Marine Macroalgae in Qatar Marine Zone

Aisha A. Al Ashwal and Ekhlas M. M. Abdelbary

Abstract Marine macroalgae are referred to as seaweeds. They are aquatic organisms belonging to two kingdoms, Plantae and Chromista, a classification based on molecular phylogeny. It is estimated that there are 17,500 seaweeds worldwide with about 8000 Green algae, over 7000 Red algae, and more than 12,500 Brown algae. The study focuses on the distribution of seaweed species in the Arabian/Persian Gulf and Gulf of Oman. Of five hundred sixty-eight (568) algal species that have been recorded, one hundred thirty-nine (139) species belong to the Chlorophyta, three hundred three (303) belong to the Rhodophyta, and for the Ochrophyta one hundred six (126) species have been recorded.

The present study is based on numerous marine surveys carried out by the Environmental Science Centre (ESC, Qatar University) and includes handpicked from off sea detritus from beaches, algae found in marine sediments from various locations, and algae detected in undersea photography and video films in Qatar Marine Zone (QMZ). The distribution of specific taxa in other Gulf States was extracted from various relevant publications.

Keywords Macroalgae · Seaweeds · Distribution · Arabian/Persian Gulf · Gulf of Oman · Qatar Marine Zone · Green algae · Brown algae · Red algae

Abbreviations

°C	Degrees centigrade (Celsius)
AGEDI	Abu Dhabi Global Data Initiative
BBAR	Biodiversity Baseline Assessment Report (Bahrain)
CBD	Convention on Biological Diversity
CO_2	Carbon dioxide
ESC	Environmental Science Center, QU
Five Oceans	Five Oceans Environmental Services

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L. A. Jawad (ed.), *The Arabian Seas: Biodiversity, Environmental Challenges and Conservation Measures*, https://doi.org/10.1007/978-3-030-51506-5_15

GBIF	Global Biodiversity Information Facility
GDEWP	General Directorate for Environment and Wildlife Protection
GHG	Greenhouse gas emissions
Gulf	Arabian/Persian Gulf
Gulfs	Arabian/Persian Gulf and Gulf of Oman
km	Kilometer
km^2	Kilometer squared
m	Meter
m^2	Meter square
ppt	Parts per thousand
psu	Practical salinity unit (measure of seawater salinity/1 gm salt/ 1000 gm water)
QMZ	Qatar Marine Zone
QNV	Qatar National Vision 2030
QU	Qatar University
SARC	Scientific and Applied Research Center (now ESC)
SCENR	Supreme Council for the Environment and Natural Reserves
Syn(s)	Synonym(s)
UAE	United Arab Emirates
μ	represents one millionth, or 10^{-6}
μg/ml	Microgram per milliliter

1 Introduction

Algae are of two groups—unicellular organisms and multicellular organisms. The multicellular organisms are known as macroalgae. According to West et al. (2016), macroalgae are seaweeds, and these are the macrobenthic forms of a group of photosynthetic non-flowering plant-like organisms. Seaweeds, seagrasses, mangroves, and phytoplankton comprise the most important primary producers in the marine environment. Algae are organic matter at the base of the food chain, as important primary producers and afford oxygen for other aquatic life; they equally participate to mass mortality of other organisms such as fish in cases of algal blooms.

Macroalgae are distributed global in both marine and freshwater bodies and in moist wetlands. Vié et al. (2009) estimated that there are 13,078 seaweeds worldwide with 3962 Green algae, over 6076 Red algae, and more than 3040 Brown algae. Brodie et al. (2010) reported approximately 10,500 seaweeds worldwide with 1500 Green algae, over 7000 Red algae, and more than 2000 Brown algae. Guiry (2012) estimated that there are 17,500 seaweeds worldwide with about 8000 Green algae, over 7000 Red algae, and more than 12,500 Brown algae.

Phytoplankton are microscopic algae, and seaweeds are macroalgae, which can be quite large. Kelps, for example, are marine seaweeds that can exceed 50 m in length. The thalloid body of macroalgae comes in a variety of forms, although, typically, it consists of a holdfast, a stipe, blades, and simple reproductive structures, but they do not have leaves or vascular tissue, true stems, and roots.

Seaweeds are grouped into three based on their dominant photosynthetic pigments. The Green algae (Chlorophyta) possess chlorophyll a, b, β-carotene, and xanthophylls and are usually more delicate than the other seaweeds and distinctly green in color. The Brown algae (Phaeophyta) possess chlorophyll a, c1, c2, β-carotene, fucoxanthin, and xanthophylls as well as carotenoids, which collectively give them an olive-green or brownish color. The Red algae (Rhodophyta) possess chlorophyll a, b, R-phycoerythrin, R-phycocyanin, α- and β-carotene, and xanthophylls which collectively portray a wide range of colors from red to almost black. Occasionally, they become light brown or yellowish due to strong sunrays and wrongly identified as Brown algae. However, the lower parts remain dark and the upper parts lighter in color; dark bases are indicative of Red algae (Hiscock 1979).

Since seaweeds are aquatic photosynthetic organisms utilizing light as a source of energy, their position in the water body is restricted to depth reached by sunlight. Accordingly, their distribution is in the shallow coastal zones and found from the intertidal to shallow subtidal zones. Seaweeds occur in a variety of habitats including coral reefs, stony rubble, and many solid bases on which they fix their holdfasts. Few may be exposed temporary by wave action in wave-exposed areas along the shore or on the edge of the reef. Many other species grow in the intermediate environments on various types of substrates (Trono 1998).

1.1 Classification of the Macroalgae

In the earlier system of classification of two kingdoms for the living organisms, the algae were included in the Plant Kingdom. In later classifications, organisms that are photosynthetic and where an embryo is the result of sexual reproduction are plants. Where the organisms are photosynthetic and the result of the fusion of the gametes is a zygote, these collectively referred to as the algae. The algae together with many other groups were placed in the broad-spectrum Kingdom Protista.

Fritsch (1975) recognized 11 algal classes: Chlorophyceae, Xanthophyceae, Chrysophyceae, Bacillariophyceae, Cryptophyceae, Dinophyceae, Chloromonadineae, Euglemineae, Phaeophceae, Rhodophycea and Myxophyceae.

Van Den Hoek et al. (1997) recognized 3 algal phyla, the Chlorophyta, the Rhodophyta, and the Heterokontophyta with a total of 21 classes; 9 belonging to the Chlorophyta (Bryopsidophyceae, Chlorophyceae, Cladophorophyceae, Charophyceae, Trentepohliophyceae, Klebsormidiophyceae, Prasinophyceae, Ulvophyceae, and Zygnematophyceae); 2 belonging to the Rhodophyta (Bangiophyceae and Florideophyceae); and 10 classes in the Heterokontophyta (Bacillariophyceae, Chrysophyceae, Dictyochophyceae, Eustigmatophyceae, Oömycetes, Parmophyceae, Phaeophyceae, Raphidophyceae, Sarcinochrysidophyceae, and Xanthophyceae). Of these, only three classes have species that are macroalgae; these are the Chlorophyceae referred to as the Green algae, the Rhodophyceae referred to as the Red algae, and the Ochrophyta referred to as the Brown algae.

The Chlorophyceae are characterized by the grass green appearance and a number of pigments including chlorophylls (chlorophyll a, b, c2), carotenes (α-carotene, β-carotene, γ-carotene), and xanthophylls (antheraxanthin, echinenone, β-cryptoxanthin, lutein, neoxanthin, siphonein, siphonoxanthin, violaxanthin, zeaxanthin). Green algae are similar to higher plants with cellulose cell walls, and the stored product of photosynthesis is starch.

The Rhodophyceae are of a variety of unicellular to multicellular morphological forms. They equally possess a number of pigments including chlorophylls (chlorophyll a), phycobilins (allophycocyanin, phycoerythrin, phycocyanin, and phycobilisomes), carotenes (α-carotene, β-carotene), and xanthophylls (antheraxanthin, α-cryptoxanthin, β-cryptoxanthin, lutein, violaxanthin, zeaxanthin). The cell wall is cellulose, hemi-cellulose, and polysulfate esters.

The Ochrophyta are characterized by an olive-green-brownish color from a number of pigments including chlorophylls (chlorophyll a, c1, c2, c3), carotenes (β-carotene, ε-carotene), and xanthophylls (zeaxanthin, lutein, antheraxanthin, violaxanthin, fucoxanthin, diatoxanthin, diadinoxanthin, neoxanthin). The cell wall is cellulose, with alginic acid.

Trono (1998) listed three major groups of seaweeds: the Chlorophyta, the Rhodophyta, and the Ochrophyta. He distinguished between them on basis of their apparent color, the cell wall composition, and the stored by-product of photosynthesis.

1.2 *Economic Importance of Seaweeds*

Seaweeds are of great economic importance:

- As an important habitat and ecosystem

Algae are photosynthetic organisms and are primary producers of energy and rich compounds. They provide food to other non-photosynthetic organisms and are the basis of the food cycle of marine life. In the marine ecosystem, the larger algae afford shelter and habitat for herbivorous fish and other invertebrate animals. The decomposers feed on decaying plants and release necessary minerals that are used by other organisms in the food web. In addition, the plant matter relatively digested by the decomposers avails as food for various marine invertebrates.

- As a food resource for humans

Seaweeds are an important marine living resource in the world for traditional use as human food in some countries like Japan, China, Hawaii, and the Philippines which dates back many decades (Kilinç et al. 2013). Nori, a red alga, is popular seafood in Japan; Sea kale and sea lettuce are edible kelps. There are 70 reported marine seaweeds used as food obtained from genera including *Porphyra*, *Laminaria*, and *Sargassum*.

- As a source of raw material for industry

The farming of several algae has proved to be a very productive form of livelihood among coastal populations. This is attributed to the discovery of natural substances in these species, which have very important applications in many industries. The depletion of most of the near shore finfish, crustaceans, and other traditional coastal fishery resources is a contributing factor to the shift in livelihood of some coastal populations from fishing to seaweed farming and gathering of natural stocks of seaweeds. However, the development and utilization of some species as a fishery resource is quite recent.

Algae provide necessary economic products in the form of natural resources in the manufacturing of industrial products. Mostly seaweeds are harvested from the wild, and efforts are made to cultivate big algae. The Red seaweeds (Rhodophyceae) produce two types of galactans: agar and agar-like polysaccharides composed of 3,6-anhydro-α-L-galactose residues and β-D-galactose, related polysaccharides, and carrageenan (Lahaye 2001). Agar is a well-known gelatinous product used as a culture medium for growth of microorganisms and in the preparation of jellies and food. Agar is used in pharmaceutical and cosmetic products. Agar is isolated from *Gelidium* spp., *Gracilaria* spp., *Gigartina* spp., *Gloiopeltis* spp., *Eucheuma* spp., *Iridaea* spp., and *Pterocladia* spp. Carrageenan is an agar-like substance extracted from Red algae commonly utilized as a paintstabilizer, in pharmaceuticals and in ice cream. It is isolated from *Chondrus crispus* (http://www.scienceclarified.com/A-Al/Algae.html). Furcellaran (Danish agar) is created by Red algae *Furcellaria lumbricalis* (Belitz and Grosch 1987).

Alginates and alginic acid appear in all Brown algae (Phaeophyceae) as skeletal components in their cell walls. These are used as food and pharmaceutical drugs, and the main source of manufacturing production is the giant kelp, *Macrocystis pyrifera*, and some species of *Ascophyllum*, Laminaria, and *Sargassum*.

Food reserves from seaweeds are important by products (polysaccharides: starches and floridean starches, laminarin and reserve carbohydrates). The cell walls polysaccharides: skeletal polysaccharides, matrix polysaccharides, and membrane lipids (fatty acids, sterols) are also commercially valuable (Rizk et al. 1999).

- Pigments

The pigments chlorophylls, carotenoids, and phycobilins found in Green algae are used as a food staining material. Pirian et al. (2017) working on macroalgal species (*Sirophysalis trinodis*, *Polycladia myrica*, *Palisada perforata*, and *Sargassum angustifolium*) revealed their antioxidant effects and α-amylase inhibitory activities. This suggests that they may have potential pharmaceutical use for antidiabetic and antioxidant use. Moreover, there is ongoing research into Green algae's health benefits. A large number of algal extracts are sold as supplement for health and different ailments. A recent interest in seaweeds is the prospective of natural products with bioactive properties. These developments are, however, constrained by the lack of information on the identities of seaweed species (Trono 1998).

A recent study of four seaweeds (*Digenea simplex*, *Cladophoropsis* sp., *Sirophysalis trinodis*, and *Sargassopsis decurrens*) collected from local beaches proved that seaweed could be valuable as a good source of minerals-comparable and higher than some higher plants. The total phenolic content μg/ml was investigated on the four species and was 22.21 ± 0.53 μg/ml, 40.12 ± 1.4 μg/ml, 221.27 ± 1.72 μg/ml, and 215.89 ± 0.59 μg/ml, respectively. The inhibitory potential [percentage] of the aqueous extract of the four seaweed samples using HPLC (value are mean ± SE, $n = 9$) was found to be 14.7 ± 1.5%, 15.4 ± 0.7%, 68 ± 1.6%, and 53 ± 0.5%, respectively. As such, their value as antioxidants should be recognized (El Obeid 2017).

- As a reducer of GHG emission

The outstanding role played by Green algae in reducing CO_2 from the atmosphere is of recent awareness of the importance of the long-neglected seaweed and seagrass ecosystems. Iron is introduced to the ocean when sea ice melts, and this fuels the growth of seaweed, which can absorb CO_2 and trap it close to the ocean land. With more glaciers melting, this could decrease the effects of global warming. However, when organisms eat the algae, the carbon is released back into the environment (Kenedy 2017).

Algae are photosynthetic and the by-product of photosynthesis in O_2. Algae through photosynthesis carry out at least a half of the total CO_2 fixation on earth. Thus, algae increase the level of dissolved oxygen in their immediate environment (Stanley 2000). However, the value of seaweeds in much broader and seagrasses contributes much more than is known towards GHG emission. Although in many countries, this value is realized, and restoring and plantations of both are carried out to combat climate change, unfortunately this is not the case in the Gulf.

Seaweeds capture and store carbon nutrients and hotspots for carbon accumulation in the biosphere with storages comparable to tropical forests and temperate (Fourqurean et al. 2012; Campbell et al. 2015). Seaweeds have proven to be very important in GHG emissions.

