# Rocky Shore Macroalgae Communities of the Azores (Portugal) and the British Isles: a Comparison for the Development of Ecological Quality Assessment Tools

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## ABSTRACT

This thesis focuses on intertidal seaweed communities on rocky shores and was planned to provide solid scientific background for the application of the EU Water Framework Directive (WFD) to the Azores based on the tool developed for British shores. The main structuring factors for rocky shore intertidal communities are briefly described and characterized for each of the two regions. Rocky shore intertidal seaweed communities of the British Isles and the Azores are compared based on presence/absence data recorded in single occasion visits to individual stretches of shore. The existing numerical indices used for the assessment of ecological quality for the WFD in the British Isles and in northern Spain have been tested for Azorean shores and adaptations proposed in order to incorporate differences between regions. A new alternative index is proposed for the Azores and possibly for remaining Macaronesian archipelagos that combines features used in the British Isles and in northern Spain. A first account is given of seaweed communities and their ecological quality classification at two rocky shores affected by shallow water hydrothermal activity. In the Azores, this is the closest to polluted shores, with which to test quality assessment tools. The accumulation of heavy metals in different seaweeds has been quantified and compared between the vicinity of shallow water hydrothermal activity and of urban development in the Azores. The concentration of heavy metals in *Fucus spiralis* has been compared between samples affected by hydrothermal seeps in the Azores and by acid mine drainage in the British Isles. Preliminary culture experiments provide an insight on the influence of temperature and acidity on the growth and photosynthesis of *F. spiralis*, as measures of metal accumulation capacity of this species.

## DEDICATION

This thesis is dedicated to all those who love me as I am, which I'm sure is not an easy task! For them I leave here a poem by Ricardo Reis that inspires me greatly.

Para ser grande, sê inteiro: nada
Teu exagera ou exclui.
Sê todo em cada coisa. Põe quanto és
No mínimo que fazes.
Assim em cada lago a lua toda
Brilha, porque alta vive.

In my own rough translation for the non-Portuguese speaking readers of this thesis:

To be great, be whole: Don't
Exaggerate or exclude nothing that is you.
Be whole in everything. Put all you are
Into the smallest thing you do.
So, in each lake, the whole moon reflects
Because it shines high.

I'm not sure if I have put all of myself in this thesis, but it has surely worn me out, and I therefore believe it does have a lot of me.

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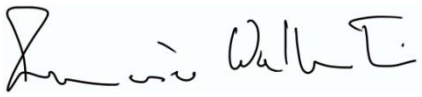
| Signature of Candidate*:* |  | Date: | 16/05/2011 |

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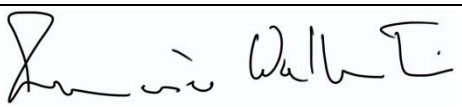
| Signature of Individual Submitting: |  |
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**Appendix 15** – Published papers within the scope of the Present thesis:

Wallenstein, F. M., Couto, R. P., Amaral, A. S., Wilkinson, M., Neto, A. I. and Rodrigues, A. S., 2009a. Baseline metal concentrations in marine algae from São Miguel (Azores) under different ecological conditions – Urban proximity and shallow water hydrothermal activity. Marine Pollution Bulletin, 58: 424-455.

Wallenstein, F. M., Terra, M. R., Pombo, J. and Neto, A. I., 2009b. Macroalgal turfs in the Azores. Marine Ecology, 30: 113-117.

# LIST OF ABBREVIATIONS

ANOSIM – Analysis of Similarities

CRF – Cualidad de Fondos Rocosos (Quality of Rocky Bottoms)

CI – Combined Index

EC – European Commission

EHWS – Extreme High Water-level Spring Tides

ELWS – Extreme Low Water-level Spring Tides

EQR – Ecological Quality Ratio

ESG – Ecological Status Group

EU – European Union

FSL – Full Species List

FSL-AZ - Full Species List (Azores)

GIG – Geographical Intercalibration Group

GRW – Graciosa

nm-MDS – non metric Multi Dimensional Scaling

MDS – Multi Dimensional Scaling

MSFD – Marine Strategy Framework Directive

NEA-GIG – North-East Atlantic geographical intercalibration group

PIX – Pico

RSL – Reduced species list

RSL – Reduced species list (Azores)

SD – Standard Deviation

SE – Standard Error

SMA – Santa Maria

SMG – São Miguel

SJG – São Jorge

TER – Terceira

UTM – Universal Transverse Mercator

WFD – Water Framework Directive

# CHAPTER 1

## GENERAL INTRODUCTION

# 1. GENERAL INTRODUCTION

The exponential growth of the World's population and industrialization of modern societies over the last two centuries have increasingly interfered with natural habitats and the biological communities associated with them, to a great extent in coastal areas where populations tend to concentrate. Nevertheless, there has been a simultaneous development of scientific knowledge on biological systems and how they are affected by the presence of Man, thus increasingly raising environmental awareness. This concern grew to such magnitude that it became necessary for governments, at national and international levels, to regulate the interference of their populations and economies with the environment. The European Union (EU) is no exception in this regard and there is vast legislation envisaging the protection of the atmosphere, soils, waters, habitats, ecosystems, etc. A good example of such legislation is the Water Framework Directive – WFD (EC, 2000), that concerns water quality aiming at maintaining and improving the aquatic environment in the Community, in which ecological water quality is considered "an overall expression of the structure and function of the biological community taking into account natural physiographic, geographical and climatic factors as well as physical and chemical conditions, including those resulting from human activities". Regarding the marine environment this directive states that macroalgae are a biological quality element to be used in defining the ecological status of transitional and coastal water bodies. Given the need to ensure that EU member states are driving efforts towards the same overall objective of the WFD, it is required that the methods developed in each country produce similar results wherever they are implemented. This process is called intercalibration. However, intercalibration problems arise with the WFD's division of the European coast into Geographical Intercalibration Groups (GIG's) which should contain broadly similar marine communities. The North East Atlantic GIG defined in the WFD extends from sub-polar conditions in Norway to warm subtropical waters in the Azores, and warmer waters off the African Coast in the Canary Islands, thus presenting big variations in intertidal communities.

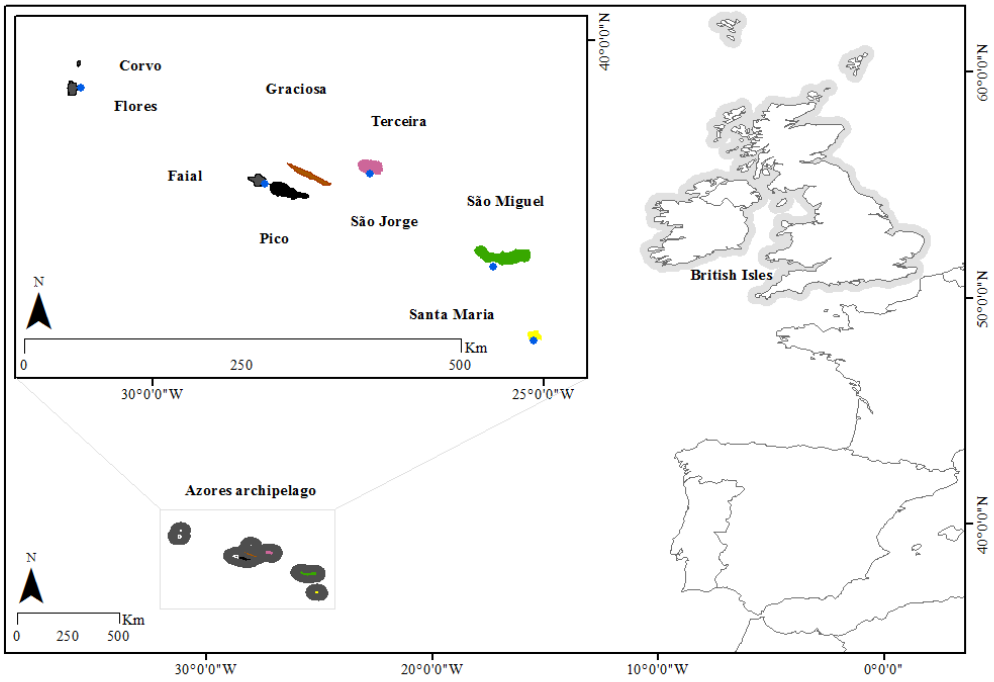
Much basic ecological data, which answer a number of questions about seaweeds never before quantified (Wilkinson *et al.*, 1988; Wells, 2002; Wells *et al.*, 2003; Wilkinson and Wood, 2003), have been used for tool development for the WFD in the British Isles and to underpin the UK/Republic of Ireland classification of intertidal rocky shores (Wells *et al.*, 2007). The applicability of such studies to the fundamentally different intertidal rocky Azorean shores and comparison to British Isles' shores is thus essential

for understanding differences between seaweed communities and to provide guidelines for adaptations required for the application of a common classification tool to both regions. Simultaneously applying tools developed in other regions, such as the one developed in northern Spain by Juanes *et al.* (2008), can help further refine methods to be used in Azorean rocky shores, ensure their applicability to wide geographical areas and enlighten us about intercalibration difficulties.

The British Isles (Fig. 1), in the northeastern part of the North Atlantic Ocean, extend over a wide geographical area from the northern Shetland Islands down to the southern Channel Islands and from the western coast of Ireland to the eastern coast of England. They comprise the countries of England, Northern Ireland, Republic of Ireland, Isle of Man, Scotland and Wales and over 5000 islands (e.g. Shetlands, Orkneys, Hebrides, Isle of Man, Channel Islands, among many others). The Azores archipelago (Fig. 1) comprises nine islands and several small islets located along a NW-SE diagonal line between latitudes 36º55' and 39º43'N and longitudes 24º46' and 31º16'W, organized in three geographical groups: (i) the eastern group - Santa Maria, São Miguel and Formigas islets ; (ii) the central group - Terceira, Graciosa, São Jorge, Pico and Faial; and (iii) the western group - Flores and Corvo (França *et al.*, 2003). Continental Portugal is 1600km east from São Miguel; Newfoundland on the American continent lies 1730km northwest, and the Madeira archipelago is situated 580km southeast of Santa Maria (Morton *et al.*, 1998).

Hydrothermal activity in shallow water near the coast in the Azores can have significant impact on the temperature and acidity of seawater. Hydrothermal vents are also important heavy metals sources, and are thus natural environments with pollution characteristics. Studies on such type of environment in the Azores show evidence of bioavailability, bioaccumulation and biomagnification of heavy metals from volcanic origin in various organisms (Amaral *et al.*, 2004; Amaral and Rodrigues, 2005; Cunha *et al.*, 2008). Such an impact, although natural, can change seaweed communities to such an extent that affected shores are assigned low ecological quality when implementing the WFD ecological assessment tools. The Azores are a perfect scenario for the study of seaweed communities subject to naturally polluted shores, as its coastline is in some places affected by shallow water hydrothermal activity.

This thesis was planned to provide a solid scientific background on intertidal rocky shore seaweed communities for testing the feasibility of the application of the British WFD tool to Azorean shores.

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Following this general introduction, chapter 2 focuses on the intertidal seaweed communities on rocky shores in the British Isles and in the Azores. These two regions, located in the northeast Atlantic, are substantially different in terms of their biogeography and climate, and therefore differences are expected in terms of their seaweed floras and in how intertidal communities are structured. The chapter starts with a brief introduction concerning descriptive studies on intertidal seaweed communities, followed by a general description of the flora and intertidal zonation patterns for each of the two regions. The abiotic and biotic factors that play a major role in structuring rocky shore intertidal communities, and the way these are affected by them, are briefly described and characterized for each of the two regions. This chapter serves as background information for a better understanding of the remaining chapters.

In chapter 3 a comparison between the rocky shore intertidal seaweed communities of the British Isles and the Azores is provided. This comparison is based on community features extracted from seaweed species presence/absence data recorded in single occasion visits to individual stretches of shore. Data were collected from several shores in six of the nine Azorean islands and compared to an existing database from the British

Isles. First, a comparison is made between the different islands within the Azores, followed by a comparison between the Azores as a whole and the British Isles. The taxonomic nomenclature for Azorean seaweed species records was that of Guiry and Guiry (2011), as shown in Appendix 1 (in electronic form on the enclosed CD).

Chapter 4 deals with an existing numerical index for the assessment of ecological quality developed successfully in the British Isles and its applicability to Azorean shores. This index is based on the same features as those used in chapter 3, and adaptations are proposed in order to incorporate differences between regions. Additionally, an index based on species abundances developed for the same purpose in northern Spain is used with a subset of Azorean shores for which abundance data were available. The ecological quality classification of Azorean shores was calculated with both methods and results compared. An alternative index is proposed for the Azores and possibly for remaining Macaronesian archipelagos that combines features used in the British Isles and in northern Spain.

Chapter 5 deals with what could be considered the closest to polluted shores in the Azores. Account is given of two rocky shores that are subject to shallow water hydrothermal activity in the Azores, how it affects seaweed communities and its ecological quality classification. The accumulation of heavy metals in different seaweeds is quantified and compared between samples collected in the vicinity of shallow water hydrothermal activity and of urban development. Additionally, the accumulation of heavy metals in *Fucus spiralis* is quantified and compared between samples affected by hydrothermal seeps in the Azores and by acid mine drainage in the British Isles. This chapter is finalized with a pilot study designed to provide an insight on the influence of temperature and acidity on the growth and photosynthesis of *F. spiralis*, as measures of metal accumulation capacity of this species.

In chapters 2 to 5 issues are analyzed and discussed separately. The general discussion within each of those chapters establishes the link with the subsequent one, and in chapter 6 some general concluding remarks are provided within a wider context.

# CHAPTER 2

## THE INTERTIDAL SEAWEED FLORA ON ROCKY SHORES OF THE NORTH-EAST ATLANTIC

# 2. THE INTERTIDAL SEAWEED FLORA ON ROCKY SHORES OF THE NORTH-EAST ATLANTIC

## 2.1 INTRODUCTION

The present chapter sets the general background for this study, which involves a comparison between intertidal seaweed assemblages from two geographically distant areas - the Azores archipelago and the British Isles. The reason for such a comparison arises from the need to assess ecological quality of coastal water bodies using marine organisms (EC, 2000) in all European Union countries which is enshrined in the European Water Framework Directive (WFD). Groups of countries were formed to intercalibrate methods, which might be different in different countries, to ensure that when used in those different countries they produce the same quality classification of shores (geographical intercalibration groups – GIG). These groups separated off distinctly different sea areas as separate GIGs i.e. Baltic, Black and Mediterranean GIGs, but all open Atlantic shores were placed in a single northeast Atlantic GIG, the NEA-GIG. The Azores archipelago and the British Isles were therefore placed in the NEA-GIG that extends from sub-polar conditions in northern Norway to warm subtropical waters in the Macaronesian archipelagos (EC, 2000), thus presenting tremendous variations in intertidal communities. Applying a common approach in analyzing the seaweed communities to two geographically different regions like the British Isles and the Azores is planned in this thesis to enable formulation of guidelines for possible quality assessment methods that are appropriate to different geographic areas.

Firstly a description of British and Azorean intertidal communities is provided, followed by a characterization of the factors that affect most such communities for each region.

## 2.2 INTERTIDAL COMMUNITIES

### 2.2.1 Overview

#### *2.2.1.1 Zonation*

Zonation is an unquestionable universal phenomenon of shore life (Lewis, 1964) related to tides, although not directly caused by them (Stephenson and Stephenson, 1949; Barnes and Hughes, 1988). From higher and drier parts down to the lower and wetter parts of the shore the types of organisms change and increases in number (Stephenson and Stephenson, 1972). Organisms able to withstand different degrees of stress (emersion, immersion) replace each other along the terrestrial-marine gradient, and the consequent zonation varies between shores. These variations are particularly notorious in the width and extent of overlap of different zones, depending ultimately on the extent of suitable microclimatic conditions – shore slope, tidal range and wave exposure (Barnes and Hughes, 1988). Few rocky shore species are ubiquitous. The majority occupies only parts of the gradients from high- to low-water mark and from wave-exposed to sheltered, with variations in distribution and abundance caused by various physical and/or chemical factors, but most importantly due to interspecific and intraspecific relationships (Lewis, 1977).

Although some authors consider zonation simply as the result of the overlapping distribution patterns of individual abundant and conspicuous species, such as barnacles, laminarian algae or lichens (Underwood and Kennelly, 1990), three major intertidal zones can be recognized throughout temperate and subtropical shores (Lewis, 1964; Stephenson and Stephenson, 1972): (1) a littorinid zone associated with lichens and myxophyceans; (2) a barnacle zone associated with various combinations of algae, mussels, limpets, snails, ascidians, polyzoans and corals, depending on the region; and (3) an algae zone, the most variable one, dominated by various associations of algal species and morphological types. The height on the shore of these major zones relative to water level at low tide varies according to the degree of wave exposure (Fig. 2.1).

Smooth rocky surfaces with an even slope present a much clearer zonation pattern than uneven mixed rocky shores of boulders and rocky platforms, which themselves might present various zonation patterns according to their geographical orientation (shaded vs. sunlit, land- or sea-ward facing) or physical nature (platform, rock-pool, overhang, crevice, etc.) (Stephenson and Stephenson, 1972).

Seaweeds are often the most conspicuous organisms in the littoral zone, and thrive best on sheltered or semi-sheltered shores with a striking vertical zonation distribution (Norton, 1985).

Broad changes from the tropics towards the poles can be observed, but one can expect the upper limit of any zone to occur in a fairly constant relative position everywhere which level varies over a limited vertical distance and in a fairly constant relation to some particular tidal level (Stephenson and Stephenson, 1972). The world distribution of temperate and/or transitional populations is particularly complicated due to variations on sea-temperatures that are influenced by ocean currents and their interaction with inshore topography (Stephenson and Stephenson, 1972). Warm-temperate regions lack both the heavy growth of large phaeophyceans that are common in cold-temperate regions. Although fair sized phaeophyceans may be common, they share space with short algal turf and various prominent rhodophyceans (Stephenson and Stephenson, 1972).

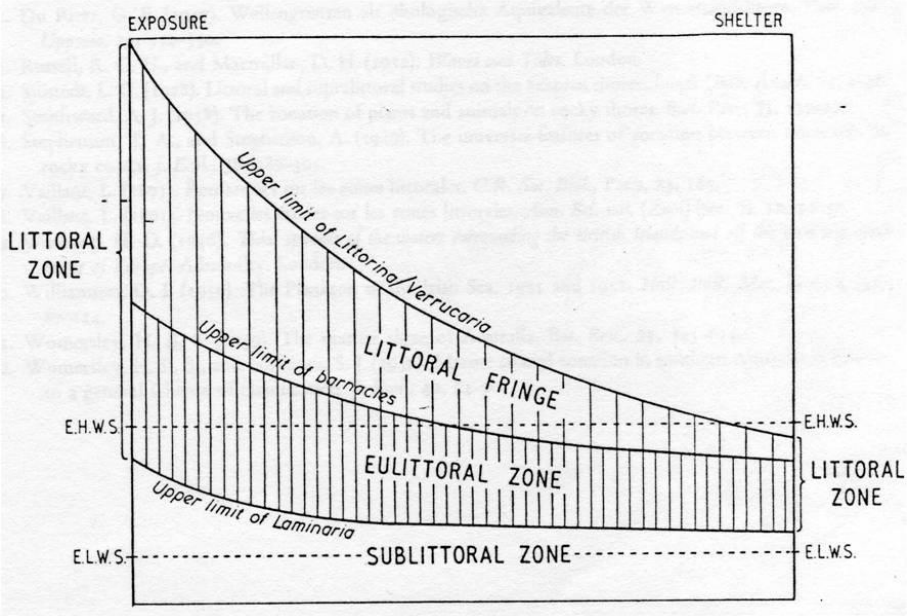


**Fig. 2.1** – Distribution of most conspicuous organisms on the shore relative to sea water level at extreme high and low tides (EHWS and ELWS, respectively) according to a wave exposure gradient (Lewis, 1964).

#### *2.2.1.2 Biotopes*

Spatial surveys of marine benthic habitats and associated biota are becoming increasingly important for environmental management. They require classification systems at a scale that is large enough to be simultaneously ecologically significant, economically viable and politically relevant. Benthic organism assemblages have been

classified as facies (Pérès and Picard, 1964), zoogeographical units (Cerame-Vivas and Gray, 1966), biocenoses (Augier, 1982; Dauvin *et al.*, 1994) and biotopes (Hiscock, 1995; Connor *et al.*, 1997; Picton and Costello, 1997; Zacharias *et al.*, 1999; Tittley and Neto, 2000; Wallenstein *et al.*, 2008). Recent habitat classification systems were developed in response to the need for natural resource managers and scientists to have a common language and a single classification standard for identifying and managing marine communities (Ball *et al.*, 2006). Hierarchical frameworks for classifying marine environments at all geographical scales have been developed in the USA (Madden and Grossman, 2004), Canada (Roff and Taylor, 2000) and Europe (Connor *et al.*, 2004), the latter incorporated into the EUNIS habitat classification (Hill *et al.*, 2010) and MESH - Mapping European Seabed Habitats (MESH, 2010). In these studies, biotopes are named after the assemblages of species and the associated habitat characteristics. They are primarily centered on the habitats and their environmental characteristics together with characterizing, faithful and constant species, with the ultimate goal of mapping their distribution and assessing their changes in time.

#### *2.2.1.3 Species richness and composition*

Geographical distribution of marine organisms is a direct result of their tolerance ranges to environmental gradients caused by latitudinal change in climatic conditions. Based on surface water temperatures and the occurrence of marine organisms Lüning (1990) divided the globe into seven biogeographical regions: (1) Arctic; (2) cold temperate Northern Hemisphere; (3) warm temperate Northern Hemisphere; (4) tropical; (5) warm temperate Southern Hemisphere; (6) cold temperate Southern Hemisphere; and (7) Antarctic. Marine species diversity is unevenly distributed across the globe, and although it tends to decrease from equatorial to polar regions (Prescott, 1969), macroalgal diversity is higher in temperate regions than the tropics and lowest at the poles (Silva, 1992).

Biogeographic affinities in intertidal communities from different regions arise as a result of the variable degree of overlap in the geographical distribution ranges of individual organisms that blurs the boundaries between such wide regions. Seaweeds are often the most conspicuous organisms in the littoral zone and the overall floras of each region are commonly used to assess the biogeographical affinities between different areas of the globe by comparing the total number of species in common between them. Widespread patterns can be recognized, namely a decrease in the

proportion of brown algae and an increase in the proportion of red algae with decreasing latitude (Lüning, 1990; Tittley and Neto, 1995, 2006; Terra *et al.*, 2008). Additionally, a study by Chapman and Chapman (1973) indicates that green/brown and red/brown algae ratios are usually higher on smaller islands than under continental conditions. This pattern is in accordance with evidence on data from the Azores, Madeira and the Canary Islands (Terra *et al.*, 2008), although not evident for the British Isles (Wells, 2002), which is possibly related to their northern location and proximity to mainland Europe as opposed to the remoteness of the oceanic Macaronesian archipelagos.

When comparing seaweed communities to assess ecological change, species composition (the actual list of species present in a given area) proves to be an unsuitable measure as a consequence of sampling and seasonal variability. In contrast, species richness (the total number of species in a given area) and aspects of macroalgae composition such as functional form and algal division are useful for studying changes in general community structure (Wells *et al.*, 2007).

### 2.2.2 The British Isles

The British Isles are probably one of the most widely studied regions in terms of rocky shore communities. They are considered a "hot-spot" of algal biodiversity in the North Atlantic (Tittley and Neto, 1995) and the highly variable climatic, tidal and physiographic nature of the shores (Lewis, 1964; Barnes and Hughes, 1988) have attracted ecologists' attention for long. As a consequence several text books on general rocky shore ecology have been published based on British intertidal communities, and hundreds of papers published on their structure and ecological factors affecting it.

#### *2.2.2.1 Zonation*

Although the widespread zonation features described on page 8 apply to the rocky shores of the British coasts, these represent an interesting variant to that found on temperate shores because of their complicated coastlines (Stephenson and Stephenson, 1972).

According to Lewis (1964) in the eulittoral zone there are three types of shores: (1) dominated by barnacles, where fucoid algae are absent due to intense grazing and/or severe hydrodynamic conditions, but not exposed enough for mussels and on steep

surfaces of sheltered shores because fucoids and mussels tend to occupy flatter surfaces; (2) shores dominated by mussels under a very variable set of conditions with several patterns of occurrence on the shore and of co-dominance/co-occurrence; and (3) shores dominated by Fucaceae on sheltered shores, although individual species of dwarf forms can be found of the most exposed shores.

To cope with the variability of British shores two zonation patterns will be described that cover two extreme situations: an exposed and a sheltered shore (Lewis, 1964; Norton, 1985; Barnes and Hughes, 1988).

An exposed shore:

(1) an uppermost wide black zone of encrusting lichens
    - *Lichina* followed by *Verrucaria* with varying densities of littorinids in the *Verrucaria* belt, depending of rock texture;

(2) a narrow whitish zone of barnacles
    - Littorinids are still abundant;
    - *Verrucaria* thins out at the barnacles upper limit that might be indistinct in gently sloping shores or on shores with intense wave action and splash and where blue-green algae and *Porphyra* can be found;
    - Limpets co-occur and become more abundant towards the lower limit of the barnacle zone;

(3) a wider blue-black zone of mussels
    - co-occurrence of *Fucus vesiculosus* f. *linearis* growing epilithically;
    - *Porphyra*, *Callithamnion* and *Rhodymenia* growing epiphytically;

(4) a narrow belt of large sized brown algae (*Alaria esculenta* with epiphytic corallines and *Laminaria digitata*)
    - co-occurrence of coralline encrusting and articulated algae, turfs of *Gigartina* (= *Mastocarpus*) and limpets at extreme low water (extending upwards to the mussels zone on gentle sloping shores).

A sheltered shore:

(1) upper-shore directly adjacent to terrestrial vegetation
    - lichens (*Verrucaria* and *Lichina*) and grasses co-exist;

(2) distinct and overlapping belts of large, brown fucoid algae

- *Pelvetia canaliculata* with few littorinids
- *Fucus spiralis*, barnacles (*Balanus*) and limpets;
- *Ascophylum nodosum* with *Polysiphonia lanosa, Ulva* and hydroids growing epiphytically, while barnacles, limpets, winkles, mussels and turfs of *Gelidium* and *Cladophora occur* beneath the fronds;
- *Fucus vesiculosus* and *Fucus serratus* become more abundant towards low-shore on flat surfaces as shingle, with *Laurencia pinnatifida*, *Leathesia difformis* and *Chondrus crispus* occuring beneath the fronds;

(3) *Laminaria digitata* and *L. sacharina* with *Himanthalia elongata* occurring sublittorally but with the fronds reaching the sublittoral fringe; *Chondrus crispus*, *Corallina officinalis* and *Furcellaria fastigiata*, among other green and brown species, growing as their epiphytes.

#### *2.2.2.2 Biotopes*

The most comprehensive approach to the classification of marine habitats and associated biological communities has been developed by Connor (2004) for Britain and Ireland. Description of methods to implement such classification, habitat descriptions and distribution charts are available online (Hill *et al.*, 2010; MESH, 2010). It consists of a series of databases that relate the geographical distribution of physical, environmental and biological data, which proves useful for marine scientists.

#### *2.2.2.3 Species richness and composition*

There are about 635 species of seaweed in the British flora according to the north Atlantic check-list of South and Tittley (1986). This is more than for the Azores but it covers a much larger area. The number of these species that can be found on a single shore is highly variable because in the British Isles there are large variations in the physical extent of intertidal shores, in characteristics such as slope, and in the rich diversity of sub-habitats such as rock pools, crevices and couloirs. Based on an analysis of 35 shores sampled between 1969 and 1978 at field meetings of the British Phycological Society, Wilkinson and Rendall (1985) calculated that the average number of species per shore was 90, made up of 44 rhodophycean species, 30 phaeophycean species and 16 chlorophycean species. This average red/brown/green ratio is broadly correct for open , relatively unpolluted, British shores in a larger sample

of 350 shores considered to set reference conditions for the Water Framework Directive (Wilkinson, personal communication). However British Phycological Society field meetings tended to concentrate on areas of known high species richness so more realistic mean totals covering a range of shore types and qualities may be represented by the 122 shores reported by Wells and Wilkinson (2002) for Northern Ireland. There was a range of 14 to 109 species per shore with an average of 68.9 species per shore with 32.7 red, 18.0 brown and 16.3 green. The British Isles are large enough for there to be geographic variation in the actual species which make up these totals. Distribution maps for all species in the British Isles are presented in Hardy and Guiry (2003) and show that there are species present throughout the whole British Isles, southern species which occur predominantly on southern and western coasts, and northern species which occur predominantly on northern and North Sea coasts.

### 2.2.3 The Azores archipelago

Research on marine algae from the Azores started in the mid nineteenth century and since then over 50 publications have contributed for the knowledge on the marine algal flora of this region [for a review of this subject see Neto (1992, 1997)]. Most initial studies were of taxonomic nature focusing on the occurrence of species lists throughout the region. It was only nearly one century later that more comprehensive ecological approaches started describing species associations and their spatial organization. Ever since the first half of last century, several studies have focused more widely on intertidal communities providing information on the vertical distribution of seaweeds and invertebrates and their trophic relations [see Neto (1992, 2007a) for a review of this subject].

#### *2.2.3.1 Zonation*

The main factors causing zonation (tides and climatic conditions) and of variability within zonation patterns (wave exposure and grazing by limpets) are quite uniform throughout rocky shores in the Azores, and thus uniformity of intertidal communities would be expected. This is not the case, though. Several studies have described the zonation patterns of Azorean rocky shores (Hawkins *et al.*, 1990; Neto, 1992; Morton *et al.*, 1998; Tittley *et al.*, 1998; Neto, 2000; Neto *et al.*, 2000), all of them recognizing

common patterns and differing only due to specificities of the particular shores sampled, that reflect the variability associated to local conditions (Fig. 2.2).

**Fig. 2.2** – Photographs of different types of shore and associated seaweed communities (a – solid bedrock shore with *Corallina elongata* and *Pterocladiella capillacea*; b – boulder shore with non-calcareous turf communities; c – pebble shore with thin filamentous communities).

The basic zonation of Azorean rocky shores can be summarized as follows:

(1) Littoral fringe (Fig. 2.3) –the transition from terrestrial maritime vegetation to the eulittoral zone, characterized by the lichens *Verrucaria maura*/*Lichinia pygmaea* and the littorinids *Melaraphe neritoides* (L.) and *Littorina striata* (King), extending to the eulittoral (the latter more abundant lower on the shore);

(2) Eulittoral zone – characterized by a belt of barnacles
   (i) Upper eulittoral (Fig. 2.4) - band of green algae (*Ulva* spp.); *Rivularia* sp.; littorinids less abundant;
   (ii) Mid-eulittoral (Fig. 2.5) - *Fucus spiralis*, *Gelidium microdon* and soft algal turf; *Patella candei gomesii* (Drouet), *P. aspera* (Roding) and *Thais haemastoma* (L.) common and extending to the sublittoral fringe;

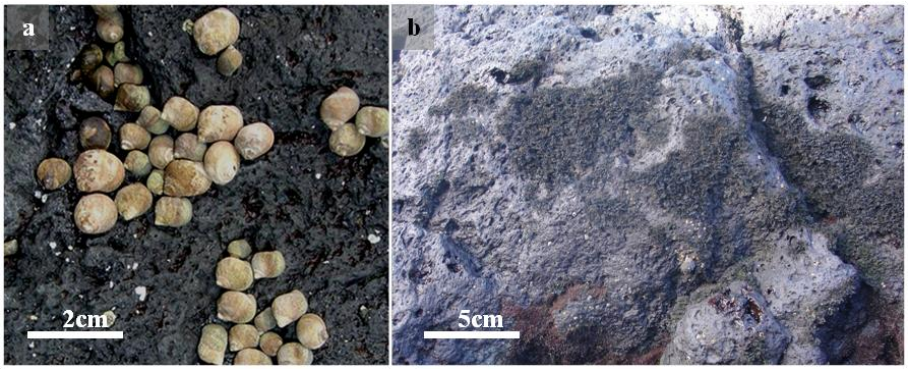


**Fig. 2.3** – Representative organisms of the littoral fringe (a – littorinids; b – *Verrucaria maura*).

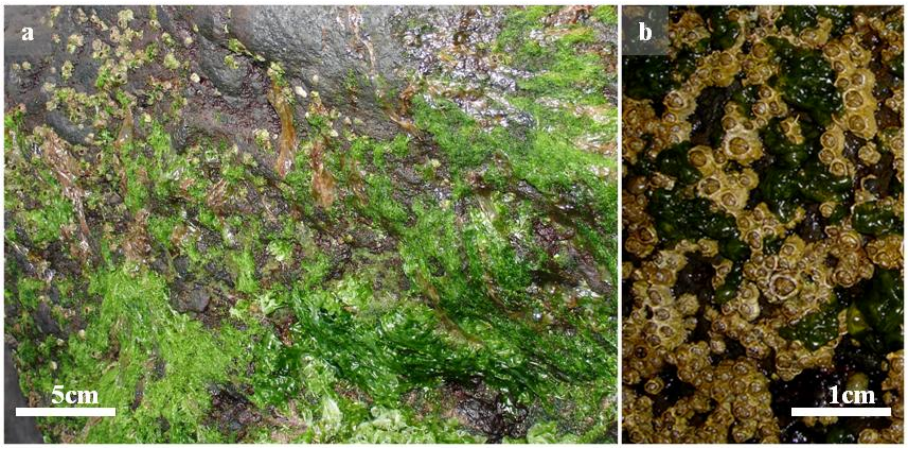


**Fig. 2.4** – Representative organisms of the upper eulittoral zone (a – foliose green algae and barnacles; b- barnacles and *Rivularia* sp.).

**Fig. 2.5** – Representative organisms of the mid-eulittoral zone (a – limpets, barnacles and non-calcareous turf; b- *Gelidium microdon* and *Fucus spiralis*).

(iii) Low eulittoral (Fig. 2.6) – coralline and soft turf; *Paracentrotus lividus* (Lamarck) common among the turf; *Codium adhaerens*;

**Fig. 2.6** – Representative organisms of the low-eulittoral zone (a – sea urchins, calcareous and non-calcareous turf seaweed assemblages).

(3) Sub-littoral fringe (Fig. 2.7) - litothamnia frequent as a first stratum and fronds (*Corallina elongata*, *Laurencia* spp. *Pterocladiella capillacea*, *Asparagopsis armata*, *Cystoseira* spp.).

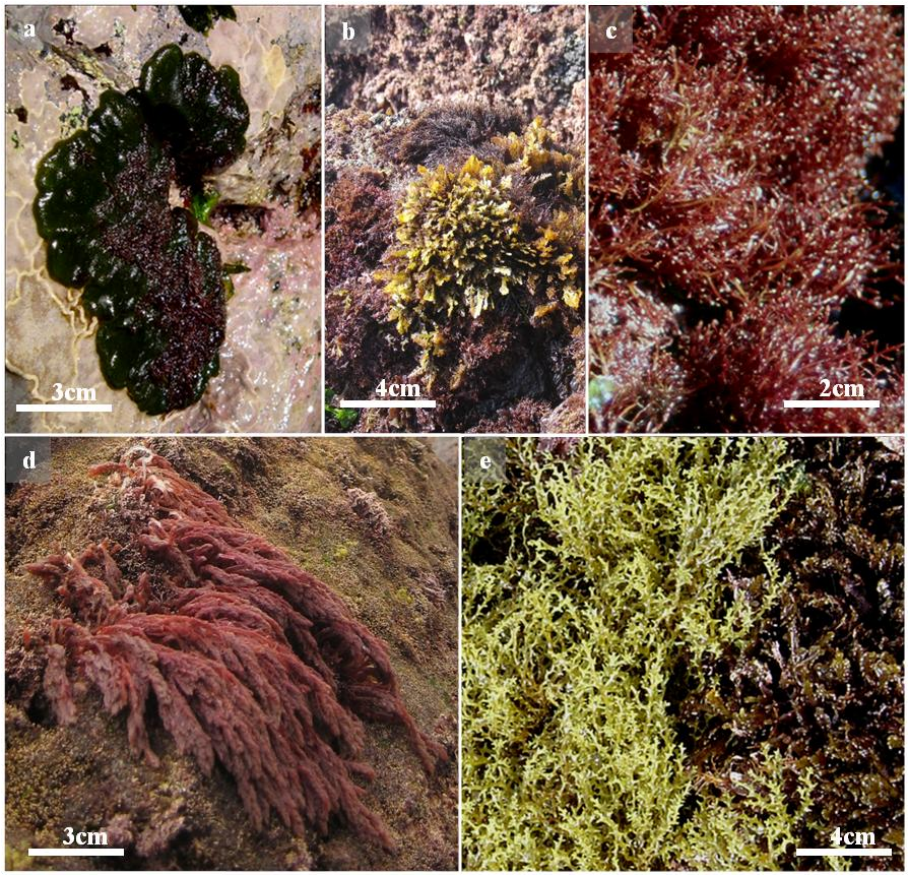


**Fig. 2.7** – Representative organisms of the sublittoral fringe (a – litothamnia and *Codium adhaerens*; b – *Laurencia* and turf seaweed assemblages; c – *Pterocladiella capillacea*; d – *Asparagopsis armata* and turf seaweed assemblages; e – *Cystoseira abies-marin*a).

The overall sequence of zonation is quite stable, although there are differences in relative abundances. The major differences between coasts are the upper limits of the littorinids that occur higher on more exposed shores, and the physiognomy of the *Fucus spiralis*/*Gelidium microdon* zone that can be absent, patchy or continuous. All zones are present throughout the year and, although of annual fluctuations in their upper and lower limits, most species are well established on the shore (Neto, 1992).

Although recognizable, however, the "universal" zones (Stephenson and Stephenson, 1972) are not as sharply defined as on mainland Europe due to the broken nature of Azorean shores which, together with the large amplitude of wave action in relation to tidal range, exaggerate microhabitat differences (Hawkins *et al.*, 1990) and enhance the overlap of zones and extension to higher levels on the shore (Lewis, 1964). Moreover, the absence of *Mytillus* and several other invertebrates like dogwhelks is striking on Azorean shores and the dominant mid-shore grazers in the Azores, *Patella* spp., important in controlling the eulittoral distribution of algae especially at the lower levels (Norton, 1985; Barnes and Hughes, 1988; Little and Kitching, 1996; Bertness, 1999),

have suffered sustained human predation and kept to very low numbers, which has allowed algal turf to dominate and prevent limpet recovery by space preemption (Martins *et al.*, 2010b).

The littoral zonation pattern spread across the islands of the Azores resembles that of Madeira (Morton *et al.*, 1998) and the Canary Islands (Lawson and Norton, 1971), and to a lesser extent the southern Iberian Peninsula (Saldanha, 1974). Similarities also exist with exposed shores in other warm water regions such as Mauritius, Bermuda, South African East coast, central West Africa, central East Africa, the Florida Keys and the Carolinas (Stephenson and Stephenson, 1972).

### *Turfs*

As mentioned in the previous section, the eulittoral zone of Azorean rocky shores is dominated by turf forming algae communities, which have attracted the attention of several authors (Chapman, 1955; Neto, 1992; Neto and Tittley, 1995; Hawkins *et al.*, 2000; Neto, 2000; Tittley and Neto, 2000; Wallenstein and Neto, 2006; Wallenstein *et al.*, 2009b). These communities are physiognomically identical to those described for Cape Verde Islands (Otero-Schmitt, 1993), the Canary Islands (Lawson and Norton, 1971), and several other regions of the world (Stephenson and Stephenson, 1972). Turfs collected in the Azores comprise 139 species of which 60 belong to the order Ceramiales, 11 to the Gigartinales and 9 to the Corallinales (Wallenstein *et al.*, 2009b). They were classified into calcareous and non-calcareous, based on the visual dominance of species of *Corallina*, *Jania* and *Haliptilon* (Neto and Tittley, 1995; Wallenstein *et al.*, 2009b). Although differences between the two types of turf are mainly due to the dominance of calcareous species, *Corallina elongata* can also be an important constituent of non-calcareous turfs. *Caulacanthus ustulatus*, *Chondracanthus acicularis*, *Gelidiella* sp., *Gelidium* spp., *Gymnogongrus griffithsiae*, are the main structuring species in the non-calcareous turf. The few other major constituents of these two types of turf differ slightly, but there is a long list of filamentous red algae that are common to both. Highly mobile substrata tend to inhibit the attachment and growth of macroalgae and favour thin, turf-like growths that are resistant to abrasion, namely fast-growing, opportunistic algae (mainly green algae and filamentous red and brown algae) that comprise non-calcareous turfs. Steep shores and small tidal ranges provide very little space for macroalgae to attach, and epiphytism may present an advantage in the competition for space. Additionally, turf-like life forms may develop as a result of

holdfast expansion and stipe regeneration and proliferation caused by strong wave action (Bertness, 1999) that is prevalent on most shores of the Azores. Other advantages of the turf life form are the retention of water, the increased surface areas for attachment of admixed algae, increased resistance to grazing and increased ability in vegetative propagation (Price and Scott, 1992). Although this life form is resistant to the prevailing harsh conditions, more delicate/fragile algae, such as the filamentous species of *Callithamnion* and *Dasya*, are able to survive as minor constituents within the turf community.

#### *2.2.3.2 Biotopes*

Tittley *et al.* (1998) and Neto (2000), in their first approach to the study of Azorean littoral biotopes, applied to Azorean littoral communities the classification defined by Hiscock (1995) and Connor (1997) for Britain and Ireland. However, the different nature of intertidal communities from a warm temperate region like the Azores and a cold temperate region like the British Isles led Tittley and Neto (2000) to provide a biotope classification adapted to the Azorean littoral reality, still based on the guidelines set for Britain and Ireland. Further work (Macedo, 2002; Couto, 2003) focused on developing methods for quantitative data collection and analysis specifically defined for Azorean shores (Wallenstein and Neto, 2006; Wallenstein *et al.*, 2010) based on Connor *et al.* (2004) hierarchical approach. The implementation of these methods started off on São Miguel island (Wallenstein *et al.*, 2008, 2010) and was then extended to Santa Maria (Wallenstein *et al.*, 2010), Graciosa (Neto, 2007b) and Pico (Neto, 2008) and their distribution mapped. The intertidal biotopes defined for Azorean shores focus on exposed rocky shores reflect the vertical distribution of macroalgae and the conspicuous species associations that vary according to local substratum specificities.

The absence of invertebrate taxa in the definition of the intertidal biotopes of the Azores reflects the low number of limpets and barnacles found during the field surveys and (presumably?) the physical seaweed domination of the shores.

#### *2.2.3.3 Species richness and composition*

The first checklist of macroalgae from the Azores was published by (Neto, 1994) and reported 307 species of which 48 were Chlorophyta, 66 were Phaeophyceae and 193 were Rhodophyta. This study brought together the existing published information and provided distributional records within the archipelago. Since then several taxonomic

studies (Tittley *et al.*, 2001; Neto *et al.*, 2002; Tittley and Neto, 2005; Afonso-Carrillo *et al.*, 2006; Rosas-Alquicira *et al.*, 2009; Tittley *et al.*, 2009; Athanasiadis and Neto, 2010; Léon-Cisneros *et al.*, 2010; Parente *et al.*, 2010; Couto *et al.*, submitted; Léon-Cisneros *et al.*, submitted) have raised the number of records to a total of 390 comprising 56 species of Chlorophyta, 74 of Phaeophyceae, and 260 of Rhodophyta (Neto *et al.*, 2005). The Azores algal flora is less species-rich than that of the Canary Islands (over 600 listed), but still a moderately rich flora given its isolated mid-Atlantic position and with a greater proportion of red algae as is typical in warm water regions as Macaronesia (Tittley and Neto, 1995, 2006; Terra *et al.*, 2008).

Within the spread of the archipelago there are no strong differences between floras of individual islands or island groups, and biogeographically the Azores algal flora shows the strongest affinities with the Iberian and Macaronesian regions, although sharing species also with tropical and subtropical America, northern Europe and the Mediterranean (Tittley and Neto, 1995, 2006; Terra *et al.*, 2008). A few species such as the green *Codium elisabethae* and the brown *Cystoseira abies-marina* are at present known only from Macaronesian islands. Additionally, the Azores represent simultaneously the southern limit of distribution for some species such as the brown alga *Schizymenia apoda* and the northern limit of distribution for some southern warm-water species such as the green alga *Anadyomene stellata* (Neto, 2007a).

The seaweed vegetation of the Azores, like Madeira and the Canary Islands, differs from that of the northern Europe and Atlantic Spain and Portugal in lacking large canopy-forming fucoids and kelps (Tittley and Neto, 2006) with algal assemblages generally characterized by turf-forming species (Neto and Tittley, 1995; Tittley and Neto, 2000; Wallenstein *et al.*, 2008).

Although there have been several studies on the taxonomy, biology and ecology of seaweeds on rocky Azorean shores over the last 30 years, some of these focusing on community structure and its variability, no attention has been directed at evaluating species richness and general macroalgal composition throughout the shores of the Archipelago. This is considered in the next chapter of the thesis after a brief review of the nature of British and Azorean shores.

## 2.3 FACTORS AFFECTING THE SHORE ENVIRONMENT

Differences between British and Azorean rocky shore seaweed communities are largely related to strong geographical differences in the factors that affect such communities. The distribution of rocky shore intertidal communities and its relation to environmental conditions have been widely studied throughout the world. Intertidal organisms are subject to a highly variable environment where the transition from fully terrestrial to fully marine conditions occurs across a very limited amount of space. Different organisms have different tolerance levels to environmental conditions (e.g. desiccation, heat, light) and thus have different distribution patterns along environmental gradients. Interspecific interactions arise when the distribution ranges of different organisms overlap, contributing further to their spatial organization. The interplay of environmental and biotic factors on intertidal rocky shores sets the scenario for a wide selection of seaweeds and invertebrates that co-exist in highly dynamic processes. The stable and regular nature of some of these factors results in generalized community distribution patterns that can be observed over different spatial scales (e.g. vertical zonation, biotopes). However, these patterns are often masked due to the highly variable nature of most other factors, usually of localized magnitude. The nature of biotic interactions between organisms does not differ at a large geographical scale as do environmental factors that affect the distribution of communities over a wide geographical area as the northeast Atlantic. Therefore biotic factors are only briefly described and attention focused on reviewing environmental factors affecting seaweeds' distribution patterns.

### 2.3.1 Overview

#### *2.3.1.1 Biotic factors*

It is important to consider animals and plants together as their interactions are likely to be related to their distribution on the shore (Stephenson and Stephenson, 1972). Physiological factors in response to local environmental gradients often fix upper distribution limits, while lower distribution boundaries are usually set by ecological (competitive exclusion or predation) and behavioural factors (Norton, 1985; Barnes and Hughes, 1988; Little and Kitching, 1996; Bertness, 1999). Competition for resources (like space, light and/or nutrients) and restricted potential to perform optimally under different environmental conditions (behavioural, physiological and/or ecological factors) set the scene for competitive ability, that depends on specialization on some

factor (growth rate, growth form, reproductive rate, aggressiveness, feeding efficiency, etc.) at the expense of poorer performance in another (Barnes and Hughes, 1988). Neither ecological factors nor natural disturbance may dramatically influence species distributions or diversity patterns if space is not limiting and low recruitment limits numbers of individual adults of each species (Bertness, 1999). Successful colonization can take place only where suitable place is available and is the result of the coincidence of the seasonal availability of propagules and the intermittent availability of space (Norton, 1985). However, space is usually a limiting factor at the intertidal zone and positive interactions like facilitation and mutualism may play important roles in the vertical distribution of some organisms, namely in dense intertidal communities that provide buffers against desiccation, heat and wave stress (Bertness, 1999). Negative interactions such as predation (as grazing) have also an important top-down effect on community structure through the limitation of the distribution of a dominant spatial competitor by restricting it to refuge habitats (usually high intertidal) where its growth and reproduction may be limited by physical stresses (Bertness, 1999).

#### *2.3.1.2 Abiotic factors*

##### *Tides*

Tides result from gravitational forces between the moon and sun and from the centripetal force of earth's rotation, and play an important role in the distribution of shoreline organisms (Bertness, 1999). When sun and moon are aligned with earth (full and new moon) these forces reinforce each other and its magnitude on the oceans' surface is greatest – maximum tidal bulges known as spring tides – as opposed to when they are at a perpendicular angle with earth (quarter phases of the moon) and their magnitude is lowest (Fig. 2.8) – minimum tidal bulges known as neap tides, both of these occurring twice a month (Bertness, 1999).

The cyclical change of the relative positions in the sun-earth-moon system makes tides travel as a wave around the Globe, suffering influence from land masses that come across its way. The timing and amplitude of tides depend on the global position of a given shore relative to the tidal bulges, as well as on shoreline and bottom topography (Bertness, 1999). As a result all oceans, and the Atlantic is no exception, work as basins with harmonic tidal oscillations around amphidromic points, where tidal fluctuations are either absent or minimal (see Fig. 2.9; Morton *et al.*, 1998).

Most shorelines on the Atlantic Ocean have semi-diurnal tides (two tides per day, two high and two low ones), with the timing of low and high water shifting forward every day by 50 minutes (Bertness, 1999). Close to the solar equinoxes (September 21 and March 21), when the sun is closest to earth, maximum tidal fluctuations occur (extreme neap and spring tides), while close to the solstices (June 21 and December 21), when the sun is farthest from earth, the minimal tidal fluctuations occur (Bertness, 1999). On subsequent tidal cycles the two high waters do not rise to the same height and the two low waters do not fall to the same low level – diurnal inequality - which is nearly negligible in most Atlantic waters, but in some places the inequality is so great that there is only one obvious tide per day. Diurnal inequality also varies monthly according to relative position of moon and earth (Stephenson and Stephenson, 1972).

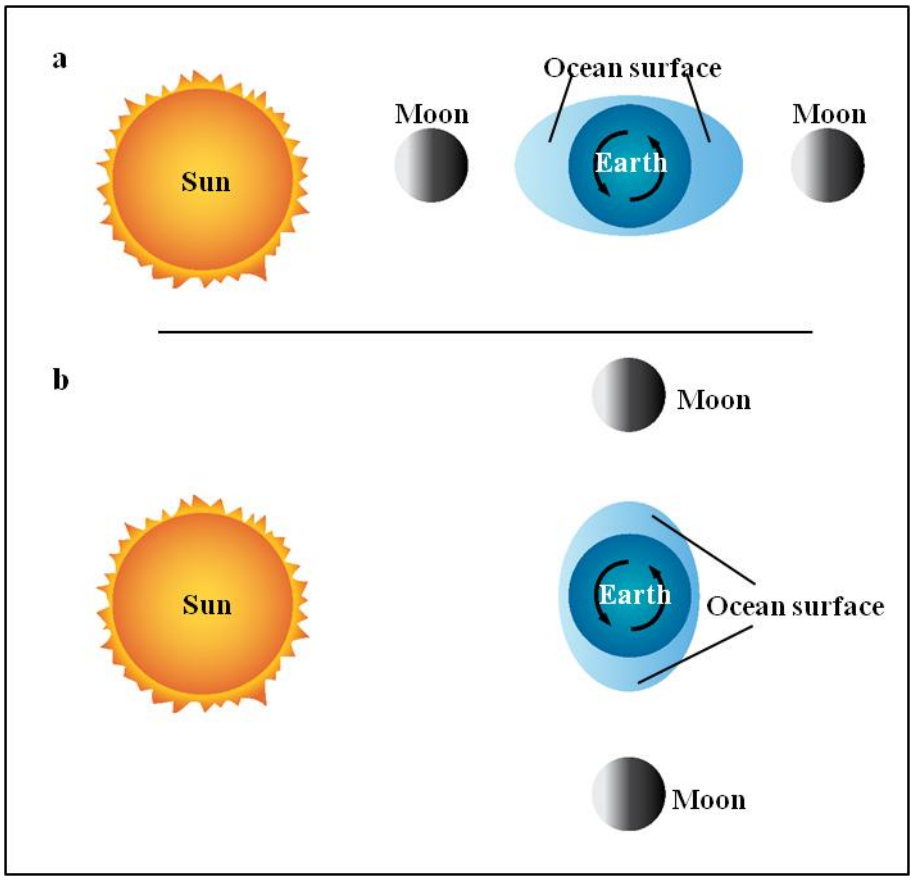


**Fig. 2.8** – Schematic representation of the Sun-Earth-Moon alignments and their influence in the formation of spring (a) and neap (b) tides [adapted from (Neto *et al.*, 2009c)].

As a consequence, tidal regime affects the portion of shore that gets exposed to air, its timing and periodicity, thus setting the general conditions of emersion and exposure to light, heat and rain that intertidal organisms are subject to at different positions on any one shore. It is therefore one of the main drivers for the vertical distribution of organisms on the shores, commonly referred to as zonation. Climatic features such as

wind and barometric pressure can locally affect tides and thus contribute to smaller scale variation in the zonation patterns (Little and Kitching, 1996).

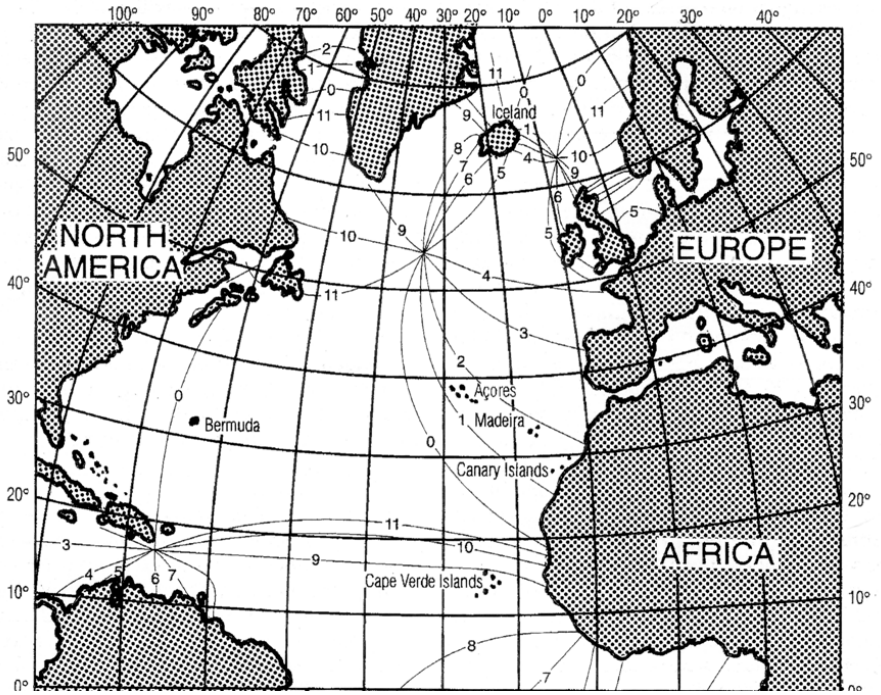


**Fig. 2.9** – Map of the north Atlantic region with representation of isotidal lines converging at the amphidromic points (Morton et al., 1998).

### *Climate*

Climatic features vary seasonally and with latitude as a result of the relative position of earth and sun. The angle of incidence of solar radiation decreases as one moves from the equator to the poles and as a result equatorial regions are subject to 12h/day of intense light and heat throughout the year, while temperate regions alternate between longer periods of lower intensity light and cooler summers and shorter periods of lower intensity light and colder winters, and polar regions alternate between 6 month periods of permanent low-intensity daylight and 6 months of cold darkness. Such differential heating sets forces in motion which produce both the earth's weather and the ocean's surface currents, the two being related intimately (Morton *et al.*, 1998). Air and sea temperatures across the globe vary with latitude as a direct result of the solar radiation variation, and four main regions are usually recognized: tropical (>20ºC in winter and >25ºC in summer); warm-temperate (<10-20ºC in winter and >16-25ºC in summer); cold-temperate regions (<0-10ºC in winter and >12-20ºC in summer); polar (<0ºC in winter and <12ºC in summer) (Stephenson and Stephenson, 1972). Surface water temperatures in the summer can vary between 20ºC around the Azores region and 12ºC around the British Isles (Fig. 2.10).

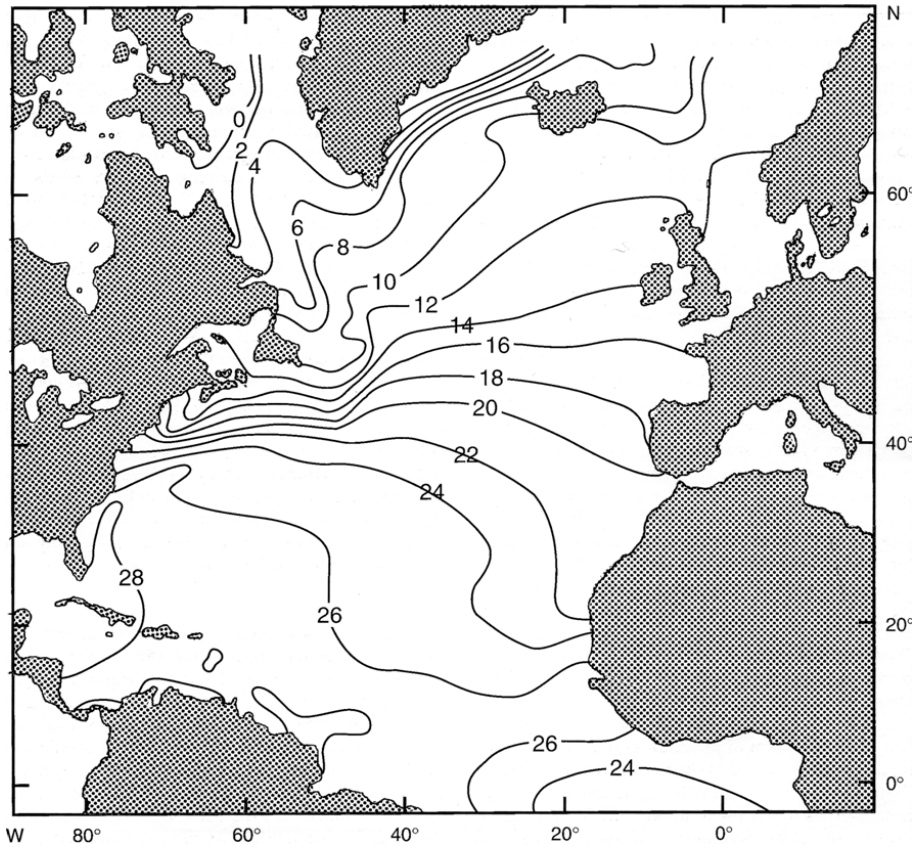


**Fig. 2.10** – Summer sea surface temperatures in the north Atlantic along 2ºC isotherms (Morton et al., 1998).

### *Superficial Ocean Circulation*

Circulation of superficial water masses is driven mainly by atmospheric circulation caused by temperature differences in the surface of the earth and its rotation (Morton *et al.*, 1998). The North Atlantic gyre circulates clockwise under the influence of the Northern Hemisphere Tradewinds and the temperate Westerlies. The Northern Equatorial Current moving westward, deflects northwards upon reaching the east coast of the American continent, then deflecting eastward when reaching temperate latitudes (Gulf Stream), deflecting southward upon reaching the European continental shores (the Canaries Current) until reaching the Northern Equatorial Current again. At about the centre of the Atlantic, the Gulf Stream breaks northwards into the North Atlantic Current and southwards into the Azores Current (Morton *et al.*, 1998). The North Atlantic Current feeds some of the major subarctic currents completing the poleward transport of tropical waters, and comprises the bulk of the Gulf Stream continuation past its branch point strengthened by the Labrador Current mixing interactions and the Slope Water Current (Rowe *et al.*, 2010). The North Atlantic Drift is considered to be an extension of the North Atlantic Current and is recognized as a shallow, widespread and

variable wind-driven surface movement of warm water that sets the boundary between the cold, subpolar region and the warm, subtropical gyre of the Northeastern Atlantic (Bischof *et al.*, 2003). A schematic representation of the main surface currents in the north Atlantic is provided in Fig. 2.11 to illustrate the main currents around the Azores and the British Isles.

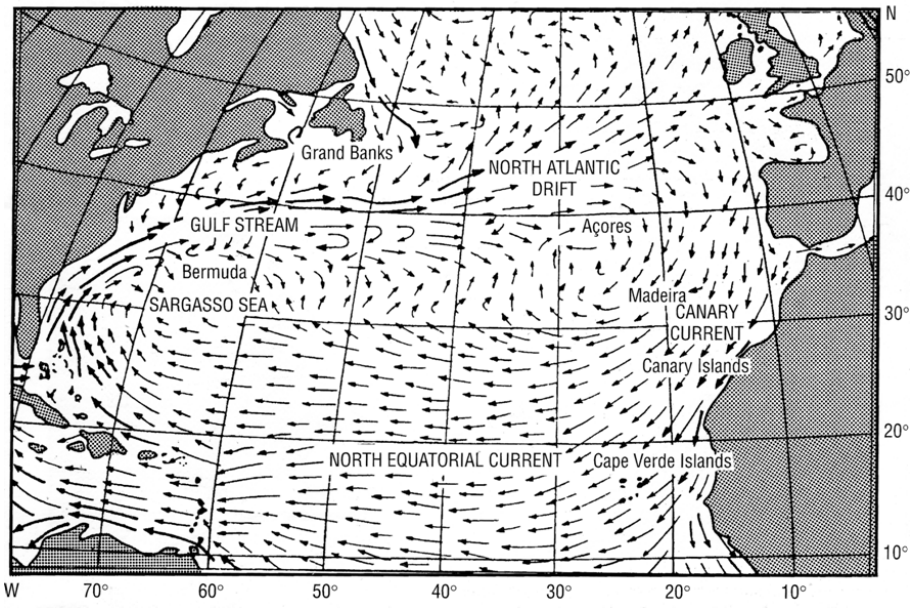


**Fig. 2.11** – Surface currents in the north Atlantic [from (Morton et al., 1998)].

Reproduction of intertidal organisms relies on the release of propagules into the water column, and thus ocean circulation and waves contribute greatly to their geographical dispersal. Ocean circulation contributes essentially for the geographical distribution of species, being the main vector for biogeographic affinities between intertidal communities at all scales, while wave action influences mainly the vertical distribution of species on the shores and contributes to the geographical dispersal at a very small localized scale.

### *Waves*

Wave exposure is one of the leading causes of major variations in the zonation between tide marks (Stephenson and Stephenson, 1972; Thomas, 1986; Russell, 1991).

Waves are the result of the interaction between winds and the ocean's surface, and fetch (distance to the nearest land mass) is an important factor in determining the type of winds and waves reaching a shore - either swell or surge, depending whether the fetch is large or small (Little and Kitching, 1996). Swell (long wavelength oceanic waves that

persist independently of their original winds) and wind-waves (smaller-scale locally wind generated waves) break differently on the shore, when their structure is influenced by the interaction with the bottom of the sea (Bertness, 1999).

The energy that is dissipated against shores, and that consequently affects intertidal communities, is therefore highly variable and depends strongly on the shore topography and physiognomy. Additionally, climatic seasonality also leads to seasonality in the intensity of wave energy that in turn influences morphological patterns of wave exposed shores where the substratum is less stable (Bertness, 1999).

Waves influence coastal organisms in several ways (Lewis, 1964; Barnes and Hughes, 1988; Little and Kitching, 1996). They have a destructive mechanical effect, either directly or indirectly by disturbing and depositing sediment and thus causing scour. As a consequence of their mechanical effect, they affect the movement of animals thereby limiting feeding, but also keeping away predators. On the other hand, by agitating water waves help renew oxygen and reduce dissolved carbon dioxide and splash areas that would not normally be covered by the tides. This is crucial for the dispersal of nutrients to intertidal organisms and of their propagules (Bertness, 1999). However, the settlement of propagules can also be prevented by sweeping algal fronds due to wave-action, which in turn reduces their shading effect (Bertness, 1999). In extreme situations, where tidal range is smaller than the average wave height, zonation patterns resulting from tidal emersion/immersion might be completely supplanted by waves. In open-coast habitats subject to oceanic swell and wind-driven waves, wave forces dominate the water movement patterns experienced by intertidal organisms (Norton, 1985).

### *Shore topography*

While approaching land forces may not be equally distributed when waves hit complex shorelines, as they are slowed down by the bottom of the shore and their crests become nearly parallel to the shore when breaking into it (Bertness, 1999). The refraction of wave energy around headlands reduces the wave energy that enters adjacent embayments, and over long periods of time this process leads to exposed headlands of hard rock and soft-sediment dominated embayments (Bertness, 1999). While it is natural to expect that oceanic shores will have a characteristically “exposed fauna and flora” the intimate interaction between waves and topography produces areas supporting

populations that are more typical of sheltered situations (Lewis, 1977). Variation in shore topography might result in fairly different sets of physical conditions to which littoral communities are subject, although being a few meters apart from each other. For example there can be a wide flat shore on a wave-exposed coast where the lower shore has exposed shore species and exposed shore zonation but the upper shore is more typically sheltered with species and zonation characteristics of sheltered shores.

### Slope

The slope of a shore is very important in controlling the type of waves and the point at which they break; on flat shores waves break far out from the shoreline and spill over the shore, while on steep shores the waves come close in before surging up the rock surface, which may increase greatly the effective intertidal zone (Little and Kitching, 1996). The flatter and more extensive the shore and the more irregular its profile, the more gentle the conditions will be, even on coasts open to the Atlantic (Lewis, 1964). Additionally, once the tide has receded the speed with which a situation dries out will depend upon its slope among other things (Lewis, 1964).

For any particular tidal range, the steeper is a shore, the less space is available. This is a crucial issue in the population control of sedentary organisms in that being limited it might pose physical constraints that lead to epiphytism and/or deformed growth, biological constraints like reduced access to light and a consequent reduced growth, and intra- and interspecific competition (Barnes and Hughes, 1988).

### Substratum

The main outlines of zonation seem not to be affected by the nature of the rock, although the presence and/or abundance of some organisms might be affected by its hardness porosity, chemical composition (Stephenson and Stephenson, 1972) and stability (Sousa, 1985). Rock type and texture determine how well water drains from the shore, and affect the microhabitats in which propagules can settle and grow (Little and Kitching, 1996), while a combined effect of wave exposure and proximity of sand on rocky shores might negatively influence such processes (Stephenson and Stephenson, 1972). As a consequence the effects of substratum type are more likely to cause variation in abundance than to set limits to distribution (Lewis, 1964). There are just a

few exceptions to this where substratum has markedly different properties such as chalk shores.

Aspect/Configuration

The configuration of rocks on a shore and its general aspect will affect the amount of light and the temperature to which organisms are subjected, and consequently their drying out at low tide (Lewis, 1964; Stephenson and Stephenson, 1972; Barnes and Hughes, 1988). Additionally, the exposure to direct wave action is related with the position organisms occupy on different aspects of the same rock.

#### *2.3.1.3 Threats to coastal ecosystems*

Coastal areas tend to be densely populated and the most common interference with the marine environment results from habitat modification or destruction (by construction, dredging and mineral exploitation), pollution (by industrial and/or domestic discharges of waste products), overexploitation of biological resources and species introduction (Barnes and Hughes, 1988; Carter, 1988).

### 2.3.2 The British Isles

The characteristics of British shores are briefly characterized in this section for comparison with those Azorean shores, given in more detail.

#### *2.3.2.1 Tides*

Tides are semidiurnal and the range of spring tides varies from 2 to 40 feet (approximately 0,6 to 12 m), being the range 12 to 20 feet (approximately 3,7 to 6 m) the commonest on most shores (Stephenson and Stephenson, 1972). Diurnal inequality is also quite variable across the British Isles (Lewis, 1964). Variation in tidal range around the British Isles is illustrated in Fig. 2.12.

#### *2.3.2.2 Shores*

The physiography of shores throughout the BI is very variable - extensive rugged and precipitous rock areas facing the Atlantic, gently sloping sedimentary shores on northern Scotland and western Ireland, lochs, channels and islands along the

mountainous coasts of Ireland and Scotland with variable in-land penetration – thus posing sharp wave-exposure gradients, and consequently abrupt changes in littoral populations and zonation patterns (Stephenson and Stephenson, 1972).

#### *2.3.2.3 Waves*

Wave exposure on British shores is highly variable, ranging from pure Atlantic shores exposed to ocean swell on the western coast of Ireland and Scotland, to very enclosed sea lochs and moderately exposed shores in numerous bays (Lewis, 1964).

#### *2.3.2.4 Climate*

According to Lewis (1964) air temperatures across the British Isles present an decreasing south-west/north-east gradient in winter (7-4ºC), and a south-east/north-west gradient in summer (17-13ºC). The average daily amount of sunshine ranges from 24% to 42% (% of total possible throughout the year) with a marked north-south increasing gradient, while the frequency of rain is higher in the north and west coasts.

#### *2.3.2.5 Seawater*

In general sea-water temperature falls progressively from south to north, with complications introduced by: (1) the comparatively land-locked nature of the Irish Sea, the English Channel and the southern North Sea; (2) the nearness of the south-eastern area to the European mainland with more extreme climatic conditions; (3) the residual circulation of surface waters eastwards into the southern North Sea via the Channel, and around the west and north of Scotland into the northern North Sea (Lewis, 1964). Sea water surface temperatures around the British Isles vary between 12ºC and 16ºC in the summer and between 7ºC and 10ºC in the winter (Fig. 2.13).

#### *2.3.2.6 Currents*

The eastward drift of the North Atlantic Current is deflected north towards the British Isles, flowing partially through the English Channel into the North Sea, and partially through the Irish Sea and round the islands then eastwards towards Norway, deflecting north-eastwards along its coast. A southward branch of this current flows along the eastern Shetland and Orkney Islands, joining the north-easterly current coming from the English Channel in the southern North Sea, flowing along the eastern North Sea up the

western Norwegian coastline (Lewis, 1964). These currents are weak and may be temporarily reversed by opposing winds (Lewis, 1964).

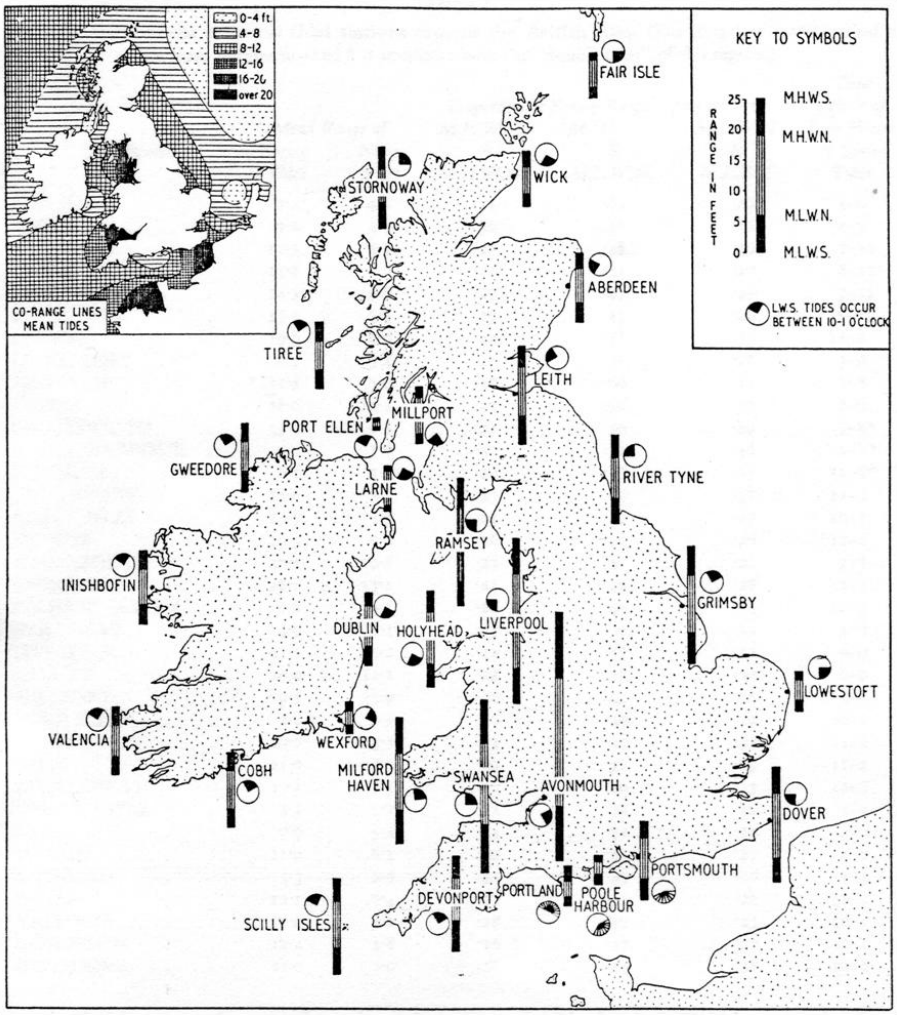


**Fig. 2.12** – Mean range of spring and neap tides at stations around the British Isles and approximate time o'clock during which low water spring tides occurs[from (Lewis, 1964)].

#### *2.3.2.7 Threats to coastal ecosystems*

Unlike the Azores, there is a diversity of uses of the coastline by Man which have the potential to cause effects on the seaweed flora. These could be divided into fertilizing and toxic effects. Fertilizing effects are due to nutrient pollution and are a known problem at various sites in Britain giving rise to nuisance blooms of opportunistic macroalgae (Anonymous, 2004). However, these macroalgal blooms are a phenomenon of sedimentary shores and of small rocks on such shores and are not really known to be a problem on solid bedrock shores (Wilkinson and Wood, 2005). High abundances of such opportunists on rocky shores are likely to be due to natural factors such as the soft nature of chalk bedrock, or naturally high turbidity, and do not cause the ecosystem degrading effects seen on sedimentary shores. Toxic effects on rocky shore macroalgae

can be due to a variety of industrial causes. One problem which is currently growing in magnitude is the escape of coal mine drainage water from abandoned coal mines onto open coast shores (Woolsey and Wilkinson, 2007a, b). This is particularly due to the large scale abandonment of the coal mining industry in Britain in the last three decades and the subsequent flooding of the mines. In the less industrialised Scottish Highlands there has been much controversy over the environmental consequences of cage farming of fish in the sea but there has been no evidence to link this with direct seaweed effects. The majority of polluting discharges are concentrated in estuaries which are outside the scope of this thesis. In consequence there are large areas of rocky shore in Britain which are little affected by Man. As a consequence of this it was difficult to find a large number of badly affected shores to calibrate the lower end of the quality scale of seaweed assessment tools being developed for rocky shore assessment for the Water Framework Directive (Wilkinson, personal communication).

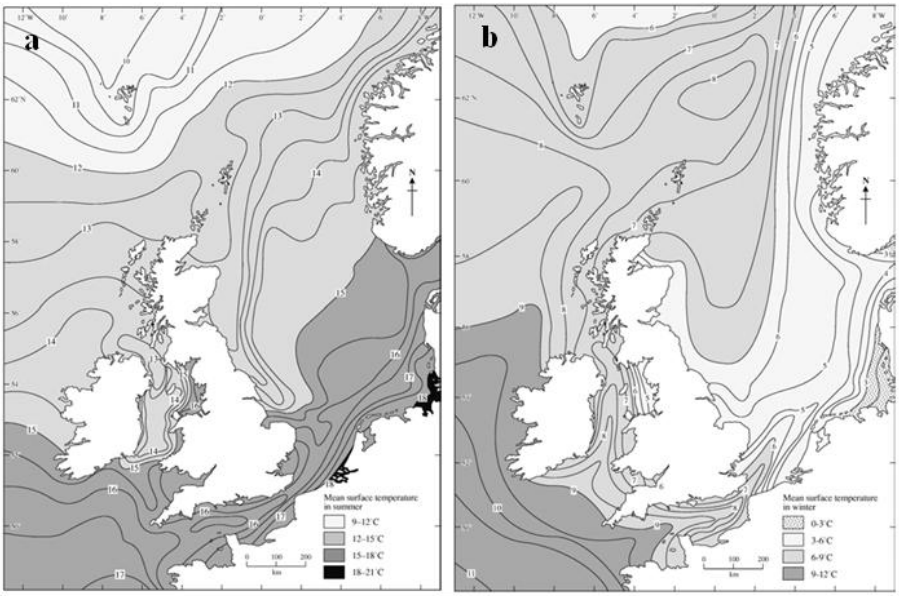


**Fig. 2.13** – Summer (a) and winter (b) isotherms for surface waters around the British Isles [from Hiscock *et al.* (2004)].

### 2.3.3 The Azores archipelago

#### *2.3.3.1 Tides*

Tides in the Azores are semi-diurnal and tidal range is less than 2 m even at extreme spring tides. The main ports of the Azores are Vila do Porto (Santa Maria), Ponta Delgada (São Miguel), Angra do Heroísmo (Terceira), Horta (Faial) and Santa Cruz das

Flores (Flores), for which tidal ranges were calculated based on 36 years' forecasts (1990-2025) under average meteorological conditions (Hidrográfico, 2000); Table 2.1).

**Table 2.1** – Maximum high water and minimum low water levels for the main ports of the Azores (indicated by blue dots in Fig. 1.1), relative to the hydrographic zero (Hidrográfico, 2000).

| | **Maximum High tide (m)** | **Minimum low tide (m)** |
|---|---|---|
| Vila do Porto | 1.88 | 0.14 |
| Ponta Delgada | 1.86 | 0.15 |
| Angra do Heroísmo | 1.83 | 0.22 |
| Horta | 1.80 | 0.27 |
| Santa Cruz das Flores | 1.72 | 0.32 |

#### *2.3.3.2 Shores*

All the islands are formed by volcanic rocks (mainly basalt) and surrounded by deep water (a depth of 1000 m may occur within 2 or 3 km off shore). The coastline of all the islands is extremely rugged and composed mainly of steep cliffs, firm bedrock platforms, boulders and cobbles, while soft sediment habitats are rare. Seashores are generally steep and of difficult access by land usually with narrow intertidal platforms where rockpools are not common. The hard black basalt rock of most shores absorbs heat from the sun creating a hot, dry, stressful environment for intertidal marine organisms during low tides. Shaded clefts and rocky overhangs, by contrast, create cooler and damper microhabitats, often colonised by species that are not found on open rock. In some places there are bays with pebbles and bedrock where sea depths of less than 30m extend several hundred meters offshore. Sand is more abundant at subtidal levels, usually at depths greater than 20 m to 40 m where it covers the rocky substratum. Coastal saltmarshes are absent in the Azores although marshy areas are present in just a few places (e.g. Lajes do Pico). Man-made alterations to the coastline have involved the construction of sea-walls and harbours that replace natural habitats by artificial ones (Morton *et al.*, 1998; Wallenstein *et al.*, 2010).

#### *2.3.3.3 Waves*

Wave exposure of Azorean shores is seasonal in nature, with the highest average values for the period January-March and the lowest values for the period June-August (Hidrográfico, 2000). Northern wave exposure is the most common and constant throughout the archipelago due to the prevailing winds, although the strongest tropical storms hit this region from southern quadrants (Table 2.2).

**Table 2.2** – Average monthly values for the probability of occurrence (%) of four wave height classes (m) for the Azores archipelago (Hidrográfico, 2000).

| | Wave height (m) | | | |
|---|---|---|---|---|
| | **<1,5** | **<2,5** | **>3.5** | **>6** |
| **January** | <10 | 45 | 40 | <5 |
| **February** | <10 | 45 | 35 | <5 |
| **March** | <10 | 40 | 30 | <5 |
| **April** | 15 | 65 | 10 | <2.5 |
| **May** | 20-25 | 70 | 5 | <2.5 |
| **June** | 35 | 85 | <10 | <1 |
| **July** | 40 | 85 | <10 | <1 |
| **August** | 40 | 80 | <10 | <2.5 |
| **September** | 30 | 70 | <10 | <2.5 |
| **October** | 20 | 55 | 10 | <2.5 |
| **November** | 15 | 45-50 | 25 | 2.5 |
| **December** | <10 | 40 | 20 | 2.5 |

#### *2.3.3.4 Climate*

The Azores archipelago, located in a warm temperate region, is mainly influenced by a subtropical anticyclone named after it, although influenced by a southern migration of the polar front during winter and thus presenting seasonality in the main climatic features (Hidrográfico, 2000).

Humidity is generally high throughout the year (>70%, Table 2.3). In the winter air temperatures and insolation are lowest (±14ºC and ±30%, respectively) and precipitation is highest (130-140 mm), while in the summer air temperatures and insolation are highest (±22ºC and ±50%, respectively) and precipitation lowest (40mm).

Winds are seasonal (stronger in winter) and quite variable (in intensity and quadrant) throughout the archipelago depending on the position of the Azores Anticyclone and its interaction with northern polar fronts and southern tropical storms. They are, however, a constant feature of this region with average speed of 15-30Km/h and blowing more frequently from northern quadrants (Hidrográfico, 2000).

#### *2.3.3.5 Seawater*

Seawater temperatures in the Azores archipelago are also seasonal with the highest values in late summer and the lowest values in early spring (Table 2.4) and with high and constant salinity (±36 psu) throughout the year (Hidrográfico, 2000). Although of the presence of numerous creeks on all islands, there are no estuarine conditions,

probably due to their small input of freshwater and the high dissipation effect of wave action.

**Table 2.3** – Average monthly values for air temperature (ºC), insolation (%), precipitation (mm) and humidity (%) in the Azores archipelago [data for the period 1961-1990, (Hidrográfico, 2000)].

| | Air temperature (ºC) | Insolation (%) | Precipitation (mm) | Humidity (%) |
|---|---|---|---|---|
| **January** | 14.0 | 28.2 | 143.2 | 77.5 |
| **February** | 14.2 | 30.0 | 122.8 | 76.8 |
| **March** | 14.7 | 32.0 | 109.8 | 75.8 |
| **April** | 15.5 | 36.5 | 79.1 | 74.2 |
| **May** | 16.9 | 40.3 | 70.3 | 75.0 |
| **June** | 19.2 | 38.2 | 47.1 | 77.5 |
| **July** | 21.3 | 48.8 | 37.7 | 73.5 |
| **August** | 22.8 | 53.8 | 52.4 | 73.0 |
| **September** | 21.8 | 46.7 | 91.2 | 73.0 |
| **October** | 19.5 | 38.7 | 117.8 | 74.8 |
| **November** | 17.1 | 32.2 | 128.7 | 76.7 |
| **December** | 15.7 | 27.3 | 141.8 | 78.5 |

**Table 2.4** – Average monthly values for the surface water temperature (ºC) and salinity ( psu) for the Azores archipelago (Hidrográfico, 2000).

| | Surface water temperature (ºC) | Surface water salinity ( psu) |
|---|---|---|
| **January** | 17.3 | 36.06 |
| **February** | 15.5 | 36.04 |
| **March** | 14.5 | 36.03 |
| **April** | 15.5 | 36.03 |
| **May** | 17.1 | 36.05 |
| **June** | 18.9 | 36.07 |
| **July** | 21.1 | 36.10 |
| **August** | 22.3 | 36.12 |
| **September** | 22.5 | 36.13 |
| **October** | 20.9 | 36.11 |
| **November** | 18.7 | 36.10 |
| **December** | 17.9 | 36.07 |

#### *2.3.3.6 Currents*

The Azores Current, integrated in the general North Atlantic circulation dominated southerly by the North Equatorial Current and northerly by the Gulf Stream, is usually weak (<1 knot) and variable with a dominantly SE direction from December to April and S from May to November (Hidrográfico, 2000). Local winds, however, may alter considerably the direction of the surface currents.

#### *2.3.3.7 Threats to coastal ecosystems*

Although remote from heavy industrial activity, the Azores Island's expanding tourism has led to strong urban development over the last 20 years, thus increasing the potential sources of seawater contaminants (e.g. marinas, commercial harbours and sewage treatment facilities). With construction concentrated on the coast, habitat destruction is the main threat to shore communities (Martins *et al.*, 2010a), which are also affected by the interference with coastal currents (Martins *et al.*, 2009). Studies on gastropods collected in marinas have shown the effects of TBTs from antifouling paints used in vessels on the reproductive system of marine gastropods (Borges *et al.*, 1998).

In the less urbanized areas, intensive agricultural exploitation of soils, and pasture for cattle dominates the landscape and strongly depends on the use of fertilizers and pesticides, which in turn contribute to the input of metals into seawater during rainy seasons that accumulate in the tissues of limpets (Cunha *et al.*, 2008). There are no records of algal blooms in the Azores due to nutrient enrichment of coastal water masses by fertilizers, possibly due to the dissipative effect on highly wave exposed shores.

Overexploitation of limpets for gastronomic purposes has reduced stocks to unrecoverable levels in some areas (Neto, 1997; Martins *et al.*, 2010b). Seaweeds (*Pterocladiella capillacea* and *Gelidium microdon*) have been harvested in the past for the production of agar (Fralick and Andrade, 1980; Santos and Duarte, 1991) and the collection of *Porphyra* sp. and *Laurencia* spp. for consumption is still an ongoing activity in some of the islands (Neto *et al.*, 2005; Patarra *et al.*, 2010). However, no reference is found to overexploitation of seaweed resources in the Azores that might threaten the envisaged populations.

The Azores can be considered a crossroad for oceanic maritime transports and consequently highly vulnerable to the introduction of species by fouling organisms or propagules in ballast waters. That has probably been the case of exotic seaweed species like *Symphyocladia marchantioides*, *Asparagopsis armata* and *Caulerpa webbiana* which have become conspicuous constituents of local communities (Neto, 1997, 2001; Cardigos *et al.*, 2006; Borges *et al.*, 2010). Such species have only been recently recorded in the Azores region and are therefore considered as introduced species, whereas *Asparagopsis armata* and *Caulerpa webbiana* have been considered invasive

because they have spread rapidly and achieved high abundances, thus replacing some well established native species such as *Pterocladiella capillacea*.

## 2.4 THE AZORES AND THE BRITISH ISLES – MAIN DIFFERENCES

Although affected by the same biotic and abiotic factors, Azorean and British shores are strikingly different due to their geographical distance. Seaweed communities are largely dominated by turfs in the Azores and fairly uniform throughout the archipelago, whereas in the British Isles they vary significantly from highly wave exposed, animal dominated shores to very sheltered algae dominated shores with striking zonation of large fucoids. The Azores archipelago lies in a warm temperate to subtropical region of the Globe and the British Isles in a truly temperate region. Climatic differences therefore arise, such as higher insolation and temperatures, both atmospheric and of the sea, in the Azores compared to the British Isles. Currents reaching the shores in these two regions differ to some extent and the biogeographic affinity between their marine floras reflects it. The tidal range is narrow and uniform throughout the Azores archipelago, while it varies substantially across the British Isles. Furthermore, the size and nature of the Azorean islands and their location in the centre of the Atlantic give rise to fairly uniform steep shores which are highly exposed to wave action. The Azores thus lack the variability in shore morphology-tidal range combinations that is common in the British Isles. Smoothly sloping and truly sheltered shores, such as many in the British Isles, are absent from the Azores islands. Unlike some British shores that are affected by mining and industrial activities, Azorean coastal waters are totally free of industrial sewage discharges and those of urban origin are quickly washed off by wave action. However, a striking feature of the Azores islands, that results from their volcanic nature, is the presence of active shallow water hydrothermal activity that gives rise to habitats with localized increased acidity and temperature and naturally enriched with heavy metals. Both the biology of intertidal organisms (Cunha *et al.*, 2008; Wallenstein *et al.*, 2009a; Wallenstein *et al.*, 2009c) and the structure of communities (see chapter 5) are locally affected by such conditions.

# CHAPTER 3

## COMPARISON OF INTERTIDAL ROCKY SHORE SEAWEED ASSEMBLAGES IN THE AZORES AND THE BRITISH ISLES

# 3. COMPARISON OF INTERTIDAL ROCKY SHORE SEAWEED ASSEMBLAGES IN THE AZORES AND THE BRITISH ISLES

## 3.1 INTRODUCTION

The reasons for comparisons between biological communities from geographically distant areas can be of varying nature, ranging from natural human curiosity or scientific interest to the economic and political need to manage ecosystems. Pure scientific interest has concentrated in describing distribution patterns and understanding the complex ecological interactions between individual organisms/populations and the physical and chemical characteristics of the habitats that they occupy. Ecosystem managers, however, are interested in simplified generalizations of such complex systems. The compromise between these two extremes requires tools that are simultaneously simple to please decision-makers and scientifically sound to provide valid interpretations of the ecological processes. In dealing with coastal communities, to cope with this duality, the best option might be to focus on simple features that are easily measurable and then relate them to environmental gradients.

Given the emphasis of this study on seaweeds within the intertidal region, this chapter will focus on features related to macroalgae that allow comparison of communities across large distances. Such features were assessed on various rocky shores throughout the Azores archipelago and their average values and variability compared between islands within the Azores archipelago and also compared to existing data on British shores.

## 3.2 COMMUNITY FEATURES FOR COMPARISON

### 3.2.1 Biodiversity and species richness

Biodiversity can be a complex concept when considered at the genetic and ecosystem levels but at the species level it is a straightforward and simple concept often used as a measure of the health of biological systems (Wilson, 1988). Diversity indices usually combine two features of a given sample/area - species richness and evenness – emphasizing each component to varying degrees (Begon *et al.*, 1990; Clarke and Warwick, 2001). Evenness reflects the number of individuals of each species in a given sample or area, and is thus directly related to abundance. Seaweeds' reproduction and growth patterns and strategies vary greatly and usually give rise to complex assemblages with continuous spatial distribution, from which individual specimens are difficult to identify. Canopy effects, epiphytism and turf growth are additional common features of these communities that increase difficulty in assessing relative abundances, making biomass the most reliable and accurate abundance measure. However, complete scraping of the substratum is required to assess biomass, which is a destructive and time consuming method. Alternatively, relative abundances are assessed by measures of substratum coverage (Littler and Littler, 1985), which depend on minimum sampling areas, depending ultimately on the type of shore being sampled (Connor and McCoy, 1979; Pfeifer *et al.*, 1996). The simplest of diversity indices is species richness, often given as the total number of species and therefore unaffected by problems related to abundance quantification (Krebs, 1985; Clarke and Warwick, 2001).

In general, marine diversity is known to decrease with latitude from the tropics to the poles due to latitudinal environmental gradients (Krebs, 1985; Begon *et al.*, 1990). Macroalgal diversity, however, does not follow such trends being higher in temperate regions than the tropics and lowest at the poles (Silva, 1992). In addition, the diversity of species in a marine flora is largely determined by the length of coastline to be colonized, the number of habitats available, the range of water temperatures in the region, and the distance to surrounding floras that might serve as source for immigrant species (Ricker, 1987; Wilson, 1988; Hawkins *et al.*, 2000). It is thus not surprising to find a richer flora in the British Isles than in the Macaronesian archipelagos (Terra *et al.*, 2008), as they are closer to tropical latitudes, subject to narrower air and seawater temperature ranges, much smaller in size, less habitat diverse and more distant from mainland. The richer flora of the Canary Islands compared to those of Madeira and Azores reinforces the trend of decreasing diversity with remoteness. However, recent

taxonomic studies have led to an increase in the number of species in the updated Azorean algal flora (see p. 19) which brought it closer to the Canarian one (Léon-Cisneros *et al.*, submitted). As such, the reduced number of seaweed species recorded for Madeira, less remote than the Azores and closer to the Canary Islands, might be solely the reflection of a poorly studied flora.

These biogeographic trends in flora composition and the continuous increase in the cumulative number of species recorded as a result of the annual turnover of ephemeral species make such a community feature undesirable for ecological comparisons between regions and for assessing ecological change (Wells *et al.*, 2007), although suitable for a general comparison between floras of different regions. However, the total species richness in a given area at any point in time remains stable over time in the absence of environmental alteration (Wilkinson and Tittley, 1979; Wells *et al.*, 2003; Wells *et al.*, 2007). As a consequence, there is a particular range of species richness that can be expected within intertidal communities (Wells, 2002), which makes single visit species diversity a useful feature to be used in ecological comparisons.

### 3.2.2 Species composition

Seaweed species have different geographical distribution ranges that reflect both their physiological tolerance to environmental gradients and their reproductive and growth strategies. Additionally, at a smaller geographical scale habitat characteristics also condition the morphology of seaweeds that can best colonize and thrive on any given shore (Littler and Littler, 1984). As a consequence species composition tends to be highly variable at any geographical scale and might therefore introduce too much noise in the comparison of community structure between two distinct areas. Furthermore, identifying all seaweeds to species level within a given stretch of coastline is very time consuming and requires great taxonomic expertise. To compare community structure based on as many variables as the number of species that are present within areas being compared might prove difficult. Therefore reducing the number of variables by categorizing seaweed species is desirable, not only for greater simplicity but also by reducing the level of expertise required. Functional form and algal division are also useful aspects of macroalgae community composition for studying changes in general community structure (Wells *et al.*, 2007).

### 3.2.3 Functional groups

There have been several studies on seaweed classification systems by functional or life form based on physiological, ecological and morphological factors [for a review see Wells (2002)]. Although life form and functional form schemes are both able to show differences in species composition for different climates, there are clear advantages to using functional forms that incorporate morphological, physiological and ecological features and are based on visual characteristics that can be more easily applied during field surveys (Wells, 2002). Despite loss of information the use of functional form as an alternative to species for studies of algal communities shows greater stability and predictability (Steneck and Dethier, 1994; Tobin *et al.*, 1998). In the present study seaweed communities from the Azores archipelago are to be compared with those of the British Isles, including those studied by Wells (2002) and some later ones (see page 53-54). Therefore, the functional group classification adopted in the present study was that adapted by Wells (2002) from Littler *et al.* (1983a) (Table 3.1).

