm cast of Zostera spp. on the shore of the Karkinitsky Gulf (Black Sea)

Cosmetic and pharmaceutical productsfrom seawees and seagrasses

The collecting of seaweed harvest
in the East-Asia countries

HOW TO PREPARE A MARINE PLANTS HERBARIUM

A herbarium is a collection of dried plants, or specimens. Usually the keepers of these collections are research institutes, universities and museums. Herbaria fall into categories such as local, regional or national depending upon their function. The history of large herbaria is decades, perhaps even centuries, old. They can be used for scientific and/or education purposes, demonstrations and studying local lore.

The available herbaria are numerous. They are characteristic of the advancement of the global or national botanical investigations, especially those relating to biodiversity. The specimens provide the most unbiased and reliable information about a regional or national flora. While the number of herbaria of terrestrial flora and the number of specimens have conspicuously increased worldwide, the herbaria of seaweeds are few because collecting, drying and handling marine plants require special time- and labor-consuming diving expeditions.

The largest collection of Black Sea marine plants is kept at The A. O. Kovalevsky Institute of Biology of the Southern Seas National Academy of Sciences of Ukraine (IBSS NASU). The nearly 30,000 specimens represent more than 500 species of green, brown and red algae. A special division comprises seagrasses collected all over the World Ocean; another division contains the specimens of macroalgae that have been collected during research cruises to the Atlantic, Indian, Pacific and Arctic Oceans for the last fifty years. Over 20,000 sheets are for marine plants of the Black Sea, with the oldest dating back to 1916. The Herbarium of macrophytes at IBSS has been included in the inventory of objects of national interest for Ukraine and is registered in the Index Herbariorum as SIBS (http://www.sweetgum.nybg.org).

Though laborious, herbarium-making is truly absorbing. Duly collected and dried specimens remain intact for decades or even centuries, providing generations of researchers material of inestimable value. The exquisite beauty of these specimens can both captivate and fascinate.

Guidelines on collecting

Marine algae and seagrasses are usually collected during research cruises or expeditions which focus specifically on biodiversity. The specimens are gathered from the sea and also from fresh algal mass cast ashore. Only whole thalli or shoots should be taken and all their parts, including attachment organs, holdfast should be intact. Many investigators prefer picking up the marine plants themselves as they are best aware of the biotopes and environmental factors, but SCUBA-divers help to get them from the deep water. The collected plants are carefully washed in sea water to remove the bottom silt and living organisms. The rinsed macrophytes from each sampling site or station are identified by species, put into plastic bags or jars filled with sea water, and are kept for further handling in the laboratory. Each plastic bag or vessel bears a label specifying the sampling date, area, depth, bottom substrate, etc. These details are also registered in the field log. If the specimens can not be placed in the herbaria within next few days, the specimens are placed into plastic containers and fixed with 3–4% formaldehyde, alcohol or other fixative.

How the specimens are prepared

Before handling a specimen, it is essential to assign the plant to a genus or species using all reliable sources. If the investigator is not familiar with the flora of the region, it is better to sort the seaweeds according to the color and shape of thalli. Compared with algae, identification of seagrasses is easier due to the smaller number of distinct diagnostic characteristics.

After identification, marine plants are placed into plastic trays or shallow laboratory dishes filled with fresh water. Each specimen is then removed and put onto a standard sheet of heavyweight A4 white paper. Depending upon the size of the plant, the sheet can be cut into 1/2, 1/4 or 1/8 pieces. A usual practice is that one sheet holds only one thallus although a few small thalli are also permissible. Smaller specimens are smoothed out with a paintbrush or a dissecting needle. Thin plastic or metal plates are placed cautiously under the sheet of heavyweight paper, so as to simultaneously remove both from the water at an angle of 30–45°.

This method permits preserving the natural shape of the thallus which is of special significance in handling higher aquatic plants. After the water has drained, the sheet with the specimen is put onto blotting absorbent paper (or you can use newspaper) and covered with gauze or cotton tissue to prevent the thallus and the absorbent paper from sticking together. Having been labeled one by one, the specimens are covered with 2–4 layers of a blotting paper and placed under the press.

Labeling

An unlabeled specimen is worthless for investigation, so labeling is an important staple in herbarium-making. Each sheet bearing a specimen is labeled with a pen. The inscription should give generic or/and species name, the date and location, latitude/longitude, depth, substrate, and the names of the collector and who determined the identity of the plant.

Drying

Like terrestrial plants, macroalgae and seagrasses are dried using a standard 32 x 45 cm plant press. Before drying, each specimen is checked for the presence of label and gauze. Wet paper is replaced with dry, if necessary. The plant press should be wrapped and bound but not so tight as to prevent damage of any part of the thallus. A marine plants herbarium should be dried under room temperature, away from open fire and bright sunlight. If available, use a fan to help dry the specimens; place it about one meter away from the press.

During the first day, the interlaying drying material should be changed as frequently as possible and once or twice a day afterwards, depending on the size and texture of the thallus and shoots, until the specimen is completely desiccated. Gauze is left on the plants until they are fully dried. The absorbing paper and gauze can be dried and re-used. When the drying is complete, the specimen is usually stuck to the paper. In other cases, white glue can use to fasten it permanently to the paper.

Storage

Desiccated marine plants are placed into water-tight paper bags, typically made of tracing paper, leaving the specimens clearly visible without unpacking. The paper bag should match the size of the herbarium sheet. All information about the specimens on the label and the herbarium sheet should be repeated on the face of the paper bag. Today many herbaria hold macroalgae and seagrasses sealed in special plastic bags. If plants of the same species are plentiful, 2–3 specimens from a habitat type are placed onto a standard sheet of heavyweight paper, and the rest are stored in the bags. Having amassed more than 20 sheets representing a species from each location, the owner may either offer some for exchange or hold them in reserve.

NOTE: in many countries, some habitats of the coastal zones have been placed under the protection of environmental law and relevant international conventions. Therefore, a collector gathering marine plants for the herbarium should be guided by local legislation. It would be wise to consult a local expert specializing in Black Sea marine plants (see Annex 1).

The herbarium room of SIBS

Specimens of the Black Sea macroalgae

Taxonomic Part

Ulva linza

Green Algae

(CHLOROPHYTA)

The color of these algae varies from light- to deep green; they can also be yellow and brownish depending upon the content of pigments, in particular chlorophyll a and b, beta-carotene and xanthophylls. Morphologically the thalli vary from unicellular to broadly branched multicellular. Green algae can be colonial, living as a loose aggregation of cells, or coenocytic, being a single large cell without cross-walls. They can be a few microns to ten meters long. Green algae reproduce by asexual, sexual and vegetative means. A sexual reproduction occurs more often and asexual reproduction is by fission, budding, fragmentation or by zoospores;. The life history of many Chlorophyta entails alternating haploid and diploid phases though in some species the generations do not alternate. As regards the vegetation term, the prevailing fraction is annual and seasonal species, the others are perennial and ephemeroid plants. All green algae are divided into two phyla, Chlorophyta and Charophyta and a few exceptions the former are marine plants. Compared with red and brown algae the knowledge of green algae is more comprehensive, however their classification poses greatest difficulty with relation to the taxonomy.

The majority of about 20000 green algae are freshwater plants, and many are terrestrial or soil species. Green algae are found in a strikingly broad range of environments: on ice, soil, trees, rocks and in hot springs. Others are symbiotic with fungi, lichens and animals. Marine Chlorophyta are represented by more than 2000 species which grow from the waters edge to 200-m in depth and it is depth that determines their pigment composition. Most of them are euryhaline and occur where salinity is from 5 to 35‰, in polluted and pure localities, on different bottom grounds and on artificial constructions. Green algae are used in coastal ecosystem monitoring as indicators of the pollution with waste effluent and other pollutants. Though most of green algae have attached forms, some may form free-floating aggregations, especially in sheltered sites of shallow bays and gulfs.

The communities of Chlorophyta, in particular, *Ulva* spp., are widely distributed along the coast of the Black Sea, and are especially rich in the localities receiving municipal and industrial sewage. During abnormally warm seasons the effluent stimulates outbreaks and the algal community expands to atypical habitats and depths, thus endangering growth of other seaweeds, feeding and migration of fish shoals.

These marine plants contain biologically active substances, natural antibiotics, vitamins and enzymes of pharmaceutical value; algal carotene has proved to be very effective in preventing some cancers, including lung cancer. In South-Eastern Asia green algae are popular food.

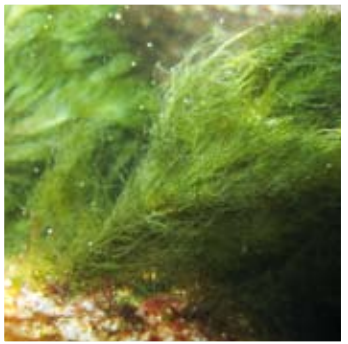
Bryopsis hypnoides J.V. Lamouroux

Synonym: *Bryopsis monoica* Funk

Morphology Thallus bushy, spheroidal, heteromorphic, richly branched, light- to dark-green, single celled, tubular; branched filaments 3–10 cm high arising from prostrate rhizoidal branch system; primary axis long and thin, less than 1 mm in diam.; axes and main branches arranged spirally or irregularly; in upper branches basal parts are even, constrictions absent; lower branches conspicuously constrictions; branches tapered apically, an order of magnitude narrower than the primary axis.

Ecology/habitat On stones, shells, sand-covered rocks, in well-illuminated sheltered areas; 0.5–10 m deep; epilithic and epiphytic; annual, peak of vegetation in spring; common for the Black Sea.

Commercial & possible use Plants of *Bryopsis hypnoides* are potential source for antibacterial, antiviral, antifungal, antiprotozoal drugs; extract has antifertility, hypoglycemic and diuretic properties and favors cardiovascular and nervous activity.



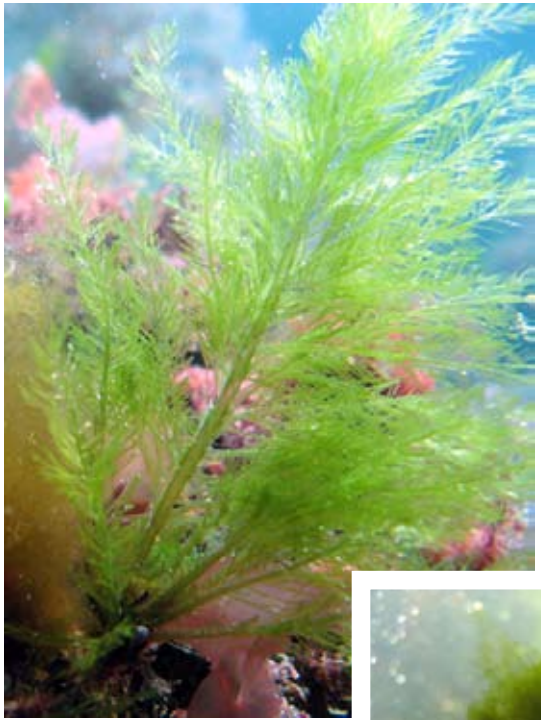
Bryopsis plumosa (Hudson) C. Agardh

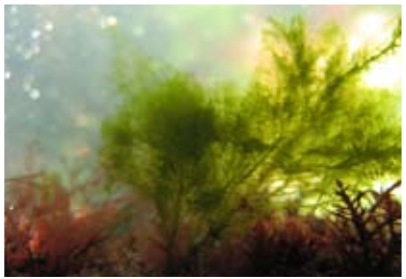
Synonym: *Bryopsis arbuscula* Lamour.

Morphology Thallus bushy, heteromorphic, richly branched, light- to dark-green, single cell, tubular, erect fronds of; branched filaments 2–15 cm long; primary axis and main branches to 1.5 mm in diam.; lower part of axis bare, upper part pinnately branched with constrictions at base; branches may have thin filamentous (less 1 mm in diam.), pinnate branchlets with constrictions at base; length of branches decreases towards the apices making thallus pyramid-shaped; apical cells rounded at tip.

Ecology/habitat On rocks, stones and shells; 0.5–15 m deep; most common in polluted seawater; epilihtic and epiphytic; seasonal, more abundant in March–April; common for the Black Sea.

Commercial & possible use The plants of *Bryopsis plumosa* are potential source for antibacterial, antiviral, antifungal, antiprotozoal drugs and lectin. The extract has antifertility, hypoglycemic and diuretic properties and favors cardiovascular and nervous activity.





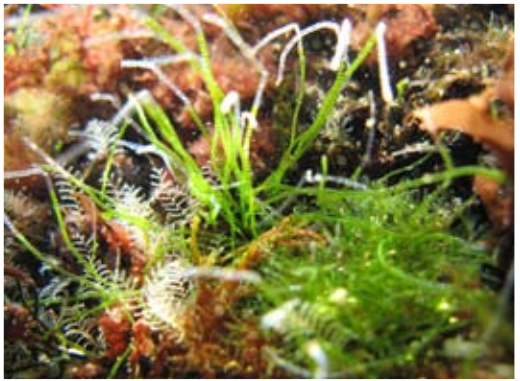
Chaetomorpha aerea (Dillwyn) Kützing

Synonym: *Conferva aërea* Dillw.

Morphology Filaments 10–15(25) cm long, forming turfs, glossy green or yellow-green; attached by basal holdfast, basal cells more than 0.8 mm long; filaments straight, cylindrical, 0.1–0.3 mm in diam.

Ecology/habitat On rocks, stones, shells, artificial substrata, ships; to 20 m deep, epilithic and epiphytic; annual, peak of vegetation in spring and summer; generally in the Black Sea.

Commercial & possible use The plants of *Chaetomorpha aerea* are a source of lectin, a specific protein important for regulation of immunity system and cancer diagnosis.



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

Synonyms: *Chaetomorpha chlorotica* (Mont.) Kütz.; *Chaetomorpha crassa* (C. Ag.) Kütz.

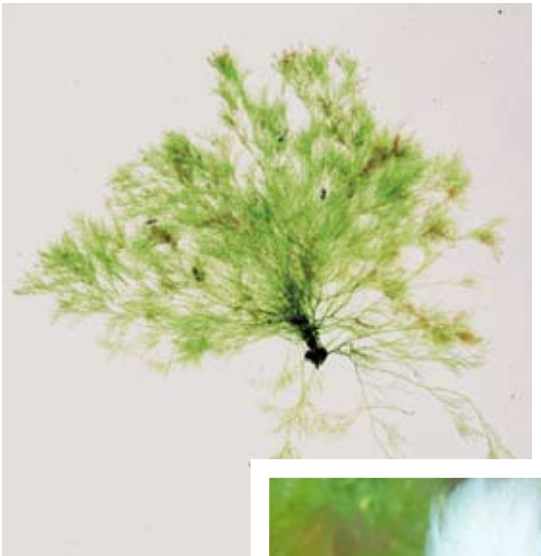
Morphology Filaments basally attached or free-floating, transparent yellow or dark green, lighter green towards distal end, tangled, flabby, twisted and curved, up to 50 cm long; texture firm, matted; cells cylindrical or slightly inflated, consistently 0.2–0.7 mm in diam. exception cells immediately above the basal cell, which are 1–2 times as long as wide; when attached, width increasing gradually from base to apex of filament.

Ecology/habitat On sand-mud bottoms, rocks and stones; to 5 m depth, among *Cystoseira* species, other macroalgae and seagrasses; annual, more abundant in spring and summer; common for the Black Sea.

Commercial & possible use The plants of *Chaetomorpha linum* have antipyretics and antiseptic properties; used in treatment of asthma and cough and as parts of traditional cosmetics (refreshing liquid, skin powder, pulp form for skin sunlight protection) in Pacific Islands.

*Cladophora albida (*Nees) Kützing

Synonym: *Conferva albida* Huds.

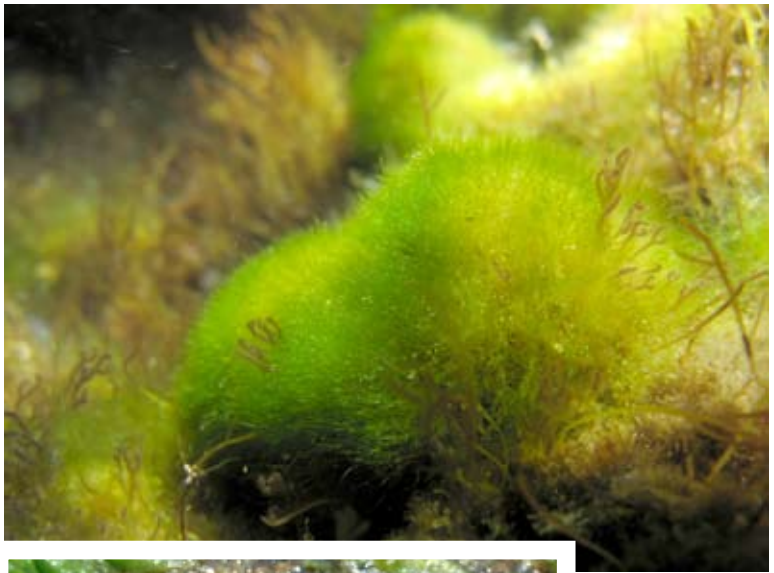


Morphology Thallus bushy, 5–50 cm long, whitish-yellow to bright olive green, richly branched; basal part give rise to rhizoids attached to substrate; consists of pseudo-dichotomously branched main axes with numerous branches of different length; branches unilateral, alternate or verticillate; ultimate branches pectinate, occasionally opposite, 2–3 branches in whorls; branches of large plants tufted, deep-intertwined, straight or slightly curved at apices, in younger plants usually crescent-shaped; apices blunt.

Ecology/habitat On overhanging rocks, stones, shells and sand; high intertidal to 20 m deep, often in sheltered locations and inlets with sandy and muddy bottom; tolerant to considerable fluctuations in salinity and temperature; epilithic, epiphytic or epizoic; annual, peak of vegetation in summer; generally distributed in the Black Sea.

Commercial & possible use Plants of *Cladophora albida* are source for medicine, contain antibiotic and antitumour BASs, PUFA and the natural antioxidant α-tocopherol.

Cladophora dalmatica Kützing



Morphology Thallus 5–10 cm high, forming green turfs or spongy globules, light- to dark-green; attached by rhizoidal holdfast; occasionally free-floating, to 50 cm long; main axis branching pseudo-dichotomous to alternate, unilateral, opposite or verticillate (up to 5–6 per axial cell); often falcate, pectinate, acropetal, unilaterally organized in thickset apical part where branches are strongly curve in all directions, usually sickle-like; apical cells cylindrical with blunt rounded ends.

Ecology/habitat Forming thick blanket on rocks, stones and shells at edge of intertidal zone, can form turfs with other low-growing algae, to 1 m deep; epilithic, free-floating and epiphytic; annual, peak of vegetation in spring and summer; recorded from the coastal zone of Ukraine, Russia and Romania.

Commercial & possible use Plants of *Cladophora dalmatica* may be used as the source of micro- and macroelements (e.g., potassium, magnesium, iron, zinc, manganese).

Cladophora laetevirens (Dillwyn) Kützing

Synonym: *Conferva laetevirens* Dillw.

Morphology Thallus 5–30 cm high, forming bushy tufts or spongy globules 2–4 cm in diam., light or bright green, well branched; attached to substrate with rhizoids growing from the basal part; composed of pseudo-dichotomously branched main axes with tufts of short branches at apices; branching alternate; outer branches arranged mainly one-side, sometimes verticillate, 1–4 branches in whorls; branches straight, usually crescent-shaped or bent in all directions; apical cells cylindrical with blunt rounded ends.

Ecology/habitat Found on stones, in crevices and small grooves of rocks in sheltered and exposed locations; 0.5–10 m deep; color changes from light to dark green lower down; epilithic, epiphytic or epizoic; annual, peak of vegetation in summer; widely distributed in the Black Sea, except Bulgarian coast.

Commercial & possible use Plants of *Cladophora laetevirens* are potential source of BASs for pharmaceuticals, contain PUFA.

Cladophora liniformis Kützing

Synonym: *Cladophora simplex* Schiff.

Morphology Thallus to 9 cm high, green, somewhat stiff, richly branched; attached to substrate with rhizoids growing from basal part; pseudo-dichotomous primary axes bear long branches, eventually 1–3 branches per axial cell; branches sometimes opposite, some axes and branches may have short branchlets positioned unilateral or alternate; apical cells cylindrical with rounded ends.

Ecology/habitat On shells or small stones, in sheltered areas, estuaries and lagoons, 0.5–5 m deep; often prostrate on mud or sand; epilithic or free-floating among macroalgae and seagrasses; annual, peak of vegetation in spring; recorded from shelthered locations of the Ukrainian, Russian and Romanian coast.

Commercial & possible use Plants of *Cladophora liniformis* are potential source of BASs for pharmaceuticals, contain PUFA.

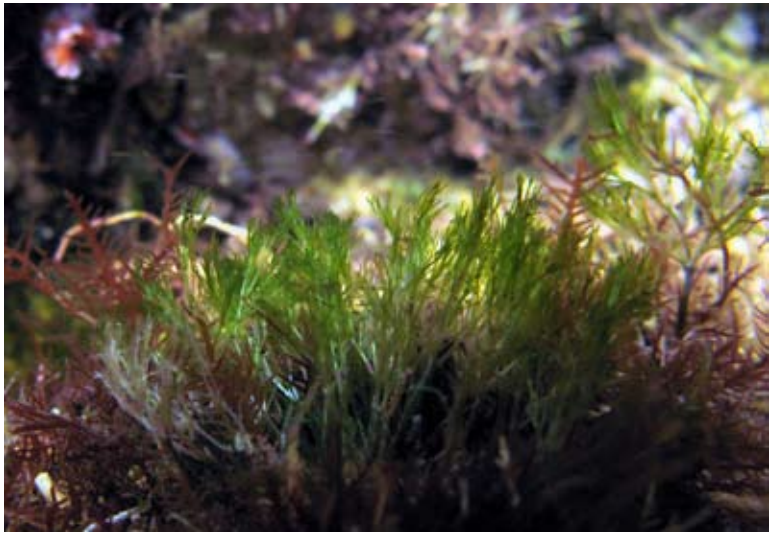
Cladophora sericea (Hudson) Kützing.