Qatar is a small country with a wealth based on fossil fuel. Obtaining fossil fuel from its source and processing it bear heavily on a small country's environment. The increase of CO_2 concentration is one of the disadvantages of obtaining fossil fuel.

2 Study Location

This study highlights the microalgae distribution in the Arabian/Persian Gulf and Gulf of Oman with emphasis on Qatar Marine Zone (QMZ). The Arabian/Persian Gulf is a semi-enclosed water body extending from the Straits of Hormuz in the south to the Shatt al-Arab in the north (Fig. 1). The Gulf is a narrow sea, about 200–370 km wide and 1000 km long. Water reaches into the Arabian Gulf from the

Fig. 1 Location of the Arabian/Persian Gulf and Gulf of Oman. Source: Naser (2016)

Indian Ocean during the Strait of Hormuz and moves northwards along the coast of Iran to Kuwait and then southwards down along the coast of Saudi Arabia. As the water follows in an anticlockwise transit around the Gulf, the salinity increases and becomes saltier due to evaporation causing it to sink below the less salty waters. These waters exist as a warmer, submerged denser and more saline water mass moving across the center of the Indian Ocean (Kämpf and Sadrinasab 2006; Abu Zinada 2011; Yimin 2011).

The Gulf of Oman is a strait (and not an actual gulf) in the western extension that connects the Arabian Sea with the Strait of Hormuz, positioned in the middle between Iran, Oman, and the United Arab Emirates (UAE). It is the entrance to the Gulf from the Arabian Sea and the Indian Ocean. Its maximum width is approximately 370 km and about 545 km long and connects with the Gulf through the shallow Strait of Hormuz.

In contrast, the Gulf of Oman and the Arabian Sea are deep seas (more than 2 km) with more stable and moderate physical states as compared to the Gulf. A particularly important advantage in moderating summer temperatures in the Arabian Sea is the effect of upwelling. These are driven by the strong southwest monsoon winds that blow across southern Arabia (Wilson et al. 2002).

The Gulf is a shallow-enclosed water body with maximum depth of 100 m. A lot of the north and west of the Gulf is lower than 50 m deep, and the west coast is comparatively low lying with extensive sand coasts and flats that extend along the coast of Saudi Arabia and beyond. Both to the north and south and along the Gulf bays, western coastline, and small offshore islands are common (Yimin 2011).

Qatar is a small peninsula in the Gulf with its borders nearly exclusively surrounded by sea, with almost 600 km of coastline and only a 60 km land border it shares with Saudi Arabia. Qatar is dry, hot, and surrounded by a semi-enclosed marine zone, hyper-saline shallow with an average depth of 35 m. Richer (2008) remarked that the strong winds, low rainfall high temperature, and low nutrient availability of the soil mean that recovery of the earthly ecosystems from disturbance is very slow. This makes the Arabian Peninsula and Qatar in specific one of the most hostile environments on land and one of the most fragile.

Great temperature fluctuations and high salinity make the Gulf surrounding Qatar unique and extreme. The local marine resources are typically surviving at their extreme tolerance of environmental parameters; however, this does not stop them from displaying the capacity to improve from mass mortality cases (Richer 2008). On the west coast, between Qatar and Bahrain, the average water depth rates from 1 to 5 m (Rezai et al. 2004). There are few water exchanges with the northern Indian Ocean through the Strait of Hormuz. Therefore, the Gulf has the highest annual temperature variation of any sea-supporting ecosystems such as corals. Water temperatures can approach as high as 34–40 °C in summer and change between below 11 and 15 °C in winter (Rezai et al. 2004). Mass mortality of fish in 2002 was attributed to extreme temperature (Al-Ansi et al. 2002), and Al-Ansi (2010) recorded a temperature of 37.8 °C in QMZ.

While the salinity levels of the open ocean are around 35 ppt, those of the Gulf are around 45 ppt and 70 ppt in the shallow regions off the northwest coast of Qatar. In the Gulf of Salwa, on the west coast of Qatar, temperature extremes and salinity may be even higher. Salinity levels as much as 200 ppt have been registered in other areas of the Arabian Gulf (Carpenter et al. 1997).

3 Materials and Methods

This study is based on material collected over years from different sources: marine surveys carried out by the ESC, handpicked material collected from sea detritus along coastline of Qatar, fouling material on oyster shells, algae retrieved from of marine sediments from different locations, and undersea photography and video films of QMZ. The distribution of specific taxa in other Gulf States is obtained from various relevant publications.

3.1 Materials

(a) Hand-collected seaweeds: these are washed with clean seawater in the field to remove adhering soil particles from substratum like mud, rocks, and others and are kept in plastic bags and transported to the ESC laboratory in an icebox for further examination. All material is labeled in the field (date of collection, location, and collector name(s)). At the laboratory, the seaweeds are re-washed with tap water. The samples are first identified and examined under the stereo-microscope on basis of morphological characters using standard references. For further confirmation and major diagnostic features, microscopic examination is carried out, and the sample is documented by photography. All the samples are preserved in 70% alcohol (wet preservation), and larger samples are kept as herbarium sheets (dry preservation). When the sample is a mixed collection individuals of the same seaweed species, are separated in labeled containers with serial numbers Diagnostic characters of species are documented by photography at the Multi-media Unit at the ESC. Preserved material is registered with their given codes in the Logbook. Voucher specimens are preserved in 70% ethanol. All materials preserved for DNA analyses are in absolute alcohol.

(b) Marine sediment samples: the collected samples are kept frozen in an icebox and delivered to the Lab. The material is defrosted at room temperature, sieved using tap water and a 0.5 mm mesh-size sieve. The larger seaweeds are handpicked and placed in labeled containers. These are examined under the stereomicroscope. Rare and interesting taxa are kept as new records in QMZ. Large algal samples are pressed and dried and are kept as herbarium specimens with information comprising the collection date, location, scientific name and category, and code of the voucher specimens.

(c) Undersea photography and video films: captures from the undersea video films are taken; these are identified to the generic level; unless the species is well-known, then it is registered by its species. Further, undersea photographs and video films are used to map seaweed beds in QMZ and to document the seaweed ecosystem, associations, and the seafloor habitat.

3.2 Methodology

The main diagnostic characters of the algae were examined to enable their identification. These were primarily based on morphological appearance and internal structure. Macroalgae can be distinguished by their color into the three major groups Green, Brown, and Red.

General shape is a good guide. Macroalgae are multicellular organisms of varying degrees of complexity and shape varying from filamentous to ribbon and thalloid forms. Internal structure showing number of cell layers and shape of cells and reproductive structures are basic in many taxonomic keys.

4 Results

4.1 Macroalgae in the Gulfs

Five hundred sixty-eight [568] species of macroalgae are recorded for all the Gulfs belonging to the three phyla: the Chlorophyta (Green algae), the Rhodophyta (Red algae), and the Ochrophyta (Brown algae).

Up to date one hundred thirty-nine (139) species of Green algae in 6 order, 18 families, and 31 genera were recorded in the Gulfs. A total of 42 Green macroalgal were recorded in QMZ belonging to 6 orders, 11 families, and 17 genera, of which *Chaetomorpha* and *Ulva* are among the most abundant genera, an estimate of 24% of the number of Green algae found in the Gulfs.

The various studies on marine algae in the Gulfs reported three hundred three (303) species of Red algae belonging to 4 classes, 17 orders, 40 families, and 103 genera in the Gulfs. In QMZ, a total of 104 Red algae species were recorded belonging to 2 classes, 10 orders, 24 families, and 50 genera—an estimate of 24% of the number of Red algae found in the Gulfs.

Up to 126 species of the Brown algae represented by 36 genera, 10 families, and 8 orders were reported in the Gulfs. Of these 55 macroalgae were recorded in QMZ belonging to 6 orders, 6 families, and 20 genera with *Padina* and *Sargassum* among the most abundant species rich genera—an estimate of 30% of those reported for the Gulfs.

In this study it is estimated that there are 201 seaweeds in QMZ, 115 Kingdom of Bahrain, 170 in the UAE, 191 in Saudi Arabia, 60 in Oman, 139 in Kuwait, 17 in Iraq, and 390 in Iran. Table 1 shows the numbers of macroalgae species in the Gulf countries and their coastline strips. Figure 2 is a histograms illustrating comparison of the numbers for the three groups in Gulf States, and Figs. 3, 4, 5, 6, 7, and 8 portray the numbers of species and their families for the three macroalgae groups in the Gulfs as compared to Qatar Marine Zone.

Table 1 Numbers of algal species recorded in Gulf States

Country	Coastline on Gulfs (km)	Green	Red	Brown	∑/Country
Qatar	563	42	104	55	201
Kingdom of Bahrain	161	30	58	27	115
UAE	1318	25	108	37	170
Saudi Arabia	700	50	89	52	191
Oman	545	29	20	11	60
Kuwait	499	32	63	44	139
Iraq	58	9	4	4	17
Iran	1700	95	205	90	390
Arabian/Persian Gulf		139	303	126	568

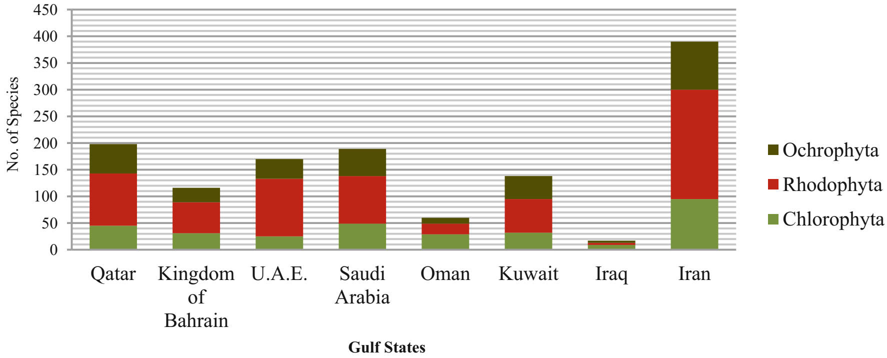


Fig. 2 Histogram showing the total number of species in the three seaweeds studied

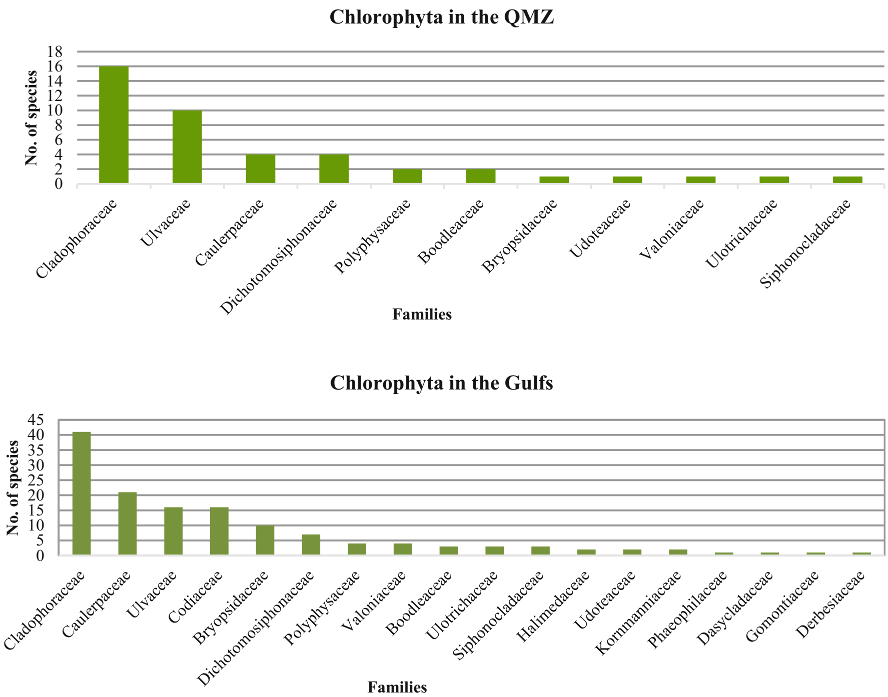


Fig. 3 Shows the variation in numbers of species in the Green algae in the QMZ as compared to the Gulfs. The Cladophoraceae is the most species rich family

4.2 The Macroalgae in QMZ

The locations of the source of the material collected or previously recorded seaweeds are shown in Fig. 9 for the three macroalgal groups.