**Table 3.1** – Algal functional groups and characteristics as described by Wells (2002).

| **Functional group (FG)** | **Group characteristics** | **Example genera** |
|---|---|---|
| FG1 | Unicellular and epiphytic, endophytic, epiphytic and endophytic forms | *Audouinella, Elachista, Epicladia* |
| FG2 | Foliose, thin, membranous and sheet-like forms | *Ulva, Petalonia, Porphyra, Scytosiphon* |
| FG3 | Uniseriate filamentous forms | *Griffithsia, Cladophora, Ectocarpus* |
| FG4 | Multiseriate and/or corticated filamentous forms | *Ceramium, Polysiphonia* |
| FG5 | Coarsely branched and highly corticated forms | *Laurencia, Chondrus, Mastocarpus* |
| FG6 | Thick, leathery and cartilaginous forms | *Fucus, Laminaria, Pelvetia* |
| FG7 | Jointed calcareous forms | *Corallina, Jania* |
| FG8 | Crustose forms | *Phymatolithon, Lithothamnion, Hildenbrandia* |

### 3.2.4 Proportions of red, brown and green seaweed species

Relative proportions of red (R), brown (B) and green (G) species of macroalgae in a local flora are known to change latitudinally over large geographical areas (Lüning, 1990) and there are studies that compare floras of different regions based on the (R+G)/B ratio (Chapman and Chapman, 1973; Cheney, 1977). This information is

easily extracted from species composition, so R/B/G proportions will be calculated for Azorean shores and compared to the British Isles.

### 3.2.5 Ecological status groups

The concept of Ecological Status Groups (ESG) was developed by Orfanidis *et al.* (2001) who divided macroalgae into two groups: ESG1 - late successionals or perennials; and ESG2 - opportunists or annuals, as an adaptation of the r- and K- type terminology of MacArthur and Wilson (1967). The idea behind this classification scheme was to evaluate shifts from pristine to degraded states in coastal ecosystems based on an index that resulted from the relative abundances of these two ESGs. Wilkinson and Wood (2003) used this classification of seaweeds to set reference conditions for coastal macrophytes in Scotland but based their study on the number of species in each of the ESG groups in order to incorporate presence/absence historical data. Later, Wells *et al.* (2007) used the ratio between the number of perennial species and the number of annual species (ESG1/ESG2) among other community features to assess ecological quality and compare shores within the British Isles. The same ESG ratio has been calculated for Azorean shores in the present study for comparison with the British Isles, and the allocation of species into the ESG groups has been broadly based on the adopted functional group system.

### 3.2.6 Opportunist species

Opportunistic species are a natural component of rocky shore seaweed communities (Wilkinson and Wood, 2003; Petersen *et al.*, 2005; Wells, 2007) and unless they form blooms of excessive biomass they should not be considered a problem resulting from anthropogenic impact (Wilkinson and Wood, 2003). However, macroalgal blooms usually of green foliose species are more likely to constitute a problem in sheltered sedimentary shores, rather than in rocky shores (Scanlan *et al.*, 2007). Therefore, if rapid growing opportunist macroalgae species are to be considered a problem on rocky shores, it is their abundance rather than their presence that can cause deleterious effects on intertidal communities. Despite this evidence, Wells *et al.* (2007) incorporated the proportion of opportunist species (known to sometimes cause a nuisance by their abundance) as a relevant feature for the classification of rocky shores' ecological

quality, and it was therefore included also in the present study as results from the Azores are to be compared with those from the British Isles. The *taxa* considered as opportunists include *Blidingia* spp., *Chaetomorpha linum*, *C. mediterranea*, *Enteromorpha* spp., *Ulva* spp., *Ectocarpus* spp., *Pilayella* spp. and *Porphyra* spp.

## 3.3 METHODS

### 3.3.1 General

The analysis of intertidal rocky shore seaweed assemblages of the Azores and comparison with those of the British Isles here presented is based on two subsets of data – one from Azorean shores and another from British shores. The Azorean dataset encompasses shores from six islands of the Archipelago surveyed during a series of expeditions throughout the period 2005-2008, conducted by the Marine Biology Section of the University of the Azores, of which the author of this thesis has been a member since 2002. A database of seaweed species presence compiled for the implementation of the WFD in the British Isles was provided by the supervisor of this thesis, and covers a wide range of shores across the full length of the British Isles surveyed throughout the period 1952-2007.

#### *3.3.1.1 Azores*

*Survey methods*

Alternation between boulder/bedrock headlands and sandy/pebble bays is common along Azorean coastlines giving place to mixed substrata in the transition areas. These situations were avoided when choosing survey sites and preference given to stretches of coastline with approximately 40m of uniform substratum, as this is the criterion used for intertidal biotope characterization studies (Wallenstein and Neto, 2006) that were conducted simultaneously.

The presence of epilithic and epiphytic seaweeds was recorded for their entire vertical distribution range along the defined stretch of coastline, including sub-habitats such as rock-pools, crevices and overhangs. To ensure a thorough coverage of the whole intertidal area each site was surveyed for about 1.5-2h at the predicted time of low water (Hidrográfico, 2011). Seaweeds were identified to species level whenever possible *in situ*, and otherwise specimens were collected and taken to the laboratory for subsequent identification. General information about each site (surveyors, location, geographical coordinates, date of survey, substratum type and sub-habitats) was recorded followed by the list of seaweeds identified *in situ* and the codes of plastic containers with specimens for identification. Seaweed species were identified in the laboratory using a compound microscope and a selection of general and specialized identification books and keys

(Dixon and Irvine, 1977; Taylor, 1978; Lawson and John, 1982; Burrows, 1991; Maggs and Hommersand, 1993; Fletcher, 1995; Irvine, 1995; Afonso-Carrillo and Sansón, 1999; Brodie et al., 2007) and all names corrected to the taxonomic nomenclature of Guiry and Guiry (2011).

### *Dataset*

The complete pool of data was collected at 88 sites distributed across 6 islands of the archipelago.

#### Santa Maria (SMA)

Santa Maria has an area of 97 $km^2$ with its north and east coasts formed of high cliffs and rocky platforms while the south coast is dominated by pebble and sandy bays (Borges, 2004). This island was surveyed during the month of July 2005 for the project "PARQMAR – caracterização, ordenamento e gestão de áreas marinhas protegidas na Macaronésia: os casos do Eco-Parque Marinho do Funchal (Madeira), Gran Canária e Tenerife (Canárias) e Santa Maria (Açores)". Surveys covered 18 sites located around the whole perimeter of the island (see Fig. 3.1), chosen to provide a balanced pool of data from pebble, boulder and bedrock shores [boulders and pebbles classified according to Leeder (1982)]. Given that the objective was to characterize biotopes, surveys covered only upward and seaward facing aspects of the shore, from which quantitative data on conspicuous species and/or morphological types were collected. Samples of turfs were scraped from the rock for posterior identification and quantification of its constituents in the laboratory. For the present study species lists from each site were extracted from both biotope and turf constituents quantification sheets.

#### São Miguel (SMG)

São Miguel is the largest island in the Azores archipelago, 750 $km^2$ in area, with a varied coastline comprising boulder fields beneath high cliffs, rocky platforms and pebble and sandy embayments. This island was surveyed partially by the author of this thesis during the months of May and June 2007 (6 sites) and partially for the project "CAMAG/ORI - Caracterização das massas de água costeiras da ilha de São Miguel" during the month of July 2008 (10 sites). Surveys covered 16 sites (see Fig. 3.2) mostly

rocky platforms and boulder fields given the representativeness of these substrata on the island. At each site the occurrence of seaweeds across the intertidal area was recorded and specimens collected whenever identification in the laboratory was required.

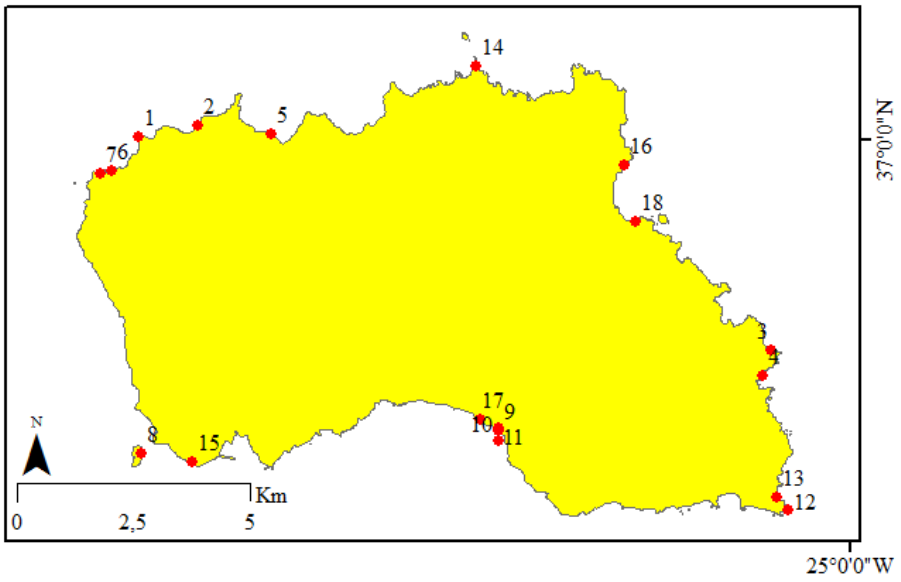


**Fig. 3.1** – Map of Santa Maria Island (colour according to the scheme used in the graphs where islands are compared) with indication of the survey sites (red dots), labeled according to the coding system in Appendix 2 (in electronic form on the enclosed CD), where UTM coordinates are also provided.

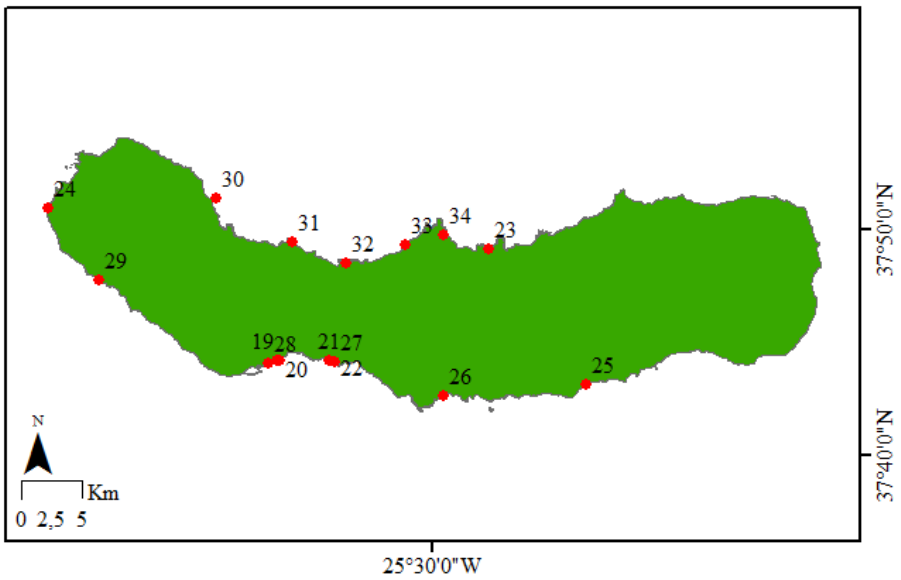


**Fig. 3.2** – Map of São Miguel Island (colour according to the scheme used in the graphs where islands are compared) with indication of the survey sites (red dots), labeled according to the coding system in Appendix 2 (in electronic form on the enclosed CD), where UTM coordinates are also provided.

Terceira (TER)

Terceira is the easternmost island of the central group, 382 km$^2$ in area, with a coastline mostly of low cliffs (Borges, 2004). This island was surveyed during the month of July 2008 for the project "CAMAG/TER - Caracterização das Massas de Água Costeiras da Ilha Terceira". Surveys covered 5 sites located in the most accessible parts of the island (see Fig. 3.3). These shores were surveyed by a 3 element team that implemented biotope characterization methods and recorded the occurrence of seaweeds across the whole surveyed intertidal area and sampling specimens whenever identification in the laboratory was required. Samples of turfs were scraped from the rock for subsequent identification and quantification of their constituents in the laboratory. For the present study species lists from each site were compiled from the qualitative records, biotope and turf constituents quantification sheets.

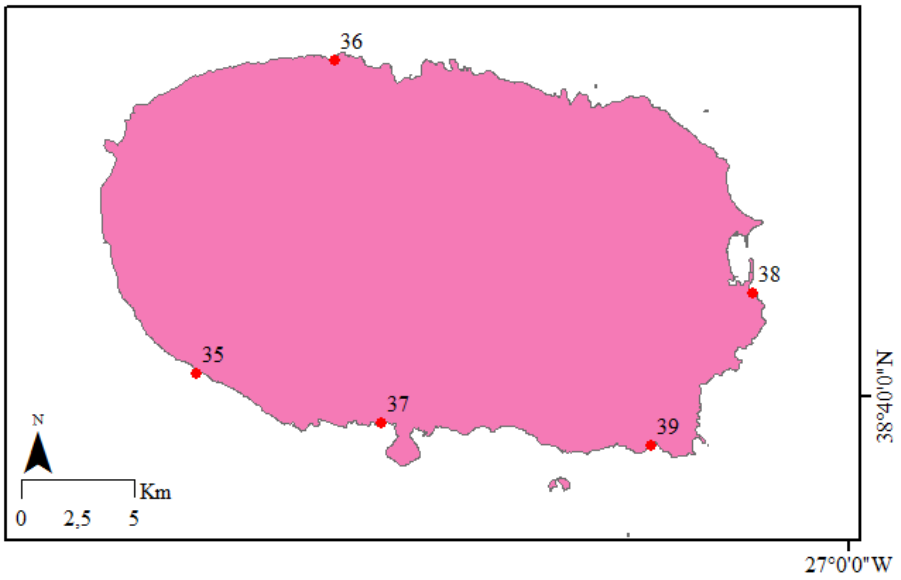


**Fig. 3.3** – Map of Terceira Island (colour according to the scheme used in the graphs where islands are compared) with indication of the survey sites (red dots), labeled according to the coding system in Appendix 2 (in electronic form on the enclosed CD), where UTM coordinates are also provided.

Graciosa (GRW)

Graciosa is the most northern island of the central group, 61km$^2$ in area, with a uniform coastline of low cliffs, while pebbles and sandy bays are restricted to the east coast (Borges, 2004). This island was surveyed during the month of July 2006 for the project "PADEL - Património natural e desenvolvimento sustentável do litoral dos Açores: a ilha Graciosa como caso de estudo". Surveys covered 13 sites located around the whole perimeter of the island (see Fig. 3.4), chosen to provide data from pebble, boulder and

bedrock shores. Given the nature of the coastline on this island it was difficult to find suitable and accessible stretches of shore with small pebbles, and thus impossible to survey a balanced pool of the three substratum categories. At each site biotope characterization methods were implemented by one team, while an additional 2-3 persons team (including the author of this thesis) concentrated on recording the occurrence of seaweeds across the whole surveyed intertidal area and sampling specimens whenever identification in the laboratory was required. Samples of turfs were scraped from the rock for posterior identification and quantification of its constituents in the laboratory. For the present study species lists from each site were compiled from the qualitative records, biotope and turf constituents quantification sheets.

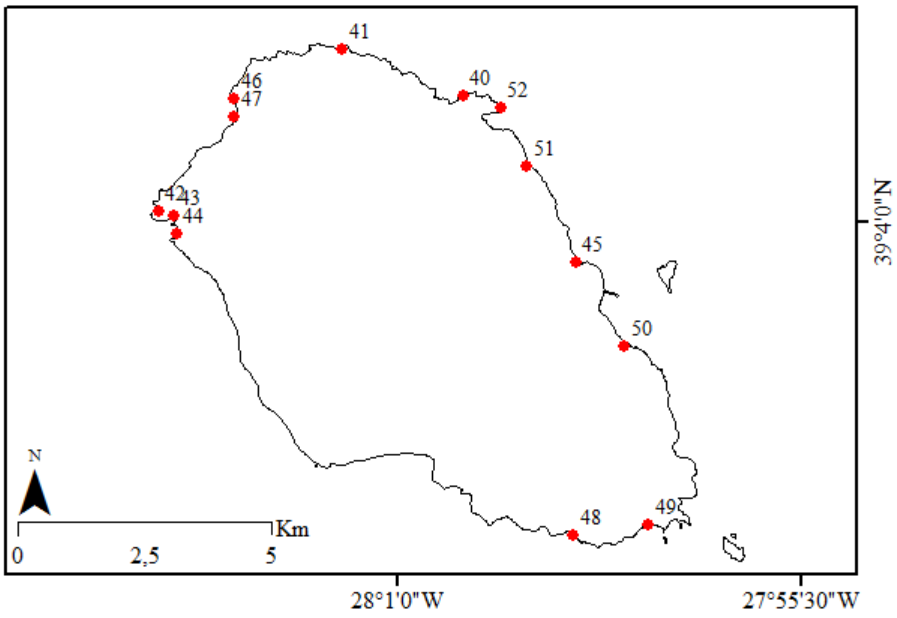


**Fig. 3.4** – Map of Graciosa Island (colour according to the scheme used in the graphs where islands are compared) with indication of the survey sites (red dots), labeled according to the coding system in Appendix 2 (in electronic form on the enclosed CD), where UTM coordinates are also provided.

Pico (PIX)

Pico is 436 km$^2$ in area and its coastline is devoid of high cliffs and usually consists of gently sloping rocky platforms (Borges, 2004). This island was surveyed during the month of July 2007 for the project "PICOBEL - Comunidades bentónicas do litoral da ilha do Pico: caracterização e monitorização". Surveys covered 32 sites located around the whole perimeter of the island (see Fig. 3.5), chosen to provide data from pebble, boulder and bedrock shores. Given the nature of the coastline on this island it was difficult to find suitable and accessible stretches of shore with small pebbles, and thus

impossible to survey a balanced pool of the three substratum categories. At each site biotope characterization methods were implemented by one team, while an additional 2-3 persons team (including the author of the present thesis) concentrated on recording the occurrence of seaweeds across the whole surveyed intertidal area and sampling specimens whenever identification in the laboratory was required. Samples of turfs were scraped from the rock for subsequent identification and quantification of their constituents in the laboratory. For the present study species lists from each site were compiled from the qualitative records, biotope and turf constituents quantification sheets.

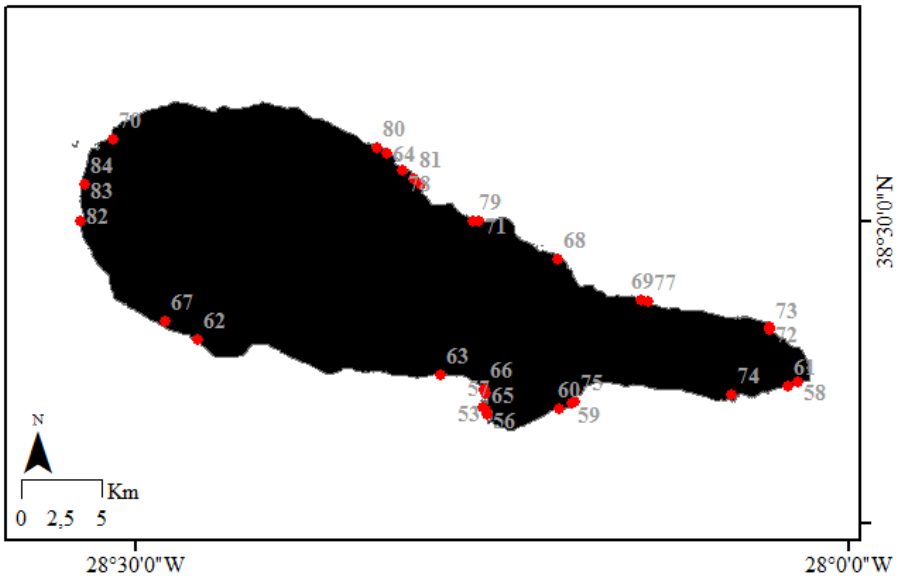


**Fig. 3.5** – Map of Pico Island (colour according to the scheme used in the graphs where islands are compared) with indication of the survey sites (red dots), labeled according to the coding system in Appendix 2 (in electronic form on the enclosed CD), where UTM coordinates are also provided.

São Jorge (SJG)

São Jorge, 246 km$^2$ in area, has a very precipitous coastline of very difficult access from land except for the "Fajãs" at the base of cliffs where boulders and pebbles accumulate (Borges, 2004). It was surveyed during the month of July 2007 during the expedition "TAPES/2007" for the project "*TAPES - Estudo da viabilidade de produção da amêijoa Tapes decussatus (Linnaeus, 1758) em aquacultura intensiva*" by the author of this thesis on a short visit with the intention of broadening the geographical range of data collected. Surveys covered 4 sites located in the most accessible parts of the island (see Fig. 3.6). At each site the occurrence of seaweeds across the intertidal area was recorded and specimens sampled whenever identification in the laboratory was required.

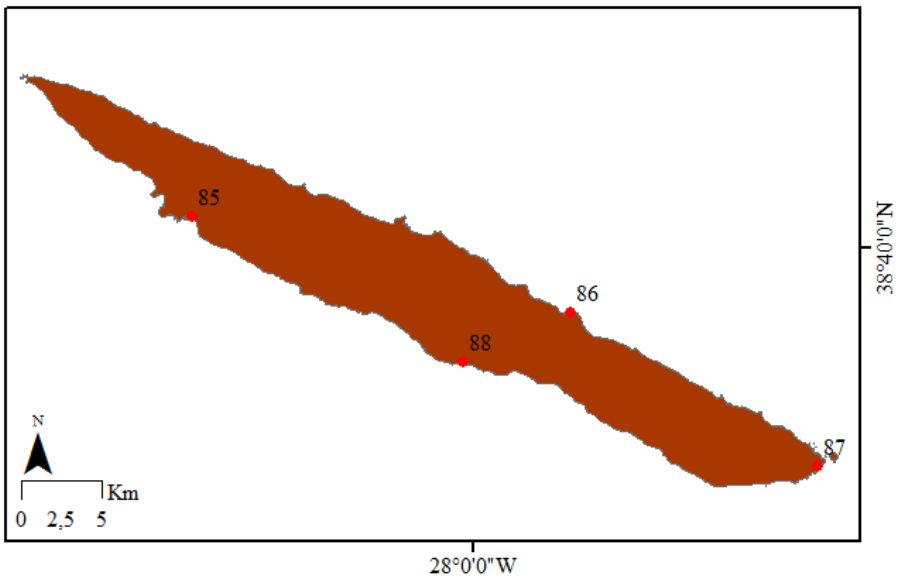


**Fig. 3.6** – Map of São Jorge Island (colour according to the scheme used in the graphs where islands are compared) with indication of the survey sites (red dots), labeled according to the coding system in Appendix 2 (in electronic form on the enclosed CD), where UTM coordinates are also provided.

#### *3.3.1.2 British Isles*

*Dataset*

The dataset used for the British Isles was provided by the supervisor of this thesis and consisted of a species x site spreadsheet based on single occasion surveys that had been constructed, largely by the supervisor of this thesis and Mr. Paul Wood, for the investigations by the Marine Plants Task Team (UK DEFRA) that led to the formulation of a tool based on species richness for quality assessment of intertidal rocky seashores for the WFD (Wells *et al.*, 2007). The list of references had been very carefully selected to only include single occasion samples where the identification was believed to be reliable and comprehensive (M. Wilkinson pers. com.). The reference list is presented below but the database additionally contains species records from 2006 and 2007 from the actual WFD monitoring carried out by Dr. Emma Wells for the Environment Agency for England and Wales.

(Burrows *et al.*, 1956; Powell, 1956; Burrows and Dixon, 1959; Jones, 1960; Burrows, 1963; Dixon, 1963; McAllister *et al.*, 1967; Norton *et al.*, 1969; Norton, 1970, 1972; Wilkinson and Roberts, 1974; Wilkinson, 1975; Norton, 1976; IOE, 1977; Tittley and Price, 1978; Norton and Powell, 1979; Price *et al.*, 1979a, b; Wilkinson, 1979; Mackie, 1980; Wilkinson, 1980, 1982; IOE, 1985, 1986; Tittley *et al.*, 1986; IOE, 1987; Cruz,

1988; IOE, 1988, 1989, 1990, 1991; Farnham, 1994; Hardy and Scott, 1994; Spurrier *et al.*, 1996; Morbey, 1997; Spurrier *et al.*, 1998; Wells, 2002) and unpublished surveys by E. Wells EA, EHS, Heriot-Watt University, MPTT, SEPA and M. Wilkinson (M. Wilkinson pers. com.).

### 3.3.2 Ecological macroalgal features

Species richness, R/B/G species proportions, ESG ratios and opportunist species proportions were calculated for each shore from both datasets (British Isles and Azores).

### 3.3.3 Data analysis

Presence/absence data were organized in an array of rows (species) and columns (sites) and compiled in excel sheets for general analyses, calculation of averages and mean deviation and graphic representation. Datasets are essentially multivariate (species composition, functional group composition, R/B/G proportions) and thus multivariate analyses were applied for the comparison of sites using the software package PRIMER (Clarke and Warwick, 2001). Analysis of variance was not used for the comparison of species richness, ESG ratios and proportion of opportunists because of unbalanced datasets from both regions, and also within the Azores dataset. Consequently, comparison was based on average (±standard deviation) and of differences assumed as significant when ranges from different regions do not overlap.

#### *3.3.3.1 Resemblance matrices*

For each set of surveyed sites two types of matrices were used for multivariate analyses – presence/absence data (large array of 0s and 1s) and scalar data (proportions of red/green/brown species; proportion of opportunist species; ESG ratios; proportions of functional groups).

Similarities were calculated between every pair of samples (sites) resulting in triangular matrices of similarity coefficients. These were calculated with the Bray-Curtis coefficient for the presence/absence datasets because it is not affected by joint absences in pairs of samples among many other criteria desirable in ecological studies (Clarke

and Warwick, 2001). Given the scalar nature of the remaining datasets, the comparison between pairs of samples was based on Euclidean distances.

#### *3.3.3.2 Multidimensional scaling – non metric (nm-MDS)*

This ordination method is constructed iteratively by successively refining the positions of the points until they satisfy, as closely as possible, the similarity relations between samples (Clarke and Warwick, 2001). The 2D nm-MDS plot is the best two-dimensional graphic representation of all samples that satisfies the conditions set by the similarity matrix, with an associated stress value that reflects the effort in representing n-dimensions (n=number of samples) two-dimensionally. As a "rule of thumb" stress values below 0.1 correspond to a good ordination with no real prospect of a misleading interpretation and values below 0.2 might need a superimposed cluster representation to validate results, while interpretation of results with stress values above 0.3 should be treated with scepticism (Clarke and Warwick, 2001).

#### *3.3.3.3 Factors*

To make the comparison between samples (sites) from different islands within the Azores, and between the Azores and the British Isles' datasets, the factor "Region" has been created and each sample was associated with a score for it. For the comparison of seaweed assemblages from different islands of the archipelago, each sample (site) was associated with a code of the respective island (SMA – Santa Maria; SMG – São Miguel; TER - Terceira; GRW - Graciosa; PIX – Pico; SJG – São Jorge) and for the comparison of Azorean and British seaweed assemblages each sample (site) was associated with a code of the region of origin (AZ – Azores; BI – British Isles).

#### *3.3.3.4 Analysis of similarities - ANOSIM*

To test for differences between samples (sites) associated to some factor (e.g. region, tidal range, substratum type) a non-parametric permutation procedure was applied to the similarity matrix underlying the ordination of samples – ANOSIM (Clarke and Warwick, 2001). This non-parametric test assumes the null hypothesis ($H_0$) that there are no differences between samples associated to each of the levels of a given factor. It randomly assigns samples to each factor level to calculate the overall coefficient of similarity (R) between levels of the given factor. The coefficient R will usually fall between 0 and 1, indicating some degree of discrimination between samples associated

to different levels of the factor being tested – approximately one if all samples associated to a given level of the factor being tested are more similar to each other than to any samples in different levels of the same factor, and approximately zero if $H_0$ is true (Clarke and Warwick, 2001). The results from ANOSIM analyses are displayed in tables as the example given in Table 3.2. Samples are compared based on their score (level 1, level 2, level 3) for factor X.

**Table 3.2** – Example table of ANOSIM result.

| | **Significance (p%)** | | **R** |
|---|---|---|---|
| Global Factor X | a | | b |
| Pairwise | Factor level 1 | Factor level 2 | Factor level 3 |
| Factor level 1 | | | |
| Factor level 2 | | c | |
| Factor level 3 | | | |

The global analysis for factor X compares all pairs of samples disregarding their scores, and gives a significance level (a) for the overall differences found between samples (R=b). The value b can vary between 0 and 1, i.e. indicating no differences between samples when b=0 and 100% difference between all samples when b=1. Additionally, a pairwise comparison is made between samples assigned to each level of factor X, and c represents the R value for differences between samples in each level of factor X.

## 3.4 RESULTS

### 3.4.1 Azores – Comparison of seaweed assemblages within and between islands

#### *3.4.1.1 General*

The list of species found throughout all 88 shores is shown in Appendix 1 (in electronic form on the enclosed CD), with indication of the respective functional group, ESG status and opportunistic status. Surveyed sites are numbered from 1 through 88 and the information regarding each shore's name, geographical coordinates and habitat characteristics are shown in Appendix 2 (in electronic form on the enclosed CD), while species composition of each surveyed shore is shown in Appendix 3 (in electronic form on the enclosed CD). The total number of species, percentages of red, brown, green and opportunistic species, percentage of species in each functional group and the ESG ratios in each surveyed shore are shown in Appendix 4 (in electronic form on the enclosed CD).

A total of 372 species was found in single visits to 88 Azorean rocky intertidal sites (Appendix 1, in electronic form on the enclosed CD), which represents approximately 95% of the total flora reported for the region. Both the total number of species and the number of exclusive species tend to increase with the number of surveyed sites on one island, except in the case of Santa Maria. The proportions of red, brown and green species relative to the total number of species found in single visit surveys do not differ greatly from the overall flora reported for the Azores. However, there are differences in the proportion of the total number of species recorded for each island in these surveys relative to the corresponding reported island floras. In São Miguel the species found during single visit surveys represent only 54% of its reported flora, in Santa Maria and Pico around 90%, in Graciosa 98%, while in São Jorge and Terceira they exceed the respective reported floras (Table 3.3).

#### *3.4.1.2 Number of species per site*

Considering all 88 samples, the average number of species per site was 43.9 (±19.4) with a maximum of 91 in São Miguel (Santo António, solid bedrock shore) and a minimum of 8 in Santa Maria (Anjos, pebble shore) and Pico (Monte, pebble shore). The frequency distribution of shores per species number interval presents an

approximately normal shape, with 80% of the shores within a 21-70 species range (Fig. 3.7a).

When comparing the average number of species per site between islands, Santa Maria stands out as the island with lowest values, Terceira with the highest ones and the remaining four islands with intermediate values. However, the variability within each island, which is lower in Terceira, does not allow any significant conclusions about differences in species number per site between islands.

**Table 3.3** – Single visit surveyed sites per island and the respective total number of species, percentage of red, brown and green species, and number of species found exclusively on each island. The shaded column contains the reported global flora data for each island and for the archipelago (Couto *et al.*, submitted; Léon-Cisneros *et al.*, submitted; Neto, unpublished data).

| | Number of sites | Number of species (R/B/G, %) | Exclusive species number | Reported total number of species (R/B/G, %) |
|---|---|---|---|---|
| Santa Maria | 18 | 118 (71/13/16) | 2 | 133 (53/29/19) |
| São Miguel | 16 | 199 (70/13/17) | 36 | 365 (65/20/15) |
| Pico | 32 | 249 (65/16/18) | 52 | 277 (66/18/17) |
| São Jorge | 4 | 113 (74/12/14) | 5 | 102 (74/11/16) |
| Terceira | 5 | 130 (68/12/20) | 2 | 91 (56/20/24) |
| Graciosa | 13 | 192 (66/19/15) | 36 | 194 (66/18/16) |
| Total | 88 | 372 (67/16/17) | | 390 (67/19/14) |

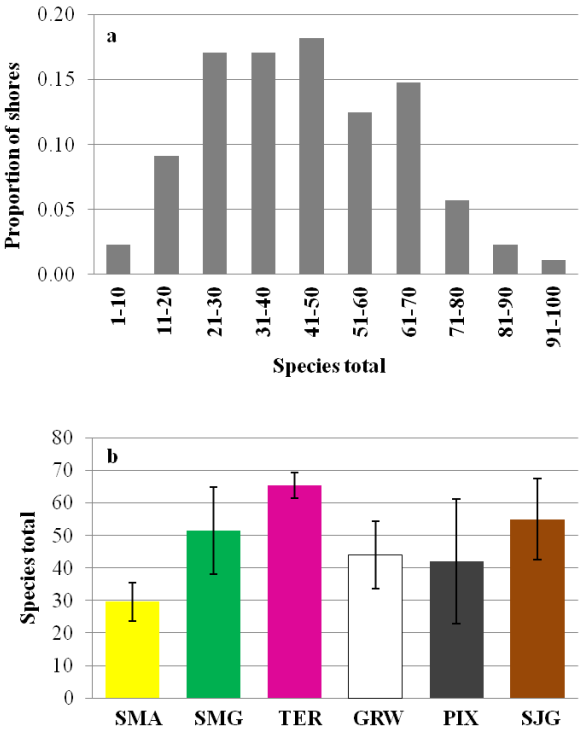


**Fig. 3.7** – (a) Number of shores per range of total species number; (b) average (±standard deviation) total species number per site (Santa Maria – yellow; São Miguel – green; Terceira – purple; Graciosa – white; Pico - dark grey; São Jorge – brown).

### *3.4.1.3 Species composition*

The highly scattered two-dimensional representation of species composition from all Azorean surveyed sites and the associated stress level (Fig. 3.8) indicate a highly variable set of data (see p. 54 in methods section for an explanation of the interpretation of stress level). To look at variability within each island and between islands, samples were labeled according to the respective island (Fig. 3.8a), a similarity analysis was run (Table 3.4) and clusters with the corresponding resemblance level were superimposed on the MDS plot to validate the interpretation of any groupings of samples.

Since data were collected in different years, in order to look at temporal variability, samples were labelled according to year (Fig. 3.8b), a similarity analysis was run (Table 3.4) and clusters with the corresponding resemblance level were superimposed on the MDS plot to validate the interpretation of any groupings of samples.

Both plots from Fig. 3.8 show as much variability within groups as between groups, and the clustering used to validate the similarity results from Table 3.4 does not clarify the apparent patterns. Many samples do not cluster with any other, and many cluster with only a few, except for the Santa Maria/2005 dataset that forms a separate cluster in both plots. The high level of stress in this MDS plot means that a two-dimensional representation does not transmit the total variability of the dataset satisfactorily, and the apparent grouping pattern is not validated by the clustering process. The fact that there was no temporal replication of the geographically disperse pool of samples does not allow any conclusions regarding geographical or temporal patterns in species composition.

**Table 3.4** – Analysis of species composition similarities (ANOSIM) between islands and sampling year, based on species presence/absence data from all surveyed sites in the Azores (SMA – Santa Maria; SMG – São Miguel; TER – Terceira; GRW – Graciosa; PIX – Pico; SJG – São Jorge; n.s. – not significant).

| | **Significance (p%)** | | | **R** | |
|---|---|---|---|---|---|
| Global - Islands | 0.1 | | | 0.458 | |
| Pairwise | SMG | TER | GRW | PIX | SJG |
| SMA | 0.761 | 0.803 | 0.809 | 0,694 | 0,779 |
| SMG | - | n.s. | 0.496 | 0,281 | n.s. |
| TER | - | - | n.s. | n.s. | 0,800 |
| GRW | - | - | - | 0,485 | n.s. |
| PIX | - | - | - | - | n.s. |
| Global - Sampling year | 0.1 | | | 0.453 | |
| Pairwise | 2006 | | 2007 | 2008 | |
| 2005 | 0.809 | | 0.576 | 0.864 | |
| 2006 | - | | 0.472 | 0.532 | |
| 2007 | - | | - | n.s. | |

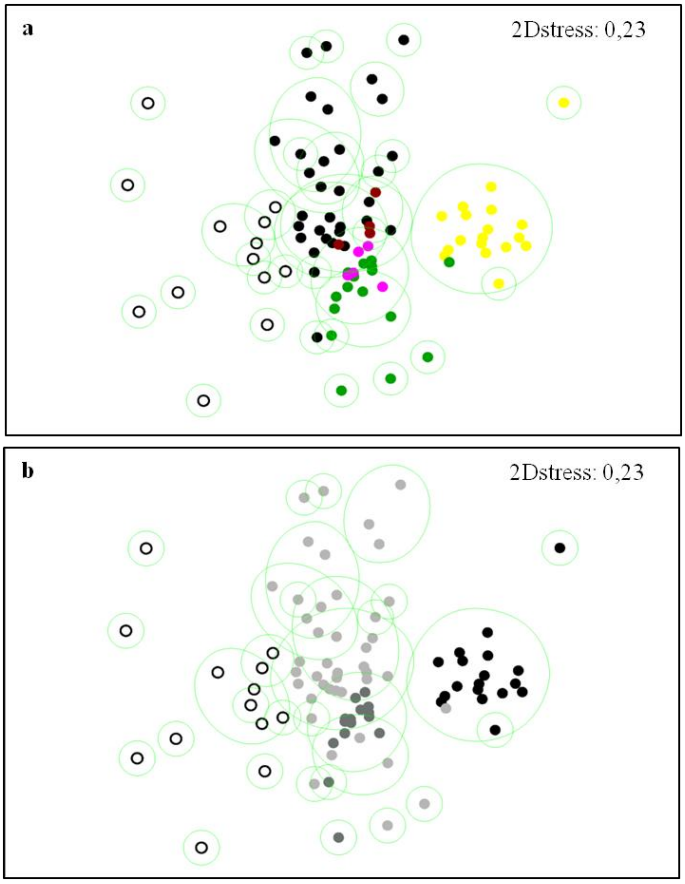


**Fig. 3.8** – Two dimensional ordination plots of all surveyed sites in the Azores based on species presence/absence data labelled according to (a) the corresponding island (Santa Maria – yellow; São Miguel – green; Terceira –purple; Graciosa – white; Pico - dark grey; São Jorge – brown; clustered by 45.8% resemblance) and (b) the corresponding sampling year (2005 – black circles; 2006 – white circles; 2007 – light grey circles; 2008 – dark grey circles; clustered by 45.3% resemblance).

#### *3.4.1.4 Functional group composition*

Differences between islands are evident in Fig. 3.9a indicating that the functional group composition of seaweed assemblages' constituents is quite variable throughout the archipelago. Despite these differences, coarsely branched corticated algae (FG5) are obviously dominant (30-40%), and filamentous algae, multiseriate corticated (FG4) and uniseriate (FG3), co-dominant if their joint relative proportion (±35%) is considered. Thin foliose algae (FG2), jointed calcareous algae (FG7) and crustose algae (FG8) are poorly represented (5-10%), while unicellular algae (FG1) and leathery and cartilaginous algae (FG6) are the least well represented of all functional groups (<5%).

Although the stress level associated with the ordination plot of all samples based of their functional group composition (Fig. 3.9b) would allow a valid interpretation of patterns, no clear groupings can be identified, except for Santa Maria. Consistently,

analysis of similarities indicates a greater difference in Santa Maria when compared to most other islands, although of the low overall dissimilarity (16.7%; Table 3.5). However, variability within this group is as high as between all samples of the whole dataset.

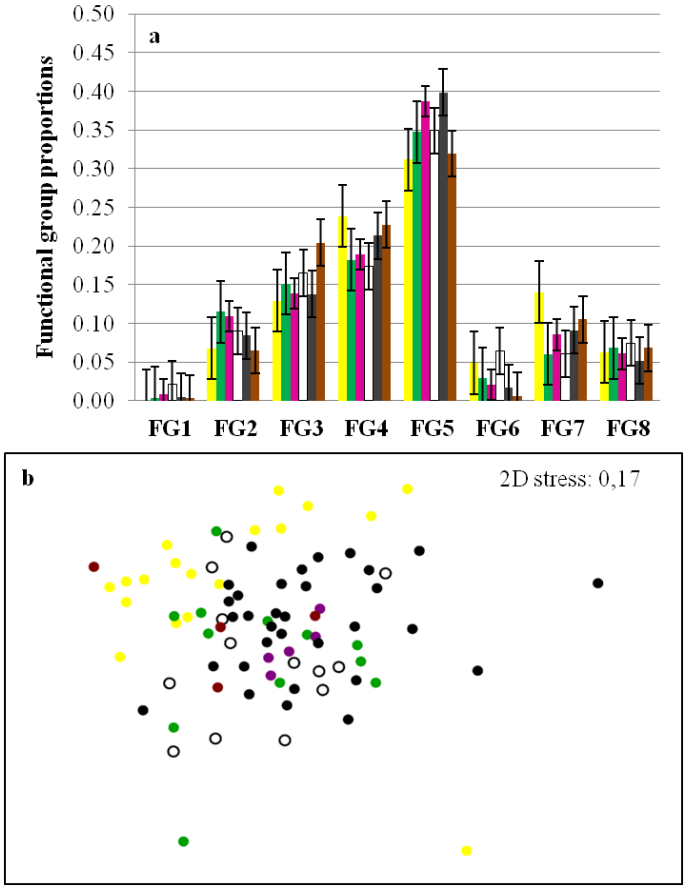


**Fig. 3.9** – (a) Average (±standard deviation) of the proportions of functional groups; (b) two dimensional ordination plot of all surveyed sites based on the proportions of functional groups in Santa Maria (yellow), São Miguel (green), Terceira (purple), Graciosa (white), Pico (dark grey) and São Jorge (brown).

**Table 3.5** – Analysis of functional group composition similarities (ANOSIM) between islands (SMA – Santa Maria; SMG – São Miguel; TER – Terceira; GRW – Graciosa; PIX – Pico; SJG – São Jorge; n.s. – not significant).

| | | **Significance (p%)** | | | **R** | |
|---|---|---|---|---|---|---|
| Global | | 0.1 | | | 0.167 | |
| Pairwise | | SMG | TER | GRW | PIX | SJG |
| | SMA | 0.302 | n.s. | 0.363 | 0.341 | n.s. |
| | SMG | - | n.s. | n.s. | n.s. | n.s. |
| | TER | - | - | n.s. | n.s. | 0.375 |
| | GRW | - | - | - | 0.180 | n.s. |
| | PIX | - | - | - | - | n.s. |

#### *3.4.1.5 Red, brown and green species proportion composition*

The overall average proportion of red, green and brown species is 0.67(±0.08), 0.19(±0.07) and 0.14(±0.06), respectively (Appendix 4, in electronic form on the enclosed CD). The maximum proportion of red species (0.86) occurred in Santa Maria (Ponta Formosa, boulder shore), where the minimum proportion of green species was also found (0.03). The minimum proportion of red species (0.43) was found in Pico (Lajes, solid bedrock shore) associated with the maximum proportion of green species (0.43). The highest proportion of brown species (0.36) occurred in Graciosa (Santa Cruz, solid bedrock shore), while one site in Santa Maria (Anjos, pebble shore) and two sites in Pico had no brown species (São Roque and Monte, two pebble shores). The average relative proportions of red, green and brown species is quite consistent throughout the surveyed islands, except for Graciosa that shows a greater proportion of browns to the detriment of the green species (Fig. 3.10a).

This consistency is reflected in the absence of clear grouping patterns of samples in the ordination plot (Fig. 3.10b). There is an overall balanced variability within and between groups of samples, but those that correspond to Graciosa (white circles) seem to be less mixed with the remaining ones. The interpretation of this MDS plot does not require the superimposition of clusters due to the low stress level associated with it, which means that the dispersal of samples is well represented two-dimensionally.

#### *3.4.1.6 ESG ratio*

The overall average ESG ratio for the archipelago was 1.4 (±0.6) (see Appendix 4, in electronic form on the enclosed CD) with 85% of the surveyed shores scoring higher than 1 (Fig. 3.11a). This indicates that there is an overall tendency for seaweed assemblages to be dominated by late successional species. The maximum ESG ratio (3.8) was recorded in Santa Maria (Ponta Formosa, boulder shore) and the lowest ratio (0.5) in São Miguel (Ferraria, hydrothermal boulder shore).

Santa Maria stands out as the island with the highest average ESG ratio and also with the highest variability (Fig. 3.11b). However, except for Terceira variability is consistently high throughout the surveyed islands, which does not permit conclusions regarding differences between islands.

### *3.4.1.7 Proportion of opportunistic species*

The overall average proportion of opportunist species was 0.10 (±0.06) (see Appendix 4, in electronic form on the enclosed CD) with a maximum of 0.38 in Santa Maria (Anjos, pebble shore), while no opportunistic species have been recorded in Santa Maria (Ponta Formosa, boulder shore), Graciosa (Santa Cruz and Lagoa, a solid bedrock and a boulder shore, respectively) and Pico (Baía de Canas, solid bedrock shore). Of all surveyed shores 70% had a proportion of 5-15% of opportunist species (Fig. 3.12a).

The lowest average proportion of opportunists was recorded for Graciosa (Fig. 3.12b). However, variability within islands is too great to allow any conclusions about significant differences between islands.

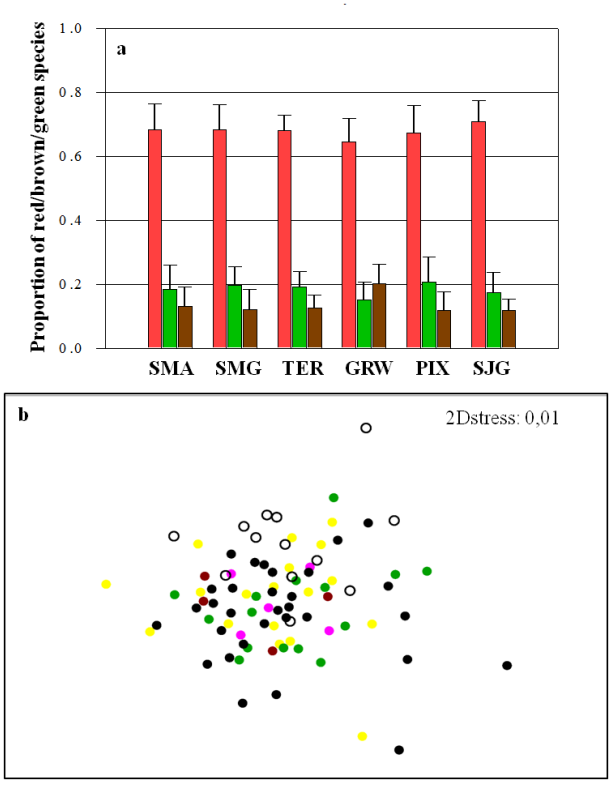


**Fig. 3.10** – (a) Average (±standard deviation) proportions of red, brown and green species; and (b) two dimensional ordination plot of all surveyed sites based on the proportions of red, brown and green species in Santa Maria (SMA, yellow), São Miguel (SMG, green), Terceira (TER, purple), Graciosa (GRW, white), Pico (PIX, dark grey) and São Jorge (SJG, brown).

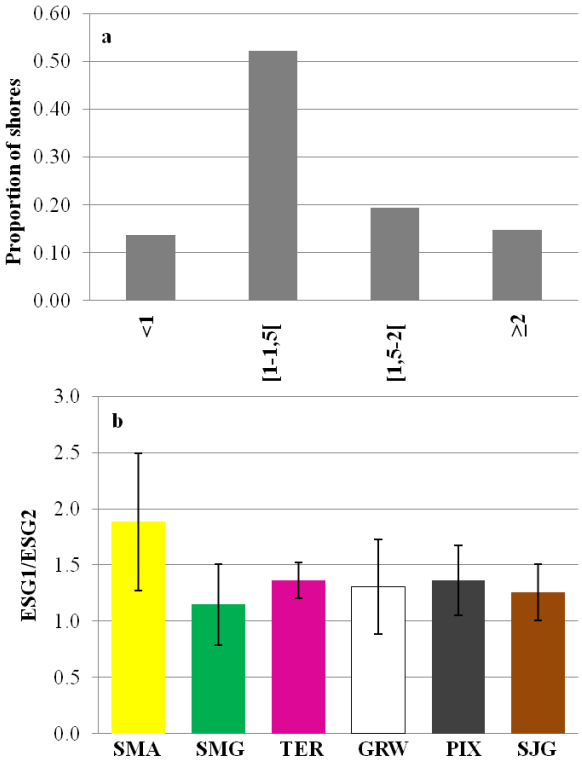


**Fig. 3.11** – (a) Proportion of shores per range of ESG1/ESG2 values; (b) average (±standard deviation) ESG1/ESG2 ratio per island (Santa Maria – SMA/yellow; São Miguel – SMG/green; Terceira – TER/purple; Graciosa – GRW/white; Pico – PIX/dark grey; São Jorge – SJG/brown).

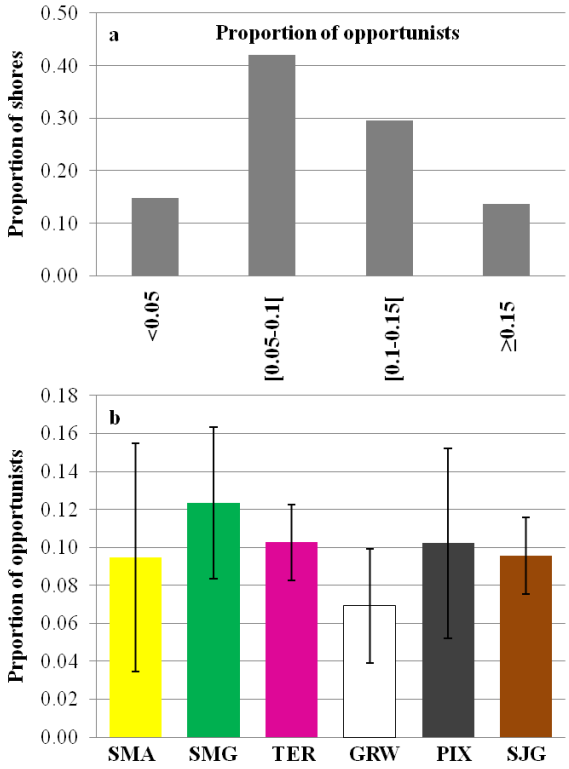


**Fig. 3.12** – (a) Proportion of shores per range of opportunist species proportion; (b) average (±standard deviation) proportion of opportunist species per island (Santa Maria – SMA/yellow; São Miguel – SMG/green; Terceira – TER/purple; Graciosa – GRW/white; Pico – PIX/dark grey; São Jorge – SJG/brown).

### 3.4.2 Azores – Comparison of seaweed assemblages between substratum types

Of all surveyed shores 55% consisted of solid bedrock platforms (Table 3.6), approximately 85% of which had basic rockpools crevices and overhangs. Pebble and boulder shores were less well represented in the pool of surveyed sites (15% and 30% respectively). The unbalanced pool of shore types is patent on all islands, and aggravated on those with lower number of surveyed shores (São Jorge and Terceira).

Species composition differs slightly (24.3%) according to substratum type (Table 3.7), whereas solid bedrock shores are more distinguished from pebbles (43.8) than from boulders (0.13), while boulders show more difference from pebbles (0.22) than from bedrock.

**Table 3.6** – Number of shores sampled per substratum category.

| | **Bedrock** | **Pebbles** | **Boulders** |
|---|---|---|---|
| Santa Maria | 10 | 5 | 3 |
| São Miguel | 11 | 1 | 4 |
| Pico | 17 | 5 | 10 |
| São Jorge | 3 | 1 | 0 |
| Terceira | 3 | 0 | 2 |
| Graciosa | 6 | 1 | 6 |
| Total | 50 | 13 | 25 |

**Table 3.7** – Analysis of species composition similarities (ANOSIM) between substratum types.

| | | **Significance (p%)** | **R** |
|---|---|---|---|
| **Global** | | 0.1 | 0.243 |
| **Pairwise** | | Pebbles | Boulders |
| | Bedrock | 0.438 | 0.13 |
| | Pebbles | - | 0.226 |

The overall high variability in the total number of species (Fig. 3.13a) and proportion of opportunist species (Fig. 3.13d) within substratum types does not allow for the conclusion of significant differences between them. Even so, pebble shores tend to be less species rich and with a greater proportion of opportunist species than solid bedrock and boulder shores. Despite these differences, both the proportions of red, green and brown species (Fig. 3.13b) and the functional group composition of these seaweed assemblages (Fig. 3.13c) are similar for all substratum types. Red species dominate all types of substratum (>60%), while pebbles tend to have a greater proportion of green

species and a smaller proportion of brown species than bedrock and boulders (Fig. 3.13b).

Coursely branched corticated (FG5) and filamentous algae (uni- and multiseriate; FG3 and FG4, respectively) dominate all types of substrata. Variability in functional group composition is generally high, but greater on pebble shores, where also foliose algae (FG2) tend to be more common.

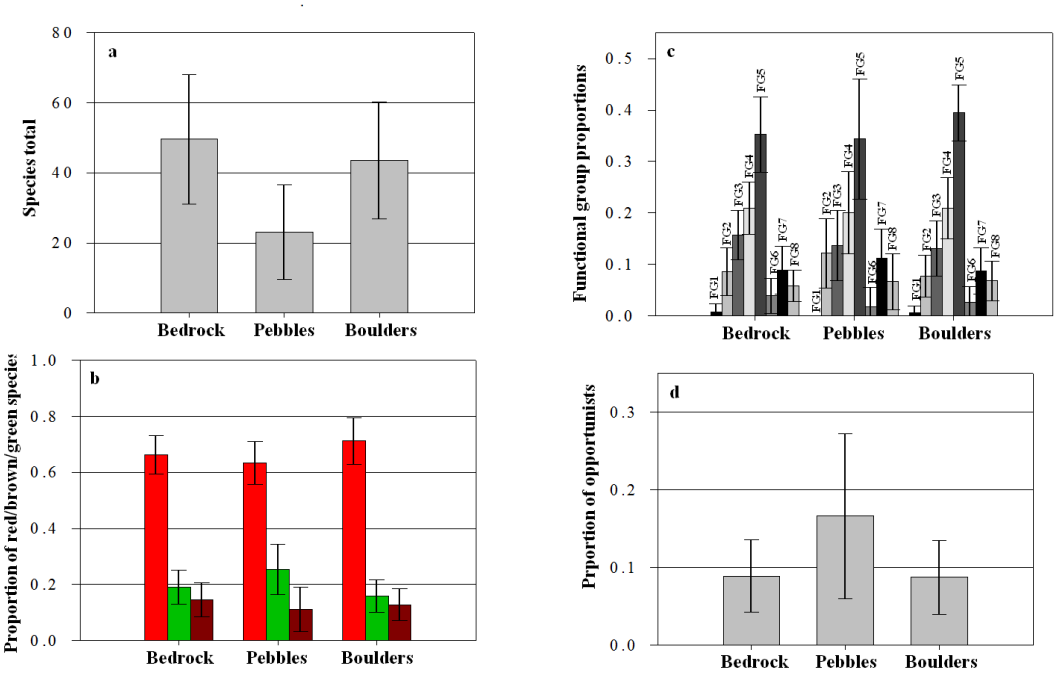


**Fig. 3.13** – Average (±standard deviation): (a) total number of species; (b) proportions of red, brown and green species; (c) proportions of functional groups; and (d) proportion of opportunist species per substratum type.

### *3.4.2.1 Azores macroalgal assemblages - Summary*

- Approximately 95% of the global flora reported for the Azores region was recorded in single visit surveys, which accounts for 54% of the reported flora for São Miguel, 90% for Santa Maria and Pico, 98% for Graciosa, and exceeds the reported floras for São Jorge and Terceira.
- The total number of species per site is highly variable both within each island and between islands. Nevertheless Santa Maria is the most species poor island and Terceira the most species rich one.

- Species composition varies as much within as between six groups of samples collected on different islands in different years, which inhibits conclusions regarding geographical or temporal patterns in species composition.
- The functional group composition of seaweed assemblages is variable throughout the archipelago and it is not possible to identify clear differences between islands. Nevertheless, coarsely branched corticated algae and filamentous algae are clearly dominant features of intertidal seaweed communities.
- The average relative proportions of red, green and brown species (67/19/14) is quite consistent throughout the surveyed islands, except for Graciosa that evidences a greater proportion of brown species in detriment of the green species. There is an overall balanced variability within and between groups of samples.
- There is an overall tendency for seaweed assemblages to be dominated by late successional species (high ESG ratios) with no evident differences between islands.
- The overall average proportion of opportunist species is highly variable, with the highest values occurring on pebble shores.
- There are no significant differences in the proportion of opportunist species between islands due to a high variability of this feature within each island.
- Pebble shores tend to be less species rich and with a greater proportion of opportunist species than solid bedrock and boulder shores. Despite these differences, both the proportions of red, green and brown species and the functional group composition of these seaweed assemblages are similar for all substratum types. Red species dominate all types of substratum, while pebbles tend to have a greater proportion of green species and a smaller proportion of brown species than bedrock and boulders. Coarsely branched corticated and filamentous algae dominate all types of substratum.

#### *3.4.2.2 Azores macroalgal assemblages - Discussion*

Assuming that the Azorean flora is well studied (see p.19 for a review of recent research on macroalgae from the Azores) it is surprising to have such a representative proportion of the overall flora of this region recorded in single visit surveys, especially considering that they all took place in the months of June/July. Moreover, seaweed species records

from single visit surveys are known to exclude some of the less conspicuous ones (Wells, 2002). Although summer is known to be the species richest and most exuberant period of the year due to favourable weather and wave exposure conditions (Wells, 2002), having 95% of the overall flora present in this period would mean that a very small proportion of the total flora accounts for natural annual and seasonal fluctuations in species composition. However, this proportion is not consistent across the islands that have been included in this study, namely on São Miguel, where the number of seaweed species recorded from one summer single visits represents only 54% of its total reported flora. This is where the Biology Department of the University of Azores is based and consequently the best studied island of the archipelago, both spatially and temporally, thus the remaining 46% of its flora account for omissions that result from methodology and also for annual and seasonal variation in species composition over two decades of macroalgal assemblage studies. Although there have been previous studies on seaweed communities on several islands of the archipelago, the surveys of the present study have been the most thorough effort ever with a common goal and uniform methods to assess seaweed diversity on São Miguel, Santa Maria, Graciosa, Terceira, Pico and São Jorge. It is thus not surprising, in such short summer surveys, to find new records for one island that has been poorly studied (the cases of São Jorge and Terceira) or have its reported flora nearly fully represented (as is the case of Santa Maria, Pico and Graciosa).

The total number of species and the number of exclusive species recorded on any given island in this study showed a tendency to increase with the number of surveyed shores, revealing a cumulative effect in species richness as a result of sampling effort. Additionally, the number of exclusive species recorded for the islands with the highest numbers of surveyed shores (São Miguel, Pico and Graciosa) represent approximately 20% of the corresponding overall total number of species recorded, as opposed to a much lower proportion in São Jorge and Terceira (±5% and 1.5%, respectively), where a substantially lower number of shores were surveyed. Similar to the definition of minimum sampling areas at smaller scales, this suggests an optimal number of shores to be surveyed in any given island to maximize the overall total number of species and the proportion of exclusive species recorded. Further studies with this objective in mind would be required, though, to draw valid conclusions about this hypothesis.

Santa Maria does not fit into the described pattern probably as a result of the survey method implemented on this island, which was the first of a series of campaigns to

thoroughly study seaweed assemblages on one island on a single occasion. At the time attention was directed mainly at characterizing biotopes that reflect the most conspicuous features on a given shore covering all rocky substratum types. Larger and more abundant seaweed species were identified *in situ* and turfs collected for identification of the smaller and less conspicuous ones. Biotope characterization methods focused on the upper and seaward facing aspects of the substratum, thus neglecting many sub-habitats such as ridges, overhangs and crevices. This is the probable underlying reason for systematically recording a lower number of species than in subsequent campaigns on the remaining islands, where there were specific teams for qualitative assessment of seaweeds on all aspects of each shore. Single occasion species richness is a highly variable feature across all surveyed shores within ranges that do not differ much between the remaining studied islands. The higher average and less variable species richness in Terceira is probably the reflex of a reduced number of surveyed shores combined with the fact that there were no surveys on pebbles. Average species richness is highest for solid bedrock shores, and effectively the islands with a greater proportion of surveyed shores of this type (São Miguel, Terceira and São Jorge) showed a higher average species richness.

Based on the theory that intermediate levels of disturbance lead to higher diversity (Sousa, 1985) one could expect boulders to exhibit a higher diversity than solid bedrock and pebbles because when exposed to generalized high wave exposure, as is the case of the Azores, boulders are less stable than solid bedrock but more stable than pebbles. However, boulder shores are less habitat-diverse than solid bedrock shores to such an extent that probably compensates for the wave disturbance factor. In fact, and in accordance with previous studies (Wallenstein and Neto, 2006; Wallenstein *et al.*, 2008), boulder shores exhibited only a slightly lower average species richness and greater species composition affinity with solid bedrock than with pebbles shores. Turfs, composed of a large number of mainly red small filamentous and coarsely branched corticated algae, have been described as a major feature on all substratum types in the Azores (Wallenstein *et al.*, 2009b; Wallenstein *et al.*, 2010) which explains the overall dominance of these algae across all substratum types. Pebble shores, however, are unsuitable habitats for the larger, leathery brown species and tend to favour the development of foliose opportunistic species that grow rapidly between disturbance events.

The unbalanced number of surveyed shores of each type of substratum is representative of the coastline of the Azores islands, which consists predominantly of solid bedrock alternating with large boulders and less frequently with pebble and sandy bays. On all surveyed islands the number of solid bedrock and boulder shores exceeded largely that of pebbles, and given the greater species composition affinity between the former two it is not surprising to find no major differences between islands. This evidence is in agreement with previous biogeographic studies on Azorean seaweed communities (Tittley and Neto, 1995; Terra *et al.*, 2008), and further substantiated if one considers that each island was surveyed in a different year, since differences between islands may also be reflecting composition changes that can be substantial in successive years (Wells, 2002). Having a higher consistency in species composition within Santa Maria than on any other island, is very likely to have resulted from the application of biotope survey methods that focus on the most conspicuous species. Despite this, variability in species composition within this island is still of the same magnitude as within the other islands and between them, probably due to the fact that turf constituents have been taken into account.

Condensing species composition data (372 taxa) into eight functional groups further increased the level of similarity between islands. Functional group composition of seaweed assemblages might vary seasonally due to physiological vulnerability of some seaweed species to environmental change (Wells, 2002). However, all surveys took place in the summer period thus suggesting that no major functional group composition changes should be expected, as was the case.

Given that islands were surveyed in separate years and that no differences are expected between them in terms of either species composition (Tittley and Neto, 1995; Terra *et al.*, 2008) or functional group composition (Wells, 2002), it seems more likely that species composition differences arose due to annual natural variation of seaweed communities.

The dominant functional groups throughout the archipelago clearly reflect the conspicuous turf communities. Jointed calcareous algae are also a dominant constituent of one type of turf ("calcareous turf" or "coralline turf") that characterizes the lower intertidal of most shores (Neto and Tittley, 1995; Tittley and Neto, 2000; Wallenstein *et al.*, 2008; Wallenstein *et al.*, 2009b). However, this functional group is represented only by 9 species while the remaining turf constituents are grouped as coarsely branched corticated and filamentous algae represented by 130 species (Wallenstein *et al.*, 2009b),

thus obscuring the importance of jointed calcareous algae on Azorean shores in terms of high abundance which gives the shore a distinctive appearance. Calcareous, crustose, red algae (litothamnia) are common in the transition to the sublittoral zone (Tittley and Neto, 2000) but occasionally overlooked when the sea conditions are rougher and/or the tide is not completely out. Furthermore, calcareous, crustose, red algae are a taxonomically difficult group and it is frequent to record the occurrence as an unidentified species (sp.) or simply as calcareous crust, which probably accounts for a lower representativeness than in reality. Thin foliose algae are mainly represented by green species of the genera *Ulva* and *Enteromorpha* that tend to bleach and die in the summer periods when the sun is more intense and rain scarcer, and thus the low representation of this functional group. Thick leathery brown algae are poorly represented in the Azores by *Fucus spiralis* in the upper littoral zone and few species of *Cystoseira* and *Sargassum* in rockpools and/or in the transition to the sublittoral (Neto *et al.*, 2000). The low representation of unicellular and microscopic uniseriate filamentous algae on Azorean shores is probably related to a reduced number of large species on which they can grow epiphytically and endophytically, and a lack of expertise in detecting their presence in the field or identifying shell boring and endophytic algae.

The relative proportions of red, brown and green species of algae tend to be stable across wide geographical areas and there is a well documented latitudinal tendency for red species to decrease and brown species to increase with latitude (Chapman and Chapman, 1973; Lüning, 1990). The overall flora of the Azores archipelago is typically temperate in that it is dominated by red species (Tittley and Neto, 1995; Terra *et al.*, 2008). Such dominance of red species is also evident not only in each island's individual flora, but also in single shore species lists from single occasion surveys. Curiously, although within a small geographical range, Graciosa is the northernmost of the surveyed islands and the only one with a higher average proportion of brown species in detriment of green species. Abundant *Cystoseira* species in the transition to the sublittoral zone are a distinctive feature on Graciosa's shores (Neto, 2007b; Neto *et al.*, 2009a) and surely account for the increased brown species proportion.

The overall high average ESG ratio observed throughout the entire dataset results from the fact that the major constituents of turfs are late successional species, namely *Corallina elongata*, *Caulacanthus ustulatus*, *Chondracanthus acicularis*, *Gastroclonium* spp., *Gelidiella* sp., *Gelidium* spp., *Gymnogongrus* spp., *Halyptilon* spp.,

*Herposiphonia* sp., *Jania* spp. *Lophosiphonia* spp., *Pterosiphonia* spp. and *Sphacelaria* spp., (Wallenstein *et al.*, 2010). Ephemeral species such as *Ceramium* spp., *Centroceras clavulatum* and *Polysiphonia* spp. are minor constituents of turfs, and thus have a weaker contribution to the ESG ratio. Santa Maria's highest average ESG ratio comes probably as a result from the implementation of the biotope survey methodology that focuses attention on the most conspicuous species (late successional ones) and neglects the smaller, less obvious species that occupy smaller subhabitats and probably ephemeral ones.

Opportunistic species tend to occur in disturbed habitats due to their ability for quick colonization and rapid growth and are not well suited for dry and insolated environments. The fact that surveys took place in the summer when insulation and desiccation are highest and wave action lowest does not provide the best conditions for opportunist algae to thrive, and it is thus natural to expect low proportions of these seaweeds. However, locally and in a short period of time it is possible that environmental conditions change and become favourable for the occurrence of opportunists. The weather in the Azores is quite variable and summer rains are common, thus creating sporadic favourable occasions for opportunist species (e.g. *Ulva* spp.), and thus variability comes as a natural feature of these seaweeds.

### 3.4.3 Azores and the British Isles – comparison of seaweed assemblages between regions

#### *3.4.3.1 General*

The pool of surveyed sites used for the comparison between seaweed assemblages from both regions included 14.5% Azorean shores and 85.5% British shores (Table 3.8). The total number of species recorded from British shores was 15% higher than that of Azorean shores, relative to the overall total number of species recorded. The number of species that are common to both regions represents only 24% of the total number of species recorded, while 30% were exclusively recorded on Azorean shores and 46% on British shores. Therefore, using the Jaccard index that is based on the number of exclusive and common species of both regions (Clarke and Warwick, 2001), there is ca. 25% similarity between both floras.

**Table 3.8** – Number of single visit surveyed sites per region, total number of species, number of species recorded exclusively in each region and number of species common to both regions and respective percentage of red, brown and green species.

| | Number of sites | Number of species (R/B/G, %) | Exclusive species number (R/B/G, %) | Common species number (R/B/G, %) |
|---|---|---|---|---|
| Azores | 88 | 372 (67/16/17) | 205 (69/16/15) | 167 (65/16/19) |
| British Isles | 520 | 481 (51/31/17) | 314 (44/39/17) | |
| Total | 608 | 686 | 519 | |

The ratio R+G/B is considerably higher on Azorean shores considering both the total number of species (5.25 *vs.* 2.19 for the British Isles) and those recorded exclusively in each region (5.25 *vs.* 1.56 for the British Isles). According to Cheney (1977), the ratio values obtained for the Azores are quite close to those of tropical floras (6), while the ones obtained for the British Isles are lower than those of temperate and cold floras (3).

#### *3.4.3.2 Number of species per site*

Fig. 3.14a and b show a tendency for the total number of species per shore to be lower on Azorean shores than on British ones. Average species richness is 28% lower on Azorean shores than on British shores (43.9 vs. 60.7, respectively; Fig. 3.14b). However, value ranges in both datasets overlap totally (minima: Azores - 8, British Isles – 6; maxima: Azores – 91, British Isles – 143), which explains the generalized high variability (Fig. 3.14b), and thus inhibits conclusions about any possible significant differences in the total number of seaweed species recorded from single visit surveys in both regions.

#### *3.4.3.3 Species composition*

The two dimensional representation of the global dataset based of species composition, its associated low stress value (Fig. 3.15) and the corresponding analysis of similarities (Table 3.9) indicate differences of great magnitude (98.9%) between seaweed assemblages from Azorean and British shores.

Despite these differences, variability within each dataset is a common pattern to both regions, indicating that seaweed assemblages vary as much within each region as between regions.

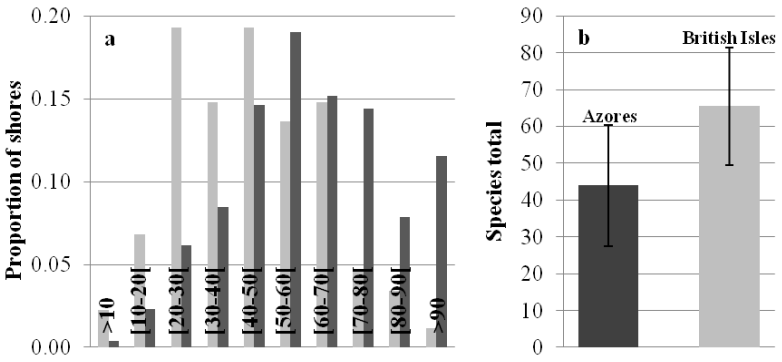


**Fig. 3.14** – (a) Percentage of shores per range of total species number; (b) average (±standard deviation) total species number per site (Azores data - dark grey; British data – light grey).

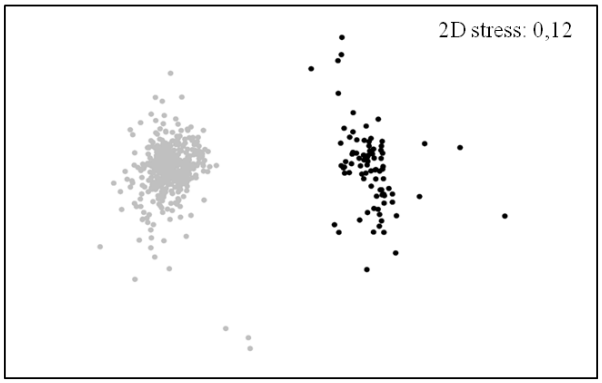


**Fig. 3.15** – Two dimensional ordination plot of all surveyed sites based on species presence/absence data (Azores data - dark grey; British data – light grey).

**Table 3.9** – Analysis of species composition similarities (ANOSIM) between Azorean and British shores.

| | **Significance (p%)** | **R** |
|---|---|---|
| **Global** | 0.1 | 0.989 |

### *3.4.3.4 Functional group composition*

Regarding the functional group composition of seaweed assembles from the Azores and the British Isles (Fig. 3.16a), the former exhibited obviously higher proportions of corticated filamentous (FG4), coarsely branched corticated (FG5) and jointed calcareous algae (FG7) and lower proportions of unicellular microscopic (FG1), foliose (FG2) and thick leathery and cartilaginous algae (FG6). The average proportions of uniseriate filamentous (FG3) and crustose algae (FG8) were also lower in the Azorean dataset, however not enough for value ranges from both datasets not to overlap due to their variability.

The overall differences in functional group composition of Azorean and British seaweed assemblages gave rise to a low stress ordination plot (Fig. 3.16b) where both datasets appear separate, validated by a significant difference of 80.2% (Table 3.10).

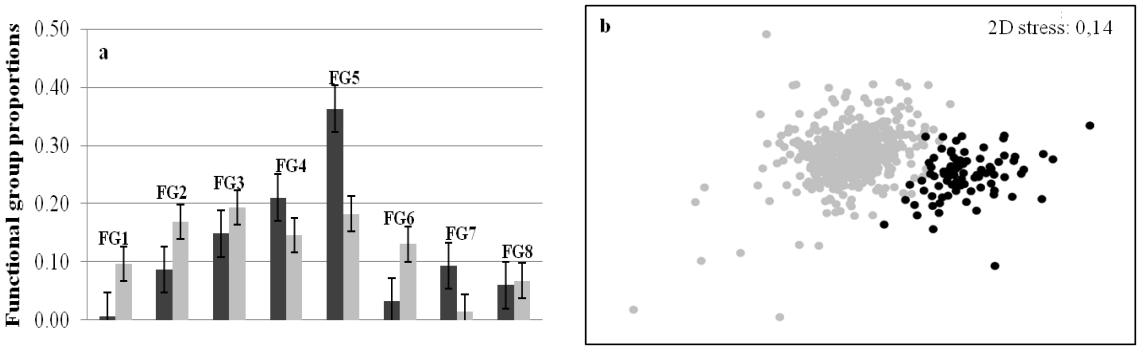


**Fig. 3.16** – (a) Average (±standard deviation) proportions of functional groups; and (b) two dimensional ordination plot of all surveyed sites based on the functional group composition of samples from the Azores (dark grey) and the British Isles (light grey).

**Table 3.10** – Analysis of functional group composition similarities (ANOSIM) between regions.

| | **Significance (p%)** | **R** |
|---|---|---|
| **Global** | 0.1 | 0.802 |

The separation of datasets is less evident when using species composition (Fig. 3.15) than functional group composition (Fig. 3.16b), as is also evidenced by a decrease in R values (Tables 3.8 and 3.9).

### *3.4.3.5 Proportion of red, brown and green species composition*

Unlike total species number per shore, the proportion of red species on Azorean shores is less variable and on average 20% higher than on British shores (Fig. 3.17a). The maximum value of this feature (86%) was common to both datasets (in Ponta Formosa, Santa Maria and Heather Island, Scotland), but the minimum recorded on Azorean shores was 43% (in Lajes, Pico), while there were two samples from the British dataset where no red species have been recorded (Newtownards, Northern Ireland and Whitehaven, England). Furthermore, the average proportion of brown species is significantly lower on Azorean than on British shores (ca. 10%). The maximum proportion of brown species found on Azorean shores was 0.36 (in Santa Cruz, a solid bedrock shore in Graciosa) and there was no record of brown species in 3 sites from the Azores (Anjos in Santa Maria and Santo Amaro and Monte in Pico, all pebble shores), while the highest proportion of brown species (0.54) was recorded in Gluss Voe

(Scotland), and no brown species were recorded in Byerstead Fault and Huntsman Outfall (Cumbria, England).

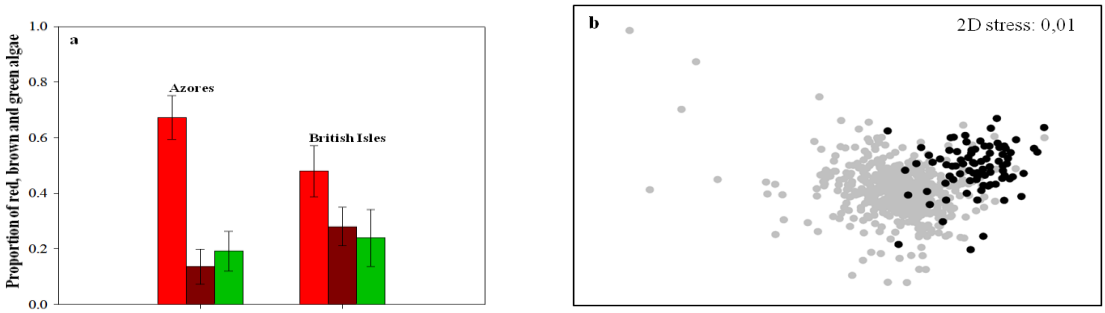


**Fig. 3.17** – (a) Average (±standard deviation) proportions of red, brown and green species; and (b) two dimensional ordination plot of all surveyed sites based on the proportions of red, brown and green species in the Azores (dark grey) and the British Isles (light grey).

**Table 3.11** – Analysis of red, brown and green proportion similarities (ANOSIM) between regions.

| | **Significance (p%)** | **R** |
|---|---|---|
| **Global** | 0.1 | 0.539 |

Although the proportion of green species tends to be lower in seaweed assemblages from the Azores, the value ranges of Azorean and British datasets overlap due to their variability (Fig. 3.17a). The maximum proportion of green species recorded for Azorean shores was 0.43 (in Lajes, a solid bedrock shore in Pico) while in Ponta Formosa (a boulder shore in Santa Maria) only 3% of the recorded species were green, whereas on British shores in Byerstead Fault (Cumbria, England) all recorded species were green., while only 3% of the species recorded in Easdale Headland (Scotland) were green.

From the ordination of samples (Fig. 3.17b) it is possible to recognize as much variability in R/B/G proportions within both datasets as between them. Despite this, the analysis of similarities (Table 3.11) indicates a 54% difference between both regions when comparing the respective proportions of red, brown and green species.

Additionally, the separation of datasets becomes even less evident when using proportions of red, brown and green species, and there is a further decrease in the R value.

#### *3.4.3.6 ESG ratio*

The maximum ESG ratio recorded in the Azores was 3.83 (in Ponta Formosa, a boulder shore in Santa Maria) and in the British Isles it was 1.53 (in Cranfield Point, Northern

Ireland), while the minimum was 0.46 in the Azores (Ferraria, a hydrothermal boulder site in São Miguel) and 0,00 in England (Whitehaven and Huntsman outfall). The frequency of distribution of Azorean shores is spread across a much wider ESG ratio range (Fig. 3.18a), which explains its greater variability than that of British shores (Fig. 3.18b). Despite the higher variability, the ESG ratio in the Azores is obviously higher than in the British Isles.

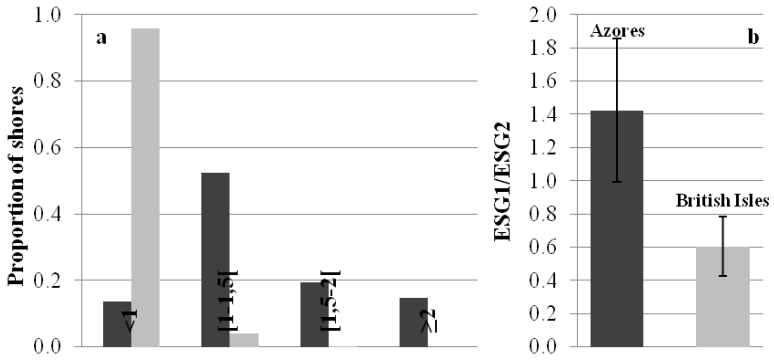


**Fig. 3.18** – (a) Percentage of shores per range of ESG ratio; (b) average (±standard deviation) ESG ratio per site (Azores data - dark grey; British data – light grey).

### *3.4.3.7 Proportion of opportunistic species*

There were several sites with no records of opportunistic species both in the Azores (4) and the British Isles (16), while the maximum recorded in the Azores was 0.38 (in Anjos, a pebble shore in Santa Maria) and 0.54 in the British Isles (in Newtownards, Northern Ireland). The proportion of opportunist species in both datasets is spread across a wide range of values which indicates high variability (Fig. 3.19a and b). The overlap of value ranges (0.10-0.15) does not allow a solid conclusion about differences between both regions, although of the lower average value in the Azores (Fig. 3.19b).

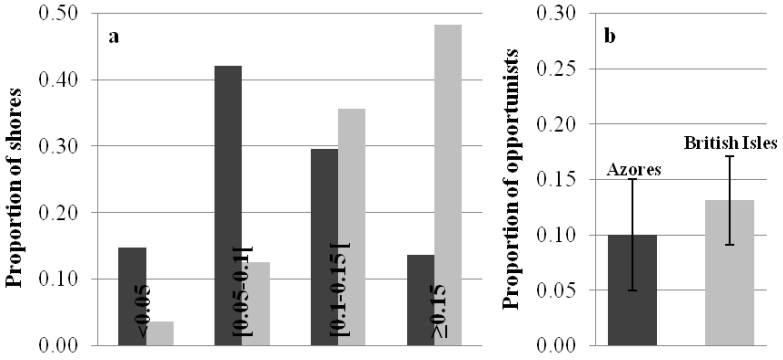


**Fig. 3.19** – (a) Percentage of shores per range of opportunist species porportion; (b) average (±standard deviation) proportion of opportunist species per site (Azores data - dark grey; British data – light grey).

#### *3.4.3.8 Comparison of Azores and British macroalgae assemblages - Summary*

- The total number of species recorded from British shores was 15% higher than that of Azorean shores, relative to the overall total number of species recorded. The number of species that are common to both regions represents only 24% of the total number of species recorded, while 30% were exclusively recorded on Azorean shores and 46% on British shores.
- There is a tendency for the total number of species per shore to be lower in the Azores than the British Isles, although value ranges in both datasets greatly overlap as a result of their variability.
- Species composition differs significantly between seaweed assemblages from Azorean and British shores. Despite these differences, variability within each dataset is a common pattern to both regions, indicating that seaweed assemblages vary as much within each region as between regions.
- The functional group composition of seaweed assemblages from the Azores exhibits higher proportions of corticated filamentous, coarsely branched, corticated and jointed calcareous algae and lower proportions of unicellular microscopic, foliose and thick leathery and cartilaginous algae.
- The proportion of red species on Azorean shores is less variable and, on average, 20% higher than on British shores, and the proportions of brown and green species tend to be lower in seaweed assemblages from the Azores.

- The ratio R+G/B species is considerably higher on Azorean shores considering both the total number of species and those recorded exclusively in each region, as is expected in warmer water regions.
- There is as much variability in R/B/G proportions within both datasets as between them, but despite this there are significant differences between both regions.
- ESG ratio values are more variable in the Azores, however this feature is obviously higher than in the British Isles.
- Although the proportion of opportunist species is highly variable in both datasets it tends to be lower in the Azores than on the British Isles.

### 3.4.4 Azores and the British Isles' micro-tidal shores – Comparison of seaweed assemblages between regions

Tidal range does not vary throughout the Azores archipelago, as it does on British shores. The tidal range for the British dataset used in the present thesis varies from 0.9 to 11.2m while it never exceeds 2m on Azorean shores. Given the influence of tidal range on coastal communities evidenced in Chapter 2 of the present thesis, a brief analysis was run to check for differences in the values of the features here analyzed on British shores with tidal ranges below and above 2m. According to the WFD (EC, 2000) tidal ranges below 2m are called micro-tidal, between 2 and 4m meso-tidal, and above 4m macro-tidal. This value was chosen to indicate whether it would be worth using a subset of British data to compare with the Azorean ±2m tidal range shores. This analysis showed no significant differences in species richness, red, green and opportunist proportions; however ESG ratios are considerably higher on British shores with a tidal range below 2m. It was therefore decided to exclude all shores with a tidal range above 2m from the British dataset to compare with the Azorean shores.

The exclusion of sites with a tidal range larger than 2m led to a reduction from 520 to 45 sites surveyed in the British Isles. As a consequence, there was reduction of 40% in the total number of species recorded compared to the same figure for the entire British dataset, with minor changes in the relative proportions or red, brown and green species (Table 3.12 vs. Table 3.1). Additionally, the total number of exclusive species was reduced in 15% as a result of a 28% increase in species exclusive to the Azores and a 44% reduction in species exclusive to the British Isles, while there was a 32% reduction in number of species common to both regions. Such changes lead to a lower Jaccard index of 21% similarity between both floras.

**Table 3.12** – Number of single visit surveyed sites per region, total number of species, number of species recorded exclusively in each region and number of species common to both regions and respective percentage of red, brown and green species.

| | Number of sites | Number of species (R/B/G, %) | Exclusive species number (R/B/G, %) | Common species number (R/B/G, %) |
|---|---|---|---|---|
| Azores | 88 | 372 (67/16/17) | 259 (69/16/15) | 113 (62/17/21) |
| British Isles | 45 | 290 (51/29/20) | 177 (44/37/19) | |
| Total | 133 | 549 | 436 | |

The exclusion of all meso- and macro-tidal sites from the British dataset has led to an almost generalized increase in the minimum and decrease in the maximum values of all analyzed features (Table 3.13), thus narrowing their ranges.

**Table 3.13** – Minimum and maximum values of total number of species, R/B/B proportion, ESG ratio and opportunist species proportion per site on Azorean and British shores (global and micro-tidal sites).

| | | Azores | British Isles | British Isles micro-tidal |
|---|---|---|---|---|
| Number of species | Minimum | 8 | 6 | 30 |
| | Maximum | 91 | 143 | 110 |
| R/B/G proportion | Minimum | 0.43/0/0 | 0/0.03/0 | 0,30/0.20/0.04 |
| | Maximum | 0.86/0.36/0.43 | 0.86/1/0.54 | 0.69/0.54/0.38 |
| ESG ratio | Minimum | 0.46 | 0 | 0.23 |
| | Maximum | 3.83 | 1.53 | 1.39 |
| Opportunist proportion | Minimum | 0 | 0 | 0 |
| | Maximum | 0.38 | 0.54 | 0.30 |

Despite these differences, the average values per site of all analyzed features in both regions were not affected by the reduction of the dataset (Fig. 3.20 vs. Figs 3.14, 3.17a, 3.18b and 3.19b).

As a consequence, the analyses of similarity between Azorean and British micro-tidal shores suffer minor changes relative to the homologue analysis with the whole British dataset, namely a 2.4% reduction in species composition differences, a 1.2% increase in functional group composition differences, and a 20% increase in R/B/G proportion composition (Table 3.14 *vs.* Tables 3.8, 3.9 and 3.10).

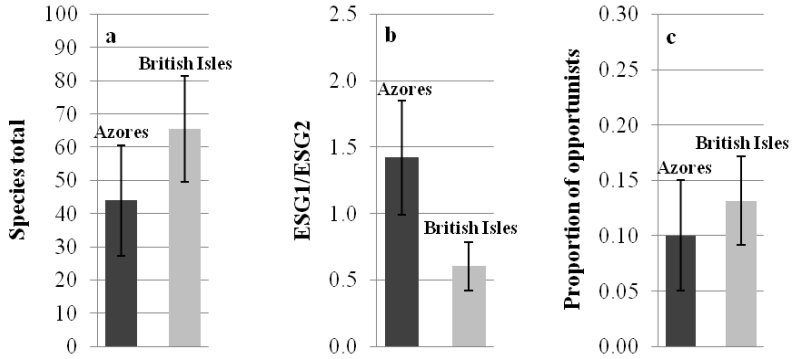


**Fig. 3.20** – Average (±standard deviation) values for: (a) total number of species; (b) ESG ratio; (c) proportion of opportunist species (Azores data - dark grey; British micro-tidal data – light grey).

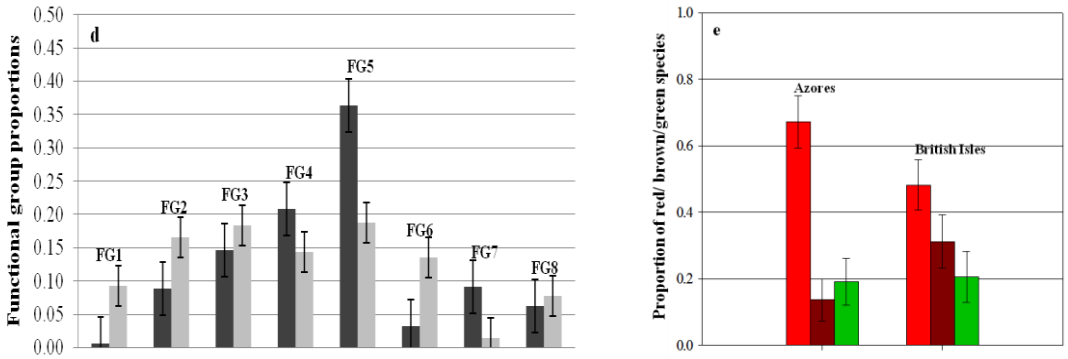


**Fig. 3.20 (cont.)** – Average (±standard deviation) values for: (d) functional groups' proportions; (e) red, brown and green species proportions (Azores data - dark grey; British micro-tidal data – light grey).

**Table 3.14** – Analysis of similarities (ANOSIM) between Azorean and British micro-tidal shores.

| | **Significance (p%)** | **R** |
|---|---|---|
| Species composition | 0.1 | 0.965 |
| Functional group composition | 0.1 | 0.790 |
| R/B/G proportion composition | 0.1 | 0.647 |

#### *3.4.4.1 Comparison of Azores and British micro-tidal macroalgae assemblages – Summary*

- As a consequence of the exclusion of all British sites with a tidal range higher than 2m, there was reduction of 40% in the total number of species recorded compared to the same figure for the entire British dataset, with minor changes in the relative proportions or red, brown and green species.
- Species common to both regions were reduced by 32% and the total number of exclusive species was reduced by 15% as a result of a 28% increase in species exclusive to the Azores and a 44% reduction in species exclusive to the British Isles.
- The value ranges of all analyzed featured were narrowed as a result of an increase in the corresponding minimum values and/or a decrease in the maximum values.
- Despite these changes, the overall observed similarities/dissimilarities between the features used to compare the two regions remained unchanged.

- Differences between shores become diluted as the information on seaweed assemblages is further condensed. The use of species composition greatly accentuates these differences, while functional group composition accentuates them to a lesser extent, then R/B/G proportions and finally ESG ratio.

#### *3.4.4.2 Azores and British macroalgae assemblages – Discussion*

The flora of the Azores is expected to be substantially less species diverse than that of the British Isles due to differences in the size of the islands and the intertidal shores, their remoteness relative to continental landmasses and environmental features related to latitude (Ricker, 1987; Wilson, 1988; Silva, 1992; Hawkins *et al.*, 2000). However, considering the overall species diversity that resulted from single occasion surveys, the difference between these two distant regions turned out not to be so substantial (15% less species in the Azores) especially if one considers the difference in the number of surveyed shores in both regions and the cumulative effect in species richness with increasing number of surveys (see p.57). Despite the small difference in the total number of species recorded for both regions, the corresponding species compositions differ greatly as a consequence of a small proportion of species that the Azores and the British Isles have in common, which reflects the reduced biogeographical affinity between them, as had already been shown in previous studies considering the global floras (Tittley and Neto, 1995, 2006; Terra *et al.*, 2008). A common feature, however, is the variability in species composition within each region that reflects physical and environmental heterogeneity throughout both regions' surveyed shores. Habitat characteristics, namely dominant shore type and sub-habitat diversity, are known to affect not only species composition but also the levels of species richness on a shore (Wells *et al.*, 2007). It is thus not surprising to also find great variability in species richness within both regions, given the large number of shores that have been surveyed, covering wide geographical ranges in both areas. Although Azorean shores have a 28% lower average species richness, the value ranges within each region totally overlap, suggesting that differences between shores exist due to habitat variability, rather than due to any geographical trend.

Although of the low biogeographic affinity in species composition between the Azores and the British Isles, given that species richness seems to respond primarily to habitat variability, one could expect seaweed communities from both regions to resemble in terms of the morphology of its constituents. However, physiology seems to play a

bigger role than morphology in the latitudinal distribution of species, and the widely described pattern of increasing proportion of red species and decreasing proportion of brown species towards the tropics that result from light and weather conditions (Lüning, 1990) leads to significant differences between functional group composition in the Azores and the British Isles. The average higher proportion of red species in the Azores, typical of warmer temperate regions, accounts for the higher proportions of corticated filamentous, coarsely branched and jointed calcareous algae, which represent the main components of this region's most striking intertidal feature – turfs. Oppositely, the Azores lack the large, leathery canopy forming species that are common on British shores, and thus account for the latter's higher average proportion of brown species and also the corresponding functional group. Foliose seaweeds are greatly represented by fast growing green species (opportunist) that thrive best under shaded and wetter environments, which is probably the reason for their average lower abundance on Azorean shores, where the weather is sunnier and light more intense than on British shores. The occurrence of opportunist species tends to be variable due to their vulnerability to environmental stress and simultaneous capability of rapidly colonization.

The ESG ratio for any given shore summarizes the functional group composition of its seaweed assemblage by giving the proportion of late successional species over the early successional ones. Given that the functional groups better represented in Azorean than in British seaweed assemblages are also mainly composed by late successional species, it is not surprising to have an overall higher average ESG ratio for Azorean shores. This index has been used in the assessment of ecological quality in diverse regions (Orfanidis *et al.*, 2001; Wells *et al.*, 2007) associating higher ESG ratios to shores that are unimpacted by human intervention and thus considered of superior ecological quality, which would suggest that ecological quality in the Azores is significantly higher than on the British Isles. However, the latitudinal influence on functional group composition must be taken into account if such distant geographical regions are to be compared. Nevertheless, within each region the lowest ESG ratio values were associated with shores that have been impacted by some sort of adverse chemical input, a shore subject to shallow water hydrothermal activity in the Azores, and two shores affected by industrial chemical waste in England. Despite the comment in section 2.3.2.7 that there is not a large number of really badly polluted rocky shores in the British Isles, there are localized areas where there are many examples of poor shores. West Cumbria on the north-west coast of England is one such area. Here there are some of the most seriously

affected shores in the UK. Within only a few km of coastline can be found shores affected by mine drainage water, slagcrete (an artificial rock formed by tipping of molten chemical waste on to the shore), and coal spoil dumping. But the two most badly affected shores in this area which are referred to here have an additional problem. In Saltom Bay, just south the town of Whitehaven, there was a discharge of cadmium and phosphate from a detergent factory. This appeared to have leaked into underground coal mine workings, which in turn leaked into an underground stream which surfaced as a spring in the mid intertidal zone. Around this point the shore was subject to foaming and was largely devoid of macrofauna and macroflora (Wilkinson, personal communication). Adjacent shores were dominated by just a few species of opportunistic green seaweeds (e.g. *Ulothrix* spp. and *Enteromorpha* spp.) to the exclusion of any ESG1 species. (This shore has now shown dramtic recovery to fucoid domination since 2007 with abatement of the pollution).