Morphology Thallus 5–50 cm high, pale- to dark-green, glossy, bushy, richly branched; attached to substrate with rhizoids; pseudo-dichotomous main axes bear many branches of various length; branching unilateral, alternate or verticillate, with 3–4 branches in whorl; branches straight or curved; terminal young branches usually considerably narrowed at apices, looking acanthaceous; apical cells and young branches distinctly tapered.

Ecology/habitat On rocks and stones, close to shore, to 3 m deep; epilithic and epiphytic, often on *Cystoseira* spp.; annual species, peak of vegetation in summer; common for the Black Sea.

Commercial & possible use Plants of *Cladophora sericea* are potential source of BASs for pharmaceuticals, contain PUFA.

Cladophora vagabunda (Linnaeus) Hoek



Morphology Thallus to 50 cm high, green, bushy, attached by rhizoidal holdfast or free-floating; primary axes pseudodichotomously branched with thick tufts of heavily ramose young branches at ends; arrangement of long branches is diverse – alternate, unilateral, opposite and verticillate, up to 5 branches eventually formed on axial cells; branches often conspicuously deflected; outer mainly one-side ramose, straight or bent to one-side; vegetative apices often slightly tapered, becoming rounded during reproduction.

Ecology/habitat On stones, rocks and in clefts, 0.5–5 m deep; in shallow seawater and brackish lagoons; annual species, peak of vegetation in summer; common for the Black Sea, except Turkish coast.

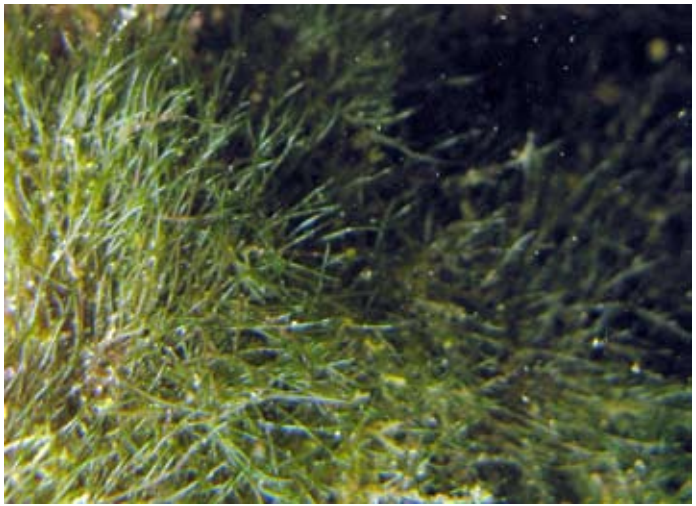
Commercial & possible use Plants of *Cladophora vagabunda* are the source of valuable protein; used in pharmaceutical medicines; 5% aquatic extract improves blood formula under adaptation to stress.

Cladophoropsis membranaceae
(Hofman Bang ex C. Agardh) Børgesen

Morphology Thallus forming bottle-green cushion-like clumps, 3–5 cm high, attached to prostrate segmented filaments or free-floating; filaments erect, 0.1–0.3 mm in diam., each with apical surculus; richly branched, branches usually unilateral, consisting of very long cells.

Ecology/habitat On stones or rocks, 1–15 m deep, epilithic, rare epiphytic; seasonal, peak of vegetation in spring and summer; common for the Ukrainian and Russia coast.

Commercial & possible use Plants of *Cladophoropsis membranaceae* have antibacterial, antiviral and antibiotic activity.



Codium vermilara (Olivi) Chiaje

Morphology Thallus 20–40 cm long, 0.3–0.8 cm thick, deep-green, large and porous, attached with basal disc-like holdfast giving rise to several erect thalli; regularly or irregularly branched, sometimes proliferous, terete with short terminal segments; utricles obovate to oblong, square ended, with appreciable apical thickening; morphologically diverse: prostrate or erect, cylindrical or flat, cushion-like or globular; branches cylindrical, gradually tapering to apices; basal part incrassate; apical branches relatively thin, the apices blunt.

Ecology/habitat On stones, rocks or shells; 5–25 m deep, in clear localities; perennial, peak of vegetation in summer; recorded from sublittoral zone of Ukrainian, Russian and Turkish coast.

Commercial & possible use Plants of *Codium vermilara* are the source of BASs, valuable polysaccharides, PUFAs and cytostatic drugs for medicine; a traditional food in Japan and other Asian countries.

Ulva clathrata (Roth) C. Agardh

Synonym: *Enteromorpha clathrata* (Roth) Grev.

Morphology Thalli forming tufts up to 15 cm long; light apple-green to dark green, usually repeatedly branched, tube-like, cylindrical; main axis distinct, diameter of thallus increasing from base to apex up to 2 cm or more; form and number of branches vary; morphological forms are related to environmental conditions.

Ecology/habitat On rocks, stones or shells, 0.5–5 m deep, in exposed and sheltered localities, epilithic and epiphytic; annual, peak of vegetation in spring and summer; common for the Black Sea.

Commercial & possible use The extract of *Ulva clathrata* has antifertility, hypoglycemic and diuretic properties and favors cardiovascular and nervous activity; antibacterial, antiviral, antifungial and antiprotozoal activity are known also.

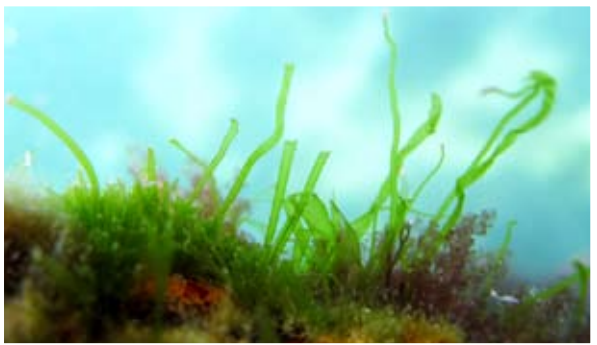
Ulva flexuosa Wulfen

Synonym: *Enteromorpha flexuosa* (Wulf.) J. Ag.

Morphology Thallus slender, to 60 cm long, green, branched, often expanded, occasionally saccate, tube-like, cylindrical, soft, delicate and brittle; primary axis usually distinct, about 2 cm in diam., branches opposite or alternative, often proliferous, either not expanded or markedly expanded apically; occasionally main axis without branches.

Ecology/habitat On stones or artificial substrata; mostly close to shore, 0.5–3 m deep, in clear and polluted seawater; epilithic and epiphytic; annual, peak of vegetation in spring; common for the Black Sea.

Commercial & possible use Plants of *Ulva flexuosa* are a source of BASs with antibacterial, antivirus and fungicide activity; used in cosmetics.



Ulva intestinalis Linnaeus

Synonym: *Enteromorpha intestinalis* (L.) Nees

Morphology Thallus tubular or compressed to nearly laminated, light- to dark-green, 5–30 cm long, to 3 cm or more broad; increasing in width from base to mid-thallus, wedge-shaped base; unbranched or branched; lower part may have constrictions and small prolifications on main axis; surface rough, often inflated; edges either smooth or sinuous to nearly-curled; upper part often torn; thallus looks parcel-like.

Ecology/habitat On stones, rocks, shells or artificial substrata, to 15 m deep, in brackish and seawater; plants often form green border on shoals; in deep-sea locations usually epiphytic, sometimes free-floating; euryhaline, tolerant to municipal sewage; annual species, peak of vegetation in summer; widely distributed in the Black Sea.

Commercial & possible use Plants of *Ulva intestinalis* are the source of essential amino acids, vitamins B (mainly B_{12}), C and F, pantothenic, folic and nicotinic acids, mineral salts, nitrogen and proteins; gibberellins, PUFAs; 5% aqueous extract is an adaptogenic and hepatoprotective means; fertilizer and fodder additive in agriculture; used as food supplement or herbal medicine.

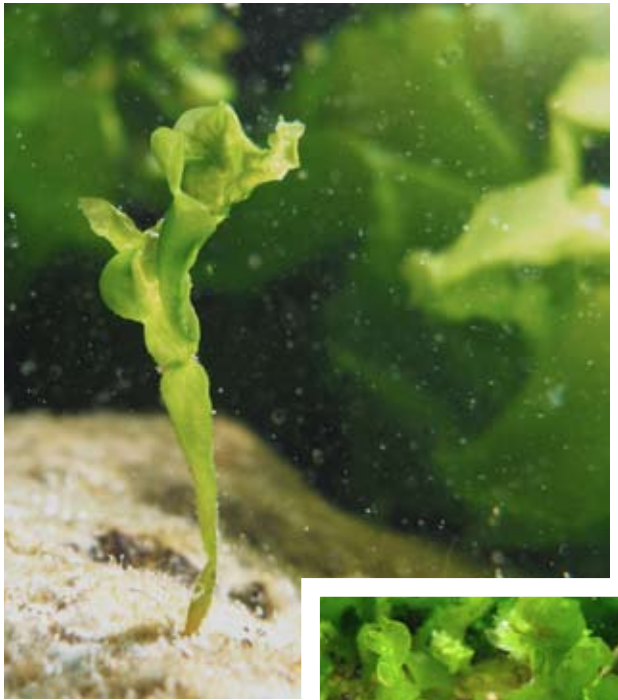
Ulva linza Linnaeus

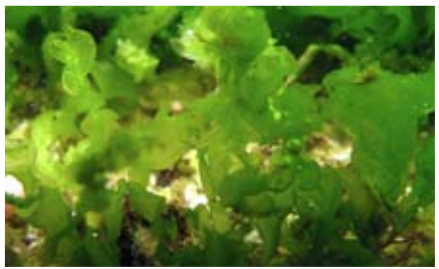
Synonym: *Enteromorpha linza* (L.) J. Ag.

Morphology Thalli laminose or ribbon-like, flat, smooth, light- or dark-green, 5–25 cm or more long, up to 5 cm or more wide; usually not branched, occasionally proliferous (mainly on the main axes); margins even, sinuous or curled; stems and margins of blade with cavities, blade may balloon throughout thallus which is appreciably broader in mid-parts than in base.

Ecology/habitat On stones and rocks, 1–5 m deep; mainly in polluted seawater, often forming patches or extensive carpets near seashore; epilithic and epiphytic; annual, peak of vegetation in summer; widely distributed in the Black Sea.

Commercial & possible use Plants of *Ulva linza* are used as a source of cytostatic and antioxidative substances and as a food additive.





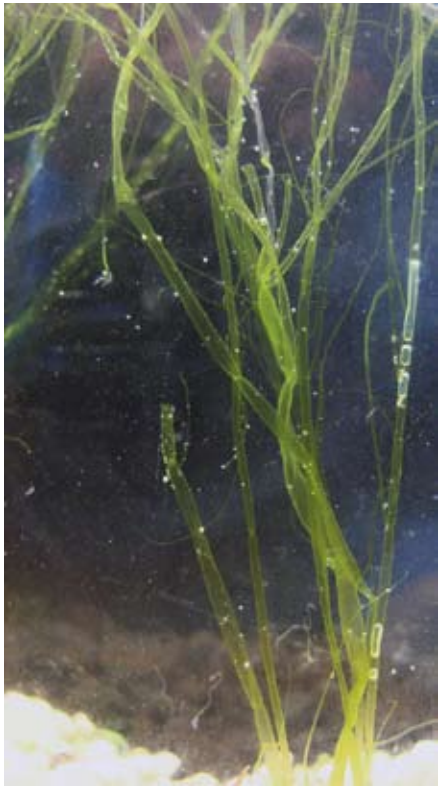
Ulva prolifera O.F. Müller

Synonym: *Enteromorpha prolifera* (O.F. Müller) J. Ag.

Morphology Thallus tubular, compressed, to 50 cm long, 1–20 cm broad, light-green; usually branched, often proliferous; main axis distinct, narrower at base; branches sometimes tapering at base and apex, may considerably broaden apically; prolifications usually long, thin, near-equal in width throughout full length.

Ecology/habitat On stones, rocks and shells, 0.5–5 m deep, most common along the waters edge; in desalinated and polluted seawater; epilithic and epiphytic; annual species, peak of vegetation in spring; common for the Black Sea.

Commercial & possible use Plants of *Ulva prolifera* are used as a source of polysaccharides with antitumor activity; basic food item in Japan, Indonesia and Korea; in some countries used as an herbal medicine, in various forms of cosmetics (shampoo, refreshing liquid and lotion).



Ulva rigida C. Agardh

Synonym: *Ulva lactuca* var. *rigida* (C. Ag.) Le Jolis

Morphology Thallus forms a flat lamina usually 5–15 cm, but can be up to 2 m long, bright-green, attached by rounded disclike holdfast, stiff in texture; coarse, rigid, oval to rounded, folded or lobate, with fluted margins and often deeply divided.

Ecology/habitat On rocks, stones or shells, to 25 m depth; epilithic on exposed shores and free-floating in harbours, sheltered bays and lagoons; tolerant to eutrophication, municipal wastes in particular; perennial, peak of vegetation in spring and summer, reproduction depends upon phases of the moon; widely distributed in the Black Sea.

Commercial & possible use Plants of *Ulva rigida* are source of nitrate, sulphate, antimicrobial and antivirus BASs, vitamins, gibberellins; contain cytostatic substances; plants are used in the treatment for boils, dropsy, urinary diseases and nose-bleeds; forage additive in mollusk aquaculture; a promising source of biogas; post-fermentation waste products are used as fertilizer, also raw material for cosmetics (refreshing liquid, shampoo, lotion and skin powder); in some countries used as food and in pulp-paper industries.

Padina pavonica and *Dictyota fasciola*

Brown Algae

(HETEROKONTOPHYTA)

The special color of brown algae is from fucoxanthin, the prevailing xanthophyll pigment, and it varies from pale beige to yellow-brown and almost black. The shape of thalli also varies broadly from filamentous to large heavily branched; unicellular or unknown colonial species. In many species plants have a thallus which, like higher plants, has a stem, leaf-like lamella, rhizoids or roots, or even the cork and the medulla. The plants grow 50–70 m long. Reproduction can be sexual, asexual and vegetative, often by vegetative buds. Haploid and diploid generations alternate in the life history. The majority of brown algae are perennial, but they can also be annual or ephemeroid.

With a few exceptions, brown algae are marine plants; about 1800 species have been identified in the World Ocean. The Sargasso Sea harbours the largest known aggregation of brown algae. Brown algae are widespread in cold temperate seas, where their abundance, biomass and productivity are greatest. The plants are usually attached to substrate or epiphytes, the free-floating unattached forms are rare. The depth of occurrence varies in a very broad range; some species may be found growing from the water edge to 100-m depth and deeper.

The brown algae *Cystoseira* spp. is the keystone of the entire coastal ecosystem of the Black Sea. Their communities are widely distributed along the northern, southern and eastern shores of the Black Sea and give shelter to a diversity of life – more than 200 species of algae, invertebrates and fish.

In Asia these algae are popular food. The total global wholesale value of dried brown algae collected in the ocean or cultivated is very high, but the cultivated plants are too expensive as raw material. Commercial interest

Cladostephus spongiosus

(Hudson) C. Agardh
Synonym: *Cladostephus verticillatus* (Lightf.) Lyngb.

Morphology Thallus bushy, filamentous, 7–20 cm high, deep-brown or umber, holdfasts discoid up to 3 cm in diam.; filaments coarse, polysiphonous, branching usually regularly dichotomous; branchlets arranged in whorls throughout thallus except near base; small branches simple, occasionally with solitary branchlets arranged unilaterally.

Ecology/habitat On stones, shells or rocks, to 25 m deep, in clear and turbulent localities; epilithic, rarely epiphytic; perennial, peak of vegetation in summer, reproduction from January through April; common for the Black Sea, except Romanian coast.

Commercial & possible use Plants of *Cladostephus verticillatus* contain antimicrobial and fungicial BASs, source of lectins.

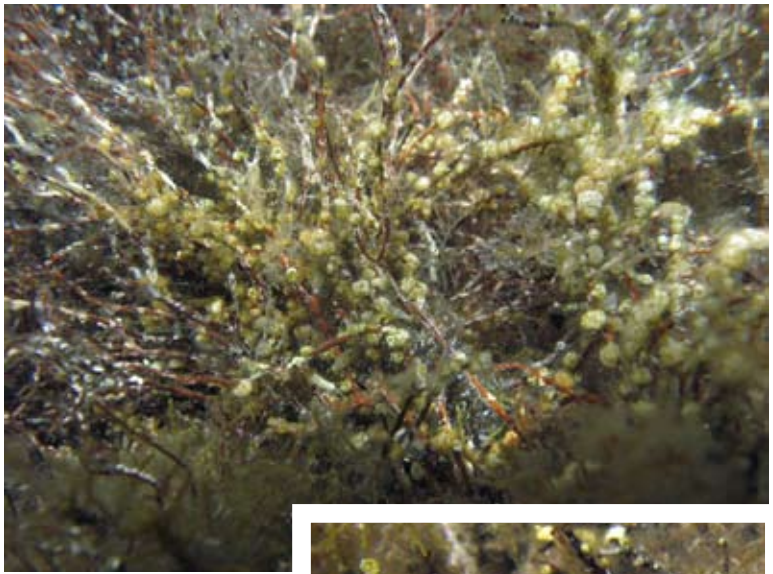
Corynophlaea umbellata
(C. Agardh) Kützing

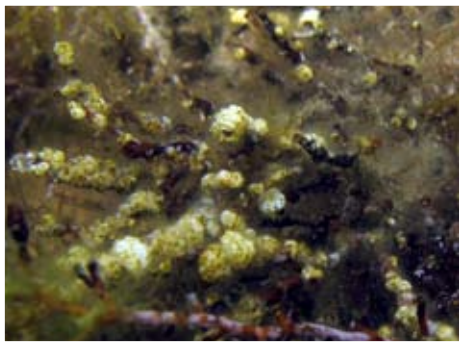
Synonym: *Leathesia umbellata* (C. Ag.) Endl.

Morphology Thallus in cushion-like clumps, 1–2.5 mm in diam., olive-brownish in young plants and yellowish with age; individual thalli often interfuse into a longer clump, sometimes more than 3 cm long.

Ecology/habitat Epiphyte, mainly on *Cystoseira* spp., 0.5–15 m deep; seasonal, peak of vegetation and reproduction from summer to autumn, generally in the Black Sea.

Commercial & possible use Unknown.





Cystoseira barbata (Stackhouse) C. Agardh

Morphology

Thallus large, bushy, richly branched, dark-brown to light-olive, 20–170 cm long, 4–12 mm wide, holdfast conical, unattached form is also known; stem very rough, bearing main and additional branches; main branches 10–40 cm long, cylindrical, arranged alternately or quasi-irregularly; branchlets often form panicles close to apices of main branches; additional branches 5–10 cm long; air vesicles present on branches during winter and spring, oblong, 7–15 mm long, 2–5 mm wide, solitary or moniliform, 2–10 per branch; receptacles develop on apices of branches, 2–20 mm long, 1–3 mm wide, oval or lanceolate, spinules absent, surface smooth and slightly sinuous; apices with a sterile spike; unattached plants prostrate, thin, 20–80 cm long; branches very thin and long, with sparse lateral branchlets; receptacles nearly always absent; air vesicles reduced.

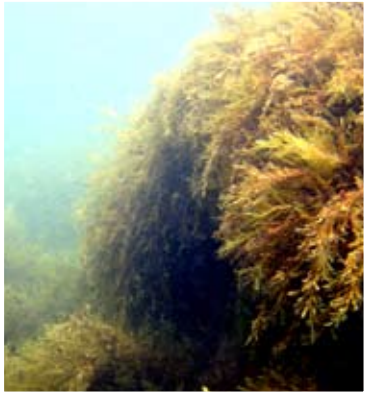
Ecology/habitat

On stones, rocks, or large shells, 0.5–20 m deep; in sheltered and semi-closed areas, rare in wave activity zones, epilithic; largest alga in the Black Sea; perennial, peak of vegetation in May–June, reproduction in April–May; during warm springs reproduction begins earlier and is of shorter duration; unattached plants have reproduction by thallus fragmentation; generally in the Black Sea, rare along Romanian coast; key species of the Black Sea coastal ecosystem.

Commercial & possible use

Plants of *Cystoseira barbata* are a source of alginic acid salts, iodine-containing amino acids, PUFA, antimicrobial, antimitotic, antiviral, antibacterial and antitumor BASs; micro- and macroelements (e.g., iodine, bromine, potassium, calcium, magnesium, chlorine, sulfur, selenium); used as a food additive in medical treatment of oncological patients in Ukraine; a component in fragrance industry and cosmetology, also as a fodder for domestic animals and farmed fish, prawns and crabs.

Cystoseira barbata



Cystoseira crinita

Cystoseira crinita Duby

Synonym: *Cystoseira barbata* var. *flaccida* (Kütz.) Woron.; *Cystoseira bosphorica* Sauv.

Morphology Thallus large, bushy, 10–120 cm high, dark-brown; holdfast giving rise to as many as 20 shoots; richly branched; stem 5–80 cm long; 2–4 mm wide, resilient, flexible and smooth; main branches 6–18 cm long; additional branches few, 3–10 cm long; air vesicles large, 5–8 mm long, 4–5 mm width, triangular, inflated, solitary; receptacles forms on surface of air vesicles, cylindrical, abortive process absent; apices blunt.

Ecology/habitat On stones or rocks, 0.5–10 m deep, rarely to 30 m deep; common on open-shores with wave activity, epilithic, occasionally epiphytic; perennial, peak of vegetation in May–June, reproduction in April–May; widely distributed in the Black Sea, rare along Romanian coast; key species of the coastal ecosystem.