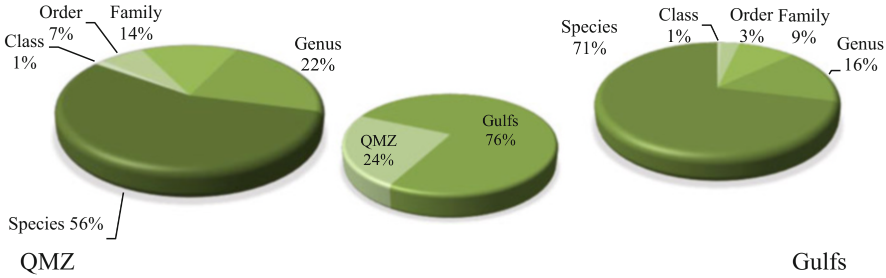


Fig. 4 Pie chart shows the percentages of taxonomic categories within the Chlorophyta QMZ as compared to the Gulfs

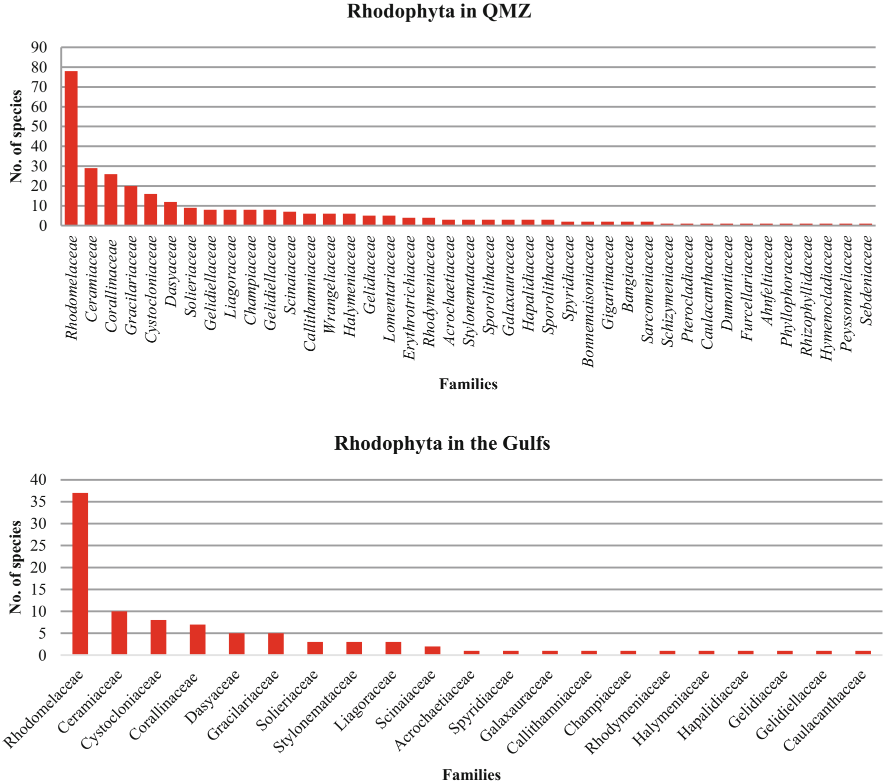


Fig. 5 Shows the variation in numbers of species in the Red algae in QMZ as compared to Gulfs. The Rhodomelaceae is the most species rich family

4.2.1 The Chlorophyta

The Green algae Class Ulvophyceae is represented in QMZ by 6 orders and 17 genera; Order Bryopsidales [Bryopsidaceae, Caulerpaceae, Dichotomosiphonaceae, and

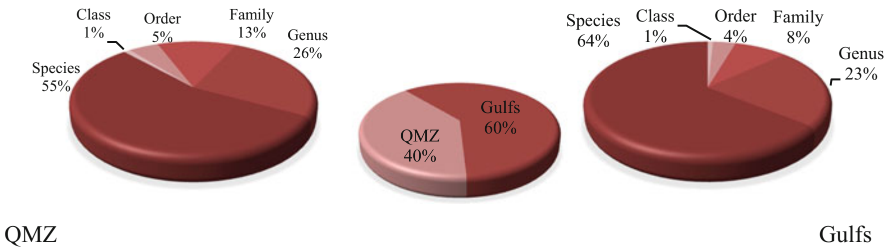


Fig. 6 Pie chart shows the percentages of taxonomic categories within the Rhodophyta QMZ as compared to Gulfs

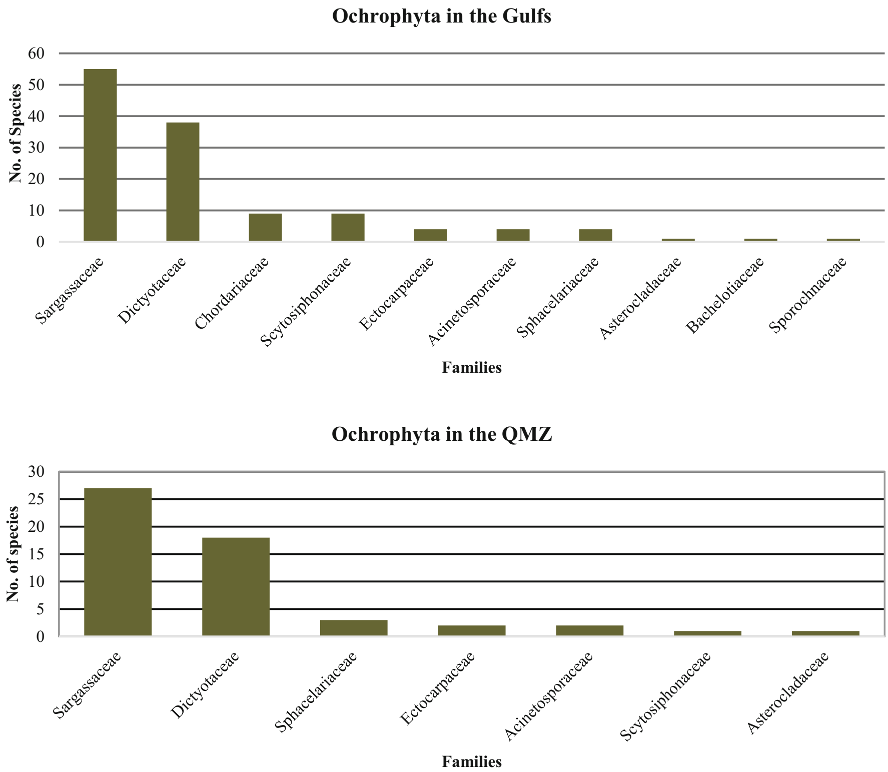


Fig. 7 Shows the variation in numbers of species in the Brown algae in the QMZ as compared to Gulfs. The Sargassaceae is the most species rich family

Udoteaceae], Order Cladophorales [Cladophoraceae], Order Dasycladales [Polyphysaceae], Order Siphonocladales [Boodleaceae, Siphonocladaceae, and Valoniaceae], Order Ulotrichales [Ulotrichaceae], and Order Ulvales [Ulvaceae].

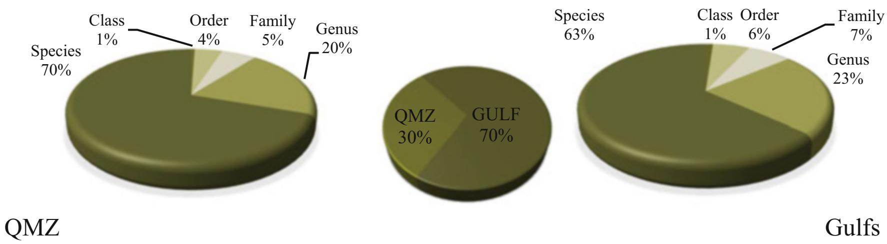


Fig. 8 Pie chart shows the percentages of taxonomic categories within the Ochrophyta QMZ and the Gulfs

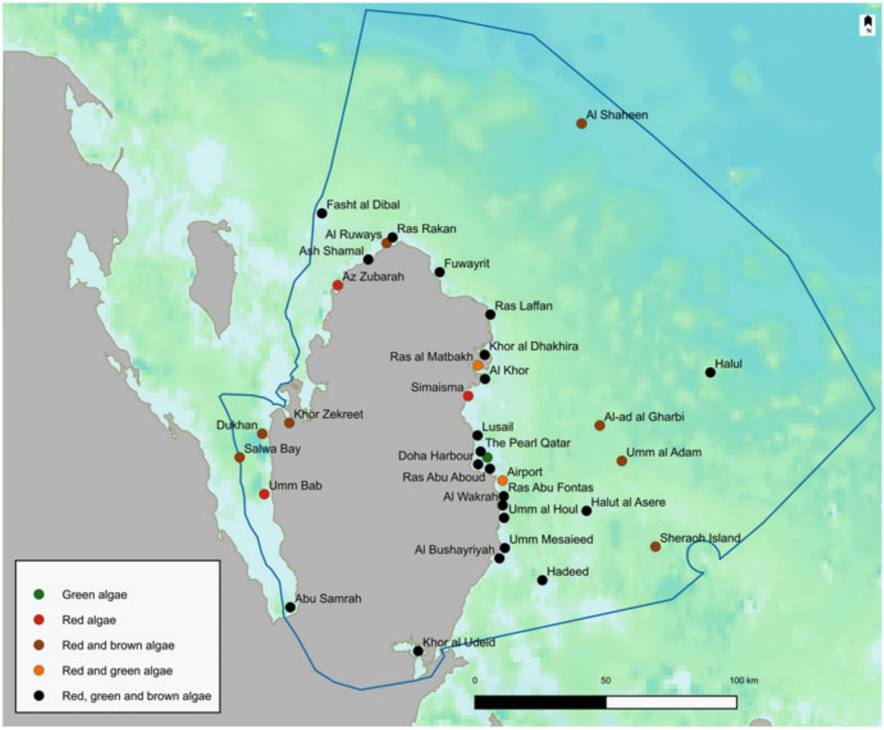


Fig. 9 Locations of macroalgae reported within QMZ (EEZ). Source: Dr. Sinan Husrevoglu, ESC

Characters Used in the Classification of the Green Algae

The classification of the Green algae is based on a number of external morphological characters as well as their anatomy. Besides morphology, life cycles are valuable as taxonomic criteria. However, in this study the identifications were based on morphological and anatomical characters because most of the species obtained were part of the alga and the samples were mostly sterile. A simple key is presented to the

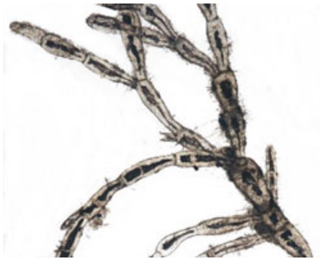

Acetabularia caliculus


Avrainvillea amadelpha undersea image


Avrainvillea amadelpha


Ulva intestinalis


Chaetomorpha linum


Cladophora coelothrix


Green algae covering coastal strip

Plate 1 Representatives of the Green algae in QMZ

genera of species in QMZ, and Plate 1 illustrates the common Green algae species in QMZ.

Key to the Green Algae in QMZ

1 Thallus with stipe, holdfast, and an expanded apex 2
1a Thallus not as above... 4
2 Expanded apex mass of filaments forming a cap .... *Parvocaulis*
2a Expanded apex not as above.. 3

3 Expanded apex calcified, fan-shaped with joint rays; holdfast discoid *Acetabularia*
3a Expanded apex not calcified, an open flabellum of entangled filaments holdfast bulbous ....*Avrainvillea*
4 Thallus spherical, hallow, and brittle... *Dictyosphaeria*
4a Thallus not as above.. 5
5 Algal body filamentous 6
5a Algal body thalloid.. 11
6 Filaments branched 7
6a Filamentous unbranched 10
7 Branched filaments forming a spongy mass .... *Boodlea*
7a Filaments forming tufted mats or cushions.. 8
8 Filaments forming mats .... *Cladophora*
8a Filaments forming cushions 9
9 Filaments forming green cushions 5 cm across ....*Cladophoropsis*
9a Filaments forming cushions or turfs with erect growth 4 cm high... *Pseudocladophora*
10 Filaments narrow 10–18 μ, prostrate, forming mats of slender cells, sometimes with
short branches and false rhizoids ....*Rhizoclonium*
10a Filaments broad > 60 μ without branching .... *Chaetomorpha*
11 Thallus erect, grey, flabellate with kidney-shaped overlapping segments, rigid with defined medulla and cortex ....*Udotea*
11a Thallus not as above... 12
12 Thallus coenocytic 13
12a Thallus not coenocytic 14
13 Thallus feather-like, branched filaments along one side, constricted at the base..*Bryopsis*
13a Thallus with erect branches from a stolon appearing as pinnate leaves*Caulerpa*
14 Thallus a cluster of green rounded vesicle joined together ....*Valonia*
14a Thallus foliose, flat, one or two layers thick 15
15 Thallus parenchymatous, flat, ribbon-like, elongated, foliose, two cells thick grass green ....*Ulva*
15a Thallus flat, tubular, hollow, one cell thick yellow green........... *Enteromorpha*

4.2.2 The Rhodophyta

The Red algae are represented in QMZ by 2 Classes; the Class Florideophyceae and the Class Stylonematophyceae; The Class Florideophyceae with 10 orders and 50 genera: Order Acrochaetiales [Acrochaetiaceae], Order Ceramiales [Callithamniaceae, Ceramiaceae, Dasyaceae, Rhodomelaceae, and Spyridiaceae], Order Corallinales [Corallinaceae, Hapalidiaceae, and Sporolithaceae], Order Gelidiales [Gelidiaceae and Gelidiellaceae], Order Gigartinales [Caulacanthaceae, Cystocloniaceae, and Solieriaceae], Order Gracilariales [Gracilariaceae], Order

Halymeniales [Halymeniaceae], Order Nemaliales [Galaxauraceae, Liagoraceae, and Scinaiaceae], and Order Rhodymeniales [Champiaceae, Hymenocladiaceae, Lomentariaceae, and Rhodymeniaceae]. The Class Stylonematophyceae is represented by one order, one family, and two genera. Order Stylonematales [Stylonemataceae] and the two genera *Stylonema* sp. and *Chroodactylon* sp.

Characters Used in the Classification of the Red Algae

Members of the Rhodophyta exhibit a wide range of colors due to their pigments. The Red algae are the most dominant seaweed group in the world and are more common in warm temperate waters. Most of the seaweeds collected from QMZ belong to this group. Commonly they are more encountered on the mid to lower shore zone (Environment Agency 1997).

The coralline algae are a unique seaweed group belonging to the Red algae and exist in both encrusting and branching forms. Coralline algae produce calcium carbonate into their tissues giving them a reddish pink stone shape. They play a major role in building reefs in many regions. Most undersea photography of dead and living reefs in QMZ shows encrustation by the coralline algae. Scuba divers did not retrieve the observed samples, and this possibly needs further study. Because the samples were sterile, the key to the Red algae is based on morphological characters and Plate 2 illustrates the common red algae species in QMZ.