Although tidal range does not seem to have much influence on species richness on British shores (Wells, 2002), since tidal range is a major structuring factor for intertidal communities it proved sensible to use the British micro-tidal shore data subset for the comparison with the Azores archipelago, where the tidal range is uniformly low. By reducing the pool of data, it is not surprising to verify that the overall number of species decreases. Despite the reduction in the number of species that are common for both regions the overall species composition affinity between the two regions remains quite unaffected. The single difference between the Azores and the British Isles that has been reinforced by excluding non-micro-tidal shores from the comparison between regions is the average number of species per shore. Nevertheless, value ranges still overlap to a great extent, while differences between the two regions in all remaining features remained unchanged, thus confirming that tidal range can be overlooked when comparing seaweed assemblages.

## 3.5 GENERAL DISCUSSION

Comparison of seaweed assemblages across wide geographical areas might prove difficult and features for comparison must be carefully chosen to effectively reflect possible difference and/or similarity patterns. To analyze the geographical distribution of each species *per se* is useful to compare seaweed floras of specific regions and assess their biogeographical affinities. However, when the need arises to assess ecological features of seaweed communities and compare them across wide areas, it is necessary to identify which environmental factors are at stake and clarify how they affect such ecological features. Extracting ecological information from species occurrence in single occasion surveys proved effective in the comparison of British shores (Wells, 2002; Wells *et al.*, 2007), which set the rationale for the comparison between Azorean and British shores.

The ecological features of seaweed communities that have been extracted from species composition are strongly correlated with each other, and thus the consistency in the patterns that they evidence. However, they are all required to incorporate different features of community composition that respond differently to the various environmental stresses (Wells *et al.*, 2007). Incorporating these features into a single index (Wells *et al.*, 2007) has been shown to provide a useful measure of ecological health to be used for comparison of different shores. Its applicability to wide geographical areas would thus be desirable as an environmental management tool. However, there are latitudinal difference patterns in these features that were identified in the comparison of the Azores and the British Isles that must be taken into account if such indices are to be compared between regions.

# CHAPTER 4

## NUMERICAL INDICES FOR ASSESSMENT OF ECOLOGICAL QUALITY OF INTERTIDAL ROCKY SEASHORES USING SEAWEEDS

# 4. NUMERICAL INDICES FOR ASSESSMENT OF ECOLOGICAL QUALITY OF INTERTIDAL ROCKY SEASHORES USING SEAWEEDS

## 4.1 INTRODUCTION

Coastal areas have historically been highly populated due to their high biological productivity and to their importance in transport routes (Wolanski *et al.*, 2004). The consequent anthropogenic pressure put on coastal habitats and communities derives from several factors among which pollution by urban-industrial areas can have both destructive and promoting effects (Lewis, 1977). Biota respond directly and/or indirectly to environmental stressors. The abundance of a given organism can be reduced simultaneously by the direct effect of a given environmental stressor and by the indirect effect of increased grazing promoted by the same environmental stressor. Changes in abundance, diversity and fitness of individuals, populations, and communities are the ultimate response to such stressors. The use of biological criteria reflect environmental problems that might otherwise be missed or underestimated when using chemical criteria alone. They integrate and account for natural ecological conditions and variability, and are therefore preferable for assessing ecological quality (Adams, 2005).

Ecosystem attributes such as diversity and abundance (habitat and biological) need to be addressed in order to allow environmental programmes to monitor ecosystem status and health (Harding, 1992). Marine environmental quality has been defined as 'the condition of a particular marine environment measured in relation to each of its intended uses, and is usually assessed quantitatively requiring both indices of condition and change, and established guidelines and objectives set by environmental, health and resource agencies' (Wells and Côté, 1988).

The permanent and drastic reduction in the number of species is the most certain indication of severe stress, but is rare and usually localized, while modest changes in species diversity, relative abundance of organisms and/or physiological changes in some species are usually more common and difficult to detect against the natural background variation (Lewis, 1977). Moreover, the impact on the ecological health of estuarine and coastal ecosystems is dependent on water circulation and dilution of pollutants and/or

nutrients, as they might affect the physiology of individual organisms without it being reflected at the ecosystem level (Wolanski *et al.*, 2004).

Diversity indices measure biological quality through the structure of the community, by summarizing species composition and relative abundances into a single measure. The Shannon-Wiener index has been one of the most commonly used in the assessment of pollution effects on marine benthic communities in the past (Simboura and Zenetos, 2002). The simplistic univariate nature of such indices and their sensitivity to sampling methodology, sample size, identification procedures and habitat type, however, has led to debate over their interpretation and use (Clarke and Warwick, 2001). Multivariate techniques, on the other hand, are based on species composition and relative abundances rather than on a single measure that summarizes these features. Comparison of communities is based on the extent to which different data sets share particular species at comparable levels of abundance, thus taking into account changes in actual taxa present (Warwick and Clarke, 1991). The most recent trend in assessing ecological quality focuses on biotic indices that use ecological classification of organisms, namely by grouping them according to morphological and/or physiological criteria or by using lower taxonomic resolution, among others. These indices are multivariate because they compare datasets based on various features simultaneously, and may be universal because such morphological and/or physiological classification criteria may help to overcome the fact that taxonomy can vary widely (Simboura and Zenetos, 2002).

Comparative spatial surveys between affected sites and non-affected ones are more suitable than temporal comparison of one same site, because they exclude relevant factors like seasonality and species introductions, although there is the need to focus on sites as physically alike as possible to ensure consistency in local variation sources (Lewis, 1977). A reason for focussing on rocky shores is that changes in hard bottom communities are well documented (Bäck *et al.*, 2002). Furthermore, there is a wide literature on rocky shore macroalgae communities and their response to pollution and nutrient enrichment (e.g. Gorostiaga and Díez, 1996; Díez *et al.*, 1999; Goshorn *et al.*, 1999; Roca *et al.*, 2003; Karez *et al.*, 2004; Krause-Jensen *et al.*, 2007; 2008). The use of macroalgae in such studies arises due to their sedentary condition and consequent integration of long-term exposure to nutrients or other pollutants that result in a decrease in species richness, an increase in abundance of a few ephemeral species with high reproductive capability and tolerance to pollution, and a simplification of community structure.

Many countries are developing environmental and ecological quality indicators as part of their international obligations such as those under Agenda 21 (UN, 2003) and OECD reviews (Simboura and Zenetos, 2002). Accordingly, in the European Union the implementation of various EU directives [the Habitats Directive (EC, 1992), the Water Framework Directive - WFD (EC, 2000), the Integrated Coastal Zone Management proposal (EC, 2002), and the Bathing Waters Directive (EC, 2006), among others] has led to the development of biological indicators to be used as tools to monitor the environment and help protect biological diversity of coastal and marine ecosystems.

The WFD aims at maintaining and improving the aquatic environment in the Community, and is primarily concerned with establishing a framework for the protection of groundwater, inland surface waters, transitional waters and coastal waters (EC, 2000). For each of these types of waters there are specific guidelines for the development of tools to assess and monitor ecological quality. The directive considers ecological status as a reflection of the quality of the structure and functioning of aquatic ecosystems. It is therefore expected that the implementation of the WFD is based on the assessment and monitoring of biological communities that reflect the physical and chemical quality of their habitats.

Within the application of the WFD the assessment of the ecological status of coastal waters (Annex V, 1.1.4 of the Directive) has to be evaluated based on macrophytes (macroalgae, salt marsh plants, seagrasses), phytoplankton and benthic invertebrates, and supported by hydromorphological and physico-chemical quality elements. This directive established that the ecological status of any given shore shall be expressed as a numerical value between zero and one - high ecological status represented by values close to one and bad ecological status by values close to zero. Such numerical value shall reflect the quality of the various biological elements relative to reference conditions (sites with no, or very minor, disturbance from human activities) and be classified according to a 5 point scale - high, good, moderate, poor and bad. The definition of boundaries between the good and moderate ecological statuses poses the most concern, since all water bodies in the European Union are expected to reach a good-high classification by 2015.

Member States are expected to intercalibrate methods to ensure coherence in the results they produce. For this purpose countries were grouped into wide Geographical Intercalibration Groups (GIGs), and all countries or parts of countries with an open Atlantic coast were placed in the northeast Atlantic GIG (NEA-GIG). The NEA-GIG

extends from sub-polar conditions in Norway to warm subtropical waters in the Azores, and warmer waters off the African Coast in the Islas Canarias, thus presenting big variations in coastal communities and posing difficulty in the generalized application of ecological quality assessment criteria.

### 4.1.1 Macroalgae and the WFD

The generic criteria set by the WFD to evaluate macroalgae communities as a biologically relevant quality element include: (1) taxonomic composition; (2) abundance; and (3) presence of sensitive taxa. However, the need to have consistent methods across wide geographical areas within each intercalibration group raises some issues that must be considered when applying these criteria.

The first two approaches to the WFD using macroalgae were proposed for the Mediterranean Sea and are univariate in nature – the first one, focusing on the upper infralittoral zone and based on the relative abundance of seaweeds classified into two ecological status groups (see p.43) was implemented in Greece (Orfanidis *et al.*, 2001, 2003; Panayotidis *et al.*, 2004) and later in the Adriatic Sea (Orlando-Bonaca *et al.*, 2008; Ivesa *et al.*, 2009; Orlando-Bonaca and Lipej, 2009). The second one, focusing on the midlittoral zone and sublittoral fringe and based on the relative proportions in the number of red and brown species, was implemented only in Italy (Giaccone and Catra, 2004). The method proposed by Orfanidis *et al.* (2001) was highly criticized by Ballesteros *et al.* (2007a; 2007b) due to its oversimplistic and univariate nature, who proposed an alternative cartography based multivariate method (CARLIT) implemented on Mediterranean shores (e.g. Mangialajo *et al.*, 2007; Asnaghi *et al.*, 2009). It consists of assigning ecological quality to shores based on the distribution of conspicuous seaweed species associations from the littoral zone and sublittoral fringe. The species associations used for this purpose are supposedly linked with known quality standards following several studies on seaweed communities along nutrient enrichment gradients (Pinedo *et al.*, 2006; Arévalo *et al.*, 2007; Pinedo *et al.*, 2007).

### 4.1.2 WFD and the northeast Atlantic

In the Atlantic the use of macroalgae for the assessment of ecological quality has focused on the abundance of nuisance opportunistic species in estuarine and coastal

ecosystems, implemented in the UK (Scanlan *et al.*, 2007; Wells, 2007) and in Portugal (Patrício *et al.*, 2007; Goela, 2009), while regarding coastal waters authors have focused on the depth distribution of sublittoral species in the mouth of the Baltic Sea (Petersen *et al.*, 2005; Schories *et al.*, 2009) and on multimetric approaches based on littoral and/or sublittoral seaweed community features, such as the FSL/RSL tool implemented in the British Isles and in Norway (Wells *et al.*, 2007) and the CFR tool on the Atlantic coast of Spain (Juanes *et al.*, 2008).

Given the fact that the present thesis deals with intertidal macroalgal communities on open Atlantic coasts, the latter two methods will be briefly described with some detail to enlighten the reader about the framework of what will be treated in the remainder of this chapter.

#### *4.1.2.1 FSL/RSL tool*

The first tool to be developed for the evaluation of ecological quality of intertidal rocky shore seaweed communities is based on species richness and has been proposed by Wells *et al.* (2007). The tool was derived for use throughout the British Isles and subsequently adopted by Norway. It is based on a large set of data (ca. 450 samples collected from ca. 350 shores) collected in single occasion visits to ±100m rocky shore stretches throughout the British Isles, where detailed and comprehensive lists of all species present (FSL – full species lists) have been recorded by experienced seaweed biologists (M. Wilkinson, pers. com.). The tool was then built on the premise that species richness can reflect ecological aspects, remaining broadly constant in the absence of environmental alteration but with quantifiable seasonal fluctuations (Wells, 2002; Wells *et al.*, 2007), and being negatively affected by pollution (Wilkinson and Tittley, 1979). It also builds on evidence that the number of species is not affected significantly by wave-exposure except on extremely exposed shores (Wells *et al.*, 2003), and although the type of shore and subhabitats do influence species richness, Wells (2008) provided a way of incorporating a species richness "correction factor" for shore description (see p.91). Despite the guidelines of the WFD to consider species abundances, there is scientific evidence that abundance of seaweeds can be naturally highly variable on British shores due to cyclic alternation between algal- and animal-dominated communities over periods of years (Hawkins and Hartnoll, 1983) and that this does not affect significantly species richness (Wells *et al.*, 2003; Wilkinson and Wood, 2003; Wells, 2008). Additionally, the use opportunist seaweed abundance as an

indicator of poor ecological quality has been proposed to incorporate the WFD tool for evaluating transitional waters and sedimentary rocky shores (Scanlan *et al.*, 2007) rather than adopting it for rocky shores, on which macroalgal blooms are not normally a problem and opportunistic species constitute a natural component of the community with highly variable abundances. Therefore, species richness was considered the relevant feature and this tool was based only on the number of species present on any shore at a given point in time. Furthermore, simple aspects of macroalgae community structure were extracted from the full species list data, namely the relative proportions of red and green species, early and late successional species and opportunistic and non-opportunistic species (see p.95). These features were chosen to incorporate different implicit ecological aspects of the macroalgae communities that might respond differently to different environmental factors. Healthier shores were expected to have higher proportions of red and late successional species and lower proportions of green and opportunistic species. During the development of the method the 350 shores in the database were subjectively assigned a quality classification by a panel of expert seaweed ecologists, according to the 5 point scale set by the WFD, and these classifications compared with the respective scores of the community features measured. The value ranges of variation of each feature within each of the five ecological quality classes were then used to set the boundaries between quality classes, and mathematical formulae were developed by statisticians to calculate the numerical value of ecological quality (EQR) for each shore (see Methods section below).

To overcome the highly demanding taxonomic expertise and time requirements involved in the identification of full species lists for every surveyed shore, Wells *et al.* (2007) suggested the use of a reduced species list (RSL) consisting of approximately 70 taxa that are present on a large proportion of shores considered to be of good or high ecological quality within a geographical area. Assessing the RSL on any shore, that is intended to work as a surrogate for the FSL, significantly reduces taxonomic expertise and time requirements, and the calculation of the corresponding ecological quality needs to be based on adjusted boundaries defined in the same way as for the FSL.

#### *4.1.2.2 CFR tool*

The tool proposed by Juanes *et al.* (2008) to assess ecological quality in northern Spain based on macroalgae for the WFD focuses both on subtidal (<30m) and intertidal rocky shore communities. Regarding intertidal rocky shores each survey envisaged the fringe

occupied by seaweeds along 3 replicate ±5m stretches of coastline. Species richness was assessed for each replicate sampling unit from a list of 51 taxa (Guinda *et al.*, 2008), given as the "characteristic macroalgae" populations for the Cantabria region and considered only "when significantly abundant (>1%, percent cover of the surveyed area)", as defined by its authors. Following the WFD guidelines this method considers macroalgae abundances by assessing both the total area occupied by the "characteristic macroalgae" populations, and the area occupied by opportunistic species within each sampling unit. Physiological status is assessed by expert judgement on the health of each sampling unit's whole macroalgal community based on features that might not be related to natural causes (depigmentation, low density, reduced frond development, physical disturbance, epiphytism). The calculation of the numerical value of ecological quality (EQR) for each shore is based on a scoring system according to defined boundaries for each feature (see p.104), with alternative values for semi-exposed and exposed shores where species richness and overall coverage are concerned. Differential weighting is assigned to the maximum possible score of each feature, namely 15 for species richness, 40 to overall cover, 30 to opportunist cover and 15 to physiological status. This tool is intended for stable substrata whereas a positive compensation scoring factor shall be applied to overall cover score in substrata that are less favourable to the attachment of algae. Similarly, a negative compensation scoring factor shall be applied to the opportunist cover score whenever invasive species are recorded.

### 4.1.3 WFD and the Azores

There are no published studies on the implementation of tools using seaweed communities for the assessment of ecological quality of coastal waters in mainland Portugal, while in the Azores coastal water bodies defined by Azevedo (2005) have been surveyed on Santa Maria, São Miguel, and Terceira under the WFD guidelines. Based on phytoplankton communities and chemical properties of water all surveyed water masses have been classified as having good and/or high ecological quality (Neto *et al.*, 2009b). Simultaneously, rocky shore communities have been qualitatively and quantitatively surveyed, and no significant differences were found between any of the surveyed shores. In fact these shores do not differ significantly from any other shores on any island that have been surveyed for different purposes by the Marine Biology Section of the University of the Azores, thus leading us to believe that there is a generalized good and/or high ecological quality of Azorean shores.

The objective of this chapter is to test the applicability of the tools developed in the British Isles to a distant geographical area – the Azores – where intertidal seaweed communities differ to a great extent from those on British shores. It was planned as an intercalibration exercise that would be expected to produce guidelines for possible adaptations needed for a wider geographical applicability of the tools. As such the method proposed by Wells *et al.* (2007) was further developed to assess the ecological quality of 88 shores on 6 different islands of the archipelago.

The publication of the method of Juanes *et al.* (2008) arose when field work had been concluded for the development of the method of Wells *et al.* (2007) on Azorean shores and thus no quantitative data had been collected with the purpose of developing the Spanish tool on the same shores for comparison of results. Nevertheless, some shores had been simultaneously surveyed quantitatively for biotope definition purposes and a subset of the data collected allowed the comparison of results using both methods.

## 4.2 METHODS

### 4.2.1 FSL/RSL tool

For the application of the FSL/RSL method proposed by Wells *et al.* (2007) the following community features were measured on each shore:

- Full species list richness / Reduced species list richness
- Proportion of red species
- Proportion of green species
- Proportion of opportunistic species
- ESG Ratio

#### *4.2.1.1 Full species list richness*

The occurrence of species on each shore was recorded on a spreadsheet following the method described in Chapter 3 of the present thesis (Appendix 3, in electronic form on the enclosed CD). Additionally, basic shore description features related to shore type and habitat type and number were recorded for each shore (see Appendix 2, in electronic form on the enclosed CD). Sites that are naturally less species rich due to the type of shore and habitat diversity could be assigned a lower quality and so a scoring system has been devised to incorporate a correction factor into the overall metric for quality classification (Table 4.1, column 2; Wells, 2002; Wells, 2008).

The scoring system reflects the contribution of dominant shore type and subhabitat type and number to the level of species richness. Accordingly, scores decrease along the following sequence of dominant shore type: Rock ridges/outcrops/platforms > Irregular rock and Boulders > Steep/Vertical rock > Pebbles/Stones/Small rocks > Shingle/Gravel. Similarly, scores decrease along the following sequence of subhabitat type: Wide shallow/Large/Deep rockpools > Basic rockpools and Crevices > Overhangs > Caves. Additionally, with increasing number of subhabitat types there is an increase in the levels of algal species richness recorded as higher subhabitat diversity results in higher species diversity. The "shore description" score of each surveyed site is calculated by summing up the highest values of "dominant shore type", "subhabitats" and "total number of subhabitats". A mixed shore of boulders and rocky platforms with large rockpools and overhangs would therefore score a total of 10, by summing up a partial score of 4 for dominant shore type (highest score of "Rock ridges/outcrops/Platforms" and "Boulders large, medium and small"; see Table 4.1), a

partial score of 4 for subhabitat type (highest score of "Large rock pools (>6m long)" and "Large overhangs and vertical rock"; see Table 4.1) and a partial score of 2 for the total number of habitats (large rockpools and overhangs).

**Table 4.1** – Basic shore description features and corresponding scoring system (adapted from Wells, 2008) .

| Shore description | Scoring system |
|---|---|
| **Dominant shore type** | |
| Rock ridges/outcrops/Platforms | 4 |
| Irregular rock | 3 |
| Boulders large, medium and small | 3 |
| Steep/Vertical rock | 2 |
| Non-specific hard substrate | 2 |
| Pebbles/Stones/Small rocks | 1 |
| Shingle/Gravel | 0 |
| **Subhabitats** | |
| Wide shallow rock pools (>3m wide; <50cm deep) | 4 |
| Large rock pools (>6m long) | 4 |
| Deep rockpools (50% > 100cm deep) | 4 |
| Basic rock pools | 3 |
| Large crevices | 3 |
| Large overhangs and vertical rock | 2 |
| Other habitats | 2 |
| Caves | 1 |
| None | 0 |
| **Total number of subhabitats** | |
| ≥4 | 4 |
| 3 | 3 |
| 2 | 2 |
| 1 | 1 |
| 0 | 0 |

### *Shore description-species richness correction factor*

This scoring system was devised for British shores based on 128 rocky shores from the Northern Ireland Littoral Survey (Wilkinson *et al.*, 1988) for which full species lists and full subhabitat data were available. It was devised to associate higher shore description scores to substratum and subhabitat types that are known to favour the attachment and survival of macroalgae. Using only shores that have been classified as "good" and "high", the mathematical relationship between "shore description" and "observed species richness" scores was then used to calculate the "expected species richness" based on "shore description". A species richness "de-shoring correction factor" was subsequently calculated for each "shore description" score within the dataset. It was calculated by dividing the average "expected species richness" by the "expected species richness" associated with each "shore description" score. The "de-shored species

richness" was then calculated by multiplying the "observed species richness" by "de-shoring correction factor". The "de-shored species richness" was then used for the overall calculation of quality classification.

Azorean and British shores differ to a great extent and species richness tends to be lower on Azorean shores, therefore it has been decided to apply the "de-shoring" procedures to the Azorean dataset to calculate a deshoring factor which specifically applies to Azorean shores. Wells (2008) use data from reference or near reference conditions for this purpose. However, given that all Azorean coastal waters are expected to have a good and/or high ecological quality (Neto *et al.*, 2009b), all sites have been used for the calculation of the "de-shoring correction factor".

#### *4.2.1.2 Reduced species list richness*

To overcome high levels of taxonomic expertise required for the identification of intertidal seaweed species Wells *et al.* (2007) and Wells (2008) suggested for the British Isles the use of a reduced set of ca. 50-70 species that are present on most high quality shores as an alternative to using the full species list. Given that all Azorean coastal waters have been assigned a good and/or high ecological quality (Neto *et al.*, 2009b) all sites have been used to extract the reduced species list from the full species list.

The reduced species list is expected to act as a surrogate for the full species list and is thus also affected by the dominant shore type and habitat diversity. Therefore, a "de-shoring correction factor" has been devised based on the correlation between "shore description" and "reduced species list richness".

#### *4.2.1.3 Proportion of red and green species*

The proportions of red and green species were calculated based on the total number of Rhodophyta and Chlorophyta, respectively, divided by the total number of species on each shore (both with the full species and reduced species lists).

#### *4.2.1.4 Proportion of opportunistic species*

According to Wells *et al.* (2007) and Wells (2008), the proportion of opportunistic species was calculated based on the total number of *Blidingia* spp., *Chaetomorpha* spp., *Ulva* spp. (including *Enteromorpha* spp.), *Ectocarpus* spp. and *Porphyra* spp. divided by the total number of species on each shore (both with the full species and reduced

species lists). This list of opportunist species was based on the genera known to form problem macroalgal blooms in the British Isles. However, these are a problem on sedimentary shores rather than solid bedrock, and their use in this tool can be questioned. Despite this fact, we have decided to keep this feature to test the applicability of the tool as it has been defined for the British Isles.

#### *4.2.1.5 ESG ratio*

The original index using the classification of species into two ecological status groups, proposed by Orfanidis *et al.* (2001; Table 4.2), was based on the relative abundances of species assigned to each of these groups. However, given that there were no abundance data in the tool developed by Wells *et al.* (2007) and Wells (2008) an alternative index was used consisting in the ratio between the total number of late successional or perennial species (ESG1) and the total number of opportunistic or annual species (ESG2). This was based on the finding of Wilkinson and Wood (2003) that the ratio of species totals in ESG1 and ESG2 was a remarkably constant feature in lists of species from apparently good or high quality shores in Scotland and Northern Ireland.

**Table 4.2** - Descriptions of the different functional groups (FG) from Wells (2002) used in placing species into the two ecological status groups by Wells *et al.* (2007).

| | **Functional groups** |
|---|---|
| **ESG 1** | Late successionals or perennials including:<br>• Coarsely branched and highly corticated forms (FG5)<br>• Thick, leathery and cartilaginous forms (FG6)<br>• Jointed calcareous forms (FG7)<br>• Crustose forms including those microscopic forms found epiphytically or endophytically (FG8) |
| **ESG 2** | Opportunists or annuals including:<br>• Unicellular and epiphytic, endophytic, epizoic and endozoic microscopic forms (FG1)<br>• Foliose, thin, membranous and sheet-like forms (FG2)<br>• Uniseriate filamentous forms (FG3)<br>• Multiseriate and/or corticated filamentous forms (FG4) |

#### *4.2.1.6 Ecological quality calculation metrics*

Although there are quality class boundaries for all macroalgal features, shores are classified based on the final ecological quality ratio (EQR) for all these features combined together. The final classification status of each shore is calculated through the average of all partial EQR values, and shores classified as bad to high ecological quality according to the scale defined in Tables 4.3 and 4.4.

On a given shore, the partial EQR value for each feature is calculated according to a sliding scale formula based on the value of each feature on that shore and the range values of the class it falls into (Tables 4.3 and 4.4, using the full species list and the reduced species list, respectively).

**Table 4.3** - Metric scoring system with classification status ranges for macroalgae "de-shored" full species list richness, Chlorophyta, Rhodophyta and opportunist proportions and ESG ratios (Wells, 2008).

| **Quality** | **Bad** | **Poor** | **Moderate** | **Good** | **High** |
|---|---|---|---|---|---|
| **EQR** | **[0.0-0.2[** | **[0.2-0.4[** | **[0.4-0.6[** | **[0.6-0.8[** | **[0.8-1.0]** |
| Species richness | [0-5[ | [5-20[ | [20-35[ | [35-55[ | ≥55 |
| Proportion of Rhodophyta | [0-0.15[ | [0.15-0.32[ | [0.32-0.42[ | [0.42-0.47[ | ≥0.47 |
| Proportion of Chlorophyta | [1.0-0.60[ | [0.60-0.40[ | [0.40-0.30[ | [0.30-0.25[ | ≤0.25 |
| Proportion of opportunists | [1.0-0.45[ | [0.45-35[ | [0.35-0.22[ | [0.22-0.15[ | ≤0.15 |
| ESG ratio | [0-0.1[ | [0.1-0.35[ | [0.35-0.5[ | [0.5-0.65[ | ≥0.65 |

**Table 4.4** - Metric scoring system with classification status ranges for macroalgae "de-shored" reduced species list richness, Chlorophyta, Rhodophyta and opportunist proportions and ESG ratios (Wells, 2008).

| **Quality** | **Bad** | **Poor** | **Moderate** | **Good** | **High** |
|---|---|---|---|---|---|
| **EQR** | **[0.0-0.2[** | **[0.2-0.4[** | **[0.4-0.6[** | **[0.6-0.8[** | **[0.8-1.0]** |
| Species richness | [0-5[ | [5-17[ | [17-25[ | [25-35[ | ≥35 |
| Proportion of Rhodophyta | [0-0.15[ | [0.15-0.35[ | [0.35-0.45[ | [0.45-0.55[ | ≥0.55 |
| Proportion of Chlorophyta | [1.0-0.80[ | [0.80-0.30[ | [0.30-0.20[ | [0.20-0.12[ | ≤0.12 |
| Proportion of opportunists | [1.0-0.50[ | [0.50-0.25[ | [0.25-0.15[ | [0.15-0.10[ | ≤0.10 |
| ESG ratio | [0-0.2[ | [0.2-0.7[ | [0.7-0.8[ | [0.8-1.0[ | ≥1.0 |

For the calculation of the partial EQR values for each of the features Wells *et al. (2007)* propose two different types of calculations are required:

- for those features that increase in value with increasing EQR (species richness, proportion of red species and the ESG ratio), the following equation is used:

$$\text{EQR} = \text{Lower EQR c} + \left[\frac{(\text{PV} - \text{Lower PVc})}{\text{PV cw}} \times \text{EQR cw}\right] \text{ (equation 4.1)}$$

- for those features that decrease in value with increasing EQR (proportion of green species, proportion and opportunist species), all of which decrease in value with increasing EQR, the following equation is used:

$$\text{EQR}=\text{Upper EQR c-}\left[\frac{(\text{PV-Lower PVc})}{\text{PV cw}}\times\text{EQR cw}\right] \quad \text{(equation 4.2)}$$

- Where:

EQR – Ecological Quality Ratio
PV – Parameter value
Lower PVc – Lower parameter value of the corresponding class range
PVcw – Parameter value class width of the corresponding class range
EQRcw – EQR class width of the corresponding class range
Lower/Upper EQRc – Lower/Upper value of the EQR in the corresponding class

To help the reader understand the calculation of the EQR value a worked example is given. If on a given shore the features score as follows:

Reduced species list richness – 16; parameter value within the range [5-17[ (i.e. PVcw=12), corresponding to EQR range [0.2-0.4[ (i.e. EQRcw=0.2), see Table 4.4;

Proportion of Rhodophyta – 0.70; parameter value within the range ≥0.47 (i.e. PVcw=0.53), corresponding to EQR range [0.8-1.0[ (i.e. EQRcw=0.2), see Table 4.4;

Proportion of Chlorophyta – 0.15; parameter value within the range [0.20-0.12[ (i.e. PVcw=0.08), corresponding to EQR range [0.6-0.8[ (i.e. EQRcw=0.2), see Table 4.4;

Proportion of opportunists – 0.10; parameter value within the range ≤0.10 (i.e. PVcw=0.1), corresponding to EQR range [0.8-1.0[ (i.e. EQRcw=0.2), see Table 4.4;

ESG ratio – 0.83; parameter value within the range [0.8-1.0[ (i.e. PVcw=0.2), corresponding to EQR range [0.6-0.8[ (i.e. EQRcw=0.2), see Table 4.4;

Using equation 4.1, the partial EQR values would come out as follows:

$$\text{EQR}^{\text{species richness}} = 0.2 + \left[\frac{(16-5)}{12}\times 0.2\right] = 0.38$$

$$EQR^{\text{percentage Rhodophyta}} = 0.8 + \left[\frac{(0.70-0.47)}{0.53} \times 0.2\right] = 0.89$$

$$EQR^{\text{ESGratio}} = 0.6 + \left[\frac{(0.83-0.8)}{0.2} \times 0.2\right] = 0.63$$

Using equation 4.2, the partial EQR values would come out as follows:

$$EQR^{\text{percentage Chlorophyta}} = 0.8 - \left[\frac{(0.15-0.12)}{0.08} \times 0.2\right] = 0{,}73$$

$$EQR^{\text{percentage opportunists}} = 1.0 - \left[\frac{(0.10-0)}{0.10} \times 0.2\right] = 0.8$$

The final EQR value for macroalgae on a single shore would be calculated as follows:

$$EQR = \frac{0.38+0.89+0.63+0.73+0.8}{5} = 0.69$$

Which would correspond to the classification "good", because it falls within the range [0.6-0.8[, (see Table 4.4).

### 4.2.2 CFR tool

For the application of the CFR method proposed by Juanes *et al.* (2008) the following community features were measured on each shore:

- Species richness - R
- Abundance/cover – C
- Opportunistic species - O
- Physiological status - S

#### *4.2.2.1 Species richness*

According to Juanes *et al.* (2008) 'the richness value (R) evaluates the number of "characteristic macroalgae" populations that are present on the surveyed shores with a significant coverage (>1%) according to a previously established list for each biogeographic region'. However, no criteria are set regarding how this list is to be defined and thus the species list used for the application of the CFR method in the present work was the reduced species list mentioned above (see p.97).

#### *4.2.2.2 Abundance/Cover*

In Juanes *et al.* (2008)'s paper 'the cover score (C) assesses the whole extent of the sampling unit, or area of shore, that is occupied by those assemblages considered all together'. However, the present study has been designed to implement the FSL/RSL tool in the Azores, and no quantification procedures had been planned to assess substratum coverage of macroalgae. Nevertheless, several of the shores surveyed qualitatively for the present study had also been surveyed quantitatively at the same time for the definition of biotopes according to the methodologies defined by Wallenstein *et al.* (2010). At three levels on the shore (high-, mid- and low-intertidal), seaweed frequencies were quantified using nine replicate quadrats (0.25x0.25m) with 36 intersections. Ecological categories such as calcareous and non-calcareous turf and foliose green algae have been used for biotope characterization and species falling outside these categories were identified *in situ* whenever possible and otherwise brought to the laboratory for identification. Turfs were assigned a calcareous or non-calcareous nature based on subjective *in situ* judgement of the dominance or not of articulated coralline species within its constituents. Furthermore, a quantitative study on turf constituents has been carried out based on samples collected in Santa Maria, São Miguel and Graciosa (Wallenstein *et al.*, 2009b).

Species abundance data used for the implementation of the CFR tool were those collected for the biotope surveys on 25 shores, 16 from Santa Maria and 9 from Graciosa (Appendix 5, in electronic form on the enclosed CD), where qualitative and biotope surveys took place simultaneously and where turfs were collected for constituent identification and quantification. Subsequently, data on turf abundances were converted into the partial abundances of the corresponding constituents according to Table 4.5. For each shore, total cover was obtained by summing up the partial coverage of all species with more than 1% cover.

#### *4.2.2.3 Opportunistic species*

'The score for opportunistic species (O) is based on the abundance of *Blidingia* spp., *Bryopsis* spp., *Chaetomorpha* spp., *Cladophora* spp., Ectocarpales, *Ulva* spp. (including *Enteromorpha* spp.) and *Ceramium* spp. in relation to the total vegetated surface' (Juanes *et al.*, 2008). According to the authors these species have been included based on studies conducted in northern Spain related with anthropogenic disturbance. In the

present work the abundances of these taxa were summed up and divided by the global cover calculated in the previous section, for each surveyed shore.

#### *4.2.2.4 Physiological status*

'The assessment of the physiological status (S) of macroalgae takes into account an expert estimation about the health of the whole macroalgae community through the combined analysis of different environmental features (reduced development of fronds, low densities, depigmentation, physical damage, level of epiphytism) which might not be related to natural causes' (Juanes *et al.*, 2008). Given the generalized high and/or good quality of Azorean shores (Neto *et al.*, 2009b) and the fact that no abnormal environmental features were noted on any of the surveyed shores, the maximum value was always assigned to this feature.

#### *4.2.2.5 Ecological quality calculation*

The formula used by Juanes *et al.* (2008) to calculate the ecological quality ratio is the arithmetic sum of the specific scores for each indicator at the surveyed site:

$$\mathrm{CFR} = \mathrm{R} + \mathrm{C} + \mathrm{O} + \mathrm{S} \quad \text{(equation 4.3)}$$

Where:

CFR – the shore quality index (known as "Quality of rocky bottoms")
R – Species richness
C – Total Coverage
O – Opportunistic coverage
S – Physiological status

Each indicator contributes differently to the ecological quality of the shore depending on the value of the corresponding feature for exposed intertidal communities (Table 4.6) and shores are classified as bad to high ecological quality according to Table 4.7.

**Table 4.5** – Calcareous and non-calcareous turf constituents and respective average percentages [based on data from Wallenstein *et al.* (2009b)].

| Turf constituents | Calcareous turf | Non-calcareous turf |
|---|---|---|
| *Acrosorium venulosum* | 0.1% | 0.1% |
| *Aglaothamnion* spp. | 0.0% | 0.2% |
| *Amphiroa* spp. | 6.8% | 1.2% |
| *Asparagopsis armata* | 0.1% | 0.0% |
| *Caulacanthus ustulatus* | 0.4% | 0.5% |
| *Centroceras clavulatum* | 1.3% | 1.6% |
| *Ceramium* spp. | 4.0% | 11.9% |
| *Chaetomorpha* spp. | 1.6% | 1.5% |
| *Chondracanthus acicularis* | 2.6% | 1.5% |
| *Chondria* spp. | 5.2% | 2.9% |
| *Cladophora* spp. | 1.5% | 3.1% |
| *Codium adhaerens* | 0.5% | 0.4% |
| *Corallina elongata* | 21.7% | 6.3% |
| *Falkenbergia rufolanosa* | 0.1% | 0.2% |
| *Fucus spiralis* | 0.0% | 0.1% |
| *Gastroclonium* spp. | 0.0% | 0.1% |
| *Gelidium* spp. | 2.3% | 12.1% |
| *Grateloupia* spp. | 0.1% | 0.1% |
| *Gymnogongrus* spp. | 0.1% | 3.7% |
| *Haliptilon* spp. | 20.9% | 5.9% |
| *Halopteris filicina* | 0.4% | 0.6% |
| *Herposiphonia* sp. | 1.7% | 12.4% |
| *Hypnea* spp. | 0.0% | 0.8% |
| *Jania* spp. | 12.1% | 2.1% |
| *Laurencia* spp. | 8.4% | 7.9% |
| *Lomentaria articulata* | 0.1% | 0.3% |
| *Lophosiphonia* spp. | 0.6% | 0.0% |
| *Osmundea* spp. | 0.9% | 2.3% |
| *Polysiphonia* spp. | 1.9% | 7.9% |
| *Pterocladiella capillacea* | 0.4% | 0.0% |
| *Pterosiphonia* spp. | 0.8% | 2.3% |
| *Sphacelaria* spp. | 0.1% | 0.3% |
| *Stypocaulon scoparium* | 2.5% | 5.6% |
| *Symphyocladia marchantioides* | 0.1% | 0.1% |
| *Ulva* spp. | 0.5% | 4.1% |

**Table 4.6** – Quality thresholds for each indicator of the EQR calculation formula and the respective community feature ranges for exposed intertidal communities based on Spanish shores (Juanes *et al.*, 2008).

| **Species Richness** | **R** | **Total cover (%)** | **C** | **Opportunist cover (%)** | **O** | **Unhealthy proportion (%)** | **S** |
|---|---|---|---|---|---|---|---|
| >3 | 15 | ≥50 | 40 | <10 | 30 | <10 | 15 |
| 3 | 11 | [30-50[ | 30 | [10-20[ | 20 | [10-30[ | 11 |
| 2 | 7 | [10-30[ | 20 | [20-30[ | 15 | [30-50[ | 7 |
| 1 | 3 | [5-10[ | 10 | [30-70[ | 5 | [50-80[ | 3 |
| 0 | 0 | <5% | 0 | ≥70 | 0 | ≥80 | 0 |
| | | Unstable substrata | 10 | | | Invase species present | -10 |

**Table 4.7** – Scoring system for ecological quality classification of rocky shores based on Spanish shores (Juanes *et al.*, 2008).

| **CFR values** | **EQR values** | **Status** |
|---|---|---|
| [100-83[ | [1-0.83[ | High |
| [83-61[ | [0.83-0.61[ | Good |
| [61-40[ | [0.61-0.40[ | Moderate |
| [40-19[ | [0.40-0.19[ | Poor |
| [19-0] | [0.19-0] | Bad |

To help the reader understand the calculation of the EQR value a worked example is given. If on a given shore the features score as follows:

Species richness – 16; parameter value within the range >3, corresponding to R score of 15, see Table 4.6;

Total coverage – 27%; parameter value within the range [10-30[, corresponding to C score of 20, see Table 4.6;

Opportunist coverage – 12%; parameter value within the range [10-20[, corresponding to O score of 20, see Table 4.6;

Unhealthy proportion – 0%; parameter value within the range <10, corresponding to S score of 15, see Table 4.6;

The overall CFR value would be calculated as follows:

$$\mathrm{CFR} = 15 + 20 + 20 + 15 = 70$$

Which would correspond to an EQR of 0.7 and thus being assigned the classification "good" because it falls within the range [0.83-0.61[ (see Table 4.7).

### 4.2.3 Comparison of tools

In this thesis the following analyses were performed:

- using the boundaries established for British shores a comparison is made between the EQR values and their corresponding classification of all surveyed Azorean shores achieved with both the full and reduced species lists methods using both the de-shored species richness and the observed species richness.
- based on the subset of data used to apply the CFR method a comparison is also made between the EQR values and their corresponding classification of Azorean shores for which abundance data were available using all three methods.

### 4.2.4 Adaptation suggestion

The results from Chapter 3 regarding differences in the features that are used in the FSL/RSL tool between Azorean and British shores suggest that quality class boundaries used for each feature are adapted to Azorean communities. The FSL and RSL tool with adapted boundaries for the Azores were named FSL-AZ and RSL-AZ, respectively, as a means to distinguish them from the original FSL and RSL tools.

Based on the subset of data used to apply the CFR method a comparison is made between the EQR values and their corresponding classification of Azorean shores achieved with the adapted FSL-AZ and RSL-AZ tools and the CFR method

### 4.2.5 A combined index proposal

Based on the conclusions drawn from the comparison between the FSL-AZ, RSL-AZ and CFR tools an alternative method is proposed. The abbreviation CI was used to name the combined index tool proposed.

## 4.3 RESULTS

### 4.3.1 FSL/RSL tool

#### *4.3.1.1 Full species list*

The mean total number of species per shore is 44, with values varying between 8 and 91, while the "Shore description" varies between 8 and 17, with an average value of 12. Detailed values for "Shore description" scores are shown in Appendix 2 (in electronic form on the enclosed CD) and for species totals per shore in Appendix 6 (in electronic form on the enclosed CD).

*"De-shoring" for the full species list richness*

Fig. 4.1 shows the relationship between "species richness" and "shore description" using data from all shores surveyed in the Azores, displaying a nonlinear relationship between the two variables with a correlation coefficient of approximately 0.2.

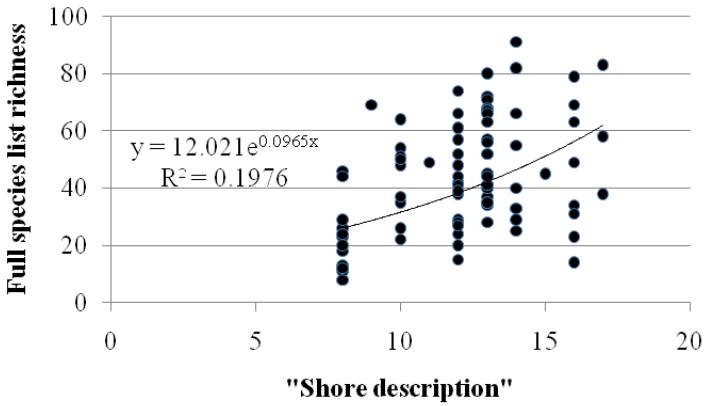


**Fig. 4.1** – Scatter plot for the variables "Shore description" and "Full species list richness", with trendline indicating an exponential relationship ($R^2$=0.1976).

To introduce the species richness correction factor for shore description into the ecological quality metric system, "de-shored species richness" was calculated through the formula of the exponential relationship between the two variables:

$$\text{"De-shored species richness"} = 12.021 \times e^{(0.0965 \times \text{"Shore description"})}$$

(equation 4.4)

"De-shored species richness" values for each "Shore description" score can be consulted in Table 4.8. When "Shore description" is lower than the mean value (12; shaded in Table 4.8) the correction factor is higher than 1 and "de-shored species richness" will be increased, whereas it will be reduced when "Shore description" is higher than the mean value and the correction factor is less than 1. The "de-shored" full species list richness values per shore are shown in Appendix 6 (in electronic form on the enclosed CD).

**Table 4.8** – Shore description scores and corresponding predicted species richness for Azorean shores.

| Shore description | Predicted species richness | Species richness correction factor |
|---|---|---|
| 8 | 26.0 | 1.47 |
| 9 | 28.7 | 1.34 |
| 10 | 31.6 | 1.21 |
| 11 | 34.7 | 1.10 |
| 12 | 38.3 | 1.00 |
| 13 | 42.1 | 0.91 |
| 14 | 46.4 | 0.82 |
| 15 | 51.1 | 0.75 |
| 16 | 56.3 | 0.68 |
| 17 | 62.0 | 0.62 |

#### *4.3.1.2 Reduced species list*

To achieve a reduced species list with a total number of ca. 50 species, the criterion used was the inclusion of those species that were present at least in 30% of the surveyed shores (Table 4.9). Using stricter criteria like 40% or 50% of the surveyed shores significantly reduced the number of species to be included in the reduced species list.

##### *"De-shoring" for the reduced species list richness*

The mean total number of species per shore is 23, with values varying between 4 and 43, while the "Shore description" varies between 8 and 17, with an average value of 12. Detailed values for "Shore description" scores are shown in Appendix 2 (in electronic form on the enclosed CD) and for species totals per shore using the reduced species list in Appendix 7 (in electronic form on the enclosed CD). Fig. 4.2 shows the correlation between reduced species list richness and shore description, displaying a nonlinear relationship between the two variables, using data from all shores surveyed in the Azores.

**Table 4.9** – Reduced species list based on the occurrence at 50%, 40% and 30% of the surveyed sites, together with the respective opportunistic and ESG classification of the species.

| | 50% | 40% | 30% | Opportunist | ESG |
|---|---|---|---|---|---|
| *Acrosorium venulosum* | | | 1 | | 2 |
| *Aglaothamnion* sp. | 1 | 1 | 1 | | 2 |
| *Amphiroa fragilissima* | | | 1 | | 1 |
| *Amphiroa rigida* | | | 1 | | 1 |
| *Asparagopsis armata* | 1 | 1 | 1 | | 1 |
| *Caulacanthus ustulatus* | | | 1 | | 1 |
| *Centroceras clavulatum* | 1 | 1 | 1 | | 2 |
| *Ceramium ciliatum* | 1 | 1 | 1 | | 2 |
| *Ceramium diaphanum* | 1 | 1 | 1 | | 2 |
| *Ceramium virgatum* | | 1 | 1 | | 2 |
| *Chondracanthus acicularis* | 1 | 1 | 1 | | 1 |
| *Chondria dasyphylla* | | 1 | 1 | | 1 |
| *Corallina elongata* | 1 | 1 | 1 | | 1 |
| *Falkenbergia rufolanosa* | | 1 | 1 | | 2 |
| *Gastroclonium reflexum* | | 1 | 1 | | 2 |
| *Gelidium microdon* | 1 | 1 | 1 | | 1 |
| *Gelidium pusillum* | 1 | 1 | 1 | | 1 |
| *Gelidium spinosum* | 1 | 1 | 1 | | 1 |
| *Grateloupia dichotoma* | | 1 | 1 | | 1 |
| *Gymnogongrus crenulatus* | | | 1 | | 1 |
| *Gymnogongrus griffithsiae* | | 1 | 1 | | 1 |
| *Haliptilon virgatum* | | | 1 | | 1 |
| *Herposiphonia secunda* | | | 1 | | 1 |
| *Hypnea musciformis* | 1 | 1 | 1 | | 2 |
| *Jania adhaerens* | | | 1 | | 1 |
| *Jania capillacea* | 1 | 1 | 1 | | 1 |
| *Jania pumila* | | | 1 | | 1 |
| *Jania rubens* | | 1 | 1 | | 1 |
| *Laurencia majuscula* | | | 1 | | 1 |
| *Laurencia minuta* | | | 1 | | 1 |
| *Lomentaria articulata* | 1 | 1 | 1 | | 1 |
| *Lophosiphonia reptabunda* | | 1 | 1 | | 1 |
| *Nemalion helminthoides* | | | 1 | | 2 |
| *Osmundea truncata* | 1 | 1 | 1 | | 1 |
| *Plocamium cartilagineum* | | | 1 | | 2 |
| *Polysiphonia denudata* | | | 1 | | 2 |
| *Pterocladiella capillacea* | 1 | 1 | 1 | | 1 |
| *Symphyocladia marchantioides* | | 1 | 1 | | 1 |
| **Rhodophyta** | **15** | **24** | **38** | | |
| *Fucus spiralis* | | | 1 | | 1 |
| *Halopteris filicina* | | 1 | 1 | | 1 |
| *Nemoderma tingitanum* | | 1 | 1 | | 1 |
| *Padina pavonica* | | | 1 | | 2 |
| *Sphacelaria* sp. | | | 1 | | 1 |
| *Stypocaulon scoparium* | 1 | 1 | 1 | | 1 |

**Table 4.9** – Reduced species list based on the occurrence at 50%, 40% and 30% of the surveyed sites, together with the respective opportunistic and ESG classification of the species.

| | 50% | 40% | 30% | Opportunist | ESG |
|---|---|---|---|---|---|
| **Phaeophyceae** | **2** | **4** | **7** | | |
| *Chaetomorpha pachynema* | 1 | 1 | 1 | 1 | 2 |
| *Cladophora prolifera* | | | 1 | | 2 |
| *Cladophora* sp. | | | 1 | | 2 |
| *Codium adhaerens* | 1 | 1 | 1 | | 1 |
| *Ulva compressa* | | | 1 | 1 | 2 |
| *Ulva intestinalis* | | | 1 | 1 | 2 |
| *Ulva rigida* | 1 | 1 | 1 | 1 | 2 |
| **Chlorophyta** | **3** | **3** | **8** | | |
| **TOTAL** | **20** | **31** | **53** | | |

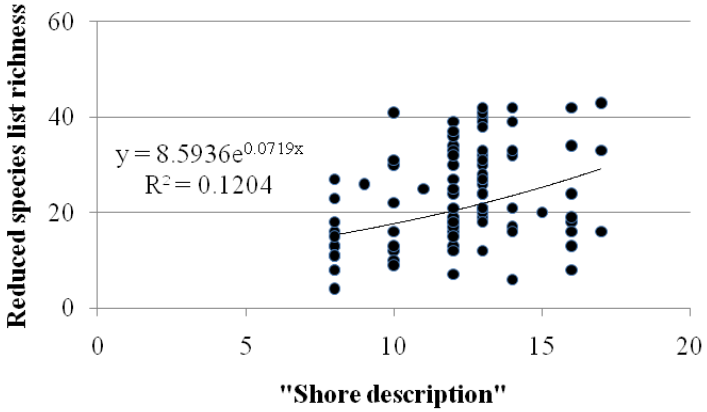


**Fig. 4.2** – Scatter plot for the variables "Shore description" and "Reduced species list richness", with trendline indicating an exponential relationship ($R^2$=0.1204).

To introduce a reduced species list richness correction factor for shore description into the ecological quality metric system, "de-shored reduced species list richness" was calculated through the formula of the exponential relationship between the two variables:

$$\text{"De-shored reduced species list richness"} = 8.5936 \times e^{(0.0719 \times \text{"Shore description"})}$$

(equation 4.5)

"De-shored reduced species list richness" values for each "Shore description" score can be consulted in Table 4.10. When "Shore description" is lower than the mean value (12; shaded in table 4.10) the correction factor is higher than 1 and "de-shored reduced species list richness" will be increased accordingly, whereas it will be reduced when "Shore description" is higher than the mean value and the correction factor is lower than

one. The "de-shored" reduced species list richness values per shore are shown in Appendix 7 (in electronic form on the enclosed CD).

**Table 4.10** – Shore description scores and corresponding predicted reduced species list richness for Azorean shores.

| Shore description | Predicted species richness | Species richness correction factor |
|---|---|---|
| 8 | 17.1 | 1.10 |
| 9 | 17.5 | 1.07 |
| 10 | 17.9 | 1.05 |
| 11 | 18.3 | 1.02 |
| 12 | 18.8 | 1.00 |
| 13 | 19.2 | 0.98 |
| 14 | 19.7 | 0.95 |
| 15 | 20.1 | 0.93 |
| 16 | 20.6 | 0.91 |
| 17 | 21.1 | 0.89 |

#### *4.3.1.3 Proportion of red, green and opportunistic species and ESG ratios*

The species richness, proportions of red, green and opportunistic species and the ESG ratios were calculated based on both the full species list and the reduced species list and are shown in Appendices 6 and 7, respectively.

#### *4.3.1.4 Ecological quality calculation metrics*

The ecological quality ratio and corresponding classification for each shore using the real and de-shored full species list and reduced species lists are shown in Appendices 6 and 7, respectively. Using the de-shored full species list and the boundaries set by Wells (2008; see Table 4.3) out of 88 Azorean shores surveyed 87 were classified as having "good" and 1 shore classified as "high" ecological quality. Using the de-shored reduced species list and the corresponding boundaries (see Table 4.4) the shore previously classified as "high" (a solid bedrock site – site 47) went down to "good", and five previously "good" shores went down to "moderate" although keeping an average EQR very close to the moderate-good boundary (±0.6). Of the latter five shores 3 of them were relatively species-poor pebble sites with low "Shore description" scores and low ESG ratios (sites 2, 7 and 77) and the other 2 were stable bedrock sites with high "Shore description" scores but low ESG ratios (sites 6 and 10).

### 4.3.2 CFR tool

The partial scores for each feature per surveyed site and the resulting EQR values and qualitative classification are shown in Table 4.11. Detailed information on species richness, substratum cover and opportunist cover per site is given in Appendix 8 (in electronic form on the enclosed CD). No shores of the subset used to calculate the CFR index were classified as having a "moderate" ecological quality, while 19 have been classified as "high" and 6 classified as "good".

**Table 4.11** – Partial scores for the calculation of the ecological quality ratio according to the method of Juanes *et al.* (2008) and the resulting shore classification. Information on each site is shown in Appendix 2 (in electronic form on the enclosed CD).

| Site nº. | R | C | O | S | EQR | Classification |
|---|---|---|---|---|---|---|
| 1 | 15 | 30 | 20 | 15 | 0.80 | good |
| 2 | 15 | 40 | 0 | 15 | 0.70 | good |
| 3 | 15 | 40 | 5 | 15 | 0.75 | good |
| 4 | 15 | 40 | 5 | 15 | 0.75 | good |
| 5 | 15 | 30 | 30 | 15 | 0.90 | high |
| 6 | 15 | 40 | 15 | 15 | 0.85 | high |
| 7 | 15 | 50 | 5 | 15 | 0.85 | high |
| 8 | 15 | 40 | 30 | 15 | 1.00 | high |
| 9 | 15 | 40 | 15 | 15 | 0.85 | high |
| 10 | 15 | 40 | 5 | 15 | 0.75 | good |
| 11 | 15 | 50 | 15 | 15 | 0.95 | high |
| 12 | 15 | 40 | 30 | 15 | 1.00 | high |
| 13 | 15 | 50 | 5 | 15 | 0.85 | high |
| 14 | 15 | 40 | 20 | 15 | 0.90 | high |
| 15 | 15 | 40 | 15 | 15 | 0.85 | high |
| 16 | 15 | 40 | 20 | 15 | 0.90 | high |
| 42 | 15 | 40 | 20 | 15 | 0.90 | high |
| 43 | 15 | 50 | 5 | 15 | 0.85 | high |
| 45 | 15 | 40 | 5 | 15 | 0.75 | good |
| 46 | 15 | 40 | 30 | 15 | 1.00 | high |
| 47 | 15 | 40 | 20 | 15 | 0.90 | high |
| 48 | 15 | 40 | 20 | 15 | 0.90 | high |
| 49 | 15 | 40 | 15 | 15 | 0.85 | high |
| 50 | 15 | 40 | 20 | 15 | 0.90 | high |
| 51 | 15 | 40 | 20 | 15 | 0.90 | high |

Additionally, most shores classified as having a good quality present EQR values that are very close to the good-high boundary.

### 4.3.3 Comparison of tools

#### *4.3.3.1 FSL and RSL tools*

In general, the change from a full to a reduced species list and the consequent decrease in species richness also leads to an increase in the ESG ratios and proportions of opportunists, which contribute to the generalized decrease in the average EQR.

Comparing results using "de-shored species richness" *vs.* "observed species richness" for all 88 surveyed shores, the classification of 4 of the most species rich shores changes from "high" to "good" or vice-versa when using the "de-shored" full species list. When using the "de-shored" reduced species list, a single species poor pebble shore goes down from "good" to "moderate" classification. The EQR values for all these shores were very near to the good-high (0.8) and moderate-good (0.6) boundaries, respectively (see Appendices 6 and 7 for detailed information).

Given the fact that all water masses in the Azores are expected to score a high and/or good ecological quality (Neto *et al.*, 2009b), it is surprising to find that "good" was the highest classification achieved by any shore when using the tools implemented in the British Isles, which could mean either that Azorean shores' ecological quality is not as high as predicted, or more likely that the tool needs adjustment to the type of macroalgae communities that are common on Azorean shores. This is more so if one considers that the proportion of red species and the ESG ratios are significantly higher on Azorean shores than on British shores and, although not significant, species richness and the proportions of green and opportunistic algae tend to be lower on Azorean shores (see Chapter 3 of the present thesis). Such evidence leads one to expect a bias in the classification of Azorean shores using the boundaries set for each of these parameters by Wells (2008) for the British Isles. If on one hand Azorean shores will tend to score higher than would be expected regarding the proportions of red, green and opportunistic algae and for the ESG ratio using the British Isles boundaries, on the other hand they will tend to score lower than expected regarding species richness.

#### *4.3.3.2 FSL, RSL and CFR tools*

EQR values come out always lowest when using the RSL tool boundaries and highest when using the CFR tool. On average the EQR values are 20% and 30% higher using the CFR method when compared with the FSL and RSL tools, respectively. As a

consequence, the ecological quality classification of shores based on the reduced species lists is sometimes lower than with either the full species list or with the CFR method (Table 4.12). In general the CFR method tends to assign higher quality classifications to the shores than both other methods as a result of higher EQR values. Of the 25 sites classified according to the 3 methods, 4 are consistently classified as "good", 17 are classified as "good" or "high", 2 are classified as "moderate" or "good" and 2 are classified as "moderate", "good" or "high".

**Table 4.12** – EQR values and classification of 25 shores using the full and reduced de-shored species lists according to Wells (2008) and the CFR method according to Juanes *et al.* (2008).

| | **EQR values** | | | **Classification** | | |
|---|---|---|---|---|---|---|
| **Site nº.** | **FSL** | **RSL** | **CFR** | **FSL** | **RSL** | **CFR** |
| 1 | 0.69 | 0.66 | 0.80 | good | good | good |
| 2 | 0.66 | 0.60 | 0.70 | good | moderate | good |
| 3 | 0.74 | 0.67 | 0.75 | good | good | good |
| 4 | 0.72 | 0.69 | 0.75 | good | good | good |
| 5 | 0.74 | 0.69 | 0.90 | good | good | high |
| 6 | 0.67 | 0.59 | 0.85 | good | moderate | high |
| 7 | 0.71 | 0.56 | 0.85 | good | moderate | high |
| 8 | 0.70 | 0.66 | 1.00 | good | good | high |
| 9 | 0.71 | 0.67 | 0.85 | good | good | high |
| 10 | 0.70 | 0.55 | 0.75 | good | moderate | good |
| 11 | 0.70 | 0.68 | 0.95 | good | good | high |
| 12 | 0.69 | 0.67 | 1.00 | good | good | high |
| 13 | 0.72 | 0.67 | 0.85 | good | good | high |
| 14 | 0.68 | 0.66 | 0.90 | good | good | high |
| 15 | 0.70 | 0.63 | 0.85 | good | good | high |
| 16 | 0.69 | 0.67 | 0.90 | good | good | high |
| 42 | 0.74 | 0.62 | 0.90 | good | good | high |
| 43 | 0.78 | 0.74 | 0.85 | good | good | high |
| 45 | 0.70 | 0.66 | 0.75 | good | good | good |
| 46 | 0.77 | 0.72 | 1.00 | good | good | high |
| 47 | 0.80 | 0.75 | 0.90 | high | good | high |
| 48 | 0.71 | 0.67 | 0.90 | good | good | high |
| 49 | 0.74 | 0.72 | 0.85 | good | good | high |
| 50 | 0.77 | 0.72 | 0.90 | good | good | high |
| 51 | 0.73 | 0.68 | 0.90 | good | good | high |

Despite the differences in the final classification of these shores, the EQR values obtained with the CFR method correlate better with those that result from using the RSL tool than the FSL tool (Table 4.13). The highest correlation between the FSL and RSL tools reflects the fact that the latter is expected to be a surrogate for the former.

**Table 4.13** – Correlation coefficients between the EQR values obtained with the FSL, RSL and CFR methods on 25 Azorean shores.

| | FSL | RSL |
|---|---|---|
| **RSL** | 0.69 | - |
| **CFR** | 0.24 | 0.38 |

### 4.3.4 Adaptation suggestion – FSL-AZ and RSL-AZ tools

To overcome this problem with the application of British classification boundaries with the FSL and RSL tools on Azorean shores, adapted boundaries are proposed (Tables 4.14 and 4.15). The tools with adapted boundaries have been named FSL-AZ and RSL-AZ, respectively.

**Table 4.14** - Metric scoring system with classification status ranges for macroalgae "de-shored" full species list richness, Chlorophyta, Rhodophyta and opportunist proportions and ESG ratios for the Azores **(FSL-AZ)**.

| Quality | Bad to Moderate | Good | High |
|---|---|---|---|
| **EQR** | **[0.0-0.6[** | **[0.6-0.8[** | **[0.8-1.0]** |
| Species richness | [0-33[ | [33-40[ | ≥40 |
| Proportion of Rhodophyta | [0-0.61[ | [0.61-0.67[ | ≥0.67 |
| Proportion of Chlorophyta | [1.0-0.19[ | [0.19-0.14[ | ≤0.14 |
| Proportion of opportunists | [1.0-0.10[ | [0.10-0.06[ | ≤0.06 |
| ESG ratio | [0-1.0[ | [1.0-1.42[ | ≥1.42 |

**Table 4.15** - Metric scoring system with classification status ranges for macroalgae "de-shored" reduced species list richness, Chlorophyta, Rhodophyta and opportunist proportions and ESG ratios for the Azores **(RSL-AZ)**.

| Quality | Bad to Moderate | Good | High |
|---|---|---|---|
| **EQR** | **[0.0-0.6[** | **[0.6-0.8[** | **[0.8-1.0]** |
| Species richness | [0-18[ | [18-21[ | ≥21 |
| Proportion of Rhodophyta | [0-0.59[ | [0.59-0.67[ | ≥0.67 |
| Proportion of Chlorophyta | [1.0-0.20[ | [0.20-0.13[ | ≤0.13 |
| Proportion of opportunists | [1.0-0.13[ | [0.13-0.08[ | ≤0.08 |
| ESG ratio | [0-1.25[ | [1.25-1.7[ | ≥1.7 |

Since there are no Azorean shores with an *a priori* classification of bad to moderate, no boundaries were proposed for these classes. The good-high boundary corresponds to the average value of each parameter for all surveyed shores (see Appendix 9, in electronic form on the enclosed CD), while the moderate-good boundary corresponds to the

average minus the mean standard deviation values of each parameter for all surveyed shores (see Appendix 10, in electronic form on the enclosed CD). Detailed information on the EQR calculations using the FSL-AZ and RSL-AZ is given in Appendices 9 and 10, respectively.

With the proposed adapted boundaries using the full species list tool 10 out of 88 shores were classified as "moderate" (sites 1, 2, 24, 44, 53, 65, 67, 71, 77, 82), while 23 sites were classified as "high" and 55 sites classified as "good" (see Appendix 9, in electronic form on the enclosed CD). Six of the ten sites assigned with moderate quality have pebbles as the dominant shore type and consequently low species richness, while the remaining four are stable bedrock shores. However, most of these have EQR values that are close to the good-moderate boundary (0.6). With the reduced species list and the adapted boundaries 33 sites were classified as "high" and 40 sites classified as "good", while one shore was classified as "poor" (site 2) and 14 shores were classified as "moderate" (sites 1, 3, 6, 7, 10, 15, 16, 18, 24, 44, 53, 67, 71, 77; see Appendix 10, in electronic form on the enclosed CD). None of the analyzed features showed consistently low or high values throughout the sites that were classified as "moderate". The site classified as "poor" is a pebble shore with very low species richness and a low ESG ratio.

#### *4.3.4.1 Comparison of the FSL-AZ and RSL-AZ tools*

There are still inconsistencies between the classifications of the FSL-AZ and RSL-AZ methods, but the correlation between their EQR values is higher than when using the British Isles boundaries (0,83 *vs.* 0,69).

Comparing results using "de-shored species richness" and "observed species richness", when using the "de-shored" full species lists the classification of 6 shores change from "high" to "good", from "good" to "moderate", or vice-versa, while when using the "de-shored" reduced species lists only one shore goes down from "good" to "moderate" classification. The EQR values for all these shores were very near to the good-high (0.8) and moderate-good (0.6) boundaries, respectively (see Appendices 9 and 10 for detailed information).

#### *4.3.4.2 Comparison of the FSL-AZ, RSL-AZ and CFR tools*

As previously with the British boundaries EQR values with the adapted boundaries come out always lowest when using the RSL-AZ tool boundaries and highest when using the CFR tool. On average the EQR values are 16% and 30% higher using the CFR method when compared with the FSL-AZ and RSL-AZ tools, respectively. As a consequence, the ecological quality classification of shores based on the reduced species lists is sometimes lower than with either the full species list or with the CFR method (Table 4.16).

**Table 4.16** – EQR values and classification of 25 shores using the full species and reduced species lists (FSL-AZ and RSL-AZ) and the CFR method according to Juanes *et al.* (2008).

| | **EQR values** | | | **Classification** | | |
|---|---|---|---|---|---|---|
| **Site nº.** | **FSL-AZ** | **RSL-AZ** | **CFR** | **FSL-AZ** | **RSL-AZ** | **CFR** |
| 1 | 0.56 | 0.51 | 0.80 | moderate | moderate | good |
| 2 | 0.55 | 0.38 | 0.70 | moderate | poor | good |
| 3 | 0.82 | 0.60 | 0.75 | high | moderate | good |
| 4 | 0.87 | 0.76 | 0.75 | high | good | good |
| 5 | 0.93 | 0.77 | 0.90 | high | good | high |
| 6 | 0.67 | 0.48 | 0.85 | good | moderate | high |
| 7 | 0.65 | 0.50 | 0.85 | good | moderate | high |
| 8 | 0.74 | 0.69 | 1.00 | good | good | high |
| 9 | 0.88 | 0.84 | 0.85 | high | high | high |
| 10 | 0.75 | 0.57 | 0.75 | good | moderate | good |
| 11 | 0.73 | 0.72 | 0.95 | good | good | high |
| 12 | 0.77 | 0.70 | 1.00 | good | good | high |
| 13 | 0.82 | 0.71 | 0.85 | high | good | high |
| 14 | 0.74 | 0.62 | 0.90 | good | good | high |
| 15 | 0.61 | 0.51 | 0.85 | good | moderate | high |
| 16 | 0.61 | 0.58 | 0.90 | good | moderate | high |
| 42 | 0.69 | 0.65 | 0.90 | good | good | high |
| 43 | 0.75 | 0.67 | 0.85 | good | good | high |
| 45 | 0.86 | 0.86 | 0.75 | high | high | good |
| 46 | 0.89 | 0.91 | 1.00 | high | high | high |
| 47 | 0.83 | 0.78 | 0.90 | high | good | high |
| 48 | 0.67 | 0.75 | 0.90 | good | good | high |
| 49 | 0.87 | 0.87 | 0.85 | high | high | high |
| 50 | 0.92 | 0.83 | 0.90 | high | high | high |
| 51 | 0.79 | 0.79 | 0.90 | good | good | high |

In general the CFR method tends to assign higher quality classifications to the shores than both other methods as a result of higher EQR values. Of the 25 sites classified according to the 3 methods, 4 are consistently classified as “high”, 13 are classified as

"good" or "high", 2 are classified as "moderate" or "good", 5 are classified as "moderate", "good" or "high", and 1 is classified as "poor", "moderate" or "good".

Despite the fact that the CFR and FSL-AZ classifications seem more consistent because nearly all shores are classified as good and/or high, the EQR values using the RSL-AZ and CFR methods correlate to a greater extent than the FSL-AZ and the CFR method (Table 4.17), as also happened when using the British boundaries (Table 4.13). This indicates that the RSL-AZ and the CFR methods are more consistent in the quantitative ranking of shore quality, although the former tends to score lower values. The adapted FSL-AZ and RSL-AZ boundaries proposed in Tables 4.14 and 4.15 lead to a decrease in correlation between the CFR quantitative scoring system and the FSL tool while the correlation with the RSL tool remained fairly constant (Tables 4.13 and 4.17), which indicates a decrease in consistency between the results using these two approaches.

**Table 4.17** – Correlation coefficients between the EQR values obtained with the FSL-AZ, RSL-AZ and CFR methods on 25 shores.

| | **FSL-AZ** | **RSL-AZ** |
|---|---|---|
| **RSL-AZ** | 0.85 | - |
| **CFR** | 0.17 | 0.39 |

### 4.3.5 A combined index proposal

A combination of the British and Spanish models is proposed based on species richness ranges proposed for the RSL-AZ mentioned previously in this chapter, while the global cover and opportunist cover follow the ranges proposed in the CFR method adapted to the calculation system of Wells *et al.* (2007).

#### *4.3.5.1 CI tool*

The features suggested to be included in the combined index are:

- Species richness - R
- Abundance/cover – C
- Opportunistic species cover - O

*Species richness*

Based on the reduced species list as in the RSL-AZ method and applying the "de-shoring" procedures (see p.118).

*Abundance/Cover*

Based on the species that are listed in the RSL relative to the total area on the shore that is covered by macroalgae.

*Opportunistic species cover*

Based on the substratum cover by ESG2 species (see p.98) relative to the total area on the shore that is covered by macroalgae.

*Ecological quality calculation metrics*

The features used in the proposed index and the corresponding value ranges are given in Table 4.18. Species richness ranges follow those proposed for the RSL-AZ mentioned previously in this chapter, while the global cover and opportunist cover follow the ranges proposed in the CFR method adapted to the Wells *et al.* (2007)´s calculation system.

**Table 4.18** - Metric scoring system with classification status ranges for macroalgae "de-shored" reduced species list richness, global cover and opportunistic cover.

| **Quality** | **Bad to Moderate** | **Good** | **High** |
|---|---|---|---|
| **EQR** | **[0.0-0.6[** | **[0.6-0.8[** | **[0.8-1.0]** |
| S – "De-shored" reduced species list richness (see equation 4.5) | [0-18[ | [18-21[ | ≥21 |
| C - Total cover (%) | [0-30[ | [30-50[ | ≥50 |
| O - Opportunist cover (%) | [100-20[ | [20-10[ | ≤10 |

Juanes *et al*. (2008) suggest that these indicators be given different importance, namely 15/100 to species richness, 40/100 to global cover, 30/100 to opportunistic cover and 15/100 to physiological status. Excluding the latter indicator due to its subjectivity, the relative weight given to S, C and O were converted to 15/85, 40/85 and 30/85, respectively, and the average EQR is calculated based on the equation:

$$\mathrm{EQR} = (0.18 \times \mathrm{EQR^S}) + (0.47 \times \mathrm{EQR^C}) + (0.35 \times \mathrm{EQR^O})$$

(equation 4.6)

Where:

EQR – Average ecological quality ratio
$EQR^S$, $EQR^C$, $EQR^O$ – Partial ecological quality ratios based on each of the indicators considered in Table 4.15.

The partial ecological quality ratios based on species richness (S) and total cover (C) are calculated through equation 4.1 as these are features that increase in value with increasing EQR, while the partial ecological quality ratio based on opportunistic cover is calculated through equation 4.2 because it decreases in value with increasing EQR.

Detailed information on the scores of each site for each feature considered in the CI tool and the EQR calculation and respective qualitative classification is given in Appendix 11 (in electronic form on the enclosed CD). Using the proposed combination of these two methods, one shore is classified as "poor" and one as "moderate", while 19 are classified as "good" and 5 as "high" (Table 4.19). The shore classified as "moderate" is a pebble shore with very low species richness even after the "de-shoring" correction factor is applied. Both shores with lower classification are species poor pebble shores.

#### *4.3.5.2 Comparison of the RSL-AZ, CFR and CI tools*

The qualitative classification obtained seems highly divergent as there are only 3 shores with identical classification using the three methods (sites 4, 46 and 50), and 5 sites with a different classification with each method (sites 6, 7, 13, 15 and 16; Table 4.19). Despite these inconsistencies, 16 in a total of 25 sites have been classified as high and/or good according to the three methods. In general the RSL-AZ tool assigns lower classifications than both other methods.

The EQR values obtained with the CI method proposed correlate better with those of the CFR method than with the RSL-AZ ones (Table 4.20), and the resulting classifications are more consistent and in agreement with the previous evaluation of Azorean coastal waters.

**Table 4.19** – EQR values and classification of 25 shores using the Azorean boundaries reduced species lists (RSL-AZ), the CFR method according to Juanes *et al.* (2008) and a combination of both methods (CI).

| | EQR values | | | Classification | | |
|---|---|---|---|---|---|---|
| **Site nº.** | **RSL-AZ** | **CFR** | **CI** | **RSL-AZ** | **CFR** | **CI** |
| 1 | 0.51 | 0.80 | 0.64 | moderate | good | good |
| 2 | 0.38 | 0.70 | 0.38 | poor | good | poor |
| 3 | 0.60 | 0.75 | 0.66 | moderate | good | good |
| 4 | 0.76 | 0.75 | 0.65 | good | good | good |
| 5 | 0.77 | 0.90 | 0.74 | good | high | good |
| 6 | 0.48 | 0.85 | 0.64 | moderate | high | good |
| 7 | 0.50 | 0.85 | 0.66 | moderate | high | good |
| 8 | 0.69 | 1.00 | 0.82 | good | high | high |
| 9 | 0.84 | 0.85 | 0.67 | high | high | good |
| 10 | 0.57 | 0.75 | 0.69 | moderate | good | good |
| 11 | 0.72 | 0.95 | 0.73 | good | high | good |
| 12 | 0.70 | 1.00 | 0.83 | good | high | high |
| 13 | 0.71 | 0.85 | 0.60 | good | high | moderate |
| 14 | 0.62 | 0.90 | 0.71 | good | high | good |
| 15 | 0.51 | 0.85 | 0.69 | moderate | high | good |
| 16 | 0.58 | 0.90 | 0.68 | moderate | high | good |
| 42 | 0.65 | 0.90 | 0.74 | good | high | good |
| 43 | 0.67 | 0.85 | 0.76 | good | high | good |
| 45 | 0.86 | 0.75 | 0.61 | high | good | good |
| 46 | 0.91 | 1.00 | 0.87 | high | high | high |
| 47 | 0.78 | 0.90 | 0.87 | good | high | high |
| 48 | 0.75 | 0.90 | 0.76 | good | high | good |
| 49 | 0.87 | 0.85 | 0.77 | high | high | good |
| 50 | 0.83 | 0.90 | 0.86 | high | high | high |
| 51 | 0.79 | 0.90 | 0.78 | good | high | good |

**Table 4.20** – Correlation coefficients between the EQR values obtained with the RSL-AZ, CFR and CI methods on 25 shores.

| | **RSL-AZ** | **CFR** |
|---|---|---|
| **CFR** | 0.39 | - |
| **CI** | 0.61 | 0.77 |

## 4.4 DISCUSSION

Despite the differences between the tools developed within the scope of the WFD by different authors in different Member States, it is of generalized acceptance that to assess complex systems different aspects must be taken into account and if possible combined, and thus a multimetric approach, considering features such as diversity, richness, opportunistic species and substratum cover is the best option (Patrício *et al.*, 2006; Ballesteros *et al.*, 2007b; Wells *et al.*, 2007; Guinda *et al.*, 2008; Juanes *et al.*, 2008; Teixeira *et al.*, 2010).

Both tools developed for the assessment of ecological quality based on rocky shore macroalgae communities in the northeast Atlantic, the FSL/RSL and the CFR methods, rely on multimetric approaches that include relevant ecological features of seaweed communities.

Species richness is a common feature used in these two methods as an alternative to using species composition. Species composition is highly variable at a local scale due to habitat heterogeneity (Little and Kitching, 1996), sampling error and seasonality (Wells *et al.*, 2007), and also at a wide latitudinal scale due to individual species geographical distribution patterns (Tittley and Neto, 1995), as also evidenced previously in Chapter 2. It is therefore an undesirable measure of ecological change. Furthermore, assessing the full range of species in a given stretch of coast requires great taxonomic expertise and is very time consuming, and thus undesirable from a management perspective. As an alternative means of recording qualitative species data several authors suggest the use of a reduced set of species that are common on shores that have not been affected by human intervention and are therefore considered of high quality (Pinedo *et al.*, 2006; Ballesteros *et al.*, 2007b; Wells *et al.*, 2007; Juanes *et al.*, 2008) to be used as reference conditions. Such an approach requires the involvement of expert knowledge for the definition of the species that are representative of high quality shores and those that are sensitive to pollution, but once the reduced species list is defined field work requires less taxonomic expertise and is less time consuming. Taxonomic expertise requirements might be further reduced by using lower taxonomic resolution in the identification of community components, e.g. using litothamnia for encrusting calcareous red species, or simplifying identification to to genus or family levels (Wells, 2002; Bates *et al.*, 2007; Puente and Juanes, 2008). However, geographical differences in species composition require that the reduced taxa lists are defined for each region separately to cope with the need to intercalibrate methods across a wide geographical area. This was suggested by

Wells *et al*. (2007) in dividing the British Isles data set into three separate regions to cope with geographical differences in species composition around the British Isles. Similarly, Guinda *et al.* (2008) also defined a reduced taxa list for the coast of Cantabria. The RSL and the CFR methods share the same philosophy of using a reduced set of taxa (e.g. species, genus) to be used as a surrogate for the full species list in reference conditions for the region where it is to be implemented. Therefore, applying these methods to Azorean macroalgal communities required the establishment of the reduced species list for this region. Given the biogeographic differences between the regions included in the NEA-GIG it would be desirable that a composite global reduced species list be produced by adding up separate RSLs from the different regions. Northern species are not likely to occur on southern shores and vice-versa and thus having a composite RSL is not likely to interfere with species richness values on any shores where this feature is being measured.

Both the FSL/RSL and the CFR tools suggest that surveys should be limited to stable substrata that favour the attachment of macroalgae to cope with the fact that substratum type influences the number of species that are present on a shore (Wells, 2002). Several of the Azorean shores that were inconsistently classified using the three methods are pebble shores. Although the tools applied to the British Isles and the Spanish coast were specifically designed for stable substrata it has been decided to include these shores in the analyses because both methods presented a way to deal with shores that are naturally species poorer. The two methods differ, however, in the way they incorporate this factor into their metric systems. The "de-shoring" correction of species richness proposed by Wells (2008) seems more reliable in that it is based on a real relationship between the observed species richness and the shore description scoring system, rather than assigning a fixed value to all shores that are less favourable to the attachment of macroalgae as suggested by Juanes *et al.* (2008). Applying the species richness "de-shoring" technique, however, requires a fair amount of data and the bigger the data set used for its calculation, the more reliable it becomes. The correlation between species richness values and shore description scores is fairly low for the Azores dataset which might suggest not using the "de-shoring" procedure and using the observed species richness instead of the "de-shored" one. Nevertheless, using this procedure proved useful in reducing species richness variability within the dataset although leading to a re-classification of shores that have EQR values close to the quality classes' boundaries, either up or down in the scale. This problem arises from the adopted EQR metric system that allows a greater variability within class ranges than between them. Two sites can

have nearly the same EQR value and fall into two different quality classes, while other two sites can have fairly different EQR values and fall into the same quality class. In the British Isles a tool has been devised by statisticians to provide a measure of confidence in the classification of water bodies using the British tools that are based on marine plants (Davey, 2009). It builds on the variability of EQR values within a given dataset and calculates the probabilities of any given EQR value to belong to each of the five quality classes (bad, poor, moderate, good and high). The nearer it is to the boundaries between two classes, the lower is the probability of belonging to the class it has been assigned and the higher is the probability of belonging to the class adjacent to it. Such a tool would be desirable to incorporate in the method proposed for the Azores. However, it requires lower quality shores to provide the statistical model with EQR values within the widest possible spectrum of quality classes. A possible way to simulate such a tool in a simple manner would be to narrow the EQR ranges for each class and leave for expert knowledge to decide on those cases where EQR values would fall between quality classes. Having the "moderate" and "good" quality classes represented by EQR values in the ranges 0.45-0.55 and 0.65-0.75, respectively, would mean that shores with EQR values between 0.55 and 0.65 would require expert knowledge to decide whether they would be assigned "moderate" or "good" quality.

Another feature in common between the tools developed by Wells *et al.* (2007) and Juanes *et al.* (2008) is opportunistic species. However, these tools differ again in the way that this feature is considered. In the FSL/RSL tool by Wells *et al.* (2007) opportunist species are only those considered to potentially constitute a bloom problem on sedimentary shores like the foliose green seaweeds, while in the CFR tool by Juanes *et al.* (2008) this feature includes also taxa that are represented by annual species like filamentous red and brown algae. Green opportunistic macroalgae are commonly known to respond to nutrient enrichment and may be more sensitive to changes in water quality than are other opportunists (Karez *et al.*, 2004). *Enteromorpha*/*Ulva*, *Chaetomorpha* or *Cladophora* are in fact the most usual species to form blooms, however there are species like the red filamentous *Ceramium* spp. and foliose *Porphyra* spp. and the filamentous brown algae *Ectocarpus* spp. that can also reach nuisance proportions (Fletcher, 1980, 1995; Vogt and Schramm, 1991). Nevertheless, macroalgal opportunists may be naturally abundant on rocky shores and represent no anthropogenic interference nor an environmental impact (Wilkinson and Wood, 2003; Petersen *et al.*, 2005; Wells, 2007), and blooms of macroalgae are generally considered to constitute a problem on relatively sheltered, sedimentary shores rather than on hard substrata

(Scanlan *et al.*, 2007). The classification of species as opportunist *vs*. non-opportunist is widely considered as crucial in assessing the impact of coastal water nutrient enrichment (e.g. Arévalo *et al.*, 2007; Krause-Jensen *et al.*, 2007; Scanlan *et al.*, 2007; Wells *et al.*, 2007).

The development of suitable and accurate indices based on macroalgae as pollution indicators requires a consensus about the pollution sensitivity level assigned to each species (Guinda *et al.*, 2008), as also mentioned by Borja *et al.* (2007) for a generalized application of an index for invertebrate fauna of soft sediments, based on the abundance of species in each of five pollution related ecological groups (Borja *et al.*, 2003). Similarly, it would be desirable to have a global seaweed species database with an indication of each species' sensitivity to pollution and nutrient enrichment based on scientific information and with the involvement of the scientific community. The need for a ranking of seaweed species according to their pollution tolerance is mentioned by Wilkinson and Rendall (1985), referring to existing successful ones in freshwater systems.

Although in the FSL/RSL tool Wells *et al.* (2007) suggest that the number of opportunist species as a proportion of the total number of species be used as a measure of community response to nutrient enrichment, most authors propose the use of abundance measures of such species based on evidence that they occur naturally in high ecological quality communities, but outcompete other species in growth under stressful conditions (e.g. Goshorn *et al.*, 1999; Pinedo *et al.*, 2006; Arévalo *et al.*, 2007; Krause-Jensen *et al.*, 2007). Given the highly variable nature of opportunistic species proportion evidenced in Chapter 3 and the fact that where macroalgal blooms are a concern it is the abundance rather than the number of opportunistic species that matters (Scanlan *et al.*, 2007), it seems more sensible to use substratum cover and abundance of representative taxa as set out generically by the WFD. As a matter of fact, most authors that have been working on the application of this Directive using macroalgae to assess ecological quality of coastal waters, have incorporated abundance in the tools developed (Orfanidis *et al.*, 2001; Pinedo *et al.*, 2006; Arévalo *et al.*, 2007; Ballesteros *et al.*, 2007b; Scanlan *et al.*, 2007; Guinda *et al.*, 2008; Juanes *et al.*, 2008; Orlando-Bonaca *et al.*, 2008), with the exception of Wells *et al.* (2007). Instead, the FSL/RSL tool uses other community features, like the relative proportions of red and green species and of late and early successional species, as a means to cope with different environmental stressors' responses of the community.

The changes in proportion of Rhodophyta and Chlorophyta species have been considered to be indicative of anthropogenic influences and shifts in quality status (Giaccone and Catra, 2004; Wells *et al.*, 2007) because large, cartilaginous and relatively hardy Phaeophyta species tend to remain constant in proportion to the total number of species, while small filamentous Rhodophyta species tend to increase with increasing environmental quality and Chlorophyta species tend to increase with decreasing quality status. However, care must be taken when applying such measures to a wide geographical scale, as the proportion of red species increases and the proportion of brown species decreases with latitude (Lüning, 1990; Tittley and Neto, 1995, 2006; Terra *et al.*, 2008), as also evidenced in Chapter 3 of the present thesis. Therefore, scales needed to be adapted in the FSL/RSL tool to reflect the latitudinal variability of these macroalgae community features between British and Azorean shores in order to avoid misclassification.

The use of a classification of seaweeds as late and early successional species, proposed to be used as a ratio between the number of species in each group in the FSL/RSL tool by Wells *et al.* (2007) and Wells (2008) as an alternative to Orfanidis *et al*. (2001)'s method using relative abundances of these groups, has been criticized by Arévalo *et al.* (2007) and Ballesteros *et al.* (2007b) for being an oversimplification of the functional-form model of macroalgae defined by Littler and Littler (1980) that does not distinguish stress-sensitive perennial species. In fact, using an oversimplified classification might overlook community patterns under intermediate pollution conditions, as evidenced in the classification of *Corallina elongata* dominated communities as indicative of good and/or high ecological quality by Orfanidis *et al.* (2001) as opposed to intermediate by Ballesteros *et al.* (2007b). However, using specific ecological classifications of seaweed species in different geographical areas or different impact sources can lead to an unmanageable tool use, and it does not allow any comparison of results between different areas or impacts. Therefore the number of ecological groups used and the assignation of species to each of them, should require consensus within the scientific community (Borja, 2005). The classification proposed by Orfanidis *et al.* (2001) has proven effective for the purpose it has been created for and has been applied in several regions (Panayotidis *et al.*, 2004; Wells *et al.*, 2007; Orlando-Bonaca *et al.*, 2008; Ivesa *et al.*, 2009; Orlando-Bonaca and Lipej, 2009). Therefore, it seems more sensible to focus scientific attention on the assignment of seaweed species to each of the two groups to best reflect their sensitivity to environmental disturbance, rather than having each research team using alternative approaches. However, according to the results from

Chapter 3 of the present thesis, there are great discrepancies in the relative proportions of seaweeds classified according to this system between British and Azorean rocky shore communities, thus requiring also an adaptation of the scales proposed in the FSL/RSL tool for this feature in order to avoid ecological quality misclassification.

Red/green/brown species proportions and the ESG ratios reflect geographically sensitive characteristics of seaweed communities. Using such features to evaluate the ecological quality of seaweed communities over a large geographical area like the NEA-GIG requires therefore an adaptation of the value ranges of such features in order to reflect local patterns. This was the reason why adaptations were proposed to the FSL/RSL tool in the present chapter. In an intercalibration exercise using the features proposed by Wells *et al.* (2007) for the classification of intertidal seaweed communities from the Basque Country (N Spain, Atlantic), Borja and Muxica (2007) also suggested an adaptation of the boundaries between ecological quality classes for that region and the inclusion of global substratum cover into the metrics used to calculate ecological quality. The increased correlation between the results obtained with the CFR method and the adapted FSL-AZ and RSL-AZ methods compared to the original FSL and RSL tool is a clear indication of an increase in consistency between these two tools as result of using more adequate boundaries for the features that vary geographically.

The alternative index proposed in the present chapter is intended to overcome the disadvantages found in the tools applied in the classification of ecological quality using data collected on Azorean shores (Wells *et al.*, 2007; Juanes *et al.*, 2008). Moreover, it is intended to combine those features that have been considered most relevant for the overall objective of such a tool, namely to reflect ecological features of seaweed communities that are responsive to environmental stressors while complying with the guidelines set out by the European Environmental Agency.

Using species richness is consensual between the FSL/RSL and CFR methods, while the comparison between intertidal seaweed communities from the British Isles and the Azores, provided in Chapter 3, showed that species richness does not differ significantly between these two regions, and can therefore be a useful feature for wide geographical application.

Relying on a reduced species list to work as a surrogate for the full species list to assess species richness is also consensual between the RSL and CFR tools. It should require, however, a preceding large scale sampling strategy implemented by taxonomically

experienced scientists to assess the full species list from which to extract the reduced taxa list, as proposed by Bates *et al.* (2007). This has been the case both for the British Isles and the Azorean archipelago, however for the tool developed in northern Spain there is no information on the method used to define the reduced species list.

The way shores' EQR values are ranked is fairly consistent between the RSL-AZ and the CFR methods, which means that both methods value shore quality in a similar way. However, the CFR method produces higher EQR values and consequently inflates classification results. Greater inconsistencies between the two methods arise due to the use of a conversion scale from quantitative to qualitative evaluation of shore. Although different quantitative methods rank ecological quality in a similar way, the conversion to a qualitative scale depends on the establishment of boundaries that aren't always obvious. The lack of severely degraded shores due to anthropogenic interference makes it difficult to establish such boundaries. If one is defining a scale based on biological communities under pristine conditions, the other end of the quality spectrum would be necessary to allow the definition of a reliable quality scale.

Proportions of red and green species and ESG ratios have been excluded from the alternative index here proposed due to their sensitivity to biogeographic characteristics of seaweed communities and the need to have a tool that can be applied over a wide geographical area without adaptation.

The method proposed by Juanes *et al.* (2008) and Guinda *et al.* (2008) recommends the use of seaweed abundance based on scientific evidence regarding the importance of overall substratum cover by macroalgae in relation to environmental disturbance. Although there is no such evidence for Azorean coastal communities, substratum cover has been included in the proposed index to cope with the WFD guidelines to include abundance for the assessment of macroalgae community response to stressful conditions. The method proposed by Wells *et al.* (2007) does not use seaweed abundance based on the grounds that the area covered by macroalgae on rocky shores can vary considerably between highly wave-exposed animal-dominated shores and sheltered algae-dominated shores (Hawkins *et al.*, 1992), and thus substratum cover considered as an inadequate feature to be used. However, if the survey method considers that the overall cover shall be measured as the abundance of species that are part of the RSL relative to the total area covered by seaweeds in a given shore, it will not depend whether it is an animal-dominated or an algae-dominated one. Additionally, if there is scientific evidence that substratum cover by seaweeds is related to exposure,

it should be possible to define such a relationship quantitatively. It would then be possible to define substratum cover variation ranges for different levels of wave exposure, as also proposed by Juanes *et al.* (2008). There are ways to calculate wave exposure based on physical data (e.g. Thomas, 1986) that could be helpful in predicting the wave-exposure of any given shore and indicate which substratum cover ranges to use. It can be further argued that abundance assessment with quadrats is very time consuming. However, using high resolution digital photography can overcome such a problem by allowing the identification of seaweeds to a fairly acceptable taxonomic level (genus, family) that can be helped with specimen identification in the lab, as in various studies on the ecology of coastal communities (e.g. Magorrian and Service, 1998; Ducrotoy and Simpson, 2001; Pech *et al.*, 2004; Álvaro *et al.*, 2008). Furthermore, regarding sampling resolution for biomonitoring studies, Bates *et al.* (2007) suggest the use of lower taxonomic resolution (genus or family levels) for abundance assessment of less conspicuous species with conspicuous ones sampled at species level.

Opportunist cover, rather than the proportion of opportunistic species, was also included in the index here proposed given the importance of such a feature evidenced in scientific literature (see p.45). However, it is here suggested that all early successional species as in the ESG2 sense, whether nuisance opportunists or naturally fast growing species, are included in this category as means to incorporate the rationale behind Orfanidis *et al.* (2001)'s work. A great proportion of substratum covered by annual fast growing species, might be indicative of a community's successional stage caused by natural factors, but can also be indicative of an environmentally disturbed community. Expert knowledge would be necessary to analyze cases of extreme opportunist cover.

The metric system adopted for the calculation of EQR values follows that of Wells (2008) because it builds on a sliding scale rather assigning a fixed value for each feature's range of variation. It is thus expected to produce more reliable EQRs that vary according to the scores of each feature on any shore.

This model apparently works well for Azorean coastal seaweed communities, despite its sensitivity to naturally species poor shores, as it generally classifies shores as having good and/or high ecological quality, which is what is expected from previous evaluations (Neto *et al.*, 2009b). Additionally, the EQR values obtained with the proposed index correlate fairly well with the RSL-AZ and the CFR method also indicating consistency between the methods. However, it needs to be tested in other

geographical areas where other methods have been implemented to compare results, namely in the British Isles and in northern Spain. It would also be beneficial to have a wider geographical application of this method, namely in other Macaronesian archipelagos and in mainland Portugal, to spread the area covered by ecological quality assessment surveys. It is also crucial that this method is tested under several pollution conditions as recommended by Guinda *et al.* (2008) to verify its applicability to impacted shores other than by nutrient enrichment. The calibration of this method is quite difficult in the Azores where pollution is nearly absent and its possible impacts diluted by the effect of strong wave action. Such a scenario forces one to work only with the top end of the quality scale, without the bottom end to calibrate its boundaries and validate its applicability.

The nearest scenario in the Azores where coastal communities are subject to environmental conditions that could be compared to coastal pollution are those where shallow water hydrothermal activity leads to increased temperature, acidity and heavy metal concentration within enclosed bays. Such is the case of Ferraria (site 24) that has been repeatedly classified as having "moderate" quality with the FSL/RSL method, although not being a naturally poor shore type.