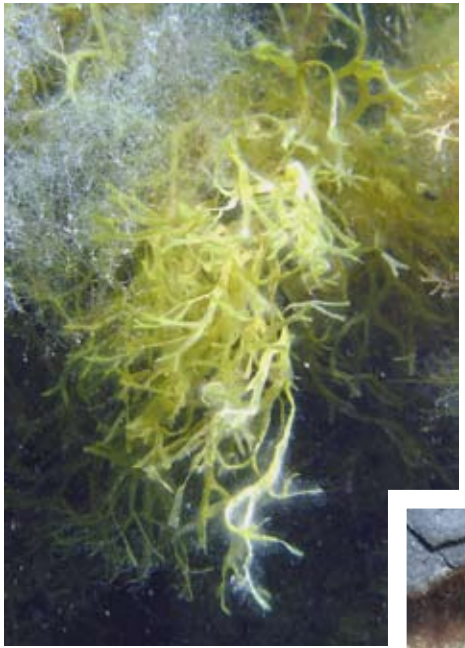
Commercial & possible use Plants of *Cystoseira crinita* are a source of alginic acid salts, PUFA, BASs with antimicrobial, antimitotic, antiviral, antibacterial and antitumor activity; as well as micro- and macroelements (e.g., iodine, bromine, potassium, calcium, magnesium, chlorine, sulfur, selenium); used as a food additive in medical treatment of oncological patients in Ukraine; a fodder for domestic animals and for farmed fish, prawn and crabs; also used in fragrance industry and cosmetology.

Dictyota dichotoma (Huds.) Lamour.

Morphology Thallus bushy, leather-like, light to dark brown, often forming small mats attached by rhizoids; blades strap-shaped, 10–20 cm long, 2 – 8 mm wide; branching dichotomous, branches with smooth margins, numerous segments, arranged near-parallel or slightly distant to each other; apex rounded or bifurcated; old thalli often sprout along the edges.

Ecology/habitat On stones, rocks, or shell rocks, 0.5–15 m deep, rare epiphytic; seasonal, peak of vegetation and reproduction from May through September; recorded from the Black Sea, except Romanian coast.

Commercial & possible use Plants of *Dictyota dichotoma* are the source of sulfophenols and BASs antitumor and antibiotic activity; use in food in Asian countries; in treatments for goiter and scrofula; a preventive medicine for heart disease and stroke.



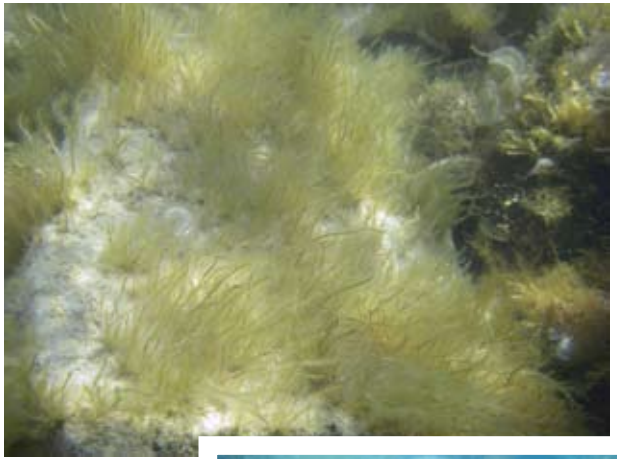
Dictyota fasciola (Roth) J.V. Lamouroux

Synonym: *Dilophus fasciola* (Roth) Howe; *Dilophus repens* (J. Ag.) J. Ag.

Morphology Thallus coarse, leathery, 2–15 cm high, brown-reddish, forming small turfs, attached by thin ramified stolons; branched dichotomously; near-linear segments 1–5 mm wide; apical segments even, acuminate, rarely curved, set at relatively large intervals from each other; sometimes thin branches appear on the thallus.

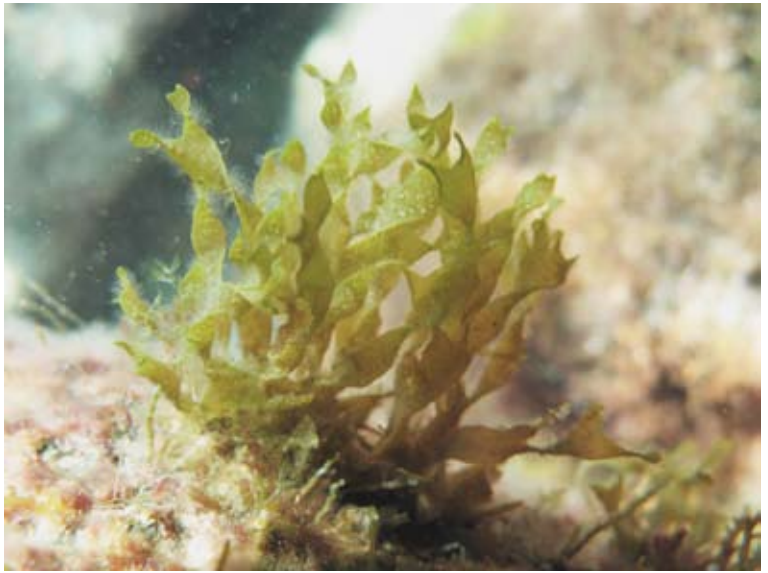
Ecology/habitat On stones, rocks, mollusk shells, to 15 m deep, in unpolluted areas with high wave activity; epilithic and epiphytic; seasonal, peak of vegetation and reproduction from late summer to autumn; common for the Black Sea, except Romanian coast.

Commercial & possible use The extract of *Dilophus fasciola* inhibits the growth of several fungi.



Dictyota spiralis Montagne

Synonym: *Dilophus spiralis* (Mont.) Hamel



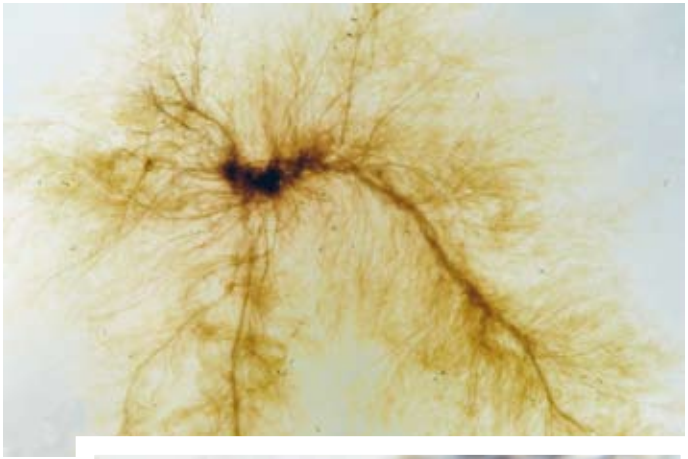
Morphology Thallus leathery, 5–15 cm high, reddish-brown, attached by decumbent stolons; branching dichotomous, often irregular; some segments cease to ramify, others grow closely by 3–4 in tuft; segments near-linear, slightly wider at nodes, basal parts often narrowed; apices broad and blunt.

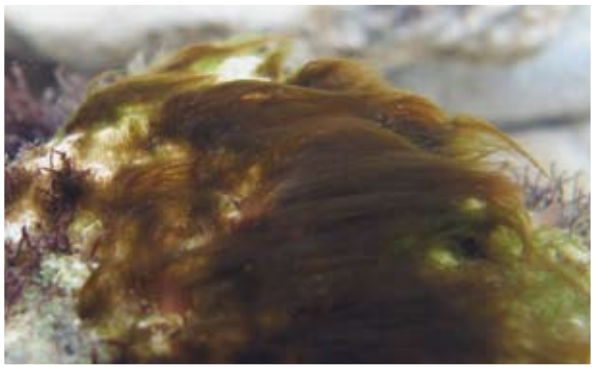
Ecology/habitat On stones or rocks, close to the water edge, to 10 m deep, in unpolluted areas with high wave activity; epilihtic and epiphytic; seasonal, population peak from August to September; common for the Black Sea, except Romanian coast.

Commercial & possible use The extract of *Dictyota spiralis* has antibacterial, antiviral and cytotoxic properties.

Ectocarpus siliculosus (Dillwyn) Lyngbye

Synonym: *Ectocarpus confervoides* Le Jolis





Morphology Thallus forming matted turfs or filamentous tufts 2–10 cm high, goldish-brown, straw-brownish or greenish, attached by rhizoids; filaments in the basal part strongly twisted, upper ends loose or gathered in small bunches; branching dichotomous, unilateral or alternate; branches mainly long, gradually narrowed to apex, often terminating in colourless hairs.

Ecology/habitat On stones, rocks, shells, or rubbles, artificial substrata, to 30 m deep; epilihtic and epiphytic; seasonal, peak of vegetation and reproduction from February through April; recorded from coastal localities.

Commercial & possible use The extract of *Ectocarpus siliculosus* has antitumor activity.

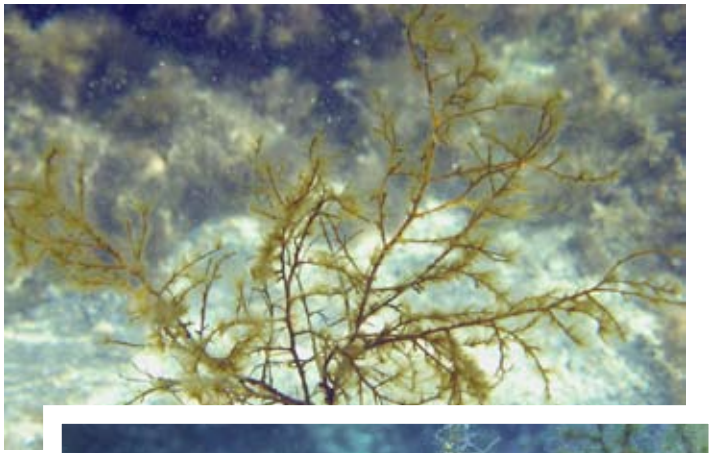
Nereia filiformis (J. Agardh) Zanardini

Synonym: *Desmarestia filiformis* J. Ag.

Morphology Thallus bushy, 8–25 cm high, 1–2 mm thick, olive-yellow, attached by holdfast; richly branched, mainly irregularly, alternately or nearly plumose; branches protruded, with small branchlets bearing thick tufts of coloured filaments, 3–15 mm long; old plants often have either few or no hairs.

Ecology/habitat On stones, rocks, or shell rocks, artificial substrata, 3–20 m deep; epilithic; perennial, peak of vegetation in May–September; common for the sublittoral zone of the Black Sea, except Romanian coast.

Commercial & possible use Extract of *Nereia filiformis* has antibacterial and antifungial activity.



Padina pavonica

(Linnaeus) Thivy in W.R. Taylor

Synonym: *Dictyota pavonia* (L.) Lamour.

Morphology Thallus as yellow-white fan-shaped plate, either smooth or, more typically, resembling cone-shaped paper bag, calcified, to 15 cm high; holdfast relatively thick with filamentous rhizoids; stalk thin, nearly flat smoothly transitioning to blade; blade one-piece or divided to small lobes; concentric zones of the blade surface formed by rows of microscopic hairs.

Ecology/habitat On stones, rocks, or shells, 0.5–5 m deep, mainly in unpolluted localities under high wave activity; occasionally close to water edge; epilithic, rarely epiphytic; seasonal, peak of vegetation and reproduction from July trough August; widely distributed in the Black Sea.

Commercial & possible use Plants of *Padina pavonica* are the source of vitamins B (thiamine, riboflavin, nicotinamide), proteins and antitumor BASs; extract has antioxidant and inflammatory activity, dermatological effect.

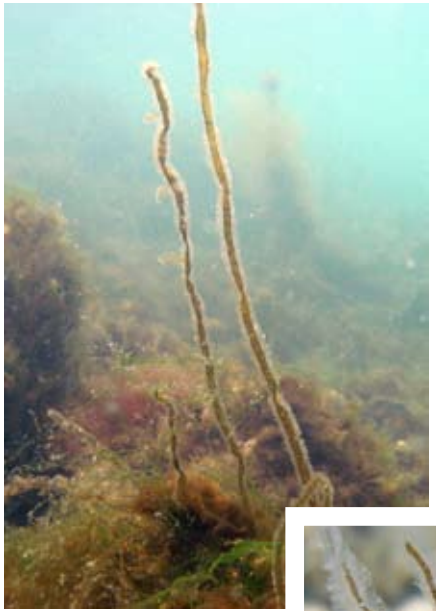
Scytosiphon lomentaria (Lyngbye) Link

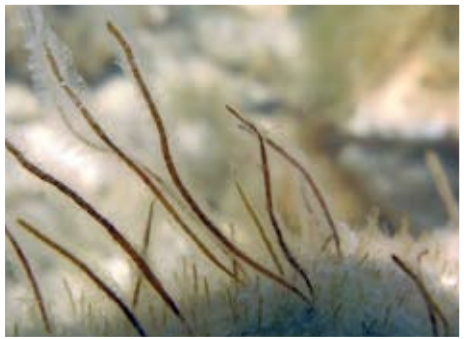
Synonym: *Scytosiphon simplicissimus* (Clemente) Cremades

Morphology Thallus tubular, 7–30 cm long, 1–2 mm thick, olive-brown, in air rust-coloured, constricted or spirally twisted.

Ecology/habitat On stones or rock, from edge of water to 1 m deep; epilithic and occasionally epiphytic on *Cystoseira* spp., in this case down to 10 m deep; seasonal, peak of vegetation and reproduction from February through March; common for the Black Sea.

Commercial & possible use The extract of *Scytosiphon lomentaria* has antioxidant, fungicidal and antitumor properties; plants are traditional food in Japan.





Spermatochnus paradoxus (Roth) Kützing

Synonym: *Stilophora paradoxa* (Roth) Aresch.

Morphology Thallus tube-like, to 25 cm high, straw-greenish; richly or sparsely branched; branches long, whip-like, sparse, narrowing toward apices; filaments near basal part with small branches, coating apical surface throughout.

Ecology/habitat On stones and shells, 1–20 m deep, epilithic and epiphytic; seasonal, peak of vegetation and reproduction from June through September; in sheltered locations of the coastal zones of Ukraine, Russia and Turkey.

Commercial & possible use Plants of *Spermatochnus paradoxus* are the source of fatty acid for bio fuel and biodiesel, other valuable chemicals.

Sphacelaria cirrosa (Roth) C. Agardh

Morphology Thallus filamentous, forming small tufts 1–3 cm high, olive-reddish-brown; holdfasts small, discoid, rarely with rhizoids; main axis and side branches very similar; branching alternate, opposite, small branchlets may diverge from main branches at sharp angle; richly branching from basal to apex; lower branches more or less divergent, tapering towards apices.

Ecology/habitat On stones or shells; to 30 m depth; epilithic, mainly epiphytic; perennial species, peak of vegetation in summer, reproduction from July through December; widely distributed in the Black Sea, except Romanian coast.

Commercial & possible use Plants of *Sphacelaria cirrosa* used in aquaculture as food for animals.

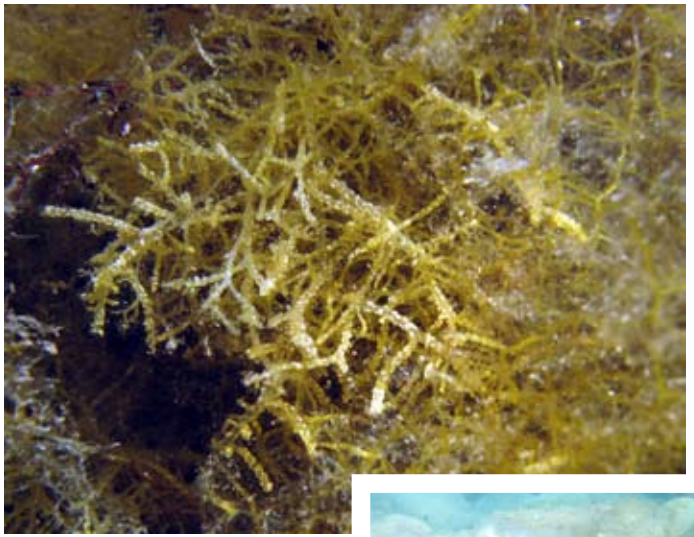
Stilophora tenella (Esper) P.C. Silva

Synonym: *Spermatochnus rhizodes* Kütz., *Stilophora rhizodes* (C. Ag.) J. Ag.

Morphology Thallus tube-like, 10–60 cm high, fawn-colour; richly branched, branching irregular or dichotomous; lesser branches solid, to 1 mm thick, tapered toward apex; branchlets nearly filamentous or top-shaped at apices.

Ecology/habitat On rocks, stones, or shell rock, 1–25 m deep; epilithic and epiphytic; seasonal, peak of vegetation and reproduction from May through September; common for the Black Sea, except Romanian coast.

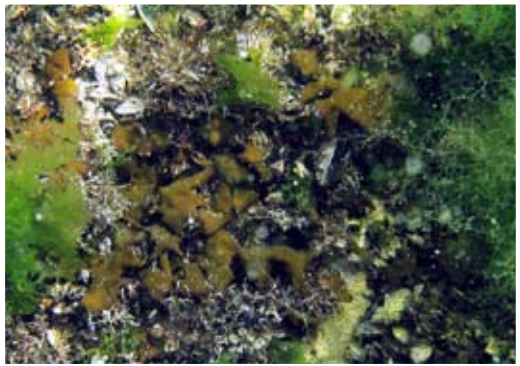
Commercial & possible use Extract of *Stilophora tenella* is used in treatment of scrofula.



Zanardinia typus

(Nardo) P.C. Silva in W. Greuter

Synonym: *Zanardinia prototypus* (Nardo) Nardo



Morphology Thallus corticated, subglobose, to 10 cm in diam., with marginal filaments; young plants olive-brown, their width lesser; thallus became black-brown, leathery with age; edges lobate, often broken; upper side of thalli smooth, under side with thick layers of rhizoids.

Ecology/habitat On stones, rocks, or shells, 0.5–20 m deep; epilithic, occasionally epiphytic; perennial, peak of vegetation in summer and autumn, reproduction from October through February; generally in the Black Sea, except Romanian coast.

Commercial & possible use Plants of *Zanardinia typus* are the sourse of phospholipids and sterols; the extract has antibacterial and antiviral activity.

Gelidium spinosum

Red Algae

(RHODOPHYTA)

The characteristic red color of these algae is due to the pigments phycoerythrin and phycocyanin coupled with chlorophyll a, beta-carotene and xanthophylls. Thalli of red algae are either single-celled or complex filamentous, their size varies from microns to meters, and their morphological structure is from corticated and calcareous (calcified) to bushy and composite articulated. The reproduction can be vegetative, sexual and asexual, and life cycles can be simple or rather complicated. An accepted viewpoint suggests that the intricacy of life cycles in red algae is the compensatory environmental adaptation that guarantees survival of the spores with two chromosome set. With regard to the duration of the life cycle two fractions are recognized, the larger includes annual and perennial species, and the minor ephemeroids. The classification of red algae remains obscure because of the complicated structure, life history and peculiar reproduction. By their origin red algae are very old, the oldest among the algal kingdom.

Generally, red algae are typical inhabitants of the sea, and grow as epilithic, epiphytic, endophytic and epizoic. Most of more than the 6,000 species which dwell in the World Ocean show preference to intertidal and subtidal zones; some found at the depths from 40 to 260 m and even deeper.

In the Black Sea red algae occupy a variety of habitats which differ in the environmental conditions and depths. A phenomenal community of red algae, the largest in the world and known as Zernov *Phyllophora* field, was discovered in 1908 in the north-western part of the sea. A century ago the unattached stock of *Phyllophora* was assessed at 11 million wet tons; by now it has reduced to almost 6,000 wet tons.

Some red algae are popular food in South-Eastern Asia; among cultivated seaweeds *Porphyra* is the most valued food. Being rich in commercially valuable polysaccharides, red algae are widely used in biotechnologies as the source of agar and carrageenan. *Gelidium* and *Gracilaria*, the two major producers of agar, are harvested mostly from the ocean, because their farming is uneconomic. The group of special significance is coralline algae which secrete calcium carbonate onto the surface of their cells and are applied in bone-replacement therapies. Plants of some species have been appreciated as the raw material for perfumery and cosmetic, while others are used in manufacturing fertilizers for agriculture.

Apoglossum ruscifolium (Turner) J. Agardh

Morphology Thallus densely tufted 2–6 cm tall, rose-pink to deep red; attachment holdfast consisting of branched prostrate axes; primary blades ovate to lanceolate, 0.5–2 cm in length, to 1 cm wide, with distinct middle rib and parallel, slightly brachiate lateral nerves, normally simple but occasionally dichotomous or alternately branched; margins even, smooth, or sinuous; lateral blades arising from the middle rib; texture membranous, young blades with short stalks, arrangement nearly pinnate.

Ecology/habitat On rocks, stones, in grottos, and other shaded sites, to 25 m deep, mainly in wave-exposed sites; epilithic, often epiphytic; perennial, peak of vegetation in spring and summer; generally distributed in the Black Sea, except Romanian coast.

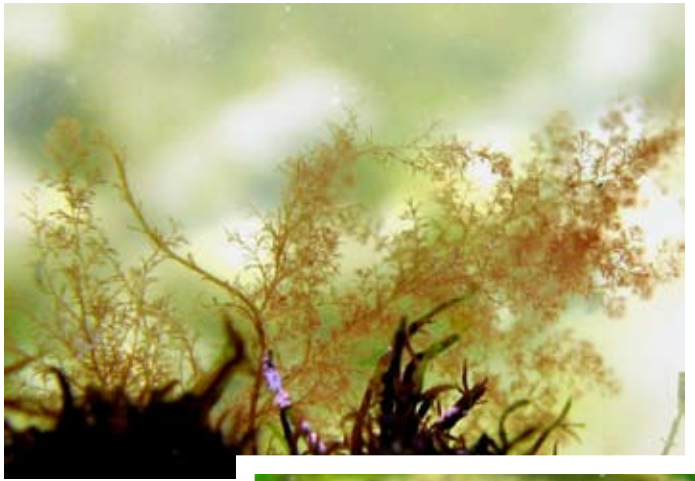
Commercial & possible use Plants of *Apoglossum ruscifolium* are the source of fatty acid for bio fuel and biodiesel.