Key to the Red Algae in QMZ

1 Thallus stony, calcified, or crustose 2
1a Thallus not stony or crustose nor calcified 6
2 Algae reef building, crustose, spreading on rocks or corals 3
2a Thallus not as above flattened 5
3 Thallus with protuberances, stony, rock-like epilithic growing close to surface. 4
3a Thallus epilithic flattened several cell layers, thick walled with flared edges 1–3 cm across .... *Sporolithon*
4 Thallus with distinct finger-like protuberances .... *Lithothamnion*
4a Thallus, subglobose protuberances, masses of single filaments ..... *Lithophyllum*
5 Thallus not stony or crustose, with calcified segments, bush-like, erect .... *Amphiroa*
5a Algae erect, small, brittle, articulated, and dichotomous branching .... *Jania*
6 Thallus microscopic or minute epiphytes small but not exceeding 5 cm high..... 7
6a Thallus not as above. Thallus more than 35 cm high 42
7 Thallus microscopic with gelatinous cell wall 8
7a Thallus minute or small 10
8 Thallus epiphyte with uniseriate filaments with red plastids .... *Stylonema*
8a Thallus without red plastids 9
9 Thallus unbranched without horns .... *Chroodactylon*
9a Thallus irregularly branched, densely tufted, branching filament tip with horns .... *Caulacanthus*
10 Thallus erect narrow axis with opposite branching, rhizoid disc present .... *Acrochaetium*
10a Thallus not as above 11
11 Thallus flexible not segmented, with dichotomous branching and with distinct whorls of filaments .... *Actinotrichia*

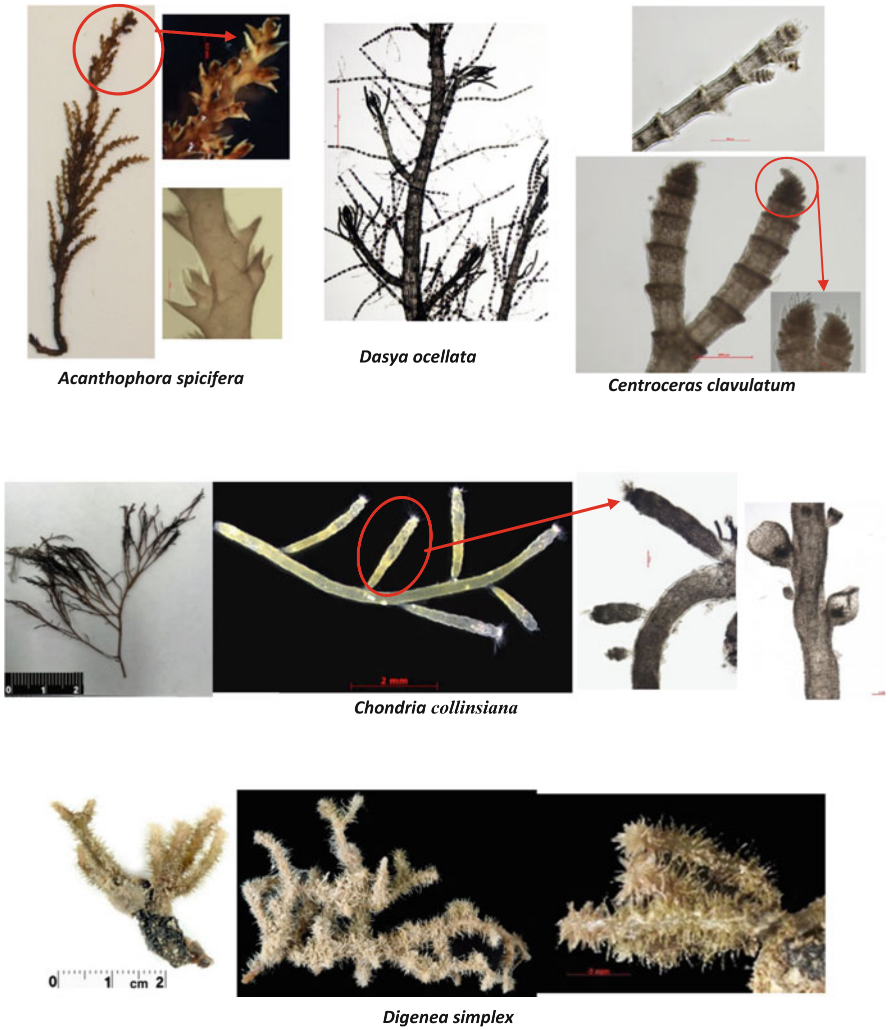


Plate 2 Representatives of the Red algae in QMZ

11a Thallus not as above 12
12 Thallus corticated 13
12a Thallus with little or no cortication 14
13 Thallus with dense cortication on axes and branches, tufted, filamentous single with 2 cells and with nodal belts and terminal spine .... *Spyridia*
13a Thallus erect, bushy, corticated, 10–25 cm high polysiphonous, with few branching, pericentral cells 5 .... *Micropeuce*
14 Thallus erect, epiphytic, slimy-gelatinous, branched with uniseriate filaments 15

14a Thallus cartilaginous, flattened with toothed margin, with slippery delicate flat blades, irregular branching, end of branches acute but not hook-like, five pericentral cells filaments pinnate .... *Chondria*
15 Thallus stiff, tough, wiry 16
15a Thallus multi-axial with stolon and entangled fine branches 17
16 Thallus terete, entangled, with creeping stolon, main axes flat with feathery short side branches appearing pinnate .... *Gelidella*
16a Thallus terete below, compressed above with no rhizines .... *Wurdemannia*
17 Thallus compressed with dichotomous and irregular branches with gelatinous matrix .... *Ceratodictyon*
17a Thallus terete, fleshy, foliose, or blade-like 18
18 Thallus terete-compressed, squashy mucus-slippery filamentous branched appearing like spaghetti .... *Nemalion*
18a Thallus not as above 19
19 Thallus erect, flat, of slippery blades 20
19a Thallus not as above 21
20 Thallus with pinnate branching, cortex 8–9 cells .... *Grateloupia*
20a Thallus cylindrical, terete hollow not blade-like segmented with irregular branching with pinnate filaments narrowed towards base, transverse diaphragms present .... *Champia*
21 Thallus slightly calcified multi-axial with discoid holdfast, solid with hollow clavate pedicelled vesicles, transverse diaphragms absent ....*Botryocladia*
21a Thallus not as above, monosiphonous or polysiphonous, branched filaments with or without spines or corticated nodal bands 22
22 Thallus monosiphonous, corticated of delicate branched filaments or pinnate 23
22a Thallus polysiphonous with or without nodal band 24
23 Filaments much branched with fine hairs, end of branching incurved spines, cortication as bands on filament nodes ....*Ceraminum*
23a Filaments of rows of bi-cellular spines, pericentral cells 4–5, nodes corticated in all branches .... *Centroceras*
24 Thallus iridescent or with blue green plastids 25
24a Thallus not as above 26
25a Thallus prostrate with rhizoids and erect polysiphonous branches 1 cm high, 4 pericentral cells, filaments uniseriate radially branched .... *Murrayella*
25a Thallus not as above 27
26 Thallus terete, small c.1.8 cm high, cartilaginous, iridescent blue .... *Yuzurua*
26a Thallus with distinct blue green plastids not iridescent blue ....*Gigartina*
27 Thallus with whorled branches or filaments 28
27a Thallus without whorled branches or filaments 31
28 Thallus axis with laterals separate on different segments 29
28a Thallus axis with lateral branches per consecutive segment 30
29 Thallus axes erect, whorled filaments polysiphonous of 4–24 siphons, nodes with bands, lateral branches monosiphonous separate on different segments .... *Polysiphonia*
29a Thallus whorled filaments without nodal belts, forming mats, with rhizoidal holdfast .... *Crouania*

30 Thallus axis terete with extensive prostrate axes, much branched, lateral branches 3 per consecutive segment, delicate, feathery, pericentral cells 9 *Herposiphonia*
30a Thallus epiphytic, similar to *Polysiphonia*, pericentral cells 5, with distinct cross and longitudinal bands, *much* branched, lateral branches on consecutive segments .... *Neosiphonia*
31 Thallus up to 13 cm tall, tufted, slightly calcified but supple, segmented, dichotomously branched without distinct whorl of filaments mucilaginous with discoid holdfast ....*Liagora*
31a Thallus not as above... 32
32 Thallus small less than 10 cm high with dense gregarious growth, flower-like, initially a dorsally-ventrally discoid structure on a stipe becoming star-shaped with ligulate appendages, cortex 3–4 cells .... *Asteromenia*
32a Thallus small but not flower-like 33
33 Thallus epiphytic or epilithic, branching alternate, appearing constricted between segments...*Gayliella*
33a Thallus not as above 34
34 Thallus much branched, end of branches truncates, 10–15 cm high, holdfast discoid .... *Chondrophycus*
34a Thallus without truncate tips.. 35
35 Thallus with tips of branches invaginate or grooved or sunken 36
35a Thallus not as above 39
36 Thallus with a palisade-like layer, epilithic, cartilaginous, 4–7 cm high with bumps and dips of terminal branches, pericentral cells 2, holdfast discoid .... *Palisada*
36a Thallus without a palisade-like layer with tips of branches thorn-like 37
37 Thallus epilithic or epiphytic, erect 38
37a Thallus not as above 40
38 Thallus cylindrical, smooth, fleshy and supple, irregularly branched, end of branches invaginate .... *Laurencia*
38a Thallus fleshy-thick-compressed, cartilaginous 5–15 cm high, pericentral cells 2, holdfast stoloniferous, branching irregular, tip of branch grooved . *Osmundea*
39 Thallus supple, erect up to 20 cm high, cylindrical radially branched with many thorn-like stellate structures, cortical cells distinct, 6–8 cells per filament .... *Hypnea*
39a Thallus fleshy, soft, branched with many short multicellular spinose branches, end of branches spirally twisted ....*Acanthophora*
40 Thallus much branched giving a hirsute appearance, not thorny .... *Digenea*
40a Thallus gelatinous-elastic without a hirsute appearance 41
41 Thallus with short stipe with globose segments .... *Scinaia*
41a Thallus with stolon giving multi-axial branches with dichotomous branching, Thallus flat-compressed .... *Sarconema*
42 Thallus epilithic, fleshy, flat above terete below, rhizines present within medullary cells, tufted, entangled, cylindrical, cortex 2–5 cells thick, creeping rhizoids present ....*Gelidium*
42a Thallus not as above 43

43 Thallus more than 35 cm high, brittle, with or without spiny branches 44
43a Thallus not more than 15 cm high 45
44 Thallus 35–75 cm high, whorled spinose branches, branching from nodes, rhizoids in medulla, nodal cross bands present ....*Eucheuma*
44a Thallus erect or decumbent, epilithic, up to 60 cm high, elastic, irregular much branching, filaments filiform uniaxial, tri-dimensional multi axial, without a central axial filament .... *Gracilaria*
45 Algae up to 14 cm high, generally similar to *Gracilaria*, cartilaginous with dichotomous branching and with terete branches tapered and bifurcate at apex ....*Hydropuntia*
45a Thallus not as above... 46
46 Thallus radially branched with many uniseriate not spiny branches, velvety with basal cortication .... *Dasya*
46a Thallus bushy, branching pinnate monosiphonous, tip sharply pointed .... *Dasysiphonia*

4.2.3 The Ochrophyta

The Brown algae, Class Phaeophyceae, is represented in QMZ by 6 orders and 20 genera: Order Asterocladales [Asterocladaceae], Order Dictyotales [Dictyotaceae], Order Ectocarpales [Chordariaceae, Acinetosporaceae, and Ectocarpaceae], Order Fucales [Sargassaceae], Order Scytosiphonales [Scytosiphonaceae], and Order Sphacelariales [Sphacelariaceae].

Characters Used in the Classification of the Brown Algae

Phylum Ochrophyta (The Brown algae) belong to the Kingdom Chromista consisting of many of the large cartilaginous forms, as well as finer forms; therefore they have a wide morphological range. Brown algae illustrate variation in structure, reproduction, and life history. They vary from simple unicellular form to multicellular organisms, colonial, and cellular forms. Their life cycle may produce haploid, diploid, and tetraspores with specialized function of parts. In this study, focus was on the diagnostic morphological features of the Brown macroalgae and Plate 3 illustrates the common Brown algae species in QMZ.

Simple Key to the Brow Macroalgae in QMZ

1 Algae filamentous of various forms 2
1a Algae thalloid of various forms 6
2 Filaments epiphytic or epilithic, small 3
2a Filaments not epiphytic, variable 4
3 Filaments small <1 cm long of several rows of cells, solid, crustaceous, branching stiff tufts with regular alternate branching segmented; propagules present variable; sporangia and spore sacs present .... *Sphacelaria*
3a Thallus not as above 5
4 Filaments hollow with age, covered with assimilatory filaments and sporangia in

Plate 3 Representatives of the Brown algae in QMZ

between, filaments tapering with round or oval apical tips .... *Nemacystus*
4a Filaments slimy, uniseriate with erect and lateral filaments and terminal sporangia with few chloroplasts per cell, ... *Ectocarpus*
5 Filaments attached to rocks or floating, erect, sparingly branched; chloroplasts numerous per cell, discoid Sporangia stalked variable in shape .... *Feldmannia*
5a Chloroplasts stellate .... *Asterocladon*
6 Thallus sac-like, flabellate fan-shaped or funnel-shaped with or without dichotomous branching 7
6a Thallus not as above 12

7 Thallus prostrate with stolon as a holdfast giving erect growth up to 30 cm high with peltate turbinate leaf-like structure with dentate margins ....*Turbinaria*
7a Thallus erect without tolon 8
8 Thallus tri-winged with branches and no floats, branches flat with serrate margins; vesicles tri-winged ....*Hormophysa*
8a Thallus flat with thin branches and air bladders 9
9 Thallus with air bladders in series or chains 10
9a Thallus with air bladders not as above, air bladders of various shaped stalked or sessile 11
10 Thallus with short stipe, long branches, and leaf-like structures, vesicles throughout Thallus, fertile branches beaded .... *Cystosiera*
10a Thallus without stipe, branching semi-alternate, vesicles ovoid and confined to upper parts only ....*Polycladia*
11 Thallus flat and compressed body very broad at base tapering towards the apex and upper section finely dissected, bladders ovoid-globose, holdfast discoid ....*Sargassopsis*
11a Thallus of stem- and leaf-like structures; main stem branched with air bladders and leaves of various sizes and shapes with serrate margins, holdfast conical ....*Sargassum*
12 Thallus sessile, globose, and sac-like slightly divided, hollow without bladders, smooth and unbranched, thin 6–7 cell layers but firm wall ....*Colpomenia*
12a Thallus flabellate or strap-shaped with or without dichotomous branching, with or without a midrib 13
13 Thallus with concentric rings of variable length 14
13a Thallus without concentric rings over 20 cm high 15
14 Thallus less than 20 cm calcified, funnel-shaped with wide lobes and with edges rolled over and under and with concentric rings and rows of hairs without midrib ....*Padina*
14a Thallus up to 35 cm high, flabellate with rhizoid holdfast branched without rolled over edges, with concentric ring of hairs on both surfaces ...*Stypopodium*
15 Thallus erect or decumbent, strap-shaped with repeated dichotomous branching, up to 20 cm high 16
15a Thallus not as above 17
16 Thallus a membranous structure, 3 cm across, middle larger cells, sporangia on surface, holdfast with rhizoids ....*Dictyota*
16a Thallus soft delicate structure, branching at V-shaped angles, wide below narrowed above, branch ends forked with rounded tips ....*Canistrocarpus*
17 Thallus broad, 5–8 cells thick, leathery, irregularly divided with no marked cortex and no midrib .... *Spatoglossum*
17a Thallus prostrate, loosely attached to rocks, holdfast with rhizoids blades erect with dichotomous branching and a single layer of central large cells sporangia on both surfaces ....*Lobophora*

5 Summary

Previous studies on seaweeds of QMZ are limited. These include Al Easa (2006) and John and Al-Thani (2014) and a number of surveys carried out by Qatar University and others. This study is an updated algal database covering the species recorded in Qatar Marine Zone. A list of the seaweeds and their distribution in the Gulfs is included and with reference to QMZ Tables 2, 3, and 4.