# CHAPTER 5

## POLLUTED SHORES IN THE AZORES

# 5. POLLUTED SHORES IN THE AZORES

## 5.1 INTRODUCTION

Although there is no significant industry in the Azores, its expanding tourism has led to strong urban development in the last 20 years, thus increasing the potential sources of sea water contaminants (e.g. marinas, commercial harbours and sewage discharges, frequently untreated) and disposal of waste materials such as plastic and glass, that can have some impact on coastal communities. In the less urbanized areas there is intensive agricultural exploitation of soils and pasture for cattle dominates the rural landscape. This depends strongly on the use of fertilizers and pesticides, which in turn contribute to the input of metals and inorganic nutrients into the sea water during the rainy seasons (Depledge *et al.*, 1992; Cunha *et al.*, 2008).

A further contribution to metal enrichment of coastal waters in the Azores is the presence of active hydrothermal vents near the coast at shallow water as a result of their volcanic nature. They provide extraordinary scenarios of increased temperature and acidity associated with high concentrations of metals that arise from discharges of sulphides (Von Damm, 1990), that are not common around the Globe. Information on macroalgae communities occurring on such specific environments provide therefore a valuable tool for future research, not only to compare with sites that are artificially enriched with heavy metals or nutrients (polluted), but also to assess the impact of increased temperature and acidity on such communities. Several indicators of ecosystem health can be used to assess the effects of naturally or artificially enriched waters on biotic communities, namely productivity, species diversity, abundance and composition, and the bioaccumulation of contaminants (Elliott and Cutts, 2004). São Miguel Island thus provides privileged natural laboratories for studies on heavy metal enriched environments with increased acidity and temperature.

The present chapter is divided into five sections that describe a sequence of approaches to a better understanding of shores affected by shallow water hydrothermal activity. The first section is a description of the habitat and its associated intertidal seaweed communities on two rocky shores that are subject to shallow water hydrothermal activity. The second section deals with the quantification of metals in intertidal seaweeds occurring on rocky shores with and without the influence of shallow water hydrothermal activity and in the proximity of urban and rural areas. This section was

planned to assess whether proximity to organic and/or chemical inputs, either of natural or anthropogenic origin, leads to increased accumulation of metals in the tissues of intertidal seaweeds on Azorean shores. In the third section an experimental approach is presented where *F. spiralis* is transplanted to a shore with hydrothermal activity and its metal accumulation levels are measured. The fourth section follows the previous one, and provides a comparison of the concentrations of metals in samples of *F. spiralis* from acid mining drainage affected sites in the British Isles with those exposed to shallow water hydrothermal activity in the Azores. The fifth section describes a pilot study with cultured *F. spiralis* in the laboratory under different temperature and pH conditions, which has been implemented to provide preliminary insights on the factors that affect metal accumulation in acidic, metal enriched environments.

## 5.2 CHARACTERIZATION OF TWO SITES WITH SHALLOW WATER HYDROTHERMAL ACTIVITY

### 5.2.1 Introduction

The shores chosen for this purpose were Ferraria and Porto Formoso (Fig. 5.1). Ferraria is located on the westernmost coast of São Miguel island while Porto Formoso is situated on the north coast.

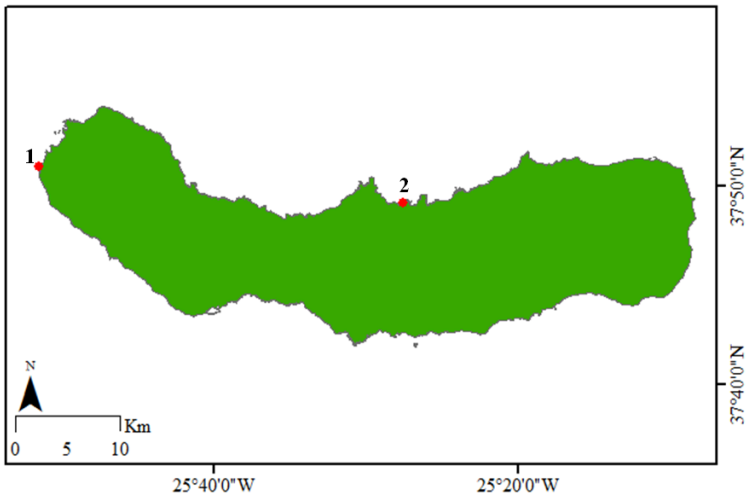


**Fig. 5.1**. Map of São Miguel Island with indication of two shores that are subject to shallow water hydrothermal activity: 1) Ferraria; and 2) Porto Formoso (for UTM coordinates please see Appendix 2, sites 24 and 23 respectively, in electronic form on the enclosed CD).

Ferraria was chosen to integrate the surveys for the comparison between Azorean and British shores (Chapter 3) and for the assessment of ecological quality using seaweeds in the Azores (Chapter 4), because seaweed assemblages that occur there look quite different from most rocky shores around this island. To what extent could shallow water hydrothermal activity, known to exist in that particular stretch of shore, affect the intertidal seaweed communities, and how would this reflect in terms of its ecological quality classification? It turned out that ecological quality was rated “moderate” and a closer look was necessary. Accessible rocky shores subject to shallow water hydrothermal activity are not easily found around the island, and a site for comparison with Ferraria was desirable. Although of difficult access from land, Porto Formoso figured as the only option available with striking differences in terms of dominant substratum and wave exposure when compared to Ferraria. Nevertheless, it was decided to characterize both shores for comparison, keeping in mind their basic structural disparity but further work on hydrothermally active shores, described in the subsequent

sections of this chapter, have been developed only at Ferraria, due to its accessibility and the nature of dominant substratum.

### 5.2.2 Ferraria

#### *5.2.2.1 General description*

Ferraria is bathing area in São Miguel Island, attractive to tourists due to its warm sea water temperature at low tide. It is easily accessible by land and consists of a semi-enclosed bay with an approximate surface area of 300m$^2$ and maximum depth of approximately 3-4m. The bay opens to the ocean through a south facing 3m wide and 2m deep aperture (Figs 5.2 and 5.3). On the eastern side of the embayment, close to land, the shore is made of basalt boulders (approximately 30m in length) that were placed there by the local authorities. On the opposite side of the bay, close to the ocean, the shore consists of a vertical solid bedrock wall (also approximately 30m in length). Ferraria is fairly sheltered from wave action given its south facing nature and the dominance of northern wave exposure throughout the archipelago.

#### *5.2.2.2 Seaweed communities*

At the time Ferraria was surveyed slight differences were observed between the seaweed assemblages on each side of the bay, namely on the boulders and on the vertical bedrock wall. Furthermore, on both sides of the bay it looked like there was a gradient in the proportions of different morphological groups of seaweeds as one moved further away from the "clean" water entrance towards the back of the bay (see Fig. 5.2). Therefore, sampling was carried out on four sections of the shore, of approximately 5m in length, on each side of the bay to check for differences in seaweed assemblages along a possible dilution gradient from the innermost part of the bay to the outermost (see Fig. 5.2). Sampling was done according to the methods described for Chapters 2 and 3 of this thesis. Detailed species lists for each stretch of shore are shown in Appendix 12 (in electronic form on the enclosed CD) and seaweed community features, as described in Chapters 3 and 4 of this thesis, are summarized in Table 5.1.

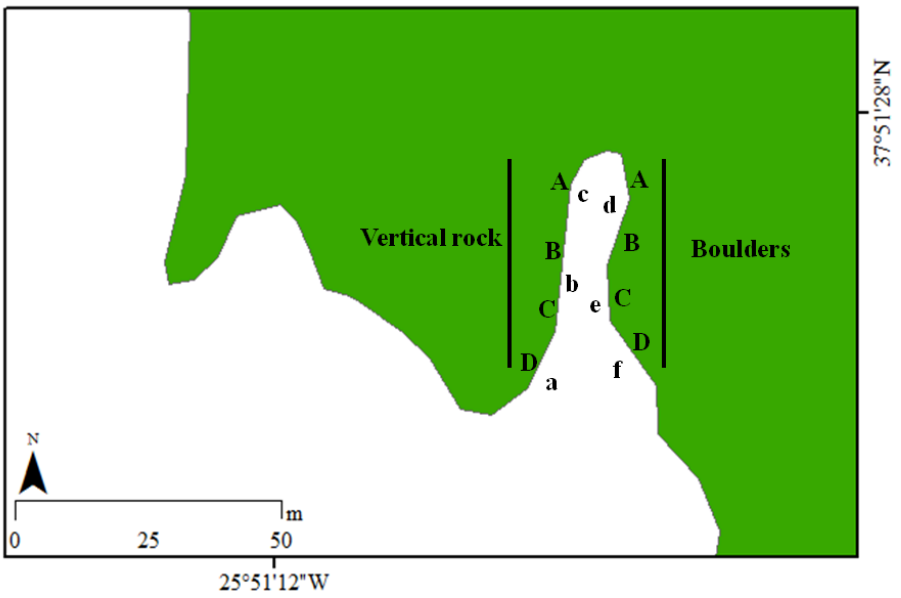


**Fig. 5.2** – Detail map of Ferraria's bathing area with indication of: 1) zones for seaweed characterization (A-D); and 2) points of measurement for water temperature, pH, salinity and dissolved oxygen (a-f). The area around A, c and d is where hydrothermal seeapage is most intensely felt.

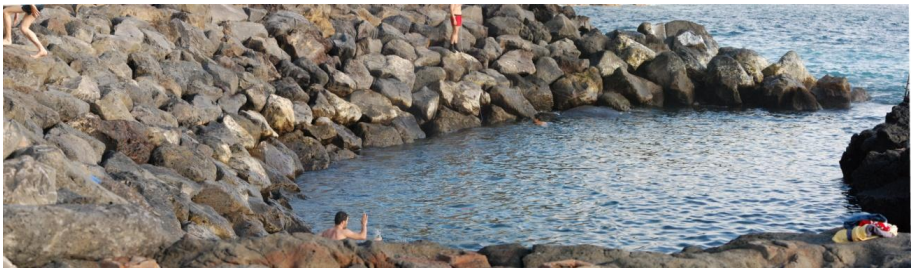

**Fig. 5.3** – Image of Ferraria's bathing area focusing on the basalt boulder side.

The bay of Ferraria is considerably species poor relative to the average species richness in the Azores (see Chapter 3), given the dominant substratum types boulders and bedrock. The average species richness does not differ between the boulder and the bedrock sides (14 and 15, respectively). However, the boulder side has on average a higher proportion of green (0.41) and brown species (0.26) and a lower proportion of red species (0.33) compared to the bedrock wall (0.24, 0.16 and 0.60, respectively. The average ESG ratio is also substantially lower for the boulder side (0.26) indicating a much smaller proportion of late successional species than for the bedrock wall (0.75). In terms of functional group composition, the boulder side shows on average higher proportions of thin foliose (FG2) and filamentous species (FG3 and FG4) and lower proportions of coarsely branched corticated species than the bedrock wall.

**Table 5.1** – Seaweed community features (species richness, proportions of Rhodophyta, Chlorophyta and Phaeophyceae, ESG ratio, functional group composition, EQR values and ecological quality classification) for 8 sections of shore within the bay of Ferraria (legend according to Fig. 5.2).

| | Boulders | | | | Vertical Rock | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **D** | **C** | **B** | **A** | **A** | **B** | **C** | **D** | **Average** |
| Species richness | 14 | 16 | 16 | 9 | 11 | 11 | 18 | 19 | 14.3 |
| Proportions: | | | | | | | | | |
| Rhodophyta | 0.36 | 0.38 | 0.38 | 0.22 | 0.45 | 0.64 | 0.61 | 0.68 | 0.46 |
| Chlorophyta | 0.29 | 0.31 | 0.38 | 0.67 | 0.36 | 0.18 | 0.22 | 0.21 | 0.33 |
| Phaeophyceae | 0.36 | 0.31 | 0.25 | 0.11 | 0.18 | 0.18 | 0.17 | 0.11 | 0.21 |
| ESG ratio | 0.27 | 0.14 | 0.33 | 0.29 | 0.57 | 0.83 | 1.00 | 0.58 | 0.50 |
| Proportions: | | | | | | | | | |
| FG1 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| FG2 | 0.29 | 0.31 | 0.38 | 0.33 | 0.27 | 0.27 | 0.28 | 0.32 | 0.31 |
| FG3 | 0.36 | 0.25 | 0.19 | 0.44 | 0.36 | 0.18 | 0.22 | 0.16 | 0.27 |
| FG4 | 0.07 | 0.19 | 0.13 | 0.11 | 0.09 | 0.09 | 0.06 | 0.05 | 0.10 |
| FG5 | 0.29 | 0.19 | 0.25 | 0.11 | 0.27 | 0.45 | 0.44 | 0.47 | 0.31 |
| FG6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| FG7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| FG8 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| EQR | 0.38 | 0.39 | 0.39 | 0.26 | 0.40 | 0.53 | 0.54 | 0.54 | 0.43 |
| Classification | poor | poor | poor | poor | mod. | mod. | mod. | mod. | mod. |

Regarding a gradient from the outermost to the innermost zone of Ferraria bay, species richness and the proportion of red species tend to decrease, while the proportion of green species tends to increase. On the boulder side there is also a decreasing trend in the proportion of brown species, which is not evident on the bedrock wall side. Regarding functional group composition, the proportion of filamentous species tends to be highest and the proportion of coarsely branched corticated species lowest at the innermost sections on both sides of the bay. The EQR values score lowest at the innermost sections on both sides of the bay, and are lower on the boulders side than those of the vertical bedrock wall side. Consequently so is the qualitative classification.

#### *5.2.2.3 Sea water*

For the characterization of sea water temperature, acidity and salinity within the bay a multi-parameter water quality meter (HI 9828, Hannah Instruments, USA) was used. Measurements were taken hourly over a period of 12h to cover a whole tidal cycle in spring and winter. In 18 June 2008 measurements were made at six points around the bay (points a-f; Fig. 5.2), and in 12 November 2008 at four points around the bay

(points a,c,d and f; Fig. 5.2). Temperature, pH and salinity variation within a 12h period in late spring and in winter 2008 are displayed in Fig. 5.4, together with the tidal height for the same day.

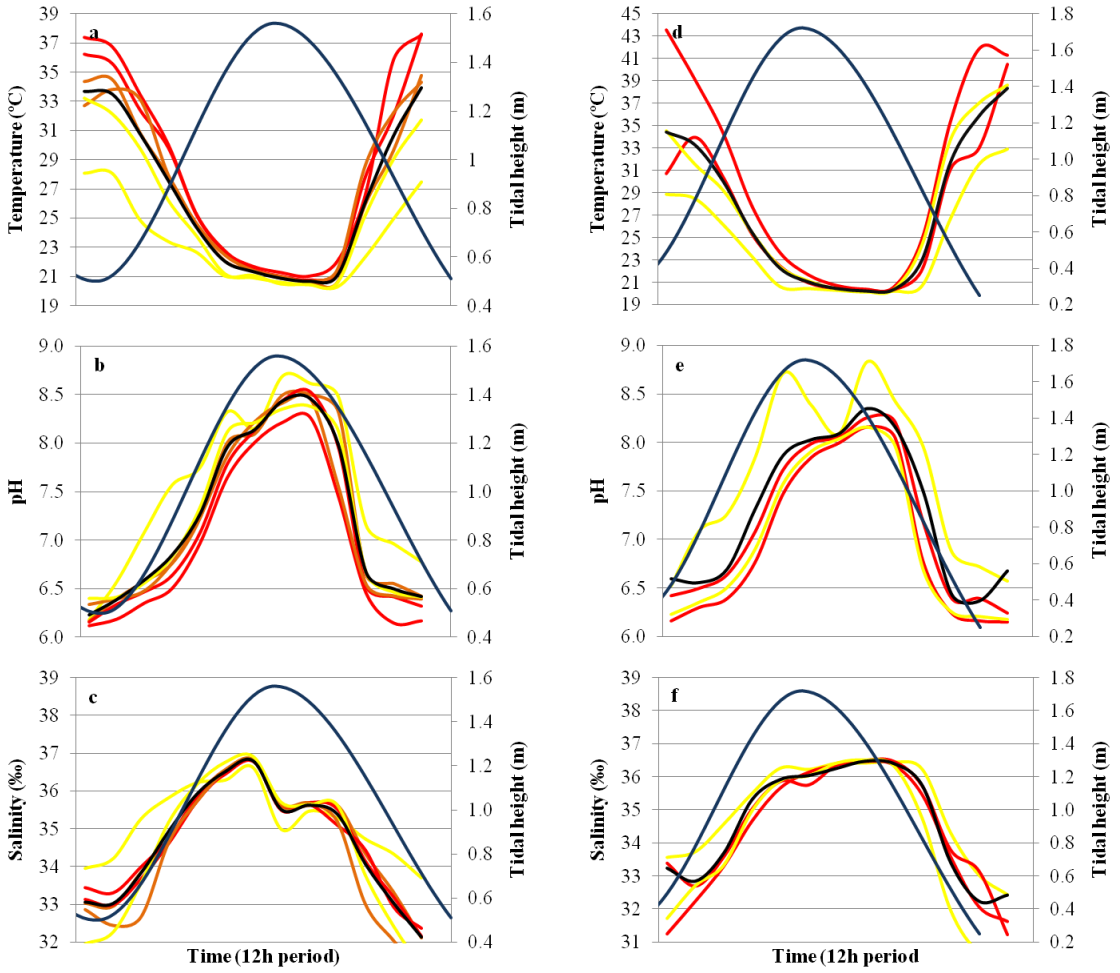


**Fig. 5.4** – Temperature (a, d), acidity (b, e) and salinity (c, f) within the bay of Ferraria over a 12h period in 18 June 2008 and 12 November 2008, respectively. Red lines correspond to the points nearest to the opening of Ferraria bay (points a and f, Fig. 5.2), orange lines correspond to the intermediate distance from the opening (points b and e, Fig. 5.2), yellow lines correspond to the points furthest away from the opening (points c and d, Fig. 5.2), the grey line corresponds to the average value and the blue line corresponds to the tidal height.

Fig. 5.4 shows that the influence of hydrothermal water becomes gretater as the tide goes out. On average there is an increase in temperature of ca. 13ºC in spring and 23ºC in winter, and a decrease of ca. two units in pH and 4 psu in salinity both in spring and winter. The greater temperature variation in the winter survey is probably related to the substantially lower water level compared to that in spring (0.25 in November *vs.* 0.50 in June). With the tide coming in (ascending part of the blue lines in Fig. 5.4) all parameter values go back to approximately "normal" sea water levels. Proximity to "clean" water input at the opening of the bay reduces the impact on temperature increase and pH decrease. This is evidenced by the greater temperature increase and pH decrease

associated with the yellow lines, compared to the orange and to the red ones. This effect, however, is not evident in terms of salinity.

### 5.2.3 Porto Formoso

#### *5.2.3.1 General description*

Hydrothermal activity can be observed at low tide along a stretch of shore of approximately 50m in Porto Formoso. The site is located in a large open bay facing north, the most wave exposed quadrant of the island throughout the year. Its access by land is difficult due to landslides that obstructed an abandoned trail that led to a disused spa resort on the cliff above it. On top of the shore there is a concrete tank that retains freshwater from hydrothermal springs. This hydrothermal input overflows and runs down the rocky shore beneath it (Fig. 5.5), which consists mainly of pebbles and small/medium boulders, although larger boulders occur off-shore (Fig. 5.6). Hydrothermal hot springs of bubbling water can also be found along the shore among the pebbles at low tide, mainly on the eastern side of this stretch of shore.

#### *5.2.3.2 Seaweed communities*

Unlike Ferraria, the shore in Porto Formoso looks rather uniform in terms of seaweed communities. This is no surprise given the uniformity in dominant substratum type and wave exposure along the shore. However, hydrothermal activity seems more intense on the easternmost end of the bay. Therefore, sampling was carried out on three 5m sections of the shore to account for differences in seaweed assemblages along a possible hydrothermal intensity gradient from east to west (see Fig. 5.5). Sampling was done according to the methods described for Chapters 2 and 3 of this thesis. Detailed species lists for each stretch of shore are shown in Appendix 12 (in electronic form on the enclosed CD) and seaweed community features, as described in Chapters 3 and 4 of this thesis, are summarized in Table 5.2.

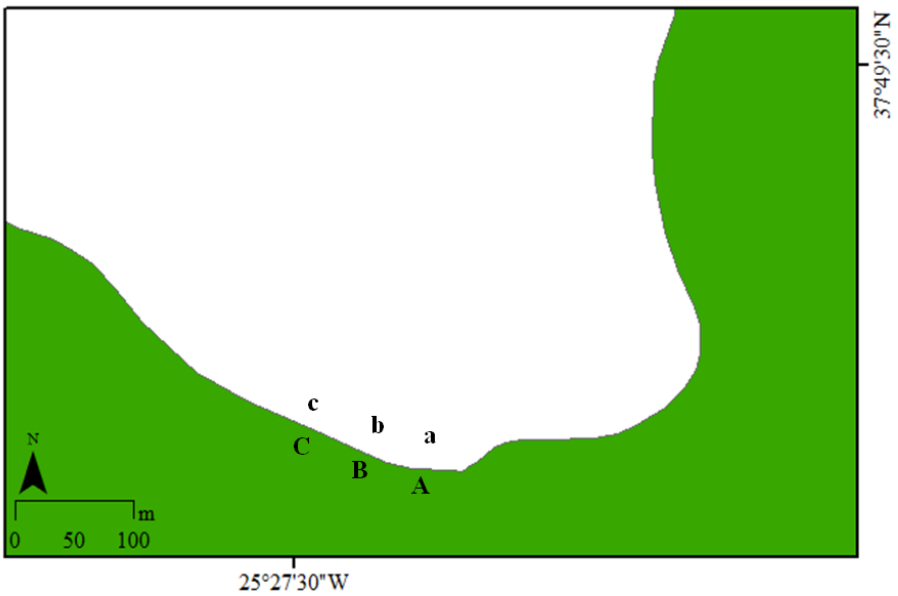


**Fig. 5.5** – Detail map of Porto Formoso's shore with indication of: 1) zones for seaweed characterization (A-C); and 2) points of measurement for water temperature, pH, salinity and dissolved oxygen (a-c).

**Fig. 5.6** – Image of the shore at Porto Formoso.

This shore is relatively species poor compared to the average value for Azorean shores (see Chapter 3), which is not surprising for this type of dominant substratum – pebbles/small boulders). There seems to be no pattern in terms of the features analyzed tor each section of shore in Porto Formoso. In terms of R/B/G proportions there is a greater similarity between sections B and C. However, section B is associated with a much lower ESG ratio (i.e. greater proportion of early successional species) and a

higher proportion of filamentous species (FG3 and FG4) than sections A and C. Although the qualitative classification ("good") is the same for all sections, the EQR value for section B is on the moderate-good boundary.

#### *5.2.3.3 Sea water*

For the characterization of sea water temperature, acidity and salinity along this stretch of shore the same multi-parameter water quality meter (HI 9828, Hannah Instruments, USA) was used. Measurements were taken hourly over a period of 12h to cover a whole tidal cycle only in spring due to increased access difficulty in winter. Measurements were taken in 8 July 2008 at three points along the shore (points a-c; Fig. 5.5). Temperature, pH and salinity variation within a 12h period in the summer of 2008 are displayed in Fig. 5.7 together with the tidal height for the same day.

**Table 5.2** – Seaweed community features (species richness, proportions of Rhodophyta, Chlorophyta and Phaeophyceae, ESG ratio, functional group composition, EQR values and ecological quality classification) at 3 sections of shore in Porto Formoso (legend according to Fig. 5.3).

| | **C** | **B** | **A** | **Average** |
|---|---|---|---|---|
| Species richness | 10 | 18 | 19 | 15.7 |
| Proportions: | | | | |
| Rhodophyta | 0.60 | 0.61 | 0.53 | 0.58 |
| Chlorophyta | 0.20 | 0.17 | 0.21 | 0.19 |
| Phaeophyceae | 0.20 | 0.22 | 0.26 | 0.23 |
| | | | | |
| ESG ratio | 1.50 | 0.80 | 2.80 | 1.70 |
| Proportions: | | | | |
| FG1 | 0.00 | 0.00 | 0.00 | 0.00 |
| FG2 | 0.10 | 0.06 | 0.05 | 0.07 |
| FG3 | 0.00 | 0.22 | 0.05 | 0.09 |
| FG4 | 0.40 | 0.39 | 0.26 | 0.35 |
| FG5 | 0.40 | 0.22 | 0.47 | 0.37 |
| FG6 | 0.10 | 0.06 | 0.11 | 0.09 |
| FG7 | 0.00 | 0.00 | 0.00 | 0.00 |
| FG8 | 0.00 | 0.06 | 0.05 | 0.04 |
| EQR | 0.64 | 0.60 | 0.70 | 0.65 |
| Classification | good | good | good | good |

As in Ferraria, the influence of hydrothermal water becomes obvious as the tide goes out, however with less magnitude than in Ferraria. The average increase in temperature is of ca. 3ºC, and the decrease in pH of 1 point and in salinity of 3 psu. With the tide

coming in (ascending part of the blue lines in Fig 5.8) all parameter values go back to approximately "normal" sea water levels in all three measuring points. Although it was expected to find greater hydrothermal activity at the eastern end of this site (point a), the intermediate point (b) showed the greatest variation in temperature, acidity and salinity, which indicate a greater impact of the hydrothermal input.

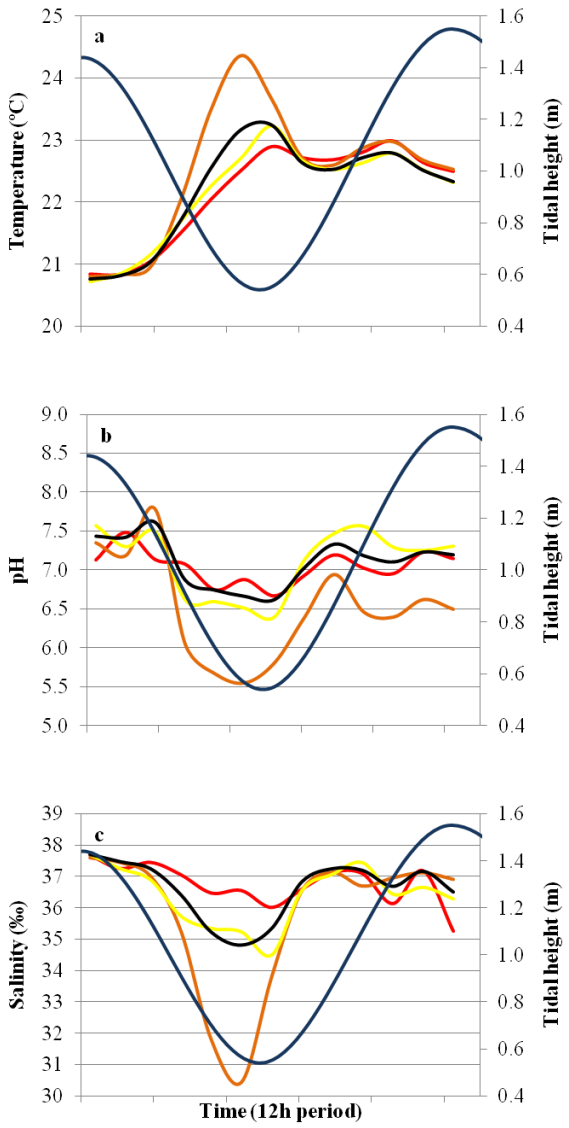


**Fig 5.7** – Average temperature, acidity and salinity at Porto Formoso over a 12h period in 8 July 2008. The red lines correspond to easternmost points (a), the yellow lines correspond to the westernmost point (c), the grey lines correspond to the average value and the blue lines correspond to the tidal height.

### 5.2.4 Discussion - Hydrothermal sites

Despite the differences in shore aspect, dominant substratum and wave exposure between Ferraria and Porto Formoso, there is a significant impact on sea water temperature, acidity and salinity at both sites caused by the input of hydrothermal water. The increase in temperature and acidity and the decrease in salinity are indicative of an input of hot and acidic freshwater. Furthermore, at both sites there is evidence that the effect of hydrothermal water is subject to dissipation with distance from its source, tidal height and wave exposure. All these factors imply an increasing mixture of hydrothermal water and sea water, and a consequent dilution of the hydrothermal inputs.

In terms of seaweed communities, the innermost part of Ferraria bay (zone A; see Fig. 5.2) and the middle zone of the shore in Porto Formoso (section B; see Fig. 5.5) share three features in common: 1) a higher proportion of early successional species (low ESG ratios); 2) higher proportions of filamentous species (FG3 and FG4); and 3) lower EQR values, when compared with the adjacent areas. The impact of the hydrothermal input is also greater in sea water surrounding these sections of shore due to their proximity to its source. It is therefore possible to establish a probable causal relationship between shallow water hydrothermal activity and the type of seaweed communities that occur on a shore that is affected by it. On rocky shores severely affected by shallow water hydrothermal activity, seaweed communities tend to be less species rich and have a disproportionally large number of early successional species compared to a normal rocky shore. When applying a tool such as the FSL/RSL (Wells *et al.*, 2007; and Chapter 4 of this thesis) for the classification of ecological quality, a community with such features will score a low ecological quality ratio and consequently get a bad classification for a reason that is perfectly natural.

## 5.3 BASELINE METAL CONCENTRATIONS IN MARINE ALGAE FROM SÃO MIGUEL (AZORES).

### 5.3.1 Introduction

Algae are one of the most suitable organisms for the study of heavy metal contamination in aquatic ecosystems. They have often been used as bioindicators for metal pollution in sea water because of their sessile nature, longevity, metal accumulation capacity and presence at sites prone to pollution (Abdallah *et al.*, 2005; Mohamed and Khaled, 2005; Misheer *et al.*, 2006; Chaudhuri *et al.*, 2007). Seaweeds are primary producers of coastal waters that accumulate chemicals that are further transferred along the trophic chain by herbivores and detritivores (Agadi *et al.*, 1978). The accumulation of metals in macroalgae results mainly from passive chemical processes and can occur either within the apparent free space between cells (rapid physico-chemical reversible process of uptake on the external surface), or inside cellular compartments (Volterra and Conti, 2000). Consequently different algae exhibit different affinities towards different metals, which in turn depend on the chemical structure of the biosorbent part of the plant (Riget *et al.*, 1997; Volterra and Conti, 2000; Stengel *et al.*, 2004; Abdallah *et al.*, 2005; Mohamed and Khaled, 2005). Since the concentration of metals in algal tissues is proportional to their concentration in the environment, they are important bioindicators of the environmental exposure to those elements thus useful as test organisms for marine pollution studies (Fletcher, 1991). Although there have been other studies on the availability of trace metals in hydrothermal environments (Weeks *et al.*, 1995; Amaral *et al.*, 2006; Zaldibar *et al.*, 2006; Amaral *et al.*, 2007; Cunha *et al.*, 2008) intertidal macroalgae communities haven't been the main object of study.

The aim of the study described in this section (Wallenstein *et al.*, 2009a) is to provide baseline concentration levels of a selected pool of chemical elements for intertidal algae that occur abundantly on rocky shores around São Miguel Island (Azores), and compare results from samples collected at sites in the vicinity of urban development and of shallow water hydrothermal activity with samples collected away from this influence.

### 5.3.2 Methods

#### *5.3.2.1 Sampling sites*

Sampling stations were selected to represent three different ecological conditions: (i) non-urban - away from major urban development; (ii) urban – next to major urban development; and (iii) hydrothermal – adjacent to shallow water hydrothermal activity (Table 5.3; Fig. 5.8). As mentioned in the previous section of this chapter, within the semi-enclosed bay of Ferraria there are no seaweeds large enough and easily available for collection in large quantities. Therefore samples were collected from a bedrock platform that lies immediately outside the mouth of Ferraria bay. It is a species rich wave-exposed wide bedrock platform with rock-pools facing west, open to the Atlantic and therefore called Ferraria-OS. In Porto Formoso there were also problems in finding seaweeds large enough and easily available for collection in large quantities, given the dominant substratum type (see section one of the present chapter). Therefore samples had to be collected from large boulders that emerge at low tide approximately at 10m away from the shore. In both cases, the hydrothermal effect might be diluted since seaweeds were collected at some distance from the input of hydrothermal water, which needs to be taken into account when analyzing the results.

**Table 5.3** - Seaweed species selected for metal analysis from each sampling site (+, present; -, absent) on São Miguel island and their respective ecological condition. *The sampling area at Ferraria-OS is located outside the bay, where hydrothermal activity is less intense.

| **Nature of location** | **Non-urban** | | **Urban** | | **Hydrothermal** | |
|---|---|---|---|---|---|---|
| **Sampling site** | Santo António | Feteiras | Ponta Delgada | Lagoa | Ferraria-OS* | Porto Formoso |
| *Corallina elongata* | + | + | + | + | + | + |
| *Gelidium microdon* | + | + | + | + | + | - |
| *Osmundea truncata* | - | + | - | + | + | - |
| *Porphyra* sp. | + | + | - | + | + | - |
| *Cystoseira humilis* | - | + | + | + | + | - |
| *Fucus spiralis* | + | + | + | + | + | - |

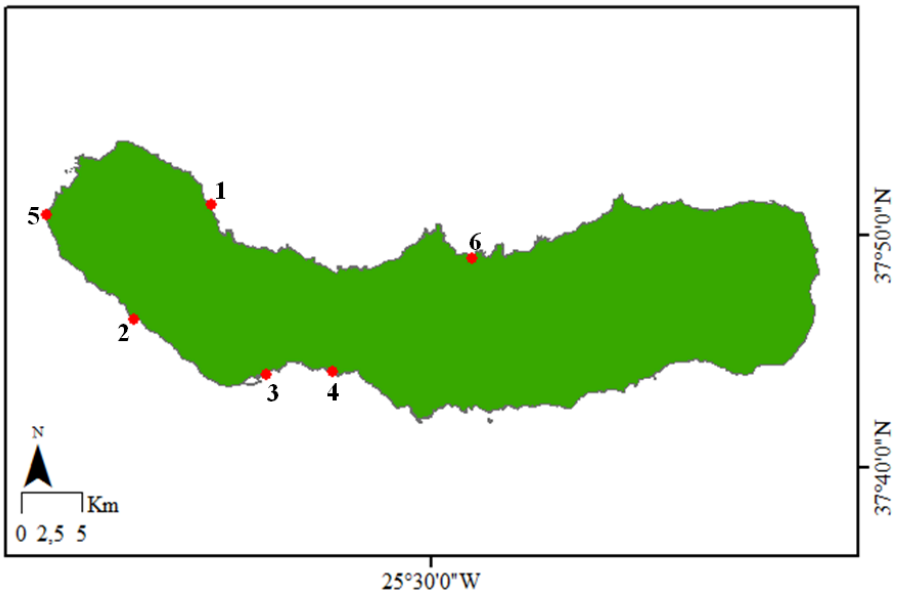


**Fig. 5.8** - Map of São Miguel Island with indication of the shores where seaweeds were sampled for metal contents analysis (1 – Santo António*; 2 – Feteiras*; 3 – Ponta Delgada**; 4 – Lagoa**; 5 - Ferraria OS***; 6 – Porto Formoso***; *non-urban; **urban; ***hydrothermal; for UTM coordinates please see Appendix 13, in electronic form on the enclosed CD).

At each station the selection of biological material was carried out according to the following criteria: (a) abundant throughout the area of study; and (b) taxonomically easy to identify and collect. Two samples of approximately 300g wet weight of each species were collected from two distinct areas at each sampling site on one occasion. Due to the need to satisfy all selection criteria, only four Rhodophyta species (*Corallina elongata*, *Gelidium microdon*, *Osmundea truncata* and *Porphyra* sp.) and two Phaeophyceae (*Cystoseira humilis* and *Fucus spiralis*) were included in the present study.

#### *5.3.2.2 Sample treatment*

Samples were taken to the laboratory, washed with sea water collected at the sampling site to remove particulate matter, scrubbed with a soft nylon brush to remove epiphytes and epifaunal species and rinsed very briefly with distilled water to remove traces of salt. They were then dried at 80ºC to constant weight, stored in sterile Eppendorf tubes, labelled and shipped to "Activation Laboratories Ltd." (Ancaster, Canada) for analysis by high resolution inductively coupled plasma mass spectrometry (HR-ICP-MS).

#### *5.3.2.3 Metal analysis*

Each sample was split into 10 microwave digestion vessels (0.5g of dried sample in each) to which 5ml of Optima $HNO_3$ and 3ml of $H_2O_2$ were added. After one hour in

the fume hood to let the forming subside, vessels were closed and subject to the microwave digestion program VEG1 (Table 5.4), then cooled down to room temperature, opened, added 0.1ml HF and 3.5ml HCl were added, the vessels were then closed and subjected to the digestion program VEG2 (Table 5.4). One empty vessel was used in each batch of digestion for blank measurement and one vessel with 0.5g of Pine needles reference material (NIST SRM 1575a) for validation of digestion methods. Microwave digestion vessels, caps and accessories were washed with detergent, rinsed with deionised water, cleaned with 5ml of concentrated $HNO_3$ and 3ml $H_2O_2$ in the microwave (CLEAN program; Table 5.4), and rinsed again with deionised water. Species for trace metal load analysis were selected only when present at least in one sampling site of each ecological condition. Concentrations of Ca, Cd, Co, Cs, Cu, Fe, Hg, K, Mg, Mn, Ni, Pb, Rb, Se and Zn were determined and results expressed in $\mu g.g^{-1}$ dry weight of plant.

**Table 5.4 -** Microwave digestion programs.

| Program | Stage | Power (Watts) | Pressure (PSI) | Time (min.) | Time at Pressure (min.) | Fan Speed ($m^3$ per min.) |
|---|---|---|---|---|---|---|
| **CLEAN** | 1 | 190 | 20 | 15 | 10 | 3.6 |
| | 2 | 513 | 50 | 15 | 10 | 3.6 |
| | 3 | 513 | 100 | 15 | 10 | 3.6 |

The supernatant liquid fraction was transferred to sterile plastic tubes for storage until metal concentration analysis. EU certified reference material (BCR-279 - *Ulva lactuca*; reference values for Cd, Cu and Zn) was subjected to the same protocol to validate the metal extraction process, and blank samples used to validate sample treatment procedures. Acid digestion vessels, caps and accessories were washed with $HNO_3$ (10%) and rinsed with DI water.

#### *5.4.2.3 Metal analysis*

The levels of Cd, Cu, Fe, Mg, Mn, Ni and Zn in the water samples and in the liquid fraction of the digested blanks, reference material and samples were quantified using Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) at "REQUIMTE – Serviço de Espectroscopia de Emissão Atómica" (chemical analyses laboratory from Universidade Nova de Lisboa – Faculdade de Ciência e Tecnologia).

#### *5.4.2.4 Data treatment*

ANOVA procedures were planned to test differences in metal levels: 1) between non-transplanted and transplanted samples; 2) between transplanted samples subject to open ocean and to hydrothermal conditions; and 3) between transplanted samples subject hydrothermal conditions for different exposure times. However, due to unfavourable sea conditions, only some of the transplanted samples could be collected, and thus ANOVA analysis was not possible. Comparison was therefore based on the mean (±standard deviation) values of metal concentrations and differences considered not significant when variation ranges overlap.

### 5.4.3 Results

Detailed metal concentration values are shown in Appendix 14 (in electronic form on the enclosed CD). Blank samples did not indicate contamination with any of the analysed elements, and metal extraction efficiency from reference material was generally high when compared to certified values (Cd - 81%; Cu - 88%; Zn - 92%; no certified values for Fe, Mg, Mn and Ni). Regarding water samples the concentration of Fe, Mn and Zn in samples collected within Ferraria bay is respectively ca. 2x, 30x and 3x higher than in those collected at Lagoa. Contrarily, the concentration of Ni is ca. 2x higher in water samples collected at a site without hydrothermal influence. Additionally,

the concentration of all metals in sea water was several orders of magnitude lower than in biological control samples of *F. spiralis*: Mg and Zn two orders of magnitude; Cu, Fe and Ni three orders of magnitude; and Cd and Mn four orders of magnitude.

The metal concentration values obtained in biological samples in the present study were highly variable as evidenced by the error bars in Fig. 5.13. Despite this, there is no apparent significant effect on metal accumulation due to the transplanting procedures of *F. spiralis* specimens (light blue *vs.* dark blue columns). Therefore, the patterns in metal accumulation that can be observed in samples transplanted to the hydrothermal site (yellow and red columns) are caused solely by the exposure to hydrothermal conditions. In general, metal accumulation tends to increase with the duration of exposure to hydrothermal conditions, as evidenced by the higher concentration values for the 90 days exposure period (red columns) than for the 45 days exposure period (yellow columns). The levels of Mg, a metal associated to chlorophyll and therefore to a main metabolic process in seaweeds, do not differ greatly between any of the sample types. However, obvious accumulation arises from the 90 day exposure, namely a twofold increase in the levels of Cd, Cu, Ni and Zn, a tenfold increase in Fe and nearly 15 times higher levels of Mn.

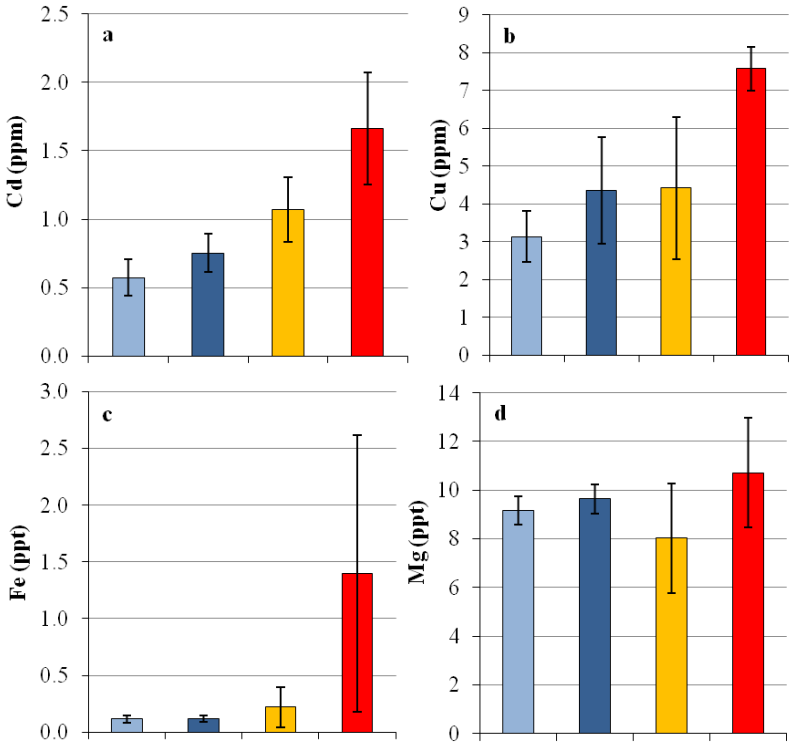


**Fig. 5.13** – Mean (±standard deviation) concentration values of Cd, Cu, Fe, Mg, Mn, Ni and Zn in samples of *F. spiralis* (light blue –untransplanted; dark blue – transplanted to non-

hydrothermal site; orange – transplanted to hydrothermal site for 45 days; red – transplanted to hydrothermal site for 90 days).

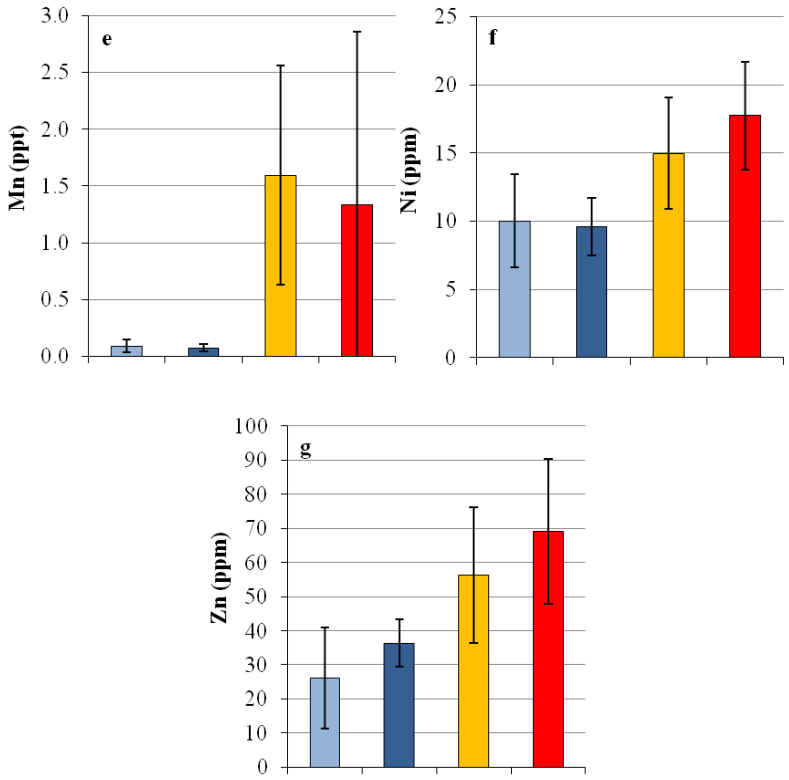


**Fig. 5.13 (cont.)** – Mean (±standard deviation) concentration values of Cd, Cu, Fe, Mg, Mn, Ni and Zn in samples of *F. spiralis* (light blue –untransplanted; dark blue – transplanted to non-hydrothermal site; orange – transplanted to hydrothermal site for 45 days; red – transplanted to hydrothermal site for 90 days).

### 5.4.4 Discussion – Metal accumulation in *F. spiralis* subject to hydrothermal water

Metal concentration values in the untransplanted samples differ from those obtained in the baseline study shown in the previous section of this chapter (Cd=1.14±0.19; Cu=1.53±0.63; Fe =323.76±449.50; Mg=8.395.00±855.00; Mn=41.38±25.05; Ni=7.92±4.96; Zn=190.12±225.53). However, both studies share a high variability of results. *F. spiralis* specimens in the Azores have a very diminute growth (maximum length of ca. 10-15 cm) when compared to specimens further north and there is thus an increased difficulty in separating older and younger parts. Additionally, this species occurs with low abundance on Azorean shores, a fact that poses difficulty in finding enough dry material for digestion and metal analysis. For this reason the presence of propagules was neglected when selecting material for metal analysis, which might have

also contributed to the variability in metal concentrations in samples of *F. spiralis*, since this species accumulates less in its propagules (Munda, 1986). Divergence between results of the present study and those of (Wallenstein *et al.*, 2009a) are possibly related to seasonal variation (Fosberg *et al.*, 1988), since the latter took place between February and April 2007, when sea water is coldest in the archipelago (see Chapter 2), and the former between November and January. Comparison of results should thus be carefully made. According to Villares *et al.* (2002) levels of metals in macroalgae vary depending on several environmental factors, and therefore caution should also be used when comparing metal levels between distant areas with very different characteristics. Nevertheless, studies comparing metal concentrations in macroalgae from contaminated and polluted sites report lower Cd and Zn concentrations at unimpacted sites when compared with polluted sites (Amado Filho *et al.*, 1999; Al-Masri *et al.*, 2003; Daka *et al.*, 2003; Lozano *et al.*, 2003; Abdallah *et al.*, 2005), which is the case of Zn concentrations in water and Cd and Zn in biological samples collected at the hydrothermally active site. In such a context and given also the increased levels of Fe and Mn in water and biological samples from this site, coastal hydrothermal vents could be considered as a source of natural pollution in terms of heavy metal enrichment. Regarding water samples, it is not surprising to find increased Fe, Mn and Zn in samples collected at the hydrothermally active site when compared to those collected at a site without such influence as these elements are reported to be associated with volcanic activity (Amaral *et al*., 2006, 2007, 2008; Zaldibar *et al*., 2006; Cunha *et al*., 2008). Previous studies on barnacles and amphipods from the Azores also report high levels of Cd and Cu associated with hydrothermally active environments (Moore *et al.*, 1995; Weeks *et al.*, 1995) as also here reported for transplanted samples. However, samples of non-hydrothermal water collected in the present study showed higher levels of Cu and Ni and equivalent levels of Cd and Mg when compared to the hydrothermal water samples. Higher contents of Cu and Ni in water samples collected at Lagoa (a site without hydrothermal activity; Appendix 13, in electronic form on the enclosed CD) are probably related to the fact that this site lies in the most urbanized stretch of coastline on this island. Consequently, it is possible that urban pollution might be responsible for the increased levels of some metals in these waters.

Despite the fact that water samples collected at the two different sites might reflect different types of pollution, the concentration of all analysed elements in the water is lower than in biological samples, thus indicating that these elements are bioavailable and that they are accumulating in macroalgae. Additionally, results here show that

samples exposed to hydrothermal activity do show a tendency to accumulate higher levels of metals, independently of their concentration in the surrounding water. Such evidence leads to believe that other factors than the composition of water are influencing the bioavailability of metals and/or their accumulation in organisms subject to hydrothermal activity. The main differences associated with hydrothermally active environments when compared to open ocean conditions, are increased temperature and acidity that are probably the cause of the increased levels of metals in the *F. spiralis* samples that were transplanted to such altered conditions.

## 5.5 COMPARISON OF METAL CONCENTRATIONS IN *F. SPIRALIS* COLLECTED ON AZOREAN AND BRITISH SHORES

### 5.5.1 Introduction

The idea of using *F. spiralis* to evaluate the accumulation of metals as a result of its exposure to shallow water hydrothermal activity arose because it could be compared with other sources of metal enriched waters in the British Isles. *F. spiralis* is the only intertidal species that the Azores and the British Isles have in common that is readily available and easy to collect in large quantities. Its wide geographical distribution makes it therefore a potential species to be used as a comparison tool between distant regions and different pollution sources. There have been studies on the effects of coal mining on seaweed communities in the British Isles, namely at Blackhall Rocks in County Durham, north-east England (Grundy, 1996) and St. Monans, Fife, east coast of Scotland (Woolsey and Wilkinson, 2007a). When de-watering pumps have been switched off in abandoned coal mines they are flooded with underground water that stays in contact with the minestone for a long period. Chemical reaction between water and coal rocks and the metabolism of sulphur bacteria that inhabit the flooded tunnels result in iron rich acidic drainage water, that surfaces diffusely near the shore. These properties of coal mine drainage water are quite similar to those of hydrothermal provenance and it was therefore planned a comparison between the metal concentrations in *F. spiralis* collected at Blackhall and St. Monans in the British Isles and specimens transplanted to Ferraria bay in the Azores. It was therefore necessary to sample *F. spiralis* specimens at other sites in the British Isles without the influence of coal mining drainage water. Within the scope of Heriot-Watt University field courses to Oban (west Scotland), Whitley Bay (north east England) and St. Monans and while accompanying Prof. Martin Wilkinson in a visit to the Orkney campus of Heriot-Watt University and in a field trip to Islay (Inner Hebrides islands, west Scotland) with one of his honours students to survey micro-tidal shores, *F. spiralis* was collected at several shores without the coal mining impact. At Islay samples were also collected in the vicinity of the Lagavulin distillery where a previous study had recorded increased accumulation of copper in seaweeds (Wilkinson and Jackson, 1992).

### 5.5.2 Methods

#### *5.5.2.1 Sampling sites*

West coast Scotland (September 2007 – Oban field course)

- North Shian (UK National Grid Reference NM 913 431) – a typical sheltered smoothly sloping rocky shore with a wide intertidal area, located at the mouth of Loch Creran.
- Seil Sound (Tigh an Trush; UK National Grid Reference NM 784 196) – a sheltered moderately sloping rocky shore with a narrow intertidal area, located in the Clachan Seil. A particular feature of this shore is the occurrence of *Himanthalia*, a species that is characteristic of wave-exposed shores, but present here on a very wave sheltered shore owing to to strong tidal currents.

East coast of northern England (September/October 2007 – Whitley Bay field course)

- Tynemouth (Priors Haven; UK National Grid Reference NZ 374 691) – a smoothly sloping rocky shore with rock-pools along a wide intertidal area, located at the mouth of river Tyne.
- Seaton Sluice (UK National Grid Reference NZ 339 769) – a moderately sloping wave-exposed rocky shore subject to sand scour, located at the mouth of Seaton Burn.
- Featherbed Rocks (UK National Grid Reference NZ 430 498) – a gently sloping wave-exposed rocky shore, with a wide intertidal area and rock-pools, located at the end of a sandy beach next to Seaham.
- Blackhall (UK National Grid Reference NZ 470 493) –gently sloping wave-exposed rocky outcrops with a wide intertidal area and rock-pools occurring along a wave-exposed sandy beach, where the water from the flooded coal mine emerges (Fig. 5.14), located beneath the site of the abandoned Blackhall colliery on the cliffs above. The rocky outcrops that are subject to greater impact of the mine drainage water lack the upper intertidal zone where *F. spiralis* is common, and therefore samples were collected in the nearest rocky outcrop where it could be found, approximately 500m to the south of the most affected one.

**Fig. 5.14** – Coal mine drainage water emerging from the sand at Blackhall Rocks.

- St. Monans (UK National Grid Reference NO 536 020) – a gently sloping wave-exposed rocky shore with a wide intertidal extension and rock-pools, where the water from the flooded coal mine is discharged onto the shore beneath the de-activated St. Monans colliery (Fig. 5.15). Samples were collected at three increasingly distant points from the drainage water input: immediately below, 50m and 100m away.

**Fig. 5.15** - Coal mine drainage water running down onto the shore at St. Monans.

Islay (October 2007)

- Port Ellen (UK National Grid Reference NR 359 456) – a sheltered rocky shore facing southeast, with a moderate slope and a short intertidal area due to the micro-tidal range (common in this region), located in the southernmost part of Islay.
- Port Charlotte (UK National Grid Reference NR 253 581) – also a sheltered rocky shore facing southeast, with a moderate slope and a short intertidal area due to the micro-tidal range, located in the centre of the western peninsula of Islay.
- Portnahaven (UK National Grid Reference NR 165 522) - a moderately exposed rocky shore facing south/southwest (facing the Atlantic), located in the south of the western peninsula of Islay.
- Kilchiaran (UK National Grid Reference NR 197 601) – a moderately sloping highly rocky shore facing west, and thus highly wave-exposed, located in the central part of the western peninsula of Islay.
- Lagavulin – located in the southeast coast of Islay, where a whisky distillery is built and operating. Two sampling sites were chosen, one rocky shore inside a sheltered bay next to the distillery (UK National Grid Reference NR 405 456), and the other in Dunyvaig Castle, a moderately exposed rocky shore just adjacent to the Lagavulin bay (UK National Grid Reference NR 406 459).

Orkney (October 2007)

- Southwick, Papa Westray (UK National Grid Reference HY 498 519) – a gently sloping, wave-exposed rocky shore located in the west coast of Papa Westray Island.
- St. Margaret's Hope (UK National Grid Reference ND 446 936) – a gently sloping, sheltered rocky shore within a bay in the north of South Ronaldsay Island.
- Bay of Skaill (UK National Grid Reference HY 229 188) – a moderately sloping rocky shore subject to strong wave-exposure, located in the west coast of Mainland Orkney.

#### *5.5.2.2 Sample treatment*

In the laboratory specimens were washed with sea water collected at the sampling site to remove particulate matter, cleaned of epiphytes with a soft nylon brush, dried to constant weight in a drying oven at 70ºC, and ground with a mortar and pestle. Subsequently, each sample was split into three 50ml Erlenmeyer flasks (approximately 0.5g of ground sample in each). To each flask 3ml $HNO_3$ (65%) were added and kept for 43h at room temperature. Distilled water was then added up to a final volume of 30 ml and flasks transferred to a heating plate at 100ºC for 4h, after which 1ml of $H_2O_2$ (30%) was added and kept on the heating plate at 100ºC for one extra hour. The content of each flask was then ultrasonicated for 2 min. at 50Hz. and spun at 3220g for 10 min. The supernatant liquid fraction was transferred to sterile plastic tubes for storage until metal concentration analysis. EU certified reference material (BCR-279 - *Ulva lactuca*; reference values for Cd, Cu and Zn) was subjected to the same protocol to validate the metal extraction process, and blank samples used to validate sample treatment procedures. Acid digestion vessels, caps and accessories were washed with $HNO_3$ (10%) and rinsed with deionised water.

#### *5.5.2.3 Metal analysis*

The levels of Cd, Cu, Fe, Mg, Mn, Ni and Zn in the liquid fraction of the digested samples were quantified using Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) at "REQUIMTE – Serviço de Espectroscopia de Emissão Atómica" (chemical analyses laboratory from Universidade Nova de Lisboa – Faculdade de Ciência e Tecnologia).

#### *5.5.2.4 Data treatment*

British Isles samples were grouped according to the nature of the shore where they have been collected as follows:

**Clean shores** - North Shian, Seil Sound, Featherbed Rocks, Kilchiaran, South Wick, St. Margaret's Hope, Bay of Skaill.

**Ports** - Port Ellen, Port Charlotte, Portnahaven.

**Rivermouths** - Tynemouth, Seaton Sluice.

**Distilleries** - Lagavulin

**Abandoned coal mines** - Blackhall, St. Monans.

Due to an unbalanced pool of samples collected at different types of shores ANOVA procedures do not apply to the dataset. Therefore, comparison between metal concentrations in *F. spiralis* samples collected at different types of shore in the Azores and the British Isles was based on the mean (±standard deviation) values of metal concentrations and differences considered not significant when variation ranges overlap.

### 5.5.3 Results

Detailed metal concentration values in each sample are shown in Appendix 14 (in electronic form on the enclosed CD) and summarized in Fig. 5.16. Results are highly variable in general, as was also the case with metal concentrations in samples collected at Azorean shores. Despite this, some associations can be identified regarding metal accumulation levels and the pollution sources to which seaweeds are subjected. From the pool of elements that were analysed, Mg is the only one with similar concentrations in all Azorean and British samples. By contrast, samples collected at the Azorean hydrothermal site and at the British coal mining sites show increased levels of Cd, Cu, Fe, Ni and Zn when compared to the samples collected at clean shores. From the samples collected at St. Monans the concentrations of Cd, Fe, Mn, Ni and Zn are significantly higher in those collected immediately next to the drainage water input than in those collected 50m and 100m away. In samples from Blackhall the Cd, Mn and Ni levels are similar to those in samples from St. Monans at a 100m distance from the drainage water input, the latter two significantly higher than in samples from clean shores. Fe concentrations, however, are lower than in St. Monans most distant collection point's samples, but still higher than in samples from clean shores. Similarly, samples collected at Lagavulin showed a higher level of Cu than those from clean shores. Furthermore, the concentrations of Cu, Fe, Mn and Zn in samples collected in the vicinity of the distillery are significantly higher than those from samples collected further away. The samples collected at Tynemouth showed higher concentrations of Mn and Zn at comparable levels as those found in samples from Blackhall and St. Monans. This is also the case of Fe and Mn concentrations in samples collected at Port Ellen and Port Charlotte. The concentration of Cu, Fe and Mn is also considerably higher in samples collected at North Shian, Seil Sound and Featherbed Rocks than in the remaining shores considered clean.

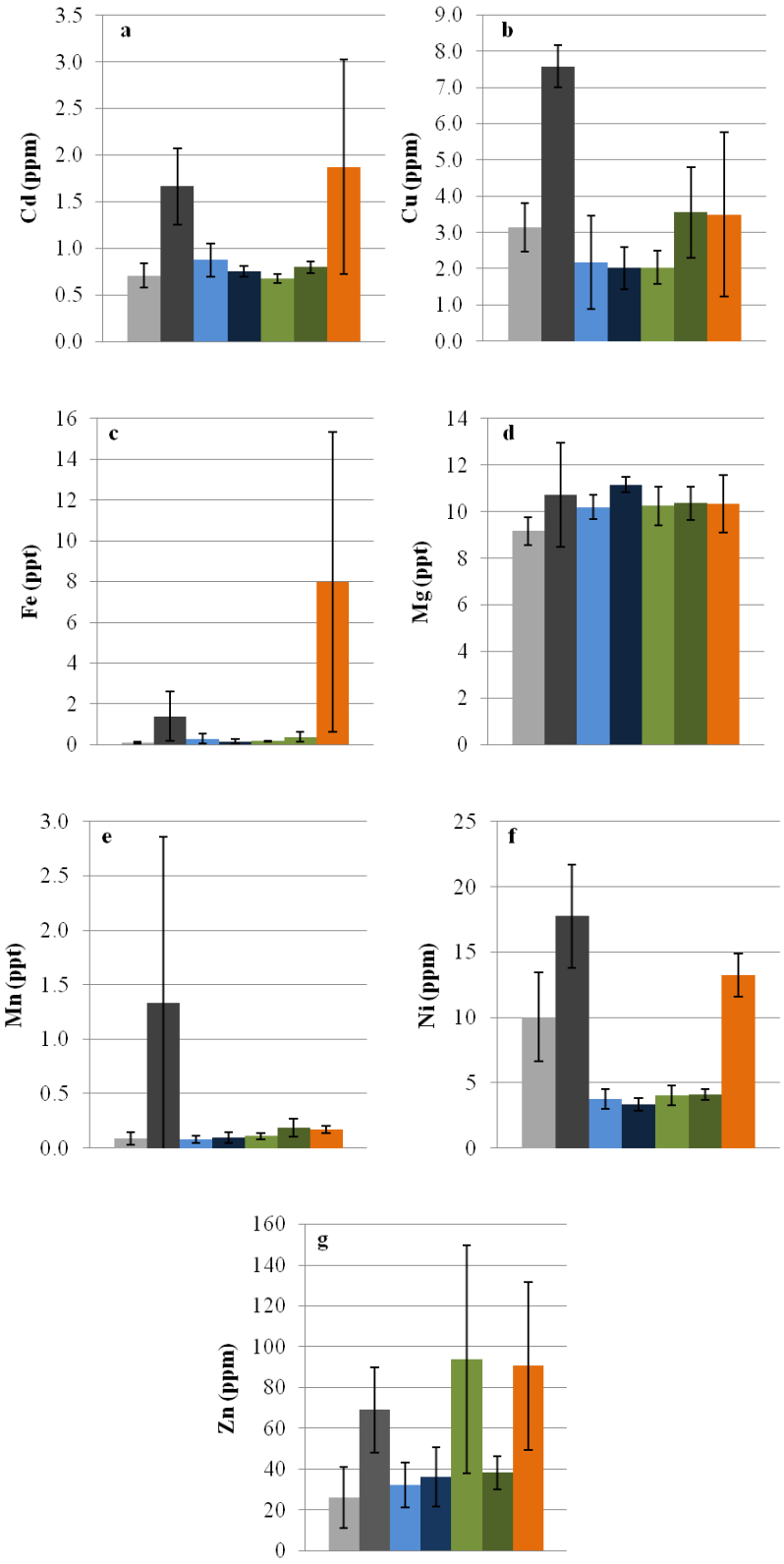


**Fig. 5.16** – Mean (±standard deviation) concentration values of Cd, Cu, Fe, Mg, Mn, Ni and Zn in samples of *F. spiralis* (light grey – Azores untransplanted samples; dark grey – Azores transplanted samples to hydrothermal site for 90 days; light blue – British Isles samples collected in "clean" sites; dark blue – British Isles samples collected in ports; light green – British Isles samples collected at the mouth of rivers; dark green – British Isles samples collected in the vicinity of whisky distilleries; orange – British Isles samples collected in the vicinity of abandoned coal mines).

### 5.5.4 Discussion – Accumulation of metals in *F. spiralis* from acid mining drainage (British Isles) and hydrothermal sites (Azores)

The greater Fe concentrations in samples transplanted to the hydrothermal site in the Azores and in those collected at the coal mining affected sites in the UK confirm the utility of *F. spiralis* as a comparative monitoring tool with wide geographical applicability. Additionally, the increased levels of Cu in samples that were collected in the vicinity of the whisky distillery are consistent with previous work on the effects of distillery discharges of water from still washing on seaweeds (Wilkinson and Jackson, 1992), which confirms the potential of *F. spiralis* as a monitoring tool for other types of pollution. Some metal concentrations found in samples collected at the mouths of rivers, ports and even at sites that were assumed to be clean can be indicative of some metal enrichment of unknown origin, and should therefore be investigated further.

Although of different origin, hydrothermal (see Appendix 14, in electronic form on the enclosed CD) and mine drainage water (Woolsey and Wilkinson, 2007a) are both freshwater inputs, acidic in nature and rich in iron . Apparently, there are further similarities in the metal contents of these two water inputs, namely regarding Cd, Cu, Mn, Ni and Zn, as they show similar increased accumulation in samples subject to both conditions. Furthermore, *F. spiralis* does not occur naturally within Ferraria bay, where the hydrothermal effect is greatest, which is also consistent with its lowest abundance at the station closest to the drainage water input in St. Monans, reported by Woolsey and Wilkinson (2007a). These authors also report a smaller size and reduced reproductive condition in *F. spiralis* specimens near the drainage water outfall as compared to specimens further away from it. However, it is not clear if the reduced growth and colonizing success of *F. spiralis* is caused by the metal contents of water or due to its low salinity and/or acidic nature. Nevertheless, it is highly probable that the same factors are inhibiting the colonization of *F. spiralis* within Ferraria bay. However, increased temperature must be considered as an additional factor influencing the colonization and growth of *F. spiralis* subject to shallow water hydrothermal activity.

The results of this and the previous sections suggest that temperature and pH conditions might increase metal bioavailability and/or the physiological capacity of *F. spiralis* for accumulating metals even when these are present at very low concentrations in the water. If this is the case, and in a global warming scenario, this species is expected to become more sensitive to the effects of pollution in terms of metal enrichment. Further

studies on the physiology of *F. spiralis* under controlled laboratory conditions should follow to clarify the results of the present work.

## 5.6 PILOT STUDY ON THE GROWTH AND PHOTOSYNTHESIS OF *FUCUS SPIRALIS* SUBJECT TO INCREASED TEMPERATURE AND ACIDITY

### 5.6.1 Introduction

There is plenty of evidence that pH influences the accumulation of metals in several organisms (e.g. Peramaki *et al.*, 1992; Kukier *et al.*, 2004; Spurgeon *et al.*, 2006) as does temperature (e.g. Gessner, 1970; Denton and Burdon-Jones, 1981; Karakoç and Dinçer, 2003; Fritioff *et al.*, 2005; Mubiana and Blust, 2007). Sites affected by hydrothermal activity and by acid mining drainage are environments with increased acidity, while hydrothermal activity also rises sea water temperature. The results on metal accumulation in *F. spiralis* transplanted to a hydrothermal site and collected in acid mining drainage affected sites (see Appendix 14, in electronic form on the enclosed CD) might be just a consequence of the increased metal enrichment of sea water that is characteristic in this type of environment, but might also be influenced by its exceptional temperature and pH conditions. In this context, a pilot study was designed to provide guidelines for more comprehensive experiments to evaluate the influence of temperature and pH in the growth and photosynthesis in *F. spiralis*.

### 5.6.2 Methods

#### *5.6.2.1 Sampling procedures*

The present study was conducted between June and October 2009, on São Miguel Island (Azores, Portugal), where tips of *F. spiralis* of about 1cm in length were collected at one open shore site (Mosteiros; see Fig. 5.12), brought to the laboratory and cleaned of epiphytes with a soft nylon brush. Water was collected at two sites in Ferraria (see Fig. 5.12), the open shore site Ferraria-OS (pH≈8) and within Ferraria bay (pH≈7), brought to the laboratory, filtered with GF/C Whatman glass fibre filters (Cat No 1822-047) and subject to microwave sterilization (2l of sea water subject to a microwave sequence of 2min. at 650W, 30s interruption, 1min. at 650W, 30s interruption and 2min. at 650W). Part of the open ocean water was acidified to pH≈7 using HCl 1M.

The experimental design outlined in Table 5.6 was implemented to test for differences in growth rates and respiration associated to temperature, pH and water type.

**Table 5.6** – Experimental design to evaluate the effect of temperature, pH and hydrothermal water on the growth (*) and photosynthesis (**) of *F. spiralis*.

| | | 15ºC | | 25ºC | |
|---|---|---|---|---|---|
| **Open ocean water** | pH≈8 | * 3 replicates (15 tips each) | ** 2 light and 2 dark bottles (≈0.5g each), 2 controls | * 3 replicates (15 tips each) | ** 2 light and 2 dark bottles (≈0.5g each), 2 controls |
| | pH≈7 | * 3 replicates (15 tips each) | ** 2 light and 2 dark bottles (≈0.5g each), 2 controls | * 3 replicates (15 tips each) | ** 2 light and 2 dark bottles (≈0.5g each), 2 controls |
| **Hydrothermal water** | pH≈7 | * 3 replicates (15 tips each) | ** 2 light and 2 dark bottles (≈0.5g each), 2 controls | * 3 replicates (15 tips each) | ** 2 light and 2 dark bottles (≈0.5g each), 2 controls |

#### *5.6.2.2 Growth*

The method used to measure growth was adapted from Burrows (1964) based on area change of excised apical segments. *F. spiralis* tips were placed in plastic vessels filled with 400ml of open sea water (pH≈8 and pH≈7) and with hydrothermal sea water (pH≈7). The experiment was kept during a period of two weeks with a 12h/12h 200µmol/$m^2$/s light/dark periods, during which water was exchanged every three days, and pH controlled four times a day (whenever necessary lowered with HCl 1M, or increased with NaOH 1N). Tips were scanned in the beginning, mid and end of this period and growth assessed from surface area increase through image analysis with the software Adobe PHOTOSHOP. Considering t0, t1 and t2 the measuring occasions, namely at the start of the experience, one and two weeks later, respectively, growth rates were calculated according to the equations:

$$w1 = {a1 - a0}/{a0} \qquad \text{(equation 5.1)}$$

$$w2 = {a1 - a2}/{a1} \qquad \text{(equation 5.2)}$$

$$wT = {a2 - a0}/{a0} \qquad \text{(equation 5.3)}$$

Where:

w1 – growth rate over week 1
w2 – growth rate over week 2
wT – growth rate over the whole 2 week experiment
a0 – surface area at t0
a1 – surface area at t1
a2 – surface area at t2

#### *5.6.2.3 Photosynthesis*

The method used to measure photosynthesis and respiration was adapted from Thomas (1988). Tips of *F. spiralis* used for the growth experiment were weighed (wet weight) and transferred to 250 ml dark and light bottles filled with open sea water (pH≈8 and pH≈7) and with hydrothermal sea water (pH≈7), sealed without trapping air bubbles, and kept for 4 hours under controlled light (200 μmol/$m^2$/s) and temperature (15ºC and 25ºC), after which dissolved oxygen was measured with a HI9829 probe (Hannah Instruments, USA). Control 250 ml dark and light bottles filled only with open sea water (pH≈8 and pH≈7) and with hydrothermal sea water (pH≈7) and no algae were kept under the same conditions. The same experiment was conducted with freshly collected *F. spiralis* tips. Net photosynthesis and respiration (relative to the weight of each sample and duration of the experiment) were calculated by subtracting dissolved oxygen values in control light bottles from *F. spiralis* light bottles and *F. spiralis* dark bottles from control dark bottles respectively.

#### *5.6.2.4 Data analysis*

Single factor analysis of variance was used to test differences in growth under different temperature, pH and water type conditions.

### 5.6.3 Results

Results on growth, photosynthesis and respiration of F. spiralis excised tips kept under different temperature, pH and sea water type conditions in the laboratory are summarized in Table 5.7. There are no statistically significant differences in growth of *F. spralis* tips kept under different temperature, pH and sea water type conditions (Table 5.8), while photosynthesis and respiration results are insufficient for variance analysis.

Despite the fact that the differences shown in Table 5.7 are not significant, some patterns can be observed. Growth values of *F. spiralis* are higher at the lower temperature, both for open ocean water and hydrothermal water. Additionally it seems that lower pH favours growth, but samples kept at pH≈8 grew more during the second week, while those kept at pH≈7 showed a decrease in growth during the same period. This latter pattern was more evident for the samples kept in water collected at the

hydrothermally active site, which also grew less than those kept in open ocean sea water independently of the temperature at which they were kept.

**Table 5.7** –Growth (percentage relative to the initial size) and photosynthesis/respiration (mg of dissolved oxygen per g of fresh sample per hour) of *F. spiralis* tips kept under controlled temperature (15ºC and 25ºC) and pH (≈7 and ≈8) conditions in open ocean (O) and hydrothermal (H) sea water.

| | | pH | Growth | | | Net photosynthesis | | Respiration Rate | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Weekly | | Total | Cultured | Fresh | Cultured | Fresh |
| 15ºC | O | 8 | w.1 | 5.5 (±1.0) | 12.8 (±3.2) | 0.60 | 1.26 | 0.13 | 0.12 |
| | | | w.2 | 6.8 (±2.6) | | (±0.10) | (±0.24) | (±0.03) | (±0.00) |
| | O | 7 | w.1 | 10.9 (±1.6) | 20.0 (±2.1) | 0.83 | 1.22 | 0.15 | 0.13 |
| | | | w.2 | 8.1 (±1.4) | | (±0.19) | (±0.14) | (±0.05) | (±0.06) |
| | H | 7 | w.1 | 8.4 (±1.5) | 12.2 (±3.0) | 0.72 | 1.78 | 0.12 | 0.16 |
| | | | w.2 | 3.5 (±1.4) | | (±0.06) | (±0.72) | (±0.06) | (±0.03) |
| 25ºC | O | 8 | w.1 | 2.7 (±2.1) | 10.3 (±1.3) | 0.06 | 1.14 | 0.16 | 0.16 |
| | | | w.2 | 7.3 (±1.2) | | (±0.11) | (±0.11) | (±0.02) | (±0.00) |
| | O | 7 | w.1 | 6.3 (±1.0) | 12.5 (±1.7) | 0.57 | 1.22 | 0.19 | 0.17 |
| | | | w.2 | 5.8 (±0.9) | | (±0.14) | (±0.16) | (±0.06) | (±0.09) |
| | H | 7 | w.1 | 6.4 (±0.8) | 9.7 (±1.4) | 0.76 | 1.33 | 0.31 | 0.19 |
| | | | w.2 | 3.1 (±0.5) | | (±0.07) | (±0.40) | (±0.03) | (±0.10) |

**Table 5.8** - Analyses of variance comparing the growth of F. spiralis tips at different temperature pH and water type conditions.

| Source | df | MS | F | P |
|---|---|---|---|---|
| Temperature | 1 | 0.1493 | 0.88 | 0.3491 |
| Residual | 268 | 0.1697 | | |
| pH | 1 | 0.1456 | 0.87 | 0.3522 |
| Residual | 178 | 0.1674 | | |
| Water type | 1 | 0.1027 | 0.57 | 0.4525 |
| Residual | 178 | 0.1812 | | |
| Temperature | 1 | 0.1056 | 0.63 | 0.4292 |
| pH | 1 | 0.1456 | 0.87 | 0.3534 |
| Temperature X pH | 1 | 0.0934 | 0.56 | 0.4572 |
| Residual | 176 | 0.1682 | | |
| Temperature | 1 | 0.2149 | 1.18 | 0.2784 |
| Water type | 1 | 0.1027 | 0.56 | 0.4533 |
| Temperature X Water type | 1 | 0.0279 | 0.15 | 0.6959 |
| Residual | 176 | 0.1819 | | |

Samples kept in the laboratory for two weeks showed lower photosynthetic rates than the freshly collected ones. Freshly collected samples kept in hydrothermal water show higher photosynthesis values independently from the temperature of the water they were kept in. However, cultured specimens show higher photosynthesis values in hydrothermal water only at the lower temperature. Samples kept at lower temperature show higher photosynthesis values independently from the type and pH of the water

they were kept in. Samples kept at a lower pH also show higher photosynthesis values independently from the type and temperature of the water they were kept in.

Respiration rates do not differ much between fresh and cultured specimens and are not affected to a great extent either by temperature or pH, although samples kept in hydrothermal water at 25ºC showed the highest respiration levels.

### 5.6.4 Discussion – The effect of temperature and pH on growth and photosynthesis of *F. spiralis*

*F. spiralis* growth response to temperature is consistent with a previous study by Fortes and Lüning (1980) that reports a temperature optimum of 15ºC for this species, which reflects its latitudinal distribution.

Growth is probably affected indirectly by the pH of sea water through photosynthesis. At lower pH levels the $H_2CO_3$ / $HCO_{3-}$ / $CO_2$ balance in sea water is shifted towards higher $CO_2$ levels, that are more easily fixed in the photosynthetic process (Blinks, 1963), thus explaining the higher growth and photosynthetic rates at lower pH. Differences in growth between the first and second weeks and also between photosynthesis values in cultured specimens and freshly collected ones might be related to the fact that in thick leathery seaweeds such as *F. spiralis* the altered sea water pH may only prevail near the surface and take some time to have some effect deeper in the tissue (Blinks, 1963).

Net photosynthesis results are highly variable and there is an abnormally low value of 0.06 for the samples kept in open ocean water at 25ºC, which would possibly be clarified if the photosynthesis/respiration experiment had been kept for a longer period of time. This would allow for a greater production of $O_2$/$CO_2$ and therefore produce more reliable results, which might also enlighten us about the higher respiration of samples kept in hydrothermal water at 25ºC, for which there is no logic explanation. According to Kangwe *et al.* (2001) exposure to metals reduces photosynthetic rates, which is in contradiction with the increased photosynthesis values associated with specimens kept in hydrothermal water compared to those kept in open ocean water at 25ºC. However, under temperature optimum conditions for *F. spiralis* (15ºC) hydrothermal water is affecting photosynthesis negatively in specimens kept in hydrothermal water and positively in freshly collected specimens. A possibility here is

that a first contact with hydrothermal water is boosting the metabolism of *F. spiralis* and depressing it after a longer exposure. This would be considered a Hormesis effect (Stebbing, 1998), a term used by toxicologists to refer to a biphasic dose response to an environmental agent characterized by a low dose stimulation or beneficial effect and a high dose inhibitory or toxic effect.

On the other hand, growth rates associated with specimens kept in hydrothermal water are considerably lower, which is in accordance with the findings of Woolsey and Wilkinson (2007a) that report smaller specimens of *F. spiralis* in the field closer to acid mining drainage than away from it. Continuous exposure to toxic compounds can affect algae after accumulation of the toxins in their walls (Kangwe *et al.*, 2001) and although other processes than photosynthesis may influence growth (Lüning, 1980) hydrothermal water is probably inhibiting both photosynthesis and growth in the long term.

The results of the present study are still preliminary but do indicate the need to investigate what exactly in the hydrothermal water is affecting the physiology of this widely distributed brown seaweed. The importance of such studies arises from the need to identify good biomarkers and understand their physiology under different temperature and acidity conditions, given the undeniable context of global warming.

## 5.7 OVERALL DISCUSSION

Despite the different nature and geographical region of the acidic, metal enriched freshwater inputs described in the present chapter, their impacts on intertidal seaweed communities are remarkably similar. At the community level species richness is reduced and species composition affected, at species level the growth and reproduction are compromised, and at the cellular level metal accumulation is higher (Woolsey and Wilkinson, 2007a; and section 1 of the present chapter). However, the input sources are localized and their effects in sea water dissipate due to dilution caused by the increasing influence of clean sea water and consequently the magnitude of its impacts on seaweed communities decreases with increasing distance from the input source. The visually obvious impacts at the community and species levels tend to become less obvious over very short distances, but at the cellular and physiological levels impacts might still exist at longer distances from the input source. It is therefore necessary to evaluate the impacts of pollution at different complementary levels. Although seaweeds are considered good biomonitoring organisms for metals, their accumulation is proportional to growth and therefore factors like salinity, temperature and pH must be accounted for as they affect seaweed growth rates (Phillips, 1990). Care must taken when comparing metal accumulation in seaweed species between geographic regions where the temperature of sea water differs greatly, as the physiological condition of seaweeds is likely to be affected by it. This is a caution that needs to be accounted for not only at the cellular and physiological levels, but also at the species and community levels as evidenced in chapters 2-4 of the present thesis.

# CHAPTER 6

DISCUSSION

# 6. DISCUSSION

The present chapter is intended discuss the main findings of this thesis and how they relate to each other. Each aspect of the investigation has been discussed in detail in the respective chapters and therefore these detailed discussions will not be repeated here.

Differences in coastal communities across wide geographical scales have attracted the attention of scientists for a long time. The idea of providing a comparison between rocky shore seaweed communities from different geographical areas is far from being novel and there is extensive bibliography on this subject such as the studies of Stephenson and Stephenson (1949, 1972), Lewis (1964) and Bertness (1999) among several others. The types of biotic and abiotic factors that affect coastal communities, and that therefore influence the distribution of organisms on the shore, are the same around the world. Abiotic factors vary geographically in magnitude, however, and consequently so do ecological processes and interactions. The way organisms and their interactions are affected by changes in the main structuring abiotic factors is also well documented, which provides a solid basis for the understanding of geographical variability in coastal communities. However, providing comparison between seaweed communities, with focus on features that reflect the overall ecological quality of rocky shores, does stand out as a useful piece of science in the context of environmental policies being implemented in the European Union. The need to have ecological quality assessment methods that produce consistent results throughout a geographically extended area with strikingly different climatic and oceanographic conditions is the basis for the intercalibration requirements set out in legislation such as the WFD and the MSFD (EC, 2000; 2008, respectively). Despite these requirements, the results of intercalibration efforts often stay within executive meetings and are rarely published in widespread scientific literature, and are therefore unavailable to the general public. In this respect, the present thesis and possible publications deriving from it are intended to provide useful scientific insights to the difficulties in intercalibrating the tools developed for the assessment of ecological quality in the northeast Atlantic region using seaweeds, namely by Wells *et al.* (2007) and Juanes *et al.*(2008).

Besides the climatic, oceanographic and geomorphological differences between the Azores archipelago and the British Isles and the inevitably different seaweed communities evidenced in chapter 2, difficulty arises in the choice of features that reflect ecological quality and that are not affected latitudinally by environmental factors.

In chapter 3 of the present thesis it is shown that scores for all features used in the tool developed by Wells *et al.* (2007) for the British Isles differ to a greater or lesser extent from those in the Azores archipelago. Species richness and the proportions of green and brown species tend to be lower in the Azores, while the proportion of red species and the ratio between the number of late and early successional species are shown to be substantially higher. Therefore the value ranges assigned to any ecological quality class for each of these features in the British Isles are necessarily different from those that should be used when applying the same tool to Azorean shores. As a consequence adaptations to the tool have been proposed in chapter 4 by suggesting different value ranges for each feature to be used in the Azores, similar to what Borja and Muxica (2007) have done for the Basque country. Such adaptations are only possible if they are based on large amounts of scientific data that provide reliable information on how these features vary within a given region, though. Such is the case of the present thesis and of the British Isles dataset that was used to devise the original tool. However, providing this kind of information is very time consuming and therefore undesirable if there is the need to check the applicability of the tool to different regions with a limited amount of time, which is usually the case with the implementation of EU directives.

To overcome this potential shortcoming, an alternative tool is proposed in the present thesis that is based only on species richness and the percentage area of rocky substratum that is covered by early and by late successional species. The proposed index avoids the use of features that vary geographically and focuses only on features that are shown to be related to ecological quality in the literature. Several authors (Wilkinson and Tittley, 1979; Wells *et al.*, 2003; Wells *et al.*, 2007) have shown that the number of seaweed species is remarkably constant over space and time and that it is higher at pristine shores when compared to impacted ones throughout the British Isles. The same pattern was observed for Azorean shores, as suggested in chapter 4 and confirmed in chapter 5 of the present thesis in which seaweed communities on shores affected by shallow water hydrothermal activity are characterized. Seaweed abundance has also been shown to decrease with environmental quality deterioration by several authors (Orfanidis *et al.*, 2001; Pinedo *et al.*, 2006; Arévalo *et al.*, 2007; Ballesteros *et al.*, 2007b; Scanlan *et al.*, 2007; Guinda *et al.*, 2008; Juanes *et al.*, 2008; Orlando-Bonaca *et al.*, 2008), and although surveys on Azorean shores haven't focused on seaweed abundances, there is empirical evidence that seaweed communities are increasingly dominated by early successional species the nearer they are to hydrothermal inputs. In fact, such evidence has led to the incorporation of early successional species cover into the proposed tool

rather than the use of opportunistic species, such as the British and Spanish tools. There is no consistency in the way different authors classify species as opportunist or not and therefore much confusion is raised with the use of such a feature. Opportunist species are frequently confused with fast growing species that are common on any shore and not necessarily more abundant at environmentally degraded ones. Fast growing species may reach nuisance proportions, usually associated with nutrient enrichment rather than with other types of pollution, but generally not on wave exposed rocky shores. Early successional species, however, although also present on any shore might be indicative of disturbance if their proportion relative to the overall substratum cover is abnormally high (Lewis, 1977). Such disturbance might be of natural or anthropogenic origin, but a shore that is largely dominated by early successional species may be recovering from some impact, although it may be artificially held at an early stage in the succession of rocky shore colonization by naturally stressful conditions such as sand scour or high turbidity (e.g. Daly and Mathieson, 1977; Littler *et al.*, 1983b). The tool proposed in the present thesis goes beyond the intercalibration exercise of the British and Spanish tools with Azorean seaweed community data. It suggests a combination of features that is believed to be more appropriate to the purpose these tools are used for. However, it hasn't been tested anywhere and further research is required to fine tune its applicability. Species richness, overall substratum cover and early successional species cover are probably affected by disturbance with different magnitudes and the tool might therefore require uneven weighting of each feature accordingly. Ideally, the tool should be tested in classifying shores affected by different types of pollution and at increasing distances from the pollution sources.

Shores affected by shallow water hydrothermal activity are the only possible environment where this tool could be tested in the Azores. A first account of this type of environment and how seaweed communities are affected by it is given in chapter 5 of the present thesis. Such environments are naturally acidic and metal enriched and are therefore comparable to anthropogenically polluted shores elsewhere, such as acid mine drainage affected shores in the British Isles. Despite the obvious differences in seaweed communities between the Azores and the British Isles, there are surprising similarities in the way these are affected by hydrothermal and acid mine drainage inputs. Functional group composition is affected in the same way and so is the accumulation of some metals in *F. spiralis*, the only large fucoid that is common to both regions. Such evidence enhances the need to consider the impacts of pollution at the biological level of individual organisms, which might not translate into obvious ecological changes and

therefore do not affect the quality of ecosystems in a visible way. Brown species are widely used as metal accumulation indicators due to the biochemical affinity of its tissues with metallic ions and the wide geographical distribution of *F. spiralis* makes it a good candidate for biomonitoring purposes. However, the way some factors that vary geographically, such as temperature and light conditions, affect the physiological response of this species to the exposure to pollutants remains fairly unknown and requires further investigation. The preliminary results presented in this thesis on the effects of temperature and acidity on growth, photosynthesis and respiration of *F. spiralis* provide a basis for further research that is needed to sustain the reliable use of this organism as a monitoring tool for the effects of pollution over a wide geographical scale. Furthermore, given the growing concerns about ocean warming and acidification, studying the effects of such factors might prove helpful in anticipating how such a tool might be affected if such scenario arises.

# CHAPTER 7

## CONCLUDING REMARKS

# 7. CONCLUDING REMARKS

Pollution and nutrient enrichment of the marine environment as a consequence of anthropogenic pressure on coastal communities are a consequence of relatively recent demographic and social-economic phenomena with exponential growth since the burst of the Industrial Revolution in the transition from the 18$^{th}$ to the 19$^{th}$ centuries. Although coastal communities have been affected by industrial and urban development ever since their early days, regulation of industrial and urban discharges to the marine environment became an issue only when their impacts started becoming obvious. It was only in the second half of the 20$^{th}$ century that environmental science, as an expansion of ecology, became alive as an active field of scientific investigation, integrating physical-chemical and biological sciences as a means to study and solve environmental problems.

The aquatic environment plays a major role at the scale of the planet, as it covers over two thirds of the Earth's surface, of which more than 90% is marine. Given that over half of the World's population lives near the coast, with tendency to increase in the future, marine environmental affairs have become of increasing generalized interest. Within the context of marine pollution and nutrient enrichment, the perspective of this generalized interest varies, though. From a purely scientific perspective marine biologists are interested in the effects of pollution and nutrient enrichment at the level of individuals (cellular, physiological, morphological) and/or populations, marine ecologists in studying these factors' influence at the overall community level (distribution and abundance of organisms, their processes and interactions), while environmental scientists would be further concerned with chemical and/or public health issues arising from them. From the perspective of pollution producers, those that use the marine environment to dispose of their waste products (polluting or nutrient enriching), assuming they have an environmentally friendly attitude, the main interest is to find the cheapest way to reduce the impact of waste products to an environmentally acceptable level. From a political perspective, environmentalists are mainly interested in spectacular impacts of pollution and nutrient enrichment when caused by large powerful private and/or public organizations, while governmental agencies are interested in the cheapest and quickest way to quantitatively assess and monitor these impacts.

Scientists are caught half way between pollution producers and pollution regulators. To a great extent they depend on financing policies for their research and its framework is

set by governmental agencies. Aside from their natural interest and concern regarding the impacts of pollution at various levels, it is expected from scientists to set guidelines for what is environmentally acceptable, and to define quick and easy tools for assessing and monitoring environmental quality and impacts. The conflict then arises – assessing the impacts of pollution on complex ecological systems in a quick and easy way with limited funds and with the responsibility of stating whether they are environmentally acceptable, or not. Temporal variability is a natural characteristic of ecosystems, and therefore quick assessments of their condition might prove faulty if not considered with caution. Easy ways to understand complex systems is a paradox by definition, and therefore dangerous. Limited funds are likely to minimize the use of expert knowledge and therefore lead to scientifically unfunded solutions. Fortunately, the responsibility in making an environmental judgement, either by scientists or by governmental agencies, works favourably to the environment. The precautionary principle avoids beneficial misclassifications, i.e. in case of doubt assume that there is a negative impact. However, such an assumption might bring substantial cost if measures are required to reverse the impact and monitor recovery.

Despite all this, the real problem of using environmental science with political interest is the danger of losing track of the pure ecological perspective, i.e. failing to understand how biological communities, their habitats and their interactions are affected in the short and long terms by anthropogenic pressure. That is what really is in stake. It is therefore crucial to use community features that reflect ecological processes in the clearest way possible. Different organisms respond in different ways and with different timing to different disturbances. Furthermore, disturbance is a natural phenomenon in ecological processes and it is not always easy to distinguish the effects of natural and anthropogenic disturbance. In either case, disturbance can affect habitats, organisms individually, populations and/or intra- and interspecific interactions. It would thus be desirable to gather information on the sensitivity of different organisms to different sources of pollution (e.g. nutrients, metals, temperature, acidity), and in what way these are affected. Their classification according to such parameters would be more useful for environmental quality assessment, than any other ecological classifications based on the anatomical, morphological and/or life cycle characteristics of species under natural undisturbed conditions.

Different features of individual organisms and of communities might be affected simultaneously by the same disturbance, and it is therefore desirable to consider as

much relevant information as possible when assessing its effects. The increasingly widespread use of multimetric approaches reflects their growing acceptance among the scientific community working with the common goal of providing tools for environmental managers to evaluate ecological quality of coastal communities. Despite their usefulness, these tools require solid scientific background that is neither quick, nor easy, nor cheap to obtain. Extensive expert knowledge is required to define which features to be used and how these are to be surveyed. Scientifically solid guidelines require the analysis of an enormous amount of ecological data with spatial and temporal replication.

Despite the efforts made in developing a tool for evaluating ecological quality of rocky shore communities within the Northeast Atlantic region, the most recent EU directive (MSFD) on the protection of the marine environment sets new guidelines on how coastal communities should be addressed and evaluated, focusing on the species composition; biomass and annual/seasonal variability of macroalgae among several other benthic organisms (EC, 2008). Money and time have been wasted if the tools developed for the previous directive are simply thrown into a drawer and forgotten, now that they have proven to be working properly for the purpose for which they have been designed. An effort should be made to include such valuable information and methods into this recent framework and build on them for further improvement within its more logical biogeographic organization.

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# APPENDICES

# Appendix 1

List of seaweeds recorded on Azorean shores and respective ecological status group (ESG), opportunist status and functional group (FG). Nomenclature according to Guiry and Guiry (2011).