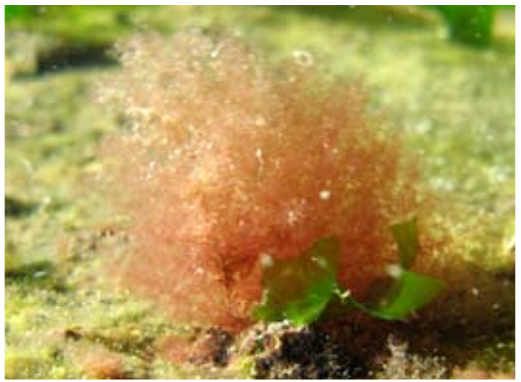
Callithamnion corymbosum
(J.E. Smith) Lyngbye

Morphology Thallus bushy, flaccid and delicate, pink to red, to 5 cm high, 0.3–0.5 mm thick; branches alternate at base, dichotomous in upper part; terminal branchlets thin, arranged spirally; each successive branching is crosswise to antecedent branch and consists of two cells of equal length; terminal cells of branchlets with two long colourless hairs easily falling away; corticaation absent or rare at base of thallus.

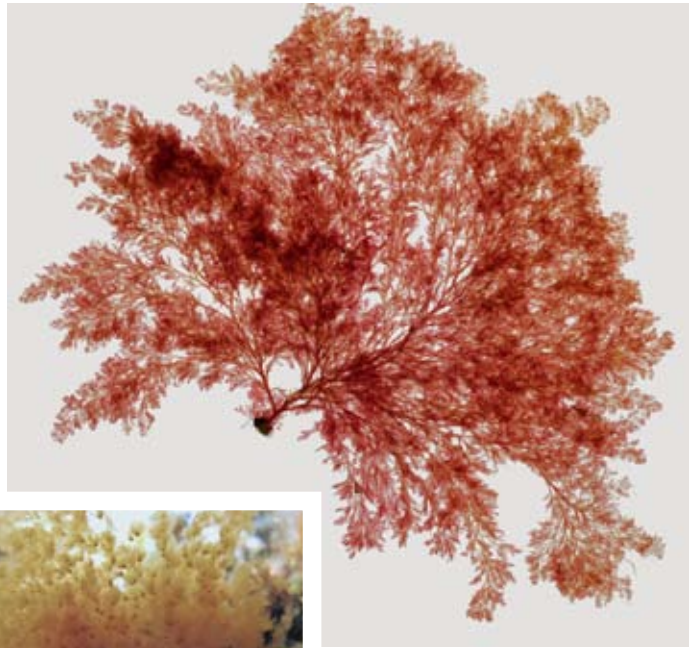
Ecology/habitat On stones, rocks, mollusc shells, artificial substrata, to 15 m deep; epilithic, often epiphytic; mainly in sheltered and polluted seawater; annual, peak of vegetation in summer; widely distributed in the Black Sea.

Commercial & possible use Plants *Callithamnion corymbosum* are the source of vitamins B (thiamine, riboflavin, nicotine amide) and lectins.





Callithamnion granulatum
(Ducluzeau) C. Agardh

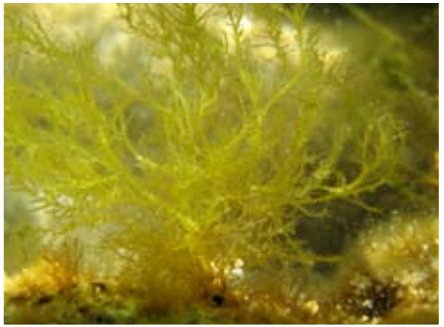


Morphology Thallus erect, bushy, delicate, of airy consistency, brownish-pink, axes 2–8 cm high, 0.2–0.6 mm thick, older plants becoming cartilaginous; main branches corticate, with short coarse-fiber regularly spirally alternately brachiated branchlets; lower branches long, alternately pinnate, with dichotomous branchlets brachiated at equal lenght and forming thick tufts at apices; each dichotomous branching is near-crosswise to antecedent branch and consists of 2 cells equal in length; terminal branches with conical apical cells and long terminal colourless hairs which are easily broken off.

Ecology/habitat On stones, rocks, artificial substrata, mainly close to the waters edge, rare to 5 m deep; in moderately to strong wave-exposed areas; epilithic, epiphytic and epizoic; annual, peak of vegetation in summer; common in the Black Sea.

Commercial & possible use The extract of *Callithamnion granulatum* has antibacterial, antiviral and cytotoxic activity.

Ceramium arborescens J. Agardh

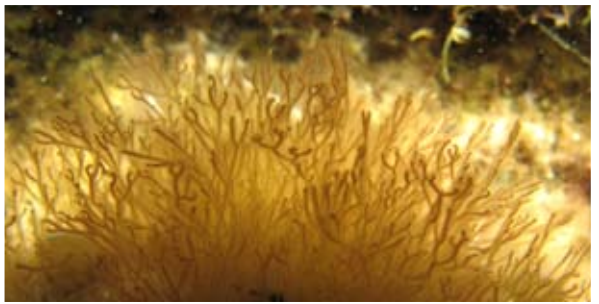


Morphology Thallus tufted, bushy, brownish-red, 8–15 cm high; main branches usually distinct, 0.4–0.8 mm diam.; branching dichotomous, bearing forked tufts of thick accessory branchlets to 0.2 mm diam. on every side; segments strangulated, barrel-shaped, their length equal to or 1.5–2 times as large as width; basal segments completely corticated, leaving narrow interstices between bands on upper nodes; uppermost cortical layer composed of small cells.

Ecology/habitat On stones, rocks and large boulders, to 20 m deep; epilithic, frequently epiphytic; annual, peak of vegetation in mid-summer; reproduction sexual and asexual, from May through July; generally distributed in the Black Sea.

Commercial & possible use Plants of *Ceramium arborescens* provide a source of antimicrobial, antiviral, anthelminthic, fungicidal and antitumor BASs; polysaccharides, agaroids, agarose, proteins, nitrogen, iodine, beta-carotene and unique xanthophylls; contain immunomodulators used in prostaglandin synthesis.

Ceramium ciliatum (J. Ellis) Ducluzeau



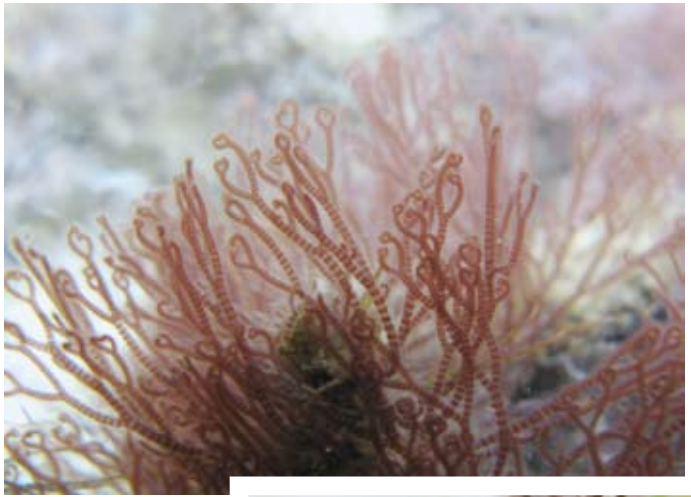
Morphology Thalli erect, turfted or as turf, rose-pink, 3–7 cm high, basal part 0.1–0.3 mm diam., fairly rigid, brittle in texture; attached by rhizoids; erect axes narrowing insignificantly upwards, nodes and internodes clearly marked; branching repeatedly pseudodichotomous, often with accessory branchlets conspicuously incurved at apices; segments 2–6 times diam. long when mature; cortical bands thick, relatively broad, bearing numerous spines of 2–4 small cells.

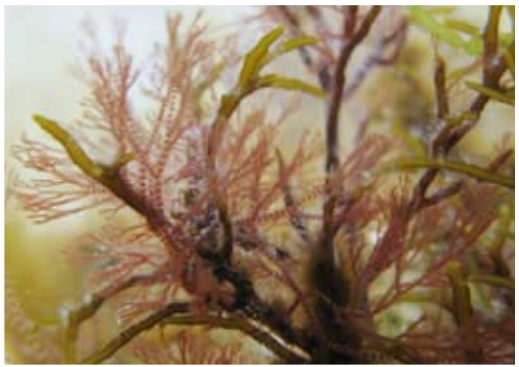
Ecology/habitat On stones and rocks, to 1 m deep, in sheltered and wave-exposed sites; epilithic, occasionally epiphytic or epizoic; seasonal, peak of vegetation in mid-summer; common for the Black Sea.

Commercial & possible use Plants of *Ceramium ciliatum* provide a source of polysaccharides, antimicrobial, antiviral, fungicidal and antitumor BASs.

Ceramium deslongchampsii Chauvin ex Duby

Synonym: *Ceramium strictum* (Kütz.) Harv.





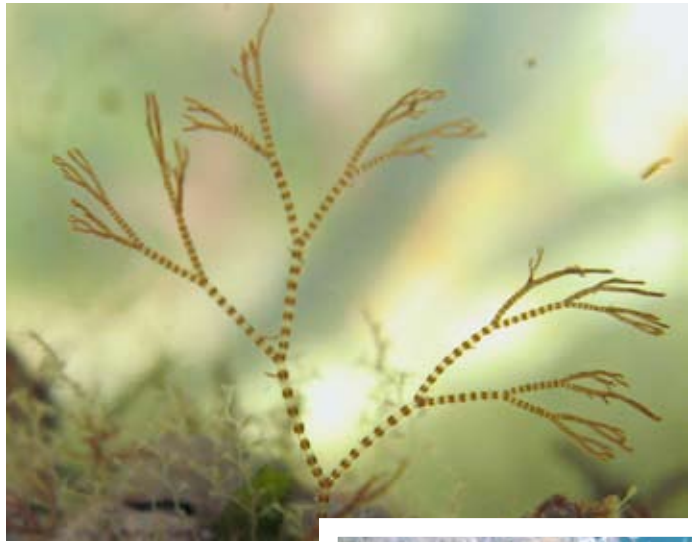
Morphology Thallus bushy, rose-red or dark brown, to 8 cm high; erect axes tufted, 0.1–0.4 mm diam., narrowing 4–5 times in upper part; nodes and internodes clearly marked; heavily branched, branching dichotomous or pseudodichotomous; branches relatively long, simple, lower part sparsely at arranged, divaricated (45–60°); apecis forked, with straight or slightly in rolled apices; main branches with many branchlets, usually with colourless hair on young branches; segments in the upper and lower parts part of thallus 4–6 times and 1.5–3 times longer than wide, respectively; corticated nodes slightly bulged, of smooth-edged bands, nearly as high as wide, separated by narrow internodes.

Ecology/habitat On stones, bed and sand-rock, shells, 0.5–20 m deep; in sheltered and wave exposed sites; epilithic, often epiphytic; annual, peak of vegetation in summer, reproduction year-round; widely distributed in the Black Sea.

Commercial & possible use Plants of *Ceramium deslongchampsii* are the source of polysaccharides, agarose, agaroids, carageenan, proteins, BASs with antimicrobial, antiviral, fungicidal and antitumor activity; food in Eastern and South-Eastern Asia.

Ceramium diaphanum (Lightfoot) Roth

Synonym: *Ceramium tenuissimum* (Roth) J.E. Aresch.; *Ceramium elegans* (Roth) Ducluz.



Morphology Thallus of numerous erect axes, pinkish-red, 6–11 cm high, heavily or sparsely branched; lower part 0.4–0.5 mm diam., decreasing to 0.1–0.3 mm diam. in outer parts; nodes and internodes clearly marked; branching regularly dichotomous or repeatedly pseudodichotomous, occasional short supplementary lateral branchlets; branches divaricated at base, the divergence angle decreases at apex, apices incurved; segments 4–5 times as long as wide, corticated nodes slightly bulged, broad and thick; internodes cylindrical.

Ecology/habitat On stones, rocks, large boulders, pebbles, or muddy sand, 0.5–20 m deep; in sheltered or moderately wave-exposed sites; epilithic, often epiphytic on larger algae and seagrasses; annual, peak of vegetation in spring and summer, reproduction year-round; widely distributed in the Black Sea.

Commercial & possible use Plants of *Ceramium diaphanum* are the source of polysaccharides, BASs with antimicrobial, antiviral and antitumor activity; plants could be used in dermatology, cosmetics, medicine and food industry.

Ceramium virgatum Roth

Synonym: *Ceramium rubrum* C.Ag.

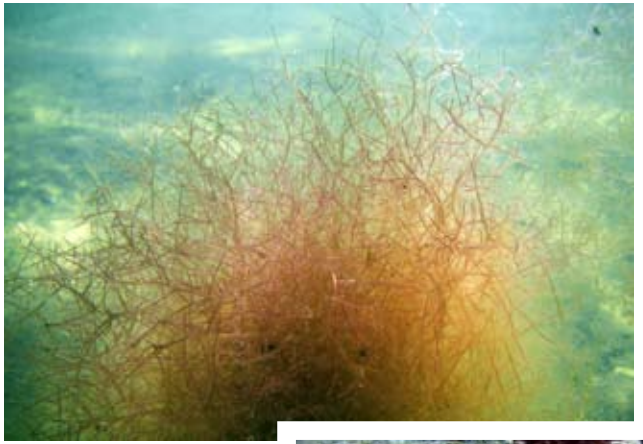
Morphology Thallus of one to several erect axes, often bushy, deep-red or brownish red, to 15 cm high, 0.5–1 mm diam., attached by discoid holdfast; segmented, richly branched, branching irregularly dichotomous or with dominant main axes having forcipate to slightly inrolled apices; segments slightly narrowed toward apex, about 1–2 times as long as wide; cortex of small cells, completely covering mature axes, often obscuring articulations.

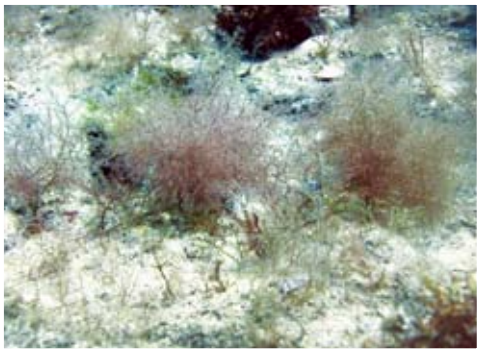
Ecology/habitat On stones, rocks and shells, artificial substrata, to 20 m deep, in sheltered to wave-exposed often polluted locations; epilithic and typically epiphytic; annual, peak of vegetation in summer and autumn, reproduction year-round; widely distributed in the Black Sea.

Commercial & possible use Plants of *Ceramium virgatum* are the source of polysaccharides, agaroids, agarose, proteins, nitrogen, iodine, lectins, beta-carotene and a number of unique xanthophylls; antimicrobial, antiviral, anthelminthic, fungicidal and antitumor BASs; contain pigments which use for textile and fragrance industries.

Chondria capillaris (Hudson) M.J. Wynne

Synonym: *Chondria tenuissima* C. Ag.





Morphology Thalli of cylindrical erect axes, brownish-red, 5–20 cm high; richly branched, main axis usually distinct, 0.5–1 mm wide at base, narrowing 3–5 times to apex; branching alternate; branches virgate, divergent or near-excurved, with numerous branchlets, 1–10 mm in length; long branches simple or slightly brachiated along entire length; branches constricted slightly basally and strongly apically; young branches with apical tufts of filaments.

Ecology/habitat On rocks, stones and shells, 0.5–28 m deep, tolerant to wave activity and pollution; epilithic, often epiphytic; annual, peak of vegetation in summer and autumn, reproduction from May through October; generally distributed in the Black Sea, except Romanian coast.

Commercial & possible use Some of *Chondria* species content laminin, spasmolytic and hypotensive α-amino acid, and domoic acid; extract has the selective suppressant of parotites virus, plants are the source for antihelminthic and antiviral medicine.

Chondria dasyphylla (Woodward) C. Agardh

Morphology Thalli of cylindrical erect axes or decumbent tufts, brownish-red or yellowish, 8–15 cm high, to 1 mm diam., tubular, coarse-fibrous, attached by basal holdfast; main axes distinct, richly branched, branching sparsely at irregular intervals; branchlets multiple, 3–20 mm long, 0.5–1 mm diam., simple or brachiated, often growing in small clusters.

Ecology/habitat On stones and mollusc shells, 0.5–20 m deep; epilithic, often epiphytic; annual, peak of vegetation in summer, reproduction sexual and asexual from May to August; common for the Black Sea, except Romanian coast.

Commercial & possible use Sarganin and glycolipids, isolated from *Chondria dasyphylla*, inhibit bacterial and fungal growth; source of angiocardial substances; a food item in Korea.

Coccotylus truncatus

(Pallas) M.J. Wynne et J.N. Heine

Synonym: *Phyllophora brodiaei* (Turn.) Endl., *Ph. truncata* (Pallas) A.D. Zinova

Morphology Thallus bushy, simple or branched, bright crimson, 5–40 cm high, attached by small holdfast or rhizoids; basal long cylindrical stem flattened at the top; apices of stem and branches with small blades; blades roughly-membranous, mainly cuneiform, cordiform, upper margins with sinuous or lobed; lobes numerous, often as long as main blade, apical parts often fan-shaped; reproductive structures occasionally along blade margins, lobes or stems of young blades.

Ecology/habitat On shell rock, sand and stones, 4–45 m deep; in unpolluted and wave-exposed areas; epilithic; perennial, peak of vegetation in spring and early summer; recorded from some localities of the Black Sea, common for Zernov *Phyllophora* fields.

Commercial & possible use Plants of *Coccotylus truncatus* are the source of agaroid, agaropectin, protein, vitamins B and antitumor BASs.

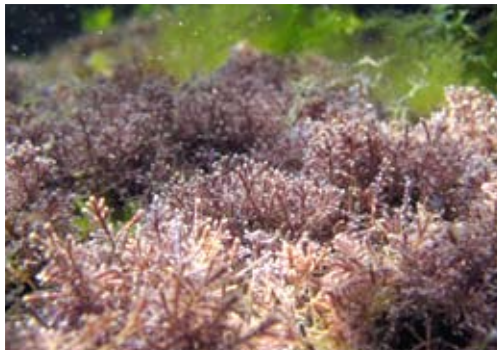
Corallina elongata J. Ellis et Solander

Synonym: *Corallina mediterranea* Aresch.

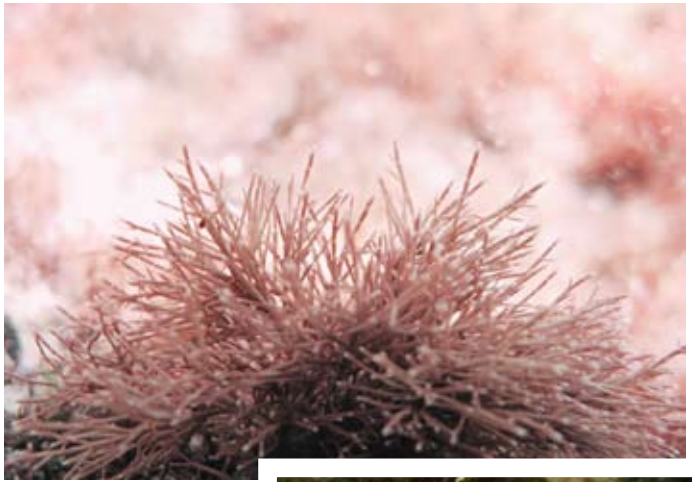
Morphology Thallus with corticated base from which erect, heavily branched, completely calcified segmented shoots emerge, lilac to pinkish-white, to 5 cm high, 0.5 mm thick; often forming thick mats; branching miscellaneous, dichotomous, alternate, opposite and pinnate, mostly in the same plane; main axes narrowing toward apex; segments usually cylindrical, occasionally cuneiform or compressed; basal segments 2–3, apical up to 4 times as long as wide.

Ecology/habitat On stones, rocks, shells, artificial substrata, to 25 m deep, mainly in unpolluted wave-exposed areas; epilithic and epiphytic; annual, peak of vegetation in summer; widely distributed in the Black Sea, except Romanian coast.

Commercial & possible use Plants of *Corallina elongata* used for producing bioenergy on an industrial scale, contain antitumor and antimicrobial BASs, terpens and phenols, PUFA, α-tocopherol, xylogalactans of agar group and alginic acids; used in medicine and dermatology.



Corallina officinalis Linnaeus



Morphology Thallus of relatively thick cortex and protruding erect segmented shoots, pale rosy, to 15 cm high; richly branched, predominantly in one plane, dichotomous and alternate below and pinnate, opposite or alternate above; main branches 0.5–1 mm thick; segments in bases and terminal branchlets cylindrical, slightly compressed and uneven, in mid part cylindrical or cuneiform, considerably compressed; segments 1–3 times as long as wide.

Ecology/habitat On stones, rocks, artificial substrata, to 3 m deep, mainly in wave-exposed areas; epilithic and epiphytic; perennial, peak of vegetation in summer; generally distributed in the Black Sea.

Commercial & possible use Plants of *Corallina officinalis* are the source for producing bioenergy; antihelmintic, antimicrobial, antibacterial and antitumor BASs, PUFA and xylogalactans of agar group.