Major contributions to macroalgae include Trono (1998), who recognized three major groups of macroalgae based on color, pigments, cell wall structure, and stored food:

1. Plant generally green to yellowish green in colr due to the dominance of chlorophyll; cell wall consisting of a pectin outer layer and inner cellulose layer; sometimes calcified; photosynthetic product is starch .... Chlorophyta
2. Plant generally red to yellowish red to dark greenish red in color due to the dominance of R-phycoerythrin; cell wall consisting of a small amount of cellulose and gelatinous or amorphous sulfated galactans such as agar, carrageenan, furcellarin, and others; food reserve is floridean starch .... Rhodophyta
3. Plant generally brown to pale brown to reddish brown in color due to the dominance of xanthophyll pigments; cell wall consisting of cellulose and alginic acid; photosynthetic product is laminarin and mannitol .... Ochrophyta

Van Den Hoek et al. (1997) classified Green algae in the Euokaryota, Kingdom Plantae in the phylum Chlorophyta which are photosynthetic organisms comprising nine classes. Of these, only one class, the Chlorophyta with 6 orders and 18 families, commonly occurs in the Gulfs. The Chlorophyta displays a wide range of morphological structures including unicellular, multicellular, coenocytic (having more than one nucleus in a cell), colonial, filamentous, and thalloid forms.

Chlorophyta are largely aquatic marine, brackish and freshwater organisms and a few species are terrestrial existing on wet soil, as soil algae in moist-wet location, on tree trunks and even on clay garden pots. Though the Chlorophyta includes unicellular organisms, some species are highly specialized. Most Chlorophyta in aquatic media are located towards the top of the water body although *Ulva* and *Cladophora* are also common on the mid and lower shoreline.

The nature of the cell wall is cellulose as in higher plants, and pectin—rarely hemi-cellulose—is present. The pigments in the Chlorophyta include chlorophylls, carotenes, and xanthophylls, and because of these, the Chlorophyta are the most depth recorded of the algal species. Overall, they resemble land plants, because they possess chlorophyll a and b and store starch in plastids. Green algae are main component of the marine environment and provide a vital food source for Marine life. Wells (1997), divided the Chlorophyta species into four major groups according to their morphological appearance flat, thin and delicate ribbons or sheets easy to tear, filamentous delicate hair like forms, consisting of a single or numerous filaments of linearly arranged uniseriate cells and tubular, cylindrical or hollow forms and thallus siphonous.

Table 2 Record of Green algal species reported to occur in the Gulfs and their taxonomic category [Bold accepted name; otherwise synonyms; [a]new record]. Flaged are in QMZ

Species and Synonyms	Flag	Species and Synonyms	Flag
Class Ulvophyceae		***Caulerpa scalpelliformis*** (R.Brown ex Turner) C.Agardh	
Order Bryopsidales		***Caulerpa sertularioides*** (S.G.Gmelin) M.Howe	■
Family Bryopsidaceae		***Caulerpa sertularioides* forma *farlowii*** (Weber-van Bosse) Børgesen	
Bryopsis corymbosa J. Agardh [*Bryopsis implexa* De Notaris]		***Caulerpa sertuiarioides*** (Grnelin) Howe ecad ***senularioides*** ***Caulerpa sertularioides*** (Gmelin) Howe ecad ***farlowii***	
Bryopsis hypnoides J.V.Lamouroux	■	***Caulerpa taxifolia*** (Vahl) C.Agardh	
Bryopsis maxima Okamura ex Segawa		***Caulerpa* sp.** J.V. Lamouroux	
Bryopsis pennata J.V.Lamouroux		**Family Codiaceae**	
Bryopsis pennata* var. *minor J. Agardh [*Bryopsis pennatula* J.Agardh]		***Codium arabicum*** Kützing [*Codium coronatum* Setchell]	
Bryopsis pennata* var. *secunda (Harvey) Collins & Hervey		***Codium bartlettii*** C.K.Tseng & W.J.Gilbert	
Bryopsis pennulata J.Agardh		***Codium boergesenii*** M.Nizamuddin	
Bryopsis plumose (Hudson) C.A.Agardh		***Codium cylindricum*** Holmes	
Trichosolen mauritianus (Børgesen) W.R.Taylor		***Codium dwarkense*** Børgesen	
***Trichosolen* sp.** Montagne		***Codium fimbriatum*** M.Nizamuddin	
Family Caulerpaceae		***Codium flabellatum*** P.C.Silva ex M.Nizamuddin	
Caulerpa brachypus Harvey		***Codium fragile*** (Suringar) Hariot	
Caulerpa chemnitzia Esper) J.V. Lamououx [*Caulerpa racemosa* [var. *peltata*] (J.V. Lamouroux) Eubank *Caulerpa peltata* J.V.Lamouroux]		***Codium geppiorum*** O.C.Schmidt ***Codium indicum*** S.C.Dixit ***Codium isthmocladum*** Vickers	
Caulerpa cupressoides (Vahl) C.Agardh		***Codium papillatum*** C.K.Tseng & W.J.Gilbert	
Caulerpa cylindracea Sonder [*Caulerpa racemosa* var. *laetevirens* f. *cylindracea* (Sonder) Weber-van Bosse]		***Codium repens*** P.L.Crouan & H.M.Crouan ***Codium simulans*** Setchell & N.L.Gardner	
Caulerpa faridii Nizamuddin		***Codium subtubulosum*** Okamura	
Caulerpa fastigiata Montagne		***Codium* sp.** Stackhouse	
Caulerpa manorensis Nizamuddin		**Family Derbesiaceae**	
Caulerpa mexicana Sonder ex Kützing [*Caulerpa crassifolia* (C.Agardh) J.Agardh]	■	***Derbesia marina*** (Lyngbye) Solier **Family Dichotomosiphonaceae**	
Caulerpa nummularia Harvey ex J.Agardh	■	***Avrainvillea amadelpha*** (Montagne) A. & E. Gepp [*Avrainvillea amadelpha* f. *montagneana* A. & E.S.Gepp]	■
Caulerpa prolifera (Forsskål) J.V.Lamouroux*	■		
Caulerpa racemose (Forsskål) J.Agardh		***Avrainvillea calathina*** Kraft & Olsen-Stojkovich	
Caulerpa racemose (Forsskål) J.Agardh var. ***peltata*** (J.V.Lamour.)		***Avrainvillea erecta*** (Berkeley) A.Gepp & E.S.Gepp	
Caulerpa racemosa var. ***lamourouxii*** f. ***requienii*** (Montagne) Weber-van Bosse		***Avrainvillea lacerata*** Harvey ex J.Agardh	
Caulerpa racemosa var. ***macrophysa*** (Sonder ex Kützing) W.R.Taylor		***Avrainvillea nigricans*** Decaisne*	■

(continued)

Table 2 (continued)

Species and Synonyms	Species and Synonyms
Avrainvillea obscura (C.Agardh) J.Agardh	***Cladophora flexuosa*** (O.F. Müller) Kützing [*Cladophora gracilis* (Griffiths) Kützing]
Avrainvillea riukiuensis Yamada	
Family Halimedaceae	***Cladophora glomerata*** (Linnaeus) Kützing*
Halimeda discoidea Decaisne	***Cladophora herpestica*** (Montagne) Kützing [*Cladophoropsis javanica* (Kützing) P.C. Silva *Cladophoropsis zollingerii* Kützing Reinbold]
Halimeda tuna (Ellis and Solander) J.V.Lamouroux	
Family Udoteaceae	
Pseudocodium devriesii Weber-van Bosse	***Cladophora koeiei*** Borgesen
Udotea indica A.Gepp & E.S.Gepp *	***Cladophora laetevirens*** (Dillwyn) Kützing
Order: Cladophorales **Family Cladophoraceae**	***Cladophora nitellopsis*** Borgesen ***Cladophora oligoclada*** Harvey
Chaetomorpha aerea (Dillwyn) Kiltzing	***Cladophora radiosa*** (Suhr) Kützing
Chaetomorpha antennina (Bory de Saint-Vincent) Kützing	***Cladophora rugulosa*** G. Martens
Chaetomorpha brachygona Harvey	***Cladophora saviniana*** Børgesen*
Chaetomorpha californica F.S. Collins	***Cladophora sericea*** (Hudson) Kützing [*Cladophora glaucescens* (A.W.Griffiths ex Harvey) Harvey]
Chaetomorpha capillaris (Kützing) Børgesen	
Chaetomorpha crassa (C.Agardh) Kützing *	***Cladophora sericioides*** Børgesen
Chaetomorpha gracilis Kützing*	***Cladophora socialis*** Kützing [*Cladophora patentirama* forma *longiarticulata* Reinbold]
Chaetomorpha indica (Kützing) Kützing	
Chaetomorpha ligustica (Kützing) Kützing	***Cladophora vagabunda*** (Linnaeus) Hoek [*Cladophora fascicularis* (Mertens ex C.Agardh) Kützing]
Chaetomorpha linum (O.F.Müller) Kützing	
Chaetomorpha linum* f. *brachyarthra (Børgesen) Kützing	***Cladophora* sp.** Kützing
Chaetomorpha ligustica (Kützing) Kützing	***Pseudocladophora conchopheria*** (Sakai) Boedeker & Leliaer [*Cladophora conchopheria* Sakai]
Chaetomorpha mediterranea (Kutzing) Kutzing	
Chaetomorpha spiralis Okamura	***Rhizoclonium grande*** Børgesen
Chaetomorpha vieillardii (Kützing) M.J.Wynne	***Rhizoclonium riparium*** (Roth) Harvey [*Rhizoclonium kerneri* Stockmayer *Rhizoclonium kochianum* Kützing *Rhizoclonium riparium* var. *implexum* (Dillwyn) Rosenvinge *Rhizoclonium implexum* (Dillwyn)]
***Chaetomorpha* sp.** Kützing	
Cladophora albida (Nees) Kützing *Cladophora magdalenae* Harvey]	
Cladophora aokii Yamada	
Cladophora coelothrix Kützing*	***Rhizoclonium tortuosum*** (Dillwyn) Kützin [*Cladophora ligustica* (Kützing) Kützing *Cladophora mediterranea* (Kützing) Kützing]
Cladophora* cf. *'coelothrix' Kützing	
Cladophora colabensis Børgesen	
Cladophora dalmatica Kützing	**Order: Dasycladales**
Cladophora echinus (Biasoletto) Kützing	

(continued)

Table 2 (continued)

Species and Synonyms
Family Dasycldaceae
***Neomeris* sp.** J.V.Lamouroux
Family Polyphysaceae
Acetabularia caliculus J.V.Lamouroux
Parvocaulis clavatus (Yamada) S. Berger et al. [*Acetabularia clavulatai* Yamada]
Parvocaulis parvulus (Solms-Laubach) S. Berger et al. [*Polyphysa parvula* (Solms-Laubach) Schnetter and Bula Meyer *Acetabularia moebii* Solms-Laubach]
***Parvocaulis* sp.** (Solms-Laubach) S.Berger, U.Fettweiss, S.Gleissberg,[L.B.Liddle, U.Richter, H.Sawitzky & G.C.Zuccarello] *
Order: Siphonocladales
Family Boodleaceae
Boodlea composite (Harvey) F.Brand
Cladophoropsis fasciculata (Kjellman) Wille [*Cladophoropsis sundanensis* Reinbold]
Cladophoropsis membranacea (Hofman Bang ex C. Agardh) Børgesen [*Cladophora membranacea* (Hofman Bang ex C.Agardh) Kützing]
Family Siphonocladaceae
Boergesenia forbesii (Harvey) Feldmann
Dictyosphaeria cavernosa (Forsskål) Børgesen
Siphonocladus feldmannii Børgesen
Family Valoniaceae
Valonia aegagropila C.Agardh
Valonia utricularis (Roth) C.Agardh*
Valonia utricularis* f. *crustacea Kuckuck
Valoniopsis pachynema (G.Martens) Børgesen
Order: Ulotrichales
Family Gomontiaceae
Gomontia polyrhiza (Lagerheim) Bornet & Flahault
Family Ulotrichaceae
Acrosiphonia spinescens (Kützing) Kjellman*

Species and Synonyms
Spongomorpha arcta (Dillwyn) Kützing
***Ulothrix* sp.** Kützing
Family Phaeophilaceae
Phaeophila dendroides (P.L. Crouan & H.M. Crouan) Batters [*Ochlochaete dendroides* P.L.Crouan & H.M.Crouan]
Family Kornmanniaceae
Blidingia marginata (J.Agardh) P.J.L.Dangeard ex Bliding
Blidingia minima (Nägeli ex Kützing) Kylin
Order: Ulvales
Family Ulvaceae
***Ulva australis* Areschoug** [*Ulva pertusa* Kjellman]
***Ulva californica* Wille**
Ulva clathrata (Roth) C. Agardh [*Enteromorpha clathrata* (Roth) Greville *Enteromorpha ramulosa* (Smith) Carmichael *Ulva ramulosa* Smith]
Ulva compressa Linnaeus [*Enteromorpha compressa* (Linnaeus) Nees]
Ulva flexuosa Wulfen [*Enteromorpha flexuosa* (Wulfen) J.Agardh subsp. *Flexuosa*]
Ulva grandis Saifullah & Nizamuddin
Ulva intestinalis Linnaeus [*Enteromorpha intestinalis* (Linnaeus) Nees]
Ulva kylinii (Bliding) Hayden, Blomster, Maggs, P.C. Silva, M.J. Stanhope & J.R. Waaland [*Enteromorpha kylinii* Bliding]
Ulva lactuca Linnaeus [*Ulva fasciata* Delile]
Ulva linza Linnaeus* [*Ulva fasciata* S.F. Gray *Enteromorpha linza* (Linnaeus) J.Agardh]

(continued)

Table 2 (continued)

Species and Synonyms	Species and Synonyms
Ulva prolifera O.F. Müller [*Enteromorpha prolifera* (O.F.Müller) J.Agardh]	***Ulvella viridis*** (Reinke) R. Nielsen, C.J. O'Kelly & B. Wysor [*Enlocladia viridis* Reinke *Acrochaete viride* (Reinke) R. Nielsen *Entocladia viridis* Reinke (Reinke) De Toni]
Ulva reticulata Forsskål	
Ulva rigida C.Agardh	
***Ulva* sp.** Linnaeus	***Enteromorpha bulbosa*** (Suhr) Montagne*****