**Appendix 1** - List of seaweeds recorded on Azorean shores and respective ecological status group (ESG), opportunist status and functional group (FG). Nomenclature according to Guiry and Guiry (2011).

| Species | Authority | ESG | Opportunist | FG |
|---|---|---|---|---|
| **Rhodophyta** | | | | |
| *Acrochaetium codii* | G.Hamel | 2 | | 1 |
| *Acrochaetium* sp. | Nägeli in Nägeli & Cramer | 2 | | 1 |
| *Acrosorium venulosum* | (Zanardini) Kylin | 2 | | 2 |
| *Acrosorium* sp. | Zanardini ex Kützing | 2 | | 2 |
| *Acrosymphyton* sp. | Sjöstedt | 2 | | 5 |
| *Aglaothamnion byssoides* | (Arnott ex Harvey) C.F.Boudouresque & M.M.Perret-Boudouresque | 2 | | 3 |
| *Aglaothamnion cordatum* | (Børgesen) Feldmann-Mazoyer | 2 | | 3 |
| *Aglaothamnion gallicum* | (Nägeli) L'Hardy-Halos & Ardré | 2 | | 3 |
| *Aglaothamnion hookeri* | (Dillwyn) Maggs & Hommersand | 2 | | 3 |
| *Aglaothamnion pseudobyssoides* | (P.L.Crouan & H.M.Crouan) Halos | 2 | | 3 |
| *Aglaothamnion roseum* | (Roth) Maggs & L'Hardy-Halos | 2 | | 3 |
| *Aglaothamnion* sp. | Feldmann-Mazoyer | 2 | | 3 |
| *Aglaothamnion tenuissimum* | (Bonnemaison) Feldmann-Mazoyer | 2 | | 3 |
| *Ahnfeltia plicata* | (Hudson) E.M.Fries | 1 | | 5 |
| *Ahnfeltiopsis devoniensis* | (Greville) P.C.Silva & DeCew | 1 | | 5 |
| *Amphiroa beauvoisii* | J.V.Lamouroux | 1 | | 7 |
| *Amphiroa fragilissima* | (Linnaeus) J.V.Lamouroux | 1 | | 7 |
| *Amphiroa rigida* | J.V.Lamouroux | 1 | | 7 |
| *Amphiroa* sp. | J.V.Lamouroux | 1 | | 7 |
| *Anotrichium furcellatum* | (J.Agardh) Baldock | 2 | | 3 |
| *Anotrichium* sp. | Nägeli | 2 | | 3 |
| *Anotrichium tenue* | (C.Agardh) Nägeli | 2 | | 3 |
| *Antithamnion cruciatum* | (C.Agardh) Nägeli | 2 | | 3 |
| *Antithamnion decipiens* | (J.Agardh) Athanasiadis | 2 | | 3 |
| *Antithamnion densum* | (Suhr) M.A.Howe | 2 | | 3 |

**Appendix 1 (cont.)** - List of seaweeds recorded on Azorean shores and respective ecological status group (ESG), opportunist status and functional group (FG). Nomenclature according to Guiry and Guiry (2011).

| Species | Authority | ESG | Opportunist | FG |
|---|---|---|---|---|
| *Antithamnion diminuatum* | Wollaston | 2 | | 3 |
| *Antithamnion* sp. | Nägeli | 2 | | 3 |
| *Antithamnionella boergesenii* | (Cormaci & G.Furnari) Athanasiadis | 2 | | 3 |
| *Aphanocladia stichidiosa* | (Funk) Ardré | 2 | | 4 |
| *Apoglossum ruscifolium* | (Turner) J.Agardh | 2 | | 2 |
| *Asparagopsis armata* | Harvey | 1 | | 4 |
| *Asparagopsis* sp. | Montagne in Barker-Webb & Berthelot | 2 | | 4 |
| *Asparagopsis taxiformis* | (Delile) Trevisan de Saint-Léon | 2 | | 4 |
| *Asteromenia peltata* | (W.R.Taylor) Huisman & A.J.K.Millar | 2 | | 5 |
| *Bangia* sp. | Lyngbye | 2 | | 3 |
| *Boergeseniella fruticulosa* | (Wulfen) Kylin | 1 | | 4 |
| *Boergeseniella thuyoides* | (Harvey) Kylin | 1 | | 4 |
| *Bonnemaisonia hamifera* | Hariot | 2 | | 4 |
| *Bornetia secundiflora* | (J.Agardh) Thuret | 2 | | 3 |
| *Botryocladia botryoides* | (Wulfen) Feldmann | 1 | | 5 |
| *Botryocladia macaronesica* | Afonso-Carillo, Sobrino, Tittley & Neto | 1 | | 5 |
| *Botryocladia* sp. | (J.Agardh) Kylin | 1 | | 5 |
| *Callithamnion corymbosum* | (Smith) Lyngbye | 2 | | 3 |
| *Callithamnion* sp. | Lyngbye | 2 | | 3 |
| *Callithamnion tetragonum* | (Withering) S.F.Gray | 2 | | 3 |
| *Catenella caespitosa* | (Withering) L.M.Irvine | 1 | | 5 |
| *Caulacanthus ustulatus* | (Mertens ex Turner) Kützing | 1 | | 5 |
| *Centroceras clavulatum* | (C.Agardh) Montagne | 2 | | 4 |
| *Ceramium atrorubescens* | Kylin | 2 | | 4 |
| *Ceramium botryocarpum* | A.W.Griffiths ex Harvey | 2 | | 4 |
| *Ceramium ciliatum* | (J.Ellis) Ducluzeau | 2 | | 4 |

**Appendix 1 (cont.)** - List of seaweeds recorded on Azorean shores and respective ecological status group (ESG), opportunist status and functional group (FG). Nomenclature according to Guiry and Guiry (2011).

| Species | Authority | ESG | Opportunist | FG |
|---|---|---|---|---|
| *Ceramium cingulatum* | Weber-van Bosse | 2 | | 4 |
| *Ceramium circinatum* | (Kützing) J.Agardh | 2 | | 4 |
| *Ceramium codii* | (H.Richards) Mazoyer | 2 | | 4 |
| *Ceramium deslongchampsii* | Chauvin ex Duby | 2 | | 4 |
| *Ceramium diaphanum* | (Lightfoot) Roth | 2 | | 4 |
| *Ceramium echionotum* | J.Agardh | 2 | | 4 |
| *Ceramium flaccidum* | (Harvey ex Kützing) Ardissone | 2 | | 4 |
| *Ceramium gaditanum* | (Clemente) Cremades | 2 | | 4 |
| *Ceramium rubrum* | C.Agardh | 2 | | 4 |
| *Ceramium* sp. | Roth | 2 | | 4 |
| *Ceramium tenerrimum* | (G.Martens) Okamura | 2 | | 4 |
| *Ceramium virgatum* | Roth | 2 | | 4 |
| *Champia parvula* | (C.Agardh) Harvey | 2 | | 5 |
| *Chondracanthus acicularis* | (Roth) Fredericq | 1 | | 5 |
| *Chondracanthus teedei* | (Mertens ex Roth) Kützing | 1 | | 5 |
| *Chondria capillaris* | (Hudson) M.J.Wynne | 1 | | 5 |
| *Chondria coerulescens* | (J.Agardh) Falkenberg | 1 | | 5 |
| *Chondria dasyphylla* | (Woodward) C.Agardh | 1 | | 5 |
| *Chondria* sp. | C.Agardh | 1 | | 5 |
| *Chylocladia verticillata* | (Lightfoot) Bliding | 2 | | 5 |
| *Coelothrix irregularis* | (Harvey) Børgesen | 2 | | 5 |
| *Corallina elongata* | J.Ellis & Solander | 1 | | 7 |
| *Corallina* sp. | Linnaeus | 1 | | 7 |
| *Calcareous crust* | | 1 | | 8 |
| *Red crust* | | 1 | | 8 |
| *Crouania attenuata* | (C.Agardh) J.Agardh | 2 | | 5 |

**Appendix 1 (cont.)** - List of seaweeds recorded on Azorean shores and respective ecological status group (ESG), opportunist status and functional group (FG). Nomenclature according to Guiry and Guiry (2011).

| Species | Authority | ESG | Opportunist | FG |
|---|---|---|---|---|
| *Cryptonemia lomation* | (Bertoloni) J.Agardh | 1 | | 5 |
| *Cryptopleura ramosa* | (Hudson) L.Newton | 2 | | 2 |
| *Ctenosiphonia hypnoides* | (Welwitsch ex J.Agardh) Falkenberg | 1 | | 5 |
| *Dasya caraibica* | Børgesen | 2 | | 4 |
| *Dasya corymbifera* | J.Agardh | 2 | | 4 |
| *Dasya crouaniana* | J.Agardh | 2 | | 4 |
| *Dasya hutchinsiae* | Harvey | 2 | | 4 |
| *Dasya rigidula* | (Kützing) Ardissone | 2 | | 4 |
| *Dasya* sp. | C.Agardh | 2 | | 4 |
| *Diplothamnion jolyi* | C.Hoek | 2 | | 3 |
| *Diplothamnion* sp. | A.B.Joly & Yamaguishi | 2 | | 3 |
| *Dipterosiphonia* sp. | Schmitz & Falkenberg in Engler & Prantl | 1 | | 5 |
| *Drachiella minuta* | (Kylin) Maggs & Hommersand | 2 | | 2 |
| *Erythrocystis montagnei* | (Derbès & Solier) P.C.Silva | 1 | | 5 |
| *Erythrodermis traillii* | (Holmes ex Batters) Guiry & Garbary | 1 | | 2 |
| *Erythrotrichia carnea* | (Dillwyn) J.Agardh | 2 | | 1 |
| *Eupogodon planus* | (C.Agardh) Kützing | 2 | | 4 |
| *Falkenbergia rufolanosa* | (Harvey) F.Schmitz | 2 | | 4 |
| *Falkenbergia* sp. | F.Schmitz in Engler & Prantl | 2 | | 4 |
| *Feldmannophycus rayssiae* | (Feldmann & G.Feldmann) Augier & Boudouresque | 1 | | 5 |
| *Gastroclonium clavatum* | (Roth) Ardissone | 1 | | 5 |
| *Gastroclonium ovatum* | (C.Agardh) Kützing | 1 | | 5 |
| *Gastroclonium reflexum* | (Chauvin) Kützing | 2 | | 5 |
| *Gelidiella pannosa* | Feldmann & G.Hamel | 1 | | 5 |
| *Gelidiella tinerfensis* | Seoane-Camba | 1 | | 5 |
| *Gelidiopsis intricata* | (C.Agardh) Vickers | 1 | | 5 |

**Appendix 1 (cont.)** - List of seaweeds recorded on Azorean shores and respective ecological status group (ESG), opportunist status and functional group (FG). Nomenclature according to Guiry and Guiry (2011).

| Species | Authority | ESG | Opportunist | FG |
|---|---|---|---|---|
| *Gelidium arbusculum* | Bory de Saint-Vincent ex Børgesen | 1 | | 5 |
| *Gelidium microdon* | Kützing | 1 | | 5 |
| *Gelidium pusillum* | (Stackhouse) Le Jolis | 1 | | 5 |
| *Gelidium* sp. | J.V.Lamouroux | 1 | | 5 |
| *Gelidium spinosum* | (S.G.Gmelin) P.C.Silva | 1 | | 5 |
| *Gigartina pistillata* | (S.G.Gmelin) Stackhouse | 1 | | 5 |
| *Gigartina* sp. | Stackhouse | 1 | | 5 |
| *Gloiocladia* sp. | J.Agardh | 1 | | 5 |
| *Gracilaria gracilis* | (Stackhouse) M.Steentoft, L.M.Irvine & W.F.Farnham | 1 | | 5 |
| *Gracilaria multipartita* | (Clemente) Harvey | 1 | | 5 |
| *Grallatoria reptans* | M.A.Howe | 2 | | 4 |
| *Grateloupia dichotoma* | J.Agardh | 1 | | 5 |
| *Grateloupia doryphora* | (Montagne) M.A.Howe | 1 | | 5 |
| *Grateloupia filicina* | (J.V.Lamouroux) C.Agardh | 2 | | 5 |
| *Grateloupia* sp. | C.Agardh | 1 | | 5 |
| *Griffithsia corallinoides* | (Linnaeus) Trevisan | 2 | | 3 |
| *Griffithsia phyllamphora* | J.Agardh | 2 | | 3 |
| *Griffithsia* sp. | C.Agardh | 2 | | 3 |
| *Gymnogongrus crenulatus* | (Turner) J.Agardh | 1 | | 5 |
| *Gymnogongrus griffithsiae* | (Turner) Martius | 1 | | 5 |
| *Gymnogongrus* sp. | Martius | 1 | | 5 |
| *Gymnothamnion elegans* | (Schousboe ex C.Agardh) J.Agardh | 2 | | 4 |
| *Haliptilon* sp. | (Decaisne) Lindley | 1 | | 7 |
| *Haliptilon virgatum* | (Zanardini) Garbary & H.W.Johansen | 1 | | 7 |
| *Halurus flosculosus* | (J.Ellis) Maggs & Hommersand | 2 | | 3 |
| *Herposiphonia secunda* | (C.Agardh) Ambronn | 1 | | 5 |

**Appendix 1 (cont.)** - List of seaweeds recorded on Azorean shores and respective ecological status group (ESG), opportunist status and functional group (FG). Nomenclature according to Guiry and Guiry (2011).

| Species | Authority | ESG | Opportunist | FG |
|---|---|---|---|---|
| *Herposiphonia* sp. | Nägeli | 1 | | 5 |
| *Heterosiphonia crispella* | (C.Agardh) M.J.Wynne | 2 | | 4 |
| *Hildenbrandia crouaniorum* | J.Agardh | 1 | | 8 |
| *Hildenbrandia rubra* | (Sommerfelt) Meneghini | 1 | | 8 |
| *Hildenbrandia* sp. | Nardo | 1 | | 8 |
| *Hydrolithon* sp. | (Foslie) Foslie | 2 | | 1 |
| *Hypnea arbuscula* | P.Dangeard | 2 | | 4 |
| *Hypnea flagelliformis* | Greville ex J.Agardh | 2 | | 4 |
| *Hypnea musciformis* | (Wulfen) J.V.Lamouroux | 2 | | 4 |
| *Hypnea* sp. | J.V.Lamouroux | 2 | | 4 |
| *Hypnea spinella* | (C.Agardh) Kützing | 2 | | 4 |
| *Hypoglossum hypoglossoides* | (Stackhouse) F.S.Collins & Hervey | 2 | | 2 |
| *Jania* sp. | J.V.Lamouroux | 1 | | 7 |
| *Jania adhaerens* | J.V.Lamouroux | 1 | | 7 |
| *Jania capillacea* | Harvey | 1 | | 7 |
| *Jania longifurca* | Zanardini | 1 | | 7 |
| *Jania pumila* | J.V.Lamouroux | 1 | | 7 |
| *Jania rubens* | (Linnaeus) J.V.Lamouroux | 1 | | 7 |
| *Laurencia hybrida* | (A.P.de Candolle) T.Lestiboudois | 1 | | 5 |
| *Laurencia brongniartii* | J.Agardh | 1 | | 5 |
| *Laurencia chondrioides* | Børgesen | 1 | | 5 |
| *Laurencia flexilis* | Setchell | 1 | | 5 |
| *Laurencia intricata* | J.V.Lamouroux | 1 | | 5 |
| *Laurencia majuscula* | (Harvey) A.H.S.Lucas | 1 | | 5 |
| *Laurencia microcladia* | Kützing | 1 | | 5 |
| *Laurencia minuta* | Vandermeulen, Garbary & Guiry | 1 | | 5 |

**Appendix 1 (cont.)** - List of seaweeds recorded on Azorean shores and respective ecological status group (ESG), opportunist status and functional group (FG). Nomenclature according to Guiry and Guiry (2011).

| Species | Authority | ESG | Opportunist | FG |
|---|---|---|---|---|
| *Laurencia obtusa* | (Hudson) J.V.Lamouroux | 1 | | 5 |
| *Laurencia* sp. | J.V.Lamouroux | 1 | | 5 |
| *Laurencia tenera* | C.K.Tseng | 1 | | 5 |
| *Laurencia viridis* | Gil-Rodríguez & Haroun | 1 | | 5 |
| *Lejolisia mediterranea* | Bornet | 2 | | 4 |
| *Liagora distenta* | (Mertens ex Roth) J.V.Lamouroux | 1 | | 5 |
| *Liagora maderensis* | Kützing | 1 | | 5 |
| *Liagora* sp. | J.V.Lamouroux | 1 | | 5 |
| *Liagora viscida* | (Forsskål) C.Agardh | 1 | | 5 |
| *Lithophyllum incrustans* | Philippi | 1 | | 8 |
| *Lithophyllum polycephalum* | Foslie | 1 | | 8 |
| *Lithophyllum* sp. | Philippi | 1 | | 8 |
| *Lomentaria articulata* | (Hudson) Lyngbye | 1 | | 5 |
| *Lomentaria clavellosa* | (Turner) Gaillon | 2 | | 5 |
| *Lomentaria linearis* | Zanardini | 1 | | 5 |
| *Lomentaria orcadensis* | (Harvey) F.S.Collins | 1 | | 5 |
| *Lophosiphonia cristata* | Falkenberg | 1 | | 5 |
| *Lophosiphonia reptabunda* | (Suhr) Kylin | 1 | | 5 |
| *Lophosiphonia* sp. | Falkenberg in F.Schmitz & Falkenberg | 1 | | 5 |
| *Mastocarpus stellatus* | (Stackhouse) Guiry | 1 | | 5 |
| *Melobesia* sp. | J.V.Lamouroux | 1 | | 8 |
| *Meredithia microphylla* | (J.Agardh) J.Agardh | 2 | | 5 |
| *Mesophyllum canariense* | (Foslie) M.Lemoine | 1 | | 8 |
| *Mesophyllum lichenoides* | (J.Ellis) Marie Lemoine | 1 | | 8 |
| *Nemalion helminthoides* | (Velley) Batters | 2 | | 5 |
| *Neosiphonia harveyi* | (J.W.Bailey) M.-S.Kim, H.-G.Choi, Guiry & G.W.Saunders | 2 | | 4 |

**Appendix 1 (cont.)** - List of seaweeds recorded on Azorean shores and respective ecological status group (ESG), opportunist status and functional group (FG). Nomenclature according to Guiry and Guiry (2011).

| Species | Authority | ESG | Opportunist | FG |
|---|---|---|---|---|
| *Neosiphonia sphaerocarpa* | (Børgesen) M.S.Kim & I.K.Lee | 2 | | 4 |
| *Nitophyllum punctatum* | (Stackhouse) Greville | 2 | | 2 |
| *Nitophyllum* sp. | Greville | 2 | | 2 |
| *Ophidocladus simpliciusculus* | (P.L.Crouan & H.M.Crouan) Falkenberg | 2 | | 4 |
| *Osmundea hybrida* | (A.P.de Candolle) K.W.Nam | 1 | | 5 |
| *Osmundea pinnatifida* | (Hudson) Stackhouse | 1 | | 5 |
| *Osmundea* sp. | Stackhouse | 1 | | 5 |
| *Osmundea truncata* | (Kützing) K.W.Nam & Maggs | 1 | | 5 |
| *Palisada corallopsis* | (Montagne) Sentíez, Fujii & Díaz | 1 | | 5 |
| *Palisada patentiramea* | (Montagne) Cassano, Sentíes, Gil-Rodríguez & M.T.Fujii | 1 | | 5 |
| *Palisada perforata* | (Bory de Saint-Vincent) K.W.Nam | 1 | | 5 |
| *Palisada poiteaui* | (J.V.Lamouroux) K.W.Nam | 1 | | 5 |
| *Peyssonnelia rubra* | (Greville) J.Agardh | 1 | | 8 |
| *Peyssonnelia* sp. | Decaisne | 1 | | 8 |
| *Peyssonnelia squamaria* | (S.G.Gmelin) Decaisne | 1 | | 8 |
| *Phyllophora crispa* | (Hudson) P.S.Dixon | 1 | | 5 |
| *Phyllophora gelidioides* | P.L.Crouan & H.M.Crouan ex Karsakoff | 1 | | 5 |
| *Phymatolithon lenormandii* | (Areschoug) W.H.Adey | 1 | | 8 |
| *Platoma* sp. | Schousboe ex F.Schmitz | 1 | | 8 |
| *Pleonosporium borreri* | (Smith) Nägeli | 2 | | 3 |
| *Pleonosporium caribaeum* | (Børgesen) R.E.Norris | 2 | | 3 |
| *Pleonosporium* sp. | Nägeli | 2 | | 3 |
| *Plocamium cartilagineum* | (Linnaeus) P.S.Dixon | 2 | | 4 |
| *Polysiphonia atlantica* | Kapraun & J.N.Norris | 2 | | 4 |
| *Polysiphonia brodiaei* | (Dillwyn) Sprengel | 2 | | 4 |
| *Polysiphonia ceramiaeformis* | P.L.Crouan & H.M.Crouan | 2 | | 4 |

**Appendix 1 (cont.)** - List of seaweeds recorded on Azorean shores and respective ecological status group (ESG), opportunist status and functional group (FG). Nomenclature according to Guiry and Guiry (2011).

| Species | Authority | ESG | Opportunist | FG |
|---|---|---|---|---|
| *Polysiphonia denudata* | (Dillwyn) Greville ex Harvey | 2 | | 4 |
| *Polysiphonia elongata* | (Hudson) Sprengel | 1 | | 4 |
| *Polysiphonia flexella* | (C.Agardh) J.Agardh | 2 | | 4 |
| *Polysiphonia furcellata* | (C.Agardh) Harvey | 2 | | 4 |
| *Polysiphonia harveyi* | J.W.Bailey | 2 | | 4 |
| *Polysiphonia havanensis* | Montagne | 2 | | 4 |
| *Polysiphonia opaca* | (C.Agardh) Moris & De Notaris | 2 | | 4 |
| *Polysiphonia scopulorum* | Harvey | 2 | | 4 |
| *Polysiphonia* sp. | Greville | 2 | | 4 |
| *Polysiphonia sphacelarioides* | J.Agardh | 2 | | 4 |
| *Polysiphonia stricta* | (Dillwyn) Greville | 2 | | 4 |
| *Polysiphonia tripinnata* | J.Agardh | 2 | | 4 |
| *Porphyra leucosticta* | Thuret | 2 | 1 | 2 |
| *Porphyra* sp. | C.Agardh | 2 | 1 | 2 |
| *Porphyra umbilicalis* | Kützing | 2 | 1 | 2 |
| *Pterocladiella capillacea* | (S.G.Gmelin) Santelices & Hommersand | 1 | | 5 |
| *Pterocladiella melanoidea* | (Schousboe ex Bornet) Santelices & Hommersand | 1 | | 5 |
| *Pterosiphonia pennata* | (C.Agardh) Sauvageau | 1 | | 5 |
| *Pterosiphonia pinnulata* | (Kützing) Maggs & Hommersand | 1 | | 5 |
| *Ptilothamnion pluma* | (Dillwyn) Thuret | 2 | | 3 |
| *Rhodomela confervoides* | (Hudson) P.C.Silva | 2 | | 4 |
| *Rhodophyllis divaricata* | (Stackhouse) Papenfuss | 2 | | 5 |
| *Rhodymenia ardissonei* | (Kuntze) Feldmann | 2 | | 5 |
| *Rhodymenia holmesii* | Ardissone | 1 | | 5 |
| *Rhodymenia pseudopalmata* | (J.V.Lamouroux) P.C.Silva | 1 | | 5 |
| *Rhodymenia* sp. | Greville | 1 | | 5 |

**Appendix 1 (cont.)** - List of seaweeds recorded on Azorean shores and respective ecological status group (ESG), opportunist status and functional group (FG). Nomenclature according to Guiry and Guiry (2011).

| Species | Authority | ESG | Opportunist | FG |
|---|---|---|---|---|
| *Schizymenia dubyi* | (Chauvin ex Duby) J.Agardh | 1 | | 5 |
| *Schottera nicaeënsis* | (J.V.Lamouroux ex Duby) Guiry & Hollenberg | 1 | | 5 |
| *Sebdenia macaronesica* | Soler-Onis, Haroun & Prud'homme van Reine | 1 | | 5 |
| *Spermothamnion flabellatum* | Bornet | 2 | | 3 |
| *Spermothamnion repens* | (Dillwyn) Rosenvinge | 2 | | 3 |
| *Sphaerococcus coronopifolius* | Stackhouse | 1 | | 5 |
| *Sphondylothamnion multifidum* | (Hudson) Nägeli | 2 | | 3 |
| *Spongites fruticulosa* | Kützing | 1 | | 8 |
| *Spyridia filamentosa* | (Wulfen) Harvey | 2 | | 4 |
| *Stylonema alsidii* | (Zanardini) K.M.Drew | 2 | | 3 |
| *Symphyocladia marchantioides* | (Harvey) Falkenberg | 1 | | 8 |
| *Taenioma nanum* | (Kützing) Papenfuss | 2 | | 4 |
| *Tiffaniella capitata* | (Schousboe ex Bornet) Doty & Meñez | 2 | | 4 |
| *Tsengia bairdii* | (Farlow) K.C.Fan & Y.P.Fan | 2 | | 5 |
| *Wrangelia penicillata* | (C.Agardh) C.Agardh | 2 | | 4 |
| *Wrangelia* sp. | C.Agardh | 2 | | 4 |
| *Wurdemannia miniata* | (Sprengel) Feldmann & G.Hamel | 1 | | 4 |
| **Phaeophyceae** | | | | |
| *Asteronema rhodochortonoides* | (Børgesen) D.G.Müller & E.R.Parodi | 2 | | 3 |
| *Bachelotia antillarum* | (Grunow) Gerloff | 2 | | 3 |
| *Cladostephus spongiosus* | (Hudson) C.Agardh | 1 | | 4 |
| *Colpomenia sinuosa* | (Mertens ex Roth) Derbès & Solier | 1 | | 5 |
| *Brown crust* | | 1 | | 8 |
| *Cystoseira* sp. | C.Agardh | 1 | | 6 |
| *Cystoseira abies-marina* | (S.G.Gmelin) C.Agardh | 1 | | 6 |
| *Cystoseira foeniculacea* | (Linnaeus) Greville | 1 | | 6 |

**Appendix 1 (cont.)** - List of seaweeds recorded on Azorean shores and respective ecological status group (ESG), opportunist status and functional group (FG). Nomenclature according to Guiry and Guiry (2011).

| Species | Authority | ESG | Opportunist | FG |
|---|---|---|---|---|
| *Cystoseira humilis* | Schousboe ex Kützing | 1 | | 6 |
| *Cystoseira wildpretii* | Nizamuddin | 1 | | 6 |
| *Dictyopteris polypodioides* | (A.P.De Candolle) J.V.Lamouroux | 1 | | 5 |
| *Dictyota bartayresiana* | J.V.Lamouroux | 2 | | 2 |
| *Dictyota dichotoma* | (Hudson) J.V.Lamouroux | 2 | | 2 |
| *Dictyota friabilis* | Setchell | 2 | | 2 |
| *Dictyota pinnatifida* | Kützing | 2 | | 2 |
| *Dictyota* sp. | J.V.Lamouroux | 2 | | 2 |
| *Ectocarpus fasciculatus* | Harvey | 2 | 1 | 3 |
| *Ectocarpus siliculosus* | (Dillwyn) Lyngbye | 2 | 1 | 3 |
| *Ectocarpus* sp. | Lyngbye | 2 | 1 | 3 |
| *Endarachne binghamiae* | J.Agardh | 2 | | 5 |
| *Endarachne* sp. | J.Agardh | 2 | | 5 |
| *Feldmannia* sp. | G.Hamel | 2 | | 1 |
| *Feldmannia globifera* | (Kützing) G.Hamel | 2 | | 1 |
| *Feldmannia irregularis* | (Kützing) G.Hamel | 2 | | 1 |
| *Feldmannia paradoxa* | (Montagne) G.Hamel | 2 | | 1 |
| *Fucus spiralis* | Linnaeus | 1 | | 6 |
| *Halopteris filicina* | (Grateloup) Kützing | 1 | | 4 |
| *Hecatonema terminale* | (Kützing) Kylin | 2 | | 1 |
| *Hincksia intermedia* | (Rosenvinge) P.C.Silva | 2 | | 3 |
| *Hincksia ovata* | (Kjellman) P.C.Silva | 2 | | 3 |
| *Hincksia rallsiae* | (Vickers) P.C.Silva | 2 | | 3 |
| *Hincksia* sp. | J.E.Gray | 2 | | 3 |
| *Hydroclathrus clathratus* | (C.Agardh) M.A.Howe | 2 | | 5 |
| *Leathesia difformis* | Areschoug | 2 | | 5 |

**Appendix 1 (cont.)** - List of seaweeds recorded on Azorean shores and respective ecological status group (ESG), opportunist status and functional group (FG). Nomenclature according to Guiry and Guiry (2011).

| Species | Authority | ESG | Opportunist | FG |
|---|---|---|---|---|
| *Lobophora variegata* | (J.V.Lamouroux) Womersley ex E.C.Oliveira | 1 | | 5 |
| *Myriactula chordae* | (Å)reschoug) Levring | 2 | | 1 |
| *Myrionema strangulans* | Greville | 2 | | 1 |
| *Nemoderma tingitanum* | Schousboe ex Bornet | 1 | | 8 |
| *Padina pavonica* | (Linnaeus) Thivy | 2 | | 2 |
| *Papenfussiella kuromo* | (Yendo) Inagaki | 2 | | 3 |
| *Petrospongium berkeleyi* | (Greville) Nägeli ex Kützing | 1 | | 1 |
| *Pilinia rimosa* | Kützing | 2 | | 1 |
| *Pseudolithoderma adriaticum* | (Hauck) Verlaque | 1 | | 8 |
| *Pseudolithoderma sp.* | Svedelius | 1 | | 8 |
| *Ralfsia* sp. | Berkeley | 1 | | 8 |
| *Ralfsia verrucosa* | (Å)reschoug) Å)reschoug | 1 | | 8 |
| *Sargassum acinarium* | (Linnaeus) Setchell | 1 | | 6 |
| *Sargassum cymosum* | C.Agardh | 1 | | 6 |
| *Sargassum furcatum* | Kützing | 1 | | 6 |
| *Sargassum* sp. | C.Agardh | 1 | | 6 |
| *Scytosiphon lomentaria* | (Lyngbye) Link | 2 | | 5 |
| *Spatoglossum solieri* | (Chauvin ex Montagne) Kützing | 2 | | 2 |
| *Sphacelaria cirrosa* | (Roth) C.Agardh | 1 | | 3 |
| *Sphacelaria fusca* | (Hudson) S.F.Gray | 1 | | 3 |
| *Sphacelaria rigidula* | Kützing | 1 | | 3 |
| *Sphacelaria* sp. | Lyngbye in Hornemann | 1 | | 3 |
| *Sphacelaria tribuloides* | Meneghini | 1 | | 3 |
| *Stypocaulon scoparium* | (Linnaeus) Kützing | 1 | | 4 |
| *Taonia atomaria* | (Woodward) J.Agardh | 2 | | 2 |
| *Zonaria tournefortii* | (J.V.Lamouroux) Montagne | 1 | | 5 |

**Appendix 1 (cont.)** - List of seaweeds recorded on Azorean shores and respective ecological status group (ESG), opportunist status and functional group (FG). Nomenclature according to Guiry and Guiry (2011).

| Species | Authority | ESG | Opportunist | FG |
|---|---|---|---|---|
| **Chlorophyta** | | | | |
| *Anadyomene saldanhae* | A.B.Joly & E.C.Oliveira | 2 | | 8 |
| *Anadyomene stellata* | (Wulfen) C.Agardh | 2 | | 8 |
| *Blidingia marginata* | (J.Agardh) P.J.L.Dangeard | 2 | 1 | 2 |
| *Blidingia minima* | (Nägeli ex Kützing) Kylin | 2 | 1 | 2 |
| *Bryopsis corymbosa* | J.Agardh | 2 | | 2 |
| *Bryopsis cupressina* | J.V.Lamouroux | 2 | | 2 |
| *Bryopsis hypnoides* | J.V.Lamouroux | 2 | | 2 |
| *Bryopsis plumosa* | (Hudson) C.Agardh | 2 | | 2 |
| *Chaetomorpha aerea* | (Dillwyn) Kützing | 2 | 1 | 3 |
| *Chaetomorpha antennina* | (Bory de Saint-Vincent) Kützing | 2 | 1 | 3 |
| *Chaetomorpha gracilis* | Kützing | 2 | 1 | 3 |
| *Chaetomorpha ligustica* | (Kützing) Kützing | 2 | 1 | 3 |
| *Chaetomorpha linum* | (O.F.Müller) Kützing | 2 | 1 | 3 |
| *Chaetomorpha pachynema* | (Montagne) Kützing | 2 | 1 | 3 |
| *Chaetomorpha sp.* | Kützing | 2 | 1 | 3 |
| *Cladophora albida* | (Nees) Kutzing | 2 | | 3 |
| *Cladophora coelothrix* | Kützing | 2 | | 3 |
| *Cladophora conferta* | P.L.Crouan & H.M.Crouan | 2 | | 3 |
| *Cladophora dalmatica* | Kützing | 2 | | 3 |
| *Cladophora hutchinsiae* | (Dillwyn) Kützing | 2 | | 3 |
| *Cladophora inclusa* | Børgesen | 2 | | 3 |
| *Cladophora laetevirens* | (Dillwyn) Kützing | 2 | | 3 |
| *Cladophora lehmanniana* | (Lindenberg) Kützing | 2 | | 3 |
| *Cladophora liebetruthii* | Grunow | 2 | | 3 |
| *Cladophora pellucida* | (Hudson) Kützing | 2 | | 3 |

**Appendix 1 (cont.)** - List of seaweeds recorded on Azorean shores and respective ecological status group (ESG), opportunist status and functional group (FG). Nomenclature according to Guiry and Guiry (2011).

| Species | Authority | ESG | Opportunist | FG |
|---|---|---|---|---|
| *Cladophora prolifera* | (Roth) Kützing | 2 | | 3 |
| *Cladophora sericea* | (Hudson) Kützing | 2 | | 3 |
| *Cladophora* sp. | Kützing | 2 | | 3 |
| *Cladophoropsis membranacea* | (Hofman Bang ex C.Agardh) Børgesen | 2 | | 3 |
| *Codium adhaerens* | C.Agardh | 1 | | 5 |
| *Codium decorticatum* | (Woodward) M.A.Howe | 1 | | 5 |
| *Codium effusum* | (Rafinesque) Delle Chiaje | 1 | | 5 |
| *Codium elisabethiae* | O.C.Schmidt | 1 | | 5 |
| *Codium fragile* | Suringar | 1 | | 5 |
| *Codium* sp. | Stackhouse | 1 | | 5 |
| *Codium taylorii* | P.C.Silva | 1 | | 5 |
| *Codium tomentosum* | Stackhouse | 1 | | 5 |
| *Codium vermilara* | (Olivi) Chiaje | 1 | | 5 |
| *Derbesia marina* | (Lyngbye) Solier | 2 | | 2 |
| *Derbesia tenuissima* | (Moris & De Notaris) P.L.Crouan & H.M.Crouan | 2 | | 2 |
| *Enteromorpha multirramosa* | Bliding | 2 | 1 | 2 |
| *Ernodesmis verticillata* | (Kützing) Børgesen | 2 | | 8 |
| *Halydictyon* sp. | Zanardini | 2 | | 8 |
| *Microdictyon boergesenii* | Setchell | 2 | | 8 |
| *Microdictyon calodictyon* | (Montagne) Kützing | 2 | | 8 |
| *Monostroma* sp. | Thuret | 2 | 1 | 2 |
| *Percursaria percursa* | (C.Agardh) Rosenvinge | 2 | | 2 |
| *Rhizoclonium tortuosum* | (Dillwyn) Kützing | 2 | | 3 |
| *Ulva clathrata* | (Roth) C.Agardh | 2 | 1 | 2 |
| *Ulva compressa* | Linnaeus | 2 | 1 | 2 |
| *Ulva flexuosa* | Wulfen | 2 | 1 | 2 |

**Appendix 1 (cont.)** - List of seaweeds recorded on Azorean shores and respective ecological status group (ESG), opportunist status and functional group (FG). Nomenclature according to Guiry and Guiry (2011).

| Species | Authority | ESG | Opportunist | FG |
|---|---|---|---|---|
| *Ulva intestinalis* | Linnaeus | 2 | 1 | 2 |
| *Ulva lactuca* | Linnaeus | 2 | 1 | 2 |
| *Ulva prolifera* | O.F.Müller | 2 | 1 | 2 |
| *Ulva rigida* | C.Agardh | 2 | 1 | 2 |
| *Ulva rotundata* | Bliding | 2 | 1 | 2 |
| *Ulva* sp. | Linnaeus | 2 | 1 | 2 |
| *Valonia macrophysa* | Kützing | 2 | | 8 |
| *Valonia* sp. | C.Agardh | 2 | | 8 |
| *Valonia utricularis* | (Roth) C.Agardh | 2 | | 8 |

# Appendix 2

List of surveyed sites, with indication of UTM coordinates (Datum: SB - São Braz; GRW-Graciosa_Base_SW_1948), island of location, and attributed code. Shore description scores calculated according to the methods described in section 4.4.1.1, based on the shore type and subhabitat characteristics.

**Appendix 2** - List of surveyed sites, with indication of UTM coordinates (Datum: SB - São Braz; GRW- Graciosa_Base_SW_1948), island of location, and attributed code. Shore description scores calculated according to the methods described in section 4.4.1.1, based on the shore type and subhabitat characteristics.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Site name** | Anjos | Anjos | Baía de Cedros | Baía de Cedros | Baía da Cré | Emissores |
| **UTM (zone 26N)** | **N** | 662788.0 | 664070.2 | 676437.9 | 676240.6 | 665654.0 | 662213.9 |
| | **W** | 4096853.0 | 4097111.6 | 4092249.4 | 4091720.5 | 4096907.2 | 4096123.9 |
| | **Datum** | SB | SB | SB | SB | SB | SB |
| | **Island** | Santa Maria | Santa Maria | Santa Maria | Santa Maria | Santa Maria | Santa Maria |
| | **Site code** | 1 | 2 | 3 | 4 | 5 | 6 |
| | **"Shore descrption" score** | 17 | 8 | 10 | 14 | 12 | 16 |
| **Shore type** | Rock ridges/outcrops/Platforms | 1 | 0 | 0 | 0 | 0 | 1 |
| | Irregular rock | 1 | 0 | 0 | 1 | 1 | 1 |
| | Boulders large, medium and small | 0 | 0 | 1 | 0 | 1 | 0 |
| | Steep/Vertical rock | 0 | 0 | 0 | 1 | 0 | 0 |
| | Non-specific hard substrate | 0 | 0 | 0 | 0 | 0 | 0 |
| | Pebbles/Stones/Small rocks | 0 | 1 | 0 | 0 | 0 | 0 |
| | Shingle/Gravel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subhabitats** | Wide shallow rock pools | 1 | 0 | 0 | 0 | 0 | 1 |
| | Large rock pools | 1 | 0 | 0 | 0 | 0 | 0 |
| | Deep rockpools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Basic rock pools | 1 | 0 | 0 | 1 | 0 | 1 |
| | Large crevices | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large overhangs and vertical rock | 0 | 0 | 0 | 1 | 1 | 0 |
| | Other habitats | 0 | 0 | 0 | 0 | 0 | 0 |
| | Caves | 0 | 0 | 0 | 0 | 0 | 0 |
| | None | 0 | 1 | 1 | 0 | 0 | 0 |
| **Number of subhabitats** | ≥4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 3 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 2 | 0 | 2 |
| | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| | 0 | 0 | 1 | 1 | 0 | 0 | 0 |

**Appendix 2 (cont.)** - List of surveyed sites, with indication of UTM coordinates (Datum: SB - São Braz; GRW- Graciosa_Base_SW_1948), island of location, and attributed code. Shore description scores calculated according to the methods described in section 4.4.1.1, based on the shore type and subhabitat characteristics.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Site name** | Emissores | Ilhéu V. Porto | Praia Formosa | Praia Formosa | Praia Formosa | Ponta Castelo |
| **UTM (zone 26N)** | **N** | 661941.4 | 662842.9 | 670558.7 | 670558.7 | 670541.7 | 676796.4 |
| | **W** | 4096072.8 | 4090031.4 | 4090514.7 | 4090293.3 | 4090565.8 | 4088800.6 |
| | **Datum** | SB | SB | SB | SB | SB | SB |
| | **Island** | Santa Maria | Santa Maria | Santa Maria | Santa Maria | Santa Maria | Santa Maria |
| | **Site code** | 7 | 8 | 9 | 10 | 11 | 12 |
| | **"Shore descrption" score** | 8 | 13 | 12 | 14 | 8 | 16 |
| **Shore type** | Rock ridges/outcrops/Platforms | 0 | 0 | 0 | 1 | 0 | 1 |
| | Irregular rock | 0 | 1 | 0 | 1 | 0 | 1 |
| | Boulders large, medium and small | 0 | 0 | 1 | 0 | 0 | 0 |
| | Steep/Vertical rock | 0 | 1 | 0 | 0 | 0 | 0 |
| | Non-specific hard substrate | 0 | 0 | 0 | 0 | 0 | 0 |
| | Pebbles/Stones/Small rocks | 1 | 0 | 0 | 0 | 1 | 0 |
| | Shingle/Gravel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subhabitats** | Wide shallow rock pools | 0 | 0 | 0 | 0 | 0 | 1 |
| | Large rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Deep rockpools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Basic rock pools | 0 | 1 | 0 | 1 | 0 | 1 |
| | Large crevices | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large overhangs and vertical rock | 0 | 0 | 1 | 0 | 0 | 0 |
| | Other habitats | 0 | 0 | 0 | 0 | 0 | 0 |
| | Caves | 0 | 0 | 0 | 0 | 0 | 0 |
| | None | 1 | 0 | 0 | 0 | 1 | 0 |
| **Number of subhabitats** | ≥4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| | 0 | 1 | 0 | 0 | 0 | 1 | 0 |

**Appendix 2 (cont.)** - List of surveyed sites, with indication of UTM coordinates (Datum: SB - São Braz; GRW- Graciosa_Base_SW_1948), island of location, and attributed code. Shore description scores calculated according to the methods described in section 4.4.1.1, based on the shore type and subhabitat characteristics.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Site name** | Ponta Castelo | Lagoinhas | Ponta Ribeiro | São Lourenço | Praia Formosa | São Lourenço |
| **UTM (zone 26N)** | **N** | 676558.0 | 670063.7 | 663951.0 | 673260.8 | 670161.0 | 673500.0 |
| | **W** | 4089091.6 | 4098387.5 | 4089850.5 | 4096260.6 | 4090768.0 | 4095027.0 |
| | **Datum** | SB | SB | SB | SB | SB | SB |
| | **Island** | Santa Maria | Santa Maria | Santa Maria | Santa Maria | Santa Maria | Santa Maria |
| | **Site code** | 13 | 14 | 15 | 16 | 17 | 18 |
| | **"Shore descrption" score** | 8 | 16 | 14 | 14 | 8 | 13 |
| **Shore type** | Rock ridges/outcrops/Platforms | 0 | 1 | 1 | 1 | 0 | 0 |
| | Irregular rock | 0 | 1 | 1 | 1 | 0 | 1 |
| | Boulders large, medium and small | 0 | 0 | 0 | 0 | 0 | 0 |
| | Steep/Vertical rock | 0 | 0 | 0 | 0 | 0 | 0 |
| | Non-specific hard substrate | 0 | 0 | 0 | 0 | 0 | 0 |
| | Pebbles/Stones/Small rocks | 1 | 0 | 0 | 0 | 1 | 0 |
| | Shingle/Gravel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subhabitats** | Wide shallow rock pools | 0 | 1 | 0 | 0 | 0 | 0 |
| | Large rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Deep rockpools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Basic rock pools | 0 | 1 | 1 | 1 | 0 | 1 |
| | Large crevices | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large overhangs and vertical rock | 0 | 0 | 0 | 0 | 0 | 0 |
| | Other habitats | 0 | 0 | 0 | 0 | 0 | 0 |
| | Caves | 0 | 0 | 0 | 0 | 0 | 0 |
| | None | 1 | 0 | 0 | 0 | 1 | 0 |
| **Number of subhabitats** | ≥4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 2 | 0 | 0 | 0 | 0 |
| | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| | 0 | 1 | 0 | 0 | 0 | 1 | 0 |

**Appendix 2 (cont.)** - List of surveyed sites, with indication of UTM coordinates (Datum: SB - São Braz; GRW- Graciosa_Base_SW_1948), island of location, and attributed code. Shore description scores calculated according to the methods described in section 4.4.1.1, based on the shore type and subhabitat characteristics.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Site name** | São Roque | São Roque | Lagoa | Lagoa | Porto Formoso | Ferraria |
| **UTM (zone 26N)** | **N** | 619746.0 | 619921.6 | 623948.0 | 624420.8 | 636981.6 | 600943.4 |
| | **W** | 4178261.2 | 4178261.2 | 4178247.0 | 4178102.6 | 4187336.3 | 4190717.2 |
| | **Datum** | SB | SB | SB | SB | SB | SB |
| | **Island** | São Miguel | São Miguel | São Miguel | São Miguel | São Miguel | São Miguel |
| | **Site code** | 19 | 20 | 21 | 22 | 23 | 24 |
| | **"Shore descrption" score** | 13 | 13 | 13 | 13 | 10 | 12 |
| **Shore type** | Rock ridges/outcrops/Platforms | 0 | 0 | 0 | 0 | 0 | 0 |
| | Irregular rock | 1 | 1 | 1 | 1 | 0 | 0 |
| | Boulders large, medium and small | 0 | 0 | 0 | 0 | 1 | 1 |
| | Steep/Vertical rock | 0 | 0 | 0 | 0 | 0 | 1 |
| | Non-specific hard substrate | 0 | 0 | 0 | 0 | 0 | 0 |
| | Pebbles/Stones/Small rocks | 0 | 0 | 0 | 0 | 0 | 0 |
| | Shingle/Gravel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subhabitats** | Wide shallow rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Deep rockpools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Basic rock pools | 1 | 1 | 1 | 1 | 0 | 0 |
| | Large crevices | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large overhangs and vertical rock | 0 | 0 | 0 | 0 | 0 | 1 |
| | Other habitats | 0 | 0 | 0 | 0 | 0 | 0 |
| | Caves | 0 | 0 | 0 | 0 | 0 | 0 |
| | None | 0 | 0 | 0 | 0 | 1 | 0 |
| **Number of subhabitats** | ≥4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

**Appendix 2 (cont.)** - List of surveyed sites, with indication of UTM coordinates (Datum: SB - São Braz; GRW- Graciosa_Base_SW_1948), island of location, and attributed code. Shore description scores calculated according to the methods described in section 4.4.1.1, based on the shore type and subhabitat characteristics.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Site name** | Ponta Garça | Água d'Alto | ETAR Lagoa | ETAR PDL | Feteiras | Santo António |
| **UTM (zone 26N)** | **N** | 644970.0 | 633361.0 | 624416.0 | 618988.0 | 605101.0 | 614730.0 |
| | **W** | 4176303.0 | 4175340.0 | 4178119.0 | 4177999.0 | 4184819.0 | 4191539.0 |
| | **Datum** | SB | SB | SB | SB | SB | SB |
| | **Island** | São Miguel | São Miguel | São Miguel | São Miguel | São Miguel | São Miguel |
| | **Site code** | 25 | 26 | 27 | 28 | 29 | 30 |
| | **"Shore descrption" score** | 14 | 13 | 14 | 17 | 14 | 14 |
| **Shore type** | Rock ridges/outcrops/Platforms | 0 | 0 | 1 | 1 | 0 | 0 |
| | Irregular rock | 1 | 1 | 0 | 1 | 1 | 1 |
| | Boulders large, medium and small | 1 | 0 | 0 | 0 | 0 | 1 |
| | Steep/Vertical rock | 0 | 0 | 0 | 0 | 0 | 0 |
| | Non-specific hard substrate | 0 | 0 | 0 | 0 | 0 | 0 |
| | Pebbles/Stones/Small rocks | 0 | 0 | 0 | 0 | 0 | 0 |
| | Shingle/Gravel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subhabitats** | Wide shallow rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Deep rockpools | 0 | 0 | 0 | 1 | 0 | 0 |
| | Basic rock pools | 1 | 1 | 1 | 1 | 1 | 1 |
| | Large crevices | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large overhangs and vertical rock | 1 | 0 | 0 | 1 | 1 | 1 |
| | Other habitats | 0 | 0 | 0 | 0 | 0 | 0 |
| | Caves | 0 | 0 | 0 | 0 | 0 | 0 |
| | None | 0 | 0 | 0 | 0 | 0 | 0 |
| **Number of subhabitats** | ≥4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 3 | 0 | 0 |
| | 2 | 2 | 0 | 0 | 0 | 2 | 2 |
| | 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 2 (cont.)** - List of surveyed sites, with indication of UTM coordinates (Datum: SB - São Braz; GRW- Graciosa_Base_SW_1948), island of location, and attributed code. Shore description scores calculated according to the methods described in section 4.4.1.1, based on the shore type and subhabitat characteristics.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Site name** | Fenais Luz | Rabo Peixe | Ribeira Grande | Ribeirinha | Cinco Ribeiras | Biscoitos |
| **UTM (zone 26N)** | **N** | 620953.0 | 625353.0 | 630177.0 | 633334.0 | 471189.0 | 477321.0 |
| | **W** | 4187999.0 | 4186271.0 | 4187770.0 | 4188537.0 | 4280851.0 | 4294722.0 |
| | **Datum** | SB | SB | SB | SB | GRW | GRW |
| | **Island** | São Miguel | São Miguel | São Miguel | São Miguel | Terceira | Terceira |
| | **Site code** | 31 | 32 | 33 | 34 | 35 | 36 |
| | **"Shore descrption" score** | 16 | 10 | 12 | 10 | 13 | 10 |
| **Shore type** | Rock ridges/outcrops/Platforms | 1 | 0 | 0 | 0 | 0 | 0 |
| | Irregular rock | 1 | 0 | 0 | 0 | 0 | 0 |
| | Boulders large, medium and small | 0 | 1 | 1 | 1 | 0 | 1 |
| | Steep/Vertical rock | 0 | 0 | 0 | 0 | 1 | 0 |
| | Non-specific hard substrate | 0 | 0 | 0 | 0 | 0 | 0 |
| | Pebbles/Stones/Small rocks | 0 | 0 | 0 | 0 | 0 | 0 |
| | Shingle/Gravel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subhabitats** | Wide shallow rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Deep rockpools | 1 | 0 | 0 | 0 | 0 | 0 |
| | Basic rock pools | 1 | 0 | 0 | 0 | 1 | 0 |
| | Large crevices | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large overhangs and vertical rock | 0 | 0 | 1 | 0 | 1 | 0 |
| | Other habitats | 0 | 0 | 0 | 0 | 0 | 0 |
| | Caves | 0 | 0 | 0 | 0 | 0 | 0 |
| | None | 0 | 1 | 0 | 1 | 0 | 1 |
| **Number of subhabitats** | ≥4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 2 | 0 | 0 | 0 | 2 | 0 |
| | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| | 0 | 0 | 1 | 0 | 1 | 0 | 1 |

**Appendix 2 (cont.)** - List of surveyed sites, with indication of UTM coordinates (Datum: SB - São Braz; GRW- Graciosa_Base_SW_1948), island of location, and attributed code. Shore description scores calculated according to the methods described in section 4.4.1.1, based on the shore type and subhabitat characteristics.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Site name** | Silveira | Praia Vitória | Salga | Santa Cruz | Santa Cruz | Ponta Redondo |
| **UTM (zone 26N)** | **N** | 479376.0 | 495787.0 | 491292.0 | 413260.0 | 410888.0 | 407277.0 |
| | **W** | 4278643.0 | 4284418.0 | 4277625.0 | 4327112.0 | 4328036.0 | 4324859.0 |
| | **Datum** | GRW | GRW | GRW | GRW | GRW | GRW |
| | **Island** | Terceira | Terceira | Terceira | Graciosa | Graciosa | Graciosa |
| | **Site code** | 37 | 38 | 39 | 40 | 41 | 42 |
| | **"Shore descrption" score** | 13 | 13 | 13 | 13 | 14 | 10 |
| **Shore type** | Rock ridges/outcrops/Platforms | 0 | 0 | 0 | 0 | 1 | 0 |
| | Irregular rock | 1 | 1 | 1 | 1 | 1 | 0 |
| | Boulders large, medium and small | 0 | 0 | 0 | 0 | 0 | 1 |
| | Steep/Vertical rock | 0 | 0 | 0 | 0 | 0 | 0 |
| | Non-specific hard substrate | 0 | 0 | 0 | 0 | 0 | 0 |
| | Pebbles/Stones/Small rocks | 1 | 0 | 0 | 0 | 0 | 0 |
| | Shingle/Gravel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subhabitats** | Wide shallow rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Deep rockpools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Basic rock pools | 1 | 1 | 1 | 1 | 1 | 0 |
| | Large crevices | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large overhangs and vertical rock | 0 | 0 | 0 | 0 | 0 | 0 |
| | Other habitats | 0 | 0 | 0 | 0 | 0 | 0 |
| | Caves | 0 | 0 | 0 | 0 | 0 | 0 |
| | None | 0 | 0 | 0 | 0 | 0 | 1 |
| **Number of subhabitats** | ≥4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

**Appendix 2 (cont.)** - List of surveyed sites, with indication of UTM coordinates (Datum: SB - São Braz; GRW- Graciosa_Base_SW_1948), island of location, and attributed code. Shore description scores calculated according to the methods described in section 4.4.1.1, based on the shore type and subhabitat characteristics.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Site name** | Porto Afonso | Porto Afonso | Lagoa | Caldeirinha | Caldeirinha | Carapacho |
| **UTM (zone 26N)** | **N** | 407582.0 | 407636.0 | 415470.0 | 408768.0 | 408768.0 | 415434.0 |
| | **W** | 4324748.0 | 4324406.0 | 4323831.0 | 4327058.0 | 4326717.0 | 4318477.0 |
| | **Datum** | GRW | GRW | GRW | GRW | GRW | GRW |
| | **Island** | Graciosa | Graciosa | Graciosa | Graciosa | Graciosa | Graciosa |
| | **Site code** | 43 | 44 | 45 | 46 | 47 | 48 |
| | **"Shore descrption" score** | 8 | 12 | 10 | 10 | 9 | 16 |
| **Shore type** | Rock ridges/outcrops/Platforms | 0 | 0 | 0 | 0 | 0 | 1 |
| | Irregular rock | 0 | 0 | 0 | 0 | 0 | 1 |
| | Boulders large, medium and small | 0 | 1 | 1 | 1 | 0 | 0 |
| | Steep/Vertical rock | 0 | 0 | 0 | 0 | 1 | 0 |
| | Non-specific hard substrate | 0 | 0 | 0 | 0 | 0 | 0 |
| | Pebbles/Stones/Small rocks | 1 | 0 | 0 | 0 | 0 | 0 |
| | Shingle/Gravel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subhabitats** | Wide shallow rock pools | 0 | 0 | 0 | 0 | 0 | 1 |
| | Large rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Deep rockpools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Basic rock pools | 0 | 0 | 0 | 0 | 0 | 1 |
| | Large crevices | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large overhangs and vertical rock | 0 | 1 | 0 | 0 | 0 | 0 |
| | Other habitats | 0 | 0 | 0 | 0 | 0 | 0 |
| | Caves | 0 | 0 | 0 | 0 | 0 | 0 |
| | None | 1 | 0 | 1 | 1 | 1 | 0 |
| **Number of subhabitats** | ≥4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| | 0 | 1 | 0 | 1 | 1 | 1 | 0 |

**Appendix 2 (cont.)** - List of surveyed sites, with indication of UTM coordinates (Datum: SB - São Braz; GRW- Graciosa_Base_SW_1948), island of location, and attributed code. Shore description scores calculated according to the methods described in section 4.4.1.1, based on the shore type and subhabitat characteristics.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Site name** | Carapacho | Fenais | Santa Catarina | Anel | Lajes | Lajes |
| **UTM (zone 26N)** | **N** | 416907.0 | 416440.0 | 414517.0 | 414014.0 | 390357.0 | 390241.0 |
| | **W** | 4318675.0 | 4322178.0 | 4325736.0 | 4326886.0 | 4250210.0 | 4251452.0 |
| | **Datum** | GRW | GRW | GRW | GRW | GRW | GRW |
| | **Island** | Graciosa | Graciosa | Graciosa | Graciosa | Pico | Pico |
| | **Site code** | 49 | 50 | 51 | 52 | 53 | 54 |
| | **"Shore descrption" score** | 12 | 13 | 12 | 15 | 16 | 13 |
| **Shore type** | Rock ridges/outcrops/Platforms | 0 | 0 | 0 | 0 | 1 | 0 |
| | Irregular rock | 0 | 1 | 0 | 1 | 1 | 1 |
| | Boulders large, medium and small | 1 | 0 | 1 | 0 | 0 | 1 |
| | Steep/Vertical rock | 0 | 0 | 0 | 0 | 0 | 0 |
| | Non-specific hard substrate | 0 | 0 | 0 | 0 | 0 | 0 |
| | Pebbles/Stones/Small rocks | 0 | 0 | 0 | 0 | 0 | 0 |
| | Shingle/Gravel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subhabitats** | Wide shallow rock pools | 0 | 0 | 0 | 0 | 1 | 0 |
| | Large rock pools | 0 | 0 | 0 | 1 | 0 | 0 |
| | Deep rockpools | 0 | 0 | 0 | 1 | 0 | 0 |
| | Basic rock pools | 0 | 1 | 0 | 0 | 1 | 1 |
| | Large crevices | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large overhangs and vertical rock | 1 | 0 | 1 | 0 | 0 | 0 |
| | Other habitats | 0 | 0 | 0 | 0 | 0 | 0 |
| | Caves | 0 | 0 | 0 | 0 | 0 | 0 |
| | None | 0 | 0 | 0 | 0 | 0 | 0 |
| **Number of subhabitats** | ≥4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 2 | 2 | 0 |
| | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 2 (cont.)** - List of surveyed sites, with indication of UTM coordinates (Datum: SB - São Braz; GRW- Graciosa_Base_SW_1948), island of location, and attributed code. Shore description scores calculated according to the methods described in section 4.4.1.1, based on the shore type and subhabitat characteristics.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Site name** | Lajes | Lajes | Lajes | Manhenha | São Caetano | São Mateus |
| **UTM (zone 26N)** | **N** | 390339.0 | 390372.0 | 390152.0 | 409461.0 | 395588.0 | 394847.0 |
| | **W** | 4251265.0 | 4249942.0 | 4250362.0 | 4251911.0 | 4250669.0 | 4250268.0 |
| | **Datum** | GRW | GRW | GRW | GRW | GRW | GRW |
| | **Island** | Pico | Pico | Pico | Pico | Pico | Pico |
| | **Site code** | 55 | 56 | 57 | 58 | 59 | 60 |
| | **"Shore descrption" score** | 13 | 13 | 11 | 10 | 8 | 12 |
| **Shore type** | Rock ridges/outcrops/Platforms | 0 | 0 | 1 | 0 | 0 | 0 |
| | Irregular rock | 1 | 1 | 0 | 0 | 0 | 1 |
| | Boulders large, medium and small | 1 | 1 | 0 | 1 | 0 | 1 |
| | Steep/Vertical rock | 0 | 0 | 0 | 0 | 0 | 0 |
| | Non-specific hard substrate | 0 | 0 | 0 | 0 | 0 | 0 |
| | Pebbles/Stones/Small rocks | 0 | 0 | 0 | 0 | 1 | 0 |
| | Shingle/Gravel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subhabitats** | Wide shallow rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Deep rockpools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Basic rock pools | 1 | 1 | 0 | 0 | 0 | 0 |
| | Large crevices | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large overhangs and vertical rock | 0 | 0 | 0 | 0 | 0 | 1 |
| | Other habitats | 0 | 0 | 0 | 0 | 0 | 0 |
| | Caves | 0 | 0 | 0 | 0 | 0 | 0 |
| | None | 0 | 0 | 1 | 1 | 1 | 0 |
| **Number of subhabitats** | ≥4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 | 1 | 1 | 0 | 0 | 0 | 1 |
| | 0 | 0 | 0 | 1 | 1 | 1 | 0 |

**Appendix 2 (cont.)** - List of surveyed sites, with indication of UTM coordinates (Datum: SB - São Braz; GRW- Graciosa_Base_SW_1948), island of location, and attributed code. Shore description scores calculated according to the methods described in section 4.4.1.1, based on the shore type and subhabitat characteristics.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Site name** | Manhenha | São Mateus | São Bartolomeu | Santo António | SIBIL | SIBIL |
| **UTM (zone 26N)** | **N** | 408856.0 | 372648.0 | 387543.0 | 384261.0 | 390341.0 | 390243.0 |
| | **W** | 4251697.0 | 4254574.0 | 4252393.0 | 4265996.0 | 4251247.0 | 4251498.0 |
| | **Datum** | GRW | GRW | GRW | GRW | GRW | GRW |
| | **Island** | Pico | Pico | Pico | Pico | Pico | Pico |
| | **Site code** | 61 | 62 | 63 | 64 | 65 | 66 |
| | **"Shore descrption" score** | 12 | 12 | 13 | 12 | 8 | 12 |
| **Shore type** | Rock ridges/outcrops/Platforms | 0 | 0 | 0 | 0 | 0 | 0 |
| | Irregular rock | 0 | 0 | 1 | 0 | 0 | 0 |
| | Boulders large, medium and small | 1 | 1 | 0 | 1 | 0 | 1 |
| | Steep/Vertical rock | 0 | 0 | 0 | 0 | 0 | 0 |
| | Non-specific hard substrate | 0 | 0 | 0 | 0 | 0 | 0 |
| | Pebbles/Stones/Small rocks | 0 | 0 | 0 | 0 | 1 | 0 |
| | Shingle/Gravel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subhabitats** | Wide shallow rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Deep rockpools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Basic rock pools | 0 | 0 | 1 | 0 | 0 | 0 |
| | Large crevices | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large overhangs and vertical rock | 1 | 1 | 0 | 1 | 0 | 1 |
| | Other habitats | 0 | 0 | 0 | 0 | 0 | 0 |
| | Caves | 0 | 0 | 0 | 0 | 0 | 0 |
| | None | 0 | 0 | 0 | 0 | 1 | 0 |
| **Number of subhabitats** | ≥4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

**Appendix 2 (cont.)** - List of surveyed sites, with indication of UTM coordinates (Datum: SB - São Braz; GRW- Graciosa_Base_SW_1948), island of location, and attributed code. Shore description scores calculated according to the methods described in section 4.4.1.1, based on the shore type and subhabitat characteristics.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Site name** | Porto Calhau | Praínha | Santo Amaro | Cais do | Baía de Canas | Piedade |
| **UTM (zone 26N)** | **N** | 370707.0 | 394717.0 | 399826.0 | 367457.0 | 389903.0 | 407753.0 |
| | **W** | 4255630.0 | 4259453.0 | 4256983.0 | 4266863.0 | 4261793.0 | 4255350.0 |
| | **Datum** | GRW | GRW | GRW | GRW | GRW | GRW |
| | **Island** | Pico | Pico | Pico | Pico | Pico | Pico |
| | **Site code** | 67 | 68 | 69 | 70 | 71 | 72 |
| | **"Shore descrption" score** | 8 | 16 | 12 | 17 | 8 | 12 |
| **Shore type** | Rock ridges/outcrops/Platforms | 0 | 1 | 0 | 1 | 0 | 0 |
| | Irregular rock | 0 | 1 | 0 | 1 | 0 | 0 |
| | Boulders large, medium and small | 0 | 0 | 1 | 0 | 0 | 1 |
| | Steep/Vertical rock | 0 | 0 | 0 | 0 | 0 | 0 |
| | Non-specific hard substrate | 0 | 0 | 0 | 0 | 0 | 0 |
| | Pebbles/Stones/Small rocks | 1 | 0 | 0 | 0 | 1 | 0 |
| | Shingle/Gravel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subhabitats** | Wide shallow rock pools | 0 | 1 | 0 | 1 | 0 | 0 |
| | Large rock pools | 0 | 0 | 0 | 1 | 0 | 0 |
| | Deep rockpools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Basic rock pools | 0 | 1 | 0 | 1 | 0 | 0 |
| | Large crevices | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large overhangs and vertical rock | 0 | 0 | 1 | 0 | 0 | 1 |
| | Other habitats | 0 | 0 | 0 | 0 | 0 | 0 |
| | Caves | 0 | 0 | 0 | 0 | 0 | 0 |
| | None | 1 | 0 | 0 | 0 | 1 | 0 |
| **Number of subhabitats** | ≥4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 3 | 0 | 0 |
| | 2 | 0 | 2 | 0 | 0 | 0 | 0 |
| | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| | 0 | 1 | 0 | 0 | 0 | 1 | 0 |

**Appendix 2 (cont.)** - List of surveyed sites, with indication of UTM coordinates (Datum: SB - São Braz; GRW- Graciosa_Base_SW_1948), island of location, and attributed code. Shore description scores calculated according to the methods described in section 4.4.1.1, based on the shore type and subhabitat characteristics.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Site name** | Piedade | alheta do Nesqui | Negrito | São Roque | Santo Amaro | São Roque |
| **UTM (zone 26N)** | **N** | 407704.0 | 405420.0 | 395784.0 | 386354.0 | 400263.0 | 385184.0 |
| | **W** | 4255179.0 | 4251134.0 | 4250700.0 | 4264090.0 | 4256853.0 | 4264913.0 |
| | **Datum** | GRW | GRW | GRW | GRW | GRW | GRW |
| | **Island** | Pico | Pico | Pico | Pico | Pico | Pico |
| | **Site code** | 73 | 74 | 75 | 76 | 77 | 78 |
| | **"Shore descrption" score** | 12 | 12 | 13 | 12 | 8 | 13 |
| **Shore type** | Rock ridges/outcrops/Platforms | 0 | 0 | 0 | 0 | 0 | 0 |
| | Irregular rock | 0 | 0 | 1 | 0 | 0 | 1 |
| | Boulders large, medium and small | 1 | 1 | 0 | 1 | 0 | 0 |
| | Steep/Vertical rock | 0 | 0 | 0 | 0 | 0 | 0 |
| | Non-specific hard substrate | 0 | 0 | 0 | 0 | 0 | 0 |
| | Pebbles/Stones/Small rocks | 0 | 0 | 0 | 0 | 1 | 0 |
| | Shingle/Gravel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subhabitats** | Wide shallow rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Deep rockpools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Basic rock pools | 0 | 0 | 1 | 0 | 0 | 1 |
| | Large crevices | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large overhangs and vertical rock | 1 | 1 | 0 | 1 | 0 | 0 |
| | Other habitats | 0 | 0 | 0 | 0 | 0 | 0 |
| | Caves | 0 | 0 | 0 | 0 | 0 | 0 |
| | None | 0 | 0 | 0 | 0 | 1 | 0 |
| **Number of subhabitats** | ≥4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

**Appendix 2 (cont.)** - List of surveyed sites, with indication of UTM coordinates (Datum: SB - São Braz; GRW- Graciosa_Base_SW_1948), island of location, and attributed code. Shore description scores calculated according to the methods described in section 4.4.1.1, based on the shore type and subhabitat characteristics.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Site name** | Baía de Canas | Santo António | Guindaste | Monte | Monte | Madalena |
| **UTM (zone 26N)** | **N** | 389517.0 | 383667.0 | 385896.0 | 365668.0 | 365500.0 | 365781.0 |
| | **W** | 4261837.0 | 4266300.0 | 4264430.0 | 4262109.0 | 4261796.0 | 4264046.0 |
| | **Datum** | GRW | GRW | GRW | GRW | GRW | GRW |
| | **Island** | Pico | Pico | Pico | Pico | Pico | Pico |
| | **Site code** | 79 | 80 | 81 | 82 | 83 | 84 |
| | **"Shore descrption" score** | 13 | 12 | 13 | 8 | 12 | 16 |
| **Shore type** | Rock ridges/outcrops/Platforms | 0 | 0 | 0 | 0 | 0 | 1 |
| | Irregular rock | 1 | 1 | 1 | 0 | 1 | 1 |
| | Boulders large, medium and small | 0 | 0 | 0 | 0 | 1 | 0 |
| | Steep/Vertical rock | 0 | 0 | 0 | 0 | 0 | 0 |
| | Non-specific hard substrate | 0 | 0 | 0 | 0 | 0 | 0 |
| | Pebbles/Stones/Small rocks | 0 | 0 | 0 | 1 | 0 | 0 |
| | Shingle/Gravel | 0 | 0 | 0 | 0 | 0 | 0 |
| **Subhabitats** | Wide shallow rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large rock pools | 0 | 0 | 0 | 0 | 0 | 0 |
| | Deep rockpools | 0 | 0 | 0 | 0 | 0 | 1 |
| | Basic rock pools | 1 | 0 | 1 | 0 | 0 | 1 |
| | Large crevices | 0 | 0 | 0 | 0 | 0 | 0 |
| | Large overhangs and vertical rock | 0 | 1 | 0 | 0 | 1 | 0 |
| | Other habitats | 0 | 0 | 0 | 0 | 0 | 0 |
| | Caves | 0 | 0 | 0 | 0 | 0 | 0 |
| | None | 0 | 0 | 0 | 1 | 0 | 0 |
| **Number of subhabitats** | ≥4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| | 1 | 1 | 1 | 1 | 0 | 1 | 0 |
| | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

**Appendix 2 (cont.)** - List of surveyed sites, with indication of UTM coordinates (Datum: SB - São Braz; GRW- Graciosa_Base_SW_1948), island of location, and attributed code. Shore description scores calculated according to the methods described in section 4.4.1.1, based on the shore type and subhabitat characteristics.

| | | | | | |
|---|---|---|---|---|---|
| | **Site name** | Velas | Santo Cristo | Topo | Calheta |
| **UTM (zone 26N)** | **N** | 395564.0 | 418799.0 | 433893.0 | 412148.0 |
| | **W** | 4281983.0 | 4276053.0 | 4266631.0 | 4273016.0 |
| | **Datum** | GRW | GRW | GRW | GRW |
| | **Island** | São Jorge | São Jorge | São Jorge | São Jorge |
| | **Site code** | 85 | 86 | 87 | 88 |
| | **"Shore descrption" score** | 12 | 8 | 13 | 13 |
| **Shore type** | Rock ridges/outcrops/Platforms | 0 | 0 | 0 | 0 |
| | Irregular rock | 1 | 0 | 1 | 1 |
| | Boulders large, medium and small | 0 | 0 | 1 | 0 |
| | Steep/Vertical rock | 0 | 0 | 0 | 0 |
| | Non-specific hard substrate | 0 | 0 | 0 | 0 |
| | Pebbles/Stones/Small rocks | 0 | 1 | 0 | 0 |
| | Shingle/Gravel | 0 | 0 | 0 | 0 |
| **Subhabitats** | Wide shallow rock pools | 0 | 0 | 0 | 0 |
| | Large rock pools | 0 | 0 | 0 | 0 |
| | Deep rockpools | 0 | 0 | 0 | 0 |
| | Basic rock pools | 0 | 0 | 1 | 1 |
| | Large crevices | 0 | 0 | 0 | 0 |
| | Large overhangs and vertical rock | 1 | 0 | 0 | 0 |
| | Other habitats | 0 | 0 | 0 | 0 |
| | Caves | 0 | 0 | 0 | 0 |
| | None | 0 | 1 | 0 | 0 |
| **Number of subhabitats** | ≥4 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 0 |
| | 1 | 1 | 0 | 1 | 1 |
| | 0 | 0 | 1 | 0 | 0 |

# Appendix 3

Species recorded at each site (site codes according to Appendix 2; 0 - absent; 1 - present).