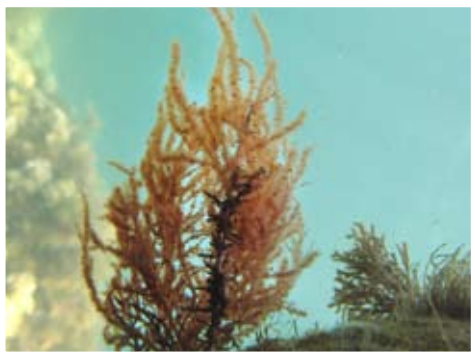
*Dasya baillouviana (*S.G. Gmelin) Montagne

Synonym: *Dasya pedicellata* (C. Ag.) C. Ag.

Morphology Thallus erect, coarsely-fibrous, pinkish to creamy, to 30 cm high, 1–4 mm thick, texture slippery; attached by small basal disc; axes irregularly and alternately branched; main axis rarely distinct; branches very long, shorter in lower parts, longer in upper parts; corticated throughout; thickset monosiphonous branchlets to 5 mm long, developing on branches of 2–3 orders, nearly absent on main axis and branches; the branchlets usually form clusters falling off after reproduction.

Ecology/habitat On stones, rocks, or shells, 0.5–20 m deep, in sheltered and wave-exposed areas; epilithic and epiphytic; seasonal, peak of vegetation in mid-summer; generally distributed in the Black Sea, except Romanian coast.

Commercial & possible use Some *Dasya* species are source of BASs with antibiotic effect.



Dasya hutchinsiae Harvey

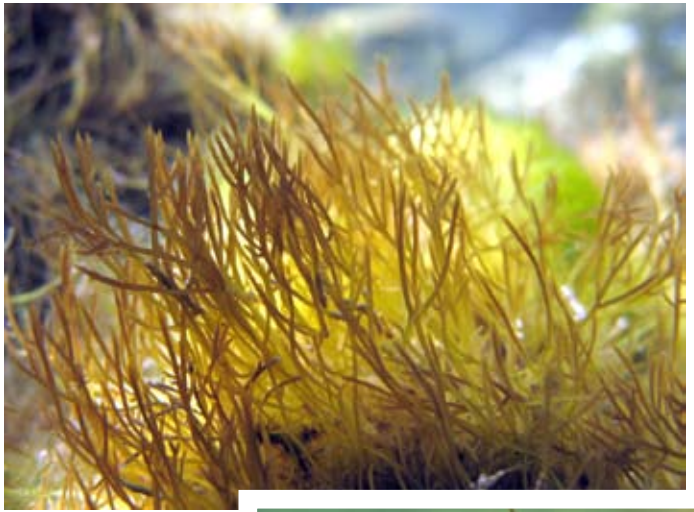
Synonym: *Dasya arbuscula* sensu Harv.

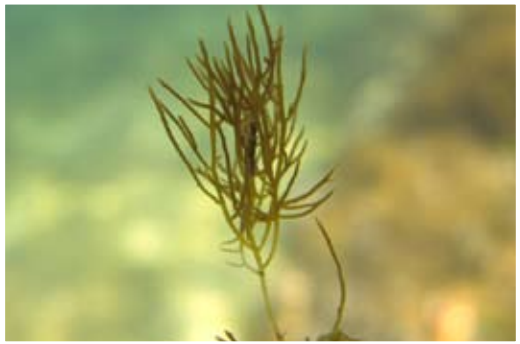
Morphology Thallus bushy, finely fibrous, tough and flexible, red to reddish, to 5 cm high, 0.2–1 mm thick, of erect axes growing singly or in tufts from discoid holdfast; branching irregularly alternate; main axis usually distinct, bearing laterals of equal length; branchlets monosiphonous, dichotomous, divergent, thickly covering branches throughout except in basal parts of main axes and stalk, 1–2 mm long clustered; cortex usually covers base of thallus, axes and branches.

Ecology/habitat On stones, rocks, 3–10 m deep, in sheltered and wave-exposed areas; epilithic and epiphytic; seasonal, peak of vegetation in mid-summer; generally distributed in the Black Sea.

Commercial & possible use Plants of *Dasya hutchinsiae* are source of antibiotic BASs and PUFA influencing cellular membrane metabolism.

Gelidium crinale (Hare ex Turner) Gaillon





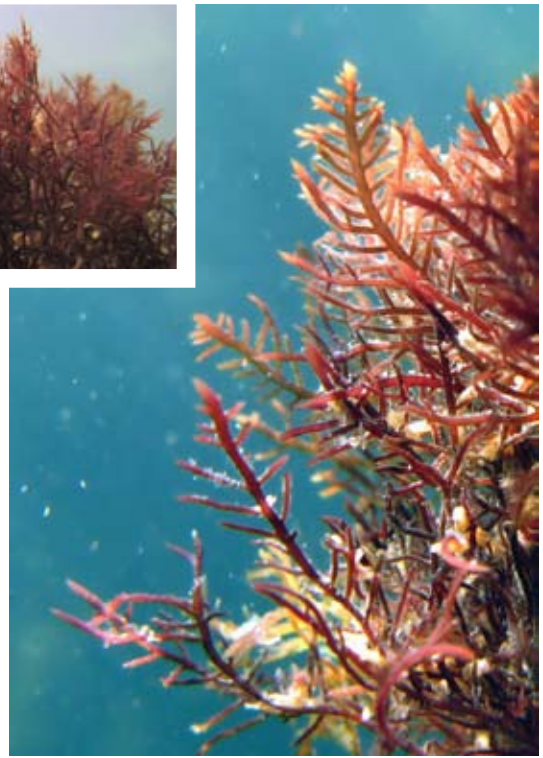
Morphology Thallus as globular bushy clumps, almost black, 3–6 cm high, large erect branches 0.3–0.5 mm thick, attached by rhizoids; large erect branches usually cylindrically compressed or nearly flat, arrangement interspersed or pinnate; branchlets mostly concentrate in uppermost part.

Ecology/habitat On stones, rocks and shell rock, or hydrotechnical constructions, 0.5–20 m deep; epilithic, often epiphytic; mainly in polluted seawater areas; perennial, peak of vegetation in summer; common for the Black Sea, except Romanian coast.

Commercial & possible use *Gelidium crinale* is a valuable commercial species, the source of high-quality agar, agarose, agaropectin, polysaccharides and sulphates, vitamins A, B, C, E, and BASs with antimicrobial, antiviral and antitumor effect; used in food in South-East Asia.

Gelidium spinosum (S.G. Gmelin) P.C. Silva

Synonym: *Gelidium latifolium* (Grev.) Bornet ex Hauck



Morphology Thallus richly branched, in bushy clumps, red to reddish-brown, 2–10 cm high, to 1 mm diam.; branches compressed or near-flat at base, branching irregular or pinnate; main branches usually long, bearing opposite short styloid or lanceolate branchlets at sharp angle to axis.

Ecology/habitat On stones, rocks and shells, 0.5–25 m deep, in clear and polluted areas; epilithic, often epiphytic on larger algae, *Cystoseira, Phyllophora, Cladostephus* etc.; perennial, peak of vegetation in mid-summer; widely distributed in the Black Sea, except Romanian coast.

Commercial & possible use *Gelidium spinosum* is a valuable commercial species, the source of high-quality agar, agarose, agaropectin, polysaccharides and sulphates, vitamins B, PP and E; BASs with antitumor, antiviral, antimicrobial and immunoprotective activity; food in South-East Asia.

Gracilaria dura (C. Agardh) J. Agardh

Morphology Thallus bushy, cartilaginous, dark-purple, 3–20 cm high, 0.3–0.9 mm diam., attached and unattached forms known; branching numerous, dichotomous and trichotomous, alternate and unilateral; branches often equal in length, sometimes connivent, with small bunches at apices; upper branches slightly narrower, obtuse; unattached thalli broader and coarser, often giving rise to cauliflower-shaped knobby galls.

Ecology/habitat Attached form grows mainly on shell rock, 5–25 m deep, perennial, peak of vegetation in summer and autumn, reproduction sexual and asexual year-round; unattached form only rarely found on silt-sand substrate in sheltered localities, 3–25 m deep, peak of vegetation in autumn, reproduction only vegetative, year-round; recorded from some localities of Ukrainian, Russian and Turkish coastal zone; the biggest assemblage of unattached form is found in Kazachiya Bay, Crimea.

Commercial & possible use *Gracilaria dura* is a valuable commercial species, the source of agar, microelements, PUFA, α-tocopherol, R-phycoerythrin, arachidonic acid, gibberellins and prostaglandins; also used as an agricultural fertilizer, in fragrance industry and food in some countries.

Gracilaria gracilis (Stackhouse) M. Steentoft, L.M. Irvine et W.F. Farnham

Synonym: *Gracilaria verrucosa* (Huds.) Papenf.

Morphology Thallus bushy, 3–40 cm high, dark-brown to dark-olive, large branches 0.3–0.8 mm diam., attached or unattached; moderately branched, main axis often distinct; branching irregularly dichotomous, alternate or unilateral; main branches very long, rod-shaped, bearing several shorter branches, often with short subulate lateral branchlets; apices elongate, pointed.

Ecology/habitat Attached form grows on shell rock in wave-exposed areas, 3–30 m deep; unattached form is infrequent, founds mainly on silty-sandy substate, in sheltered seawater locations, 3–15 m depth; perennial, peak of vegetation in autumn, reproduction year-round; common for the Black Sea, the largest assemblage of unattached form is found in Kazachiya Bay, Crimea.

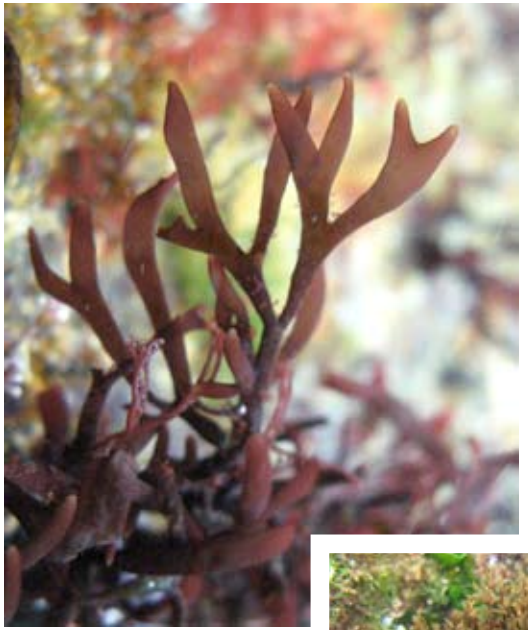
Commercial & possible use *Gracilaria gracilis* is a valuable commercial species, the source of agar, vitamins B, microelements, PUFA, in particular arachidonic acid, R-phycoerythrin, α-tocopherol, gibberellins and prostaglandins; used as an agricultural fertilizer, in fragrance industry and food in some countries.

Grateloupia dichotoma J. Agardh

Morphology Thallus flat, dark-brown, basal part cuneiform, with short cylindrical stem, to 7 cm high, attachment to substrate with holdfast; branching regularly or irregularly dichotomous; branches linear, linear-cuneated or lance-oblong, 0.5–2 mm wide, with blunt or pointed apices often arranged at same level; laterals may develop on both sides of branches.

Ecology/habitat On stones, rocks, artificial substrata, to 10 m deep, mainly in extremely wave-exposed sites, epilithic; perennial, peak of vegetation from late summer to early autumn; recorded from some locations of Ukrainian, Russian and Turkish coast.

Commercial & possible use Plants of *Grateloupia dichotoma* provide the source of agar, vitamins B and E (thiamine, riboflavin, α-tocopherol), pantothenic and nicotine acids, mineral salts, antihelmintic and antitumor BASs; a foodstuff in some Asian countries.



Haliptilon virgatum
(Zanardini) Garbary et H.W. Johansen
Synonym: *Corallina granifera* Ell. et Soland.

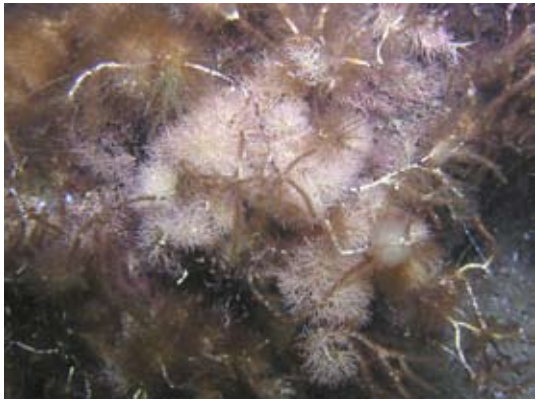
Morphology Thallus of multilayer corticated base and divergent, small, erect, segmented, bushy calcified clumps, rosy to grayish, 2.5–5 cm high; branching opposite, pinnate, quasi-dichotomous or thrichotomous; main branches 0.3 mm thick, narrowing at apex to 0.1 mm; most segments of main branches with branchlets arranged oppositely, alternately, fan-shaped or in whorls; segments cylindrical or nearly flat, more or less cuneiform; length of segments and terminal branchlets are 3–4 times and 5–6 times as large as wide, respectively; apex rare swollen.

Ecology/habitat On stones, rocks and boulders, 0.5–15 m deep, in wave-exposed areas; epilithic, often epiphytic; perennial, peak of vegetation in summer; widely distributed in the Black Sea, except Romanian coast.

Commercial & possible use Plants of *Haliptilon virgatum* used for producing bioenergy, contain PUFA, α-tocopherol and xylogalactans of agar group; extract has antihelmintic, antitumor and antimicrobial activity.

Jania rubens (Linnaeus) J.V. Lamouroux

Synonym: *Corallina rubens* L.

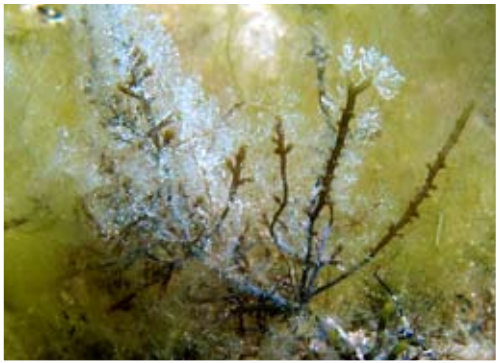


Morphology Thallus forming dense, erect stiff tufts, with multilayered base, to 3 cm high, 0.2–0.3 mm thick, pink to grayish, often as dense, quasi-globular, bushy clump, attached by small disc; branching regularly dichotomous, branches straight or slightly curved, divergent, ending in same plane, terminal branchlets very slender; branching segments cuneate, apical segments cylindrical; not or only slightly tapered, with rounded apex; segments 3–6 times as long as wide.

Ecology/habitat On stones, rocks, or shells, 1–15 m deep, in sheltered and wave-exposed areas, tolerant to irradiance, mostly in sublittoral zone; epilithic, often epiphytic; perennial, peak of vegetation in mid-summer; common for the Black Sea.

Commercial & possible use Plants of *Jania rubens* are the source of antitumor BASs; extract has antihelmintic and antifouling activity.

Laurencia coronopus J. Agardh

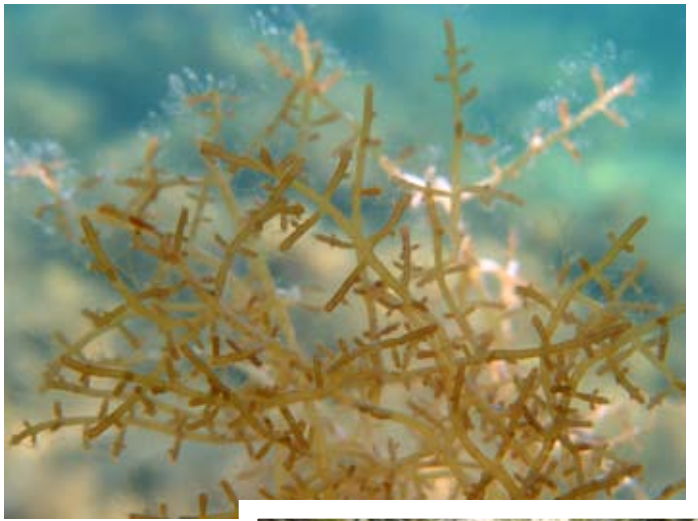


Morphology Thallus brushy, 5–15 cm high, 0.5–3 mm thick, colour varies from yellow to greenish-brown and reddish-brown, attached by basal holdfast; main axis slightly compressed in upper part, bears short tubular or club-shaped branchlets; branches with short prolifications, arranged diversely, in different planes, some regularly, alternately or oppositely, others are whorled, close to apex in same plane.

Ecology/habitat On stones and rocks, artificial substrata, 0.2–15 m deep, often forming thick cover, in clear locations; epilithic, often epiphytic; perennial, peak of vegetation in late spring and summer; reproduction almost year-round; widely distributed in the Black Sea, except Romanian coast.

Commercial & possible use *Laurencia coronopus* is a valuable commercial species, the source of antimicrobial, fungicidal and antitumor BASs, PUFA, agaroids; contain rare micro-elements (strontium, rubidium, zirconium etc.); used as foodstuff in some countries of South-East Asia.

Laurencia obtusa (Hudson) J.V. Lamouroux



Morphology Thallus forming supple, erect, bushy plants, amber-yellow, 5–10 cm high, 0.5–1.5 mm thick, soft, delicate, fragile; attached by small disc bearing one to several main axes with long and short branches; branching alternate, opposite, radial or whorled; main axis covered with short tubular or near-clavate radially positioned simply or widely brachiated branchlets with blunt or round apices, frequently grouped in twos or threes.

Ecology/habitat On rocks, stones and shells, 0.5–15 m deep, in clear sheltered and wave-exposed locations; epilithic, often epiphytic on larger algae and seagrasses; perennial, peak of vegetation from late spring through mid-summer; widely distributed in the Black Sea, except Romanian coast.

Commercial & possible use *Laurencia obtusa* is a valuable commercial species, the source of antimicrobial (laurentine, lauren), fungicidal and antitumor BASs, PUFA and agaroids; contain rare microelements (strontium, rubidium, zirconium); plants have antiseptic property and are used in treatment of stomach ailment and hemorrhoids in some Asian countries, as food in Indonesia.

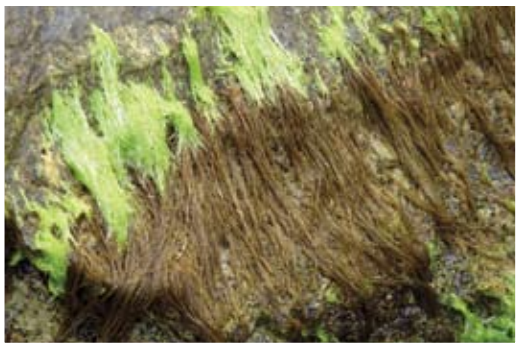
Lomentaria clavellosa (Turner) Gaillon

Morphology Thallus cylindrical, hollow, rough, pink to reddish, can form dense turfs, 2–10 cm high, 0.5–1 mm thick; main axis distinct, narrowed, quasi-segmented; cross septa absent; main branches relatively long, near-equal in length; branching opposite, alternate or verticillate; branchlets short, irregularly arranged.

Ecology/habitat On stones, rocks, shells, 1–15 m deep, in sheltered and wave-exposed areas; epilithic and epiphytic; annual, peak of vegetation in summer and early autumn; widely distributed in the Black Sea.

Commercial & possible use Plants of *Lomentaria clavellosa* are source of antimicrobial and antitoxic BASs.

Nemalion helminthoides (Velley) Batters



Morphology Thallus cord-like, simple, dark red or brownish, 15–40 cm high, 2–5 mm diam., attached by holdfast from which several other thalli usually emerge; typically not branched, rarely with 1–2 branches; similarly thick throughout, rarely narrowing basally and apically.

Ecology/habitat On stones, rocks and large boulders, intertidal to 0.5 m deep, sporadically to 10 m depth, in unpolluted areas; epilithic, rare epiphytic; seasonal, peak of vegetation in spring and early summer; recorded from coastal zone of the Black Sea.

Commercial & possible use A foodstuff in Japan.

Nitophyllum punctatum (Stackhouse) Greville

Morphology Thalli of tufts of blades, delicate and membranous, rosy-pink to brownish-red with age, tearing easily, attached by solid discoid holdfast; blades to 7 cm high, 0.2–1 cm wide, thin, usually incrassated at base and rarely throughout to apex; the most-divided blades consist of fairly regularly dichotomous branched linear, cuneiform or broad segments with widely divergent branches; always with dichotomously branched apices rounded at the tips; macroscopic and microscopic veins absent; blade margins even, smooth, slightly sinuous, more or less curled.

Ecology/habitat On stones, rocks, 1–10 m deep, mostly in sublittoral zone, in wave-exposed sites; epilithic, often epiphytic; perennial, peak of vegetation in late spring; recorded from some localities along the Ukrainian, Russian and Turkish coast.

Commercial & possible use Unknown.

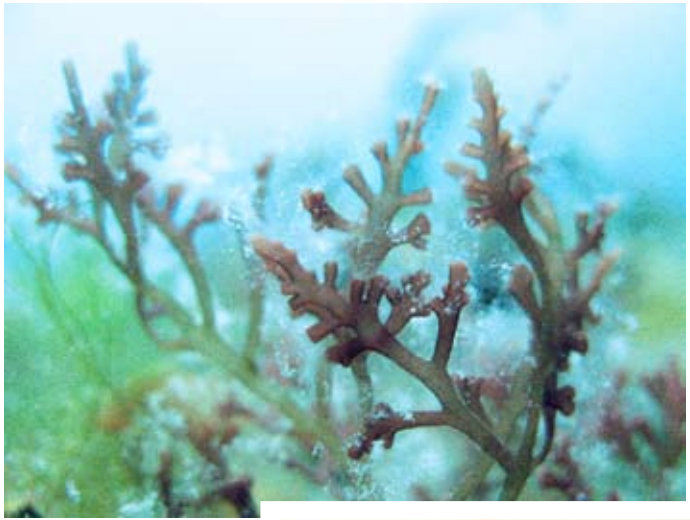
Osmundea pinnatifida (Hudson) Stackhouse

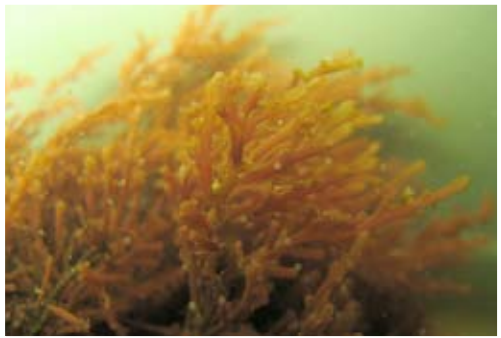
Synonym: *Laurencia pinnatifida* (Huds.) Lamour.