Table 3 Record of Red algal species reported to occur in the Gulfs and their taxonomic category [Bold accepted name; otherwise synonyms; [a]new record]. Flaged are in QMZ

Species and Synonyms	Species and Synonyms
Class Florideophyceae	***Ceramium cimbricum*** H.E. Petersen [*Ceramium fastigiatum* (Wulfen ex Roth) Harvey]
Order Ahnfeltiales	
Family Ahnfeltiaceae	***Ceramium cimbricum*** f. ***flaccidum*** (H.E. Petersen) G. Funari and Serio [*Ceramium fastigiatum* f. *flaccidum* H.E. Petersen *Eupogodon pilosus* (Weber-van Bosse) P.C. Silva *Dasyopsis pilosa* Weber-van Bosse]
Ahnfeltia plicata (Hudson) E.M.Fries	
Order Acrochaetiales	
Family Acrochaetiaceae	
Acrochaetium bahreinii Børgesen* *Audouinella bahreinii* (Børgesen) Garbary	***Ceramium cingulatum*** Weber-van Bosse
	Ceramium codii (Richards) Feldmann-Mazoyer*
Acrochaetium microscopicum (Nägeli ex Kützing) Nägeli	***Ceramium cruciatum*** F.S.Collins and Hervey
Acrochaetium savianum (Meneghini)Nageli	***Ceramium deslongchampsii*** Chauvin ex Duby*
Acrochaetium robustum Børgesen	***Ceramium diaphanum*** (Lightfoot) Roth* [*Ceramium gracillimum* (Kützing) Zanardini]
***Acrochaetium* sp.** Nägeli	
Order Bonnemaisoniales	***Ceramium floridanum*** J.Agardh
Family Bonnemaisoniaceae	***Ceramium luetzelburgii*** O.C.Schmidt
Asparagopsis armata Harvey [*Falkenbergia rufolanosa* (Harvey) F.Schmitz]	***Ceramium maryae*** Weber-van Bosse*
	Ceramium macilentum J.Agardh
Asparagopsis taxiformis (Delile) Trevisan de Saint-Léon	[*Ceramium mazatlanense* E.Y.Dawson]
Order Ceramiales	***Ceramium manorense*** P. Anand [*Ceramium strictum* (Kützing) Harvey *Ceramium strictum* Harvey]
Family Callithamniaceae	
Aglaothamnion cordatum (Børgesen) Feldmann-Mazoyer [*Callithamnion cordatum* Børgesen]	***Ceramium subverticillatum*** (Grunow) Weber-van Bosse
Aglaothamnion hookeri (Dillwyn) Maggs et Hommersand	***Ceramium tenerrimum*** (Martens) Okamura
***Callithamnion* sp.** Lyngbye	***Ceramium truncatum*** H.E. Petersen
***Callithamnieae* sp.** Schmitz	***Ceramium upolense*** G.R.South & Skelton
Crouania attenuate (C.Agardh) J.Agardh*	***Ceramium* sp.** Roth
***Crouania* sp.** J.Agardh	***Corallophila bella*** (Setchell & N.L. Gardner) R.E. Norris [*Centroceras bellum* Setchell and N.L.Gardner]
Family Ceramiaceae	
Antithamnion cruciatum (C.Agardh) Nägeli	***Corallophila huysmansii*** (Weber-van Bosse) R.E.Norris
Centroceras clavulatum (C. Agardh) Montagne	***Corallophila kleiwegii*** Weber-van Bosse [*Centroceras apiculata* Yamada *Corallophila apiculata* (Yamada) R.E.Norris]
Centroceras hyalacanthum Kützing	
Ceramium borneense Weber-van Bosse [*Ceramium subdichotomum* Weber-van Bosse]	

(continued)

Table 3 (continued)

Species and Synonyms	Species and Synonyms
Gayliella flaccida (Harvey ex Kützing) T.O. Chou & L.J. McIvor [*Ceramium flaccidum* (Harvey ex Kützing) Ardissone *Ceramium masonii* E.Y.Dawson]	***Acanthophora nayadiformis*** (Delile) Papenfuss [*Acanthophora delilei* J.V.Lamouroux]
	Acanthophora spicifera (M.Vahl)) Børgesen
Gayliella transversalis (F.S. Collins and Hervey) T.O. Cho & Fredericq [*Ceramium. transversal* Collins & Harvey]	***Chondria arcuata*** Hollenberg
	Chondria bernardii P.[J.L.] .Dangeard
Family Dasyaceae	***Chondria capillaris*** (Hudson) M.J.Wynne*
Dasya anastomosans (Weber-van Bosse) M.J. Wynne [*Dasya pilosa* (Weber-van Bosse) A.Millar]	***Chondria collinsiana*** M.A.Howe
	Chondria cornuta Børgesen
Dasya baillouviana (S.G. Gmelin) Montagne] [*Dasya pedicellata* (C.Agardh) C.Agardh	***Chondria dasyphylla*** (Woodward) C.Agardh
	Chondria nidifica Harvey
Dasya* cf. *corymbifera J.Agardh	***Chondria oppositiclada*** E.Y.Dawson*
Dasya elongate Sonder*	***Chondria seticulosa*** (Forsskål) C. Agardh [*Chondria hypnoides* Børgesen]
Dasya ocellata (Grateloup) Harvey*	
Dasya baillouviana (S.G. Gmelin) Montagne [*Dasya pedicellata* (C.Agardh) C.Agardh]	***Chondria*** sp.C.Agardh
	Chondriopsis dasyphylla* f. *pyrifera J. Agardh [*Laurencia intricata* Suhr]
Dasya rigidula (Kützing) Ardissone	
***Dasya* sp.** C. Agardh [*Pogonophorella* P.C.Silva]	***Chondrophycus glandulifer*** (Kützing) Lipkin and P.C. Silva [*Laurencia glandulifera* (Kützing) Kützing]
***Dasysiphonia* sp.** I.K.Lee & J.A.West*	***Chondrophycus undulatus*** (Yamada) Garbary & Harper [*Laurencia undulata* Yamada]
Heterosiphonia crispella (C. Agardh) M.J. Wynne [*Heterosiphonia crispella* var. *laxa* (Borgesen) M.J. Wynne]	
Micropeuce feredayae (Harvey) Kylin ex P.C. Silva* [*Dasya feredayae* Harvey]	***Digenea simplex*** (Wulfen) C. Agardh
	Herposiphonia dendroidea Hollenberg
	Herposiphonia tenella (C.Agardh) Ambronn
Family Delesseriaceae	***Herposiphonia secunda*** (C. Agardh) Ambronn [*Herposiphonia secunda* (C. Agardh) Ambronn f. *tenella* (C. Agardh) M.J. Wynne *Herposiphonia tenella* (C.Agardh) Nägeli]
Apoglossum spathulatum (Sonder) Womersley & Shepley [*Hypoglossum spathulatum* (Sonder) Kützing]	
Caloglossa leprieurii (Montagne) G.Martens	***Herposiphonia* sp**. Nägeli
Cryptopleura robusta M.J.Wynne	***Laurencia dendroidea*** J. Agardh [*Laurencia majuscula* (Harvey) A.H.S. Lucas] *Laurencia obtusa* (Hudson) J.V.Lamouroux var. *majuscula* Harvey]
***Hypoglossum* sp**.Kützing	
Myriogramme okhaensis Børgesen	
Taenioma nanum (Kützing) Papenfuss	***Laurencia elata*** (C.Agardh) J.D.Hooker & Harvey
Family Rhodomelaceae	***Laurencia filiformis*** (C. Agardh) Montagne
Acanthophora muscoides de Saint-Vincent (Linnaeus) Bory	***Laurencia intricata*** J.V.Lamouroux

(continued)

Table 3 (continued)

Species and Synonyms	Species and Synonyms
Laurencia microcladia Kützing	***Palisada intermedia*** (Yamada) K.W. Nam [*Laurencia intermedia* Yamada *Chondrophycus intermedius* (Yamada) Garbary & J.T.Harper]
Laurencia minuta Vandermeulen, Garbary & Guiry	***Palisada paniculata*** (Kützing) J.N. Norris [*Laurencia paniculata* Kützing]
Laurencia minuta* subsp. *scammaccae G.Furnari & Cormaci*	***Palisada patentiramea*** (Montagne) Cassano, Sentíes, Gil-Rodríguez & M.T. Fujii [*Laurencia patentiramea* (Montagne) Kützing *Chondrophycus patentirameus* (Montagne)K.W.Nam]
Laurencia obtuse (Hudson) J.V.Lamouroux	***Palisada perforata*** (Bory de Saint-Vincent) K.W. Nam [*Chondrophycus papillosus* (C. Agardh) D.J. Garbary & J.T. Harper *Laurencia papillosa* (C.Agardh) Greville *Laurencia perforata* (Bory de Saint-Vincent) Montagne]
Laurencia obtusa* var. *compacta A.B.Cribb	***Palisada thuyoides*** (Kützing) Cassano, Sentíes, Gil-Rodríguez & M.T. Fuji [*Laurencia paniculata* (C. Agardh) J. Agardh *Chondrophycus paniculatus* (C. Agardh) G. Furnari *Laurencia thuyoides* Kützing *Chondrophycus thuyoides* (Kützing) G.Furnari]
Laurencia obtusa* var. *delilii (C.Agardh) Zanardini	***Polysiphonia atlantica*** Kapraun and J.N.Norris*
Laurencia obtusa* var. *mollissima A.B.Cribb*	***Polysiphonia bifurcate*** Hollenberg*
Laurencia platyclada Borgesen	***Leptosiphonia brodiei*** (Dillwyn) A.M.Savoie & G.W.Saunders [*Polysiphonia brodiei* (Dillwyn) Sprengel]
Laurencia pyramidalis Bory de Saint-Vincent ex Kützing*	***Polysiphonia coacta*** C.K.Tseng*
Laurencia snyderae E.Y.Dawson	***Polysiphonia codicola*** Zanardini ex Frauenfeld
Laurencia snyderae* var. *guadalupensis E.Y.Dawson	***Polysiphonia crassicollis*** Børgesen
***Laurencia* spp.** J.V.Lamouroux A-Z	***Carradoriella denudata*** (Dillwyn) A.M.Savoie & G.W.Saunders [*Polysiphonia denudata* (Dillwyn) Greville ex Harvey *Polysiphonia variegata* (C.Agardh) Zanardini]
Leveillea jungermannioides (Hering & G.Martens) Harvey	***Polysiphonia kampsaxii*** Børgesen
Lophocladia lallemandii (Montagne) F.Schmitz	***Polysiphonia opaca*** (C.Agardh) Moris & De Notaris
Lophosiphonia obscura (C. Agardh) Falkenberg [*Lophosiphonia subadunca* (Kützing) Falkenberg]	***Polysiphonia platycarpa*** Børgesen
Melanothamnus somalensis Bornet & Falkenberg	
Murrayella periclados (C.Agardh) F.Schmitz*	
Neosiphonia collabens (C. Agardh) Díaz-Tapia & Bárbara* [*Streblocladia collabens* (C.Agardh) Falkenberg]	
Neosiphonia ferulacea (Suhr ex J. Agardh) S.M. GuimarÃ£es & M.T. Fujii [*Polysiphonia ferulacea* Suhr ex J.Agardh]	
Neosiphonia sertularioides (Grateloup) K.W.Nam & P.J.Kang* [*Polysiphonia flaccidissima* Hollenberg]	
Neosiphonia sphaerocarpa (Børgesen) M.-S.Kim & I.K.Lee*	
Neosiphonia tongatensis (Harvey ex Kützing) M.-S.Kim & I.K.Lee *	
Osmundea coelenterata(D.L. Ballantine et Aponte) M.T. Fujii Sentíes* [*Laurencia coelenterata* D.L. Ballantine et Aponte]	
Osmundea hybrid (A.P. de Candolle) K.W.Nam	
Osmundea pedicularioides (Børgesen) G. Funari, Serio & Cormaci [*Laurencia pedicularioides* Børgesen]	

(continued)

Table 3 (continued)

Species and Synonyms
Polysiphonia scopulorum Harvey var. ***villum*** (J. Agardh) Hollenberg [*Lophosiphonia villum* (J.Agardh) Setchell and Gardner]
Polysiphonia subtilissima Montagne
Polysiphonia tuticorinensis Børgesen
***Polysiphonia* spp.** Greville A-Z
Tolypiocladia condensate (Weber-van Bosse) P.C.Silva
Tolypiocladia glomerulata (C. Agardh) F. Schmitz [*Roschera glomerulata* (C. Agardh) Weber-van Bosse *Hutchinsia glomerulata* C. Agardh *Polysiphonia calacantha* Harvey *Polysiphonia glomerulata* (C. Agardh) Sprengel *Polysiphonia inflata* G. Martens *Roschera glomerulata* (C. Agardh) Weber-van Bosse *Sphacelaria cupressina* Harvey *Vertebrata glomerulata* (C.Agardh) Kuntze]
Yuzurua poiteaui (J.V.Lamouroux) Martin-Lescanne
Family Sarcomeniaceae
Cottoniella filamentosa (M.A. Howe) Borgesen
Platysiphonia delicate (Clemente) Cremades [*Melobesia lejolisii* Rosanoff *Platysiphonia miniata* (C. Agardh) Borgesen *Conferva delicata* Clemente *Hutchinsia miniata* C. Agardh *Platysiphonia miniata* (C. Agardh) Børgesen *Sarcomenia miniata* (C.Agardh) J.Agardh]
Family Spyridiaceae
Spyridia filamentosa (Wulfen) Harvey
Spyridia filamentosa forma *gracile*
Spyridia hypnoides (Bory de Saint-Vincent) Papenfuss
Family Wrangeliaceae
Anotrichium tenue (C. Agardh) Nägeli [*Griffithsia tenuis* C.Agardh]
Griffithsia globulifera Harvey ex Kützing
Griffithsia sp. C.Agardh