**Appendix 3** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta** | | | | | | | |
| *Acrochaetium codii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrochaetium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosorium venulosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrossorium* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Acrosymphyton* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion byssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion cordatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion galicum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion hookeri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion pseudobyssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion roseum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Aglaothamnion tenuissimum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ahnfeltia plicata* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Ahnfeltiopsis devoniensis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Amphiroa beauvoisii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa fragilissima* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Amphiroa rigida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa* sp. | 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| *Anotrichium furcellatum* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Anotrichium* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Anotrichium tenue* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Antithamnion cruciatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion decipiens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion densum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion diminuatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnionella boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aphanocladia stichidiosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Apoglossum ruscifolium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis armata* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Asparagopsis* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis taxiformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asteromenia peltata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bangia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Boergeseniella fruticulosa* | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Boergeseniella thuyoides* | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Bonnemaisonia hamifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bornetia secundiflora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia botryoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Calcareous crust* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion corymbosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Callithamnion tetragonum* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Catenella caespitosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Caulacanthus ustulatus* | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| *Centroceras clavulatum* | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| *Ceramium atrorubescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium botrycarpum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium ciliatum* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ceramium cingulatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium circinatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium codii* | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Ceramium deslongchampii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium diaphanum* | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Ceramium echionotum* | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Ceramium flaccidum* | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Ceramium gaditanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium rubrum* | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| *Ceramium* sp. | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Ceramium tenerrimum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium virgatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Champia parvula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondracanthus acicularis* | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Chondracanthus teedei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria capillaris* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Chondria coerulescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria dasyphylla* | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Chondria* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chylocladia verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Coelothrix irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Corallina elongata* | 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| *Corallina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Crouania attenuata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cryptonemia lomation* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cryptopleura ramosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ctenosiphonia hypnoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya caraibica* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Dasya corymbifera* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Dasya crouaniana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Dasya rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diplothamnion jolyi* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Diplothamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dipterosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Drachiella minuta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrocystis montagnei* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Erythrodermis traillii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrotrichia carnea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Eupogodon planus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Falkenbergia rufolanosa* | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Falkenbergia* sp. | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Feldmannophycus rayssiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium clavatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium ovatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium reflexum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiella pannosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiella tinerfensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiopsis intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium arbusculum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium microdon* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Gelidium pusillum* | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| *Gelidium* sp. | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| *Gelidium spinosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gigartina pistillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gigartina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gloiocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria gracilis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Gracilaria multipartita* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grallatoria reptans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia dichotoma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia doryphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia filicina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Griffithsia corallinoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia phyllamphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnogongrus crenulatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnogongrus griffithsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnogongrus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnothamnion elegans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon* sp. | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Haliptilon virgatum* | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Halurus flosculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Herposiphonia secunda* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Herposiphonia* sp. | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Heterosiphonia crispella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia crouaniorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydrolithon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea arbuscula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea flagelliformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea musciformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Hypnea spinella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypoglossum hypoglossoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania* sp. | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| *Jania adhaerens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania capillacea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania longifurca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania pumila* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania rubens* | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| *Laurencia hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia brongniartii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia chondrioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia flexilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia majuscula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia microcladia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia minuta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia obtusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Laurencia tenera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia viridis* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Lejolisia mediterranea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora distenta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora maderensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora viscida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum incrustans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum polycephalum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum* sp. | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Lomentaria articulata* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Lomentaria clavellosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria linearis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria orcadensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia cristata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia reptabunda* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mastocarpus stellatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Melobesia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Meredithia microphylla* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum canariense* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum lichenoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemalion helminthoides* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Neosiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Neosiphonia sphaerocarpa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nitophyllum punctatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nytophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ophidocladus simpliciusculus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Osmundea hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea pinnatifida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea* sp. | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Osmundea truncata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada corallopsis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada patentiramea* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Palisada perforata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada poiteaui* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia squamaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora crispa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora gelidioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phymatolithon lenormandii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Platoma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium borreri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium caribaeum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Plocamium cartilagineum* | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| *Polysiphonia atlantica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia brodiaei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia ceramiaeformis* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia denudata* | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Polysiphonia elongata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia flexella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia furcellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia havanensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia opaca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia scopulorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia* sp. | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Polysiphonia sphacelaria* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia stricta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia tripinnata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra leucosticta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra umbilicalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterocladiella capillacea* | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Pterocladiella melanoidea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pennata* | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Pterosiphonia pinnulata* | 1 | 0 | 1 | 1 | 0 | 0 | 1 |
| *Ptilothamnion pluma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Red crust | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Rhodomela confervoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodophyllis divaricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia ardissonei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Rhodymenia holmesii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia pseudopalmata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Schizymenia dubyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Schottera nicaeensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sebdenia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion flabellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion repens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphaerococcus coronopifolius* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphondylothamnion multifidum* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Spongites fruticulosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spyridia filamentosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stylonema alsidii* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Symphyocladia marchantioides* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Taenioma nanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tiffaniella capitata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tsengia bairdii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia penicillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wurdemannia miniata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Phaeophyceae** | | | | | | | |
| *Asteronema rhodochortonoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bachelotia antillarum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Brown crust | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladostephus spongious* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Colpomenia sinuosa* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Cystoseira* sp. | 1 | 0 | 1 | 0 | 1 | 1 | 0 |
| *Cystoseira abies-marina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira foeniculacea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira humilis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Cystoseira wildpretii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyopteris polypodioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota bartayresiana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota dichotoma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota friabilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota pinnatifida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus fasciculatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus siliculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Endarachne binghamiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Endarachne* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmania* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia globifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia paradoxa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Phaeophyceae (cont.)** | | | | | | | |
| *Fucus spiralis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Halopteris filicina* | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Hecatonema terminale* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia intermedia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia ovata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia rallsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydroclathrus clathratus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Leathesia difformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lobophora variegata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myriactula chordae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myrionema strangulans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemoderma tingitanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Padina pavonia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Papenfussiella kuromo* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Petrospongium berkeleyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pilinia rimosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudolithoderma adriaticum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudolithoderma sp.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia verrucosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum acinarium* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Sargassum cymosum* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Sargassum furcatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum* sp. | 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| *Scytosiphon lomentaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spatoglossum solieri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria cirrosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria fusca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria tribuloides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Styocaulon scoparia* | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Taonia atomaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Zonaria tournefortii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Chlorophyta** | | | | | | | |
| *Anadyomene saldanhae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anadyomene stellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia marginata* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia minima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis corymbosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis cupressina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis hypnoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis plumosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha aerea* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Chaetomorpha antennina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Chaetomorpha gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha ligustica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha linum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha pachynema* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora albida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora coelothrix* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora conferta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora dalmatica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora inclusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora laetervirens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora lehmanniana* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Cladophora liebetruthii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora pellucida* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora prolifera* | 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| *Cladophora sericea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora* sp. | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Cladophoropsis membranacea* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Codium adhaerens* | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Codium decorticatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium effusum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium elisabethae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium fragile* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium taylorii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium tomentosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium vermilara* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia marina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia tenuissima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Enteromorpha multirramosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ernodesmis verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Halydictyon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon calodictyon* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Monostroma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Percursaria percursa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhizoclonium tortuosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva clathrata* | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Ulva compressa* | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ulva flexuosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva intestinalis* | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| *Ulva lactuca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva prolifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva rigida* | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Ulva rotundata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Ulva* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia macrophysa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia utricularis* | 1 | 0 | 1 | 0 | 1 | 0 | 1 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta** | | | | | | | |
| *Acrochaetium codii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrochaetium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosorium venulosum* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Acrossorium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosymphyton* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion byssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion cordatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion galicum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion hookeri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion pseudobyssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion roseum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion* sp. | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Aglaothamnion tenuissimum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ahnfeltia plicata* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Ahnfeltiopsis devoniensis* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Amphiroa beauvoisii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa fragilissima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa rigida* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Amphiroa* sp. | 0 | 1 | 0 | 0 | 1 | 1 | 1 |
| *Anotrichium furcellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium tenue* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion cruciatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion decipiens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion densum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion diminuatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnionella boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aphanocladia stichidiosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Apoglossum ruscifolium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis armata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis taxiformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asteromenia peltata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bangia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Boergeseniella fruticulosa* | 1 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Boergeseniella thuyoides* | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Bonnemaisonia hamifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bornetia secundiflora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia botryoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Calcareous crust* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion corymbosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion tetragonum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Catenella caespitosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Caulacanthus ustulatus* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Centroceras clavulatum* | 0 | 1 | 1 | 0 | 1 | 0 | 1 |
| *Ceramium atrorubescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium botrycarpum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium ciliatum* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Ceramium cingulatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium circinatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium codii* | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Ceramium deslongchampii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium diaphanum* | 1 | 1 | 1 | 0 | 1 | 0 | 1 |
| *Ceramium echionotum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium flaccidum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium gaditanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium rubrum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium* sp. | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Ceramium tenerrimum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium virgatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Champia parvula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondracanthus acicularis* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Chondracanthus teedei* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Chondria capillaris* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria coerulescens* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Chondria dasyphylla* | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| *Chondria* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chylocladia verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Coelothrix irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Corallina elongata* | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| *Corallina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Crouania attenuata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cryptonemia lomation* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cryptopleura ramosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ctenosiphonia hypnoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya caraibica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya corymbifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya crouaniana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Diplothamnion jolyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diplothamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dipterosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Drachiella minuta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrocystis montagnei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrodermis traillii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrotrichia carnea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Eupogodon planus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Falkenbergia rufolanosa* | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Falkenbergia* sp. | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Feldmannophycus rayssiae* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Gastroclonium clavatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium ovatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium reflexum* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Gelidiella pannosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiella tinerfensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiopsis intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium arbusculum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium microdon* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Gelidium pusillum* | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| *Gelidium* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium spinosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gigartina pistillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gigartina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gloiocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria multipartita* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grallatoria reptans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia dichotoma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia doryphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia filicina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia corallinoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia phyllamphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnogongrus crenulatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnogongrus griffithsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnogongrus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnothamnion elegans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon* sp. | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| *Haliptilon virgatum* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Halurus flosculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Herposiphonia secunda* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Herposiphonia* sp. | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Heterosiphonia crispella* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Hildenbrandia crouaniorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydrolithon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea arbuscula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea flagelliformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea musciformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea* sp. | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Hypnea spinella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypoglossum hypoglossoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania* sp. | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| *Jania adhaerens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania capillacea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania longifurca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania pumila* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania rubens* | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| *Laurencia hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia brongniartii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia chondrioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia flexilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia majuscula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia microcladia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia minuta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia obtusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia* sp. | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| *Laurencia tenera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia viridis* | 1 | 1 | 1 | 0 | 1 | 0 | 1 |
| *Lejolisia mediterranea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora distenta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora maderensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora viscida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum incrustans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum polycephalum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria articulata* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Lomentaria clavellosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria linearis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria orcadensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia cristata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia reptabunda* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mastocarpus stellatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Melobesia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Meredithia microphylla* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum canariense* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum lichenoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemalion helminthoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Neosiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Neosiphonia sphaerocarpa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nitophyllum punctatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nytophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ophidocladus simpliciusculus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Osmundea hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea pinnatifida* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Osmundea* sp. | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Osmundea truncata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada corallopsis* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Palisada patentiramea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada perforata* | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Palisada poiteaui* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia squamaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora crispa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora gelidioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phymatolithon lenormandii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Platoma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium borreri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium caribaeum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Plocamium cartilagineum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia atlantica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia brodiaei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia ceramiaeformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia denudata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia elongata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia flexella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia furcellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia havanensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia opaca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia scopulorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia* sp. | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Polysiphonia sphacelaria* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia stricta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia tripinnata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra leucosticta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra umbilicalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterocladiella capillacea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterocladiella melanoidea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pennata* | 1 | 1 | 1 | 0 | 0 | 0 | 1 |
| *Pterosiphonia pinnulata* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Ptilothamnion pluma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Red crust | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| *Rhodomela confervoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodophyllis divaricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia ardissonei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Rhodymenia holmesii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia pseudopalmata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Schizymenia dubyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Schottera nicaeensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sebdenia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion flabellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion repens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphaerococcus coronopifolius* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphondylothamnion multifidum* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Spongites fruticulosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spyridia filamentosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stylonema alsidii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Symphyocladia marchantioides* | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Taenioma nanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tiffaniella capitata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tsengia bairdii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia penicillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wurdemannia miniata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Phaeophyceae** | | | | | | | |
| *Asteronema rhodochortonoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bachelotia antillarum* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Brown crust | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladostephus spongious* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Colpomenia sinuosa* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Cystoseira* sp. | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| *Cystoseira abies-marina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira foeniculacea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira humilis* | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Cystoseira wildpretii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyopteris polypodioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota bartayresiana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota dichotoma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota friabilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota pinnatifida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota* sp. | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus fasciculatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus siliculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Endarachne binghamiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Endarachne* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmania* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia globifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia paradoxa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|
| **Phaeophyceae (cont.)** | | | | | | | |
| *Fucus spiralis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Halopteris filicina* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Hecatonema terminale* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia intermedia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia ovata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia rallsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydroclathrus clathratus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Leathesia difformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lobophora variegata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myriactula chordae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myrionema strangulans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemoderma tingitanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Padina pavonia* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Papenfussiella kuromo* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Petrospongium berkeleyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pilinia rimosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudolithoderma adriaticum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudolithoderma sp.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia verrucosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum acinarium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum cymosum* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum furcatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum* sp. | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| *Scytosiphon lomentaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spatoglossum solieri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria cirrosa* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Sphacelaria fusca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria tribuloides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Styocaulon scoparia* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Taonia atomaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Zonaria tournefortii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Chlorophyta** | | | | | | | |
| *Anadyomene saldanhae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anadyomene stellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia marginata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia minima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis corymbosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis cupressina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis hypnoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis plumosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha aerea* | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Chaetomorpha antennina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Chaetomorpha gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha ligustica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha linum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha pachynema* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora albida* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora coelothrix* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Cladophora conferta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora dalmatica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora inclusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora laetervirens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora lehmanniana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora liebetruthii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora pellucida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora prolifera* | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| *Cladophora sericea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora* sp. | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Cladophoropsis membranacea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium adhaerens* | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Codium decorticatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium effusum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium elisabethae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium fragile* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium taylorii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium tomentosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium vermilara* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia marina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia tenuissima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Enteromorpha multirramosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ernodesmis verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Halydictyon* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Microdictyon boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon calodictyon* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Monostroma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Percursaria percursa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhizoclonium tortuosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva clathrata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva compressa* | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Ulva flexuosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva intestinalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva lactuca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva prolifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva rigida* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ulva rotundata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Ulva* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia macrophysa* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Valonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia utricularis* | 1 | 0 | 1 | 0 | 1 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta** | | | | | | | |
| *Acrochaetium codii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrochaetium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosorium venulosum* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Acrossorium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosymphyton* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion byssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion cordatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion galicum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion hookeri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion pseudobyssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion roseum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion* sp. | 1 | 1 | 0 | 1 | 0 | 0 | 1 |
| *Aglaothamnion tenuissimum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ahnfeltia plicata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ahnfeltiopsis devoniensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa beauvoisii* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa fragilissima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa rigida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium furcellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium* sp. | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Anotrichium tenue* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion cruciatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion decipiens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion densum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion diminuatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnionella boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aphanocladia stichidiosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Apoglossum ruscifolium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis armata* | 0 | 1 | 0 | 1 | 0 | 1 | 1 |
| *Asparagopsis* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis taxiformis* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Asteromenia peltata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bangia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Boergeseniella fruticulosa* | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Boergeseniella thuyoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bonnemaisonia hamifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bornetia secundiflora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia botryoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Calcareous crust* | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Callithamnion corymbosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion tetragonum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Catenella caespitosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Caulacanthus ustulatus* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Centroceras clavulatum* | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Ceramium atrorubescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium botrycarpum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium ciliatum* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Ceramium cingulatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium circinatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium codii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium deslongchampii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium diaphanum* | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| *Ceramium echionotum* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium flaccidum* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ceramium gaditanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium rubrum* | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| *Ceramium* sp. | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Ceramium tenerrimum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium virgatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Champia parvula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondracanthus acicularis* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Chondracanthus teedei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria capillaris* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria coerulescens* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Chondria dasyphylla* | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Chondria* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chylocladia verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Coelothrix irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Corallina elongata* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Corallina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Crouania attenuata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cryptonemia lomation* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cryptopleura ramosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ctenosiphonia hypnoides* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya caraibica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya corymbifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya crouaniana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya rigidula* | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Dasya* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diplothamnion jolyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diplothamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dipterosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Drachiella minuta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrocystis montagnei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrodermis traillii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrotrichia carnea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Eupogodon planus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Falkenbergia rufolanosa* | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| *Falkenbergia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannophycus rayssiae* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Gastroclonium clavatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium ovatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium reflexum* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Gelidiella pannosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiella tinerfensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiopsis intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium arbusculum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium microdon* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Gelidium pusillum* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Gelidium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium spinosum* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Gigartina pistillata* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Gigartina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gloiocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria multipartita* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Grallatoria reptans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia dichotoma* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Grateloupia doryphora* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Grateloupia filicina* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Grateloupia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia corallinoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia phyllamphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnogongrus crenulatus* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Gymnogongrus griffithsiae* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Gymnogongrus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnothamnion elegans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon virgatum* | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Halurus flosculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Herposiphonia secunda* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Herposiphonia* sp. | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Heterosiphonia crispella* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Hildenbrandia crouaniorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia rubra* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Hildenbrandia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydrolithon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea arbuscula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea flagelliformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea musciformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Hypnea spinella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypoglossum hypoglossoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania* sp. | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Jania adhaerens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania capillacea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania longifurca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania pumila* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania rubens* | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Laurencia hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia brongniartii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia chondrioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia flexilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia majuscula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia microcladia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia minuta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia obtusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia* sp. | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Laurencia tenera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia viridis* | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Lejolisia mediterranea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora distenta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora maderensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora viscida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum incrustans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum polycephalum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria articulata* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Lomentaria clavellosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria linearis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria orcadensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia cristata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia reptabunda* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mastocarpus stellatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Melobesia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Meredithia microphylla* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum canariense* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum lichenoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemalion helminthoides* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Neosiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Neosiphonia sphaerocarpa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nitophyllum punctatum* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Nytophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ophidocladus simpliciusculus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Osmundea hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea pinnatifida* | 0 | 1 | 0 | 1 | 0 | 1 | 1 |
| *Osmundea* sp. | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Osmundea truncata* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Palisada corallopsis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada patentiramea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada perforata* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Palisada poiteaui* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Peyssonnelia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia squamaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora crispa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora gelidioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phymatolithon lenormandii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Platoma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium borreri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium caribaeum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Plocamium cartilagineum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia atlantica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia brodiaei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia ceramiaeformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia denudata* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Polysiphonia elongata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia flexella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia furcellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia havanensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia opaca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia scopulorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia sphacelaria* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia stricta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia tripinnata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra leucosticta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra* sp. | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Porphyra umbilicalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterocladiella capillacea* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Pterocladiella melanoidea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pennata* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pinnulata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ptilothamnion pluma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Red crust | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodomela confervoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodophyllis divaricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia ardissonei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Rhodymenia holmesii* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Rhodymenia pseudopalmata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Schizymenia dubyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Schottera nicaeensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sebdenia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion flabellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion repens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphaerococcus coronopifolius* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphondylothamnion multifidum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spongites fruticulosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spyridia filamentosa* | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Stylonema alsidii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Symphyocladia marchantioides* | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| *Taenioma nanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tiffaniella capitata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tsengia bairdii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia penicillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wurdemannia miniata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Phaeophyceae** | | | | | | | |
| *Asteronema rhodochortonoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bachelotia antillarum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Brown crust | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Cladostephus spongious* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Colpomenia sinuosa* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Cystoseira* sp. | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Cystoseira abies-marina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira foeniculacea* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Cystoseira humilis* | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Cystoseira wildpretii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyopteris polypodioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota bartayresiana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota dichotoma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota friabilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota pinnatifida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus fasciculatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus siliculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Endarachne binghamiae* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Endarachne* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmania* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia globifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia paradoxa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|
| **Phaeophyceae (cont.)** | | | | | | | |
| *Fucus spiralis* | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Halopteris filicina* | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Hecatonema terminale* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia intermedia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia ovata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia rallsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydroclathrus clathratus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Leathesia difformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lobophora variegata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myriactula chordae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myrionema strangulans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemoderma tingitanum* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Padina pavonia* | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| *Papenfussiella kuromo* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Petrospongium berkeleyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pilinia rimosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudolithoderma adriaticum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudolithoderma sp.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Ralfsia verrucosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum acinarium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum cymosum* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Sargassum furcatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum* sp. | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Scytosiphon lomentaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spatoglossum solieri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria cirrosa* | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Sphacelaria fusca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria tribuloides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Styocaulon scoparia* | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| *Taonia atomaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Zonaria tournefortii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Chlorophyta** | | | | | | | |
| *Anadyomene saldanhae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anadyomene stellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia marginata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia minima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis corymbosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis cupressina* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Bryopsis hypnoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis plumosa* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Chaetomorpha aerea* | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| *Chaetomorpha antennina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Chaetomorpha gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha ligustica* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Chaetomorpha linum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha pachynema* | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Chaetomorpha* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Cladophora albida* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Cladophora coelothrix* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Cladophora conferta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora dalmatica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora inclusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora laetervirens* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Cladophora lehmanniana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora liebetruthii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora pellucida* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Cladophora prolifera* | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| *Cladophora sericea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora* sp. | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Cladophoropsis membranacea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium adhaerens* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Codium decorticatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium effusum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium elisabethae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium fragile* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium taylorii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium tomentosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium vermilara* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia marina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia tenuissima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Enteromorpha multirramosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ernodesmis verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Halydictyon* sp. | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Microdictyon boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon calodictyon* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Monostroma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Percursaria percursa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhizoclonium tortuosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva clathrata* | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| *Ulva compressa* | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| *Ulva flexuosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva intestinalis* | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| *Ulva lactuca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva prolifera* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Ulva rigida* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Ulva rotundata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Ulva* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia macrophysa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia utricularis* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta** | | | | | | | |
| *Acrochaetium codii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrochaetium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosorium venulosum* | 1 | 0 | 1 | 1 | 0 | 1 | 0 |
| *Acrossorium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosymphyton* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion byssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion cordatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion galicum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion hookeri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion pseudobyssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion roseum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion* sp. | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Aglaothamnion tenuissimum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ahnfeltia plicata* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Ahnfeltiopsis devoniensis* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Amphiroa beauvoisii* | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Amphiroa fragilissima* | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Amphiroa rigida* | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| *Amphiroa* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium furcellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium tenue* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Antithamnion cruciatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion decipiens* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion densum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion diminuatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnionella boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aphanocladia stichidiosa* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Apoglossum ruscifolium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis armata* | 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| *Asparagopsis* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis taxiformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asteromenia peltata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bangia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Boergeseniella fruticulosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Boergeseniella thuyoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bonnemaisonia hamifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bornetia secundiflora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia botryoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Calcareous crust* | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Callithamnion corymbosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion* sp. | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Callithamnion tetragonum* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Catenella caespitosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Caulacanthus ustulatus* | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Centroceras clavulatum* | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| *Ceramium atrorubescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium botrycarpum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium ciliatum* | 0 | 1 | 0 | 0 | 1 | 1 | 1 |
| *Ceramium cingulatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium circinatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium codii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium deslongchampii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium diaphanum* | 1 | 1 | 1 | 0 | 1 | 0 | 1 |
| *Ceramium echionotum* | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| *Ceramium flaccidum* | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Ceramium gaditanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium rubrum* | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Ceramium* sp. | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Ceramium tenerrimum* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Ceramium virgatum* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Champia parvula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondracanthus acicularis* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Chondracanthus teedei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria capillaris* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria coerulescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria dasyphylla* | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| *Chondria* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chylocladia verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Coelothrix irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Corallina elongata* | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Corallina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Crouania attenuata* | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| *Cryptonemia lomation* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cryptopleura ramosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ctenosiphonia hypnoides* | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| *Dasya caraibica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya corymbifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya crouaniana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diplothamnion jolyi* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Diplothamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dipterosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Drachiella minuta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrocystis montagnei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrodermis traillii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrotrichia carnea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Eupogodon planus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Falkenbergia rufolanosa* | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Falkenbergia* sp. | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Feldmannophycus rayssiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium clavatum* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Gastroclonium ovatum* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Gastroclonium reflexum* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Gelidiella pannosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiella tinerfensis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Gelidiopsis intricata* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Gelidium arbusculum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium microdon* | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Gelidium pusillum* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Gelidium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium spinosum* | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Gigartina pistillata* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Gigartina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gloiocladia* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Gracilaria gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria multipartita* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grallatoria reptans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia dichotoma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia doryphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia filicina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia corallinoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia phyllamphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnogongrus crenulatus* | 1 | 1 | 1 | 0 | 0 | 1 | 1 |
| *Gymnogongrus griffithsiae* | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Gymnogongrus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnothamnion elegans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon virgatum* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Halurus flosculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Herposiphonia secunda* | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| *Herposiphonia* sp. | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| *Heterosiphonia crispella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia crouaniorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia rubra* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydrolithon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea arbuscula* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Hypnea flagelliformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea musciformis* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Hypnea* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Hypnea spinella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypoglossum hypoglossoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania adhaerens* | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Jania capillacea* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Jania longifurca* | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| *Jania pumila* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Jania rubens* | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Laurencia hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia brongniartii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia chondrioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia flexilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia majuscula* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Laurencia microcladia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia minuta* | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| *Laurencia obtusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Laurencia tenera* | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Laurencia viridis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lejolisia mediterranea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora distenta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora maderensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora viscida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum incrustans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum polycephalum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria articulata* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Lomentaria clavellosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria linearis* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Lomentaria orcadensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia cristata* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Lophosiphonia reptabunda* | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| *Lophosiphonia* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Mastocarpus stellatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Melobesia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Meredithia microphylla* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum canariense* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum lichenoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemalion helminthoides* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Neosiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Neosiphonia sphaerocarpa* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Nitophyllum punctatum* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Nytophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ophidocladus simpliciusculus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Osmundea hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea pinnatifida* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Osmundea* sp. | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Osmundea truncata* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Palisada corallopsis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada patentiramea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada perforata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada poiteaui* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia squamaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora crispa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora gelidioides* | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| *Phymatolithon lenormandii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Platoma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium borreri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium caribaeum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Plocamium cartilagineum* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Polysiphonia atlantica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia brodiaei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia ceramiaeformis* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia denudata* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Polysiphonia elongata* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Polysiphonia flexella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia furcellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia havanensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia opaca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia scopulorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia* sp. | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| *Polysiphonia sphacelaria* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia stricta* | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Polysiphonia tripinnata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra leucosticta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra* sp. | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| *Porphyra umbilicalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterocladiella capillacea* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Pterocladiella melanoidea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pennata* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Pterosiphonia pinnulata* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ptilothamnion pluma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Red crust | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| *Rhodomela confervoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodophyllis divaricata* | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| *Rhodymenia ardissonei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Rhodymenia holmesii* | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Rhodymenia pseudopalmata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Schizymenia dubyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Schottera nicaeensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sebdenia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion flabellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion repens* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Sphaerococcus coronopifolius* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Sphondylothamnion multifidum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spongites fruticulosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spyridia filamentosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stylonema alsidii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Symphyocladia marchantioides* | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Taenioma nanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tiffaniella capitata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tsengia bairdii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia penicillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wurdemannia miniata* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| **Phaeophyceae** | | | | | | | |
| *Asteronema rhodochortonoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bachelotia antillarum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Brown crust | 1 | 1 | 1 | 0 | 1 | 0 | 0 |
| *Cladostephus spongious* | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Colpomenia sinuosa* | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Cystoseira* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira abies-marina* | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Cystoseira foeniculacea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira humilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira wildpretii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyopteris polypodioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota bartayresiana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota dichotoma* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Dictyota friabilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota pinnatifida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus fasciculatus* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Ectocarpus siliculosus* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Ectocarpus* sp. | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Endarachne binghamiae* | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Endarachne* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmania* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Feldmannia globifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia paradoxa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|
| **Phaeophyceae (cont.)** | | | | | | | |
| *Fucus spiralis* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Halopteris filicina* | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| *Hecatonema terminale* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Hincksia intermedia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia ovata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia rallsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydroclathrus clathratus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Leathesia difformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lobophora variegata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myriactula chordae* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Myrionema strangulans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemoderma tingitanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Padina pavonia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Papenfussiella kuromo* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Petrospongium berkeleyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pilinia rimosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudolithoderma adriaticum* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Pseudolithoderma sp.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia verrucosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum acinarium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum cymosum* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum furcatum* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Scytosiphon lomentaria* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Spatoglossum solieri* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Sphacelaria cirrosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria fusca* | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| *Sphacelaria rigidula* | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| *Sphacelaria* sp. | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| *Sphacelaria tribuloides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Styocaulon scoparia* | 1 | 1 | 0 | 1 | 1 | 1 | 0 |
| *Taonia atomaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Zonaria tournefortii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Chlorophyta** | | | | | | | |
| *Anadyomene saldanhae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anadyomene stellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia marginata* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia minima* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Bryopsis corymbosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis cupressina* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Bryopsis hypnoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis plumosa* | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| *Chaetomorpha aerea* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Chaetomorpha antennina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Chaetomorpha gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha ligustica* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Chaetomorpha linum* | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| *Chaetomorpha pachynema* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Chaetomorpha* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Cladophora albida* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Cladophora coelothrix* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora conferta* | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Cladophora dalmatica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora inclusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora laetervirens* | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| *Cladophora lehmanniana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora liebetruthii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora pellucida* | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Cladophora prolifera* | 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| *Cladophora sericea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora* sp. | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Cladophoropsis membranacea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium adhaerens* | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| *Codium decorticatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium effusum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium elisabethae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium fragile* | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Codium* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Codium taylorii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium tomentosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium vermilara* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia marina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia tenuissima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Enteromorpha multirramosa* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Ernodesmis verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Halydictyon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon calodictyon* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Monostroma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Percursaria percursa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhizoclonium tortuosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva clathrata* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva compressa* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Ulva flexuosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva intestinalis* | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| *Ulva lactuca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva prolifera* | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Ulva rigida* | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Ulva rotundata* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Ulva* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Valonia macrophysa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia utricularis* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta** | | | | | | | |
| *Acrochaetium codii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrochaetium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosorium venulosum* | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Acrossorium* sp. | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Acrosymphyton* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion byssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion cordatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion galicum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion hookeri* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Aglaothamnion pseudobyssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion roseum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion* sp. | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Aglaothamnion tenuissimum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ahnfeltia plicata* | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| *Ahnfeltiopsis devoniensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa beauvoisii* | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Amphiroa fragilissima* | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| *Amphiroa rigida* | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Amphiroa* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium furcellatum* | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Anotrichium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium tenue* | 1 | 1 | 0 | 1 | 0 | 0 | 1 |
| *Antithamnion cruciatum* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Antithamnion decipiens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion densum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion diminuatum* | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Antithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnionella boergesenii* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Aphanocladia stichidiosa* | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Apoglossum ruscifolium* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis armata* | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| *Asparagopsis* sp. | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis taxiformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asteromenia peltata* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Bangia* sp. | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Boergeseniella fruticulosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Boergeseniella thuyoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bonnemaisonia hamifera* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Bornetia secundiflora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia botryoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Calcareous crust* | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| *Callithamnion corymbosum* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Callithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion tetragonum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Catenella caespitosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Caulacanthus ustulatus* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Centroceras clavulatum* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Ceramium atrorubescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium botrycarpum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium ciliatum* | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| *Ceramium cingulatum* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium circinatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium codii* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium deslongchampii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium diaphanum* | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Ceramium echionotum* | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| *Ceramium flaccidum* | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Ceramium gaditanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium rubrum* | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Ceramium* sp. | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Ceramium tenerrimum* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium virgatum* | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| *Champia parvula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondracanthus acicularis* | 1 | 1 | 1 | 0 | 0 | 0 | 1 |
| *Chondracanthus teedei* | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Chondria capillaris* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria coerulescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria dasyphylla* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Chondria* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chylocladia verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Coelothrix irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Corallina elongata* | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| *Corallina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Crouania attenuata* | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| *Cryptonemia lomation* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Cryptopleura ramosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ctenosiphonia hypnoides* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Dasya caraibica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya corymbifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya crouaniana* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Dasya hutchinsiae* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Dasya rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diplothamnion jolyi* | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Diplothamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dipterosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Drachiella minuta* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Erythrocystis montagnei* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrodermis traillii* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Erythrotrichia carnea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Eupogodon planus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Falkenbergia rufolanosa* | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| *Falkenbergia* sp. | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| *Feldmannophycus rayssiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium clavatum* | 1 | 1 | 0 | 1 | 0 | 0 | 1 |
| *Gastroclonium ovatum* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium reflexum* | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Gelidiella pannosa* | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Gelidiella tinerfensis* | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| *Gelidiopsis intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium arbusculum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium microdon* | 1 | 1 | 1 | 0 | 1 | 0 | 1 |
| *Gelidium pusillum* | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Gelidium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium spinosum* | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Gigartina pistillata* | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Gigartina* sp. | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Gloiocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria multipartita* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grallatoria reptans* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Grateloupia dichotoma* | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| *Grateloupia doryphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia filicina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia corallinoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia phyllamphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnogongrus crenulatus* | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Gymnogongrus griffithsiae* | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Gymnogongrus* sp. | 1 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Gymnothamnion elegans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon virgatum* | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Halurus flosculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Herposiphonia secunda* | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| *Herposiphonia* sp. | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Heterosiphonia crispella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia crouaniorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia rubra* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Hildenbrandia* sp. | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Hydrolithon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea arbuscula* | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| *Hypnea flagelliformis* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea musciformis* | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| *Hypnea* sp. | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Hypnea spinella* | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Hypoglossum hypoglossoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania* sp. | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Jania adhaerens* | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Jania capillacea* | 1 | 1 | 1 | 0 | 0 | 0 | 1 |
| *Jania longifurca* | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Jania pumila* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania rubens* | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Laurencia hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia brongniartii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia chondrioides* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Laurencia flexilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia majuscula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia microcladia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia minuta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia obtusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia tenera* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Laurencia viridis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lejolisia mediterranea* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Liagora distenta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora maderensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora viscida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum incrustans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum polycephalum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria articulata* | 1 | 1 | 1 | 0 | 1 | 0 | 0 |
| *Lomentaria clavellosa* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Lomentaria linearis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria orcadensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia cristata* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Lophosiphonia reptabunda* | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Lophosiphonia* sp. | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Mastocarpus stellatus* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Melobesia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Meredithia microphylla* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Mesophyllum canariense* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum lichenoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemalion helminthoides* | 1 | 1 | 1 | 0 | 1 | 0 | 0 |
| *Neosiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Neosiphonia sphaerocarpa* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Nitophyllum punctatum* | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Nytophyllum* sp. | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Ophidocladus simpliciusculus* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Osmundea hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea pinnatifida* | 1 | 1 | 1 | 0 | 1 | 0 | 1 |
| *Osmundea* sp. | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Osmundea truncata* | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| *Palisada corallopsis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada patentiramea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada perforata* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Palisada poiteaui* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia squamaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora crispa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora gelidioides* | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| *Phymatolithon lenormandii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Platoma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium borreri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium caribaeum* | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Pleonosporium* sp. | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Plocamium cartilagineum* | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| *Polysiphonia atlantica* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Polysiphonia brodiaei* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia ceramiaeformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia denudata* | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Polysiphonia elongata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia flexella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia furcellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia harveyi* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Polysiphonia havanensis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Polysiphonia opaca* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Polysiphonia scopulorum* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Polysiphonia* sp. | 0 | 1 | 1 | 1 | 1 | 1 | 0 |
| *Polysiphonia sphacelaria* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Polysiphonia stricta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia tripinnata* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra leucosticta* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Porphyra* sp. | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Porphyra umbilicalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterocladiella capillacea* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Pterocladiella melanoidea* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pennata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pinnulata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ptilothamnion pluma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Red crust | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Rhodomela confervoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodophyllis divaricata* | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Rhodymenia ardissonei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Rhodymenia holmesii* | 0 | 1 | 1 | 0 | 1 | 0 | 1 |
| *Rhodymenia pseudopalmata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia* sp. | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Schizymenia dubyi* | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Schottera nicaeensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sebdenia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion flabellatum* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Spermothamnion repens* | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Sphaerococcus coronopifolius* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphondylothamnion multifidum* | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Spongites fruticulosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spyridia filamentosa* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Stylonema alsidii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Symphyocladia marchantioides* | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Taenioma nanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tiffaniella capitata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tsengia bairdii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia penicillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia* sp. | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Wurdemannia miniata* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| **Phaeophyceae** | | | | | | | |
| *Asteronema rhodochortonoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bachelotia antillarum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Brown crust | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| *Cladostephus spongious* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Colpomenia sinuosa* | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| *Cystoseira* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira abies-marina* | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| *Cystoseira foeniculacea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira humilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira wildpretii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyopteris polypodioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota bartayresiana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota dichotoma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota friabilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota pinnatifida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ectocarpus fasciculatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus siliculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Endarachne binghamiae* | 1 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Endarachne* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmania* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Feldmannia globifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia paradoxa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---|---|---|---|---|---|---|---|
| **Phaeophyceae (cont.)** | | | | | | | |
| *Fucus spiralis* | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| *Halopteris filicina* | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Hecatonema terminale* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia intermedia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia ovata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia rallsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia* sp. | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Hydroclathrus clathratus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Leathesia difformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lobophora variegata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myriactula chordae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myrionema strangulans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemoderma tingitanum* | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| *Padina pavonia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Papenfussiella kuromo* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Petrospongium berkeleyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pilinia rimosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudolithoderma adriaticum* | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| *Pseudolithoderma sp.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia verrucosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum acinarium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum cymosum* | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Sargassum furcatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Scytosiphon lomentaria* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Spatoglossum solieri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria cirrosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria fusca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Sphacelaria tribuloides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Styocaulon scoparia* | 1 | 1 | 0 | 1 | 0 | 1 | 1 |
| *Taonia atomaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Zonaria tournefortii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Chlorophyta** | | | | | | | |
| *Anadyomene saldanhae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anadyomene stellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia marginata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia minima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis corymbosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis cupressina* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis hypnoides* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis plumosa* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha aerea* | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Chaetomorpha antennina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Chaetomorpha gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha ligustica* | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Chaetomorpha linum* | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Chaetomorpha pachynema* | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Chaetomorpha* sp. | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Cladophora albida* | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Cladophora coelothrix* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora conferta* | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Cladophora dalmatica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora inclusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora laetervirens* | 0 | 0 | 1 | 1 | 1 | 1 | 0 |
| *Cladophora lehmanniana* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Cladophora liebetruthii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora pellucida* | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| *Cladophora prolifera* | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| *Cladophora sericea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora* sp. | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| *Cladophoropsis membranacea* | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Codium adhaerens* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Codium decorticatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium effusum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium elisabethae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium fragile* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium taylorii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium tomentosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium vermilara* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia marina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia tenuissima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Enteromorpha multirramosa* | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| *Ernodesmis verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Halydictyon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon calodictyon* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Monostroma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Percursaria percursa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhizoclonium tortuosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva clathrata* | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| *Ulva compressa* | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Ulva flexuosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva intestinalis* | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Ulva lactuca* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva prolifera* | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| *Ulva rigida* | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| *Ulva rotundata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Ulva* sp. | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Valonia macrophysa* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Valonia* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Valonia utricularis* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta** | | | | | | | |
| *Acrochaetium codii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrochaetium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosorium venulosum* | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Acrossorium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosymphyton* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Aglaothamnion byssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion cordatum* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Aglaothamnion galicum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion hookeri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion pseudobyssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion roseum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion* sp. | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Aglaothamnion tenuissimum* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ahnfeltia plicata* | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Ahnfeltiopsis devoniensis* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Amphiroa beauvoisii* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Amphiroa fragilissima* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa rigida* | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Amphiroa* sp. | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Anotrichium furcellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium* sp. | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium tenue* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion cruciatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion decipiens* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Antithamnion densum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion diminuatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnionella boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aphanocladia stichidiosa* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Apoglossum ruscifolium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis armata* | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Asparagopsis* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis taxiformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asteromenia peltata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bangia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Boergeseniella fruticulosa* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Boergeseniella thuyoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bonnemaisonia hamifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bornetia secundiflora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia botryoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Calcareous crust* | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Callithamnion corymbosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion tetragonum* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Catenella caespitosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Caulacanthus ustulatus* | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Centroceras clavulatum* | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| *Ceramium atrorubescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium botrycarpum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium ciliatum* | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| *Ceramium cingulatum* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Ceramium circinatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium codii* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Ceramium deslongchampii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium diaphanum* | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Ceramium echionotum* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Ceramium flaccidum* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium gaditanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium rubrum* | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Ceramium* sp. | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Ceramium tenerrimum* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Ceramium virgatum* | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| *Champia parvula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondracanthus acicularis* | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Chondracanthus teedei* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Chondria capillaris* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria coerulescens* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Chondria dasyphylla* | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| *Chondria* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chylocladia verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Coelothrix irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Corallina elongata* | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Corallina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Crouania attenuata* | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Cryptonemia lomation* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cryptopleura ramosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ctenosiphonia hypnoides* | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Dasya caraibica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya corymbifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya crouaniana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diplothamnion jolyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diplothamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dipterosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Drachiella minuta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrocystis montagnei* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Erythrodermis traillii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrotrichia carnea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Eupogodon planus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Falkenbergia rufolanosa* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Falkenbergia* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Feldmannophycus rayssiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium clavatum* | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Gastroclonium ovatum* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Gastroclonium reflexum* | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Gelidiella pannosa* | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Gelidiella tinerfensis* | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Gelidiopsis intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium arbusculum* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Gelidium microdon* | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Gelidium pusillum* | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Gelidium* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Gelidium spinosum* | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Gigartina pistillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gigartina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gloiocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria multipartita* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grallatoria reptans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia dichotoma* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Grateloupia doryphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia filicina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Griffithsia corallinoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia phyllamphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Gymnogongrus crenulatus* | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Gymnogongrus griffithsiae* | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Gymnogongrus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnothamnion elegans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon* sp. | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon virgatum* | 1 | 1 | 0 | 1 | 0 | 0 | 1 |
| *Halurus flosculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Herposiphonia secunda* | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Herposiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Heterosiphonia crispella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia crouaniorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydrolithon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea arbuscula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea flagelliformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea musciformis* | 1 | 1 | 1 | 0 | 1 | 0 | 0 |
| *Hypnea* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Hypnea spinella* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Hypoglossum hypoglossoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania* sp. | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Jania adhaerens* | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Jania capillacea* | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Jania longifurca* | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Jania pumila* | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Jania rubens* | 1 | 1 | 1 | 0 | 1 | 0 | 0 |
| *Laurencia hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia brongniartii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia chondrioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia flexilis* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia majuscula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia microcladia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia minuta* | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Laurencia obtusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia* sp. | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia tenera* | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| *Laurencia viridis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lejolisia mediterranea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora distenta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora maderensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora viscida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum incrustans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum polycephalum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria articulata* | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| *Lomentaria clavellosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria linearis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria orcadensis* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Lophosiphonia cristata* | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Lophosiphonia reptabunda* | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Lophosiphonia* sp. | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Mastocarpus stellatus* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Melobesia* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Meredithia microphylla* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum canariense* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum lichenoides* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Nemalion helminthoides* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Neosiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Neosiphonia sphaerocarpa* | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Nitophyllum punctatum* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nytophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ophidocladus simpliciusculus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Osmundea hybrida* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea pinnatifida* | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Osmundea* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Osmundea truncata* | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Palisada corallopsis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada patentiramea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada perforata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada poiteaui* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Peyssonnelia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Peyssonnelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia squamaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora crispa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora gelidioides* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Phymatolithon lenormandii* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Platoma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Pleonosporium borreri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium caribaeum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Plocamium cartilagineum* | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| *Polysiphonia atlantica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia brodiaei* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Polysiphonia ceramiaeformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia denudata* | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| *Polysiphonia elongata* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Polysiphonia flexella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia furcellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia havanensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia opaca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia scopulorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia* sp. | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| *Polysiphonia sphacelaria* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia stricta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia tripinnata* | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Porphyra leucosticta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra umbilicalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterocladiella capillacea* | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| *Pterocladiella melanoidea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pennata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pinnulata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ptilothamnion pluma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Red crust | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Rhodomela confervoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodophyllis divaricata* | 1 | 0 | 1 | 1 | 0 | 1 | 0 |
| *Rhodymenia ardissonei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Rhodymenia holmesii* | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Rhodymenia pseudopalmata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Schizymenia dubyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Schottera nicaeensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sebdenia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Spermothamnion flabellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion repens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphaerococcus coronopifolius* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphondylothamnion multifidum* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Spongites fruticulosa* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Spyridia filamentosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stylonema alsidii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Symphyocladia marchantioides* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Taenioma nanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tiffaniella capitata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tsengia bairdii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia penicillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wurdemannia miniata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Phaeophyceae** | | | | | | | |
| *Asteronema rhodochortonoides* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bachelotia antillarum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Brown crust | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Cladostephus spongious* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Colpomenia sinuosa* | 0 | 1 | 1 | 1 | 1 | 1 | 0 |
| *Cystoseira* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira abies-marina* | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Cystoseira foeniculacea* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Cystoseira humilis* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Cystoseira wildpretii* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Dictyopteris polypodioides* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Dictyota bartayresiana* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Dictyota dichotoma* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Dictyota friabilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota pinnatifida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota* sp. | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| *Ectocarpus fasciculatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus siliculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Endarachne binghamiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Endarachne* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmania* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Feldmannia globifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia irregularis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Feldmannia paradoxa* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|---|
| **Phaeophyceae (cont.)** | | | | | | | |
| *Fucus spiralis* | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Halopteris filicina* | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Hecatonema terminale* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia intermedia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia ovata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia rallsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydroclathrus clathratus* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Leathesia difformis* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Lobophora variegata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myriactula chordae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myrionema strangulans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemoderma tingitanum* | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Padina pavonia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Papenfussiella kuromo* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Petrospongium berkeleyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pilinia rimosa* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Pseudolithoderma adriaticum* | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Pseudolithoderma sp.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia verrucosa* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Sargassum acinarium* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Sargassum cymosum* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Sargassum furcatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Scytosiphon lomentaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spatoglossum solieri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria cirrosa* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Sphacelaria fusca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria* sp. | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Sphacelaria tribuloides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Styocaulon scoparia* | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Taonia atomaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Zonaria tournefortii* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| **Chlorophyta** | | | | | | | |
| *Anadyomene saldanhae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anadyomene stellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia marginata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia minima* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis corymbosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis cupressina* | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Bryopsis hypnoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis plumosa* | 1 | 0 | 1 | 1 | 0 | 1 | 0 |
| *Chaetomorpha aerea* | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Chaetomorpha antennina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Chaetomorpha gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha ligustica* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Chaetomorpha linum* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Chaetomorpha pachynema* | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| *Chaetomorpha* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Cladophora albida* | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| *Cladophora coelothrix* | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Cladophora conferta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora dalmatica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora inclusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora laetervirens* | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Cladophora lehmanniana* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Cladophora liebetruthii* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Cladophora pellucida* | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Cladophora prolifera* | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Cladophora sericea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora* sp. | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Cladophoropsis membranacea* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Codium adhaerens* | 1 | 1 | 1 | 0 | 1 | 0 | 1 |
| *Codium decorticatum* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Codium effusum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium elisabethae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium fragile* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium taylorii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium tomentosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium vermilara* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Derbesia marina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia tenuissima* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Enteromorpha multirramosa* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Ernodesmis verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Halydictyon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon calodictyon* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Monostroma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Percursaria percursa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhizoclonium tortuosum* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ulva clathrata* | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| *Ulva compressa* | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Ulva flexuosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva intestinalis* | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| *Ulva lactuca* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Ulva prolifera* | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Ulva rigida* | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Ulva rotundata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Ulva* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Valonia macrophysa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia* sp. | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Valonia utricularis* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta** | | | | | | | |
| *Acrochaetium codii* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Acrochaetium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosorium venulosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrossorium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosymphyton* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion byssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion cordatum* | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Aglaothamnion galicum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion hookeri* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Aglaothamnion pseudobyssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion roseum* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Aglaothamnion* sp. | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| *Aglaothamnion tenuissimum* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Ahnfeltia plicata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ahnfeltiopsis devoniensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa beauvoisii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa fragilissima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa rigida* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Amphiroa* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium furcellatum* | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Anotrichium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium tenue* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion cruciatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion decipiens* | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Antithamnion densum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion diminuatum* | 0 | 1 | 0 | 0 | 1 | 1 | 0 |
| *Antithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnionella boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aphanocladia stichidiosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Apoglossum ruscifolium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis armata* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Asparagopsis* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis taxiformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asteromenia peltata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bangia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Boergeseniella fruticulosa* | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| *Boergeseniella thuyoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bonnemaisonia hamifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bornetia secundiflora* | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Botryocladia botryoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Calcareous crust* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion corymbosum* | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Callithamnion* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Callithamnion tetragonum* | 1 | 0 | 0 | 1 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Catenella caespitosa* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Caulacanthus ustulatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Centroceras clavulatum* | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Ceramium atrorubescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium botrycarpum* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Ceramium ciliatum* | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| *Ceramium cingulatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium circinatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium codii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium deslongchampii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium diaphanum* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Ceramium echionotum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium flaccidum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium gaditanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium rubrum* | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Ceramium* sp. | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Ceramium tenerrimum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium virgatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Champia parvula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondracanthus acicularis* | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Chondracanthus teedei* | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Chondria capillaris* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria coerulescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria dasyphylla* | 1 | 1 | 0 | 0 | 1 | 0 | 1 |
| *Chondria* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chylocladia verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Coelothrix irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Corallina elongata* | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Corallina* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Crouania attenuata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cryptonemia lomation* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cryptopleura ramosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ctenosiphonia hypnoides* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Dasya caraibica* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Dasya corymbifera* | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Dasya crouaniana* | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Dasya hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diplothamnion jolyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diplothamnion* sp. | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Dipterosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Drachiella minuta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrocystis montagnei* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Erythrodermis traillii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrotrichia carnea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Eupogodon planus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Falkenbergia rufolanosa* | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Falkenbergia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannophycus rayssiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium clavatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium ovatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium reflexum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiella pannosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiella tinerfensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiopsis intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium arbusculum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium microdon* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium pusillum* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Gelidium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium spinosum* | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| *Gigartina pistillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gigartina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gloiocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria multipartita* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grallatoria reptans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia dichotoma* | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Grateloupia doryphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia filicina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia* sp. | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Griffithsia corallinoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia phyllamphora* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Griffithsia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnogongrus crenulatus* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Gymnogongrus griffithsiae* | 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| *Gymnogongrus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnothamnion elegans* | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Haliptilon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon virgatum* | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| *Halurus flosculosus* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Herposiphonia secunda* | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Herposiphonia* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Heterosiphonia crispella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia crouaniorum* | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Hildenbrandia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydrolithon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea arbuscula* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Hypnea flagelliformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea musciformis* | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Hypnea* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Hypnea spinella* | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Hypoglossum hypoglossoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania adhaerens* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Jania capillacea* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Jania longifurca* | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| *Jania pumila* | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| *Jania rubens* | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Laurencia hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia brongniartii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia chondrioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia flexilis* | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Laurencia intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia majuscula* | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| *Laurencia microcladia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia minuta* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Laurencia obtusa* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia tenera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia viridis* | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Lejolisia mediterranea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora distenta* | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| *Liagora maderensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Liagora viscida* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum incrustans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum polycephalum* | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Lithophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria articulata* | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Lomentaria clavellosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria linearis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria orcadensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia cristata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia reptabunda* | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Lophosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mastocarpus stellatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Melobesia* sp. | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| *Meredithia microphylla* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Mesophyllum canariense* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum lichenoides* | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Nemalion helminthoides* | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| *Neosiphonia harveyi* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Neosiphonia sphaerocarpa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nitophyllum punctatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nytophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ophidocladus simpliciusculus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Osmundea hybrida* | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Osmundea pinnatifida* | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Osmundea* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea truncata* | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Palisada corallopsis* | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| *Palisada patentiramea* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Palisada perforata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada poiteaui* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia squamaria* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Phyllophora crispa* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Phyllophora gelidioides* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Phymatolithon lenormandii* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Platoma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium borreri* | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium caribaeum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Plocamium cartilagineum* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Polysiphonia atlantica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia brodiaei* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Polysiphonia ceramiaeformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia denudata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia elongata* | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Polysiphonia flexella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia furcellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia havanensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia opaca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia scopulorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia* sp. | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Polysiphonia sphacelaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia stricta* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Polysiphonia tripinnata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra leucosticta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Porphyra umbilicalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterocladiella capillacea* | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Pterocladiella melanoidea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pennata* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Pterosiphonia pinnulata* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Ptilothamnion pluma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Red crust | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodomela confervoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodophyllis divaricata* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Rhodymenia ardissonei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Rhodymenia holmesii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia pseudopalmata* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Rhodymenia* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Schizymenia dubyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Schottera nicaeensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sebdenia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion flabellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion repens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphaerococcus coronopifolius* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphondylothamnion multifidum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spongites fruticulosa* | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| *Spyridia filamentosa* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Stylonema alsidii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Symphyocladia marchantioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Taenioma nanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tiffaniella capitata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tsengia bairdii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia penicillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wurdemannia miniata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Phaeophyceae** | | | | | | | |
| *Asteronema rhodochortonoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bachelotia antillarum* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Brown crust | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladostephus spongious* | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| *Colpomenia sinuosa* | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Cystoseira* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira abies-marina* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Cystoseira foeniculacea* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Cystoseira humilis* | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Cystoseira wildpretii* | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Dictyopteris polypodioides* | 0 | 1 | 1 | 0 | 0 | 1 | 0 |
| *Dictyota bartayresiana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota dichotoma* | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| *Dictyota friabilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota pinnatifida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota* sp. | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Ectocarpus fasciculatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus siliculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Endarachne binghamiae* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Endarachne* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmania* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Feldmannia globifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia irregularis* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Feldmannia paradoxa* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
|---|---|---|---|---|---|---|---|
| **Phaeophyceae (cont.)** | | | | | | | |
| *Fucus spiralis* | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Halopteris filicina* | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Hecatonema terminale* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia intermedia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia ovata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia rallsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydroclathrus clathratus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Leathesia difformis* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Lobophora variegata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myriactula chordae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myrionema strangulans* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Nemoderma tingitanum* | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Padina pavonia* | 1 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Papenfussiella kuromo* | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Petrospongium berkeleyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pilinia rimosa* | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Pseudolithoderma adriaticum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudolithoderma sp.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Ralfsia verrucosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum acinarium* | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Sargassum cymosum* | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Sargassum furcatum* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Sargassum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Scytosiphon lomentaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spatoglossum solieri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria cirrosa* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria fusca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria tribuloides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Styocaulon scoparia* | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| *Taonia atomaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Zonaria tournefortii* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| **Chlorophyta** | | | | | | | |
| *Anadyomene saldanhae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anadyomene stellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia marginata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia minima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis corymbosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis cupressina* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Bryopsis hypnoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis plumosa* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Chaetomorpha aerea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha antennina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Chaetomorpha gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha ligustica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha linum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha pachynema* | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| *Chaetomorpha* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora albida* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Cladophora coelothrix* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora conferta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora dalmatica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora inclusa* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Cladophora laetervirens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora lehmanniana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora liebetruthii* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora pellucida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora prolifera* | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
| *Cladophora sericea* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Cladophora* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophoropsis membranacea* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium adhaerens* | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| *Codium decorticatum* | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| *Codium effusum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium elisabethae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium fragile* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Codium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium taylorii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium tomentosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium vermilara* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Derbesia marina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia tenuissima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Enteromorpha multirramosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ernodesmis verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Halydictyon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon calodictyon* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Monostroma* sp. | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Percursaria percursa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhizoclonium tortuosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva clathrata* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Ulva compressa* | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ulva flexuosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva intestinalis* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Ulva lactuca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva prolifera* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Ulva rigida* | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| *Ulva rotundata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 43 | 44 | 45 | 46 | 47 | 48 | 49 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Ulva* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia macrophysa* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Valonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia utricularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta** | | | | | | | |
| *Acrochaetium codii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrochaetium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosorium venulosum* | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Acrossorium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosymphyton* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion byssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion cordatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion galicum* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion hookeri* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion pseudobyssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion roseum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion* sp. | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Aglaothamnion tenuissimum* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ahnfeltia plicata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ahnfeltiopsis devoniensis* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa beauvoisii* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Amphiroa fragilissima* | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| *Amphiroa rigida* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Amphiroa* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium furcellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium tenue* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion cruciatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion decipiens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion densum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion diminuatum* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnionella boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aphanocladia stichidiosa* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Apoglossum ruscifolium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis armata* | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Asparagopsis* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis taxiformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asteromenia peltata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bangia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Boergeseniella fruticulosa* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Boergeseniella thuyoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bonnemaisonia hamifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bornetia secundiflora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia botryoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Calcareous crust* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion corymbosum* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion tetragonum* | 1 | 1 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Catenella caespitosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Caulacanthus ustulatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Centroceras clavulatum* | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Ceramium atrorubescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium botrycarpum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium ciliatum* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Ceramium cingulatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium circinatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium codii* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium deslongchampii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium diaphanum* | 1 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Ceramium echionotum* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Ceramium flaccidum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium gaditanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium rubrum* | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Ceramium* sp. | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Ceramium tenerrimum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium virgatum* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Champia parvula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondracanthus acicularis* | 1 | 0 | 1 | 0 | 1 | 1 | 0 |
| *Chondracanthus teedei* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria capillaris* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria coerulescens* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria dasyphylla* | 1 | 1 | 1 | 0 | 0 | 1 | 1 |
| *Chondria* sp. | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Chylocladia verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Coelothrix irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Corallina elongata* | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| *Corallina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Crouania attenuata* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Cryptonemia lomation* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cryptopleura ramosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ctenosiphonia hypnoides* | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Dasya caraibica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya corymbifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya crouaniana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diplothamnion jolyi* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Diplothamnion* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dipterosiphonia* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Drachiella minuta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrocystis montagnei* | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Erythrodermis traillii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrotrichia carnea* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Eupogodon planus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Falkenbergia rufolanosa* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Falkenbergia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannophycus rayssiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium clavatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium ovatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium reflexum* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Gelidiella pannosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiella tinerfensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiopsis intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium arbusculum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium microdon* | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Gelidium pusillum* | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| *Gelidium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium spinosum* | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| *Gigartina pistillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gigartina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gloiocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria multipartita* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grallatoria reptans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia dichotoma* | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia doryphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia filicina* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia corallinoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia phyllamphora* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Griffithsia* sp. | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Gymnogongrus crenulatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnogongrus griffithsiae* | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Gymnogongrus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnothamnion elegans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon virgatum* | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| *Halurus flosculosus* | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Herposiphonia secunda* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Herposiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Heterosiphonia crispella* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Hildenbrandia crouaniorum* | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydrolithon* sp. | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea arbuscula* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Hypnea flagelliformis* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Hypnea musciformis* | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
| *Hypnea* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Hypnea spinella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypoglossum hypoglossoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania adhaerens* | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Jania capillacea* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Jania longifurca* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Jania pumila* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Jania rubens* | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Laurencia hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia brongniartii* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia chondrioides* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Laurencia flexilis* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Laurencia intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Laurencia majuscula* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Laurencia microcladia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia minuta* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Laurencia obtusa* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Laurencia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia tenera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia viridis* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Lejolisia mediterranea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora distenta* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora maderensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Liagora viscida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum incrustans* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum polycephalum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria articulata* | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Lomentaria clavellosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria linearis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria orcadensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia cristata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia reptabunda* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Lophosiphonia* sp. | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Mastocarpus stellatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Melobesia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Meredithia microphylla* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Mesophyllum canariense* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum lichenoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemalion helminthoides* | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Neosiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Neosiphonia sphaerocarpa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nitophyllum punctatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nytophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ophidocladus simpliciusculus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Osmundea hybrida* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea pinnatifida* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Osmundea* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea truncata* | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| *Palisada corallopsis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada patentiramea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada perforata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada poiteaui* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Peyssonnelia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia* sp. | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Peyssonnelia squamaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora crispa* | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora gelidioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phymatolithon lenormandii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Platoma* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium borreri* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium caribaeum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Plocamium cartilagineum* | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Polysiphonia atlantica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia brodiaei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia ceramiaeformis* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia denudata* | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Polysiphonia elongata* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia flexella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia furcellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia havanensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia opaca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia scopulorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia* sp. | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Polysiphonia sphacelaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia stricta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia tripinnata* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Porphyra leucosticta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra* sp. | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra umbilicalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterocladiella capillacea* | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| *Pterocladiella melanoidea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pennata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pinnulata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ptilothamnion pluma* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Red crust | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodomela confervoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodophyllis divaricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia ardissonei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Rhodymenia holmesii* | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Rhodymenia pseudopalmata* | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Schizymenia dubyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Schottera nicaeensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sebdenia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion flabellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion repens* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Sphaerococcus coronopifolius* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Sphondylothamnion multifidum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spongites fruticulosa* | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Spyridia filamentosa* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Stylonema alsidii* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Symphyocladia marchantioides* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Taenioma nanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tiffaniella capitata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tsengia bairdii* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Wrangelia penicillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wurdemannia miniata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Phaeophyceae** | | | | | | | |
| *Asteronema rhodochortonoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bachelotia antillarum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Brown crust | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladostephus spongious* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Colpomenia sinuosa* | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Cystoseira* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira abies-marina* | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| *Cystoseira foeniculacea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira humilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira wildpretii* | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Dictyopteris polypodioides* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota bartayresiana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota dichotoma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota friabilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota pinnatifida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus fasciculatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus siliculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Endarachne binghamiae* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Endarachne* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmania* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia globifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia paradoxa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|---|---|
| **Phaeophyceae (cont.)** | | | | | | | |
| *Fucus spiralis* | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Halopteris filicina* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Hecatonema terminale* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia intermedia* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Hincksia ovata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia rallsiae* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydroclathrus clathratus* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Leathesia difformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lobophora variegata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myriactula chordae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myrionema strangulans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemoderma tingitanum* | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Padina pavonia* | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Papenfussiella kuromo* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Petrospongium berkeleyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pilinia rimosa* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Pseudolithoderma adriaticum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudolithoderma sp.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia* sp. | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia verrucosa* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum acinarium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum cymosum* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum furcatum* | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| *Sargassum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Scytosiphon lomentaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spatoglossum solieri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria cirrosa* | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| *Sphacelaria fusca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria* sp. | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Sphacelaria tribuloides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Styocaulon scoparia* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Taonia atomaria* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Zonaria tournefortii* | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| **Chlorophyta** | | | | | | | |
| *Anadyomene saldanhae* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Anadyomene stellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia marginata* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Blidingia minima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis corymbosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis cupressina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis hypnoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis plumosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha aerea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha antennina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Chaetomorpha gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha ligustica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha linum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha pachynema* | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| *Chaetomorpha* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora albida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora coelothrix* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Cladophora conferta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora dalmatica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora inclusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora laetervirens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora lehmanniana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora liebetruthii* | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Cladophora pellucida* | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| *Cladophora prolifera* | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Cladophora sericea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora* sp. | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Cladophoropsis membranacea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium adhaerens* | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| *Codium decorticatum* | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Codium effusum* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Codium elisabethae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium fragile* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium taylorii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium tomentosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium vermilara* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia marina* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Derbesia tenuissima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Enteromorpha multirramosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ernodesmis verticillata* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Halydictyon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon calodictyon* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Monostroma* sp. | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Percursaria percursa* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Rhizoclonium tortuosum* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Ulva clathrata* | 1 | 1 | 1 | 0 | 0 | 0 | 1 |
| *Ulva compressa* | 1 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Ulva flexuosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva intestinalis* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Ulva lactuca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva prolifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva rigida* | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Ulva rotundata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Ulva* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia macrophysa* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Valonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia utricularis* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta** | | | | | | | |
| *Acrochaetium codii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrochaetium* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosorium venulosum* | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| *Acrossorium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosymphyton* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion byssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion cordatum* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Aglaothamnion galicum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion hookeri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion pseudobyssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion roseum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion* sp. | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Aglaothamnion tenuissimum* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Ahnfeltia plicata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ahnfeltiopsis devoniensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa beauvoisii* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa fragilissima* | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Amphiroa rigida* | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium furcellatum* | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Anotrichium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium tenue* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion cruciatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion decipiens* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Antithamnion densum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion diminuatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion* sp. | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Antithamnionella boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aphanocladia stichidiosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Apoglossum ruscifolium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis armata* | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| *Asparagopsis* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis taxiformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asteromenia peltata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bangia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Boergeseniella fruticulosa* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Boergeseniella thuyoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bonnemaisonia hamifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bornetia secundiflora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia botryoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Calcareous crust* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion corymbosum* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Callithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion tetragonum* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Catenella caespitosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Caulacanthus ustulatus* | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| *Centroceras clavulatum* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Ceramium atrorubescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium botrycarpum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium ciliatum* | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Ceramium cingulatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium circinatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium codii* | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Ceramium deslongchampii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium diaphanum* | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Ceramium echionotum* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium flaccidum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium gaditanum* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium rubrum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium* sp. | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Ceramium tenerrimum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium virgatum* | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Champia parvula* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondracanthus acicularis* | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| *Chondracanthus teedei* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Chondria capillaris* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria coerulescens* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Chondria dasyphylla* | 1 | 1 | 0 | 1 | 0 | 1 | 1 |
| *Chondria* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chylocladia verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Coelothrix irregularis* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Corallina elongata* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Corallina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Crouania attenuata* | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Cryptonemia lomation* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cryptopleura ramosa* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ctenosiphonia hypnoides* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya caraibica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya corymbifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya crouaniana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya rigidula* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Dasya* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Diplothamnion jolyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diplothamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dipterosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Drachiella minuta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrocystis montagnei* | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Erythrodermis traillii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrotrichia carnea* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Eupogodon planus* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Falkenbergia rufolanosa* | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| *Falkenbergia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannophycus rayssiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium clavatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium ovatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium reflexum* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Gelidiella pannosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiella tinerfensis* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiopsis intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium arbusculum* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Gelidium microdon* | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| *Gelidium pusillum* | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Gelidium* sp. | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Gelidium spinosum* | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Gigartina pistillata* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Gigartina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gloiocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria gracilis* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Gracilaria multipartita* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grallatoria reptans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia dichotoma* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Grateloupia doryphora* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Grateloupia filicina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia corallinoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia phyllamphora* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Griffithsia* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnogongrus crenulatus* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Gymnogongrus griffithsiae* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Gymnogongrus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnothamnion elegans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon virgatum* | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Halurus flosculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Herposiphonia secunda* | 1 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Herposiphonia* sp. | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| *Heterosiphonia crispella* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia crouaniorum* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Hildenbrandia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydrolithon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea arbuscula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea flagelliformis* | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Hypnea musciformis* | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| *Hypnea* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Hypnea spinella* | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Hypoglossum hypoglossoides* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania* sp. | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Jania adhaerens* | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Jania capillacea* | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| *Jania longifurca* | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Jania pumila* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Jania rubens* | 1 | 1 | 0 | 1 | 1 | 1 | 0 |
| *Laurencia hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia brongniartii* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Laurencia chondrioides* | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Laurencia flexilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia majuscula* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Laurencia microcladia* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Laurencia minuta* | 0 | 1 | 0 | 0 | 1 | 1 | 1 |
| *Laurencia obtusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia tenera* | 1 | 1 | 0 | 0 | 1 | 0 | 1 |
| *Laurencia viridis* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Lejolisia mediterranea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora distenta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora maderensis* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora* sp. | 1 | 1 | 1 | 0 | 0 | 1 | 1 |
| *Liagora viscida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum incrustans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum polycephalum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria articulata* | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| *Lomentaria clavellosa* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Lomentaria linearis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Lomentaria orcadensis* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia cristata* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Lophosiphonia reptabunda* | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Lophosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mastocarpus stellatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Melobesia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Meredithia microphylla* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum canariense* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum lichenoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemalion helminthoides* | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| *Neosiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Neosiphonia sphaerocarpa* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Nitophyllum punctatum* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nytophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ophidocladus simpliciusculus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Osmundea hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea pinnatifida* | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Osmundea* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea truncata* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Palisada corallopsis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada patentiramea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada perforata* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Palisada poiteaui* | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| *Peyssonnelia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia squamaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora crispa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora gelidioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phymatolithon lenormandii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Platoma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium borreri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium caribaeum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Plocamium cartilagineum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia atlantica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia brodiaei* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Polysiphonia ceramiaeformis* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Polysiphonia denudata* | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| *Polysiphonia elongata* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Polysiphonia flexella* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia furcellata* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Polysiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia havanensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia opaca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia scopulorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia* sp. | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Polysiphonia sphacelaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia stricta* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Polysiphonia tripinnata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra leucosticta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra umbilicalis* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Pterocladiella capillacea* | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Pterocladiella melanoidea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pennata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pinnulata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ptilothamnion pluma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Red crust | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodomela confervoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodophyllis divaricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia ardissonei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Rhodymenia holmesii* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Rhodymenia pseudopalmata* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia* sp. | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Schizymenia dubyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Schottera nicaeensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sebdenia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion flabellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion repens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphaerococcus coronopifolius* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Sphondylothamnion multifidum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spongites fruticulosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spyridia filamentosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stylonema alsidii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Symphyocladia marchantioides* | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| *Taenioma nanum* | 0 | 1 | 0 | 0 | 1 | 1 | 0 |
| *Tiffaniella capitata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tsengia bairdii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia penicillata* | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Wrangelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wurdemannia miniata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Phaeophyceae** | | | | | | | |
| *Asteronema rhodochortonoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bachelotia antillarum* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Brown crust | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladostephus spongious* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Colpomenia sinuosa* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Cystoseira* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira abies-marina* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Cystoseira foeniculacea* | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| *Cystoseira humilis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Cystoseira wildpretii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyopteris polypodioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota bartayresiana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota dichotoma* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota friabilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota pinnatifida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus fasciculatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus siliculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Endarachne binghamiae* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Endarachne* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmania* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia globifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia paradoxa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
|---|---|---|---|---|---|---|---|
| **Phaeophyceae (cont.)** | | | | | | | |
| *Fucus spiralis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Halopteris filicina* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Hecatonema terminale* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia intermedia* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia ovata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia rallsiae* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Hincksia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydroclathrus clathratus* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Leathesia difformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lobophora variegata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myriactula chordae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myrionema strangulans* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Nemoderma tingitanum* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Padina pavonia* | 1 | 1 | 0 | 1 | 0 | 0 | 1 |
| *Papenfussiella kuromo* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Petrospongium berkeleyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pilinia rimosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudolithoderma adriaticum* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Pseudolithoderma sp.* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Ralfsia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia verrucosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum acinarium* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Sargassum cymosum* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Sargassum furcatum* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Scytosiphon lomentaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spatoglossum solieri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria cirrosa* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Sphacelaria fusca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria* sp. | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| *Sphacelaria tribuloides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Styocaulon scoparia* | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| *Taonia atomaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Zonaria tournefortii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Chlorophyta** | | | | | | | |
| *Anadyomene saldanhae* | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| *Anadyomene stellata* | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Blidingia marginata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia minima* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Bryopsis corymbosa* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Bryopsis cupressina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis hypnoides* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Bryopsis plumosa* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Chaetomorpha aerea* | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| *Chaetomorpha antennina* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Chaetomorpha gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha ligustica* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Chaetomorpha linum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha pachynema* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Chaetomorpha* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora albida* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Cladophora coelothrix* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Cladophora conferta* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Cladophora dalmatica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora inclusa* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Cladophora laetervirens* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Cladophora lehmanniana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora liebetruthii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora pellucida* | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Cladophora prolifera* | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Cladophora sericea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora* sp. | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Cladophoropsis membranacea* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Codium adhaerens* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Codium decorticatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium effusum* | 0 | 1 | 0 | 0 | 1 | 1 | 1 |
| *Codium elisabethae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium fragile* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium taylorii* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Codium tomentosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium vermilara* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Derbesia marina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia tenuissima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Enteromorpha multirramosa* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Ernodesmis verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Halydictyon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon calodictyon* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Monostroma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Percursaria percursa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhizoclonium tortuosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva clathrata* | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Ulva compressa* | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| *Ulva flexuosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva intestinalis* | 0 | 1 | 0 | 0 | 1 | 1 | 1 |
| *Ulva lactuca* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ulva prolifera* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Ulva rigida* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Ulva rotundata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Ulva* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia macrophysa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia utricularis* | 1 | 0 | 0 | 0 | 1 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta** | | | | | | | |
| *Acrochaetium codii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrochaetium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosorium venulosum* | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Acrossorium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosymphyton* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion byssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion cordatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion galicum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion hookeri* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion pseudobyssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion roseum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion* sp. | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Aglaothamnion tenuissimum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ahnfeltia plicata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ahnfeltiopsis devoniensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa beauvoisii* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Amphiroa fragilissima* | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| *Amphiroa rigida* | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Amphiroa* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Anotrichium furcellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium tenue* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion cruciatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion decipiens* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Antithamnion densum* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Antithamnion diminuatum* | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Antithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnionella boergesenii* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Aphanocladia stichidiosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Apoglossum ruscifolium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis armata* | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| *Asparagopsis* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis taxiformis* | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Asteromenia peltata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bangia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Boergeseniella fruticulosa* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Boergeseniella thuyoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bonnemaisonia hamifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bornetia secundiflora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia botryoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Calcareous crust* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion corymbosum* | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Callithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion tetragonum* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Catenella caespitosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Caulacanthus ustulatus* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Centroceras clavulatum* | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| *Ceramium atrorubescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium botrycarpum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium ciliatum* | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Ceramium cingulatum* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Ceramium circinatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium codii* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium deslongchampii* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Ceramium diaphanum* | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Ceramium echionotum* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Ceramium flaccidum* | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Ceramium gaditanum* | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Ceramium rubrum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ceramium tenerrimum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium virgatum* | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Champia parvula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondracanthus acicularis* | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| *Chondracanthus teedei* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria capillaris* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria coerulescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria dasyphylla* | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Chondria* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chylocladia verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Coelothrix irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Corallina elongata* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Corallina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Crouania attenuata* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Cryptonemia lomation* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cryptopleura ramosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ctenosiphonia hypnoides* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Dasya caraibica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya corymbifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya crouaniana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diplothamnion jolyi* | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Diplothamnion* sp. | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Dipterosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Drachiella minuta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrocystis montagnei* | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Erythrodermis traillii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrotrichia carnea* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Eupogodon planus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Falkenbergia rufolanosa* | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Falkenbergia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannophycus rayssiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium clavatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium ovatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium reflexum* | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| *Gelidiella pannosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiella tinerfensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiopsis intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium arbusculum* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Gelidium microdon* | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Gelidium pusillum* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Gelidium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium spinosum* | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| *Gigartina pistillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gigartina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gloiocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria multipartita* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grallatoria reptans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia dichotoma* | 1 | 1 | 1 | 0 | 1 | 1 | 0 |
| *Grateloupia doryphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia filicina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia corallinoides* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Griffithsia phyllamphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia* sp. | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Gymnogongrus crenulatus* | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| *Gymnogongrus griffithsiae* | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Gymnogongrus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnothamnion elegans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon virgatum* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Halurus flosculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Herposiphonia secunda* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Herposiphonia* sp. | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Heterosiphonia crispella* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Hildenbrandia crouaniorum* | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Hildenbrandia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydrolithon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea arbuscula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea flagelliformis* | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Hypnea musciformis* | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Hypnea* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Hypnea spinella* | 1 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Hypoglossum hypoglossoides* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Jania* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Jania adhaerens* | 1 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Jania capillacea* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Jania longifurca* | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Jania pumila* | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| *Jania rubens* | 1 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Laurencia hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia brongniartii* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Laurencia chondrioides* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Laurencia flexilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia majuscula* | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Laurencia microcladia* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Laurencia minuta* | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Laurencia obtusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia tenera* | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Laurencia viridis* | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Lejolisia mediterranea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora distenta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora maderensis* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Liagora* sp. | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Liagora viscida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum incrustans* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum polycephalum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria articulata* | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Lomentaria clavellosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria linearis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria orcadensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia cristata* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Lophosiphonia reptabunda* | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Lophosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mastocarpus stellatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Melobesia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Meredithia microphylla* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum canariense* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum lichenoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemalion helminthoides* | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Neosiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Neosiphonia sphaerocarpa* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Nitophyllum punctatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nytophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ophidocladus simpliciusculus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Osmundea hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Osmundea pinnatifida* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Osmundea* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea truncata* | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| *Palisada corallopsis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada patentiramea* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Palisada perforata* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Palisada poiteaui* | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Peyssonnelia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia squamaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora crispa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora gelidioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phymatolithon lenormandii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Platoma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium borreri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium caribaeum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Plocamium cartilagineum* | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Polysiphonia atlantica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia brodiaei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia ceramiaeformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia denudata* | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Polysiphonia elongata* | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Polysiphonia flexella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia furcellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia havanensis* | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Polysiphonia opaca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia scopulorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia* sp. | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Polysiphonia sphacelaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia stricta* | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Polysiphonia tripinnata* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Porphyra leucosticta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra umbilicalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterocladiella capillacea* | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Pterocladiella melanoidea* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pennata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pinnulata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ptilothamnion pluma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Red crust | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodomela confervoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodophyllis divaricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia ardissonei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Rhodymenia holmesii* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Rhodymenia pseudopalmata* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Rhodymenia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Schizymenia dubyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Schottera nicaeensis* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Sebdenia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion flabellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion repens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphaerococcus coronopifolius* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphondylothamnion multifidum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spongites fruticulosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spyridia filamentosa* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Stylonema alsidii* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Symphyocladia marchantioides* | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Taenioma nanum* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Tiffaniella capitata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tsengia bairdii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia penicillata* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Wrangelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wurdemannia miniata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Phaeophyceae** | | | | | | | |
| *Asteronema rhodochortonoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bachelotia antillarum* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Brown crust | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladostephus spongious* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Colpomenia sinuosa* | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| *Cystoseira* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira abies-marina* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Cystoseira foeniculacea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira humilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira wildpretii* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Dictyopteris polypodioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota bartayresiana* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Dictyota dichotoma* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Dictyota friabilis* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Dictyota pinnatifida* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Dictyota* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus fasciculatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus siliculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Endarachne binghamiae* | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Endarachne* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmania* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia globifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Feldmannia paradoxa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|
| **Phaeophyceae (cont.)** | | | | | | | |
| *Fucus spiralis* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Halopteris filicina* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Hecatonema terminale* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia intermedia* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Hincksia ovata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia rallsiae* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Hincksia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydroclathrus clathratus* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Leathesia difformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lobophora variegata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myriactula chordae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myrionema strangulans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemoderma tingitanum* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Padina pavonia* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Papenfussiella kuromo* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Petrospongium berkeleyi* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Pilinia rimosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudolithoderma adriaticum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudolithoderma sp.* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Ralfsia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia verrucosa* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Sargassum acinarium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum cymosum* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Sargassum furcatum* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Sargassum* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Scytosiphon lomentaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spatoglossum solieri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria cirrosa* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Sphacelaria fusca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Sphacelaria tribuloides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Styocaulon scoparia* | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| *Taonia atomaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Zonaria tournefortii* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| **Chlorophyta** | | | | | | | |
| *Anadyomene saldanhae* | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Anadyomene stellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia marginata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia minima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis corymbosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis cupressina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis hypnoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis plumosa* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Chaetomorpha aerea* | 1 | 0 | 1 | 1 | 0 | 1 | 0 |
| *Chaetomorpha antennina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Chaetomorpha gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha ligustica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha linum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha pachynema* | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Chaetomorpha* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora albida* | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Cladophora coelothrix* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Cladophora conferta* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Cladophora dalmatica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora inclusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora laetervirens* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Cladophora lehmanniana* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Cladophora liebetruthii* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Cladophora pellucida* | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora prolifera* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Cladophora sericea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Cladophoropsis membranacea* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Codium adhaerens* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Codium decorticatum* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Codium effusum* | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Codium elisabethae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium fragile* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium taylorii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium tomentosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium vermilara* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia marina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia tenuissima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Enteromorpha multirramosa* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Ernodesmis verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Halydictyon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon boergesenii* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Microdictyon calodictyon* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Monostroma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Percursaria percursa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhizoclonium tortuosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva clathrata* | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Ulva compressa* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Ulva flexuosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva intestinalis* | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Ulva lactuca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva prolifera* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Ulva rigida* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Ulva rotundata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Ulva* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia macrophysa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia utricularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 71 | 72 | 73 | 74 | 75 | 76 | 77 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta** | | | | | | | |
| *Acrochaetium codii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrochaetium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosorium venulosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrossorium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosymphyton* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion byssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion cordatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion galicum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion hookeri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion pseudobyssoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion roseum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Aglaothamnion tenuissimum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ahnfeltia plicata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ahnfeltiopsis devoniensis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Amphiroa beauvoisii* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa fragilissima* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Amphiroa rigida* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Amphiroa* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium furcellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium tenue* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion cruciatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion decipiens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion densum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion diminuatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnionella boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aphanocladia stichidiosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Apoglossum ruscifolium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis armata* | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Asparagopsis* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis taxiformis* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Asteromenia peltata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bangia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Boergeseniella fruticulosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Boergeseniella thuyoides* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Bonnemaisonia hamifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bornetia secundiflora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia botryoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Calcareous crust* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion corymbosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion tetragonum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 71 | 72 | 73 | 74 | 75 | 76 | 77 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Catenella caespitosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Caulacanthus ustulatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Centroceras clavulatum* | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| *Ceramium atrorubescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium botrycarpum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium ciliatum* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Ceramium cingulatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium circinatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium codii* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Ceramium deslongchampii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium diaphanum* | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| *Ceramium echionotum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium flaccidum* | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| *Ceramium gaditanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium rubrum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium tenerrimum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium virgatum* | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Champia parvula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondracanthus acicularis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Chondracanthus teedei* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Chondria capillaris* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria coerulescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria dasyphylla* | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Chondria* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chylocladia verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Coelothrix irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Corallina elongata* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Corallina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Crouania attenuata* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Cryptonemia lomation* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cryptopleura ramosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ctenosiphonia hypnoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya caraibica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya corymbifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya crouaniana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diplothamnion jolyi* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Diplothamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dipterosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Drachiella minuta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrocystis montagnei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrodermis traillii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrotrichia carnea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 71 | 72 | 73 | 74 | 75 | 76 | 77 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Eupogodon planus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Falkenbergia rufolanosa* | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Falkenbergia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannophycus rayssiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium clavatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium ovatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium reflexum* | 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Gelidiella pannosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiella tinerfensis* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Gelidiopsis intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium arbusculum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium microdon* | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Gelidium pusillum* | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| *Gelidium* sp. | 0 | 1 | 0 | 0 | 1 | 1 | 0 |
| *Gelidium spinosum* | 0 | 1 | 1 | 1 | 0 | 1 | 0 |
| *Gigartina pistillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gigartina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gloiocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria multipartita* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grallatoria reptans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia dichotoma* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Grateloupia doryphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia filicina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia corallinoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia phyllamphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnogongrus crenulatus* | 0 | 1 | 0 | 0 | 1 | 1 | 0 |
| *Gymnogongrus griffithsiae* | 1 | 1 | 1 | 1 | 0 | 1 | 0 |
| *Gymnogongrus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnothamnion elegans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon virgatum* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Halurus flosculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Herposiphonia secunda* | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Herposiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Heterosiphonia crispella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia crouaniorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydrolithon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea arbuscula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea flagelliformis* | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Hypnea musciformis* | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Hypnea* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 71 | 72 | 73 | 74 | 75 | 76 | 77 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Hypnea spinella* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Hypoglossum hypoglossoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania adhaerens* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Jania capillacea* | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Jania longifurca* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Jania pumila* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Jania rubens* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Laurencia hybrida* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Laurencia brongniartii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia chondrioides* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Laurencia flexilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia intricata* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Laurencia majuscula* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Laurencia microcladia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia minuta* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Laurencia obtusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia* sp. | 0 | 0 | 1 | 1 | 1 | 1 | 0 |
| *Laurencia tenera* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia viridis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lejolisia mediterranea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora distenta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora maderensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora viscida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum incrustans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum polycephalum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Lomentaria articulata* | 0 | 0 | 1 | 1 | 1 | 1 | 0 |
| *Lomentaria clavellosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria linearis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria orcadensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia cristata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia reptabunda* | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Lophosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mastocarpus stellatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Melobesia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Meredithia microphylla* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum canariense* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum lichenoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemalion helminthoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Neosiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Neosiphonia sphaerocarpa* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Nitophyllum punctatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nytophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ophidocladus simpliciusculus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 71 | 72 | 73 | 74 | 75 | 76 | 77 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Osmundea hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea pinnatifida* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Osmundea* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea truncata* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Palisada corallopsis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada patentiramea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada perforata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada poiteaui* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia squamaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora crispa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora gelidioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phymatolithon lenormandii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Platoma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium borreri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium caribaeum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Plocamium cartilagineum* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Polysiphonia atlantica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia brodiaei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia ceramiaeformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia denudata* | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Polysiphonia elongata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia flexella* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Polysiphonia furcellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia havanensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia opaca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia scopulorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia* sp. | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Polysiphonia sphacelaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia stricta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia tripinnata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra leucosticta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra umbilicalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterocladiella capillacea* | 0 | 1 | 1 | 1 | 1 | 1 | 0 |
| *Pterocladiella melanoidea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pennata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pinnulata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ptilothamnion pluma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Red crust | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodomela confervoides* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Rhodophyllis divaricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia ardissonei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 71 | 72 | 73 | 74 | 75 | 76 | 77 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Rhodymenia holmesii* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Rhodymenia pseudopalmata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Schizymenia dubyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Schottera nicaeensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sebdenia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion flabellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion repens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphaerococcus coronopifolius* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphondylothamnion multifidum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spongites fruticulosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spyridia filamentosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stylonema alsidii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Symphyocladia marchantioides* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Taenioma nanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tiffaniella capitata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tsengia bairdii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia penicillata* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Wrangelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wurdemannia miniata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Phaeophyceae** | | | | | | | |
| *Asteronema rhodochortonoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bachelotia antillarum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Brown crust | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladostephus spongious* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Colpomenia sinuosa* | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| *Cystoseira* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira abies-marina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira foeniculacea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira humilis* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Cystoseira wildpretii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyopteris polypodioides* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Dictyota bartayresiana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota dichotoma* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Dictyota friabilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota pinnatifida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus fasciculatus* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Ectocarpus siliculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Endarachne binghamiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Endarachne* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmania* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia globifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia paradoxa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 71 | 72 | 73 | 74 | 75 | 76 | 77 |
|---|---|---|---|---|---|---|---|
| **Phaeophyceae (cont.)** | | | | | | | |
| *Fucus spiralis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Halopteris filicina* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Hecatonema terminale* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia intermedia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia ovata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia rallsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydroclathrus clathratus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Leathesia difformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lobophora variegata* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Myriactula chordae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myrionema strangulans* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Nemoderma tingitanum* | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Padina pavonia* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Papenfussiella kuromo* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Petrospongium berkeleyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pilinia rimosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudolithoderma adriaticum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudolithoderma sp.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia verrucosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum acinarium* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Sargassum cymosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum furcatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Scytosiphon lomentaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spatoglossum solieri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria cirrosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria fusca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Sphacelaria tribuloides* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Styocaulon scoparia* | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| *Taonia atomaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Zonaria tournefortii* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| **Chlorophyta** | | | | | | | |
| *Anadyomene saldanhae* | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| *Anadyomene stellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia marginata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia minima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis corymbosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis cupressina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis hypnoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis plumosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha aerea* | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| *Chaetomorpha antennina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 71 | 72 | 73 | 74 | 75 | 76 | 77 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Chaetomorpha gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha ligustica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha linum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha pachynema* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Chaetomorpha* sp. | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Cladophora albida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora coelothrix* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora conferta* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Cladophora dalmatica* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Cladophora hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora inclusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora laetervirens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora lehmanniana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora liebetruthii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora pellucida* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Cladophora prolifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora sericea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora* sp. | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Cladophoropsis membranacea* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Codium adhaerens* | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| *Codium decorticatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium effusum* | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Codium elisabethae* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Codium fragile* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium taylorii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium tomentosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium vermilara* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia marina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Derbesia tenuissima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Enteromorpha multirramosa* | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Ernodesmis verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Halydictyon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon calodictyon* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Monostroma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Percursaria percursa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhizoclonium tortuosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva clathrata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva compressa* | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Ulva flexuosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva intestinalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva lactuca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva prolifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva rigida* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Ulva rotundata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 71 | 72 | 73 | 74 | 75 | 76 | 77 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Ulva* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia macrophysa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia utricularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 78 | 79 | 80 | 81 | 82 | 83 | 84 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta** | | | | | | | |
| *Acrochaetium codii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrochaetium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosorium venulosum* | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Acrossorium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acrosymphyton* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion byssoides* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion cordatum* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion galicum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion hookeri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion pseudobyssoides* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion roseum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aglaothamnion* sp. | 1 | 1 | 0 | 1 | 0 | 0 | 1 |
| *Aglaothamnion tenuissimum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ahnfeltia plicata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ahnfeltiopsis devoniensis* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Amphiroa beauvoisii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amphiroa fragilissima* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Amphiroa rigida* | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Amphiroa* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium furcellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Anotrichium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Anotrichium tenue* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion cruciatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion decipiens* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Antithamnion densum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion diminuatum* | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Antithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnionella boergesenii* | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Aphanocladia stichidiosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Apoglossum ruscifolium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis armata* | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Asparagopsis* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Asparagopsis taxiformis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Asteromenia peltata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bangia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Boergeseniella fruticulosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Boergeseniella thuyoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bonnemaisonia hamifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bornetia secundiflora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia botryoides* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Botryocladia macaronesica* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Botryocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Calcareous crust* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion corymbosum* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Callithamnion* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Callithamnion tetragonum* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 78 | 79 | 80 | 81 | 82 | 83 | 84 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Catenella caespitosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Caulacanthus ustulatus* | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Centroceras clavulatum* | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| *Ceramium atrorubescens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium botrycarpum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium ciliatum* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Ceramium cingulatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium circinatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium codii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium deslongchampii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium diaphanum* | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium echionotum* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium flaccidum* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Ceramium gaditanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium rubrum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium tenerrimum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium virgatum* | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Champia parvula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondracanthus acicularis* | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Chondracanthus teedei* | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Chondria capillaris* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria coerulescens* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Chondria dasyphylla* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondria* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chylocladia verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Coelothrix irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Corallina elongata* | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| *Corallina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Crouania attenuata* | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Cryptonemia lomation* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cryptopleura ramosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ctenosiphonia hypnoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya caraibica* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Dasya corymbifera* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya crouaniana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya hutchinsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dasya rigidula* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Dasya* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diplothamnion jolyi* | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Diplothamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dipterosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Drachiella minuta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrocystis montagnei* | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Erythrodermis traillii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Erythrotrichia carnea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 78 | 79 | 80 | 81 | 82 | 83 | 84 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Eupogodon planus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Falkenbergia rufolanosa* | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| *Falkenbergia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannophycus rayssiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium clavatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gastroclonium ovatum* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Gastroclonium reflexum* | 1 | 0 | 0 | 0 | 1 | 1 | 0 |
| *Gelidiella pannosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiella tinerfensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidiopsis intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium arbusculum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium microdon* | 1 | 0 | 1 | 0 | 1 | 1 | 1 |
| *Gelidium pusillum* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Gelidium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium spinosum* | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| *Gigartina pistillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gigartina* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gloiocladia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gracilaria multipartita* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grallatoria reptans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia dichotoma* | 1 | 0 | 1 | 1 | 0 | 1 | 0 |
| *Grateloupia doryphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia filicina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Grateloupia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia corallinoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia phyllamphora* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Griffithsia* sp. | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Gymnogongrus crenulatus* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Gymnogongrus griffithsiae* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnogongrus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gymnothamnion elegans* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Haliptilon virgatum* | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Halurus flosculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Herposiphonia secunda* | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Herposiphonia* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Heterosiphonia crispella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia crouaniorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hildenbrandia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydrolithon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypnea arbuscula* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Hypnea flagelliformis* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Hypnea musciformis* | 0 | 1 | 0 | 1 | 0 | 1 | 1 |
| *Hypnea* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 78 | 79 | 80 | 81 | 82 | 83 | 84 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Hypnea spinella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hypoglossum hypoglossoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania adhaerens* | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| *Jania capillacea* | 1 | 1 | 0 | 1 | 0 | 0 | 1 |
| *Jania longifurca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Jania pumila* | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Jania rubens* | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Laurencia hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia brongniartii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia chondrioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia flexilis* | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Laurencia intricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia majuscula* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Laurencia microcladia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia minuta* | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Laurencia obtusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Laurencia* sp. | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Laurencia tenera* | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Laurencia viridis* | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Lejolisia mediterranea* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Liagora distenta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora maderensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Liagora* sp. | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Liagora viscida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum incrustans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum polycephalum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lithophyllum* sp. | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| *Lomentaria articulata* | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| *Lomentaria clavellosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria linearis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lomentaria orcadensis* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Lophosiphonia cristata* | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| *Lophosiphonia reptabunda* | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Lophosiphonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mastocarpus stellatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Melobesia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Meredithia microphylla* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Mesophyllum canariense* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Mesophyllum lichenoides* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Nemalion helminthoides* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Neosiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Neosiphonia sphaerocarpa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nitophyllum punctatum* | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Nytophyllum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ophidocladus simpliciusculus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 78 | 79 | 80 | 81 | 82 | 83 | 84 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Osmundea hybrida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea pinnatifida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Osmundea truncata* | 1 | 0 | 1 | 1 | 0 | 1 | 0 |
| *Palisada corallopsis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada patentiramea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada perforata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Palisada poiteaui* | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Peyssonnelia rubra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Peyssonnelia squamaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora crispa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora gelidioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phymatolithon lenormandii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Platoma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Pleonosporium borreri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pleonosporium caribaeum* | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| *Pleonosporium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Plocamium cartilagineum* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Polysiphonia atlantica* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Polysiphonia brodiaei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia ceramiaeformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia denudata* | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| *Polysiphonia elongata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia flexella* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia furcellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia harveyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia havanensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia opaca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia scopulorum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia* sp. | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Polysiphonia sphacelaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia stricta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia tripinnata* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra leucosticta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Porphyra umbilicalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterocladiella capillacea* | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| *Pterocladiella melanoidea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pennata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pterosiphonia pinnulata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ptilothamnion pluma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Red crust | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodomela confervoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodophyllis divaricata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhodymenia ardissonei* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 78 | 79 | 80 | 81 | 82 | 83 | 84 |
|---|---|---|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | | | | |
| *Rhodymenia holmesii* | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| *Rhodymenia pseudopalmata* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Rhodymenia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Schizymenia dubyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Schottera nicaeensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sebdenia macaronesica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion flabellatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spermothamnion repens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphaerococcus coronopifolius* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphondylothamnion multifidum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spongites fruticulosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spyridia filamentosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Stylonema alsidii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Symphyocladia marchantioides* | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| *Taenioma nanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tiffaniella capitata* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Tsengia bairdii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia penicillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wrangelia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Wurdemannia miniata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Phaeophyceae** | | | | | | | |
| *Asteronema rhodochortonoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bachelotia antillarum* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Brown crust | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladostephus spongious* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Colpomenia sinuosa* | 0 | 1 | 0 | 1 | 0 | 1 | 1 |
| *Cystoseira* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira abies-marina* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Cystoseira foeniculacea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira humilis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Cystoseira wildpretii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyopteris polypodioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota bartayresiana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota dichotoma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota friabilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota pinnatifida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dictyota* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus fasciculatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus siliculosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Endarachne binghamiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Endarachne* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmania* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia globifera* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia irregularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Feldmannia paradoxa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 78 | 79 | 80 | 81 | 82 | 83 | 84 |
|---|---|---|---|---|---|---|---|
| **Phaeophyceae (cont.)** | | | | | | | |
| *Fucus spiralis* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Halopteris filicina* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Hecatonema terminale* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia intermedia* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia ovata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia rallsiae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hincksia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hydroclathrus clathratus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Leathesia difformis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Lobophora variegata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myriactula chordae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Myrionema strangulans* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemoderma tingitanum* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Padina pavonia* | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Papenfussiella kuromo* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Petrospongium berkeleyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pilinia rimosa* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Pseudolithoderma adriaticum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudolithoderma sp.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ralfsia verrucosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum acinarium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum cymosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum furcatum* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Scytosiphon lomentaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Spatoglossum solieri* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria cirrosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria fusca* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria rigidula* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria* sp. | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Sphacelaria tribuloides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Styocaulon scoparia* | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| *Taonia atomaria* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Zonaria tournefortii* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| **Chlorophyta** | | | | | | | |
| *Anadyomene saldanhae* | 1 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Anadyomene stellata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia marginata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Blidingia minima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis corymbosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis cupressina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis hypnoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Bryopsis plumosa* | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Chaetomorpha aerea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha antennina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 78 | 79 | 80 | 81 | 82 | 83 | 84 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Chaetomorpha gracilis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha ligustica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha linum* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha pachynema* | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| *Chaetomorpha* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora albida* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora coelothrix* | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Cladophora conferta* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora dalmatica* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora hutchinsiae* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora inclusa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora laetervirens* | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Cladophora lehmanniana* | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora liebetruthii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora pellucida* | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Cladophora prolifera* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Cladophora sericea* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophora* sp. | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cladophoropsis membranacea* | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Codium adhaerens* | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Codium decorticatum* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Codium effusum* | 0 | 1 | 0 | 1 | 0 | 1 | 1 |
| *Codium elisabethae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium fragile* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium taylorii* | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium tomentosum* | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Codium vermilara* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Derbesia marina* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Derbesia tenuissima* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Enteromorpha multirramosa* | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ernodesmis verticillata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Halydictyon* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon boergesenii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Microdictyon calodictyon* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Monostroma* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Percursaria percursa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rhizoclonium tortuosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva clathrata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva compressa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva flexuosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva intestinalis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva lactuca* | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Ulva prolifera* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ulva rigida* | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Ulva rotundata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 78 | 79 | 80 | 81 | 82 | 83 | 84 |
|---|---|---|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | | | | |
| *Ulva* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia macrophysa* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Valonia* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Valonia utricularis* | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 85 | 86 | 87 | 88 |
|---|---|---|---|---|
| **Rhodophyta** | | | | |
| *Acrochaetium codii* | 0 | 0 | 0 | 0 |
| *Acrochaetium* sp. | 0 | 0 | 1 | 0 |
| *Acrosorium venulosum* | 0 | 0 | 0 | 0 |
| *Acrossorium* sp. | 0 | 0 | 0 | 0 |
| *Acrosymphyton* sp. | 0 | 0 | 0 | 0 |
| *Aglaothamnion byssoides* | 0 | 0 | 0 | 0 |
| *Aglaothamnion cordatum* | 0 | 0 | 0 | 0 |
| *Aglaothamnion galicum* | 0 | 0 | 0 | 0 |
| *Aglaothamnion hookeri* | 0 | 0 | 1 | 0 |
| *Aglaothamnion pseudobyssoides* | 0 | 0 | 0 | 0 |
| *Aglaothamnion roseum* | 0 | 0 | 0 | 0 |
| *Aglaothamnion* sp. | 1 | 1 | 1 | 1 |
| *Aglaothamnion tenuissimum* | 0 | 0 | 0 | 0 |
| *Ahnfeltia plicata* | 0 | 0 | 0 | 0 |
| *Ahnfeltiopsis devoniensis* | 0 | 0 | 0 | 0 |
| *Amphiroa beauvoisii* | 1 | 0 | 0 | 0 |
| *Amphiroa fragilissima* | 1 | 1 | 1 | 0 |
| *Amphiroa rigida* | 1 | 0 | 0 | 0 |
| *Amphiroa* sp. | 0 | 0 | 0 | 0 |
| *Anotrichium furcellatum* | 0 | 0 | 0 | 0 |
| *Anotrichium* sp. | 0 | 0 | 0 | 0 |
| *Anotrichium tenue* | 0 | 0 | 0 | 0 |
| *Antithamnion cruciatum* | 0 | 0 | 0 | 0 |
| *Antithamnion decipiens* | 0 | 1 | 0 | 0 |
| *Antithamnion densum* | 0 | 0 | 0 | 0 |
| *Antithamnion diminuatum* | 0 | 1 | 0 | 0 |
| *Antithamnion* sp. | 0 | 0 | 0 | 0 |
| *Antithamnionella boergesenii* | 0 | 0 | 0 | 0 |
| *Aphanocladia stichidiosa* | 0 | 0 | 1 | 0 |
| *Apoglossum ruscifolium* | 0 | 0 | 0 | 0 |
| *Asparagopsis armata* | 1 | 0 | 1 | 1 |
| *Asparagopsis* sp. | 0 | 0 | 0 | 0 |
| *Asparagopsis taxiformis* | 0 | 0 | 0 | 0 |
| *Asteromenia peltata* | 0 | 0 | 0 | 0 |
| *Bangia* sp. | 0 | 0 | 0 | 0 |
| *Boergeseniella fruticulosa* | 0 | 0 | 0 | 0 |
| *Boergeseniella thuyoides* | 0 | 0 | 0 | 0 |
| *Bonnemaisonia hamifera* | 0 | 0 | 0 | 0 |
| *Bornetia secundiflora* | 0 | 0 | 0 | 0 |
| *Botryocladia botryoides* | 0 | 0 | 0 | 0 |
| *Botryocladia macaronesica* | 0 | 0 | 0 | 0 |
| *Botryocladia* sp. | 0 | 0 | 0 | 0 |
| *Calcareous crust* | 0 | 0 | 0 | 0 |
| *Callithamnion corymbosum* | 0 | 0 | 1 | 0 |
| *Callithamnion* sp. | 1 | 1 | 1 | 1 |
| *Callithamnion tetragonum* | 0 | 0 | 0 | 1 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 85 | 86 | 87 | 88 |
|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | |
| *Catenella caespitosa* | 0 | 0 | 0 | 0 |
| *Caulacanthus ustulatus* | 0 | 0 | 1 | 1 |
| *Centroceras clavulatum* | 1 | 1 | 1 | 1 |
| *Ceramium atrorubescens* | 0 | 0 | 1 | 0 |
| *Ceramium botrycarpum* | 0 | 0 | 0 | 0 |
| *Ceramium ciliatum* | 0 | 0 | 1 | 1 |
| *Ceramium cingulatum* | 0 | 1 | 0 | 0 |
| *Ceramium circinatum* | 0 | 0 | 1 | 0 |
| *Ceramium codii* | 0 | 1 | 1 | 0 |
| *Ceramium deslongchampii* | 0 | 0 | 0 | 0 |
| *Ceramium diaphanum* | 1 | 1 | 1 | 1 |
| *Ceramium echionotum* | 1 | 0 | 0 | 0 |
| *Ceramium flaccidum* | 0 | 1 | 1 | 0 |
| *Ceramium gaditanum* | 0 | 0 | 0 | 0 |
| *Ceramium rubrum* | 0 | 0 | 0 | 0 |
| *Ceramium* sp. | 0 | 0 | 0 | 0 |
| *Ceramium tenerrimum* | 0 | 0 | 0 | 0 |
| *Ceramium virgatum* | 0 | 1 | 1 | 1 |
| *Champia parvula* | 0 | 0 | 0 | 0 |
| *Chondracanthus acicularis* | 1 | 0 | 1 | 1 |
| *Chondracanthus teedei* | 0 | 0 | 1 | 0 |
| *Chondria capillaris* | 0 | 0 | 1 | 0 |
| *Chondria coerulescens* | 0 | 0 | 0 | 0 |
| *Chondria dasyphylla* | 1 | 0 | 1 | 0 |
| *Chondria* sp. | 0 | 0 | 0 | 0 |
| *Chylocladia verticillata* | 0 | 0 | 0 | 0 |
| *Coelothrix irregularis* | 0 | 0 | 0 | 0 |
| *Corallina elongata* | 1 | 1 | 1 | 1 |
| *Corallina* sp. | 0 | 0 | 0 | 0 |
| *Crouania attenuata* | 0 | 0 | 1 | 1 |
| *Cryptonemia lomation* | 0 | 0 | 0 | 0 |
| *Cryptopleura ramosa* | 0 | 0 | 0 | 0 |
| *Ctenosiphonia hypnoides* | 0 | 1 | 0 | 0 |
| *Dasya caraibica* | 0 | 0 | 0 | 0 |
| *Dasya corymbifera* | 0 | 0 | 0 | 0 |
| *Dasya crouaniana* | 0 | 0 | 0 | 0 |
| *Dasya hutchinsiae* | 0 | 0 | 0 | 0 |
| *Dasya rigidula* | 0 | 0 | 0 | 0 |
| *Dasya* sp. | 0 | 0 | 0 | 0 |
| *Diplothamnion jolyi* | 0 | 1 | 1 | 0 |
| *Diplothamnion* sp. | 0 | 0 | 0 | 0 |
| *Dipterosiphonia* sp. | 0 | 0 | 0 | 0 |
| *Drachiella minuta* | 0 | 0 | 0 | 0 |
| *Erythrocystis montagnei* | 0 | 0 | 1 | 0 |
| *Erythrodermis traillii* | 0 | 0 | 0 | 0 |
| *Erythrotrichia carnea* | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 85 | 86 | 87 | 88 |
|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | |
| *Eupogodon planus* | 0 | 0 | 0 | 0 |
| *Falkenbergia rufolanosa* | 1 | 1 | 1 | 1 |
| *Falkenbergia* sp. | 0 | 0 | 0 | 0 |
| *Feldmannophycus rayssiae* | 0 | 0 | 0 | 0 |
| *Gastroclonium clavatum* | 0 | 0 | 0 | 0 |
| *Gastroclonium ovatum* | 0 | 0 | 0 | 0 |
| *Gastroclonium reflexum* | 0 | 0 | 0 | 1 |
| *Gelidiella pannosa* | 0 | 0 | 0 | 0 |
| *Gelidiella tinerfensis* | 0 | 0 | 1 | 1 |
| *Gelidiopsis intricata* | 0 | 0 | 0 | 0 |
| *Gelidium arbusculum* | 0 | 0 | 0 | 0 |
| *Gelidium microdon* | 1 | 0 | 1 | 1 |
| *Gelidium pusillum* | 1 | 1 | 1 | 1 |
| *Gelidium* sp. | 1 | 0 | 0 | 0 |
| *Gelidium spinosum* | 1 | 1 | 1 | 1 |
| *Gigartina pistillata* | 0 | 0 | 0 | 0 |
| *Gigartina* sp. | 0 | 0 | 0 | 0 |
| *Gloiocladia* sp. | 0 | 0 | 0 | 0 |
| *Gracilaria gracilis* | 0 | 0 | 0 | 0 |
| *Gracilaria multipartita* | 0 | 0 | 0 | 0 |
| *Grallatoria reptans* | 0 | 0 | 0 | 0 |
| *Grateloupia dichotoma* | 0 | 0 | 1 | 0 |
| *Grateloupia doryphora* | 0 | 0 | 0 | 0 |
| *Grateloupia filicina* | 0 | 0 | 1 | 0 |
| *Grateloupia* sp. | 0 | 0 | 0 | 0 |
| *Griffithsia corallinoides* | 0 | 0 | 0 | 0 |
| *Griffithsia phyllamphora* | 0 | 0 | 0 | 0 |
| *Griffithsia* sp. | 0 | 0 | 0 | 0 |
| *Gymnogongrus crenulatus* | 1 | 0 | 1 | 0 |
| *Gymnogongrus griffithsiae* | 1 | 0 | 1 | 0 |
| *Gymnogongrus* sp. | 0 | 0 | 0 | 0 |
| *Gymnothamnion elegans* | 1 | 0 | 0 | 1 |
| *Haliptilon* sp. | 0 | 0 | 0 | 0 |
| *Haliptilon virgatum* | 0 | 0 | 1 | 1 |
| *Halurus flosculosus* | 0 | 0 | 0 | 0 |
| *Herposiphonia secunda* | 1 | 1 | 0 | 0 |
| *Herposiphonia* sp. | 1 | 1 | 1 | 0 |
| *Heterosiphonia crispella* | 0 | 1 | 0 | 0 |
| *Hildenbrandia crouaniorum* | 1 | 1 | 1 | 0 |
| *Hildenbrandia rubra* | 0 | 0 | 0 | 0 |
| *Hildenbrandia* sp. | 0 | 0 | 0 | 0 |
| *Hydrolithon* sp. | 0 | 0 | 0 | 0 |
| *Hypnea arbuscula* | 0 | 0 | 0 | 0 |
| *Hypnea flagelliformis* | 0 | 0 | 0 | 0 |
| *Hypnea musciformis* | 0 | 0 | 1 | 0 |
| *Hypnea* sp. | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 85 | 86 | 87 | 88 |
|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | |
| *Hypnea spinella* | 0 | 0 | 1 | 0 |
| *Hypoglossum hypoglossoides* | 0 | 0 | 0 | 0 |
| *Jania* sp. | 0 | 0 | 0 | 0 |
| *Jania adhaerens* | 1 | 1 | 0 | 0 |
| *Jania capillacea* | 1 | 0 | 1 | 1 |
| *Jania longifurca* | 0 | 1 | 0 | 0 |
| *Jania pumila* | 1 | 1 | 0 | 0 |
| *Jania rubens* | 1 | 1 | 1 | 0 |
| *Laurencia hybrida* | 0 | 0 | 0 | 0 |
| *Laurencia brongniartii* | 0 | 0 | 1 | 0 |
| *Laurencia chondrioides* | 0 | 0 | 1 | 0 |
| *Laurencia flexilis* | 1 | 0 | 1 | 0 |
| *Laurencia intricata* | 0 | 0 | 0 | 0 |
| *Laurencia majuscula* | 0 | 0 | 1 | 0 |
| *Laurencia microcladia* | 0 | 0 | 0 | 0 |
| *Laurencia minuta* | 0 | 1 | 0 | 0 |
| *Laurencia obtusa* | 0 | 0 | 0 | 0 |
| *Laurencia* sp. | 0 | 0 | 1 | 1 |
| *Laurencia tenera* | 0 | 1 | 1 | 0 |
| *Laurencia viridis* | 0 | 0 | 0 | 0 |
| *Lejolisia mediterranea* | 0 | 0 | 0 | 0 |
| *Liagora distenta* | 0 | 0 | 0 | 0 |
| *Liagora maderensis* | 0 | 0 | 0 | 0 |
| *Liagora* sp. | 0 | 0 | 1 | 0 |
| *Liagora viscida* | 0 | 0 | 0 | 0 |
| *Lithophyllum incrustans* | 0 | 0 | 0 | 0 |
| *Lithophyllum polycephalum* | 0 | 0 | 0 | 0 |
| *Lithophyllum* sp. | 0 | 0 | 0 | 0 |
| *Lomentaria articulata* | 1 | 0 | 1 | 1 |
| *Lomentaria clavellosa* | 0 | 0 | 0 | 0 |
| *Lomentaria linearis* | 0 | 0 | 0 | 0 |
| *Lomentaria orcadensis* | 0 | 0 | 0 | 0 |
| *Lophosiphonia cristata* | 0 | 0 | 1 | 0 |
| *Lophosiphonia reptabunda* | 1 | 1 | 1 | 0 |
| *Lophosiphonia* sp. | 0 | 0 | 0 | 0 |
| *Mastocarpus stellatus* | 0 | 0 | 0 | 0 |
| *Melobesia* sp. | 0 | 0 | 0 | 0 |
| *Meredithia microphylla* | 0 | 0 | 0 | 0 |
| *Mesophyllum canariense* | 0 | 0 | 0 | 0 |
| *Mesophyllum lichenoides* | 0 | 0 | 0 | 0 |
| *Nemalion helminthoides* | 0 | 0 | 1 | 0 |
| *Neosiphonia harveyi* | 0 | 0 | 0 | 0 |
| *Neosiphonia sphaerocarpa* | 0 | 0 | 0 | 0 |
| *Nitophyllum punctatum* | 0 | 0 | 0 | 0 |
| *Nytophyllum* sp. | 0 | 0 | 0 | 0 |
| *Ophidocladus simpliciusculus* | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 85 | 86 | 87 | 88 |
|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | |
| *Osmundea hybrida* | 0 | 0 | 0 | 0 |
| *Osmundea pinnatifida* | 0 | 0 | 0 | 0 |
| *Osmundea* sp. | 0 | 0 | 0 | 0 |
| *Osmundea truncata* | 0 | 0 | 1 | 1 |
| *Palisada corallopsis* | 0 | 0 | 0 | 0 |
| *Palisada patentiramea* | 0 | 0 | 0 | 0 |
| *Palisada perforata* | 0 | 0 | 1 | 0 |
| *Palisada poiteaui* | 0 | 0 | 0 | 1 |
| *Peyssonnelia rubra* | 0 | 0 | 0 | 0 |
| *Peyssonnelia* sp. | 0 | 0 | 0 | 0 |
| *Peyssonnelia squamaria* | 0 | 0 | 0 | 0 |
| *Phyllophora crispa* | 0 | 0 | 0 | 0 |
| *Phyllophora gelidioides* | 0 | 0 | 0 | 0 |
| *Phymatolithon lenormandii* | 0 | 0 | 0 | 0 |
| *Platoma* sp. | 0 | 0 | 0 | 0 |
| *Pleonosporium borreri* | 0 | 0 | 0 | 0 |
| *Pleonosporium caribaeum* | 0 | 0 | 0 | 0 |
| *Pleonosporium* sp. | 0 | 0 | 0 | 0 |
| *Plocamium cartilagineum* | 0 | 1 | 1 | 1 |
| *Polysiphonia atlantica* | 0 | 0 | 0 | 1 |
| *Polysiphonia brodiaei* | 0 | 0 | 0 | 0 |
| *Polysiphonia ceramiaeformis* | 0 | 0 | 0 | 0 |
| *Polysiphonia denudata* | 0 | 1 | 1 | 0 |
| *Polysiphonia elongata* | 0 | 0 | 0 | 0 |
| *Polysiphonia flexella* | 0 | 0 | 0 | 0 |
| *Polysiphonia furcellata* | 0 | 0 | 0 | 0 |
| *Polysiphonia harveyi* | 0 | 0 | 0 | 0 |
| *Polysiphonia havanensis* | 0 | 0 | 0 | 0 |
| *Polysiphonia opaca* | 0 | 0 | 0 | 0 |
| *Polysiphonia scopulorum* | 0 | 0 | 0 | 0 |
| *Polysiphonia* sp. | 0 | 0 | 1 | 0 |
| *Polysiphonia sphacelaria* | 0 | 0 | 0 | 0 |
| *Polysiphonia stricta* | 0 | 0 | 0 | 0 |
| *Polysiphonia tripinnata* | 0 | 1 | 0 | 0 |
| *Porphyra leucosticta* | 0 | 0 | 0 | 0 |
| *Porphyra* sp. | 0 | 0 | 0 | 0 |
| *Porphyra umbilicalis* | 0 | 0 | 0 | 0 |
| *Pterocladiella capillacea* | 1 | 0 | 1 | 1 |
| *Pterocladiella melanoidea* | 0 | 0 | 0 | 0 |
| *Pterosiphonia pennata* | 0 | 0 | 1 | 0 |
| *Pterosiphonia pinnulata* | 0 | 0 | 0 | 0 |
| *Ptilothamnion pluma* | 0 | 0 | 0 | 0 |
| Red crust | 0 | 0 | 0 | 0 |
| *Rhodomela confervoides* | 0 | 0 | 0 | 0 |
| *Rhodophyllis divaricata* | 0 | 0 | 0 | 0 |
| *Rhodymenia ardissonei* | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 85 | 86 | 87 | 88 |
|---|---|---|---|---|
| **Rhodophyta (cont.)** | | | | |
| *Rhodymenia holmesii* | 0 | 0 | 0 | 1 |
| *Rhodymenia pseudopalmata* | 0 | 0 | 0 | 0 |
| *Rhodymenia* sp. | 0 | 0 | 1 | 0 |
| *Schizymenia dubyi* | 0 | 0 | 0 | 0 |
| *Schottera nicaeensis* | 0 | 0 | 0 | 0 |
| *Sebdenia macaronesica* | 0 | 0 | 0 | 0 |
| *Spermothamnion flabellatum* | 0 | 0 | 0 | 0 |
| *Spermothamnion repens* | 0 | 0 | 0 | 0 |
| *Sphaerococcus coronopifolius* | 0 | 0 | 0 | 0 |
| *Sphondylothamnion multifidum* | 0 | 0 | 0 | 1 |
| *Spongites fruticulosa* | 0 | 0 | 0 | 0 |
| *Spyridia filamentosa* | 0 | 0 | 0 | 0 |
| *Stylonema alsidii* | 0 | 1 | 0 | 0 |
| *Symphyocladia marchantioides* | 1 | 1 | 1 | 1 |
| *Taenioma nanum* | 0 | 0 | 0 | 0 |
| *Tiffaniella capitata* | 0 | 0 | 0 | 0 |
| *Tsengia bairdii* | 0 | 0 | 0 | 0 |
| *Wrangelia penicillata* | 0 | 0 | 0 | 0 |
| *Wrangelia* sp. | 0 | 0 | 0 | 0 |
| *Wurdemannia miniata* | 0 | 0 | 0 | 0 |
| **Phaeophyceae** | | | | |
| *Asteronema rhodochortonoides* | 0 | 0 | 0 | 0 |
| *Bachelotia antillarum* | 0 | 0 | 0 | 0 |
| Brown crust | 0 | 0 | 0 | 0 |
| *Cladostephus spongious* | 0 | 0 | 0 | 0 |
| *Colpomenia sinuosa* | 1 | 0 | 1 | 0 |
| *Cystoseira* sp. | 0 | 0 | 0 | 0 |
| *Cystoseira abies-marina* | 0 | 0 | 0 | 0 |
| *Cystoseira foeniculacea* | 0 | 0 | 1 | 0 |
| *Cystoseira humilis* | 0 | 0 | 0 | 0 |
| *Cystoseira wildpretii* | 0 | 0 | 0 | 0 |
| *Dictyopteris polypodioides* | 0 | 0 | 0 | 0 |
| *Dictyota bartayresiana* | 0 | 0 | 0 | 0 |
| *Dictyota dichotoma* | 0 | 0 | 0 | 0 |
| *Dictyota friabilis* | 0 | 0 | 0 | 0 |
| *Dictyota pinnatifida* | 0 | 0 | 0 | 0 |
| *Dictyota* sp. | 0 | 0 | 0 | 0 |
| *Ectocarpus fasciculatus* | 0 | 0 | 0 | 0 |
| *Ectocarpus siliculosus* | 0 | 0 | 0 | 0 |
| *Ectocarpus* sp. | 0 | 0 | 0 | 0 |
| *Endarachne binghamiae* | 0 | 0 | 0 | 0 |
| *Endarachne* sp. | 0 | 0 | 0 | 0 |
| *Feldmania* sp. | 0 | 0 | 0 | 0 |
| *Feldmannia globifera* | 0 | 0 | 0 | 0 |
| *Feldmannia irregularis* | 0 | 0 | 0 | 0 |
| *Feldmannia paradoxa* | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 85 | 86 | 87 | 88 |
|---|---|---|---|---|
| **Phaeophyceae (cont.)** | | | | |
| *Fucus spiralis* | 0 | 0 | 0 | 0 |
| *Halopteris filicina* | 1 | 1 | 0 | 1 |
| *Hecatonema terminale* | 0 | 0 | 0 | 0 |
| *Hincksia intermedia* | 0 | 0 | 0 | 0 |
| *Hincksia ovata* | 0 | 0 | 1 | 0 |
| *Hincksia rallsiae* | 0 | 0 | 0 | 0 |
| *Hincksia* sp. | 0 | 0 | 0 | 0 |
| *Hydroclathrus clathratus* | 0 | 0 | 0 | 0 |
| *Leathesia difformis* | 0 | 0 | 0 | 0 |
| *Lobophora variegata* | 0 | 0 | 0 | 0 |
| *Myriactula chordae* | 0 | 0 | 0 | 0 |
| *Myrionema strangulans* | 0 | 0 | 0 | 0 |
| *Nemoderma tingitanum* | 1 | 1 | 1 | 0 |
| *Padina pavonia* | 1 | 0 | 1 | 0 |
| *Papenfussiella kuromo* | 0 | 0 | 0 | 0 |
| *Petrospongium berkeleyi* | 0 | 0 | 0 | 0 |
| *Pilinia rimosa* | 0 | 0 | 0 | 0 |
| *Pseudolithoderma adriaticum* | 1 | 1 | 0 | 0 |
| *Pseudolithoderma sp.* | 0 | 0 | 0 | 0 |
| *Ralfsia* sp. | 0 | 1 | 0 | 0 |
| *Ralfsia verrucosa* | 0 | 0 | 0 | 0 |
| *Sargassum acinarium* | 0 | 0 | 0 | 0 |
| *Sargassum cymosum* | 0 | 0 | 1 | 0 |
| *Sargassum furcatum* | 0 | 0 | 0 | 0 |
| *Sargassum* sp. | 0 | 0 | 0 | 0 |
| *Scytosiphon lomentaria* | 0 | 0 | 0 | 0 |
| *Spatoglossum solieri* | 0 | 0 | 0 | 0 |
| *Sphacelaria cirrosa* | 0 | 0 | 1 | 1 |
| *Sphacelaria fusca* | 0 | 0 | 0 | 0 |
| *Sphacelaria rigidula* | 1 | 0 | 0 | 0 |
| *Sphacelaria* sp. | 1 | 1 | 1 | 0 |
| *Sphacelaria tribuloides* | 0 | 0 | 0 | 0 |
| *Styocaulon scoparia* | 1 | 1 | 1 | 1 |
| *Taonia atomaria* | 0 | 0 | 0 | 0 |
| *Zonaria tournefortii* | 0 | 0 | 0 | 0 |
| **Chlorophyta** | | | | |
| *Anadyomene saldanhae* | 0 | 0 | 0 | 0 |
| *Anadyomene stellata* | 0 | 0 | 0 | 0 |
| *Blidingia marginata* | 0 | 0 | 0 | 0 |
| *Blidingia minima* | 0 | 0 | 0 | 0 |
| *Bryopsis corymbosa* | 0 | 0 | 0 | 0 |
| *Bryopsis cupressina* | 0 | 0 | 0 | 0 |
| *Bryopsis hypnoides* | 0 | 0 | 0 | 0 |
| *Bryopsis plumosa* | 0 | 0 | 0 | 0 |
| *Chaetomorpha aerea* | 1 | 1 | 1 | 0 |
| *Chaetomorpha antennina* | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 85 | 86 | 87 | 88 |
|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | |
| *Chaetomorpha gracilis* | 0 | 0 | 0 | 1 |
| *Chaetomorpha ligustica* | 0 | 0 | 0 | 0 |
| *Chaetomorpha linum* | 0 | 0 | 0 | 0 |
| *Chaetomorpha pachynema* | 1 | 1 | 1 | 1 |
| *Chaetomorpha* sp. | 0 | 0 | 0 | 0 |
| *Cladophora albida* | 1 | 0 | 0 | 1 |
| *Cladophora coelothrix* | 1 | 0 | 1 | 1 |
| *Cladophora conferta* | 0 | 0 | 0 | 0 |
| *Cladophora dalmatica* | 0 | 0 | 0 | 0 |
| *Cladophora hutchinsiae* | 0 | 0 | 0 | 0 |
| *Cladophora inclusa* | 0 | 0 | 0 | 0 |
| *Cladophora laetervirens* | 0 | 0 | 0 | 0 |
| *Cladophora lehmanniana* | 0 | 0 | 0 | 0 |
| *Cladophora liebetruthii* | 0 | 0 | 0 | 0 |
| *Cladophora pellucida* | 1 | 0 | 1 | 0 |
| *Cladophora prolifera* | 1 | 0 | 0 | 1 |
| *Cladophora sericea* | 0 | 0 | 0 | 0 |
| *Cladophora* sp. | 1 | 0 | 1 | 0 |
| *Cladophoropsis membranacea* | 0 | 0 | 1 | 0 |
| *Codium adhaerens* | 1 | 1 | 1 | 1 |
| *Codium decorticatum* | 0 | 0 | 0 | 0 |
| *Codium effusum* | 0 | 0 | 0 | 0 |
| *Codium elisabethae* | 0 | 0 | 0 | 0 |
| *Codium fragile* | 0 | 0 | 0 | 0 |
| *Codium* sp. | 0 | 0 | 0 | 0 |
| *Codium taylorii* | 0 | 0 | 0 | 0 |
| *Codium tomentosum* | 0 | 0 | 0 | 0 |
| *Codium vermilara* | 0 | 0 | 0 | 0 |
| *Derbesia marina* | 0 | 0 | 0 | 0 |
| *Derbesia tenuissima* | 0 | 0 | 0 | 0 |
| *Enteromorpha multirramosa* | 0 | 0 | 1 | 1 |
| *Ernodesmis verticillata* | 0 | 0 | 0 | 0 |
| *Halydictyon* sp. | 0 | 0 | 0 | 0 |
| *Microdictyon boergesenii* | 0 | 0 | 0 | 0 |
| *Microdictyon calodictyon* | 0 | 0 | 0 | 0 |
| *Monostroma* sp. | 0 | 0 | 0 | 0 |
| *Percursaria percursa* | 0 | 0 | 0 | 0 |
| *Rhizoclonium tortuosum* | 0 | 0 | 0 | 0 |
| *Ulva clathrata* | 1 | 0 | 0 | 1 |
| *Ulva compressa* | 0 | 0 | 0 | 0 |
| *Ulva flexuosa* | 1 | 0 | 0 | 0 |
| *Ulva intestinalis* | 1 | 1 | 1 | 1 |
| *Ulva lactuca* | 0 | 0 | 0 | 0 |
| *Ulva prolifera* | 0 | 0 | 0 | 0 |
| *Ulva rigida* | 1 | 1 | 1 | 0 |
| *Ulva rotundata* | 0 | 0 | 0 | 0 |

**Appendix 3 (cont.)** - Species recorded at each site (Site codes according to Appendix 2; 0 - absent; 1 - present)

| Site code | 85 | 86 | 87 | 88 |
|---|---|---|---|---|
| **Chlorophyta (cont.)** | | | | |
| *Ulva* sp. | 0 | 0 | 0 | 0 |
| *Valonia macrophysa* | 0 | 0 | 0 | 1 |
| *Valonia* sp. | 0 | 0 | 0 | 0 |
| *Valonia utricularis* | 0 | 0 | 0 | 0 |

# Appendix 4

Full species list richness, ESG ratio, proportions of Rhodophyta, Chlorophyta, Phaeophyceae and opportunist species, functional group proportions and respective average values (Avg.) and standard deviations (SD) per island, for the Azores archipelago, for the British Isles and for the British Isles meso-tidal shores.