Morphology Thallus forming extensive turfs, rosy-brown and reddish, erect axes 5–15 cm high, 1–4 mm wide, 0.5–1 mm thick, attached by holdfasts; fresh plants have a strong chemical smell and flavour; basal part tubular, upper part compressed to near-flat; branching irregularly or alternately-distichous, in 4–5 orders, pinnate; branches divergent, linear, usually tapered toward base; apices rounded or lobed; branchlets short, slightly brachiated, multipartite, divergent, blunted or widened apically.

Ecology/habitat On stones, large boulders, sand rocks, 3–20 m deep; in clear wave-exposed and moderately sheltered areas; epilithic, often epiphytic; perennial, peak of vegetation in summer, reproduction sexual and asexual from spring through summer; generally in the Black Sea, except Romanian coast.

Commercial & possible use Plants of *Osmundea pinnatifida* contain agaroids, micro- and macroelements, including rare group, PUFA and cyclic ether rhodophytin; extract has anti-fouling activity; used as a food item in Portugal.

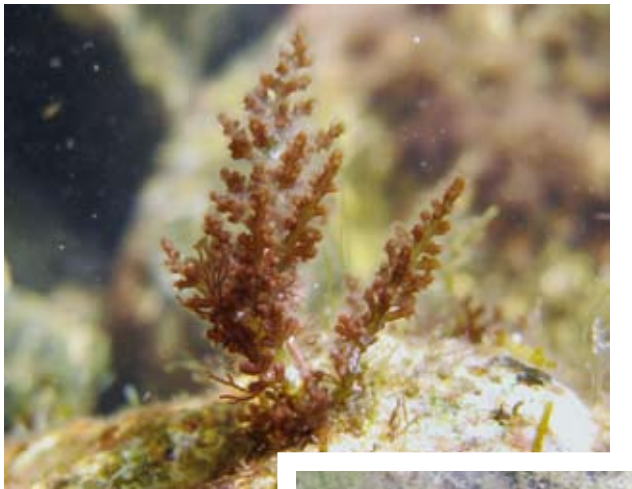




Palisada perforata

(Bory de Saint-Vincent) K.W. Nam

Synonym: *Laurencia papillosa* (C. Ag.) Grev.; *Chondrophicus papillosus* (C. Ag.) Garbary et J. Harper



Morphology Thallus bearing several erect axes, brownish-red to cream, to 15 cm high, 2–3 mm thick, stiff, cartilaginous, attached by basal disc; branching radial, paniculate, often pyramidal; main axis not distinct; long branches alternately arranged, partly oppositely; thickly covered with tubular or near-clavate branchlets of varying length and form, with wing-shaped apices; ramuli short all over the thallus, papillose.

Ecology/habitat On stones, rocks, shells, to 2 m deep; in sheltered and wave-exposed areas, epilithic and epiphytic; perennial, peak of vegetation in summer; common for the Black Sea.

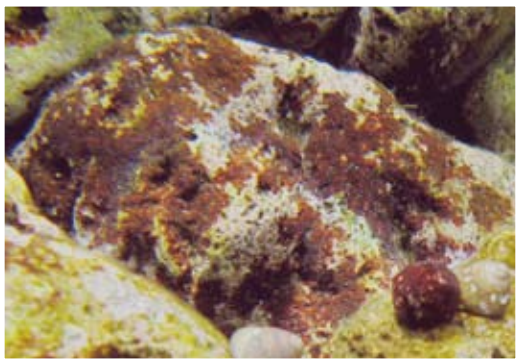
Commercial & possible use Plants of *Palisada perforata* are the source of antimicrobial, fungicidal and antitumor BASs, PUFA, phycocolloids, agaroids and phenol-bromides, rare microelements; also provide natural fertilizer; used as food in some countries of South-East Asia.

Peyssonnelia dubyi P.L. Crouan & H.M. Crouan

Synonym: *Hildenbrandia dubyi* P.L.Crouan & H.M.Crouan ex Kütz.

Morphology Thallus corticated, 0.1–0.2 mm-thick cork, bordeaux-red and bright-red, forming small widely diverging lamellae; prostrate, tightly attached to substrate along full length; 1–4 cm diam.; with concentric markings on surface; rhizoids on lower surface absent.

Ecology/habitat On stones, rocks, shells, in shallow areas and sublittoral zone, on pebbles in sheltered areas, 0.5–20 m deep; tolerant to currents and wave action; epilithic and epiphytic; perennial, peak of vegetation in summer and autumn, reproduction year-round; widely distributed in the Black Sea.



Commercial & possible use Plants of *Peyssonnelia dubyi* provide BASs for pharmaceutics.

Phyllophora crispa (Hudson.) P.S. Dixon

Synonym: *Phyllophora nervosa* (DC) Grev.

Morphology Thallus bushy, deep-red, the basal part giving rise to small holdfast or prostrate branched shoots which may merge into relatively thick basal layer; erect shoots 2–50 cm high; stalks short cylindrical, flattened at apex where vase and shoots emerge; blade linear, linear-ovoid, heavily brachiated, with dense median rib and attenuated curled margins, 2–8 cm long and 1–3 mm wide; young blades form on surface of old blades, mainly on upper half on thick ribs.

Ecology/habitat On stones, pebbles, rocks and shell rock, 0.2–52 m deep; forming belt of communities on 10–20 m depth; perennial, peak of vegetation in spring and early summer; vegetative reproduction year-round, sexual and asexual from November through March; torn off fragments of thalli live on as unattached form, in particular, in Zernov`s *Phyllophora* field, former the most extensive in the world; widely distributed in the Black Sea.

Commercial & possible use Plants of *Phyllophora crispa* are used as source of agaroid, agaropectin, protein, vitamins B and antitumor BASs.

Phymatolithon lenormandii

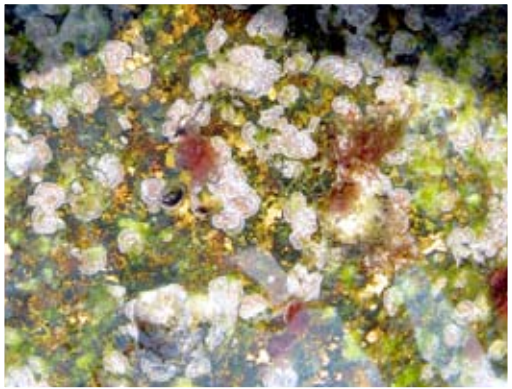
(J.E. Areschoug) W.H. Adey

Synonym: *Lithothamnion lenormandii* (J.E. Aresch.) Foslie

Morphology Thallus forms small crusts, 1–8 mm thick, purple-red to violet with whitish patches, tight attached to substrates; edges usually rounded-lobed; surface of young crusts smooth, later changing to scaly, zonately lined; adjacent crusts often merged.

Ecology/habitat On stones, pebbles and shells, artifical substrata, 0.5–20 m deep, typical epilithic; perennial, common for the Ukrainian, Russian and Romanian coast.

Commercial & possible use Plants of *Phymatolithon lenormandii* are used in agriculture as fodder and litter for livestock, soil fertilizer, for acid lake and pond amelioration and enrichment of running water with potassium; some *Phymatolithon* species are objects of aquaculture in Great Britain and France.



Polysiphonia elongata (Hudson) Sprengel

Morphology Thallus to 30 cm high, bushy, consisting of single erect axis with narrow to broad outline, bright red to brownish-red, attached by holdfast and rhizoids; main axes segmented, 1–2 mm diam., decreasing gradually; thallus unbranched in basal parts and richly branched in upper parts; branching pseudodichotomous and alternate on slender branchlets, often falling off closer to apices; segments 2–3 diam. long when young, less in main axis; erect axes with 4 periaxial cells; cortex well developed, especially on basic nodes; young branches not corticated or partially cortical.

Ecology/habitat On stones, rocks, large boulders, shells, artificial substrata, intertidal to 45 m deep, in clear and polluted areas; epilithic, often epiphytic on larger algae; perennial, peak of vegetation in spring and early summer, reproduction year-round; common for the Black Sea.

Commercial & possible use Plants of *Polysiphonia elongata* are the source of antimicrobial, antiviral and cytotoxic BASs, phenol derivatives, essential amino acids, α-tocopherol.

Polysiphonia fucoides (Hudson) Greville

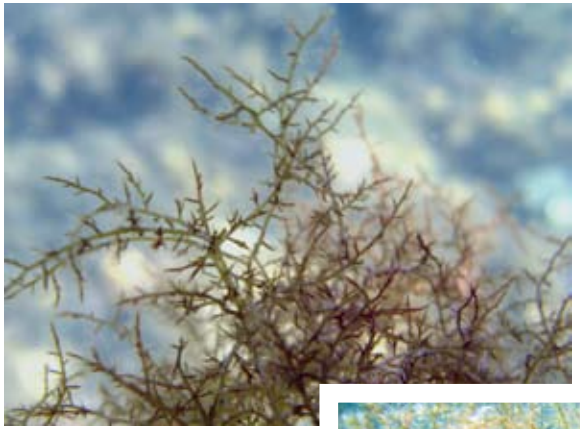
Synonym: *Polysiphonia violacea* (Roth) Spreng.; *Polysiphonia nigrescens* (Huds.) Grev. ex Harv.

Morphology Thallus of few to many main axes, bushy, often pyramid-shaped, segmented, flabby and slippery, purple- or brownish-red, to 20 cm high, 0.3–0.7 mm diam.; attached by rhizoids and holdfast; branching highly variable, main axes usually remaining distinct, bearing many branched laterals in irregular spirals to alternate arrangement, typically with corymbose apices, segments 2–3 diam. long in basal part and 2–5 diam. long in young axes, with four peripheral siphons; cortex covers most of thallus, except for short branchlets.

Ecology/habitat On stones, rocks, shells, artificial substrata, 1–10 m deep; epilithic, frequently epiphytic; tolerant to pollution and wave-exposure; annual, peak of vegetation in summer; widely distributed in the Black Sea.

Commercial & possible use Plants of *Polysiphonia fucoides* are the source of antimicrobial BASs, phenol derivatives, essential amino acids; used in food and as herbal medicine in some Asian countries.

Polysiphonia subulifera (C. Agardh) Harvey



Morphology Thallus consisting of numerous branched erect axes, 5–15 cm high, to 20 cm broad, brownish or bright red, attached by rhizoids; segmented, distinct main axes lacking, erect axes to 0.3–0.7 mm diam., irregularly alternatively branched to several orders with ultimate numerous branchlets short and spine-like, simple or brachiated; non-uniformly spread often making thallus semi-spherical; main branches long, with 12–13 straight or spiral periaxial cells, segments 1.5–2 diameters long, cortex absent.

Ecology/habitat On stones, rocks and shells, from water edge to 20 depth; in moderate to extremely wave-sheltered pure and polluted areas; tolerant to irradiance; epilithic, mostly epiphytic; annual, peak of vegetation from spring through autumn; widely distributed in the Black Sea.

Commercial & possible use Plants of *Polysiphonia subulifera* provide the source of phenol derivatives, essential amino acids, antimicrobial, antibacterial, antiviral and cytotoxic BASs and PUFA; extract has antifouling activity.

Porphyra leucosticta Thuret

Morphology Thallus laminar, bluish-purple, 5–15 cm long, 4–10 cm broad; blade solitary, rounded or oval, sometimes quasi-lobed, with smooth or slightly convex base, edges even or folded; often narrowed at base.

Ecology/habitat On stones and rocks, intertidal to 10 m deep; in sheltered locations of bays and gulfs; epilithic and epiphytic; tolerant to considerably fluctuating salinity and pollution; seasonal, peak of vegetation from December through March; common for the Black Sea.

Commercial & possible use Plants of *Porphyra leucosticta* are the source of high-quality protein, nitrogen, phosphorus, vitamins B and C, mineral elements, polysaccharide porphyran, antitumor BASs; food in Japan, China, Israel and Portugal; can use as fodder additive.

Zostera marina

Higher Plants

(MAGNOLIOPHYTA)

Seagrasses are monocotyledonous vascular plants, but are not true grasses. They are called seagrasses since they usually grow in extensive underwater meadows, similar to fields of terrestrial grasses. These plants are unique in that their life history develops under the seawater. Their root system with stems is buried within a soft substrate and they reproduce in two ways – vegetative by rhizome which grows year round and bears lateral shoots and sexual by seeds. Seagrasses have flowers fertilized by water-borne pollen.

There are about 60 species of seagrasses within 12 genera. They grow along the coastlines of all continents, in coastal and estuarine areas, where they form extensive underwater meadows. They are not, however, found north of the Arctic Circle and south of the Antarctic Circle. Seagrass communities in the tropics are multispecific, but in the temperate zones they are mainly unispecific. Most communities have similar structure and functions. They have been acknowledged as crucial nursery habitat for estuarine fisheries and wildlife. Due to their sensitivity to nutrient enrichment and eutrophication, seagrasses are reliable biological indicators of estuarine water quality and ecosystem health.

The scope and value of ecosystem services that seagrass communities provide gratis are remarkably high. Of primary significance is their relatively high organic production; high standing crops producing large amounts of dissolved and particulate detritus which form the basis of important food chains. Epibiotic organisms are very often attached to the leaves and erect shoots of seagrasses. The roots and rhizomes of seagrasses stabilize the habitat through binding the substrate and retarding erosion. The leaves form a baffle which slows and retards current and wave activity. The dense leaf offers shelter for an extremely diverse fauna. Since the leaf baffle generates and entrains autochthonous as well as allochthonous organic matter, an active environment is formed for decomposition and nutrient cycling.

In the Black Sea, higher plants are represented by five spices of seagrasses and two of flowering plants. Most abundant *Zostera marina* (eelgrass) and *Zostera noltii* form beds which occupy vast areas. They are found in shallow bays, gulfs, coastal salt lakes, estuaries, river mouths and flood plains, and grow from the waters edge to 17 m depth.

Ruppia cirrosa (Petagna) Grande

Synonym: *Ruppia spiralis* L. ex Dumort., *R. maritima* subsp. *spiralis* L. ex Dumort.

Morphology Shoots are filiform, 20–40 cm long, richly branched; blades alternate, narrow-linear, to 10 cm long, 0.4–0.8 mm wide, sheath distinct, well-developed; rhizome light brown, 1–3 mm in diam., with 1–2 roots per node; male and female flowers in terminal two-flower inflorescences, remaining in leaf sheath until flowering; after flowering the stalks increase in length to 10–40 cm and twist spirally (see pictures A, B); seeds drupaceous, consisting of 2–3 ovoid or oblique-oviform drupelets 2–3 mm long.

Ecology/habitat In seawater and brackish areas, under 3–19‰ salinity, on silty-sandy substrates or shell rock, 0.1–7 m deep, resistant to wave activity; perennial, peak of vegetation in June–July; reproduction sexual and vegetative, flowering from June trough September, fruiting from August to October; common for the Ukrainian coast, rare in other regions.

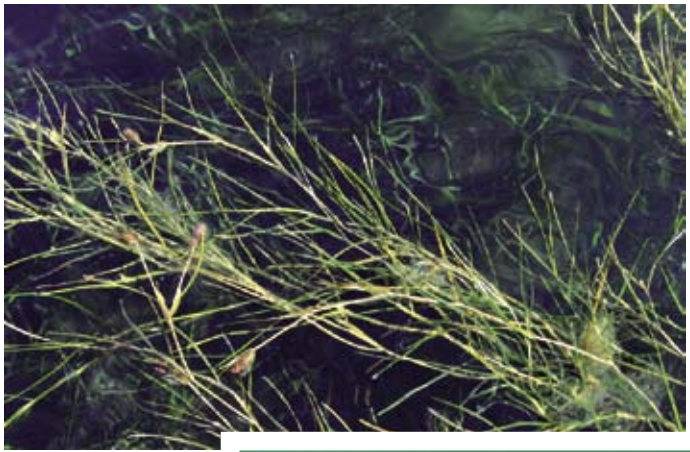
Commercial & possible use *Ruppia cirrhosa* is a promising raw material for industry and agriculture; an important link in food chain of fish and marine birds.

pic. A

pic. B

Stuckenia pectinata (Linnaeus) Börner

Synonym: *Potamogeton pectinatus* L.



Morphology Shoots thread-like, to 2 m long, richly branched; blades narrow-linear, alternate, 2–15 cm long, 0.5–2.5 mm wide, with long ligula (4–12 mm) and three veins, marginal ones indistinct, leaf sheath open, 20–50 mm long; rhizomes white or light brown, 1.5–5.0 mm in diam., creeping; roots 2–4 cm long, 4–8 per node; starchy wintering buds emerge on rhizomes; inflorescence spike-like, 3–6 cm long, moniliform; peduncle thread-like, 10–25 cm long; flowers bisexual; seeds drupaceous, of 1–4 drupelets; drupelet brown, 2.5–5 mm long, 2–3 mm wide, with short beak.

Ecology/habitat Common in sheltered gulfs, buys, fresh, brackish and sea waters, under 3–19‰ salinity, on silty–sandy sediment, 0.5–8 m deep; perennial, peak of vegetation in May–June; reproduction predominantly vegetative, the rate of sexual reproduction depends upon the year; shoots usually dying off in winter, but leaving living rhizomes; common for the Ukrainian coast, rare in other regions.

Commercial & possible use Plants of *Stuckenia pectinata* rich in pectic substance (rdestin); the tubers are fodder for livestock; an important element in the food chain of fish and marine birds.

Zannichellia palustris Linnaeus

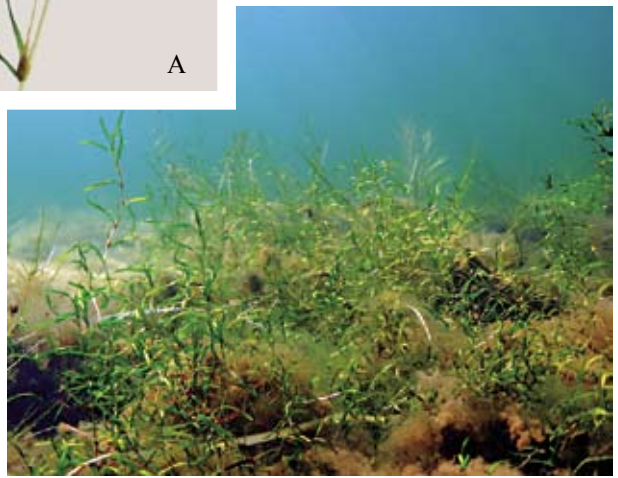
Synonym: *Zannichellia major* (Hartman) Boenn. ex Reichenb., *Z. palustris* var. *major* (Hartman) W.D.J. Koch.

Morphology Stem thread-like, 20–50 cm long, branched; leaves linear, 2–5 cm long, to 1 mm wide, with large stipules and one vein; rhizome creeping, looking much alike the prostrate stems, with 1–2 roots per node; flowers axillary, unisexual; perianth absent; seed drupaceous, of 2 (4) drupelets on short incrassated stalk, 2.5–3.5 mm long, 1–1.5 mm wide, with beak 1–1.5 mm long, margin convex, minutely dentate.

Ecology/habitat In fresh, brackish and sea water, protected from wave activity, under salinity from 3–19.0‰, mostly on silty sediments, 0.5–1.5 m deep; perennial, peak of vegetation in July–August; reproduction sexual and vegetative, flowering in June–August, fruiting from August through September (picture A); distributed in the sheltered areas of Ukrainian, Russian and Romanian coast.

Commercial & possible use Plants of *Zannichellia palustris* are significant element in the food chain of fish and marine birds.


A



Zostera marina Linnaeus

Morphology Large shoots, bearing 3–8 bright-green linear leaves to 2 m long, 3–12 mm wide; leaf blade with 3–7 main veins, with lateral ones at a distance from each edge, leaf sheath closed; rhizome light to dark brown, 1.2–5 mm in diam., creeping, branched, bearing 2–12 roots 5–20 cm long at each nodeg generative shoots repeatedly branched, bearing numerous leaves and spathes; with 6–14 male and female flowers per spadix; seeds elongate ellipsoid, 2.5–4 mm long, light to dark brown, seed surface with 16–20 distinct ridges.

Ecology/habitat Forming extensive beds in sheltered bays, gulfs and lagoons, under 6.5–19‰ salinity, on silty-sandy sediments, 0.2–17 m deep; perennial, peak of vegetation in May–June, leaves fall during late summer–early autumn, with old blades washing ashore; reproduction sexual (February–July) and vegetative, year-round; widely distributed along Ukrainian coast, rare in other regions.

Commercial & possible use Plants of *Zostera marina* rich in protein, contain zosterin and hemicelluloses used in industry and medicine; storm casts used as a vehicle for cubed and granulated feed; dry leaves have thermo-insulating, and putrefaction-resistant properties.

Zostera noltii Hornemann

Synonym: *Zostera nana* Roth,
Z. minor (Cavol.) Nolte ex Reichenb.

Morphology Shoots to 1 m long, emerge from apices of creeping branched rhizomes, each bears 2–5 narrow-linear leaves, 0.5–2 mm wide; leaf blade with three longitudinal veins, one central, two lateral and close to each edge, lateral veins barely visible; apex rounded; leaf sheath open, with overlapping auriculate flaps; rhizome light to dark brown, 0.5–2 mm in diam., with 1–4 roots per node; generative shoots 2–25 cm long, always lateral, sparsely branched, bearing 1–6 spathes, with 4–5 male and female flowers per spadix, perianth absent; seeds ovoid, elliptic, 1.5–2 mm in diam., brown; surface smooth, with beak.