Species and Synonyms
Gymnophycus sp. Huisman & Kraft
Pleonosporium borreri (Smith) Nägeli [*Callithamnion borreri* var. *elongatum* Kützing]
***Spermothamnion* sp.** Areschoug
Order Corallinales
Family Corallinaceae
Hydrolithon boreale (Foslie) Y.M. Chamberlain
Hydrolithon farinosum (J.V. Lamouroux) Penrose and Y.M. Chamberlain [*Fosliella farinose* (Lamouroux) Howe *Melobesia farinosa* Lamouroux]
Hydrolithon improcerum (Foslie and M.Howe) Foslie
Hydrolithon* prox. *rupestris (Foslie) Penrose
***Hydrolithon* sp.** (Foslie) Foslie
Amphiroa fragilissima (Linnaeus) J.V. Lamouroux
***Amphiroa* sp.** J.V. Lamouroux
Jania adhaerans J.V. Lamouroux
Jania pumila J.V.Lamouroux
Jania rubens (Linnaeus) J.V. Lamouroux
Jania tenella (Kützing) Grunow
Jania ungulate (Yendo) Yendo f. ***brevior*** (Yendo) Yendo
***Jania* sp.** J.V.Lamouroux
Lithophyllum acrocamptum Heydrich [*Lithothamnion incrassatum* (Foslie) Jadin]
Lithophyllum kotschyanum Unger
Lithophyllum prototypum (Foslie) Foslie [*Titanoderma prototypum* (Foslie) Woelkerling, Y.M. Chamberlain and P.C.Silva]
Lithophyllum acrocamptum Heydrich [*Lithophyllum* prox. *incrassatum* (Foslie) Foslie
***Lithophyllum* sp.** Philippi [*Lithothamnium* R.A.Philippi]
Neogoniolithon brassica-florida (Harvey) Setchell & L.R. Mason [*Neogoniolithon fosliei* (Heydrich) Setchell and Mason]

(continued)

Table 3 (continued)

Species and Synonyms	Species and Synonyms
Neogoniolithon misakiense (Foslie) Setchell & L.R.Mason	***Caulacanthus ustulatus*** (Mertens ex Turner) Kützing*
Pneophyllum fragile Kützing	**Family Cystocloniaceae**
***Pneophyllum* sp**. Kützing	***Hypnea anastomosans*** Papenfuss, Lipkin & P.C.Silva*
Spongites tunicate D.L.Penrose	***Hypnea aspera*** Kützing
***Spongites* sp.** Kützing	[*Hypnea boergesenii* T. Tanaka]
Titanoderma pustulatum (J.V.Lamouroux) Nägeli	***Hypnea cornuta*** (Kützing) J.Agardh
Family Hapalidiaceae	***Hypnea charoide*** J.V. Lamouroux
Endosiphonia horrida (C.Agardh) P.C.Silva	***Hypnea ecklonii*** Suhr
Lithothamnion muelleri Lenormand ex Rosanoff	***Hypnea flagelliformis*** Greville ex J.Agardh
***Lithothamnion* sp.** Heydrich	***Hypnea hamulosa*** (Esper) Lamouroux
Family Sporolithaceae	***Hypnea musciformis*** (Wulfen) J.V. Lamouroux*
Sporolithon* prox. *Episporum (M.Howe) Dawson	***Hypnea nidulans*** Setchell
Sporolithon molle (Heydrich) Heydrich*	***Hypnea pannosa*** Agardh
Sporolithon ptychoides Heydrich	***Calliblepharis saidana*** (Holmes) M.Y. Yang & M.S. Kim, 2017* [*Hypnea saidana Holmes*]
Order Gelidiales	***Hypnea spinella*** (C.Agardh) Kützing
Family Gelidiellaceae	***Hypnea valentiae*** (Turner) Montagne
Gelidiella acerosa (Forsskål) Feldmann and G.Hamel	[*Hypnea cervicornis* J. Agardh]
Gelidiella myriocladа (Børgesen) Feldmann & G.Hamel	***Hypnea* spp.** J.V.Lamouroux A-Z
Gelidiella ramellosa (Kützing) Feldmann et G.Hamel	**Family Dumontiaceae**
Gelidiella rigidiuscula (Feldmann) Feldmann & G.Hamel	***Dudresnaya* sp**. P.L.Crouan & H.M.Crouan
***Gelidiella* sp.** Feldmann & G.Hamel	**Family Furcellariaceae**
Family Gelidiaceae	***Furcellaria lumbricalis*** (Hudson) J.V. Lamouroux
Gelidium chilense (Montagne) Santelices and Montalva	[*Furcellaria fastigiata* (Hudson) J.V. Lamouroux]
Gelidium crinale (Hare ex Turner) Gaillon	**Family Gigartinaceae**
Gelidium micropterum Kützing	***Chondracanthus acicularis*** (Roth) Fredericq
Gelidium pusillum (Stackhouse) Le Jolis	[*Gigartina acicularis* (Roth) J.V. Lamouroux]
Gelidium pusillum var. ***pulvinatum*** (C.Agardh) Feldmann	***Chondrus ocellatus*** Holmes
***Gelidium* spp**. V. Lamouroux	**Family Phyllophoraceae**
Family Pterocladiaceae	***Ahnfeltiopsis pygmaea*** (J. Agardh) P.C. Silva et DeCew
Pterocladia heteroplatos (Børgesen) Umamaheswara Rao & Kaliaperumal [*Gelidium heteroplatos* Børgesen]	[*Gymnogongrus pygmaeus* J.Agardh]
	Family Rhizophyllidaceae
Order Gigartinales	***Portieria japonica*** (Harvey) P.C.Silva
Family Caulacanthaceae	

(continued)

Table 3 (continued)

Species and Synonyms	Species and Synonyms
Family Solieriaceae	***Gracilaria vieillardii*** P.C. Silva
Eucheuma denticulatum (N.L.Burman) F.S.Collins and Hervey	***Gracilaria* sp.** Greville
Meristotheca papulosa (Montagne) J.Agardh	***Gracilariopsis* sp.** E.Y.Dawson
Sarconema filiforme (Sonder) Kylin	***Hydropuntia edulis*** (S.G.Gmelin) Gurgel & Fredericq* [*Gracilaria edulis* (S.G.Gmelin) P.C.Silva]
Solieria anastomosans P.W.Gabrielson and Kraft	**Order Halymeniales**
Solieria dura (Zanardini) F. Schmitz	**Family Halymeniaceae**
Solieria filiformis (Kützing) P.W.Gabrielson	***Corynomorpha prismatica*** (J.Agardh) J.Agardh
Solieria robusta (Greville) Kylin [*Solieria australis* Harvey]	***Cryptonemia coriacea*** F.Schmitz
Solieria tenuis J. Zhang & E. Xia	***Grateloupia comorinii*** Børgesen
Wurdemannia miniata (Sprengel) Feldmann and G.Hamel	***Grateloupia filicina*** (J.V.Lamouroux) C.Agardh
Order Gracilariales	***Grateloupia somalensis*** Hauck
Family Gracilariaceae	***Grateloupia* sp.** C.Agardh*
Gracilaria arcuate Zanardini	***Halymenia dilatata*** Zanardini
Gracilaria armata (C. Agardh) Greville	***Halymenia porphyraeformis*** Parkinson
Gracilaria canaliculata Sonder [*Gracilaria crassa* Harvey ex J.Agardh]	**Order Nemaliales** **Family Galaxauraceae**
Gracilaria corticata (J.Agardh) J.Agardh	***Actinotrichia fragilis*** (Forsskål) Børgesen
Gracilaria foliifera (Forsskål) Børgesen	***Galaxaura rugose*** (J.Ellis & Solander) J.V.Lamouroux [*Galaxaura lapidescens* (J.Ellis & Solander) J.V.Lamouroux *Galaxaura flagelliformis* Kjellman *emend*. Børgesen]
Gracilaria gracilis **(**Stackhouse) Steentoft, L.M. Irvine et W.F Farnham	
Gracilaria mammillaris (Montagne) Howe [*Gracilaria veleroae* Dawson]	***Dichotomaria obtusata*** (J.Ellis & Solander) Lamarck
Gracilaria millardetii (Montagne) J. Agardh	**Family Liagoraceae**
Gracilaria pulvinata Skottsberg [*Gracilaria pygmaea* V.J. Chapman]	***Dermonema pulvinatum*** (Grunow) Fan ***Dermonema virens*** (J. Agardh) Pedroche and Avila Ortiz
Gracilaria robusta Setchell	***Helminthocladia australis*** Harvey
Gracilaria salicornia (C. Agardh) E.Y. Dawson* [*Corallopsis cacalia* J.Agardh]	***Liagora ceranoides*** J.V.Lamouroux ***Liagora distenta*** (Mertens ex Roth) J.V.Lamouroux
Gracilaria spinulosa (Okamura) C.F. Chang et B.M. Xia	***Liagora filiformis*** Fan & Li
Gracilaria sullivanii Yamamoto & Trono*	***Liagora viscida*** (Forsskål) C.Agardh
Gracilaria textorii (Suringar) De Toni	***Nemalian* sp.** Duby*
Agarophyton vermiculophyllum ***(***Ohmi) Gurgel, J.N.Norris et Fredericq [*Gracilaria vermiculophylla* (Ohmi) Papenfuss]*	**Family Scinaiaceae** ***Scinaia carnosa*** (Kützing) J. Agardh*

(continued)

Table 3 (continued)

Species and Synonyms	Species and Synonyms
Scinaia fascicularis (Borgesen) Huisman	***Lomentaria* sp.** Lyngbye
Scinaia furcellata (Turner) J. Agardh	**Family Rhodymeniaceae**
Scinaia hatei Borgesen	***Botryocladia leptopoda*** (J. Agardh) Kylin
Scinaia moniliformis J. Agardh	***Botryocladia* sp**. (J.Agardh) Kylin
Scinaia tsinglanensis C.K.Tseng	***Rhodymenia dissecta*** Børgesen
***Scinaia* sp.** Bivona Bernardi	***Rhodymenia* sp.** Greville.
Order Nemastomatales	**Order Sebdeniales**
Family Schizymeniaceae	**Family Sebdeniaceae**
Platoma heteromorphum Schils	***Sebdenia flabellate*** (J.Agardh) P.G.Parkinson
Order Peyssonneliales	**Class Bangiophyceae**
Family Peyssonneliaceae	**Order Bangiales**
Peyssonnelia simulans Weber-van Bosse	**Family** Bangiaceae
[*Peyssonnelia miniata* (C.Agardh) Børgesen]	***Bangia atropurpurea*** (Mertens ex Roth) C.Agardh
Order Rhodymeniales	***Bangia fuscopurpurea*** (Dillwyn) Lyngbye
Family Champiaceae	**Class Compsopogonophyceae**
Champia compressa Harvey	**Order Erythropeltidales**
Champia compressa var. ***scindica*** Børgesen	**Family Erythrotrichiaceae**
Champia globulifera Børgesen	***Erythrotrichia carnea*** (Dillwyn) J.Agardh
Champia indica Børgesen	***Erythrotrichia vexillaris*** (Montagne) G.Hamel
Champia kotschyana Endlicher & Diesing	***Erythrocladia irregularis*** Rosenvinge
Champia parvula (C.Agardh) Harvey*	***Sahlingia subintegra*** (Rosenvinge) Kornmann
Champia zonata (J. Agardh) J. Agardh	[*Erythrocladia* f. *irregularis* Rosenvinge
***Champia* spp.** Desvaux	*Erythrocladia subintegra* Rosenvinge]
Family Hymenocladiaceae	**Class Stylonematophyceae**
Asteromenia peltata (W.R.Taylor) Huisman & A.J.K.Millar	**Order Stylonematales**
Family Lomentariaceae	**Family Stylonemataceae**
Ceratodictyon intricatum (C.Agardh) R.E.Norris	***Chroodactylon ornatum*** (C.Agardh) Basson *
Ceratodictyon planicaule (W.R.Taylor) M.J.Wynne*	[*Asterocystis ornata* (C.Agardh) Hamel]
Ceratodictyon variabile (J. Agardh) R.E. Norris	***Chroodactylon* sp.** Hansgirg
[*Gelidiopsis variabilis* (Greville ex J. Agardh) F. Schmitz]	***Stylonema alsidii*** (Zanardini) K.M.Drew*
Lomentaria corallicola Børgesen	
Lomentaria divaricate (Durant) M.J. Wynne [*Lomentaria baileyana* (Harvey) Farlow]	

Table 4 Record of Brown algal species reported to occur in the Gulfs and their taxonomic category [Bold accepted name; otherwise synonyms; [a]new record]. Flaged are in QMZ

Species and Synonyms	QMZ
Class Phaeophyceae	
Order Asterocladales	
Family Asterocladaceae	
Asterocladon rhodochortonoides (Børgesen) Uwai, Nagasato, Motomura & Kogame* [*Ectocarpus rhodochortonoides* Børgesen]	(flag)
Order Scytothamnales	
Family Bachelotiaceae	
Bachelotia antillarum (Grunow) Gerloff	
Order Dictyotales	
Family Dictyotaceae	
Canistrocarpus cervicornis (Kützing) De Paula & De Clerck [*Dictyota cervicornis* Kützing *Dictyota indica* Sonder ex Kützing]	(flag)
Canistrocarpus crispatus (J.V.Lamouroux) De Paula & De Clerck* [*Dictyota crispata* J.V.Lamouroux]	(flag)
Dictyopteris australis f. ***karachiensis*** Nizamuddin & Saifullah	
Dictyopteris hoytii W.R. Taylor	
Dictyopteris macrocarpa (Areschoug) O.C.Schmidt	
Dictyopteris polypodioides (De Candolle) J.V. Lamouroux [*Dictyopteris membranacea* (Stackhouse) Batters]	
Dictyota bartayresiana J.V.Lamouroux*	(flag)
Dictyota ciliolata Sonder ex Kützing	
Dictyota dichotoma (Hudson) J.V. Lamouroux [*Dictyota volubilis* Kützing]	(flag)
Dictyota dichotoma* var. *intricata (C. Agardh) Greville	
Dictyota friabilis Setchell	
Dictyota implexa (Desfontaines) J.V. Lamouroux [*Dictyota dichotoma* var. *intricata* (C. Agardh) Greville,] *Dictyota divaricata* (J.Agardh) J.Agardh *Dictyota linearis* (C.Agardh) Greville]	(flag)
Dictyota indica Anand	
***Dictyota* spp.** J.V.Lamouroux A-Z	(flag)
Taonia atomaria (Woodward) J.Agardh	
Lobophora variegata (J.V. Lamouroux) Womersley ex E.C. Oliveira* [*Zonaria variegata* (J.V. Lamouroux) C. Agardh *Pocockiella variegata* (J.V.Lamouroux) Papenfuss]	(flag)
Padina antillarum (Kützing) ***Piccone*** [*Zonaria antillaru* Kützing]	
Padina australis Hauck	(flag)
Padina boergesenii Allender & Kraft [*Padina gymnospora sensu* Vickers]	(flag)
Padina boryana Thivy [*Padina tenuis* Bory *Padina commersonii* Børgesen]	(flag)
Padina distromaticaHauck	
Padina dubia Hauck	
Padina glabra Gaillard	
Padina gymnospora (Kützing) Sonder [*Padina crassa* Yamada]	(flag)
Padina minor Yamada	(flag)
Padina pavonica (Linnaeus) Thivy	(flag)
Padina tetrastromatica Hauck	(flag)
***Padina* spp.** Adanson A-Z	(flag)
Spatoglossum asperum J. Agardh	
Spatoglossum dichotomum C.K.Tseng & Lu	
Spatoglossum variabile Figari & De Notaris	(flag)
Stoechospermum polypodioides (C. Agardh) Kützing* [*Stoechospermum marginatum* (C.Agardh) Kützing]	(flag)