**Appendix 4** – Full species list richness, ESG ratio, proportions of Rhodophyta, Chlorophyta, Phaeophyceae and opportunist species, functional group proportions and respective average values (Avg.) and standard deviations (SD) per island, for the Azores archipelago, for the British Isles and for the British Isles meso-tidal shores.

| **Site code** | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Full species list richness** | | 38 | 8 | 35 | 40 | 42 | 23 | 26 | 28 | 29 | 33 | 18 | 34 | 23 | 31 | 33 |
| **ESG ratio** | | 1.24 | 1.67 | 1.19 | 2.33 | 1.47 | 2.29 | 0.86 | 2.11 | 3.83 | 1.75 | 2.60 | 2.09 | 1.88 | 3.43 | 1.20 |
| **Proportions** | **Rhodophyta** | 0.58 | 0.63 | 0.83 | 0.75 | 0.76 | 0.65 | 0.69 | 0.61 | 0.86 | 0.64 | 0.61 | 0.68 | 0.74 | 0.71 | 0.64 |
| | **Chlorophyta** | 0.29 | 0.38 | 0.11 | 0.08 | 0.12 | 0.17 | 0.23 | 0.18 | 0.03 | 0.15 | 0.22 | 0.18 | 0.17 | 0.16 | 0.21 |
| | **Phaeophyceae** | 0.13 | 0.00 | 0.06 | 0.18 | 0.12 | 0.17 | 0.08 | 0.21 | 0.10 | 0.21 | 0.17 | 0.15 | 0.09 | 0.13 | 0.15 |
| | **Opportunists** | 0.13 | 0.38 | 0.09 | 0.03 | 0.02 | 0.09 | 0.12 | 0.04 | 0.00 | 0.06 | 0.06 | 0.03 | 0.04 | 0.06 | 0.12 |
| | **FG1** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | **fFG2** | 0.11 | 0.25 | 0.06 | 0.00 | 0.02 | 0.04 | 0.08 | 0.00 | 0.03 | 0.09 | 0.06 | 0.00 | 0.00 | 0.03 | 0.09 |
| | **FG3** | 0.11 | 0.13 | 0.14 | 0.08 | 0.17 | 0.13 | 0.19 | 0.21 | 0.00 | 0.15 | 0.06 | 0.09 | 0.17 | 0.10 | 0.18 |
| | **FG4** | 0.26 | 0.00 | 0.29 | 0.28 | 0.26 | 0.26 | 0.31 | 0.25 | 0.24 | 0.21 | 0.17 | 0.24 | 0.26 | 0.23 | 0.27 |
| | **FG5** | 0.21 | 0.50 | 0.31 | 0.40 | 0.29 | 0.26 | 0.23 | 0.29 | 0.45 | 0.27 | 0.39 | 0.35 | 0.35 | 0.35 | 0.21 |
| | **FG6** | 0.05 | 0.00 | 0.03 | 0.10 | 0.07 | 0.09 | 0.00 | 0.07 | 0.00 | 0.09 | 0.00 | 0.09 | 0.00 | 0.06 | 0.06 |
| | **FG7** | 0.16 | 0.13 | 0.09 | 0.13 | 0.12 | 0.17 | 0.12 | 0.11 | 0.21 | 0.12 | 0.22 | 0.12 | 0.17 | 0.23 | 0.12 |
| | **FG8** | 0.11 | 0.00 | 0.09 | 0.03 | 0.07 | 0.04 | 0.08 | 0.07 | 0.07 | 0.06 | 0.11 | 0.12 | 0.04 | 0.00 | 0.06 |

**Appendix 4 (cont.)** – Full species list richness, ESG ratio, proportions of Rhodophyta, Chlorophyta, Phaeophyceae and opportunist species, functional group proportions and respective average values (Avg.) and standard deviations (SD) per island, for the Azores archipelago, for the British Isles and for the British Isles meso-tidal shores.

| **Site code** | | **16** | **17** | **18** | **19** | **20** | **21** | **22** | **23** | **24** | **25** | **26** | **27** | **28** | **29** | **30** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Full species list richness** | | 29 | 29 | 34 | 37 | 41 | 45 | 41 | 26 | 38 | 82 | 72 | 55 | 58 | 66 | 91 |
| **ESG ratio** | | 1.07 | 1.90 | 1.00 | 1.6 | 1.4 | 1.1 | 1.6 | 1.60 | 0.46 | 1.65 | 1.40 | 1.12 | 1.23 | 1.54 | 0.75 |
| **Proportions** | **Rhodophyta** | 0.69 | 0.59 | 0.68 | 0.65 | 0.54 | 0.62 | 0.61 | 0.58 | 0.50 | 0.70 | 0.69 | 0.71 | 0.74 | 0.76 | 0.73 |
| | **Chlorophyta** | 0.21 | 0.17 | 0.24 | 0.19 | 0.27 | 0.22 | 0.27 | 0.15 | 0.29 | 0.17 | 0.14 | 0.18 | 0.21 | 0.15 | 0.21 |
| | **Phaeophyceae** | 0.10 | 0.24 | 0.09 | 0.16 | 0.20 | 0.16 | 0.12 | 0.27 | 0.21 | 0.13 | 0.17 | 0.11 | 0.05 | 0.09 | 0.07 |
| | **Opportunists** | 0.14 | 0.14 | 0.18 | 0.1 | 0.1 | 0.1 | 0.1 | 0.08 | 0.24 | 0.07 | 0.13 | 0.16 | 0.16 | 0.09 | 0.10 |
| | **FG1** | 0.00 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.00 | 0.03 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| | **fFG2** | 0.07 | 0.17 | 0.12 | 0.1 | 0.2 | 0.1 | 0.1 | 0.04 | 0.26 | 0.07 | 0.10 | 0.16 | 0.09 | 0.11 | 0.13 |
| | **FG3** | 0.17 | 0.10 | 0.15 | 0.1 | 0.1 | 0.1 | 0.1 | 0.15 | 0.26 | 0.16 | 0.14 | 0.13 | 0.14 | 0.12 | 0.14 |
| | **FG4** | 0.31 | 0.21 | 0.26 | 0.1 | 0.1 | 0.2 | 0.2 | 0.27 | 0.13 | 0.17 | 0.22 | 0.16 | 0.17 | 0.15 | 0.25 |
| | **FG5** | 0.24 | 0.24 | 0.26 | 0.5 | 0.4 | 0.3 | 0.3 | 0.35 | 0.29 | 0.40 | 0.36 | 0.36 | 0.47 | 0.45 | 0.30 |
| | **FG6** | 0.03 | 0.10 | 0.03 | 0.0 | 0.0 | 0.1 | 0.0 | 0.12 | 0.00 | 0.01 | 0.03 | 0.02 | 0.02 | 0.00 | 0.01 |
| | **FG7** | 0.10 | 0.14 | 0.09 | 0.1 | 0.0 | 0.0 | 0.1 | 0.00 | 0.00 | 0.12 | 0.10 | 0.11 | 0.07 | 0.08 | 0.10 |
| | **FG8** | 0.07 | 0.03 | 0.09 | 0.1 | 0.1 | 0.1 | 0.1 | 0.08 | 0.03 | 0.05 | 0.04 | 0.05 | 0.05 | 0.09 | 0.07 |

**Appendix 4 (cont.)** – Full species list richness, ESG ratio, proportions of Rhodophyta, Chlorophyta, Phaeophyceae and opportunist species, functional group proportions and respective average values (Avg.) and standard deviations (SD) per island, for the Azores archipelago, for the British Isles and for the British Isles meso-tidal shores.

| **Site code** | | **31** | **32** | **33** | **34** | **35** | **36** | **37** | **38** | **39** | **40** | **41** | **42** | **43** | **44** | **45** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Full species list richness** | | 63 | 54 | 48 | 51 | 71 | 64 | 68 | 57 | 67 | 52 | 25 | 37 | 46 | 27 | 22 |
| **ESG ratio** | | 0.66 | 0.86 | 1.29 | 0.59 | 1.29 | 1.29 | 1.72 | 1.11 | 1.39 | 1.08 | 0.79 | 1.06 | 1.00 | 1.08 | 2.14 |
| **Proportions** | **Rhodophyta** | 0.79 | 0.65 | 0.67 | 0.69 | 0.72 | 0.73 | 0.69 | 0.63 | 0.63 | 0.62 | 0.52 | 0.59 | 0.65 | 0.52 | 0.77 |
| | **Chlorophyta** | 0.10 | 0.28 | 0.25 | 0.24 | 0.13 | 0.19 | 0.19 | 0.26 | 0.19 | 0.19 | 0.12 | 0.24 | 0.15 | 0.22 | 0.05 |
| | **Phaeophyceae** | 0.11 | 0.07 | 0.08 | 0.08 | 0.15 | 0.08 | 0.12 | 0.11 | 0.18 | 0.19 | 0.36 | 0.16 | 0.20 | 0.26 | 0.18 |
| | **Opportunists** | 0.08 | 0.13 | 0.17 | 0.16 | 0.06 | 0.09 | 0.10 | 0.14 | 0.12 | 0.08 | 0.00 | 0.08 | 0.09 | 0.11 | 0.00 |
| | **FG1** | 0.00 | 0.02 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.04 | 0.03 | 0.00 | 0.00 | 0.05 |
| | **fFG2** | 0.10 | 0.07 | 0.10 | 0.14 | 0.07 | 0.11 | 0.09 | 0.16 | 0.12 | 0.10 | 0.08 | 0.14 | 0.09 | 0.11 | 0.05 |
| | **FG3** | 0.19 | 0.22 | 0.17 | 0.25 | 0.11 | 0.17 | 0.13 | 0.16 | 0.12 | 0.13 | 0.16 | 0.14 | 0.26 | 0.30 | 0.05 |
| | **FG4** | 0.27 | 0.26 | 0.15 | 0.22 | 0.23 | 0.17 | 0.18 | 0.19 | 0.18 | 0.21 | 0.24 | 0.14 | 0.20 | 0.15 | 0.18 |
| | **FG5** | 0.27 | 0.31 | 0.48 | 0.29 | 0.42 | 0.36 | 0.41 | 0.37 | 0.37 | 0.31 | 0.36 | 0.35 | 0.30 | 0.30 | 0.41 |
| | **FG6** | 0.05 | 0.02 | 0.00 | 0.00 | 0.04 | 0.00 | 0.01 | 0.02 | 0.03 | 0.10 | 0.12 | 0.03 | 0.09 | 0.07 | 0.00 |
| | **FG7** | 0.06 | 0.07 | 0.04 | 0.00 | 0.06 | 0.14 | 0.10 | 0.05 | 0.07 | 0.10 | 0.00 | 0.03 | 0.04 | 0.04 | 0.14 |
| | **FG8** | 0.06 | 0.02 | 0.06 | 0.10 | 0.06 | 0.05 | 0.07 | 0.05 | 0.07 | 0.06 | 0.00 | 0.16 | 0.02 | 0.04 | 0.14 |

**Appendix 4 (cont.)** – Full species list richness, ESG ratio, proportions of Rhodophyta, Chlorophyta, Phaeophyceae and opportunist species, functional group proportions and respective average values (Avg.) and standard deviations (SD) per island, for the Azores archipelago, for the British Isles and for the British Isles meso-tidal shores.

| **Site code** | | **46** | **47** | **48** | **49** | **50** | **51** | **52** | **53** | **54** | **55** | **56** | **57** | **58** | **59** | **60** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Full species list richness** | | 48 | 69 | 49 | 44 | 67 | 41 | 45 | 14 | 40 | 52 | 35 | 49 | 50 | 24 | 61 |
| **ESG ratio** | | 1.82 | 1.03 | 0.96 | 2.38 | 1.58 | 1.28 | 0.80 | 1.80 | 1.00 | 1.26 | 2.50 | 1.04 | 1.27 | 2.00 | 0.97 |
| **Proportions** | **Rhodophyta** | 0.73 | 0.65 | 0.65 | 0.66 | 0.69 | 0.68 | 0.67 | 0.43 | 0.55 | 0.63 | 0.71 | 0.73 | 0.66 | 0.75 | 0.67 |
| | **Chlorophyta** | 0.13 | 0.12 | 0.18 | 0.11 | 0.10 | 0.12 | 0.22 | 0.43 | 0.20 | 0.19 | 0.11 | 0.16 | 0.20 | 0.13 | 0.21 |
| | **Phaeophyceae** | 0.15 | 0.23 | 0.16 | 0.23 | 0.21 | 0.20 | 0.11 | 0.14 | 0.25 | 0.17 | 0.17 | 0.10 | 0.14 | 0.13 | 0.11 |
| | **Opportunists** | 0.06 | 0.06 | 0.06 | 0.07 | 0.06 | 0.12 | 0.11 | 0.14 | 0.08 | 0.02 | 0.03 | 0.06 | 0.10 | 0.08 | 0.11 |
| | **FG1** | 0.00 | 0.07 | 0.04 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 |
| | **fFG2** | 0.08 | 0.04 | 0.10 | 0.07 | 0.07 | 0.07 | 0.18 | 0.07 | 0.10 | 0.06 | 0.06 | 0.14 | 0.10 | 0.04 | 0.11 |
| | **FG3** | 0.15 | 0.16 | 0.12 | 0.14 | 0.18 | 0.15 | 0.22 | 0.21 | 0.15 | 0.12 | 0.11 | 0.12 | 0.12 | 0.13 | 0.13 |
| | **FG4** | 0.13 | 0.26 | 0.20 | 0.14 | 0.12 | 0.15 | 0.16 | 0.21 | 0.28 | 0.25 | 0.14 | 0.16 | 0.22 | 0.21 | 0.21 |
| | **FG5** | 0.40 | 0.32 | 0.31 | 0.41 | 0.40 | 0.37 | 0.31 | 0.36 | 0.33 | 0.31 | 0.43 | 0.33 | 0.38 | 0.46 | 0.38 |
| | **FG6** | 0.04 | 0.07 | 0.04 | 0.11 | 0.07 | 0.05 | 0.04 | 0.00 | 0.03 | 0.06 | 0.06 | 0.00 | 0.04 | 0.00 | 0.08 |
| | **FG7** | 0.10 | 0.04 | 0.08 | 0.07 | 0.06 | 0.07 | 0.02 | 0.14 | 0.10 | 0.12 | 0.14 | 0.16 | 0.10 | 0.17 | 0.05 |
| | **FG8** | 0.10 | 0.03 | 0.10 | 0.07 | 0.09 | 0.10 | 0.07 | 0.00 | 0.03 | 0.08 | 0.06 | 0.04 | 0.04 | 0.00 | 0.03 |

**Appendix 4 (cont.)** – Full species list richness, ESG ratio, proportions of Rhodophyta, Chlorophyta, Phaeophyceae and opportunist species, functional group proportions and respective average values (Avg.) and standard deviations (SD) per island, for the Azores archipelago, for the British Isles and for the British Isles meso-tidal shores.

| **Site code** | | **61** | **62** | **63** | **64** | **65** | **66** | **67** | **68** | **69** | **70** | **71** | **72** | **73** | **74** | **75** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Full species list richness** | | 74 | 61 | 66 | 57 | 13 | 52 | 20 | 79 | 66 | 83 | 11 | 15 | 24 | 28 | 63 |
| **ESG ratio** | | 1.24 | 1.03 | 1.28 | 1.38 | 1.17 | 1.17 | 1.00 | 1.08 | 1.20 | 1.37 | 1.20 | 2.00 | 1.67 | 1.80 | 1.33 |
| **Proportions** | **Rhodophyta** | 0.68 | 0.70 | 0.65 | 0.82 | 0.54 | 0.77 | 0.55 | 0.67 | 0.68 | 0.72 | 0.55 | 0.73 | 0.75 | 0.68 | 0.59 |
| | **Chlorophyta** | 0.20 | 0.20 | 0.23 | 0.11 | 0.31 | 0.13 | 0.35 | 0.16 | 0.15 | 0.14 | 0.27 | 0.20 | 0.17 | 0.18 | 0.19 |
| | **Phaeophyceae** | 0.12 | 0.10 | 0.12 | 0.07 | 0.15 | 0.10 | 0.10 | 0.16 | 0.17 | 0.13 | 0.18 | 0.07 | 0.08 | 0.14 | 0.22 |
| | **Opportunists** | 0.07 | 0.10 | 0.09 | 0.05 | 0.15 | 0.08 | 0.25 | 0.08 | 0.06 | 0.04 | 0.27 | 0.20 | 0.13 | 0.07 | 0.11 |
| | **FG1** | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| | **fFG2** | 0.05 | 0.10 | 0.09 | 0.04 | 0.15 | 0.08 | 0.15 | 0.11 | 0.09 | 0.05 | 0.18 | 0.07 | 0.04 | 0.04 | 0.08 |
| | **FG3** | 0.14 | 0.16 | 0.17 | 0.16 | 0.15 | 0.08 | 0.15 | 0.10 | 0.17 | 0.17 | 0.09 | 0.13 | 0.08 | 0.07 | 0.17 |
| | **FG4** | 0.27 | 0.20 | 0.14 | 0.26 | 0.15 | 0.29 | 0.15 | 0.27 | 0.21 | 0.20 | 0.18 | 0.27 | 0.29 | 0.25 | 0.22 |
| | **FG5** | 0.41 | 0.43 | 0.45 | 0.39 | 0.38 | 0.40 | 0.25 | 0.33 | 0.36 | 0.37 | 0.36 | 0.40 | 0.50 | 0.46 | 0.32 |
| | **FG6** | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.02 | 0.05 | 0.00 | 0.00 | 0.00 | 0.04 | 0.03 |
| | **FG7** | 0.05 | 0.07 | 0.05 | 0.09 | 0.08 | 0.12 | 0.15 | 0.06 | 0.05 | 0.08 | 0.09 | 0.13 | 0.08 | 0.07 | 0.13 |
| | **FG8** | 0.08 | 0.05 | 0.08 | 0.07 | 0.08 | 0.04 | 0.15 | 0.06 | 0.09 | 0.05 | 0.09 | 0.00 | 0.00 | 0.07 | 0.03 |

**Appendix 4 (cont.)** – Full species list richness, ESG ratio, proportions of Rhodophyta, Chlorophyta, Phaeophyceae and opportunist species, functional group proportions and respective average values (Avg.) and standard deviations (SD) per island, for the Azores archipelago, for the British Isles and for the British Isles meso-tidal shores.

| **Site code** | | **76** | **77** | **78** | **79** | **80** | **81** | **82** | **83** | **84** | **85** | **86** | **87** | **88** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Full species list richness** | | 27 | 12 | 41 | 35 | 20 | 56 | 8 | 39 | 69 | 52 | 44 | 80 | 44 |
| **ESG ratio** | | 1.25 | 0.71 | 1.05 | 1.19 | 2.33 | 1.33 | 1.00 | 1.79 | 1.23 | 1.74 | 1.10 | 1.29 | 0.91 |
| **Proportions** | **Rhodophyta** | 0.78 | 0.58 | 0.71 | 0.69 | 0.75 | 0.75 | 0.75 | 0.67 | 0.68 | 0.62 | 0.75 | 0.76 | 0.70 |
| | **Chlorophyta** | 0.19 | 0.42 | 0.27 | 0.14 | 0.20 | 0.14 | 0.25 | 0.21 | 0.20 | 0.23 | 0.11 | 0.13 | 0.23 |
| | **Phaeophyceae** | 0.04 | 0.00 | 0.02 | 0.17 | 0.05 | 0.11 | 0.00 | 0.13 | 0.12 | 0.15 | 0.14 | 0.11 | 0.07 |
| | **Opportunists** | 0.07 | 0.33 | 0.10 | 0.00 | 0.10 | 0.04 | 0.13 | 0.08 | 0.06 | 0.12 | 0.09 | 0.06 | 0.11 |
| | **FG1** | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 |
| | **fFG2** | 0.04 | 0.17 | 0.07 | 0.00 | 0.05 | 0.07 | 0.13 | 0.08 | 0.10 | 0.10 | 0.05 | 0.05 | 0.07 |
| | **FG3** | 0.11 | 0.17 | 0.24 | 0.26 | 0.10 | 0.20 | 0.00 | 0.10 | 0.14 | 0.21 | 0.20 | 0.18 | 0.23 |
| | **FG4** | 0.30 | 0.25 | 0.12 | 0.20 | 0.10 | 0.20 | 0.25 | 0.21 | 0.17 | 0.15 | 0.30 | 0.21 | 0.25 |
| | **FG5** | 0.44 | 0.33 | 0.44 | 0.37 | 0.55 | 0.38 | 0.63 | 0.51 | 0.32 | 0.31 | 0.20 | 0.43 | 0.34 |
| | **FG6** | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.04 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.03 | 0.00 |
| | **FG7** | 0.04 | 0.08 | 0.07 | 0.09 | 0.10 | 0.11 | 0.00 | 0.05 | 0.10 | 0.15 | 0.14 | 0.06 | 0.07 |
| | **FG8** | 0.07 | 0.00 | 0.05 | 0.03 | 0.10 | 0.02 | 0.00 | 0.05 | 0.13 | 0.08 | 0.11 | 0.04 | 0.05 |

**Appendix 4 (cont.)** – Full species list richness, ESG ratio, proportions of Rhodophyta, Chlorophyta, Phaeophyceae and opportunist species, functional group proportions and respective average values (Avg.) and standard deviations (SD) per island, for the Azores archipelago, for the British Isles and for the British Isles meso-tidal shores.

| Island | | Santa Maria | | São Miguel | | Terceira | | Graciosa | | Pico | | São Jorge | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD | Avg. | SD |
| **Full species list richness** | | 29.6 | 5.9 | 54.3 | 13.41 | 65.4 | 3.9 | 44.0 | 10.5 | 42.0 | 19.3 | 55.0 | 12.5 |
| **ESG ratio** | | 1.9 | 0.6 | 1.2 | 0.34 | 1.4 | 0.2 | 1.3 | 0.4 | 1.36 | 0.31 | 1.3 | 0.3 |
| **Proportions** | **Rhodophyta** | 0.68 | 0.06 | 0.7 | 0.06 | 0.68 | 0.04 | 0.65 | 0.05 | 0.67 | 0.06 | 0.71 | 0.05 |
| | **Chlorophyta** | 0.18 | 0.05 | 0.2 | 0.05 | 0.19 | 0.03 | 0.15 | 0.05 | 0.21 | 0.05 | 0.17 | 0.05 |
| | **Phaeophyceae** | 0.13 | 0.05 | 0.1 | 0.05 | 0.13 | 0.03 | 0.20 | 0.04 | 0.12 | 0.04 | 0.12 | 0.03 |
| | **Opportunists** | 0.1 | 0.1 | 0.1 | 0.03 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.1 | 0.1 | 0.0 |
| | **FG1** | 0.0 | 0.0 | 0.0 | 0.01 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **fFG2** | 0.1 | 0.0 | 0.1 | 0.04 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 |
| | **FG3** | 0.1 | 0.0 | 0.2 | 0.04 | 0.1 | 0.0 | 0.2 | 0.0 | 0.1 | 0.0 | 0.2 | 0.0 |
| | **FG4** | 0.2 | 0.0 | 0.2 | 0.04 | 0.2 | 0.0 | 0.2 | 0.0 | 0.2 | 0.0 | 0.2 | 0.0 |
| | **FG5** | 0.3 | 0.1 | 0.4 | 0.06 | 0.4 | 0.0 | 0.3 | 0.0 | 0.4 | 0.1 | 0.3 | 0.1 |
| | **FG6** | 0.0 | 0.0 | 0.0 | 0.02 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | **FG7** | 0.1 | 0.0 | 0.1 | 0.03 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 |
| | **FG8** | 0.1 | 0.0 | 0.1 | 0.03 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 |

**Appendix 4 (cont.)** – Full species list richness, ESG ratio, proportions of Rhodophyta, Chlorophyta, Phaeophyceae and opportunist species, functional group proportions and respective average values (Avg.) and standard deviations (SD) per island, for the Azores archipelago, for the British Isles and for the British Isles meso-tidal shores.

| Region | | AZORES | | British Isles | | British Isles meso-tidal | |
|---|---|---|---|---|---|---|---|
| | | Avg. | SD | Avg. | SD | Avg. | SD |
| **Full species list richness** | | 43.9 | 19.4 | 60.7 | 23.2 | 65.4 | 16.8 |
| **ESG ratio** | | 1.42 | 0.57 | 0.53 | 0.22 | 0.60 | 0.18 |
| **Proportions** | **Rhodophyta** | 0.67 | 0.08 | 0.48 | 0.09 | 0.48 | 0.06 |
| | **Chlorophyta** | 0.19 | 0.07 | 0.24 | 0.10 | 0.31 | 0.07 |
| | **Phaeophyceae** | 0.14 | 0.06 | 0.28 | 0.07 | 0.21 | 0.06 |
| | **Opportunists** | 0.10 | 0.06 | 0.15 | 0.07 | 0.13 | 0.04 |
| | **FG1** | 0.01 | 0.01 | 0.10 | 0.05 | 0.09 | 0.03 |
| | **fFG2** | 0.09 | 0.05 | 0.17 | 0.06 | 0.17 | 0.03 |
| | **FG3** | 0.15 | 0.05 | 0.19 | 0.06 | 0.18 | 0.04 |
| | **FG4** | 0.21 | 0.06 | 0.15 | 0.04 | 0.14 | 0.03 |
| | **FG5** | 0.36 | 0.08 | 0.18 | 0.06 | 0.19 | 0.05 |
| | **FG6** | 0.03 | 0.03 | 0.13 | 0.04 | 0.13 | 0.03 |
| | **FG7** | 0.09 | 0.05 | 0.01 | 0.01 | 0.02 | 0.01 |
| | **FG8** | 0.06 | 0.04 | 0.07 | 0.05 | 0.08 | 0.05 |

# Appendix 5

Total cover and opportunist species cover (%) based on relative abundance (%) of taxa per site with discrimination of calcareous and non-calcareous turf components.

**Appendix 5** - Total cover and opportunist species cover (%) based on relative abundance (%) of taxa per site with discrimination of calcaeous and non-calcareous turf components.

| **Site code** | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| **Total cover** | 44.9% | 37.0% | 60.0% | 61.4% | 48.9% |
| **Opportunist cover** | 18.5% | 85.9% | 30.1% | 30.8% | 8.1% |
| *Asparagopsis armata* | | | | | |
| *Bryopsis* sp. | | | | | |
| *Chondria dasyphilla* | | | | | |
| *Cladophora* spp. | | | | | |
| *Cladostephus spongiosus* | | | | 2.6% | |
| *Codium adhaerens* | | | | | 4.6% |
| *Colpomenia sinuosa* | | | | | |
| *Cystoseira* spp. | | | 2.0% | | 6.8% |
| *Erect calcareous* | | | | | |
| *Falkenbergia rufolanosa* | | | | | |
| *Fucus spiralis* | | | | 3.5% | |
| *Gelidium* sp. | | | | | 2.4% |
| *Grateloupia* sp. | | | | | |
| *Green foliose* | 6.8% | 29.1% | 14.7% | 16.8% | |
| *Halopteris/Stypocaulon* | 3.0% | | | | |
| *Hypnea musciformis* | | | | | |
| *Laurencia/Osmundea* | 10.5% | | 26.9% | 25.8% | 17.5% |
| *Lomentaria articulata* | | | | | |
| *Nemalion helminthoides* | | | | 1.9% | |
| *Padina pavonica* | | | | | |
| *Porphyra* sp. | | | | | |
| *Pterocladiella capillacea* | | | | | |
| *Rhodymenia holmesii* | | | | | |
| *Red crust* | 4.8% | | 6.6% | | |
| **Calcareous turf** | **19.7%** | | | **5.9%** | **7.7%** |
| *Amphiroa* spp. | 1.2% | 0.0% | 0.0% | 0.4% | 0.5% |
| *Ceramium* spp. | 0.7% | 0.0% | 0.0% | 0.2% | 0.3% |
| *Chondracanthus acicularis* | 0.5% | 0.0% | 0.0% | 0.1% | 0.2% |
| *Chondria* spp. | 0.9% | 0.0% | 0.0% | 0.3% | 0.4% |
| *Corallina elongata* | 3.9% | 0.0% | 0.0% | 1.2% | 1.5% |
| *Gelidium* spp. | 0.4% | 0.0% | 0.0% | 0.1% | 0.2% |
| *Haliptilon* spp. | 3.8% | 0.0% | 0.0% | 1.1% | 1.5% |
| *Herposiphonia* sp. | 0.3% | 0.0% | 0.0% | 0.1% | 0.1% |
| *Jania* spp. | 2.3% | 0.0% | 0.0% | 0.7% | 0.9% |
| *Laurencia* spp. | 1.6% | 0.0% | 0.0% | 0.5% | 0.6% |
| *Polysiphonia* spp. | 0.3% | 0.0% | 0.0% | 0.1% | 0.1% |
| *Pterosiphonia* spp. | 0.1% | 0.0% | 0.0% | 0.0% | 0.1% |
| *Stypocaulon scoparium* | 0.4% | 0.0% | 0.0% | 0.1% | 0.2% |
| **Non-calcareous turf** | | **7.9%** | **9.9%** | **5.0%** | **9.9%** |
| *Centroceras clavulatum* | 0.0% | 0.1% | 0.2% | 0.1% | 0.2% |
| *Ceramium* spp. | 0.0% | 0.8% | 0.9% | 0.5% | 0.9% |

**Appendix 5 (cont.)** - Total cover and opportunist species cover (%) based on relative abundance (%) of taxa per site with discrimination of calcaeous and non-calcareous turf components.

| **Site code** | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| **Non-calcareous turf (cont.)** | | | | | |
| *Chondria* spp. | 0.0% | 0.2% | 0.2% | 0.1% | 0.2% |
| *Cladophora* spp. | 0.0% | 0.2% | 0.2% | 0.1% | 0.2% |
| *Corallina elongata* | 0.0% | 0.4% | 0.6% | 0.3% | 0.6% |
| *Gelidium* spp. | 0.0% | 0.9% | 1.1% | 0.6% | 1.1% |
| *Gymnogongrus* spp. | 0.0% | 0.3% | 0.4% | 0.2% | 0.4% |
| *Haliptilon* spp. | 0.0% | 0.4% | 0.5% | 0.3% | 0.5% |
| *Herposiphonia* sp. | 0.0% | 0.8% | 1.0% | 0.5% | 1.0% |
| *Jania* spp. | 0.0% | 0.1% | 0.2% | 0.1% | 0.2% |
| *Laurencia* spp. | 0.0% | 0.6% | 0.7% | 0.4% | 0.7% |
| *Osmundea* spp. | 0.0% | 0.1% | 0.2% | 0.1% | 0.2% |
| *Polysiphonia* spp. | 0.0% | 0.5% | 0.7% | 0.3% | 0.7% |
| *Pterosiphonia* spp. | 0.0% | 0.2% | 0.2% | 0.1% | 0.2% |
| *Stypocaulon scoparium* | 0.0% | 0.3% | 0.3% | 0.2% | 0.3% |
| *Ulva* spp. | 0.0% | 0.2% | 0.2% | 0.1% | 0.2% |

**Appendix 5 (cont.)** - Total cover and opportunist species cover (%) based on relative abundance (%) of taxa per site with discrimination of calcaeous and non-calcareous turf components.

| **Site code** | **6** | **7** | **8** | **9** | **10** |
|---|---|---|---|---|---|
| **Total cover** | 57.3% | 60.5% | 74.2% | 66.3% | 81.3% |
| **Opportunist cover** | 25.4% | 37.5% | 2.8% | 29.5% | 36.0% |
| *Asparagopsis armata* | | | | | |
| *Bryopsis* sp. | | | | | |
| *Chondria dasyphilla* | | | | | |
| *Cladophora* spp. | | | | | |
| *Cladostephus spongiosus* | | | | | |
| *Codium adhaerens* | | | | | |
| *Colpomenia sinuosa* | | | | | |
| *Cystoseira* spp. | 10.1% | | 25.3% | | |
| *Erect calcareous* | | | | | 13.7% |
| *Falkenbergia rufolanosa* | | | | | |
| *Fucus spiralis* | | | | | |
| *Gelidium* sp. | | | | | |
| *Grateloupia* sp. | | | | | |
| *Green foliose* | 13.0% | 21.6% | | 10.6% | 24.2% |
| *Halopteris/Stypocaulon* | | 10.0% | | 21.3% | 14.0% |
| *Hypnea musciformis* | | | | | |
| *Laurencia/Osmundea* | 11.2% | 8.7% | 21.5% | 4.1% | 3.0% |
| *Lomentaria articulata* | | | | | |
| *Nemalion helminthoides* | | | | | |
| *Padina pavonica* | | | | | |
| *Porphyra* sp. | | | | | |
| *Pterocladiella capillacea* | | | | | |
| *Rhodymenia holmesii* | | | | | |
| *Red crust* | 2.2% | 5.7% | | 2.1% | |
| **Calcareous turf** | **20.9%** | **14.6%** | **27.4%** | **2.6%** | **15.0%** |
| *Amphiroa* spp. | 1.3% | 0.9% | 1.7% | 0.2% | 0.9% |
| *Ceramium* spp. | 0.8% | 0.5% | 1.0% | 0.1% | 0.5% |
| *Chondracanthus acicularis* | 0.5% | 0.3% | 0.7% | 0.1% | 0.4% |
| *Chondria* spp. | 0.9% | 0.7% | 1.2% | 0.1% | 0.7% |
| *Corallina elongata* | 4.1% | 2.9% | 5.4% | 0.5% | 3.0% |
| *Gelidium* spp. | 0.4% | 0.3% | 0.6% | 0.1% | 0.3% |
| *Haliptilon* spp. | 4.0% | 2.8% | 5.3% | 0.5% | 2.9% |
| *Herposiphonia* sp. | 0.3% | 0.2% | 0.4% | 0.0% | 0.2% |
| *Jania* spp. | 2.4% | 1.7% | 3.1% | 0.3% | 1.7% |
| *Laurencia* spp. | 1.6% | 1.2% | 2.2% | 0.2% | 1.2% |
| *Polysiphonia* spp. | 0.4% | 0.3% | 0.5% | 0.0% | 0.3% |
| *Pterosiphonia* spp. | 0.2% | 0.1% | 0.2% | 0.0% | 0.1% |
| *Stypocaulon scoparium* | 0.5% | 0.3% | 0.6% | 0.1% | 0.3% |
| **Non-calcareous turf** | | | | **25.6%** | **11.4%** |
| *Centroceras clavulatum* | 0.0% | 0.0% | 0.0% | 0.4% | 0.2% |
| *Ceramium* spp. | 0.0% | 0.0% | 0.0% | 2.5% | 1.1% |

**Appendix 5 (cont.)** - Total cover and opportunist species cover (%) based on relative abundance (%) of taxa per site with discrimination of calcaeous and non-calcareous turf components.

| **Site code** | **6** | **7** | **8** | **9** | **10** |
|---|---|---|---|---|---|
| **Non-calcareous turf (cont.)** | | | | | |
| *Chondria* spp. | 0.0% | 0.0% | 0.0% | 0.6% | 0.3% |
| *Cladophora* spp. | 0.0% | 0.0% | 0.0% | 0.6% | 0.3% |
| *Corallina elongata* | 0.0% | 0.0% | 0.0% | 1.5% | 0.6% |
| *Gelidium* spp. | 0.0% | 0.0% | 0.0% | 2.9% | 1.3% |
| *Gymnogongrus* spp. | 0.0% | 0.0% | 0.0% | 0.9% | 0.4% |
| *Haliptilon* spp. | 0.0% | 0.0% | 0.0% | 1.3% | 0.6% |
| *Herposiphonia* sp. | 0.0% | 0.0% | 0.0% | 2.5% | 1.1% |
| *Jania* spp. | 0.0% | 0.0% | 0.0% | 0.5% | 0.2% |
| *Laurencia* spp. | 0.0% | 0.0% | 0.0% | 1.9% | 0.8% |
| *Osmundea* spp. | 0.0% | 0.0% | 0.0% | 0.5% | 0.2% |
| *Polysiphonia* spp. | 0.0% | 0.0% | 0.0% | 1.8% | 0.8% |
| *Pterosiphonia* spp. | 0.0% | 0.0% | 0.0% | 0.5% | 0.2% |
| *Stypocaulon scoparium* | 0.0% | 0.0% | 0.0% | 0.9% | 0.4% |
| *Ulva* spp. | 0.0% | 0.0% | 0.0% | 0.5% | 0.2% |

**Appendix 5 (cont.)** - Total cover and opportunist species cover (%) based on relative abundance (%) of taxa per site with discrimination of calcaeous and non-calcareous turf components.

| **Site code** | **11** | **12** | **13** | **14** | **15** |
|---|---|---|---|---|---|
| **Total cover** | 73.3% | 74.0% | 69.3% | 60.5% | 67.3% |
| **Opportunist cover** | 20.3% | 2.7% | 63.0% | 15.5% | 25.1% |
| *Asparagopsis armata* | | | | | |
| *Bryopsis* sp. | | | | | |
| *Chondria dasyphilla* | | | | | 2.8% |
| *Cladophora* spp. | | | | 2.1% | 2.9% |
| *Cladostephus spongiosus* | | | | | |
| *Codium adhaerens* | 9.3% | 3.6% | 6.2% | | |
| *Colpomenia sinuosa* | | | | | |
| *Cystoseira* spp. | | 9.7% | | 5.6% | 4.1% |
| *Erect calcareous* | | | | 4.7% | |
| *Falkenbergia rufolanosa* | | | | | |
| *Fucus spiralis* | | | | | 4.5% |
| *Gelidium* sp. | | | | | |
| *Grateloupia* sp. | | | | | |
| *Green foliose* | 9.5% | | 42.0% | 6.0% | 11.0% |
| *Halopteris/Stypocaulon* | 17.4% | | 9.2% | 6.0% | 6.8% |
| *Hypnea musciformis* | | | | | |
| *Laurencia/Osmundea* | | 32.3% | 4.2% | 18.7% | 7.4% |
| *Lomentaria articulata* | | | | | |
| *Nemalion helminthoides* | | | | | |
| *Padina pavonica* | | | | | |
| *Porphyra* sp. | | | | | |
| *Pterocladiella capillacea* | | | | | |
| *Rhodymenia holmesii* | | | | | |
| *Red crust* | 10.0% | 2.5% | | | 4.1% |
| **Calcareous turf** | **14.5%** | **25.9%** | **3.5%** | **17.5%** | **19.1%** |
| *Amphiroa* spp. | 0.9% | 1.6% | 0.2% | 1.1% | 1.2% |
| *Ceramium* spp. | 0.5% | 0.9% | 0.1% | 0.6% | 0.7% |
| *Chondracanthus acicularis* | 0.3% | 0.6% | 0.1% | 0.4% | 0.5% |
| *Chondria* spp. | 0.7% | 1.2% | 0.2% | 0.8% | 0.9% |
| *Corallina elongata* | 2.9% | 5.1% | 0.7% | 3.4% | 3.8% |
| *Gelidium* spp. | 0.3% | 0.6% | 0.1% | 0.4% | 0.4% |
| *Haliptilon* spp. | 2.8% | 5.0% | 0.7% | 3.4% | 3.7% |
| *Herposiphonia* sp. | 0.2% | 0.4% | 0.1% | 0.3% | 0.3% |
| *Jania* spp. | 1.7% | 3.0% | 0.4% | 2.0% | 2.2% |
| *Laurencia* spp. | 1.1% | 2.0% | 0.3% | 1.4% | 1.5% |
| *Polysiphonia* spp. | 0.3% | 0.5% | 0.1% | 0.3% | 0.3% |
| *Pterosiphonia* spp. | 0.1% | 0.2% | 0.0% | 0.1% | 0.1% |
| *Stypocaulon scoparium* | 0.3% | 0.6% | 0.1% | 0.4% | 0.4% |
| **Non-calcareous turf** | **12.7%** | | **4.3%** | | **4.5%** |
| *Centroceras clavulatum* | 0.2% | 0.0% | 0.1% | 0.0% | 0.1% |
| *Ceramium* spp. | 1.2% | 0.0% | 0.4% | 0.0% | 0.4% |

**Appendix 5 (cont.)** - Total cover and opportunist species cover (%) based on relative abundance (%) of taxa per site with discrimination of calcaeous and non-calcareous turf components.

| **Site code** | **11** | **12** | **13** | **14** | **15** |
|---|---|---|---|---|---|
| **Non-calcareous turf (cont.)** | | | | | |
| *Chondria* spp. | 0.3% | 0.0% | 0.1% | 0.0% | 0.1% |
| *Cladophora* spp. | 0.3% | 0.0% | 0.1% | 0.0% | 0.1% |
| *Corallina elongata* | 0.7% | 0.0% | 0.2% | 0.0% | 0.3% |
| *Gelidium* spp. | 1.4% | 0.0% | 0.5% | 0.0% | 0.5% |
| *Gymnogongrus* spp. | 0.5% | 0.0% | 0.2% | 0.0% | 0.2% |
| *Haliptilon* spp. | 0.7% | 0.0% | 0.2% | 0.0% | 0.2% |
| *Herposiphonia* sp. | 1.2% | 0.0% | 0.4% | 0.0% | 0.4% |
| *Jania* spp. | 0.2% | 0.0% | 0.1% | 0.0% | 0.1% |
| *Laurencia* spp. | 0.9% | 0.0% | 0.3% | 0.0% | 0.3% |
| *Osmundea* spp. | 0.2% | 0.0% | 0.1% | 0.0% | 0.1% |
| *Polysiphonia* spp. | 0.9% | 0.0% | 0.3% | 0.0% | 0.3% |
| *Pterosiphonia* spp. | 0.3% | 0.0% | 0.1% | 0.0% | 0.1% |
| *Stypocaulon scoparium* | 0.4% | 0.0% | 0.1% | 0.0% | 0.2% |
| *Ulva* spp. | 0.3% | 0.0% | 0.1% | 0.0% | 0.1% |

**Appendix 5 (cont.)** - Total cover and opportunist species cover (%) based on relative abundance (%) of taxa per site with discrimination of calcaeous and non-calcareous turf components.

| **Site code** | **16** | **42** | **43** | **45** | **46** |
|---|---|---|---|---|---|
| **Total cover** | 55.0% | 74.5% | 89.9% | 55.5% | 60.1% |
| **Opportunist cover** | 19.9% | 14.3% | 51.3% | 40.0% | 8.1% |
| *Asparagopsis armata* | | | | | |
| *Bryopsis* sp. | | | | | |
| *Chondria dasyphilla* | | | | | |
| *Cladophora* spp. | | | | | |
| *Cladostephus spongiosus* | | | | | |
| *Codium adhaerens* | | 2.6% | 3.4% | | |
| *Colpomenia sinuosa* | | | | | |
| *Cystoseira* spp. | | | | 3.6% | 17.7% |
| *Erect calcareous* | | 30.6% | 22.3% | | 18.2% |
| *Falkenbergia rufolanosa* | | | | | |
| *Fucus spiralis* | | | | | |
| *Gelidium* sp. | | | | | |
| *Grateloupia* sp. | | | | | |
| *Green foliose* | 9.4% | 2.6% | 39.3% | 11.9% | |
| *Halopteris/Stypocaulon* | 5.2% | 2.6% | | 5.5% | |
| *Hypnea musciformis* | | | | | |
| *Laurencia/Osmundea* | 19.9% | 9.9% | | | 6.3% |
| *Lomentaria articulata* | | | | | |
| *Nemalion helminthoides* | | | | | |
| *Padina pavonica* | | | | | |
| *Porphyra* sp. | | | | | |
| *Pterocladiella capillacea* | | | 4.7% | | |
| *Rhodymenia holmesii* | | | | | |
| *Red crust* | | | | | 3.7% |
| **Calcareous turf** | **20.6%** | **3.4%** | | **5.8%** | |
| *Amphiroa* spp. | 1.3% | 0.2% | 0.0% | 0.4% | 0.0% |
| *Ceramium* spp. | 0.7% | 0.1% | 0.0% | 0.2% | 0.0% |
| *Chondracanthus acicularis* | 0.5% | 0.1% | 0.0% | 0.1% | 0.0% |
| *Chondria* spp. | 0.9% | 0.2% | 0.0% | 0.3% | 0.0% |
| *Corallina elongata* | 4.0% | 0.7% | 0.0% | 1.1% | 0.0% |
| *Gelidium* spp. | 0.4% | 0.1% | 0.0% | 0.1% | 0.0% |
| *Haliptilon* spp. | 4.0% | 0.7% | 0.0% | 1.1% | 0.0% |
| *Herposiphonia* sp. | 0.3% | 0.1% | 0.0% | 0.1% | 0.0% |
| *Jania* spp. | 2.4% | 0.4% | 0.0% | 0.7% | 0.0% |
| *Laurencia* spp. | 1.6% | 0.3% | 0.0% | 0.5% | 0.0% |
| *Polysiphonia* spp. | 0.4% | 0.1% | 0.0% | 0.1% | 0.0% |
| *Pterosiphonia* spp. | 0.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| *Stypocaulon scoparium* | 0.5% | 0.1% | 0.0% | 0.1% | 0.0% |
| **Non-calcareous turf** | | **22.9%** | **20.2%** | **28.7%** | **14.2%** |
| *Centroceras clavulatum* | 0.0% | 0.4% | 0.3% | 0.4% | 0.2% |
| *Ceramium* spp. | 0.0% | 2.2% | 1.9% | 2.8% | 1.4% |

**Appendix 5 (cont.)** - Total cover and opportunist species cover (%) based on relative abundance (%) of taxa per site with discrimination of calcaeous and non-calcareous turf components.

| **Site code** | **16** | **42** | **43** | **45** | **46** |
|---|---|---|---|---|---|
| **Non-calcareous turf (cont.)** | | | | | |
| *Chondria* spp. | 0.0% | 0.6% | 0.5% | 0.7% | 0.4% |
| *Cladophora* spp. | 0.0% | 0.5% | 0.5% | 0.7% | 0.3% |
| *Corallina elongata* | 0.0% | 1.3% | 1.1% | 1.6% | 0.8% |
| *Gelidium* spp. | 0.0% | 2.6% | 2.2% | 3.2% | 1.6% |
| *Gymnogongrus* spp. | 0.0% | 0.8% | 0.7% | 1.0% | 0.5% |
| *Haliptilon* spp. | 0.0% | 1.2% | 1.0% | 1.5% | 0.7% |
| *Herposiphonia* sp. | 0.0% | 2.2% | 2.0% | 2.8% | 1.4% |
| *Jania* spp. | 0.0% | 0.4% | 0.4% | 0.5% | 0.3% |
| *Laurencia* spp. | 0.0% | 1.7% | 1.5% | 2.1% | 1.0% |
| *Osmundea* spp. | 0.0% | 0.4% | 0.4% | 0.5% | 0.3% |
| *Polysiphonia* spp. | 0.0% | 1.6% | 1.4% | 2.0% | 1.0% |
| *Pterosiphonia* spp. | 0.0% | 0.5% | 0.4% | 0.6% | 0.3% |
| *Stypocaulon scoparium* | 0.0% | 0.8% | 0.7% | 1.0% | 0.5% |
| *Ulva* spp. | 0.0% | 0.5% | 0.4% | 0.6% | 0.3% |

**Appendix 5 (cont.)** - Total cover and opportunist species cover (%) based on relative abundance (%) of taxa per site with discrimination of calcaeous and non-calcareous turf components.

| **Site code** | **47** | **48** | **49** | **50** | **51** |
|---|---|---|---|---|---|
| **Total cover** | 72.1% | 82.3% | 56.8% | 72.8% | 67.1% |
| **Opportunist cover** | 11.6% | 16.1% | 22.9% | 12.4% | 11.5% |
| *Asparagopsis armata* | | | | | |
| *Bryopsis* sp. | | | | | |
| *Chondria dasyphilla* | | | | | |
| *Cladophora* spp. | | 2.4% | | | |
| *Cladostephus spongiosus* | | | | | |
| *Codium adhaerens* | | | | | |
| *Colpomenia sinuosa* | | | | | |
| *Cystoseira* spp. | 26.6% | 8.3% | | 3.3% | 18.4% |
| *Erect calcareous* | | 12.3% | 18.0% | 2.9% | 6.3% |
| *Falkenbergia rufolanosa* | | 2.4% | | | |
| *Fucus spiralis* | | | | | |
| *Gelidium* sp. | | | | 1.6% | |
| *Grateloupia* sp. | | | | | |
| *Green foliose* | 2.7% | 4.9% | 7.9% | | |
| *Halopteris/Stypocaulon* | | | | | |
| *Hypnea musciformis* | | | | | |
| *Laurencia/Osmundea* | 11.6% | 3.7% | | 18.4% | 8.0% |
| *Lomentaria articulata* | | | | | |
| *Nemalion helminthoides* | 3.6% | | | | |
| *Padina pavonica* | | | | | |
| *Porphyra* sp. | | | | | |
| *Pterocladiella capillacea* | 3.5% | 3.4% | | | |
| *Rhodymenia holmesii* | | | | | |
| *Red crust* | 5.8% | 1.5% | 6.6% | | 2.8% |
| **Calcareous turf** | **2.0%** | **33.3%** | **12.0%** | **26.0%** | **11.6%** |
| *Amphiroa* spp. | 0.1% | 2.1% | 0.7% | 1.6% | 0.7% |
| *Ceramium* spp. | 0.1% | 1.2% | 0.4% | 0.9% | 0.4% |
| *Chondracanthus acicularis* | 0.0% | 0.8% | 0.3% | 0.6% | 0.3% |
| *Chondria* spp. | 0.1% | 1.5% | 0.5% | 1.2% | 0.5% |
| *Corallina elongata* | 0.4% | 6.6% | 2.4% | 5.1% | 2.3% |
| *Gelidium* spp. | 0.0% | 0.7% | 0.3% | 0.6% | 0.3% |
| *Haliptilon* spp. | 0.4% | 6.4% | 2.3% | 5.0% | 2.2% |
| *Herposiphonia* sp. | 0.0% | 0.5% | 0.2% | 0.4% | 0.2% |
| *Jania* spp. | 0.2% | 3.8% | 1.4% | 3.0% | 1.3% |
| *Laurencia* spp. | 0.2% | 2.6% | 0.9% | 2.0% | 0.9% |
| *Polysiphonia* spp. | 0.0% | 0.6% | 0.2% | 0.5% | 0.2% |
| *Pterosiphonia* spp. | 0.0% | 0.2% | 0.1% | 0.2% | 0.1% |
| *Stypocaulon scoparium* | 0.0% | 0.7% | 0.3% | 0.6% | 0.3% |
| **Non-calcareous turf** | **16.4%** | **10.0%** | **12.2%** | **20.6%** | **20.0%** |
| *Centroceras clavulatum* | 0.3% | 0.2% | 0.2% | 0.3% | 0.3% |
| *Ceramium* spp. | 1.6% | 1.0% | 1.2% | 2.0% | 1.9% |

**Appendix 5 (cont.)** - Total cover and opportunist species cover (%) based on relative abundance (%) of taxa per site with discrimination of calcaeous and non-calcareous turf components.

| **Site code** | **47** | **48** | **49** | **50** | **51** |
|---|---|---|---|---|---|
| **Non-calcareous turf (cont.)** | | | | | |
| *Chondria* spp. | 0.4% | 0.3% | 0.3% | 0.5% | 0.5% |
| *Cladophora* spp. | 0.4% | 0.2% | 0.3% | 0.5% | 0.5% |
| *Corallina elongata* | 0.9% | 0.6% | 0.7% | 1.2% | 1.1% |
| *Gelidium* spp. | 1.8% | 1.1% | 1.4% | 2.3% | 2.2% |
| *Gymnogongrus* spp. | 0.6% | 0.4% | 0.4% | 0.7% | 0.7% |
| *Haliptilon* spp. | 0.8% | 0.5% | 0.6% | 1.1% | 1.0% |
| *Herposiphonia* sp. | 1.6% | 1.0% | 1.2% | 2.0% | 1.9% |
| *Jania* spp. | 0.3% | 0.2% | 0.2% | 0.4% | 0.4% |
| *Laurencia* spp. | 1.2% | 0.7% | 0.9% | 1.5% | 1.5% |
| *Osmundea* spp. | 0.3% | 0.2% | 0.2% | 0.4% | 0.4% |
| *Polysiphonia* spp. | 1.1% | 0.7% | 0.8% | 1.4% | 1.4% |
| *Pterosiphonia* spp. | 0.3% | 0.2% | 0.2% | 0.4% | 0.4% |
| *Stypocaulon scoparium* | 0.6% | 0.3% | 0.4% | 0.7% | 0.7% |
| *Ulva* spp. | 0.3% | 0.2% | 0.3% | 0.4% | 0.4% |

# Appendix 6

Shore description score and correction factor, observed and de-shored full species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and average EQR and quality status class for each Azorean shore according to the FSL tool.

**Appendix 6** - Shore description score and correction factor, observed and de-shored full species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and averge EQR and quality status class for each Azorean shore according to the FSL tool.

| Site code | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 17 | 8 | 10 | 14 | 12 | 16 | 8 | 13 | 12 | 14 | 8 | 16 | 8 | 16 |
| **Shore correction factor** | 0.62 | 1.47 | 1.21 | 0.82 | 1.00 | 0.68 | 1.47 | 0.91 | 1.00 | 0.82 | 1.47 | 0.68 | 1.47 | 0.68 |
| **Observed species richness (S)** | 38 | 8 | 35 | 40 | 42 | 23 | 26 | 28 | 29 | 33 | 18 | 34 | 23 | 31 |
| **EQR-S** | 0.63 | 0.24 | 0.60 | 0.65 | 0.67 | 0.44 | 0.48 | 0.51 | 0.52 | 0.57 | 0.37 | 0.59 | 0.44 | 0.55 |
| **De-shored species richness (S')** | 23 | 12 | 42 | 33 | 42 | 16 | 38 | 25 | 29 | 27 | 26 | 23 | 34 | 21 |
| **EQR-S'** | 0.45 | 0.29 | 0.67 | 0.57 | 0.67 | 0.34 | 0.63 | 0.47 | 0.52 | 0.50 | 0.49 | 0.44 | 0.58 | 0.41 |
| **Proportion of Chlorophyta (C)** | 0.29 | 0.38 | 0.11 | 0.08 | 0.12 | 0.17 | 0.23 | 0.18 | 0.03 | 0.15 | 0.22 | 0.18 | 0.17 | 0.16 |
| **EQR-C** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of Rhodophyta (R)** | 0.58 | 0.63 | 0.83 | 0.75 | 0.76 | 0.65 | 0.69 | 0.61 | 0.86 | 0.64 | 0.61 | 0.68 | 0.74 | 0.71 |
| **EQR-R** | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **ESG Ratio (ESG)** | 1.24 | 1.67 | 1.19 | 2.33 | 1.47 | 2.29 | 0.86 | 2.11 | 3.83 | 1.75 | 2.60 | 2.09 | 1.88 | 3.43 |
| **EQR-ESG** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.92 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of opportunists (O)** | 0.13 | 0.38 | 0.09 | 0.03 | 0.02 | 0.09 | 0.12 | 0.04 | 0.00 | 0.06 | 0.06 | 0.03 | 0.04 | 0.06 |
| **EQR-O** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Average EQR** | 0.73 | 0.65 | 0.72 | 0.73 | 0.74 | 0.69 | 0.68 | 0.70 | 0.71 | 0.72 | 0.68 | 0.72 | 0.69 | 0.71 |
| **Quality status class** | good | good | good | good | good | good | good | good | good | good | good | good | good | good |
| **Average EQR - "De-shored"** | 0.69 | 0.66 | 0.74 | 0.72 | 0.74 | 0.67 | 0.71 | 0.70 | 0.71 | 0.70 | 0.70 | 0.69 | 0.72 | 0.68 |
| **Quality status class - "De-shored"** | good | good | good | good | good | good | good | good | good | good | good | good | good | good |

**Appendix 6 (cont.)** - Shore description score and correction factor, observed and de-shored full species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and averge EQR and quality status class for each Azorean shore according to the FSL tool.

| Site code | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 14 | 14 | 8 | 13 | 13 | 13 | 13 | 13 | 10 | 12 | 14 | 13 | 14 | 17 |
| **Shore correction factor** | 0.82 | 0.82 | 1.47 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 1.21 | 1.00 | 0.82 | 0.91 | 0.82 | 0.62 |
| **Observed species richness (S)** | 33 | 29 | 29 | 34 | 37 | 41 | 45 | 41 | 26 | 38 | 82 | 72 | 55 | 58 |
| **EQR-S** | 0.57 | 0.52 | 0.52 | 0.59 | 0.62 | 0.66 | 0.70 | 0.66 | 0.48 | 0.63 | 1.00 | 0.94 | 0.80 | 0.82 |
| **De-shored species richness (S')** | 27 | 24 | 43 | 31 | 34 | 37 | 41 | 37 | 32 | 38 | 68 | 65 | 45 | 36 |
| **EQR-S'** | 0.50 | 0.45 | 0.68 | 0.54 | 0.58 | 0.62 | 0.66 | 0.62 | 0.55 | 0.63 | 0.90 | 0.88 | 0.70 | 0.61 |
| **Proportion of Chlorophyta (C)** | 0.21 | 0.21 | 0.17 | 0.24 | 0.19 | 0.27 | 0.22 | 0.27 | 0.15 | 0.29 | 0.17 | 0.14 | 0.18 | 0.21 |
| **EQR-C** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of Rhodophyta (R)** | 0.64 | 0.69 | 0.59 | 0.68 | 0.65 | 0.54 | 0.62 | 0.61 | 0.58 | 0.50 | 0.70 | 0.69 | 0.71 | 0.74 |
| **EQR-R** | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **ESG Ratio (ESG)** | 1.20 | 1.07 | 1.90 | 1.00 | 1.64 | 1.41 | 1.14 | 1.56 | 1.60 | 0.46 | 1.65 | 1.40 | 1.12 | 1.23 |
| **EQR-ESG** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.62 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of opportunists (O)** | 0.12 | 0.14 | 0.14 | 0.18 | 0.11 | 0.12 | 0.13 | 0.12 | 0.08 | 0.24 | 0.07 | 0.13 | 0.16 | 0.16 |
| **EQR-O** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Average EQR** | 0.72 | 0.71 | 0.70 | 0.72 | 0.73 | 0.73 | 0.74 | 0.73 | 0.70 | 0.65 | 0.80 | 0.79 | 0.76 | 0.77 |
| **Quality status class** | good | good | good | good | good | good | good | good | good | good | high | good | good | good |
| **Average EQR - "De-shored"** | 0.70 | 0.69 | 0.74 | 0.71 | 0.72 | 0.73 | 0.73 | 0.73 | 0.71 | 0.65 | 0.78 | 0.78 | 0.74 | 0.72 |
| **Quality status class - "De-shored"** | good | good | good | good | good | good | good | good | good | good | good | good | good | good |

**Appendix 6 (cont.)** - Shore description score and correction factor, observed and de-shored full species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and averge EQR and quality status class for each Azorean shore according to the FSL tool.

| Site code | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 14 | 14 | 16 | 10 | 12 | 10 | 13 | 10 | 13 | 13 | 13 | 13 | 14 | 10 |
| **Shore correction factor** | 0.82 | 0.82 | 0.68 | 1.21 | 1.00 | 1.21 | 0.91 | 1.21 | 0.91 | 0.91 | 0.91 | 0.91 | 0.82 | 1.21 |
| **Observed species richness (S)** | 66 | 91 | 63 | 54 | 48 | 51 | 71 | 64 | 68 | 57 | 67 | 52 | 25 | 37 |
| **EQR-S** | 0.89 | 1.00 | 0.86 | 0.79 | 0.73 | 0.76 | 0.93 | 0.87 | 0.90 | 0.82 | 0.90 | 0.77 | 0.47 | 0.62 |
| **De-shored species richness (S')** | 54 | 75 | 43 | 65 | 48 | 62 | 64 | 78 | 62 | 52 | 61 | 47 | 21 | 45 |
| **EQR-S'** | 0.79 | 0.96 | 0.68 | 0.88 | 0.73 | 0.85 | 0.88 | 0.98 | 0.85 | 0.77 | 0.85 | 0.72 | 0.41 | 0.70 |
| **Proportion of Chlorophyta (C)** | 0.15 | 0.21 | 0.10 | 0.28 | 0.25 | 0.24 | 0.13 | 0.19 | 0.19 | 0.26 | 0.19 | 0.19 | 0.12 | 0.24 |
| **EQR-C** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of Rhodophyta (R)** | 0.76 | 0.73 | 0.79 | 0.65 | 0.67 | 0.69 | 0.72 | 0.73 | 0.69 | 0.63 | 0.63 | 0.62 | 0.52 | 0.59 |
| **EQR-R** | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **ESG Ratio (ESG)** | 1.54 | 0.75 | 0.66 | 0.86 | 1.29 | 0.59 | 1.29 | 1.29 | 1.72 | 1.11 | 1.39 | 1.08 | 0.79 | 1.06 |
| **EQR-ESG** | 1.00 | 0.86 | 0.80 | 0.92 | 1.00 | 0.76 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.88 | 1.00 |
| **Proportion of opportunists (O)** | 0.09 | 0.10 | 0.08 | 0.13 | 0.17 | 0.16 | 0.06 | 0.09 | 0.10 | 0.14 | 0.12 | 0.08 | 0.00 | 0.08 |
| **EQR-O** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Average EQR** | 0.78 | 0.77 | 0.74 | 0.74 | 0.75 | 0.70 | 0.79 | 0.78 | 0.78 | 0.76 | 0.78 | 0.76 | 0.67 | 0.72 |
| **Quality status class** | good | good | good | good | good | good | good | good | good | good | good | good | good | good |
| **Average EQR - "De-shored"** | 0.76 | 0.76 | 0.70 | 0.76 | 0.75 | 0.72 | 0.78 | 0.80 | 0.77 | 0.75 | 0.77 | 0.75 | 0.66 | 0.74 |
| **Quality status class - "De-shored"** | good | good | good | good | good | good | good | good | good | good | good | good | good | good |

**Appendix 6 (cont.)** - Shore description score and correction factor, observed and de-shored full species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and averge EQR and quality status class for each Azorean shore according to the FSL tool.

| Site code | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 8 | 12 | 10 | 10 | 9 | 16 | 12 | 13 | 12 | 15 | 16 | 13 | 13 | 13 |
| **Shore correction factor** | 1.47 | 1.00 | 1.21 | 1.21 | 1.34 | 0.68 | 1.00 | 0.91 | 1.00 | 0.75 | 0.68 | 0.91 | 0.91 | 0.91 |
| **Observed species richness (S)** | 46 | 27 | 22 | 48 | 69 | 49 | 44 | 67 | 41 | 45 | 14 | 40 | 52 | 35 |
| **EQR-S** | 0.71 | 0.49 | 0.43 | 0.73 | 0.91 | 0.74 | 0.69 | 0.90 | 0.66 | 0.70 | 0.32 | 0.65 | 0.77 | 0.60 |
| **De-shored species richness (S')** | 68 | 27 | 27 | 58 | 92 | 33 | 44 | 61 | 41 | 34 | 10 | 36 | 47 | 32 |
| **EQR-S'** | 0.90 | 0.49 | 0.49 | 0.83 | 1.00 | 0.58 | 0.69 | 0.85 | 0.66 | 0.58 | 0.26 | 0.61 | 0.72 | 0.56 |
| **Proportion of Chlorophyta (C)** | 0.15 | 0.22 | 0.05 | 0.13 | 0.12 | 0.18 | 0.11 | 0.10 | 0.12 | 0.22 | 0.43 | 0.20 | 0.19 | 0.11 |
| **EQR-C** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of Rhodophyta (R)** | 0.65 | 0.52 | 0.77 | 0.73 | 0.65 | 0.65 | 0.66 | 0.69 | 0.68 | 0.67 | 0.43 | 0.55 | 0.63 | 0.71 |
| **EQR-R** | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **ESG Ratio (ESG)** | 1.00 | 1.08 | 2.14 | 1.82 | 1.03 | 0.96 | 2.38 | 1.58 | 1.28 | 0.80 | 1.80 | 1.00 | 1.26 | 2.50 |
| **EQR-ESG** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.98 | 1.00 | 1.00 | 1.00 | 0.89 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of opportunists (O)** | 0.09 | 0.11 | 0.00 | 0.06 | 0.06 | 0.06 | 0.07 | 0.06 | 0.12 | 0.11 | 0.14 | 0.08 | 0.02 | 0.03 |
| **EQR-O** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Average EQR** | 0.74 | 0.70 | 0.69 | 0.75 | 0.78 | 0.74 | 0.74 | 0.78 | 0.73 | 0.72 | 0.66 | 0.73 | 0.76 | 0.72 |
| **Quality status class** | good | good | good | good | good | good | good | good | good | good | good | good | good | good |
| **Average EQR - "De-shored"** | 0.78 | 0.70 | 0.70 | 0.77 | 0.80 | 0.71 | 0.74 | 0.77 | 0.73 | 0.69 | 0.65 | 0.72 | 0.75 | 0.71 |
| **Quality status class - "De-shored"** | good | good | good | good | high | good | good | good | good | good | good | good | good | good |

**Appendix 6 (cont.)** - Shore description score and correction factor, observed and de-shored full species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and averge EQR and quality status class for each Azorean shore according to the FSL tool.

| Site code | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 11 | 10 | 8 | 12 | 12 | 12 | 13 | 12 | 8 | 12 | 8 | 16 | 12 | 17 |
| **Shore correction factor** | 1.10 | 1.21 | 1.47 | 1.00 | 1.00 | 1.00 | 0.91 | 1.00 | 1.47 | 1.00 | 1.47 | 0.68 | 1.00 | 0.62 |
| **Observed species richness (S)** | 49 | 50 | 24 | 61 | 74 | 61 | 66 | 57 | 13 | 52 | 20 | 79 | 66 | 83 |
| **EQR-S** | 0.74 | 0.75 | 0.45 | 0.85 | 0.95 | 0.85 | 0.89 | 0.82 | 0.31 | 0.77 | 0.40 | 0.99 | 0.89 | 1.00 |
| **De-shored species richness (S')** | 54 | 61 | 35 | 61 | 74 | 61 | 60 | 57 | 19 | 52 | 29 | 54 | 66 | 51 |
| **EQR-S'** | 0.79 | 0.85 | 0.60 | 0.85 | 0.95 | 0.85 | 0.84 | 0.82 | 0.39 | 0.77 | 0.53 | 0.79 | 0.89 | 0.76 |
| **Proportion of Chlorophyta (C)** | 0.16 | 0.20 | 0.13 | 0.21 | 0.20 | 0.20 | 0.23 | 0.11 | 0.31 | 0.13 | 0.35 | 0.16 | 0.15 | 0.14 |
| **EQR-C** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of Rhodophyta (R)** | 0.73 | 0.66 | 0.75 | 0.67 | 0.68 | 0.70 | 0.65 | 0.82 | 0.54 | 0.77 | 0.55 | 0.67 | 0.68 | 0.72 |
| **EQR-R** | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **ESG Ratio (ESG)** | 1.04 | 1.27 | 2.00 | 0.97 | 1.24 | 1.03 | 1.28 | 1.38 | 1.17 | 1.17 | 1.00 | 1.08 | 1.20 | 1.37 |
| **EQR-ESG** | 1.00 | 1.00 | 1.00 | 0.98 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of opportunists (O)** | 0.06 | 0.10 | 0.08 | 0.11 | 0.07 | 0.10 | 0.09 | 0.05 | 0.15 | 0.08 | 0.25 | 0.08 | 0.06 | 0.04 |
| **EQR-O** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Average EQR** | 0.75 | 0.75 | 0.69 | 0.77 | 0.79 | 0.77 | 0.78 | 0.77 | 0.66 | 0.76 | 0.68 | 0.80 | 0.78 | 0.80 |
| **Quality status class** | good | good | good | good | good | good | good | good | good | good | good | good | good | high |
| **Average EQR - "De-shored"** | 0.76 | 0.77 | 0.72 | 0.77 | 0.79 | 0.77 | 0.77 | 0.77 | 0.68 | 0.76 | 0.71 | 0.76 | 0.78 | 0.75 |
| **Quality status class - "De-shored"** | good | good | good | good | good | good | good | good | good | good | good | good | good | good |

**Appendix 6 (cont.)** - Shore description score and correction factor, observed and de-shored full species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and averge EQR and quality status class for each Azorean shore according to the FSL tool.

| Site code | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 8 | 12 | 12 | 12 | 13 | 12 | 8 | 13 | 13 | 12 | 13 | 8 | 12 | 16 |
| **Shore correction factor** | 1.47 | 1.00 | 1.00 | 1.00 | 0.91 | 1.00 | 1.47 | 0.91 | 0.91 | 1.00 | 0.91 | 1.47 | 1.00 | 0.68 |
| **Observed species richness (S)** | 11 | 15 | 24 | 28 | 63 | 27 | 12 | 41 | 35 | 20 | 56 | 8 | 39 | 69 |
| **EQR-S** | 0.28 | 0.33 | 0.45 | 0.51 | 0.86 | 0.49 | 0.29 | 0.66 | 0.60 | 0.40 | 0.81 | 0.24 | 0.64 | 0.91 |
| **De-shored species richness (S')** | 16 | 15 | 24 | 28 | 57 | 27 | 18 | 37 | 32 | 20 | 51 | 12 | 39 | 47 |
| **EQR-S'** | 0.35 | 0.33 | 0.45 | 0.51 | 0.82 | 0.49 | 0.37 | 0.62 | 0.56 | 0.40 | 0.76 | 0.29 | 0.64 | 0.72 |
| **Proportion of Chlorophyta (C)** | 0.27 | 0.20 | 0.17 | 0.18 | 0.19 | 0.19 | 0.42 | 0.27 | 0.14 | 0.20 | 0.14 | 0.25 | 0.21 | 0.20 |
| **EQR-C** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of Rhodophyta (R)** | 0.55 | 0.73 | 0.75 | 0.68 | 0.59 | 0.78 | 0.58 | 0.71 | 0.69 | 0.75 | 0.75 | 0.75 | 0.67 | 0.68 |
| **EQR-R** | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **ESG Ratio (ESG)** | 1.20 | 2.00 | 1.67 | 1.80 | 1.33 | 1.25 | 0.71 | 1.05 | 1.19 | 2.33 | 1.33 | 1.00 | 1.79 | 1.23 |
| **EQR-ESG** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.84 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of opportunists (O)** | 0.27 | 0.20 | 0.13 | 0.07 | 0.11 | 0.07 | 0.33 | 0.10 | 0.00 | 0.10 | 0.04 | 0.13 | 0.08 | 0.06 |
| **EQR-O** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Average EQR** | 0.66 | 0.67 | 0.69 | 0.70 | 0.77 | 0.70 | 0.63 | 0.73 | 0.72 | 0.68 | 0.76 | 0.65 | 0.73 | 0.78 |
| **Quality status class** | good | good | good | good | good | good | good | good | good | good | good | good | good | good |
| **Average EQR - "De-shored"** | 0.67 | 0.67 | 0.69 | 0.70 | 0.76 | 0.70 | 0.64 | 0.73 | 0.71 | 0.68 | 0.75 | 0.66 | 0.73 | 0.75 |
| **Quality status class - "De-shored"** | good | good | good | good | good | good | good | good | good | good | good | good | good | good |

**Appendix 6 (cont.)** - Shore description score and correction factor, observed and de-shored full species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and averge EQR and quality status class for each Azorean shore according to the FSL tool.

| Site code | 85 | 86 | 87 | 88 |
|---|---|---|---|---|
| **Shore description** | 12 | 8 | 13 | 13 |
| **Shore correction factor** | 1.00 | 1.47 | 0.91 | 0.91 |
| **Observed species richness (S)** | 52 | 44 | 80 | 44 |
| **EQR-S** | 0.77 | 0.69 | 1.00 | 0.69 |
| **De-shored species richness (S')** | 52 | 65 | 73 | 40 |
| **EQR-S'** | 0.77 | 0.88 | 0.94 | 0.65 |
| **Proportion of Chlorophyta (C)** | 0.23 | 0.11 | 0.13 | 0.23 |
| **EQR-C** | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of Rhodophyta (R)** | 0.62 | 0.75 | 0.76 | 0.70 |
| **EQR-R** | 0.01 | 0.01 | 0.01 | 0.01 |
| **ESG Ratio (ESG)** | 1.74 | 1.10 | 1.29 | 0.91 |
| **EQR-ESG** | 1.00 | 1.00 | 1.00 | 0.95 |
| **Proportion of opportunists (O)** | 0.12 | 0.09 | 0.06 | 0.11 |
| **EQR-O** | 1.00 | 1.00 | 1.00 | 1.00 |
| **Average EQR** | 0.75 | 0.74 | 0.80 | 0.73 |
| **Quality status class** | good | good | high | good |
| **Average EQR - "De-shored"** | 0.75 | 0.78 | 0.79 | 0.72 |
| **Quality status class - "De-shored"** | good | good | good | good |

# Appendix 7

Shore description score and correction factor, observed and de-shored reduced species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and average EQR and quality status class for each Azorean shore according to the RSL tool.