Ecology/habitat Forming extensive beds in shallows and estuarine waters, under 3–19‰ salinity, on sandy and silty-sandy sediments, 0.2–11 m deep; perennial, peak of vegetation in July, reproduction sexual (April–August) and vegetative, year-round; widely distributed along the Ukrainian coast, common for other regions.

Commercial & possible use Storm casts of *Zostera noltii* is a promising raw material for agriculture, industry, medicine and as a fodder for farmed fishes.

Annexes

ANNEX 1. DIVERSITY OF THE BLACK SEA MARINE PLANTS

DIAGRAMS

TABLE

ANNEX 2. MARINE PROTECTED AREAS OF THE BLACK SEA

DIAGRAMS

Status	Date designated	Total area (km^2)	Marine area (km^2)
National Biosphere Reserve, or Biosphere Zapovednik for Ukraine			
Dunaiskiy (Danube Delta)[1] RO, UA			
- Ukranian part	1998	464.00	122.86
- Romanian part	1991	5,765.11	1,216.97
Chernomorskiy (Black Sea), UA	1927 (2006)	891.29	749.81
Nature Reserve, or State Nature Zapovednik for Ukraine			
Karadagskiy (Karadag), UA	1979	28.74	8.09
Lebyazhie ostrova (Swan Isles), ornithological, branch of Crimean Nature Reserve, UA	1991	96.12	95.63
Mys Martiyan (Cape Martyan), UA	1973	2.40	1.20
Opukskiy (Opuk), UA	1998	15.92	0.62
TOTAL			

Status	Date designated	Total area (km^2)	Marine area (km^2)
National Nature Park			
Dzharylgachskiy, UA	2009	100	24.69
Kolkheti, GE	1999	445.55	157.42
Tuzlovskie limani (The Estuaries of Tuzla), UA	2010	278.65	8.83
Regional Landscape Park			
Bakal'skaya Kosa (Bakal'sk spit), UA			
Lis'ya Bay – Echki-Dag (Lisya Bay – Mt. Echki-Dag), UA			
Tihaya Buchta (Tikhaya Bay), UA			
TOTAL			

Status	Date designated	Total area (km^2)	Marine area (km^2)
Nature Preserve, or State Nature Zakaznik for Ukraine and Russia			
Bolshoi Utrish, floristic, landscape and marine, RU	1994		
Karkinitskiy zaliv (Karkinitsky Gulf), ornithological, UA	1978		
Buhta Kazach'ya (Kazach'ya Bay), zoological, UA	1998		
Mys Aya (Cape Aya), landscape, UA	1982		
Vama Veche – 2 Mai marine areas, scientific, RO	2007		
Yagorlitskiy, ornithological, UA	1974		
Zernov's Phyllophora Field, botanical, UA	2009		
Zmeinyi ostrov (Zmeinyi Isle), zoological, UA	1998		
TOTAL			

Status	Date designated	Total area (km^2)	Marine area (km^2)
Marine Protected Area			
Mangalia underwater Sulphurous Springs, RO			
Marine area from Cape Tuzla, RO			
Methanogenic Structures from Sfantu Gheorghe, RO			
Submerged beach from Eforie, RO			
Local Nature Phenomenon[2]			
CMA[3] at Cape Ay-Todor, UA			
CMA at Cape Atlesh, UA			
CMA at Cape Chauda, UA			
CMA at Cape Fiolent, UA			
CMA at Cape Karangat, UA			
CMA at Cape Lucull, UA			
CMA at Cape Plaka, UA			
CMA at Mt Ayu-Dag, UA			
CMA at rock Diva and Mt. Koshka, UA			
CMA at the coastal landslide Dzhangul, UA			
CMA at the Tauric Chersonesos Reserve, UA			
CMA at the mountain range Karaul-Oba, UA			
CMA between Laspi Bay and Cape Sarych, UA			
CMA between the urban village Novyi Svet and town Sudak, UA			
CMA between the villages Solnechnogorskoye and Malorechenskoye, UA			
Meganom Peninsula, UA			
TOTAL			

DIAGRAMS

ANNEX 3. INTERNATIONAL CONVENTIONS AND AGREEMENTS ON THE PROTECTION OF BIODIVERSITY

GLOBAL

The Convention on Wetlands of International Importance (Ramsar Convention); Ramsar, 1971;
http://www.ramsar.org

The Convention Concerning the Protection of the World Cultural and Natural Heritage; Paris, 1972;
http://whc.unesco.org

The Convention on Biological Diversity (CBD); Rio de Janeiro, 1992;
http://www.cbd.int

The Global Strategy for Plant Conservation (GSPC); The Hague, 2002;
http://www.iucn.org

EUROPE

Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention); Bern, 1979;
http://conventions.coe.int/treaty/en/treaties/html/104.htm

European Conservation Strategy; Brussels, 1990;
http://www.coe.int

The Pan-European Biological and Landscape Diversity Strategy (PEBLDS); Sofia, 1995;
http://www.peblds.org/

The Agreement on the Conservation of Cetaceans of the Black Sea, the Mediterranean Sea and the contiguous Atlantic area (ACCOBAMS); Monaco, 1996;
http://www.accobams.org

Pan European Ecological Network (PEEN or EECONET); Strasbourg, 1997;
http://www.eeconet.org/eeconet/index.html

The European Landscape Convention (Florence Convention); Florence, 2000;
http://www.coe.int

Natura 2000 Networking Programme (NNP), Council of Europe, 2000;
http://www.natura.org

European Plant Conservation Strategy; Czech Republic, 2001;
http://www.plantaeuropa.org

THE BLACK SEA

The Convention on the Protection of the Black Sea Against Pollution (Bucharest Convention); Bucharest, 1992;
http://www.blacksea-commission.org

Strategic Action Plan for the Environmental Protection and Rehabilitation of the Black Sea; Sofia, 2009;
http://www.blacksea-commission.org/_bssap2009.asp

GLOSSARY

ABRASIVE COAST – high steep receding coast of a sea, ocean or other water body exposed to and destroyed by continuous corrosive attack of the surf

ACCUMULATIVE COAST – advancing coast of a sea, ocean, lake or reservoir composed of sediments brought with waves and surf

ACUMINATE – tapered gradually to a long pointed tip; a reference to leaf apices or filaments

ACUTE – ending in a sharp point, forming an angle of less than 90 degrees

AGAR – a phycocolloid occurring in the cell walls and intercellular spaces of different red algae; chemically, agar is a sulfated polysaccharide

AGAROSE – one of two separable components of agar found in some red algae; has a remarkable gelling property

AIR VESICLE (air-bladder) – a small bladder containing a variety of gases (nitrogen, oxygen and carbon dioxide) and aiding in the buoyancy of certain plants (e.g. brown algae)

ALGA (*pl.* algae) — a lower plant that reproduces by spores; algae lack true vascular tissues, flowers, and seeds

ALTERNATELY BRANCHED – a pattern of branching in which one branch appears on one side of the stalk and, farther up, the next branch appears on the opposite side, alternating back and forth up the stalk

ANNUAL – living one year or less, during which time the life history is completed; also meaning, yearly or of a year's growth

ANTHERIDIUM (*pl*. antheridia) – a haploid structure or organ producing and containing male gametes

ANTIOXIDANT – a molecule capable of inhibiting the oxidation of other molecules; may be of natural origin and also laboratory-synthesized

APEX – pertains to the tip, distal end, or terminal part (adj. apical)

APICAL – located at the tip or highest point

ASEXUAL REPRODUCTION – the reproduction without the involvement of originated fertilization, usually by diploid spores, propagation by division, stolons, etc.

ASSOCIATION – the major taxon in classification of vegetation

AUTOCHTHONOUS – native or indigenous (referring to an organism or a species)

AXIAL CELL – the central cell of an axis, sometimes being distinguishable among medullary cells in transverse section

AXIL – the angle between the axis and any organ or structures

AXIS (*pl.* axes) – a stem-like stalk on which parts or structures are arranged, a line or point forming the center of an object

BAS – biologically active substance(s); a substance having pronounced physiological activity and producing either stimulatory or inhibitory impact on in vivo or in vitro biological processes

BASAL – belonging to or attached to a base; also towards the base or point of attachment

BENCH – a submarine slope or its part generated by abrasive processes in the parent material adjacent to a cliff's basement

BENTHOS – the organisms which live on, in, or near the seabed or sea bottom

BIFURCATION – the splitting into two parts

BIOTOPE – the physical habitat with its associated, distinctive biological communities

BISEXUAL – the condition in which the same thallus produces both male and female gametes

BLADE – a flat, leafy portion of a plant; part of a thallus that is erect and essentially flattened or leaf-like

BRANCHLET – a small secondary or higher-order branch, usually the ultimate branch in a system of branching (ramulus)

CALCIFIED – involving deposition of calcium carbonate in or on cell walls of the thallus; encrusted or impregnated with calcium carbonate (lime)

CARRAGEENAN – polysaccharide obtained from red algae, having commercial significance and use

CARTILAGINOUS – firm, tough, and elastic when living; also gristly or having a tough (hard) texture, rather like cartilage

CLAVATE – wedge-shaped or club-shaped, elongated, with a gradual increase in diameter increasing abruptly near apex

CLIFF – coastal highwall that limits the coastal terrace from the dry land

COASTAL ZONE – the space in which land-based activities and terrestrial environments influence the marine environment and vice versa

COMMUNITY – the aggregate of autotrophic and heterotrophic organisms within the limits of a uniform ecotope; often used as a synonym of biocenosis

CONJUGATION – fusion of usually similar gametes; also coupled, joined, or connected

CONTINENTAL SHELF – the seabed adjacent to a continent to depths of around 200 m, or where the continental slope drops steeply to the ocean floor (the legislation defines it as "the sea bed and subsoil of the submarine areas adjacent to the coast...to a depth of 200 m")

CORTEX – the outer tissue of a thallus (with or without an enclosing epidermis) that contains photosynthetic pigments

CORTICATED – having a cortex or an outer coating of cells, rhizoids, etc. arising from cortical cells, often by secondary growth of an axis

DECUMBENT – prostrate and curving upwards; growing horizontally but with extremities ascending; also creeping or growing parallel to the substratum

DICHOTOMOUS – forking equally, bearing two equal branches at each branch point; bifurcate

DISCOID – disc-like or in the form of a disc; also being circular in outline and having thick, blunt edges

DRUPELET – fleshy fruit derived from a single carpel, usually containing a single seed

ENDEMIC – a native organism restricted to a particular area or geographical location

EPILITHTIC – an organism growing on stone, rock, or hard substate

EPIPHYTE – a plant growing on the outside of another plant in a non-parasitic relationship (air plant); a plant epibiont

EPIZOIC – an organism living on the surface of an animal, sometimes being specifically associated

ERECT – upright or growing upwards away from a substratum

ESSENTIAL AMINO ACIDS – amino acids that cannot be synthesized by human or animal organisms

FILAMENT – a plant or branch composed of a linear group of cells joined at their walls, also a chain of cells forming a hair-like strand

FLOWERING PLANT – a plant which ovules and then seeds, developing within an enclosed ovary

FROND – a leaf-like or erect portion of a thallus; often used to define the entire erect portion of a foliaceous or foliose thallus other than the attachment structure

GALL – an abnormal swelling of plant tissue caused by another microorganism, organism, or an external injury

GAMETES – the sexual male and female cells, each gamete is haploid, has only single set of chromosomes

GAMETOPHYTE – the haploid phase of algae that undergo alternation of generations, with each of its cells containing only a single set of chromosomes

GLOBOSE – globe-shaped; nearly spherical, like a ball, or being rounded in shape

HABITAT – the local environment or the place in which a plant or animal lives; for marine environments it is defined according to geographical location, physiographic features and the physical and chemical environment

HAIR – a colorless, typically elongate, unicellular or multicelular structure; also a unicellular or multicellular filament growing from the surface of a thallus, often deciduous

HEMICELLULOSES – a branched polysaccharide, consists of shorter chains of sugar units

HIGHER PLANTS – the group seed-bearing plants which have vegetative (stem, leaf, root) and reproductive organs

HOLDFAST – the attachment organ of a seaweed; a root-like, single cell or group of cells that anchors an alga to the substratum

INFLORESCENCE – a group or arrangement of flowers on a plant

IRREGULARLY BRANCHED – disordered arrangement of branches on a plant

KEKUR – a natural pillar- or cone-like rock, commonly located in rivers, seas or on their shores; a stack

LAGOON – a shallow body of coastal salt water (from brackish to hypersaline) partially separated from an adjacent sea by sand banks or shingle, or, less frequently, by rocks

LATERAL – at, from, or towards the side (edge); an axis formed as a branch from the main axis or from another lateral axis

LEAF – in vascular plants, the vascularized appendage originating from the stem; in algae, the flattened part of the axis

LEAF SHEATH – the lower portion of a leaf which clasps the stem; one of the wing-like extensions to the margins of the petiole which wrap around and enclose the stem

LECTINS – carbohydrate-binding proteins (i.e. glycoproteins) found in seaweeds and a wide variety of other life-forms; they are of potential economic importance as topical drug delivery systems

LIFE CYCLE, OR LIFE HISTORY – a period involving all different generations of a species succeeding each other through means of reproduction, whether through asexual reproduction or sexual reproduction

LIGULE – a projection at the base of a leaf blade (e.g. in grasses)

LINEAR – long and narrow, with parallel margins; also slightly broader than filiform

LITTORAL –the area of the shore (intertidal zone) that is occupied by marine organisms which are adapted to or need alternating exposure to air and wetting by submersion, splash or spray; it is divided into subzones

LOWER PLANTS – common name for algae, fungi, lichens, the group of simply organized organisms, and their body is a thallus

MACROSCOPIC PLANT – a plant large enough to be seen by the unaided eye

MEDITERRANIZATION – the phenomenon under which species of the Mediterranean origin overcome ecological barriers in the Turkish Straits and penetrate into the Black Sea, that can be due to the global climate and environment changes, including eutrophication

MERISTEM – the tissue in growth zones of plants that consists of undifferentiated cells (meristematic cells)

MICROSCOPIC PLANT – a plant too small to be reliably observed without the aid of a microscope

MPA – marine protected area, any area of the marine environment that has been reserved by federal, state, territorial tribal or local laws or regulations to provide lasting protection for part or all the natural and cultural resources therein

NODE – the site on an axis from which blades and/or branches arise, with rings being formed at the junction of each successive axial cell

OOGONIUM (*pl.* oogonia) – a single celled female gametangium; also a swollen cell containing one or more ova or eggs

OPPOSITE – referring to a leaf or/and branch arrangement where two leaves or branches arise at the same position at a single node but on reverse sides of the stem; also referring to locations in the same transverse line but removed by 180° on an axis

PEDUNCLE – a stalk bearing a group of organs (inflorescence); a peduncle is larger than a pedicel

PERENNIAL – a plant living for three or more years

PERIANTH – the outer envelope of a flower, consisting of either the calyx or the corolla, or both

PERIPHYTON – a mixed complex of algae, cyanobacteria, heterotrophic microbes, etc. that is attached to submerged surfaces in most aquatic ecosystems

PHYCOCOLLOIDS – a colloidal substance obtained from seaweeds (e.g. agar, carrageenan, laminarin) and composed of high-molecular weight polymers of simple sugars; used commercially for its stabilizing, thickening and gelling properties

PHYLUM (*pl.* phyla) – a major taxonomical division representing a separate evolutionary line of plant

PHYTOCENOSIS – the assemblage of plants sharing the same habitat and developing special interrelations within a homogeneous ecotope

PINNATE – having branchlets set closely together on opposite sides of the main axis, arranged like the plumes of a feather

PLANE – a smooth flat surface or with growth in one plane, resulting in a two-dimensional structure

POLYSIPHONOUS – a compound column consisting of many adnate tubes

PROLIFICATION – an outgrowth on the surface of thallus; also the production of extensive terminal and/or lateral branches

PROSTRATE – lying flat upon the substratum; also growing along (parallel) and often adherent to the substratum

PSEUDODICHOTOMOUS – forming two unequal branches, or having two equal branches at branch points but with one being derived from a lateral branch

PSEUDOLITTORAL – in the seas with the absent tidal cycle, the portion of the shore exposed under the impact of blowing winds, sea currents, periodical or cyclical non-tidal fluctuations of the sea level

PUFA – polyunsaturated fatty acids; remarkable for highest bioactivity, they are the precursors of biosynthesis of some hormone-like substances (prostaglandins)

RAMULUS – a little branch or branchlet; usually applied to the ultimate (final) division of a branching frond, as well as a small or secondary branch

RECEPTACLE – a fertile area (branch or branchlet) on which gametangia or sporangia are formed

RHIZOID – a decurrent intercellular filament, arising in the proximal part of a thallus; also a unicellular or uniseriate root-like filament serving for attachment

RHIZOME – a prostrate, thickened axis which allows vegetative (asexual) propagation; in flowering plants, a true rhizome is an underground stem usually growing horizontally

RIM – an encircling belt, girdle or fascia on some part of a plant

ROOT — the part of a vascular plant that typically grows downward into the soil and serves to anchor the plant

SALINITY – a measure of the total quantity of dissolved solids in water (‰), expressed as parts per thousand

SEAWEED – a macroscopic marine alga (non-vascular plant)

SEDIMENTS – particulate matter that has settled to the bottom, including deposits of mud, sand, and gravel

SEGMENT – one of several clear portions of division of an organism, such as a unit of a jointed column, or the portions (divisions) of a thallus between points of branching

SEICHE – a standing wave in an enclosed or partially enclosed body of water on lakes, reservoirs, swimming pools, bays, and seas

SEXUAL REPRODUCTION – the creation a new organism by meiosis or fertilization, involving the fusion of sexual gametes

SIPHON – long tubular cell along the central axis of thallus

SIPHONOUS – consisting of a single or many rows of cells, with or without cortication but without periaxial cells

SPATHE – a large bract that completely ensheaths the base of an inflorescence

SPHERICAL – in the shape of a sphere or globe; ball-shaped or rounded

SPICULES – a needle-like scale or bristle

SPIT – a type of bar or beach; one end connects the (sand) spit with dry land, the far end goes into the (sea) water

SPORES – microscopic germs of algae, bacteria, fungi having diploid set of chromosomes, produced asexually or, less often, sexually and providing species reproduction

SPOROPHYTE – asexual generation of algae with diploid set of chtomosomes

STALK – any stem-like supporting cell; also the unexpanded, basal part of a leaflet

STEM – one of two main structural axes of a vascular plant; stem is normally divided into nodes and internodes, the nodes hold buds which grow into one or more leaves, inflorescence (flowers), cones or other stems

STIPULES – outgrowths borne on either side of the base of a leafstalk (petiole); morphologically variable and might appear as glands, scales, hairs, spines, or laminar (leaf-like) structures

STOLON – a horizontal branch or portion of plant axis usually occurring at ground level and serving for lateral growth

STYLOID – long and tapered, like a pen or stylus

SUBLITTORAL– the seawater zone exposed to air only at its upper limit

SUBULATE – awl-shaped or like a shoemaker's awl; tapering from a narrow or moderately broad base to a very fine point

SUPRALITTORAL – the surf zone, which is splashed but is not submerged by seawater, that adjoins the deeper littoral zone of the sea

SURCULUS – a young shoot, sprout, branch, or sucker; a runner that attaches a plant to the substratum, as well as supports erect shoots

SYNUSIA (*pl.* synusiae) – a group of species with similar life forms and ecological requirements; an independent structural part of a phytocenosis

TAXON (*pl.* taxa) – using for the taxonomical classification (e.g. species, genus, family, etc.)

TERETE – like a slender, tapering cylinder, and more or less circular in any cross-section

THALLUS – an algal body with no differentiation into true roots, stems or leaves

TRICHOTOMOUS – divided into three parts; bearing three branches at each branch point; also a condition in which an axis branches into three lobes of equal status

TUBULAR – hollow and cylindrical; pipe-like

TUFT – a cluster of filaments, branches or branchlets attached at a single basal point; a small cluster (bunch) of elongated (flexible) and erect filaments that are close together at the base

TURF – a dense-growing, short, thick intertwined mat of small plants like a lawn; it is especially common in exposed habitats

VEGETATIVE PROPAGATION – a form of asexual reproduction, formation of a new plant by the separation of a small part, often by breakage without the formation of specialized reproductive structures

VEIN (*pl*. veins) – a small branch from a midrib; parallel (radiating) thickenings or differentiated cell rows in blade or flattened axis; also small linear thickenings of the frond that resemble the veinings of leaves

WHORL – three or more branches arising from a single node on a stalk, appearing as spokes of a wheel (adj. verticillate)

ZYGOTE – the initial cell formed when a new organism is produced by means of sexual reproduction; a zygote is synthesized through fusion of male and female gametes

TAXONOMIC INDEX

REFERENCES

Abbott, I.A. (1996) Ethnobotany of seaweeds: clues to uses of seaweeds. Hydrobiologia 326/327: 15-20.

Anggadiredja, J. (1995) The Indonesian seaweeds natural products. Proceedings International Conference on the use of traditional medicine and other natural products in health care, Malaysia (6, 1993, Penang), 290-297.

Apryshko, G.N., Nekhoroshev, M.V., Ivanov, V.N. and Milchakova, N.A. (2005) Antitumor substances from marine macroalgae of the Mediterranean Basin. Algologiya, 15(4): 485-488 (in Rus.).

Aysel, V., Erduğan, H. (1995) Checklist of Black Sea seaweeds. Tr. J. of Botany 19: 545-554.

Aysel, V., Erduğan H., Dural Tarakçı B. and Okudan E.Ş. (2005) Marine algae and seagrasses of Giresun shores (Black Sea, Turkey). J. Black Sea/Mediterranean Environment, 11: 241-255.