(continued)

Table 4 (continued)

Species and Synonyms
Stypopodium japonica (Harvey) P.C.Silva*
Order Ectocarpales
Family Acinetosporaceae
Feldmannia columellaris (Børgesen) Islam
Feldmannia indica (Sonder) Womersley ad Bailey [*Giffordia duchassaingiana* (Grunow) W.R. Taylor *Giffordia indica* (Sonder) Papenfuss *Hincksia indica* (Sonder) J. Tanaka]
Feldmannia irregularis (Kützing) G. Hamel [*Ectocarpus irregularis* Kützing]
Feldmannia michelliae (Harvey) H-S. Kim [*Ectocarpus michelliae* Harvey *Giffordia mitchellae* (Harvey) Hamel *Hincksia mitchelliae* (Harvey) P.C.Silva]
Family Chordariaceae
Cladosiphon occidentalis Kylin
Cladosiphon zosterae (J.Agardh) Kylin
Myriactula arabica (Kützing) Feldmann ***Myrionema orbiculare*** J.Agardh
Nemacystus decipiens (Suringar) Kuckuck
Nemacystis erythraeus (J.Agardh) Sauvageau
Stilophora iranica Børgesen
Stilophora tenella Esper) P.C. Silva [*Stilophora rhizodes* J.Agardh]
Tinocladia crassa (Suringar) Kylin
Family Ectocarpaceae
Ectocarpus cryptophilus Børgesen
Ectocarpus rallsiae Vickers [*Giffordia rallsiae* (Vickers) W.R.Taylor]
Ectocarpus siliculosus (Dillwyn) Lyngbye [*Ectocarpus confervoides* Le Jolis]
Ectocarpus sp. Lyngbye
Order Fucales
Family Sargassaceae
Polycladia indica (Thivy & Doshi) Draisma, Ballesteros, F. Rousseau & T. Thibaut [*Cystoseira indica* (Thivy& Doshi) Mairh]
Polycladia myrica (S.G. Gmelin) Draima, Ballesteros, F. Rousseau & T. Thibaut [*Cystoseira myrica* (S.G. Gmelin) C. Agardh]
Cystoseira rayssiae E.Ramon
Cystoseira spp. C.Agardh A-Z [*Cystophyllum* spp. J.Agardh]
Sirophysalis trinodis (Forsskal) Kützing [*Cystoseira trinodis* (Forskål) C. Agardh *Cystoseira virgata* Endlicher & Diesing]
Hormophysa cuneiformis (J.F. Gmelin) P.C. Silva [*Hormophysa triquetra* (C.Agardh) Kützing]
Nizamuddinia zanardinii (Schiffner) P.C. Silva [*Sargassum yemenense* forma *monstrosum* Zanardini] *Sargassopsis zanardinii* (Schiffner) M. Nizamuddin S. Hiscock, L. Barratt & R.F.G.Ormond *Sargassum zanardinii* Schiffner]
Sargassopsis decurrens (R. Brown ex Turner) Trevisan [*Sargassum decurrens* (R.Brown ex Turner) C.Agardh]
Sargassopsis heteromorphum (J. Agardh) R.R.M. Dixon & Huisman [*Sargassum heteromorphum* J.Agardh]
Sargassum acinaciforme Montagne
Sargassum agardhianum Farlow
Sargassum angustifolium C. Agardh [*Sargassum flexile* Greville]

(continued)

Table 4 (continued)

Species and Synonyms	Species and Synonyms
Sargassum aquifolium (Turner) C. Agardh [*Sargassum crassifolium* J. Agardh *Sargassum binderi* Sonder ex J.Agardh]	***Sargassum oligocystum*** Montagne ***Sargassum palmeri*** Grunow ***Sargassum persicum*** Kützing
Sargassum asperifolium Hering and G.Martens ex J.Agardh	***Sargassum plagiophyllum*** J. Agardh
Sargassum assimile Harvey [*Sargassum* (*Sargassum*) *assimile* Harvey]	***Sargassum platycarpum*** Montagne ***Sargassum spinuligerum*** Sonder
Sargassum baccularia (Mertens) C. Agardh	***Sargassum swartzii*** C. Agardh [*Sargassum acutifolium* Greville *Sargassum wightii Greville* ex J.Agardh]
Sargassum boveanum J.Agardh	
Sargassum boveanum var. ***aterrimum*** Grunow	
Sargassum carpophyllum J. Agardh	***Sargassum tenerrimum*** J.Agardh
Sargassum cervicorne Greville	***Sargassum tenuissimum*** (Endlicher & Diesing) Grunow [*Sargassum vulgare* C.Agardh var. *tenuissimum* Endlicher & Diesing]
Sargassum dentifolium (Turner) C. Agardh [*Sargassum denticulatum* Børgesen]	***Sargassum virgatum*** C.Agardh
Sargassum filifolium (C.Agardh) C.Agardh *	***Sargassum vulgare*** C.Agardh
Sargassum filipendula C.Agardh	***Sargassum vulgare*** var. ***angustifolium*** (Turner) C.Agardh
Sargassum filipendula var. ***laxum*** J.Agardh	***Sargassum vulgare*** var. ***latifolium*** Endlicher & Diesing
Sargassum flavifolium Kützing	***Sargassum* sp.** C.Agardh
Sargassum fluitans (Børgesen) Børgesen*	***Stephanocystis neglecta*** (Setchell and N.L. Gardner) Draisma et al. [*Cystoseira neglecta* Setchell and N.L.Gardner]
Sargassum gemmiphorum C.K. Tseng et B. Lu	
Sargassum glaucescens J. Agardh	***Turbinaria conoides*** (J.Agardh) Kützing
Sargassum henslowianum C. Agardh	***Turbinaria ornata*** (Turner) J. Agardh var. ***ornata*** f. ***evesiculosa*** (E.S. Barton) W.R.Taylor
Sargassum herbaceum Kützing [*Sargassum cristaefolium* C. Agardh]	**Order Scytosiphonales**
Sargassum ilicifolium (Turner) C.Agardh	**Family Scytosiphonaceae**
Sargassum lacerifolium (Turner) C.Agardh*	***Colpomenia sinuosa*** (Mertens ex Roth) Derbès & Solier [*Asperococcus sinuosus* (Mertens ex Roth) Bory var. *lobatus* Endlicher & Diesing]
Sargassum latifolium (Turner) C.Agardh	
Sargassum latifolium var. ***polycarpum*** (Figari & De Notaris) Grunow	***Hydroclathrus clathratus*** (C.Agardh) M.Howe
Sargassum longifructum C.K. Tseng and B. Lu	***Iyengaria stellate*** (Børgesen) Børgesen
Sargassum natans (Linnaeus) Gaillon	***Jolyna laminarioides*** S.M. Guimaraes

(continued)

Table 4 (continued)

Species and Synonyms	Species and Synonyms
Rosenvingea floridana (W.R.Taylor) W.R.Taylor	***Sphacelaria rigidula*** Kützing [*Sphacelaria furcigera* Kützing]
Rosenvingea intricata (J.Agardh) Børgesen	
Rosenvingea orientalis (J. Agardh) Borgesen	***Sphacelaria tribuloides*** Meneghini
Scytosiphon dotyi M.J.Wynne	***Sphacelaria* sp.** Lyngbye
Scytosiphon lomentaria (Lyngbye) Link	**Order Sporochnales**
Order Sphacelariales	**Family Sporochnaceae**
Family Sphacelariaceae	***Sporochnus pedunculatus*** (Hudson) C.Agardh
Sphacelaria novae-hollandiae Sonder*	

Chlorophyta Species

Group A: Plants are flattened, often thin and delicate may be easy to tear, and also tubular, cylindrical or hollow, which is often evident on cross section of the specimen. Smaller forms may also take on a slightly filamentous but cylindrical appearance (filiform) but microscopic examination will clarify this as they will be multiseriate (several cells wide).

Group B: Plants filamentous in form, tend to be very fine, delicate and hair like. Generally consist of a single or numerous filaments of linearly arranged cells which may be more clearly seen under microscopic examination. These species are uniseriate (one cell wide).

Group C: Plants microscopic, growing on or in other species of algae or rocks and shells, may be uni- or multi-cellular but are often difficult to locate. *Sykidion moorei* (this species is a single round cell located within *Blidingia* sp. only).

Group D: Plants are siphonous, they do not have cross walls, and cellular material moves freely throughout the filaments. They resemble those species of Group B with a filamentous appearance. *Bryopsis plumosa* (this species tends to be very fine, delicate and feather like with a regular opposite branching pattern in a single plane only).

The Red algae comprise multicellular and unicellular taxa. Some consider the Red algae as less advanced than the Green and Brown algae, and they do not contain any motile form unlike the others. The pigments in the Rhodophyta equally possess a number of pigments including chlorophylls (chlorophyll a), phycobilins (allophycocyanin, phycocyanin, phycoerythrin, and phycobilisomes), carotenes (-α-carotene, β-carotene), and xanthophylls (α-cryptoxanthin, β-cryptoxanthin, lutein, antheraxanthin, zeaxanthin, violaxanthin).

The cell walls in the Red algae are composed of is cellulose, hemi-cellulose, and polysulfate esters. A unique seaweed group belonging to the Red algae are the coralline algae, which exist in producing and branching types. Coralline algae excrete calcium carbonate into their tissues giving them a reddish pink stone characters. They play a major role in building reefs in many regions. Red algae are a traditional part of oriental cuisine.

They portray varying morphological characters from single cells to filamentous forms of a single chains of cells through to compact tissues in the form of cylindrical or flattened branches and sometimes membrane similar fronds.

There are numerous vernacular names in the Red algae, which illustrate the variability in their morphological appearance. Wells (1997) recognized five (5) groups in the Red algae by the following diagnostic characters: calcareous flat fronds, pink-purple becoming white when bleached; flattened often leaf-like compressed fronds, in-rolled or wide; cartilaginous-gelatinous, thin, or leaf-like, coarse or stiff cylindrical structure, or bead-like with filamentous branching; filamentous thread-like, multiseriate, fine delicate, hair like branches; and small delicate filamentous forms. In the Gulfs record 4 classes of the Rhodophyta with 17 orders and 40 families.

Rhodophyta Species

Group A: Plants calcareous, hard and limy present as both a crust forming over the surface of rocks and algal fronds, including microscopic forms, and as an erect system. Generally pink or purple in colour, but turning white on bleaching. This group also includes those non-calcareous encrusting forms, present as a large stain on the rock surface.

Group B: Plants with main blade or frond flattened or compressed, often leaflike, may occasionally be in-rolled, often with a wide blade which may vary from tough and leathery to thin, membranous and slightly elastic.

This group may take on a variety of morphological forms composed of wide, flat or channelled fronds, simple single blades, split blades and highly branched forms.

Group C: Plants not completely flattened, thin or leaf-like, generally thick, cartilaginous, wiry or gelatinous, appearing as a course or stiff cylindrical structure but may also be slightly compressed, bead-like or hollow ranging from 0.5mm to 5mm wide with no filamentous branching. Some species display minimal irregular branching, other species may be highly and regularly branched.

Gro*up D*: Plants consisting of thread-like, multiseriate forms (several cells in width), consisting of a main axis up to 1mm thick and numerous filamentous branches usually less than 0.25mm and of varying length. Branches may either be uniformly arranged or irregular and are often fine, delicate and hair like. Requires microscopic identification.

Group E: Plants very fine, filamentous and delicate, only one cell wide and may display limited branching or be highly and regularly branched. This group includes the small and epiphytic plants present as either prostrate or erect forms often appearing as a small spot or tuft on rock surfaces and other algae. Microscopic identification is necessary.

The diagnostic features of the Brown algae include a root-like structure that anchors them on a substrate and can create environments resembling forests underwater. In the Gulfs occure one class of the Ochrophyta with 8 orders and 10 families.

The diagnostic features of the Brown algae include a root-like structure that anchors them on a substrate and can create environments resembling forests underwater. They contain the pigments chlorophylls (chlorophyll a, c1, c2, and c3), carotenes (β-carotene, ε-carotene), and xanthophylls (zeaxanthin, lutein, antheraxanthin, violaxanthin, fucoxanthin, diatoxanthin, diadinoxanthin, neoxanthin) (Van Den Hoek et al. 1997). These give them their characteristic coloration, which may be olive-green, or various shades of brown, light to yellowish, and from golden to dark brown. The cell wall is cellulose, with alginic acid. Bleaching and decomposition can cause a change in their color to a yellowish brown or green. The color may also change considerably under the microscope due to the light. The nature of the cell wall is cellulose as in higher plants and pectin and rarely hemi-cellulose. Brown algae are found in nutrient-rich temperate waters; they provide an important food source for marine life, and they are almost exclusively found in marine environments. Brown algae include *Macrocystis* kelp, which is among the fastest growing alga known, with measure growth exceeding a 50 cm per day and the total length of over 60 m (http://www.seacortez.com).

There are numerous vernacular names in the Brown algae, which illustrate the variability in their morphological appearance. According to Wells (1997), the Brown algae species fall under six categories. These are large and cartilaginous forms, thick thread-like forms, filamentous forms, flat thin thalloid forms, tubular and hollow forms, and crusts, mats, or cushion forms on rocky surfaces.

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