Bixler, H.J., Porse, H. (2010). A decade of change in the seaweed hydrocolloids industry. J. Appl. Phycology (published online 22 May 2010).

Black Sea Biological Diversity. Romania (1997), comp. A. Petrana. New York, Unit. Nat. Publ., Black Sea Environ. Ser., 4, pp. 1-245.

Black Sea Biological Diversity. Ukraine (1998), comp. Zaitsev, Yu.P. and Alexandrov, B.G. New York, Unit. Nat. Publ., Black Sea Environ. Ser., 7, pp. 1-351.

Blinova, E.I. (2007) Seaweeds and seagrasses of the European part of Russia (flora, distribution, biology, resources, mariculture). Moscow, VNIRO Press, pp. 1-114 (in Rus.).

Bologa, A.S. (2001) Recent changes in the Black Sea ecosystem. Ocean Yearbook 15: 463-474.

Boudouresque, C.F., Cadiou, G. and Le Direach, L. (2005) Marine protected area. A tool for coastal areas management. In: Strategic management of marine ecosystems, Levner, E., Linkov, I. and Proth, J.M. (eds.). Netherlands, Springer Publ., 29-52.

Boyko, L.I., Mikulich, D.V. and Antsupova, L.V. (2006) Biochemical potential of macrophytes. In: The northwestern Black Sea: Biology and Ecology. Kiev, Naukova Dumka Publ., 524-528 (in Rus.).

Burrows, E.M. (1991) Seaweeds of the British Isles. Vol. 2 Chlorophyta. British Museum (Natural History), London HMSO, pp. 1-238.

Commercial algae of the USSR: The Guide (1971) Voszhinskaya, V.B., Tsapko, A.S., Blinova, E.I, Kalugina, A.A. and Petrov, Yu.E. (eds.). Moscow, Pischevaya promyshlennost, pp. 1-270 (in Rus.).

Constanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P. and van den Belt, M. (1997) The value of the world's ecosystem services and natural capital. Nature 387: 253-260.

den Hartog, C. (1970) The sea-grasses of the World. Amsterdam, North-Holland Publication Company, pp. 1-275.

den Hartog, C. and Phillips, R.C. (2001). Common structures and properties of seagrass beds fringing the coasts of the world. In: Ecological comparisons of sedimentary shores, Reise, K. (ed.), Chap. 9. Berlin, Springer-Verlag, 195-212.

Dimitrova-Konaklieva, S.D. (2000) Flora of the marine algae of Bulgaria (Rhodophyta, Phaeophyta, Chlorophyta). Sofia - Moscow, Pensoft Publ., pp. 1-306 (in Bulgarian).

Dixon, P.S. and Irvine, L.M. (1977) Seaweeds of the British Isles. Vol. 1 Rhodophyta. Part 1: Introduction, Nemaliales, Gigartinales. British Museum (Natural History), London HMSO, pp. 1-252.

Dumont, H.J. (ed.) (1999) Black Sea Red Data Book. Ghent, Belgium, pp. 1-413.

Dzhaoshvili, Sh.V. (1989) Role of river floods in the coastal dynamics. Izvestiya AN SSSR. Ser. Geography, 4: 92-97.

Evstigneyeva, I.K. (2005) The morphostructure of Black sea *Laurencia* spp. (Rhodophyta) and its variability. Algologiya 15(1): 28-43 (in Rus.).

Genhai, Z. (1998) Study on the resource of marine pharmaceutical algae and its applications in Nanji Islands Marine Nature Conservation Area. Donghai-Mar. Sci. 16(2): 63-68 (in Chinese).

Gönlügür Demirci, G., and Karakan, İ. (2006) Seagrass distribution in coast of Sinop (Middle Black Sea). Turk. Bot. J. 4: 201-211.

Gromov, V.V. (2007) Seasonal dynamics of dominant algae in seaweed communities of the Black Sea. In: Ecosystem investigations of the Sea of Azov, the Black and Caspian seas and their coasts. Russian Ac. Sci., Apatity, KNC MMBI, UNC, 107-129 (in Rus.).

Haynes, R.R. and Hellquist, C.B. (2000) Potamogetonaceae Dumortier. In: Flora of North America north of Mexico, 22: Magnoliophyta: Alismatidae, Arecidae, Commelinidae (in part) and Zingiberidae: Flora of North America Editorial Committee (eds.), New York, Oxford, 47-74.

Hudson, J.B., Kim, J.H., Lee, M.K., DeWreede, R.E. and Hong, Y.K. (1999) Antiviral compounds in extracts of Korean seaweeds: evidence for multiple activities. J. Appl. Phycol. 10: 427-434.

Irvine, L.M. (1983) Seaweeds of the British Isles. Vol. 1 Rhodophyta. Part 2A Cryptonemiales (sensu stricto), Palmariales, Rhodymeniales. British Museum (Natural History), London HMSO, pp. 1-115.

Irvine, L.M. and Chamberlain, Y.M. (1994) Seaweeds of the British Isles. Vol. 1 Rhodophyta. Part 2B Corallinales, Hildenbrandiales. British Museum (Natural History), London HMSO, pp. 1-276.

Kalugina-Gutnik, A.A. (1975) The phytobenthos of the Black Sea. Kiev, Naukova Dumka Publ., pp. 1-246 (in Rus.).

Kalugina-Gutnik, A.A. (1979) Macrophytobenthos. In: The fundamentals of biological productivity in the Black Sea. Kiev, Naukova Dumka Publ., 123-142 (in Rus.).

Kalugina-Gutnik, A.A. and Evstigneyeva, I.K. (1993) Morphobiological and production characteristics of *Phyllophora nervosa* and *Ph. brodiaei* of Zernov *Phyllophora* field in 1986 and 1989. Ecologiya Morya 44: 70-80 (in Rus.).

Kalugina-Gutnik, A.A. and Mironova, N.V. (1987) The seasonal dynamics of growth of the red alga *Gracilaria verrucosa* in the Black Sea. Biologiya Morya 4: 53-61 (in Rus.).

Kamenarska, Z., Serkedjieva, J., Najdenski, H., Stefanov K., Tsvetkova I., Dimitrova-Konakliyeva S. and Popov S. (2009) Antibacterial, antivirusal and cytotoxic activities of some red and brown seaweeds from the Black Sea. Botanica Marina 32: 80-86.

Khailov, K.M., Prazukin A.V., Kovardakov, S.A. and Rygalov, V.E. (1992) Functional morphology of marine algae. Kiev, Naukova Dumka Publ., pp. 1-280 (in Rus.).

Klochkova, N.G. and Berezovskaya, V.A. (1997) Algae of the Kamchatka Shelf: distribution, biology and chemical composition. Vladivostok, Petropavlovsk-Kamchatskiy, Dalnauka Publ., pp. 1-154 (in Rus.).

Kolomyichuk, T.V., Syomik, L.I., Tkachenko, F.P. and Gladky, T.V. (2003) The adaptogenic activity of algal extracts: the renewal of peripheric blood in rats under persistent stress. Bulletin of ONU 8(1): 197-206 (in Ukrainian).

Kostenko, N.S., Evstigneyeva, I.K. and Dikiy, E.A. (2004) Macrophytic plants. In: Karadag, hydrobiological investigations. Simferopol, SONAT, 152-165 (in Rus.).

Kuda T., Tsunekawa M., Hishia T., and Araki Y. (1984) Screening of marine algae from the French Mediterranean coast for antibacterial and antifungal activity. Botanica Marina 27 (8): 381-386.

Kuo, J. and den Hartog, C. (2001) Seagrass taxonomy and identification key. In: Global seagrass research methods, Short, F.T. and Coles, R.G. (eds.). Amsterdam, Elsevier Science B.V., 5-30.

Lakshmi V., Goel A.K., Srivastava M.N., Kulshreshtha D.K., Raghubir, R. (2006) Bioactivity of marine organisms: Part IX - Screening of some marine flora from the Indian Coasts. Indian J. of Exp. Biology 44(02): 137-141.

Littler, D.S., Littler, M.M., Bucher, K.E. and Norris, J.N. (1989) Marine plants of the Caribbean. Washington, Smithsonian Institution, pp. 1-263.

Littler, M.M. and Littler, D.S. (1980) The evolution of thallus form and survival strategies in benthic marine algae: field and laboratory tests of a functional form model. Amer. Naturalist 116(1): 25-44.

Littler, M.M., Littler, D.S. and Brooks B.L. (2010) Marine macroalgal diversity assessment of Saba Bank, Netherlands Antilles. Plos One 5(5): e10677.

Maggs, C.A. and Hommersand, M.H. (1993). Seaweed of the British Isles. Vol. 1 Rhodophyta. Part 3A, Ceramiales. British Museum (Natural History), London HMSO, pp. 1-444.

Maslov, I.I., Sarkina, I.S., Belich, T.V. and Sadogurskyi, S.E. (1998) Annotated catalogue of algae and fungi of «Cape Martiyan» Nature Reserve. Yalta, Nikitsky Botanical Garden Press, pp. 1-31 (in Rus.).

Maximova, O.V. and Luchina, N.P. (2002) Modern state of macrophytobenthos of the north Caucasian coast: a response to eutrophication of the Black Sea basin. In: Multidisciplinary studies of the northeastern part of the Black Sea. Moscow, Nauka Publ., 297-308 (in Rus.).

Maximova, O.V. and Rybnikov, P.V. (1993) Morphological diversity of attached *Phyllophora nervosa* (D.C.) Grev. from the northeastern Black Sea: the problems of classification. In: Biology of the Black Sea agarophytes: *Phyllophora nervosa* (D.C.) Grev. Moscow, IO RAN Press, 25-38 (in Rus.).

McHugh, D. J. (2003) A guide to the seaweed industry. FAO fisheries technical paper 441, Food and Agriculture Organization of The United Nations, Rome, pp. 1-121.

Milchakova, N.A. (1996) On the communities of *Zannichellia major* Boenn. in the Kerch Strait (Black Sea). Gydrobiologicheski zhurnal 32(5): 14-18 (in Rus.).

Milchakova, N.A. (1999) On the status of seagrass communities in the Black Sea. Aquatic Botany 65: 21-32.

Milchakova, N.A. (2002) Fucophyceae of the Black Sea: taxonomic composition and distribution. Intern. J. on Algae 4(4): 53-68.

Milchakova, N.A. (2002) New species of macroalgae in the Black Sea flora. Ekologiya Morya 63: 19-24 (in Rus.).

Milchakova, N.A. (2003) Macrophytobenthos. In: Modern condition of biological diversity in the near-shore zone of the Crimea (the Black Sea sector), Eremeyev, V.N. and Gayevskaya, A.V. (eds.). Sevastopol, EKOSI-Gidrophizika Press, 152-208 (in Rus.).

Milchakova, N.A. (2003) Seagrasses of the Black, Caspian and Aral Seas and the Sea of Azov. In: World Atlas of Seagrasses. Berkeley, Univ. of California Press, 59-64.

Milchakova, N.A. (2003) Systematic composition and distribution of Black Sea green macrophytes (Chlorophyceae Wille s.l.). Intern. J. on Algae 5(1): 45-58.

Milchakova, N.A. (2005) Red algae (Rhodophyta, Rhodophyceae) of the Black Sea. Taxonomic composition and distribution. Intern. J. on Algae 7(4): 334-354.

Milchakova, N.A. (2007) The regional aspects of the phytodiversity of Black Sea macrophyte flora. Morskoi ecologichesky zhurnal 1(1): 44-54 (in Rus.).

Milchakova, N.A. (2008) Role of marine protected areas in the conservation of the Azov-and-Black sea region biodiversity. Proc. IV Int. Conf.: Present aspects of the ecology of the Azov and Black sea region (10, 2008, Kerch), Kerch, 162-168 (in Rus.).

Milchakova, N.A., Aysel, V. and Erduğan, H. (2006) The taxonomic structure and distribution of red algae (Rhodophyceae excl. Ceramiales) in the Black Sea. Algologiya 16(2): 227-245 (in Rus.).

Milchakova, N.A. and Phillips, R.C. (2003) Black sea seagrasses. Marine Pollution Bulletin 46(6): 695-699.

Milchakova, N.A. and Shakhmatova, O.A. (2007) The catalase activity of the common Black sea macroalgae in the marine pollution area. Morskoi ecologichesky zhurnal 6(2): 44-57 (in Rus.).

Mironova, N.V. (2000) The morpho-biological description and occurrence of *Gracilaria verrucosa* (Huds.) in the Black Sea. Ecologiya Morya 50: 48-52 (in Rus.).

Mironova, N.V. (2000) The morpho-biological description and distribution of *Gracilaria dura* (Ag.) J. Ag. in the Black Sea. Ecologiya Morya 51: 63-67 (in Rus.).

Morozova-Vodyanitskaya, N.V. (1959) Aquatic plant associations in the Black Sea. Proc. Sevastopol Biol. Station 11: 3-28 (in Rus.).

Mosyakin, S.L. and Fedoronchuk, M.M. (1999) Vascular plants of Ukraine: a nomenclatural checklist. Kiev, N.G. Kholodny Inst. of Botany, pp. 1-346.

Munda, I.M. (1990) Resourses and possibilities for exploitation of North Adriatic seaweeds. Hydrobiologia 204/205: 309-315.

Nagai, T. and Yukimoto, T. (2003) Preparation and functional properties of beverages made from sea algae. Food Chemistry 81: 327-332.

Noda, H., Amano, H., Arashima, K., Hashimoto, S. and Nisizawa, K. (1989) Studies on the antitumour activity of marine algae. Nippon Suisan Gakkaishi: Formerly Bull. Japan. Soc. Sci. Fish. 55(7): 1259-1264.

Novaczek, Ir. (2001) A Guide to the common edible and medicinal sea plants of the Pacific Islands. Community Fisheries Training Pacific Series, University of the South Pacific, Secretariat of the Pacific Community, 3A, pp. 1-48.

Oguz, Temel (ed.). (2008) State of the environment of the Black Sea (2001 - 2006/7), Publications of the Commission on the Protection of the Black Sea against Pollution. Black Sea Commission (BSC) 2008-3. Istanbul, Turkey, pp. 1-448.

Ovodov, Yu.S. (1998) Polysaccharides of flowering plants: structure and physiological activity. Bioorganicheskay Khimiya 24(7): 483-501 (in Rus.).

Perestenko, L.P. (1994) Red algae of the seas of the Russian Far-East. St. Petersburg, Olga Publ. House, pp. 1-332 (in Rus.).

Phillips, R.C. and Durako, M.J. (2000) Global status of seagrasses. In: Seas at the Millenium: an environmental evaluation, Sheppard, C.R.C. (ed.). Vol. III: Global Issues and Processes, Chap. 107. Amsterdam, Elsevier Science B.V., pp. 1-16.

Phillips, R.C. and Meñez, E.G. (1988) Seagrasses. Smithsonian Contributions to the Marine Sciences, 34, pp. 1-104.

Phillips, R.C. and Milchakova, N.A. (2003) Seagrass ecosystems. Morskoi ecologichesky zhurnal 2(2): 29-39.

Phillips, R.C., Milchakova, N.A. and Alexandrov, V.V. (2006) Growth dynamics of *Zostera* in Sevastopol Bay (Crimea, Black Sea). Aquat. Bot. 85: 244–248.

Popov, D., Naidenova, E., Koparova-Pavlova, I., Dimitrova-Konaklieva, St. and Dryanovska-Nonetska, L. (1985) Pre-screening data about cytotoxic impact of aquatic extracts of marine algae and higher plants. Pharmacy 35(4): 10-14 (in Bulg.).

Przhemenetskaya (Makienko), V.F. (2000) The Herbarium of marine algae. Vladivostok, Dalnauka Publ., pp. 1-101 (in Rus.).

Sava, D. (2006) Algae-macrophytes of the Romanian litoral zone of the Black Sea. Illustrative Gude. Constanţa, Ovidius University Press, pp. 1-148 (in Romanian).

Sburlea, A. and Bologa, S.A. (2006) Associated macroalgae of the perennial alga *Cystoseira barbata*, a key species at the Romanian Black Sea shore. Proc. National Conference on biodiversity and human impact on Black Sea and its littoral ecosystems, Scientific Annals of Al. I. Cuza University, Iasi, 41-46.

Taskin, E., Öztürk, M., Kurt, O. and Öztürk, M. (2008) The check-list of the marine flora of Turkey. Manisa, Turkey, pp. 1-87 (in Turkish).

The northwestern Black Sea: the biology and ecology (2006), Zaitsev, Yu.P., Alexandrov, B.G. and Minicheva, G.G. (eds.). Kiev, Naukova Dumka Publ., pp. 1-703 (in Rus.).

The Red Book of Ukraine. The world of plants (2009), Didukh, M.Ya. (ed.). Kiev, Globalconsulting Press, pp. 1-900 (in Ukr.).

Tsuda, R.T. and Abbott, I.A. (1985) Collection, handling, preservation and logistics. In: Handbook of phycological methods: Volume 4: Ecological field methods: Macroalgae (Vol. 4), Littler, M.M. and Littler, D.S. (eds.), London, Cambridge University Press, 67-86.

Usov, A.I. and Chischov, O.S. (1988) Chemical research of the algae. In: New in life, science and techniques, Ser. of Chemistry, 5. Moscow, Znanie Publ., pp. 1-48 (in Rus.).

Vekhov, V.N. (1992) Eelgrass (*Zostera marina* L.) of the White Sea. Moscow, Moscow State University Press, pp. 1-144 (in Rus).

Vilkova, O.Yu. (2005) Contemporary state of brown seaweed *Cystoseira* spp. stock in the Russian part of the Black Sea. In: Marine coastal ecosystems: seaweeds, invertebrates and products of their recycling. Proc. of the Second int. scientific-and-practical conf. (2, 2005, Archangelsk). Moscow, VNIRO Press, 20–23 (in Rus.).

Vinogradova, K.L. (1974) Ulva Algae (Chlorophyta) of the USSR seas. Leningrad, Nauka Publ. House, pp. 1-168 (in Rus.).

World Atlas of Seagrasses (2003), Green, E.P. and Short, F.T. (eds.). Berkeley, University of California Press, pp. 1-300.

Xia, B. and Abbott, I.A. (1987) Edible seaweeds of China and their place in the Chinese diet. Economic Botany 41(3): 341-353.

Zaharia, T, Micu, D., Todorova, V., Maximov, V. and Nita, V. (2008) The development of an indicative ecologically coherent network of marine protected areas in Romania. Constanta, Romart Design, pp. 1-32.

Zaika, V.E., Boltachev, A.R., Zuev, G.V., Kovalev, A.V., Milchakova, N.A. and Sergeeva, N.G. (2004) Floristic and faunistic changes of Crimean shelf of the Black Sea after 1995-1998. Morskoi ecologicheskiy zhurnal 3(2): 37-44 (in Rus.).

Zaitsev, Yu.P. and Mamaev, V. (1997) Marine biological diversity in the Black Sea. A study of change and decline. United Nations Publications, New York, pp. 1-208.

Zaitsev, V.P., Azhgikhin, I.S. and Gandel, V.G. (1980) Complex use of marine organisms. Moscow, Pischevaya promyshlennost, pp. 1-279 (in Rus.).

Zemke-White, W.L. and Ohno, M. (1999) World seaweed utilization: an end-of-century summary. J. of App. Phycology 11: 369-376.

Zenetos, A., Gofas, S., Verlaque, M., Cinar, M.E., García Raso, J.E., Bianchi, C.N., Morri, C., Azzurro E., Bilegenoglu, M., Frogilia C. et. al. (2010) Alien species in the Mediterranean Sea by 2010. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part I. Spatial distribution. Medit. Mar. Sci., 11/2: 381-493

Zenkovich, V.P. (1958) The morphology and dynamics of the Soviet coast of the Black Sea. Vol. 1. Moscow, Academia Nauk of USSR Publ., pp. 1-187 (in Rus.).

Zenkovich, V.P. (1960) Morphology and dynamics of the Soviet coast of the Black Sea. Vol. 2. Moscow, Academia Nauk of USSR Publ., pp. 1-216 (in Rus.).

Zernov, S.A. (1913) On study of life in the Black Sea. Reports of the Imperial Academy of Sciences, Ser., 7, 32(1), pp. 1-299 (in Rus.).

Zhirkov, I.A. (2010) Life on the bottom: bioecology and biogeography of benthos. Moscow, KMK Press, pp. 1-453 (in Rus.).

Zinova, A.D. (1967) Manual on green, brown and red algae of the southern seas of the USSR. Leningrad, Nauka Publ. House, pp. 1-400 (in Rus.).

Zubia, M., Fabre M.-S., Kerjean, V., Deslandes, E. (2009) Antioxidant and cytotoxic activities of some red algae (Rhodophyta) from Brittany coasts (France). Botanica Marina 52 (3): 268–277.

The general and scientific information from the next websites were also used:
http://www.algaebase.org
http://www.barunajaya.com
http://www.biogro.com.au
http://www.cmsdata.iucn.org
http://www.ecbsea.org
http://www.foodtech-international.com
http://www.headnet.ru
http://www.mpaglobal.org
http://www.nashkray.kiev.ua
http://www.npwrc.usgs.gov/resource/plants/pondweed/pondweed.html (Version 16JUL97)
http://www.oceanproduce.com
http://www.rusmedserv.com
http://www.seaweed.ir

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This illustrative field Guide describes marine plants and bottom vegetation of the Black Sea, its commercial use and protection, and the techniques applied towards preparing a seaweed herbarium. General information about the Black Sea and the habitats of marine plants are also included. The short articles about 74 common species of marine plants with information by morphology, ecology, distribution and commercial use are represented in taxonomic part; each species is illustrated with underwater photos.

Useful listings of the marine protected area in the Black Sea, international conventions and agreements on preservation of the biological and landscape diversity are provided in this book, as well as a list of regional experts, references and glossary. This Guide is intended for scientists, teachers, students, divers and tourists as a significant source for species identification of the Black Sea marine plants.

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