**Appendix 7** - Shore description score and correction factor, observed and de-shored reduced species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature, averge EQR and quality status class for each Azorean shore according to the RSL tool.

| Site code | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 17 | 8 | 10 | 14 | 12 | 16 | 8 | 13 | 12 | 14 | 8 | 16 | 8 | 16 |
| **Shore correction factor** | 0.70 | 1.33 | 1.15 | 0.87 | 1.00 | 0.75 | 1.33 | 0.93 | 1.00 | 0.87 | 1.33 | 0.75 | 1.33 | 0.75 |
| **Observed species richness (S)** | 16 | 4 | 12 | 21 | 18 | 13 | 13 | 12 | 13 | 17 | 13 | 18 | 11 | 16 |
| **EQR-S** | 0.38 | 0.16 | 0.32 | 0.50 | 0.43 | 0.33 | 0.33 | 0.32 | 0.33 | 0.40 | 0.33 | 0.43 | 0.30 | 0.38 |
| **De-shored species richness (S')** | 11 | 5 | 14 | 18 | 18 | 10 | 17 | 11 | 13 | 15 | 17 | 14 | 15 | 12 |
| **EQR-S'** | 0.30 | 0.21 | 0.35 | 0.43 | 0.43 | 0.28 | 0.41 | 0.30 | 0.33 | 0.36 | 0.41 | 0.34 | 0.36 | 0.32 |
| **Proportion of Chlorophyta (C)** | 0.38 | 0.50 | 0.25 | 0.10 | 0.17 | 0.31 | 0.31 | 0.25 | 0.08 | 0.24 | 0.23 | 0.22 | 0.27 | 0.31 |
| **EQR-C** | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 |
| **Proportion of Rhodophyta (R)** | 0.50 | 0.50 | 0.67 | 0.71 | 0.72 | 0.54 | 0.54 | 0.50 | 0.77 | 0.59 | 0.54 | 0.67 | 0.55 | 0.56 |
| **EQR-R** | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **ESG Ratio (ESG)** | 1.29 | 1.00 | 1.40 | 1.63 | 2.00 | 0.86 | 0.63 | 2.00 | 3.33 | 0.70 | 2.25 | 1.57 | 2.67 | 1.67 |
| **EQR-ESG** | 1.00 | 0.80 | 1.00 | 1.00 | 1.00 | 0.66 | 0.37 | 1.00 | 1.00 | 0.40 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of opportunists (O)** | 0.19 | 0.50 | 0.25 | 0.05 | 0.06 | 0.15 | 0.23 | 0.08 | 0.00 | 0.12 | 0.08 | 0.06 | 0.09 | 0.13 |
| **EQR-O** | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Average EQR** | 0.68 | 0.59 | 0.66 | 0.70 | 0.69 | 0.60 | 0.54 | 0.66 | 0.67 | 0.56 | 0.67 | 0.69 | 0.66 | 0.68 |
| **Quality status class** | good | noderat | good | good | good | noderat | noderat | good | good | noderat | good | good | good | good |
| **Average EQR - "De-shored"** | 0.66 | 0.60 | 0.67 | 0.69 | 0.69 | 0.59 | 0.56 | 0.66 | 0.67 | 0.55 | 0.68 | 0.67 | 0.67 | 0.66 |
| **Quality status class - "De-shored"** | good | noderat | good | good | good | noderat | noderat | good | good | noderat | good | good | good | good |

**Appendix 7 (cont.)** - Shore description score and correction factor, observed and de-shored reduced species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature, averge EQR and quality status class for each Azorean shore according to the RSL tool.

| Site code | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 14 | 14 | 8 | 13 | 13 | 13 | 13 | 13 | 10 | 12 | 14 | 13 | 14 | 17 |
| **Shore correction factor** | 0.87 | 0.87 | 1.33 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 1.15 | 1.00 | 0.87 | 0.93 | 0.87 | 0.70 |
| **Observed species richness (S)** | 16 | 16 | 16 | 19 | 20 | 21 | 26 | 21 | 13 | 16 | 42 | 40 | 32 | 33 |
| **EQR-S** | 0.38 | 0.38 | 0.38 | 0.45 | 0.48 | 0.50 | 0.62 | 0.50 | 0.33 | 0.38 | 0.84 | 0.83 | 0.74 | 0.76 |
| **De-shored species richness (S')** | 14 | 14 | 21 | 18 | 19 | 20 | 24 | 20 | 15 | 16 | 36 | 37 | 28 | 23 |
| **EQR-S'** | 0.35 | 0.35 | 0.51 | 0.42 | 0.44 | 0.46 | 0.58 | 0.46 | 0.37 | 0.38 | 0.81 | 0.81 | 0.65 | 0.55 |
| **Proportion of Chlorophyta (C)** | 0.31 | 0.25 | 0.25 | 0.32 | 0.20 | 0.19 | 0.19 | 0.29 | 0.23 | 0.25 | 0.17 | 0.15 | 0.19 | 0.18 |
| **EQR-C** | 0.99 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of Rhodophyta (R)** | 0.50 | 0.63 | 0.56 | 0.58 | 0.65 | 0.57 | 0.62 | 0.62 | 0.62 | 0.69 | 0.71 | 0.73 | 0.72 | 0.73 |
| **EQR-R** | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **ESG Ratio (ESG)** | 1.00 | 1.29 | 0.78 | 1.11 | 1.86 | 2.50 | 1.17 | 1.63 | 1.60 | 1.00 | 1.80 | 2.08 | 1.29 | 1.54 |
| **EQR-ESG** | 0.80 | 1.00 | 0.56 | 0.91 | 1.00 | 1.00 | 0.97 | 1.00 | 1.00 | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of opportunists (O)** | 0.19 | 0.19 | 0.19 | 0.26 | 0.10 | 0.14 | 0.12 | 0.14 | 0.15 | 0.25 | 0.10 | 0.08 | 0.16 | 0.15 |
| **EQR-O** | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Average EQR** | 0.64 | 0.68 | 0.59 | 0.67 | 0.70 | 0.70 | 0.72 | 0.70 | 0.67 | 0.64 | 0.77 | 0.77 | 0.75 | 0.75 |
| **Quality status class** | good | good | noderat | good | good | good | good | good | good | good | good | good | good | good |
| **Average EQR - "De-shored"** | 0.63 | 0.67 | 0.61 | 0.67 | 0.69 | 0.69 | 0.71 | 0.69 | 0.67 | 0.64 | 0.76 | 0.76 | 0.73 | 0.71 |
| **Quality status class - "De-shored"** | good | good | good | good | good | good | good | good | good | good | good | good | good | good |

**Appendix 7 (cont.)** - Shore description score and correction factor, observed and de-shored reduced species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature, averge EQR and quality status class for each Azorean shore according to the RSL tool.

| Site code | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 14 | 14 | 16 | 10 | 12 | 10 | 13 | 10 | 13 | 13 | 13 | 13 | 14 | 10 |
| **Shore correction factor** | 0.87 | 0.87 | 0.75 | 1.15 | 1.00 | 1.15 | 0.93 | 1.15 | 0.93 | 0.93 | 0.93 | 0.93 | 0.87 | 1.15 |
| **Observed species richness (S)** | 33 | 39 | 24 | 30 | 27 | 16 | 39 | 41 | 41 | 32 | 30 | 24 | 6 | 10 |
| **EQR-S** | 0.76 | 0.82 | 0.58 | 0.70 | 0.64 | 0.38 | 0.82 | 0.83 | 0.83 | 0.74 | 0.70 | 0.58 | 0.22 | 0.28 |
| **De-shored species richness (S')** | 29 | 34 | 18 | 35 | 27 | 18 | 36 | 47 | 38 | 30 | 28 | 22 | 5 | 12 |
| **EQR-S'** | 0.67 | 0.78 | 0.43 | 0.79 | 0.64 | 0.44 | 0.81 | 0.87 | 0.82 | 0.70 | 0.66 | 0.53 | 0.20 | 0.31 |
| **Proportion of Chlorophyta (C)** | 0.12 | 0.21 | 0.17 | 0.23 | 0.26 | 0.25 | 0.18 | 0.15 | 0.20 | 0.22 | 0.13 | 0.21 | 0.00 | 0.20 |
| **EQR-C** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of Rhodophyta (R)** | 0.73 | 0.67 | 0.79 | 0.70 | 0.67 | 0.63 | 0.67 | 0.76 | 0.66 | 0.63 | 0.67 | 0.71 | 0.83 | 0.80 |
| **EQR-R** | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **ESG Ratio (ESG)** | 3.13 | 1.29 | 1.18 | 1.50 | 1.45 | 1.67 | 1.79 | 2.15 | 1.56 | 1.67 | 2.33 | 1.40 | 1.00 | 1.00 |
| **EQR-ESG** | 1.00 | 1.00 | 0.98 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 0.80 |
| **Proportion of opportunists (O)** | 0.09 | 0.13 | 0.13 | 0.13 | 0.15 | 0.19 | 0.10 | 0.07 | 0.12 | 0.16 | 0.10 | 0.13 | 0.00 | 0.10 |
| **EQR-O** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Average EQR** | 0.75 | 0.77 | 0.71 | 0.74 | 0.73 | 0.68 | 0.77 | 0.77 | 0.77 | 0.75 | 0.74 | 0.72 | 0.61 | 0.62 |
| **Quality status class** | good | good | good | good | good | good | good | good | good | good | good | good | good | good |
| **Average EQR - "De-shored"** | 0.74 | 0.76 | 0.68 | 0.76 | 0.73 | 0.69 | 0.76 | 0.78 | 0.76 | 0.74 | 0.73 | 0.71 | 0.60 | 0.62 |
| **Quality status class - "De-shored"** | good | good | good | good | good | good | good | good | good | good | good | good | good | good |

**Appendix 7 (cont.)** - Shore description score and correction factor, observed and de-shored reduced species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature, averge EQR and quality status class for each Azorean shore according to the RSL tool.

| Site code | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 8 | 12 | 10 | 10 | 9 | 16 | 12 | 13 | 12 | 15 | 16 | 13 | 13 | 13 |
| **Shore correction factor** | 1.33 | 1.00 | 1.15 | 1.15 | 1.24 | 0.75 | 1.00 | 0.93 | 1.00 | 0.81 | 0.75 | 0.93 | 0.93 | 0.93 |
| **Observed species richness (S)** | 23 | 7 | 9 | 22 | 26 | 19 | 24 | 27 | 17 | 20 | 8 | 27 | 33 | 21 |
| **EQR-S** | 0.55 | 0.23 | 0.27 | 0.53 | 0.62 | 0.45 | 0.58 | 0.64 | 0.40 | 0.48 | 0.25 | 0.64 | 0.76 | 0.50 |
| **De-shored species richness (S')** | 31 | 7 | 10 | 25 | 32 | 14 | 24 | 25 | 17 | 16 | 6 | 25 | 31 | 20 |
| **EQR-S'** | 0.71 | 0.23 | 0.29 | 0.61 | 0.75 | 0.35 | 0.58 | 0.60 | 0.40 | 0.39 | 0.22 | 0.60 | 0.71 | 0.46 |
| **Proportion of Chlorophyta (C)** | 0.26 | 0.43 | 0.00 | 0.14 | 0.19 | 0.11 | 0.17 | 0.15 | 0.18 | 0.15 | 0.50 | 0.22 | 0.09 | 0.10 |
| **EQR-C** | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 |
| **Proportion of Rhodophyta (R)** | 0.57 | 0.57 | 0.89 | 0.73 | 0.65 | 0.79 | 0.71 | 0.70 | 0.76 | 0.70 | 0.25 | 0.59 | 0.73 | 0.67 |
| **EQR-R** | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 |
| **ESG Ratio (ESG)** | 1.30 | 1.33 | 3.50 | 2.67 | 1.36 | 1.38 | 2.00 | 1.45 | 2.40 | 1.50 | 1.67 | 1.45 | 2.00 | 3.20 |
| **EQR-ESG** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of opportunists (O)** | 0.13 | 0.14 | 0.00 | 0.09 | 0.12 | 0.05 | 0.13 | 0.11 | 0.12 | 0.10 | 0.25 | 0.11 | 0.03 | 0.00 |
| **EQR-O** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Average EQR** | 0.71 | 0.65 | 0.66 | 0.71 | 0.72 | 0.69 | 0.72 | 0.73 | 0.68 | 0.70 | 0.65 | 0.73 | 0.75 | 0.70 |
| **Quality status class** | good | good | good | good | good | good | good | good | good | good | good | good | good | good |
| **Average EQR - "De-shored"** | 0.74 | 0.65 | 0.66 | 0.72 | 0.75 | 0.67 | 0.72 | 0.72 | 0.68 | 0.68 | 0.64 | 0.72 | 0.74 | 0.69 |
| **Quality status class - "De-shored"** | good | good | good | good | good | good | good | good | good | good | good | good | good | good |

**Appendix 7 (cont.)** - Shore description score and correction factor, observed and de-shored reduced species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature, averge EQR and quality status class for each Azorean shore according to the RSL tool.

| Site code | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 11 | 10 | 8 | 12 | 12 | 12 | 13 | 12 | 8 | 12 | 8 | 16 | 12 | 17 |
| **Shore correction factor** | 1.07 | 1.15 | 1.33 | 1.00 | 1.00 | 1.00 | 0.93 | 1.00 | 1.33 | 1.00 | 1.33 | 0.75 | 1.00 | 0.70 |
| **Observed species richness (S)** | 25 | 31 | 18 | 30 | 39 | 34 | 38 | 33 | 11 | 36 | 15 | 42 | 32 | 43 |
| **EQR-S** | 0.60 | 0.72 | 0.43 | 0.70 | 0.82 | 0.78 | 0.82 | 0.76 | 0.30 | 0.81 | 0.37 | 0.84 | 0.74 | 0.85 |
| **De-shored species richness (S')** | 27 | 36 | 24 | 30 | 39 | 34 | 35 | 33 | 15 | 36 | 20 | 32 | 32 | 30 |
| **EQR-S'** | 0.64 | 0.80 | 0.57 | 0.70 | 0.82 | 0.78 | 0.80 | 0.76 | 0.36 | 0.81 | 0.47 | 0.73 | 0.74 | 0.70 |
| **Proportion of Chlorophyta (C)** | 0.20 | 0.19 | 0.17 | 0.13 | 0.18 | 0.12 | 0.18 | 0.12 | 0.27 | 0.14 | 0.33 | 0.14 | 0.13 | 0.12 |
| **EQR-C** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 |
| **Proportion of Rhodophyta (R)** | 0.68 | 0.68 | 0.72 | 0.80 | 0.69 | 0.76 | 0.68 | 0.82 | 0.55 | 0.78 | 0.60 | 0.69 | 0.81 | 0.74 |
| **EQR-R** | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **ESG Ratio (ESG)** | 2.13 | 1.38 | 1.57 | 1.14 | 1.60 | 1.83 | 1.24 | 1.54 | 1.75 | 2.00 | 1.50 | 1.63 | 1.29 | 1.69 |
| **EQR-ESG** | 1.00 | 1.00 | 1.00 | 0.94 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of opportunists (O)** | 0.08 | 0.13 | 0.11 | 0.10 | 0.13 | 0.09 | 0.13 | 0.09 | 0.18 | 0.11 | 0.27 | 0.10 | 0.09 | 0.07 |
| **EQR-O** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 |
| **Average EQR** | 0.72 | 0.74 | 0.69 | 0.73 | 0.77 | 0.76 | 0.76 | 0.75 | 0.66 | 0.76 | 0.67 | 0.77 | 0.75 | 0.77 |
| **Quality status class** | good | good | good | good | good | good | good | good | good | good | good | good | good | good |
| **Average EQR - "De-shored"** | 0.73 | 0.76 | 0.72 | 0.73 | 0.77 | 0.76 | 0.76 | 0.75 | 0.67 | 0.76 | 0.69 | 0.75 | 0.75 | 0.74 |
| **Quality status class - "De-shored"** | good | good | good | good | good | good | good | good | good | good | good | good | good | good |

**Appendix 7 (cont.)** - Shore description score and correction factor, observed and de-shored reduced species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature, averge EQR and quality status class for each Azorean shore according to the RSL tool.

| Site code | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 8 | 12 | 12 | 12 | 13 | 12 | 8 | 13 | 13 | 12 | 13 | 8 | 12 | 16 |
| **Shore correction factor** | 1.33 | 1.00 | 1.00 | 1.00 | 0.93 | 1.00 | 1.33 | 0.93 | 0.93 | 1.00 | 0.93 | 1.33 | 1.00 | 0.75 |
| **Observed species richness (S)** | 8 | 12 | 19 | 21 | 31 | 18 | 11 | 24 | 18 | 15 | 28 | 8 | 25 | 34 |
| **EQR-S** | 0.25 | 0.32 | 0.45 | 0.50 | 0.72 | 0.43 | 0.30 | 0.58 | 0.43 | 0.37 | 0.66 | 0.25 | 0.60 | 0.78 |
| **De-shored species richness (S')** | 11 | 12 | 19 | 21 | 29 | 18 | 15 | 22 | 17 | 15 | 26 | 11 | 25 | 26 |
| **EQR-S'** | 0.29 | 0.32 | 0.45 | 0.50 | 0.68 | 0.43 | 0.36 | 0.53 | 0.40 | 0.37 | 0.62 | 0.29 | 0.60 | 0.61 |
| **Proportion of Chlorophyta (C)** | 0.38 | 0.25 | 0.11 | 0.10 | 0.19 | 0.22 | 0.45 | 0.17 | 0.06 | 0.13 | 0.11 | 0.25 | 0.12 | 0.12 |
| **EQR-C** | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of Rhodophyta (R)** | 0.38 | 0.67 | 0.79 | 0.71 | 0.65 | 0.72 | 0.55 | 0.79 | 0.78 | 0.80 | 0.79 | 0.75 | 0.72 | 0.71 |
| **EQR-R** | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **ESG Ratio (ESG)** | 1.00 | 2.00 | 2.17 | 2.00 | 1.58 | 2.00 | 0.83 | 2.00 | 2.60 | 2.75 | 2.11 | 1.00 | 2.57 | 1.83 |
| **EQR-ESG** | 0.80 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.63 | 1.00 | 1.00 | 1.00 | 1.00 | 0.80 | 1.00 | 1.00 |
| **Proportion of opportunists (O)** | 0.38 | 0.25 | 0.11 | 0.10 | 0.13 | 0.11 | 0.36 | 0.08 | 0.00 | 0.13 | 0.07 | 0.13 | 0.08 | 0.06 |
| **EQR-O** | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Average EQR** | 0.61 | 0.66 | 0.69 | 0.70 | 0.74 | 0.69 | 0.59 | 0.72 | 0.69 | 0.67 | 0.73 | 0.61 | 0.72 | 0.76 |
| **Quality status class** | good | good | good | good | good | good | noderat | good | good | good | good | good | good | good |
| **Average EQR - "De-shored"** | 0.62 | 0.66 | 0.69 | 0.70 | 0.74 | 0.69 | 0.60 | 0.71 | 0.68 | 0.67 | 0.73 | 0.62 | 0.72 | 0.72 |
| **Quality status class - "De-shored"** | good | good | good | good | good | good | noderat | good | good | good | good | good | good | good |

**Appendix 7 (cont.)** - Shore description score and correction factor, observed and de-shored reduced species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature, averge EQR and quality status class for each Azorean shore according to the RSL tool.

| Site code | 85 | 86 | 87 | 88 |
|---|---|---|---|---|
| **Shore description** | 12 | 8 | 13 | 13 |
| **Shore correction factor** | 1.00 | 1.33 | 0.93 | 0.93 |
| **Observed species richness (S)** | 37 | 27 | 42 | 27 |
| **EQR-S** | 0.81 | 0.64 | 0.84 | 0.64 |
| **De-shored species richness (S')** | 37 | 36 | 39 | 25 |
| **EQR-S'** | 0.81 | 0.81 | 0.82 | 0.60 |
| **Proportion of Chlorophyta (C)** | 0.19 | 0.19 | 0.14 | 0.15 |
| **EQR-C** | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of Rhodophyta (R)** | 0.65 | 0.67 | 0.74 | 0.78 |
| **EQR-R** | 0.01 | 0.01 | 0.01 | 0.01 |
| **ESG Ratio (ESG)** | 2.36 | 1.45 | 1.63 | 1.45 |
| **EQR-ESG** | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of opportunists (O)** | 0.11 | 0.15 | 0.10 | 0.07 |
| **EQR-O** | 1.00 | 1.00 | 1.00 | 1.00 |
| **Average EQR** | 0.76 | 0.73 | 0.77 | 0.73 |
| **Quality status class** | good | good | good | good |
| **Average EQR - "De-shored"** | 0.76 | 0.76 | 0.77 | 0.72 |
| **Quality status class - "De-shored"** | good | good | good | good |

# Appendix 8

De-shored reduced species list richness, total cover and opportunistic species cover, and respective partial scores for the calculation of the CFR index and corresponding ecological quality ratios (EQR) and quality status class for each Azorean shore according to the CFR tool.

**Appendix 8** - De-shored reduced species list richness, total cover and opportunistic species cover, and respective partial scores for the calculation of the CFR index and corresponding ecological quality ratios (EQR) and quality status class for each Azorean shore according to the CFR tool.

| **Site code** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species richness (R)** | 16 | 4 | 12 | 21 | 18 | 13 | 13 | 12 | 13 | 17 | 13 | 18 | 11 | 16 | 16 |
| **R** | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| **Total cover (C)** | 0.45 | 0.37 | 0.60 | 0.61 | 0.49 | 0.57 | 0.61 | 0.74 | 0.66 | 0.81 | 0.73 | 0.74 | 0.69 | 0.60 | 0.67 |
| **C** | 30 | 40 | 40 | 40 | 30 | 40 | 50 | 40 | 40 | 40 | 50 | 40 | 50 | 40 | 40 |
| **Opportunistic cover (O)** | 0.18 | 0.86 | 0.30 | 0.31 | 0.08 | 0.25 | 0.37 | 0.03 | 0.29 | 0.36 | 0.20 | 0.03 | 0.63 | 0.15 | 0.25 |
| **O** | 20 | 0 | 5 | 5 | 30 | 15 | 5 | 30 | 15 | 5 | 15 | 30 | 5 | 20 | 15 |
| **Unhealthy proportion (S)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **S** | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| **CFR** | 80 | 70 | 75 | 75 | 90 | 85 | 85 | 100 | 85 | 75 | 95 | 100 | 85 | 90 | 85 |
| **EQR** | 0.8 | 0.7 | 0.75 | 0.75 | 0.9 | 0.85 | 0.85 | 1 | 0.85 | 0.75 | 0.95 | 1 | 0.85 | 0.9 | 0.85 |
| **Quality status class** | good | good | good | good | high | high | high | high | high | good | high | high | high | high | high |

**Appendix 8 (cont.)** - De-shored reduced species list richness, total cover and opportunistic species cover, and respective partial scores for the calculation of the CFR index and corresponding ecological quality ratios (EQR) and quality status class for each Azorean shore according to the CFR tool.

| **Site code** | **16** | **42** | **43** | **45** | **46** | **47** | **48** | **49** | **50** | **51** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Species richness (R)** | 16 | 10 | 23 | 9 | 22 | 26 | 19 | 24 | 27 | 17 |
| **R** | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| **Total cover (C)** | 0.55 | 0.74 | 0.90 | 0.55 | 0.60 | 0.72 | 0.82 | 0.57 | 0.73 | 0.67 |
| **C** | 40 | 40 | 50 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| **Opportunistic cover (O)** | 0.20 | 0.14 | 0.51 | 0.40 | 0.08 | 0.12 | 0.16 | 0.23 | 0.12 | 0.11 |
| **O** | 20 | 20 | 5 | 5 | 30 | 20 | 20 | 15 | 20 | 20 |
| **Unhealthy proportion (S)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **S** | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| **CFR** | 90 | 90 | 85 | 75 | 100 | 90 | 90 | 85 | 90 | 90 |
| **EQR** | 0.9 | 0.9 | 0.85 | 0.75 | 1 | 0.9 | 0.9 | 0.85 | 0.9 | 0.9 |
| **Quality status class** | high | high | high | good | high | high | high | high | high | high |

# Appendix 9

Shore description score and correction factor, observed and de-shored full species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and average EQR and quality status class for each Azorean shore according to the FSL-AZ tool.

**Appendix 9** - Shore description score and correction factor, observed and de-shored full species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and averge EQR and quality status class for each Azorean shore according to the FSL-AZ tool.

| Site code | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 17 | 8 | 10 | 14 | 12 | 16 | 8 | 13 | 12 | 14 | 8 | 16 | 8 | 16 |
| **Shore correction factor** | 0.62 | 1.47 | 1.21 | 0.82 | 1.00 | 0.68 | 1.47 | 0.91 | 1.00 | 0.82 | 1.47 | 0.68 | 1.47 | 0.68 |
| **Observed species richness (S)** | 38 | 8 | 35 | 40 | 42 | 23 | 26 | 28 | 29 | 33 | 18 | 34 | 23 | 31 |
| **EQR-S** | 0.74 | 0.15 | 0.66 | 1.00 | 1.00 | 0.42 | 0.47 | 0.51 | 0.53 | 0.60 | 0.33 | 0.63 | 0.42 | 0.56 |
| **De-shored species richness (S')** | 23 | 12 | 42 | 33 | 42 | 16 | 38 | 25 | 29 | 27 | 26 | 23 | 34 | 21 |
| **EQR-S'** | 0.43 | 0.21 | 1.00 | 0.60 | 1.00 | 0.28 | 0.75 | 0.46 | 0.53 | 0.49 | 0.48 | 0.42 | 0.62 | 0.38 |
| **Proportion of Chlorophyta (C)** | 0.29 | 0.38 | 0.11 | 0.08 | 0.12 | 0.17 | 0.23 | 0.18 | 0.03 | 0.15 | 0.22 | 0.18 | 0.17 | 0.16 |
| **EQR-C** | 0.53 | 0.46 | 0.84 | 0.89 | 0.83 | 0.66 | 0.57 | 0.65 | 0.95 | 0.75 | 0.58 | 0.65 | 0.66 | 0.71 |
| **Proportion of Rhodophyta (R)** | 0.58 | 0.63 | 0.83 | 0.75 | 0.76 | 0.65 | 0.69 | 0.61 | 0.86 | 0.64 | 0.61 | 0.68 | 0.74 | 0.71 |
| **EQR-R** | 0.57 | 0.65 | 0.90 | 0.85 | 0.86 | 0.74 | 0.81 | 0.60 | 0.92 | 0.69 | 0.60 | 0.80 | 0.84 | 0.82 |
| **ESG Ratio (ESG)** | 1.24 | 1.67 | 1.19 | 2.33 | 1.47 | 2.29 | 0.86 | 2.11 | 3.83 | 1.75 | 2.60 | 2.09 | 1.88 | 3.43 |
| **EQR-ESG** | 0.71 | 1.00 | 0.69 | 1.00 | 1.00 | 1.00 | 0.51 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of opportunists (O)** | 0.13 | 0.38 | 0.09 | 0.03 | 0.02 | 0.09 | 0.12 | 0.04 | 0.00 | 0.06 | 0.06 | 0.03 | 0.04 | 0.06 |
| **EQR-O** | 0.58 | 0.42 | 0.67 | 0.99 | 0.99 | 0.67 | 0.59 | 0.98 | 1.00 | 0.80 | 0.97 | 0.98 | 0.97 | 0.78 |
| **Average EQR** | 0.63 | 0.54 | 0.75 | 0.95 | 0.93 | 0.70 | 0.59 | 0.75 | 0.88 | 0.77 | 0.69 | 0.81 | 0.78 | 0.78 |
| **Quality status class** | good | noderat | good | high | high | good | noderat | good | high | good | good | high | good | good |
| **Average EQR - "De-shored"** | 0.56 | 0.55 | 0.82 | 0.87 | 0.93 | 0.67 | 0.65 | 0.74 | 0.88 | 0.75 | 0.73 | 0.77 | 0.82 | 0.74 |
| **Quality status class - "De-shored"** | noderat | noderat | high | high | high | good | good | good | high | good | good | good | high | good |

**Appendix 9 (cont.)** - Shore description score and correction factor, observed and de-shored full species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and averge EQR and quality status class for each Azorean shore according to the FSL-AZ tool.

| Site code | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 14 | 14 | 8 | 13 | 13 | 13 | 13 | 13 | 10 | 12 | 14 | 13 | 14 | 17 |
| **Shore correction factor** | 0.82 | 0.82 | 1.47 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 1.21 | 1.00 | 0.82 | 0.91 | 0.82 | 0.62 |
| **Observed species richness (S)** | 33 | 29 | 29 | 34 | 37 | 41 | 45 | 41 | 26 | 38 | 82 | 72 | 55 | 58 |
| **EQR-S** | 0.60 | 0.53 | 0.53 | 0.63 | 0.71 | 1.00 | 1.00 | 1.00 | 0.47 | 0.74 | 1.00 | 1.00 | 1.00 | 1.00 |
| **De-shored species richness (S')** | 27 | 24 | 43 | 31 | 34 | 37 | 41 | 37 | 32 | 38 | 68 | 65 | 45 | 36 |
| **EQR-S'** | 0.49 | 0.43 | 1.00 | 0.56 | 0.62 | 0.72 | 1.00 | 0.72 | 0.57 | 0.74 | 1.00 | 1.00 | 1.00 | 0.68 |
| **Proportion of Chlorophyta (C)** | 0.21 | 0.21 | 0.17 | 0.24 | 0.19 | 0.27 | 0.22 | 0.27 | 0.15 | 0.29 | 0.17 | 0.14 | 0.18 | 0.21 |
| **EQR-C** | 0.58 | 0.59 | 0.67 | 0.57 | 0.60 | 0.54 | 0.58 | 0.54 | 0.74 | 0.53 | 0.68 | 0.80 | 0.63 | 0.59 |
| **Proportion of Rhodophyta (R)** | 0.64 | 0.69 | 0.59 | 0.68 | 0.65 | 0.54 | 0.62 | 0.61 | 0.58 | 0.50 | 0.70 | 0.69 | 0.71 | 0.74 |
| **EQR-R** | 0.69 | 0.81 | 0.58 | 0.80 | 0.73 | 0.53 | 0.64 | 0.60 | 0.57 | 0.49 | 0.82 | 0.81 | 0.82 | 0.84 |
| **ESG Ratio (ESG)** | 1.20 | 1.07 | 1.90 | 1.00 | 1.64 | 1.41 | 1.14 | 1.56 | 1.60 | 0.46 | 1.65 | 1.40 | 1.12 | 1.23 |
| **EQR-ESG** | 0.70 | 0.63 | 1.00 | 0.60 | 1.00 | 0.80 | 0.67 | 1.00 | 1.00 | 0.28 | 1.00 | 0.79 | 0.65 | 0.71 |
| **Proportion of opportunists (O)** | 0.12 | 0.14 | 0.14 | 0.18 | 0.11 | 0.12 | 0.13 | 0.12 | 0.08 | 0.24 | 0.07 | 0.13 | 0.16 | 0.16 |
| **EQR-O** | 0.59 | 0.57 | 0.57 | 0.55 | 0.59 | 0.59 | 0.58 | 0.59 | 0.72 | 0.51 | 0.73 | 0.58 | 0.56 | 0.56 |
| **Average EQR** | 0.63 | 0.63 | 0.67 | 0.63 | 0.73 | 0.69 | 0.69 | 0.75 | 0.70 | 0.51 | 0.85 | 0.80 | 0.73 | 0.74 |
| **Quality status class** | good | good | good | good | good | good | good | good | good | noderat | high | good | good | good |
| **Average EQR - "De-shored"** | 0.61 | 0.61 | 0.76 | 0.62 | 0.71 | 0.63 | 0.69 | 0.69 | 0.72 | 0.51 | 0.85 | 0.80 | 0.73 | 0.68 |
| **Quality status class - "De-shored"** | good | good | good | good | good | good | good | good | good | noderat | high | good | good | good |

**Appendix 9 (cont.)** - Shore description score and correction factor, observed and de-shored full species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and averge EQR and quality status class for each Azorean shore according to the FSL-AZ tool.

| Site code | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 14 | 14 | 16 | 10 | 12 | 10 | 13 | 10 | 13 | 13 | 13 | 13 | 14 | 10 |
| **Shore correction factor** | 0.82 | 0.82 | 0.68 | 1.21 | 1.00 | 1.21 | 0.91 | 1.21 | 0.91 | 0.91 | 0.91 | 0.91 | 0.82 | 1.21 |
| **Observed species richness (S)** | 66 | 91 | 63 | 54 | 48 | 51 | 71 | 64 | 68 | 57 | 67 | 52 | 25 | 37 |
| **EQR-S** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.45 | 0.71 |
| **De-shored species richness (S')** | 54 | 75 | 43 | 65 | 48 | 62 | 64 | 78 | 62 | 52 | 61 | 47 | 21 | 45 |
| **EQR-S'** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.37 | 1.00 |
| **Proportion of Chlorophyta (C)** | 0.15 | 0.21 | 0.10 | 0.28 | 0.25 | 0.24 | 0.13 | 0.19 | 0.19 | 0.26 | 0.19 | 0.19 | 0.12 | 0.24 |
| **EQR-C** | 0.75 | 0.59 | 0.86 | 0.53 | 0.56 | 0.57 | 0.82 | 0.61 | 0.60 | 0.55 | 0.60 | 0.60 | 0.83 | 0.56 |
| **Proportion of Rhodophyta (R)** | 0.76 | 0.73 | 0.79 | 0.65 | 0.67 | 0.69 | 0.72 | 0.73 | 0.69 | 0.63 | 0.63 | 0.62 | 0.52 | 0.59 |
| **EQR-R** | 0.85 | 0.83 | 0.87 | 0.73 | 0.79 | 0.81 | 0.83 | 0.84 | 0.81 | 0.67 | 0.66 | 0.62 | 0.51 | 0.58 |
| **ESG Ratio (ESG)** | 1.54 | 0.75 | 0.66 | 0.86 | 1.29 | 0.59 | 1.29 | 1.29 | 1.72 | 1.11 | 1.39 | 1.08 | 0.79 | 1.06 |
| **EQR-ESG** | 1.00 | 0.45 | 0.39 | 0.52 | 0.74 | 0.36 | 0.74 | 0.74 | 1.00 | 0.65 | 0.79 | 0.64 | 0.47 | 0.63 |
| **Proportion of opportunists (O)** | 0.09 | 0.10 | 0.08 | 0.13 | 0.17 | 0.16 | 0.06 | 0.09 | 0.10 | 0.14 | 0.12 | 0.08 | 0.00 | 0.08 |
| **EQR-O** | 0.65 | 0.61 | 0.70 | 0.58 | 0.56 | 0.56 | 0.97 | 0.63 | 0.60 | 0.57 | 0.59 | 0.72 | 1.00 | 0.69 |
| **Average EQR** | 0.85 | 0.70 | 0.77 | 0.67 | 0.73 | 0.66 | 0.87 | 0.76 | 0.80 | 0.69 | 0.73 | 0.71 | 0.65 | 0.64 |
| **Quality status class** | high | good | good | good | good | good | high | good | high | good | good | good | good | good |
| **Average EQR - "De-shored"** | 0.85 | 0.70 | 0.77 | 0.67 | 0.73 | 0.66 | 0.87 | 0.76 | 0.80 | 0.69 | 0.73 | 0.71 | 0.64 | 0.69 |
| **Quality status class - "De-shored"** | high | good | good | good | good | good | high | good | high | good | good | good | good | good |

**Appendix 9 (cont.)** - Shore description score and correction factor, observed and de-shored full species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and averge EQR and quality status class for each Azorean shore according to the FSL-AZ tool.

| Site code | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 8 | 12 | 10 | 10 | 9 | 16 | 12 | 13 | 12 | 15 | 16 | 13 | 13 | 13 |
| **Shore correction factor** | 1.47 | 1.00 | 1.21 | 1.21 | 1.34 | 0.68 | 1.00 | 0.91 | 1.00 | 0.75 | 0.68 | 0.91 | 0.91 | 0.91 |
| **Observed species richness (S)** | 46 | 27 | 22 | 48 | 69 | 49 | 44 | 67 | 41 | 45 | 14 | 40 | 52 | 35 |
| **EQR-S** | 1.00 | 0.49 | 0.40 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.25 | 1.00 | 1.00 | 0.66 |
| **De-shored species richness (S')** | 68 | 27 | 27 | 58 | 92 | 33 | 44 | 61 | 41 | 34 | 10 | 36 | 47 | 32 |
| **EQR-S'** | 1.00 | 0.49 | 0.49 | 1.00 | 1.00 | 0.61 | 1.00 | 1.00 | 1.00 | 0.62 | 0.17 | 0.69 | 1.00 | 0.58 |
| **Proportion of Chlorophyta (C)** | 0.15 | 0.22 | 0.05 | 0.13 | 0.12 | 0.18 | 0.11 | 0.10 | 0.12 | 0.22 | 0.43 | 0.20 | 0.19 | 0.11 |
| **EQR-C** | 0.75 | 0.58 | 0.94 | 0.82 | 0.83 | 0.63 | 0.84 | 0.85 | 0.83 | 0.58 | 0.42 | 0.59 | 0.60 | 0.84 |
| **Proportion of Rhodophyta (R)** | 0.65 | 0.52 | 0.77 | 0.73 | 0.65 | 0.65 | 0.66 | 0.69 | 0.68 | 0.67 | 0.43 | 0.55 | 0.63 | 0.71 |
| **EQR-R** | 0.74 | 0.51 | 0.86 | 0.84 | 0.74 | 0.74 | 0.76 | 0.81 | 0.81 | 0.79 | 0.42 | 0.54 | 0.68 | 0.83 |
| **ESG Ratio (ESG)** | 1.00 | 1.08 | 2.14 | 1.82 | 1.03 | 0.96 | 2.38 | 1.58 | 1.28 | 0.80 | 1.80 | 1.00 | 1.26 | 2.50 |
| **EQR-ESG** | 0.60 | 0.64 | 1.00 | 1.00 | 0.61 | 0.58 | 1.00 | 1.00 | 0.73 | 0.48 | 1.00 | 0.60 | 0.72 | 1.00 |
| **Proportion of opportunists (O)** | 0.09 | 0.11 | 0.00 | 0.06 | 0.06 | 0.06 | 0.07 | 0.06 | 0.12 | 0.11 | 0.14 | 0.08 | 0.02 | 0.03 |
| **EQR-O** | 0.67 | 0.59 | 1.00 | 0.79 | 0.97 | 0.79 | 0.76 | 0.96 | 0.59 | 0.59 | 0.57 | 0.73 | 0.99 | 0.98 |
| **Average EQR** | 0.75 | 0.56 | 0.84 | 0.89 | 0.83 | 0.75 | 0.87 | 0.92 | 0.79 | 0.69 | 0.53 | 0.69 | 0.80 | 0.86 |
| **Quality status class** | good | noderat | high | high | high | good | high | high | good | good | noderat | good | good | high |
| **Average EQR - "De-shored"** | 0.75 | 0.56 | 0.86 | 0.89 | 0.83 | 0.67 | 0.87 | 0.92 | 0.79 | 0.61 | 0.52 | 0.63 | 0.80 | 0.84 |
| **Quality status class - "De-shored"** | good | noderat | high | high | high | good | high | high | good | good | noderat | good | good | high |

**Appendix 9 (cont.)** - Shore description score and correction factor, observed and de-shored full species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and averge EQR and quality status class for each Azorean shore according to the FSL-AZ tool.

| Site code | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 11 | 10 | 8 | 12 | 12 | 12 | 13 | 12 | 8 | 12 | 8 | 16 | 12 | 17 |
| **Shore correction factor** | 1.10 | 1.21 | 1.47 | 1.00 | 1.00 | 1.00 | 0.91 | 1.00 | 1.47 | 1.00 | 1.47 | 0.68 | 1.00 | 0.62 |
| **Observed species richness (S)** | 49 | 50 | 24 | 61 | 74 | 61 | 66 | 57 | 13 | 52 | 20 | 79 | 66 | 83 |
| **EQR-S** | 1.00 | 1.00 | 0.44 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.24 | 1.00 | 0.36 | 1.00 | 1.00 | 1.00 |
| **De-shored species richness (S')** | 54 | 61 | 35 | 61 | 74 | 61 | 60 | 57 | 19 | 52 | 29 | 54 | 66 | 51 |
| **EQR-S'** | 1.00 | 1.00 | 0.67 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 1.00 | 0.53 | 1.00 | 1.00 | 1.00 |
| **Proportion of Chlorophyta (C)** | 0.16 | 0.20 | 0.13 | 0.21 | 0.20 | 0.20 | 0.23 | 0.11 | 0.31 | 0.13 | 0.35 | 0.16 | 0.15 | 0.14 |
| **EQR-C** | 0.71 | 0.59 | 0.82 | 0.58 | 0.59 | 0.60 | 0.57 | 0.85 | 0.51 | 0.81 | 0.48 | 0.70 | 0.75 | 0.78 |
| **Proportion of Rhodophyta (R)** | 0.73 | 0.66 | 0.75 | 0.67 | 0.68 | 0.70 | 0.65 | 0.82 | 0.54 | 0.77 | 0.55 | 0.67 | 0.68 | 0.72 |
| **EQR-R** | 0.84 | 0.77 | 0.85 | 0.80 | 0.80 | 0.82 | 0.74 | 0.89 | 0.53 | 0.86 | 0.54 | 0.80 | 0.81 | 0.83 |
| **ESG Ratio (ESG)** | 1.04 | 1.27 | 2.00 | 0.97 | 1.24 | 1.03 | 1.28 | 1.38 | 1.17 | 1.17 | 1.00 | 1.08 | 1.20 | 1.37 |
| **EQR-ESG** | 0.62 | 0.73 | 1.00 | 0.58 | 0.72 | 0.62 | 0.73 | 0.78 | 0.68 | 0.68 | 0.60 | 0.64 | 0.70 | 0.78 |
| **Proportion of opportunists (O)** | 0.06 | 0.10 | 0.08 | 0.11 | 0.07 | 0.10 | 0.09 | 0.05 | 0.15 | 0.08 | 0.25 | 0.08 | 0.06 | 0.04 |
| **EQR-O** | 0.79 | 0.60 | 0.68 | 0.59 | 0.76 | 0.61 | 0.65 | 0.97 | 0.56 | 0.72 | 0.50 | 0.72 | 0.80 | 0.98 |
| **Average EQR** | 0.79 | 0.74 | 0.76 | 0.71 | 0.77 | 0.73 | 0.74 | 0.90 | 0.50 | 0.81 | 0.50 | 0.77 | 0.81 | 0.87 |
| **Quality status class** | good | good | good | good | good | good | good | high | noderat | high | noderat | good | high | high |
| **Average EQR - "De-shored"** | 0.79 | 0.74 | 0.80 | 0.71 | 0.77 | 0.73 | 0.74 | 0.90 | 0.53 | 0.81 | 0.53 | 0.77 | 0.81 | 0.87 |
| **Quality status class - "De-shored"** | good | good | high | good | good | good | good | high | noderat | high | noderat | good | high | high |

**Appendix 9 (cont.)** - Shore description score and correction factor, observed and de-shored full species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and averge EQR and quality status class for each Azorean shore according to the FSL-AZ tool.

| Site code | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 8 | 12 | 12 | 12 | 13 | 12 | 8 | 13 | 13 | 12 | 13 | 8 | 12 | 16 |
| **Shore correction factor** | 1.47 | 1.00 | 1.00 | 1.00 | 0.91 | 1.00 | 1.47 | 0.91 | 0.91 | 1.00 | 0.91 | 1.47 | 1.00 | 0.68 |
| **Observed species richness (S)** | 11 | 15 | 24 | 28 | 63 | 27 | 12 | 41 | 35 | 20 | 56 | 8 | 39 | 69 |
| **EQR-S** | 0.20 | 0.27 | 0.44 | 0.51 | 1.00 | 0.49 | 0.22 | 1.00 | 0.66 | 0.36 | 1.00 | 0.15 | 0.77 | 1.00 |
| **De-shored species richness (S')** | 16 | 15 | 24 | 28 | 57 | 27 | 18 | 37 | 32 | 20 | 51 | 12 | 39 | 47 |
| **EQR-S'** | 0.29 | 0.27 | 0.44 | 0.51 | 1.00 | 0.49 | 0.32 | 0.72 | 0.58 | 0.36 | 1.00 | 0.21 | 0.77 | 1.00 |
| **Proportion of Chlorophyta (C)** | 0.27 | 0.20 | 0.17 | 0.18 | 0.19 | 0.19 | 0.42 | 0.27 | 0.14 | 0.20 | 0.14 | 0.25 | 0.21 | 0.20 |
| **EQR-C** | 0.54 | 0.59 | 0.69 | 0.65 | 0.60 | 0.62 | 0.43 | 0.54 | 0.79 | 0.59 | 0.79 | 0.56 | 0.59 | 0.59 |
| **Proportion of Rhodophyta (R)** | 0.55 | 0.73 | 0.75 | 0.68 | 0.59 | 0.78 | 0.58 | 0.71 | 0.69 | 0.75 | 0.75 | 0.75 | 0.67 | 0.68 |
| **EQR-R** | 0.54 | 0.84 | 0.85 | 0.81 | 0.58 | 0.87 | 0.57 | 0.82 | 0.81 | 0.85 | 0.85 | 0.85 | 0.79 | 0.81 |
| **ESG Ratio (ESG)** | 1.20 | 2.00 | 1.67 | 1.80 | 1.33 | 1.25 | 0.71 | 1.05 | 1.19 | 2.33 | 1.33 | 1.00 | 1.79 | 1.23 |
| **EQR-ESG** | 0.70 | 1.00 | 1.00 | 1.00 | 0.76 | 0.72 | 0.43 | 0.62 | 0.69 | 1.00 | 0.76 | 0.60 | 1.00 | 0.71 |
| **Proportion of opportunists (O)** | 0.27 | 0.20 | 0.13 | 0.07 | 0.11 | 0.07 | 0.33 | 0.10 | 0.00 | 0.10 | 0.04 | 0.13 | 0.08 | 0.06 |
| **EQR-O** | 0.48 | 0.53 | 0.58 | 0.74 | 0.59 | 0.73 | 0.44 | 0.61 | 1.00 | 0.60 | 0.98 | 0.58 | 0.72 | 0.97 |
| **Average EQR** | 0.49 | 0.65 | 0.71 | 0.74 | 0.71 | 0.68 | 0.42 | 0.72 | 0.79 | 0.68 | 0.87 | 0.55 | 0.77 | 0.81 |
| **Quality status class** | noderat | good | good | good | good | good | noderat | good | good | good | high | noderat | good | high |
| **Average EQR - "De-shored"** | 0.51 | 0.65 | 0.71 | 0.74 | 0.71 | 0.68 | 0.44 | 0.66 | 0.77 | 0.68 | 0.87 | 0.56 | 0.77 | 0.81 |
| **Quality status class - "De-shored"** | noderat | good | good | good | good | good | noderat | good | good | good | high | noderat | good | high |

**Appendix 9 (cont.)** - Shore description score and correction factor, observed and de-shored full species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and averge EQR and quality status class for each Azorean shore according to the FSL-AZ tool.

| Site code | 85 | 86 | 87 | 88 |
|---|---|---|---|---|
| **Shore description** | 12 | 8 | 13 | 13 |
| **Shore correction factor** | 1.00 | 1.47 | 0.91 | 0.91 |
| **Observed species richness (S)** | 52 | 44 | 80 | 44 |
| **EQR-S** | 1.00 | 1.00 | 1.00 | 1.00 |
| **De-shored species richness (S')** | 52 | 65 | 73 | 40 |
| **EQR-S'** | 1.00 | 1.00 | 1.00 | 0.80 |
| **Proportion of Chlorophyta (C)** | 0.23 | 0.11 | 0.13 | 0.23 |
| **EQR-C** | 0.57 | 0.84 | 0.82 | 0.57 |
| **Proportion of Rhodophyta (R)** | 0.62 | 0.75 | 0.76 | 0.70 |
| **EQR-R** | 0.62 | 0.85 | 0.86 | 0.82 |
| **ESG Ratio (ESG)** | 1.74 | 1.10 | 1.29 | 0.91 |
| **EQR-ESG** | 1.00 | 0.65 | 0.74 | 0.55 |
| **Proportion of opportunists (O)** | 0.12 | 0.09 | 0.06 | 0.11 |
| **EQR-O** | 0.59 | 0.65 | 0.79 | 0.59 |
| **Average EQR** | 0.76 | 0.80 | 0.84 | 0.71 |
| **Quality status class** | good | good | high | good |
| **Average EQR - "De-shored"** | 0.76 | 0.80 | 0.84 | 0.67 |
| **Quality status class - "De-shored"** | good | good | high | good |

# Appendix 10

Shore description score and correction factor, observed and de-shored reduced species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature and average EQR and quality status class for each Azorean shore according to the RSL-AZ tool.

**Appendix 10** - Shore description score and correction factor, observed and de-shored reduced species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature, averge EQR and quality status class for each Azorean shore according to the RSL-AZ tool.

| Site code | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 17 | 8 | 10 | 14 | 12 | 16 | 8 | 13 | 12 | 14 | 8 | 16 | 8 | 16 |
| **Shore correction factor** | 0.62 | 1.47 | 1.21 | 0.82 | 1.00 | 0.68 | 1.47 | 0.91 | 1.00 | 0.82 | 1.47 | 0.68 | 1.47 | 0.68 |
| **Observed species richness (S)** | 38 | 8 | 35 | 40 | 42 | 23 | 26 | 28 | 29 | 33 | 18 | 34 | 23 | 31 |
| **EQR-S** | 0.74 | 0.15 | 0.66 | 1.00 | 1.00 | 0.42 | 0.47 | 0.51 | 0.53 | 0.60 | 0.33 | 0.63 | 0.42 | 0.56 |
| **De-shored species richness (S')** | 23 | 12 | 42 | 33 | 42 | 16 | 38 | 25 | 29 | 27 | 26 | 23 | 34 | 21 |
| **EQR-S'** | 0.43 | 0.21 | 1.00 | 0.60 | 1.00 | 0.28 | 0.75 | 0.46 | 0.53 | 0.49 | 0.48 | 0.42 | 0.62 | 0.38 |
| **Proportion of Chlorophyta (C)** | 0.29 | 0.38 | 0.11 | 0.08 | 0.12 | 0.17 | 0.23 | 0.18 | 0.03 | 0.15 | 0.22 | 0.18 | 0.17 | 0.16 |
| **EQR-C** | 0.53 | 0.46 | 0.84 | 0.89 | 0.83 | 0.66 | 0.57 | 0.65 | 0.95 | 0.75 | 0.58 | 0.65 | 0.66 | 0.71 |
| **Proportion of Rhodophyta (R)** | 0.58 | 0.63 | 0.83 | 0.75 | 0.76 | 0.65 | 0.69 | 0.61 | 0.86 | 0.64 | 0.61 | 0.68 | 0.74 | 0.71 |
| **EQR-R** | 0.57 | 0.65 | 0.90 | 0.85 | 0.86 | 0.74 | 0.81 | 0.60 | 0.92 | 0.69 | 0.60 | 0.80 | 0.84 | 0.82 |
| **ESG Ratio (ESG)** | 1.24 | 1.67 | 1.19 | 2.33 | 1.47 | 2.29 | 0.86 | 2.11 | 3.83 | 1.75 | 2.60 | 2.09 | 1.88 | 3.43 |
| **EQR-ESG** | 0.71 | 1.00 | 0.69 | 1.00 | 1.00 | 1.00 | 0.51 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Proportion of opportunists (O)** | 0.13 | 0.38 | 0.09 | 0.03 | 0.02 | 0.09 | 0.12 | 0.04 | 0.00 | 0.06 | 0.06 | 0.03 | 0.04 | 0.06 |
| **EQR-O** | 0.58 | 0.42 | 0.67 | 0.99 | 0.99 | 0.67 | 0.59 | 0.98 | 1.00 | 0.80 | 0.97 | 0.98 | 0.97 | 0.78 |
| **Average EQR** | 0.63 | 0.54 | 0.75 | 0.95 | 0.93 | 0.70 | 0.59 | 0.75 | 0.88 | 0.77 | 0.69 | 0.81 | 0.78 | 0.78 |
| **Quality status class** | good | mod. | good | high | high | good | mod. | good | high | good | good | high | good | good |
| **Average EQR - "De-shored"** | 0.56 | 0.55 | 0.82 | 0.87 | 0.93 | 0.67 | 0.65 | 0.74 | 0.88 | 0.75 | 0.73 | 0.77 | 0.82 | 0.74 |
| **Quality status class - "De-shored"** | mod. | mod. | high | high | high | good | good | good | high | good | good | good | high | good |

**Appendix 10 (cont.)** - Shore description score and correction factor, observed and de-shored reduced species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature, averge EQR and quality status class for each Azorean shore according to the RSL-AZ tool.

| Site code | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 14 | 14 | 8 | 13 | 13 | 13 | 13 | 13 | 10 | 12 | 14 | 13 | 14 | 17 |
| **Shore correction factor** | 0.82 | 0.82 | 1.47 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 1.21 | 1.00 | 0.82 | 0.91 | 0.82 | 0.62 |
| **Observed species richness (S)** | 33 | 29 | 29 | 34 | 37 | 41 | 45 | 41 | 26 | 38 | 82 | 72 | 55 | 58 |
| **EQR-S** | 0.60 | 0.53 | 0.53 | 0.63 | 0.71 | 1.00 | 1.00 | 1.00 | 0.47 | 0.74 | 1.00 | 1.00 | 1.00 | 1.00 |
| **De-shored species richness (S')** | 27 | 24 | 43 | 31 | 34 | 37 | 41 | 37 | 32 | 38 | 68 | 65 | 45 | 36 |
| **EQR-S'** | 0.49 | 0.43 | 1.00 | 0.56 | 0.62 | 0.72 | 1.00 | 0.72 | 0.57 | 0.74 | 1.00 | 1.00 | 1.00 | 0.68 |
| **Proportion of Chlorophyta (C)** | 0.21 | 0.21 | 0.17 | 0.24 | 0.19 | 0.27 | 0.22 | 0.27 | 0.15 | 0.29 | 0.17 | 0.14 | 0.18 | 0.21 |
| **EQR-C** | 0.58 | 0.59 | 0.67 | 0.57 | 0.60 | 0.54 | 0.58 | 0.54 | 0.74 | 0.53 | 0.68 | 0.80 | 0.63 | 0.59 |
| **Proportion of Rhodophyta (R)** | 0.64 | 0.69 | 0.59 | 0.68 | 0.65 | 0.54 | 0.62 | 0.61 | 0.58 | 0.50 | 0.70 | 0.69 | 0.71 | 0.74 |
| **EQR-R** | 0.69 | 0.81 | 0.58 | 0.80 | 0.73 | 0.53 | 0.64 | 0.60 | 0.57 | 0.49 | 0.82 | 0.81 | 0.82 | 0.84 |
| **ESG Ratio (ESG)** | 1.20 | 1.07 | 1.90 | 1.00 | 1.64 | 1.41 | 1.14 | 1.56 | 1.60 | 0.46 | 1.65 | 1.40 | 1.12 | 1.23 |
| **EQR-ESG** | 0.70 | 0.63 | 1.00 | 0.60 | 1.00 | 0.80 | 0.67 | 1.00 | 1.00 | 0.28 | 1.00 | 0.79 | 0.65 | 0.71 |
| **Proportion of opportunists (O)** | 0.12 | 0.14 | 0.14 | 0.18 | 0.11 | 0.12 | 0.13 | 0.12 | 0.08 | 0.24 | 0.07 | 0.13 | 0.16 | 0.16 |
| **EQR-O** | 0.59 | 0.57 | 0.57 | 0.55 | 0.59 | 0.59 | 0.58 | 0.59 | 0.72 | 0.51 | 0.73 | 0.58 | 0.56 | 0.56 |
| **Average EQR** | 0.63 | 0.63 | 0.67 | 0.63 | 0.73 | 0.69 | 0.69 | 0.75 | 0.70 | 0.51 | 0.85 | 0.80 | 0.73 | 0.74 |
| **Quality status class** | good | good | good | good | good | good | good | good | good | mod. | high | good | good | good |
| **Average EQR - "De-shored"** | 0.61 | 0.61 | 0.76 | 0.62 | 0.71 | 0.63 | 0.69 | 0.69 | 0.72 | 0.51 | 0.85 | 0.80 | 0.73 | 0.68 |
| **Quality status class - "De-shored"** | good | good | good | good | good | good | good | good | good | mod. | high | good | good | good |

**Appendix 10 (cont.)** - Shore description score and correction factor, observed and de-shored reduced species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature, averge EQR and quality status class for each Azorean shore according to the RSL-AZ tool.

| Site code | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 14 | 14 | 16 | 10 | 12 | 10 | 13 | 10 | 13 | 13 | 13 | 13 | 14 | 10 |
| **Shore correction factor** | 0.82 | 0.82 | 0.68 | 1.21 | 1.00 | 1.21 | 0.91 | 1.21 | 0.91 | 0.91 | 0.91 | 0.91 | 0.82 | 1.21 |
| **Observed species richness (S)** | 66 | 91 | 63 | 54 | 48 | 51 | 71 | 64 | 68 | 57 | 67 | 52 | 25 | 37 |
| **EQR-S** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.45 | 0.71 |
| **De-shored species richness (S')** | 54 | 75 | 43 | 65 | 48 | 62 | 64 | 78 | 62 | 52 | 61 | 47 | 21 | 45 |
| **EQR-S'** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.37 | 1.00 |
| **Proportion of Chlorophyta (C)** | 0.15 | 0.21 | 0.10 | 0.28 | 0.25 | 0.24 | 0.13 | 0.19 | 0.19 | 0.26 | 0.19 | 0.19 | 0.12 | 0.24 |
| **EQR-C** | 0.75 | 0.59 | 0.86 | 0.53 | 0.56 | 0.57 | 0.82 | 0.61 | 0.60 | 0.55 | 0.60 | 0.60 | 0.83 | 0.56 |
| **Proportion of Rhodophyta (R)** | 0.76 | 0.73 | 0.79 | 0.65 | 0.67 | 0.69 | 0.72 | 0.73 | 0.69 | 0.63 | 0.63 | 0.62 | 0.52 | 0.59 |
| **EQR-R** | 0.85 | 0.83 | 0.87 | 0.73 | 0.79 | 0.81 | 0.83 | 0.84 | 0.81 | 0.67 | 0.66 | 0.62 | 0.51 | 0.58 |
| **ESG Ratio (ESG)** | 1.54 | 0.75 | 0.66 | 0.86 | 1.29 | 0.59 | 1.29 | 1.29 | 1.72 | 1.11 | 1.39 | 1.08 | 0.79 | 1.06 |
| **EQR-ESG** | 1.00 | 0.45 | 0.39 | 0.52 | 0.74 | 0.36 | 0.74 | 0.74 | 1.00 | 0.65 | 0.79 | 0.64 | 0.47 | 0.63 |
| **Proportion of opportunists (O)** | 0.09 | 0.10 | 0.08 | 0.13 | 0.17 | 0.16 | 0.06 | 0.09 | 0.10 | 0.14 | 0.12 | 0.08 | 0.00 | 0.08 |
| **EQR-O** | 0.65 | 0.61 | 0.70 | 0.58 | 0.56 | 0.56 | 0.97 | 0.63 | 0.60 | 0.57 | 0.59 | 0.72 | 1.00 | 0.69 |
| **Average EQR** | 0.85 | 0.70 | 0.77 | 0.67 | 0.73 | 0.66 | 0.87 | 0.76 | 0.80 | 0.69 | 0.73 | 0.71 | 0.65 | 0.64 |
| **Quality status class** | high | good | good | good | good | good | high | good | high | good | good | good | good | good |
| **Average EQR - "De-shored"** | 0.85 | 0.70 | 0.77 | 0.67 | 0.73 | 0.66 | 0.87 | 0.76 | 0.80 | 0.69 | 0.73 | 0.71 | 0.64 | 0.69 |
| **Quality status class - "De-shored"** | high | good | good | good | good | good | high | good | high | good | good | good | good | good |

**Appendix 10 (cont.)** - Shore description score and correction factor, observed and de-shored reduced species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature, averge EQR and quality status class for each Azorean shore according to the RSL-AZ tool.

| Site code | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 8 | 12 | 10 | 10 | 9 | 16 | 12 | 13 | 12 | 15 | 16 | 13 | 13 | 13 |
| **Shore correction factor** | 1.47 | 1.00 | 1.21 | 1.21 | 1.34 | 0.68 | 1.00 | 0.91 | 1.00 | 0.75 | 0.68 | 0.91 | 0.91 | 0.91 |
| **Observed species richness (S)** | 46 | 27 | 22 | 48 | 69 | 49 | 44 | 67 | 41 | 45 | 14 | 40 | 52 | 35 |
| **EQR-S** | 1.00 | 0.49 | 0.40 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.25 | 1.00 | 1.00 | 0.66 |
| **De-shored species richness (S')** | 68 | 27 | 27 | 58 | 92 | 33 | 44 | 61 | 41 | 34 | 10 | 36 | 47 | 32 |
| **EQR-S'** | 1.00 | 0.49 | 0.49 | 1.00 | 1.00 | 0.61 | 1.00 | 1.00 | 1.00 | 0.62 | 0.17 | 0.69 | 1.00 | 0.58 |
| **Proportion of Chlorophyta (C)** | 0.15 | 0.22 | 0.05 | 0.13 | 0.12 | 0.18 | 0.11 | 0.10 | 0.12 | 0.22 | 0.43 | 0.20 | 0.19 | 0.11 |
| **EQR-C** | 0.75 | 0.58 | 0.94 | 0.82 | 0.83 | 0.63 | 0.84 | 0.85 | 0.83 | 0.58 | 0.42 | 0.59 | 0.60 | 0.84 |
| **Proportion of Rhodophyta (R)** | 0.65 | 0.52 | 0.77 | 0.73 | 0.65 | 0.65 | 0.66 | 0.69 | 0.68 | 0.67 | 0.43 | 0.55 | 0.63 | 0.71 |
| **EQR-R** | 0.74 | 0.51 | 0.86 | 0.84 | 0.74 | 0.74 | 0.76 | 0.81 | 0.81 | 0.79 | 0.42 | 0.54 | 0.68 | 0.83 |
| **ESG Ratio (ESG)** | 1.00 | 1.08 | 2.14 | 1.82 | 1.03 | 0.96 | 2.38 | 1.58 | 1.28 | 0.80 | 1.80 | 1.00 | 1.26 | 2.50 |
| **EQR-ESG** | 0.60 | 0.64 | 1.00 | 1.00 | 0.61 | 0.58 | 1.00 | 1.00 | 0.73 | 0.48 | 1.00 | 0.60 | 0.72 | 1.00 |
| **Proportion of opportunists (O)** | 0.09 | 0.11 | 0.00 | 0.06 | 0.06 | 0.06 | 0.07 | 0.06 | 0.12 | 0.11 | 0.14 | 0.08 | 0.02 | 0.03 |
| **EQR-O** | 0.67 | 0.59 | 1.00 | 0.79 | 0.97 | 0.79 | 0.76 | 0.96 | 0.59 | 0.59 | 0.57 | 0.73 | 0.99 | 0.98 |
| **Average EQR** | 0.75 | 0.56 | 0.84 | 0.89 | 0.83 | 0.75 | 0.87 | 0.92 | 0.79 | 0.69 | 0.53 | 0.69 | 0.80 | 0.86 |
| **Quality status class** | good | mod. | high | high | high | good | high | high | good | good | mod. | good | good | high |
| **Average EQR - "De-shored"** | 0.75 | 0.56 | 0.86 | 0.89 | 0.83 | 0.67 | 0.87 | 0.92 | 0.79 | 0.61 | 0.52 | 0.63 | 0.80 | 0.84 |
| **Quality status class - "De-shored"** | good | mod. | high | high | high | good | high | high | good | good | mod. | good | good | high |

**Appendix 10 (cont.)** - Shore description score and correction factor, observed and de-shored reduced species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature, averge EQR and quality status class for each Azorean shore according to the RSL-AZ tool.

| Site code | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 11 | 10 | 8 | 12 | 12 | 12 | 13 | 12 | 8 | 12 | 8 | 16 | 12 | 17 |
| **Shore correction factor** | 1.10 | 1.21 | 1.47 | 1.00 | 1.00 | 1.00 | 0.91 | 1.00 | 1.47 | 1.00 | 1.47 | 0.68 | 1.00 | 0.62 |
| **Observed species richness (S)** | 49 | 50 | 24 | 61 | 74 | 61 | 66 | 57 | 13 | 52 | 20 | 79 | 66 | 83 |
| **EQR-S** | 1.00 | 1.00 | 0.44 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.24 | 1.00 | 0.36 | 1.00 | 1.00 | 1.00 |
| **De-shored species richness (S')** | 54 | 61 | 35 | 61 | 74 | 61 | 60 | 57 | 19 | 52 | 29 | 54 | 66 | 51 |
| **EQR-S'** | 1.00 | 1.00 | 0.67 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.35 | 1.00 | 0.53 | 1.00 | 1.00 | 1.00 |
| **Proportion of Chlorophyta (C)** | 0.16 | 0.20 | 0.13 | 0.21 | 0.20 | 0.20 | 0.23 | 0.11 | 0.31 | 0.13 | 0.35 | 0.16 | 0.15 | 0.14 |
| **EQR-C** | 0.71 | 0.59 | 0.82 | 0.58 | 0.59 | 0.60 | 0.57 | 0.85 | 0.51 | 0.81 | 0.48 | 0.70 | 0.75 | 0.78 |
| **Proportion of Rhodophyta (R)** | 0.73 | 0.66 | 0.75 | 0.67 | 0.68 | 0.70 | 0.65 | 0.82 | 0.54 | 0.77 | 0.55 | 0.67 | 0.68 | 0.72 |
| **EQR-R** | 0.84 | 0.77 | 0.85 | 0.80 | 0.80 | 0.82 | 0.74 | 0.89 | 0.53 | 0.86 | 0.54 | 0.80 | 0.81 | 0.83 |
| **ESG Ratio (ESG)** | 1.04 | 1.27 | 2.00 | 0.97 | 1.24 | 1.03 | 1.28 | 1.38 | 1.17 | 1.17 | 1.00 | 1.08 | 1.20 | 1.37 |
| **EQR-ESG** | 0.62 | 0.73 | 1.00 | 0.58 | 0.72 | 0.62 | 0.73 | 0.78 | 0.68 | 0.68 | 0.60 | 0.64 | 0.70 | 0.78 |
| **Proportion of opportunists (O)** | 0.06 | 0.10 | 0.08 | 0.11 | 0.07 | 0.10 | 0.09 | 0.05 | 0.15 | 0.08 | 0.25 | 0.08 | 0.06 | 0.04 |
| **EQR-O** | 0.79 | 0.60 | 0.68 | 0.59 | 0.76 | 0.61 | 0.65 | 0.97 | 0.56 | 0.72 | 0.50 | 0.72 | 0.80 | 0.98 |
| **Average EQR** | 0.79 | 0.74 | 0.76 | 0.71 | 0.77 | 0.73 | 0.74 | 0.90 | 0.50 | 0.81 | 0.50 | 0.77 | 0.81 | 0.87 |
| **Quality status class** | good | good | good | good | good | good | good | high | mod. | high | mod. | good | high | high |
| **Average EQR - "De-shored"** | 0.79 | 0.74 | 0.80 | 0.71 | 0.77 | 0.73 | 0.74 | 0.90 | 0.53 | 0.81 | 0.53 | 0.77 | 0.81 | 0.87 |
| **Quality status class - "De-shored"** | good | good | high | good | good | good | good | high | mod. | high | mod. | good | high | high |

**Appendix 10 (cont.)** - Shore description score and correction factor, observed and de-shored reduced species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature, averge EQR and quality status class for each Azorean shore according to the RSL-AZ tool.

| Site code | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 8 | 12 | 12 | 12 | 13 | 12 | 8 | 13 | 13 | 12 | 13 | 8 | 12 | 16 |
| **Shore correction factor** | 1.47 | 1.00 | 1.00 | 1.00 | 0.91 | 1.00 | 1.47 | 0.91 | 0.91 | 1.00 | 0.91 | 1.47 | 1.00 | 0.68 |
| **Observed species richness (S)** | 11 | 15 | 24 | 28 | 63 | 27 | 12 | 41 | 35 | 20 | 56 | 8 | 39 | 69 |
| **EQR-S** | 0.20 | 0.27 | 0.44 | 0.51 | 1.00 | 0.49 | 0.22 | 1.00 | 0.66 | 0.36 | 1.00 | 0.15 | 0.77 | 1.00 |
| **De-shored species richness (S')** | 16 | 15 | 24 | 28 | 57 | 27 | 18 | 37 | 32 | 20 | 51 | 12 | 39 | 47 |
| **EQR-S'** | 0.29 | 0.27 | 0.44 | 0.51 | 1.00 | 0.49 | 0.32 | 0.72 | 0.58 | 0.36 | 1.00 | 0.21 | 0.77 | 1.00 |
| **Proportion of Chlorophyta (C)** | 0.27 | 0.20 | 0.17 | 0.18 | 0.19 | 0.19 | 0.42 | 0.27 | 0.14 | 0.20 | 0.14 | 0.25 | 0.21 | 0.20 |
| **EQR-C** | 0.54 | 0.59 | 0.69 | 0.65 | 0.60 | 0.62 | 0.43 | 0.54 | 0.79 | 0.59 | 0.79 | 0.56 | 0.59 | 0.59 |
| **Proportion of Rhodophyta (R)** | 0.55 | 0.73 | 0.75 | 0.68 | 0.59 | 0.78 | 0.58 | 0.71 | 0.69 | 0.75 | 0.75 | 0.75 | 0.67 | 0.68 |
| **EQR-R** | 0.54 | 0.84 | 0.85 | 0.81 | 0.58 | 0.87 | 0.57 | 0.82 | 0.81 | 0.85 | 0.85 | 0.85 | 0.79 | 0.81 |
| **ESG Ratio (ESG)** | 1.20 | 2.00 | 1.67 | 1.80 | 1.33 | 1.25 | 0.71 | 1.05 | 1.19 | 2.33 | 1.33 | 1.00 | 1.79 | 1.23 |
| **EQR-ESG** | 0.70 | 1.00 | 1.00 | 1.00 | 0.76 | 0.72 | 0.43 | 0.62 | 0.69 | 1.00 | 0.76 | 0.60 | 1.00 | 0.71 |
| **Proportion of opportunists (O)** | 0.27 | 0.20 | 0.13 | 0.07 | 0.11 | 0.07 | 0.33 | 0.10 | 0.00 | 0.10 | 0.04 | 0.13 | 0.08 | 0.06 |
| **EQR-O** | 0.48 | 0.53 | 0.58 | 0.74 | 0.59 | 0.73 | 0.44 | 0.61 | 1.00 | 0.60 | 0.98 | 0.58 | 0.72 | 0.97 |
| **Average EQR** | 0.49 | 0.65 | 0.71 | 0.74 | 0.71 | 0.68 | 0.42 | 0.72 | 0.79 | 0.68 | 0.87 | 0.55 | 0.77 | 0.81 |
| **Quality status class** | mod. | good | good | good | good | good | mod. | good | good | good | high | mod. | good | high |
| **Average EQR - "De-shored"** | 0.51 | 0.65 | 0.71 | 0.74 | 0.71 | 0.68 | 0.44 | 0.66 | 0.77 | 0.68 | 0.87 | 0.56 | 0.77 | 0.81 |
| **Quality status class - "De-shored"** | mod. | good | good | good | good | good | mod. | good | good | good | high | mod. | good | high |

**Appendix 10 (cont.)** - Shore description score and correction factor, observed and de-shored reduced species list richness, proportions of Chlorophyta, Rhodophyta and opportunist species, ESG ratios, partial ecological quality ratios (EQR) for each feature, averge EQR and quality status class for each Azorean shore according to the RSL-AZ tool.

| Site code | 85 | 86 | 87 | 88 |
|---|---|---|---|---|
| **Shore description** | 12 | 8 | 13 | 13 |
| **Shore correction factor** | 1.00 | 1.47 | 0.91 | 0.91 |
| **Observed species richness (S)** | 52 | 44 | 80 | 44 |
| **EQR-S** | 1.00 | 1.00 | 1.00 | 1.00 |
| **De-shored species richness (S')** | 52 | 65 | 73 | 40 |
| **EQR-S'** | 1.00 | 1.00 | 1.00 | 0.80 |
| **Proportion of Chlorophyta (C)** | 0.23 | 0.11 | 0.13 | 0.23 |
| **EQR-C** | 0.57 | 0.84 | 0.82 | 0.57 |
| **Proportion of Rhodophyta (R)** | 0.62 | 0.75 | 0.76 | 0.70 |
| **EQR-R** | 0.62 | 0.85 | 0.86 | 0.82 |
| **ESG Ratio (ESG)** | 1.74 | 1.10 | 1.29 | 0.91 |
| **EQR-ESG** | 1.00 | 0.65 | 0.74 | 0.55 |
| **Proportion of opportunists (O)** | 0.12 | 0.09 | 0.06 | 0.11 |
| **EQR-O** | 0.59 | 0.65 | 0.79 | 0.59 |
| **Average EQR** | 0.76 | 0.80 | 0.84 | 0.71 |
| **Quality status class** | good | good | high | good |
| **Average EQR - "De-shored"** | 0.76 | 0.80 | 0.84 | 0.67 |
| **Quality status class - "De-shored"** | good | good | high | good |

# Appendix 11

Shore description score and correction factor, observed and de-shored reduced species list richness, total and opportunistic species cover and corresponding partial ecological quality ratios (EQR) for each feature, averge EQR and quality status class for each Azorean shore according to the CI tool.

**Appendix 11** - Shore description score and correction factor, observed and de-shored reduced species list richness, total and opportunistic species cover and corresponding partial ecological quality ratios (EQR) for each feature, averge EQR and quality status class for each Azorean shore according to the CI tool.

| Site code | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 17 | 8 | 10 | 14 | 12 | 16 | 8 | 13 | 12 | 14 | 8 | 16 | 8 | 16 |
| **Shore correction factor** | 0.70 | 1.33 | 1.15 | 0.87 | 1.00 | 0.75 | 1.33 | 0.93 | 1.00 | 0.87 | 1.33 | 0.75 | 1.33 | 0.75 |
| **Observed species richness (S)** | 16 | 4 | 12 | 21 | 18 | 13 | 13 | 12 | 13 | 17 | 13 | 18 | 11 | 16 |
| **EQR-S** | 0.53 | 0.13 | 0.40 | 0.60 | 0.40 | 0.43 | 0.43 | 0.40 | 0.43 | 0.57 | 0.43 | 0.40 | 0.37 | 0.53 |
| **De-shored species richness (S')** | 11 | 5 | 14 | 18 | 18 | 10 | 17 | 11 | 13 | 15 | 17 | 14 | 15 | 12 |
| **EQR-S'** | 0.37 | 0.18 | 0.46 | 0.41 | 0.40 | 0.33 | 0.58 | 0.37 | 0.43 | 0.49 | 0.58 | 0.45 | 0.49 | 0.40 |
| **Total cover (C)** | 0.45 | 0.37 | 0.60 | 0.61 | 0.49 | 0.57 | 0.61 | 0.74 | 0.66 | 0.81 | 0.73 | 0.74 | 0.69 | 0.60 |
| **EQR-C** | 0.75 | 0.67 | 0.84 | 0.85 | 0.79 | 0.83 | 0.84 | 0.90 | 0.87 | 0.93 | 0.89 | 0.90 | 0.88 | 0.84 |
| **Opportunist cover (O)** | 18% | 86% | 30% | 31% | 8% | 25% | 37% | 3% | 29% | 36% | 20% | 3% | 63% | 15% |
| **EQR-O** | 0.63 | 0.11 | 0.52 | 0.52 | 0.84 | 0.56 | 0.47 | 0.94 | 0.53 | 0.48 | 0.60 | 0.95 | 0.28 | 0.69 |
| **Average EQR** | 0.67 | 0.38 | 0.65 | 0.69 | 0.74 | 0.66 | 0.64 | 0.82 | 0.67 | 0.70 | 0.71 | 0.82 | 0.58 | 0.73 |
| **Quality status class** | good | poor | good | good | good | good | good | high | good | good | good | high | mod. | good |
| **Average EQR - "De-shored"** | 0.64 | 0.38 | 0.66 | 0.65 | 0.74 | 0.64 | 0.66 | 0.82 | 0.67 | 0.69 | 0.73 | 0.83 | 0.60 | 0.71 |
| **Quality status class - "De-shored"** | good | poor | good | good | good | good | good | high | good | good | good | high | mod. | good |

**Appendix 11 (cont.)** - Shore description score and correction factor, observed and de-shored reduced species list richness, total and opportunistic species cover and corresponding partial ecological quality ratios (EQR) for each feature, averge EQR and quality status class for each Azorean shore according to the CI tool.

| **Site code** | **15** | **16** | **17** | **18** | **19** | **20** | **21** | **22** | **23** | **24** | **25** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shore description** | 14 | 14 | 10 | 8 | 10 | 10 | 9 | 16 | 12 | 13 | 12 |
| **Shore correction factor** | 0.87 | 0.87 | 1.15 | 1.33 | 1.15 | 1.15 | 1.24 | 0.75 | 1.00 | 0.93 | 1.00 |
| **Observed species richness (S)** | 16 | 16 | 10 | 23 | 9 | 22 | 26 | 19 | 24 | 27 | 17 |
| **EQR-S** | 0.53 | 0.53 | 0.33 | 1.00 | 0.30 | 1.00 | 1.00 | 0.47 | 1.00 | 1.00 | 0.57 |
| **De-shored species richness (S')** | 14 | 14 | 12 | 31 | 10 | 25 | 32 | 14 | 24 | 25 | 17 |
| **EQR-S'** | 0.46 | 0.46 | 0.38 | 1.00 | 0.35 | 1.00 | 1.00 | 0.48 | 1.00 | 1.00 | 0.57 |
| **Total cover (C)** | 0.67 | 0.55 | 0.74 | 0.90 | 0.55 | 0.60 | 0.72 | 0.82 | 0.57 | 0.73 | 0.67 |
| **EQR-C** | 0.87 | 0.82 | 0.90 | 0.96 | 0.82 | 0.84 | 0.89 | 0.93 | 0.83 | 0.89 | 0.87 |
| **Opportunist cover (O)** | 25% | 20% | 14% | 51% | 40% | 8% | 12% | 16% | 23% | 12% | 11% |
| **EQR-O** | 0.56 | 0.60 | 0.71 | 0.36 | 0.45 | 0.84 | 0.77 | 0.68 | 0.58 | 0.75 | 0.77 |
| **Average EQR** | **0.701** | 0.69 | 0.73 | 0.76 | 0.60 | 0.87 | 0.87 | 0.76 | 0.77 | 0.86 | 0.78 |
| **Quality status class** | **good** | good | good | good | mod. | high | high | good | good | high | good |
| **Average EQR - "De-shored"** | **0.688** | 0.68 | 0.74 | 0.76 | 0.61 | 0.87 | 0.87 | 0.76 | 0.77 | 0.86 | 0.78 |
| **Quality status class - "De-shored"** | **good** | good | good | good | good | high | high | good | good | high | good |

# Appendix 12

Recorded taxa at different points in Ferraria and Porto Formoso (see Figs 5.2 and 5.5, respectively).

**Appendix 12** - Recorded taxa at different points in Ferraria and Porto Formoso (see Figs 5.2 and 5.5, respectively).

| | Ferraria | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Species** | **Boulders** | | | | **Vertical rock** | | | |
| | **A** | **B** | **C** | **D** | **D** | **C** | **B** | **A** |
| *Acrosorium venulosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Aglaothamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Antithamnion decipiens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Callithamnion corymbosum* | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Callithamnion* sp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Callithamnion tetragonum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Caulacanthus ustulatus* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Centroceras clavulatum* | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium ciliatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ceramium diaphanum* | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Ceramium rubrum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chondracanthus acicularis* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Ctenosiphonia hypnoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Diplothamnion jolyi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Falkenbergia rufolanosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Gelidium microdon* | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| *Gelidium pusillum* | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| *Gymnogongrus crenulatus* | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| *Herposiphonia secunda* | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| *Lophosiphonia reptabunda* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nitophyllum punctatum* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| *Palisada poiteaui* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Phyllophora gelidioides* | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Polysiphonia* sp. | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Polysiphonia sphacelaria* | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polysiphonia stricta* | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| *Porphyra* sp. | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| *Rhodymenia holmesii* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Symphyocladia marchantioides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Rhodophyta** | **5** | **6** | **6** | **2** | **5** | **7** | **11** | **13** |
| *Cladostephus spongiosus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Colpomenia sinuosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Brown crust* | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Cystoseira abies-marina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus fasciculatus* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ectocarpus siliculosus* | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Endarachne binghamiae* | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| *Hecatonema terminale* | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Nemoderma tingitanum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum cymosum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sargassum furcatum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Scytosiphon lomentaria* | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| *Sphacelaria rigidula* | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 |
| *Sphacelaria* sp. | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |

**Appendix 12 (cont.)** - Recorded taxa at different points in Ferraria and Porto Formoso (see Figs 5.2 and 5.5, respectively).

| | Ferraria | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Species** | **Boulders** | | | | **Vertical rock** | | | |
| | **A** | **B** | **C** | **D** | **D** | **C** | **B** | **A** |
| *Stypocaulon scoparium* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Phaeophyceae** | **5** | **5** | **4** | **1** | **2** | **2** | **3** | **2** |
| *Blidingia minima* | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Bryopsis cupressina* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Bryopsis plumosa* | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Chaetomorpha aerea* | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Cladophora albida* | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Cladophora conferta* | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Cladophora laetervirens* | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Codium adhaerens* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Codium fragile* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ulva compressa* | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 |
| *Ulva intestinalis* | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| *Ulva prolifera* | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 |
| *Ulva rigida* | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| **Chlorophyta** | **4** | **5** | **6** | **6** | **4** | **2** | **4** | **4** |

**Appendix 12 (cont.)** - Recorded taxa at different points in Ferraria and Porto Formoso (see Figs 5.2 and 5.5, respectively).

| Species | Porto Formoso lders/Pebbles | | |
|---|---|---|---|
| | **C** | **B** | **A** |
| *Acrosorium venulosum* | 0 | 0 | 0 |
| *Aglaothamnion* sp. | 0 | 1 | 0 |
| *Antithamnion decipiens* | 0 | 1 | 0 |
| *Callithamnion corymbosum* | 0 | 0 | 0 |
| *Callithamnion* sp. | 0 | 0 | 0 |
| *Callithamnion tetragonum* | 0 | 0 | 0 |
| *Caulacanthus ustulatus* | 0 | 0 | 0 |
| *Centroceras clavulatum* | 0 | 0 | 0 |
| *Ceramium ciliatum* | 0 | 1 | 0 |
| *Ceramium diaphanum* | 1 | 1 | 0 |
| *Ceramium rubrum* | 0 | 1 | 1 |
| *Chondracanthus acicularis* | 1 | 1 | 1 |
| *Ctenosiphonia hypnoides* | 1 | 0 | 0 |
| *Diplothamnion jolyi* | 0 | 1 | 0 |
| *Falkenbergia rufolanosa* | 1 | 1 | 1 |
| *Gelidium microdon* | 0 | 0 | 0 |
| *Gelidium pusillum* | 1 | 1 | 1 |
| *Gymnogongrus crenulatus* | 1 | 0 | 1 |
| *Herposiphonia secunda* | 0 | 0 | 0 |
| *Lophosiphonia reptabunda* | 1 | 0 | 0 |
| *Nitophyllum punctatum* | 0 | 0 | 0 |
| *Palisada poiteaui* | 1 | 1 | 0 |
| *Phyllophora gelidioides* | 0 | 0 | 0 |
| *Polysiphonia* sp. | 1 | 1 | 0 |
| *Polysiphonia sphacelaria* | 0 | 0 | 0 |
| *Polysiphonia stricta* | 0 | 0 | 1 |
| *Porphyra* sp. | 0 | 0 | 0 |
| *Rhodymenia holmesii* | 0 | 0 | 0 |
| *Symphyocladia marchantioides* | 1 | 0 | 0 |
| **Rhodophyta** | **10** | **11** | **6** |
| *Cladostephus spongiosus* | 1 | 1 | 0 |
| *Colpomenia sinuosa* | 1 | 0 | 0 |
| *Brown crust* | 0 | 0 | 0 |
| *Cystoseira abies-marina* | 1 | 0 | 0 |
| *Ectocarpus fasciculatus* | 0 | 0 | 0 |
| *Ectocarpus siliculosus* | 0 | 0 | 0 |
| *Endarachne binghamiae* | 0 | 0 | 0 |
| *Hecatonema terminale* | 0 | 0 | 0 |
| *Nemoderma tingitanum* | 0 | 1 | 0 |
| *Sargassum cymosum* | 0 | 1 | 1 |
| *Sargassum furcatum* | 1 | 0 | 0 |
| *Scytosiphon lomentaria* | 0 | 0 | 0 |
| *Sphacelaria rigidula* | 0 | 0 | 0 |
| *Sphacelaria* sp. | 0 | 0 | 0 |

**Appendix 12 (cont.)** - Recorded taxa at different points in Ferraria and Porto Formoso (see Figs 5.2 and 5.5, respectively).

| Species | Porto Formoso lders/Pebbles | | |
|---|---|---|---|
| | **C** | **B** | **A** |
| *Stypocaulon scoparium* | 1 | 1 | 1 |
| **Phaeophyceae** | **5** | **4** | **2** |
| *Blidingia minima* | 0 | 0 | 0 |
| *Bryopsis cupressina* | 0 | 0 | 0 |
| *Bryopsis plumosa* | 0 | 0 | 0 |
| *Chaetomorpha aerea* | 1 | 1 | 0 |
| *Cladophora albida* | 0 | 0 | 0 |
| *Cladophora conferta* | 0 | 0 | 0 |
| *Cladophora laetervirens* | 0 | 0 | 0 |
| *Codium adhaerens* | 1 | 1 | 1 |
| *Codium fragile* | 1 | 0 | 0 |
| *Ulva compressa* | 0 | 0 | 1 |
| *Ulva intestinalis* | 1 | 0 | 0 |
| *Ulva prolifera* | 0 | 1 | 0 |
| *Ulva rigida* | 0 | 0 | 0 |
| **Chlorophyta** | **4** | **3** | **2** |

# Appendix 13

Element concentration (mean ± SE; μg.g-1, dry weight) in algae species collected at each sampling site, their respective UTM coordinates and nature of site (*-non-urban; ** - urban; *** - hydrothermal; na - not available; a - one sample only).

**Appendix 13** - Element concentration (mean±SE; µg.g-1, dry weight) in algae species collected at each sampling site, their respective UTM coordinates and nature of site (* - non-urban; ** - urban; *** - hydrothermal; na – not available; a – one sample only).

| Sample Site | Element | *Corallina elongata* | *Gelidium microdon* |
|---|---|---|---|
| Santo António* | Ca | 257000.00±10000.00 | 1087.50±312.50 |
| UTM | Cd | 0.15±0.00 | 0.29±0.10 |
| W - 4191463.6 | Co | 0.05±0.01 | 0.11±0.03 |
| N - 614360.0 | Cs | 0.02±0.00 | 0.02±0.01 |
| | Cu | 1.23±0.69 | 1.34±0.32 |
| | Fe | 45.75±10.95 | 48.80±3.80 |
| | Hg | <0.005 | 0.01±0.00 |
| | K | 5210.00±250.00 | 14585.00±5315.00 |
| | Mg | 26550.00±350.00 | 1805.00±525.00 |
| | Mn | 8.32±0.54 | 12.10±1.40 |
| | Ni | 0.60±0.00 | 4.45±0.45 |
| | Pb | 0.17±0.03 | 0.09±0.00 |
| | Rb | 0.08±0.00 | 6.12±2.36 |
| | Se | <0.20 | 0.20a |
| | Zn | 12.90±0.00 | 17.60±5.30 |
| Feteiras* | Ca | 241500.00±5500.00 | 1280.00±10.00 |
| UTM | Cd | 0.34±0.00 | 0.34±0.02 |
| W - 4182317.7 | Co | 0.37±0.29 | 0.18±0.01 |
| N - 608001.3 | Cs | 0.03±0.01 | 0.03±0.00 |
| | Cu | 1.11±0.11 | 4.19±0.60 |
| | Fe | 797.15±772.85 | 72.95±6.45 |
| | Hg | <0.005 | 0.01±0.00 |
| | K | 4125.00±25.00 | 15600.00±0.00 |
| | Mg | 25400.00±400.00 | 2060.00±60.00 |
| | Mn | 28.83±22.37 | 10.65±0.25 |
| | Ni | 1.30±0.90 | 8.40±0.70 |
| | Pb | 0.40±0.22 | 0.25±0.15 |
| | Rb | 0.19±0.16 | 6.70±0.02 |
| | Se | <0.20 | <0.20 |
| | Zn | 8.35±1.55 | 29.20±4.70 |
| Ponta Delgada** | Ca | 231500.00±3500.00 | 1845.00±135.00 |
| UTM | Cd | 0.07±0.00 | 0.21±0.00 |
| W - 4177899.5 | Co | 0.23±0.08 | 0.27±0.05 |
| N - 618918.4 | Cs | 0.02±0.00 | 0.03±0.00 |
| | Cu | 1.18±0.15 | 6.60±0.09 |
| | Fe | 513.50±161.50 | 336.50±119.50 |
| | Hg | <0.005 | 0.01±0.00 |
| | K | 5060.00±10.00 | 19550.00±550.00 |
| | Mg | 22400.00±700.00 | 2025.00±65.00 |
| | Mn | 15.30±2.90 | 18.60±2.70 |
| | Ni | 0.85±0.15 | 7.60±0.60 |
| | Pb | 0.50±0.01 | 0.41±0.05 |
| | Rb | 0.02±0.01 | 7.88±0.07 |
| | Se | <0.20 | <0.20 |
| | Zn | 29.25±1.35 | 105.00±1.00 |

**Appendix 13 (cont.)** - Element concentration (mean±SE; µg.g-1, dry weight) in algae species collected at each sampling site, their respective UTM coordinates and nature of site (* - non-urban; ** - urban; *** - hydrothermal; na – not available; a – one sample only).

| Sample Site | Element | *Corallina elongata* | *Gelidium microdon* |
|---|---|---|---|
| Lagoa** | Ca | 234000.00±4000.00 | 1620.00±180.00 |
| UTM | Cd | 0.26±0.07 | 0.45±0.03 |
| W - 4178146.0 | Co | 0.21±0.10 | 0.20±0.02 |
| N - 624344.6 | Cs | 0.02±0.00 | 0.03±0.00 |
| | Cu | 0.98±0.17 | 4.11±0.39 |
| | Fe | 335.00±167.00 | 107.70±24.30 |
| | K | 3305.00±305.00 | 21050.00±950.00 |
| | Hg | <0.005 | 0.01±0.00 |
| | Mg | 21750.00±250.00 | 2045.00±55.00 |
| | Mn | 11.83±2.38 | 13.70±1.10 |
| | Ni | 0.80±0.20 | 7.35±0.85 |
| | Pb | 0.45±0.05 | 0.17±0.02 |
| | Rb | 0.49±0.08 | 7.69±0.41 |
| | Se | <0.2 | <0.2 |
| | Zn | 14.40±3.30 | 42.35±3.15 |
| Ferraria OS*** | Ca | 251500.00±5500.00 | 1385.00±95.00 |
| UTM | Cd | 0.10±0.01 | 0.32±0.02 |
| W - 4190618.4 | Co | 0.18±0.04 | 0.79±0.04 |
| N - 600912.1 | Cs | 0.01±0.00 | 0.03±0.00 |
| | Cu | 0.71±0.14 | 4.18±0.20 |
| | Fe | 263.50±13.50 | 1060.50±159.50 |
| | Hg | <0.005 | 0.01±0.00 |
| | K | 3660.00±330.00 | 16850.00±1950.00 |
| | Mg | 22200.00±200.00 | 2215.00±25.00 |
| | Mn | 26.30±4.20 | 29.10±1.40 |
| | Ni | 0.45±0.05 | 15.05±1.85 |
| | Pb | 0.29±0.03 | 0.83±0.20 |
| | Rb | 0.41±0.04 | 7.83±1.07 |
| | Se | <0.20 | 0.30a |
| | Zn | 34.80±28.20 | 39.35±8.25 |
| Porto Formoso*** | Ca | 260500.00±500.00 | na |
| UTM | Cd | 0.03±0.00 | na |
| W - 4187175.0 | Co | 0.05±0.01 | na |
| N - 635802.4 | Cs | 0.01±0.00 | na |
| | Cu | 0.24±0.00 | na |
| | Fe | 94.75±8.25 | na |
| | Hg | <0.005 | na |
| | K | 2945.00±525.00 | na |
| | Mg | 22350.00±250.00 | na |
| | Mn | 59.55±9.05 | na |
| | Ni | 0.30±0.00 | na |
| | Pb | 0.14±0.02 | na |
| | Rb | 0.51±0.20 | na |
| | Se | <0.2 | na |
| | Zn | 38.80±7.10 | na |

**Appendix 13 (cont.)** - Element concentration (mean±SE; µg.g-1, dry weight) in algae species collected at each sampling site, their respective UTM coordinates and nature of site (* - non-urban; ** - urban; *** - hydrothermal; na – not available; a – one sample only).

| Sample Site | Element | *Osmundea truncata* | *Porphyra* sp |
|---|---|---|---|
| Santo António* | Ca | na | 2175.00±155.00 |
| UTM | Cd | na | 0.41±0.00 |
| W - 4191463.6 | Co | na | 0.08±0.01 |
| N - 614360.0 | Cs | na | 0.01±0.00 |
| | Cu | na | 3.26±0.09 |
| | Fe | na | 53.25±8.65 |
| | Hg | na | <0.005 |
| | K | na | 32350.00±650.00 |
| | Mg | na | 5785.00±585.00 |
| | Mn | na | 11.45±0.15 |
| | Ni | na | 1.00±0.00 |
| | Pb | na | 0.17±0.01 |
| | Rb | na | 5.12±0.04 |
| | Se | na | 0.20a |
| | Zn | na | 9.85±0.65 |
| Feteiras* | Ca | 6315.00±215.00 | 3085.00±515.00 |
| UTM | Cd | 0.68±0.03 | 1.01±0.03 |
| W - 4182317.7 | Co | 0.21±0.04 | 0.24±0.04 |
| N - 608001.3 | Cs | 0.05±0.00 | 0.01±0.00 |
| | Cu | 4.14±0.29 | 6.74±0.04 |
| | Fe | 168.00±58.00 | 322.50±87.50 |
| | Hg | <0.005 | <0.005 |
| | K | 39150.00±250.00 | 26700.00±300.00 |
| | Mg | 3035.00±565.00 | 4485.00±195.00 |
| | Mn | 20.20±1.10 | 23.45±0.95 |
| | Ni | 8.15±0.15 | 1.25±0.15 |
| | Pb | 0.17±0.01 | 0.10±0.01 |
| | Rb | 18.40±0.30 | 5.71±0.00 |
| | Se | 0.20a | <0.20 |
| | Zn | 14.30±0.40 | 13.25±0.95 |
| Ponta Delgada** | Ca | na | na |
| UTM | Cd | na | na |
| W - 4177899.5 | Co | na | na |
| N - 618918.4 | Cs | na | na |
| | Cu | na | na |
| | Fe | na | na |
| | Hg | na | na |
| | K | na | na |
| | Mg | na | na |
| | Mn | na | na |
| | Ni | na | na |
| | Pb | na | na |
| | Rb | na | na |
| | Se | na | na |
| | Zn | na | na |

**Appendix 13 (cont.)** - Element concentration (mean±SE; µg.g-1, dry weight) in algae species collected at each sampling site, their respective UTM coordinates and nature of site (* - non-urban; ** - urban; *** - hydrothermal; na – not available; a – one sample only).

| Sample Site | Element | *Osmundea truncata* | *Porphyra* sp |
|---|---|---|---|
| Lagoa** | Ca | 14050.00±2550.00 | 8550.00±10.00 |
| UTM | Cd | 0.53±0.04 | 1.05±0.00 |
| W - 4178146.0 | Co | 0.62±0.10 | 0.15±0.00 |
| N - 624344.6 | Cs | 0.05±0.00 | 0.01±0.00 |
| | Cu | 3.41±0.27 | 7.49±0.15 |
| | Fe | 971.50±38.50 | 116.00±1.00 |
| | K | 55700.00±2500.00 | 40450.00±550.00 |
| | Hg | <0.005 | <0.005 |
| | Mg | 7545.00±525.00 | 4235.00±165.00 |
| | Mn | 25.45±0.55 | 22.85±0.75 |
| | Ni | 10.60±0.80 | 1.10±0.00 |
| | Pb | 0.56±0.09 | 0.18±0.01 |
| | Rb | 20.65±0.85 | 5.63±0.03 |
| | Se | <0.2 | <0.2 |
| | Zn | 22.55±1.05 | 28.90±0.10 |
| Ferraria OS*** | Ca | 4955.00±325.00 | 2800.00a |
| UTM | Cd | 0.73±0.03 | 0.79a |
| W - 4190618.4 | Co | 0.39±0.15 | 0.66a |
| N - 600912.1 | Cs | 0.06±0.00 | 0.06a |
| | Cu | 3.20±0.13 | 5.21a |
| | Fe | 489.50±113.50 | 157.00a |
| | Hg | <0.005 | <0.005 |
| | K | 42150.00±2650.00 | 46400.00a |
| | Mg | 6205.00±875.00 | 6500.00a |
| | Mn | 24.20±0.30 | 30.70a |
| | Ni | 7.40±0.60 | 1.80a |
| | Pb | 0.26±0.03 | 0.17a |
| | Rb | 18.40±0.50 | 12.40a |
| | Se | 1.10a | <0.20 |
| | Zn | 261.70±213.30 | 15.80a |
| Porto Formoso*** | Ca | na | na |
| UTM | Cd | na | na |
| W - 4187175.0 | Co | na | na |
| N - 635802.4 | Cs | na | na |
| | Cu | na | na |
| | Fe | na | na |
| | Hg | na | na |
| | K | na | na |
| | Mg | na | na |
| | Mn | na | na |
| | Ni | na | na |
| | Pb | na | na |
| | Rb | na | na |
| | Se | na | na |
| | Zn | na | na |

**Appendix 13 (cont.)** - Element concentration (mean±SE; µg.g-1, dry weight) in algae species collected at each sampling site, their respective UTM coordinates and nature of site (* - non-urban; ** - urban; *** - hydrothermal; na – not available; a – one sample only).

| Sample Site | Element | *Cystoseira humilis* | *Fucus spiralis* |
|---|---|---|---|
| Santo António* | Ca | na | 10750.00±150.00 |
| UTM | Cd | na | 1.19±0.05 |
| W - 4191463.6 | Co | na | 0.25±0.04 |
| N - 614360.0 | Cs | na | 0.12±0.00 |
| | Cu | na | 0.95±0.08 |
| | Fe | na | 24.40±1.10 |
| | Hg | na | 0.01±0.00 |
| | K | na | 31950.00±950.00 |
| | Mg | na | 7900.00±80.00 |
| | Mn | na | 27.95±5.35 |
| | Ni | na | 6.65±0.85 |
| | Pb | na | 0.18±0.00 |
| | Rb | na | 0.18±0.01 |
| | Se | na | <0.20 |
| | Zn | na | 15.20±0.80 |
| Feteiras* | Ca | 9745.00±355.00 | 11300.00±700.00 |
| UTM | Cd | 1.08±0.02 | 1.46±0.22 |
| W - 4182317.7 | Co | 0.24±0.02 | 2.19±1.90 |
| N - 608001.3 | Cs | 0.03±0.00 | 0.13±0.02 |
| | Cu | 0.89±0.06 | 2.42±0.13 |
| | Fe | 86.85±52.15 | 1205.60±1174.40 |
| | Hg | <0.005 | 0.01±0.00 |
| | K | 78350.00±3550.00 | 30100.00±300.00 |
| | Mg | 11300.00±400.00 | 9810.00±2590.00 |
| | Mn | 5.46±1.32 | 37.25±16.05 |
| | Ni | 1.00±0.00 | 19.85±12.85 |
| | Pb | 0.18±0.04 | 0.26±0.04 |
| | Rb | 0.12±0.00 | 0.25±0.02 |
| | Se | <0.20 | <0.20 |
| | Zn | 7.50±0.00 | 116.30±101.70 |
| Ponta Delgada** | Ca | 9030.00±80.00 | 10350.00±150.00 |
| UTM | Cd | 0.16±0.03 | 1.06±0.11 |
| W - 4177899.5 | Co | 0.06±0.00 | 0.41±0.06 |
| N - 618918.4 | Cs | 0.02±0.00 | 0.10±0.02 |
| | Cu | 1.24±0.21 | 2.22±0.08 |
| | Fe | 34.70±3.50 | 281.30±233.70 |
| | Hg | 0.01±0.00 | 0.01±0.00 |
| | K | 74050.00±250.00 | 38650.00±350.00 |
| | Mg | 11900.00±500.00 | 8145.00±295.00 |
| | Mn | 3.54±0.16 | 29.20±3.00 |
| | Ni | 0.60±0.00 | 3.80±0.00 |
| | Pb | 0.20±0.01 | 0.38±0.01 |
| | Rb | 0.09±0.01 | 0.14±0.08 |
| | Se | <0.20 | <0.20 |
| | Zn | 10.95±0.25 | 55.60±1.80 |

**Appendix 13 (cont.)** - Element concentration (mean±SE; µg.g-1, dry weight) in algae species collected at each sampling site, their respective UTM coordinates and nature of site (* - non-urban; ** - urban; *** - hydrothermal; na – not available; a – one sample only).

| Sample Site | Element | *Cystoseira humilis* | *Fucus spiralis* |
|---|---|---|---|
| Lagoa** | Ca | 9420.00±440.00 | 9160.00±260.00 |
| UTM | Cd | 0.38±0.01 | 0.86±0.07 |
| W - 4178146.0 | Co | 0.10±0.00 | 0.23±0.01 |
| N - 624344.6 | Cs | 0.02±0.00 | 0.08±0.00 |
| | Cu | 0.76±0.03 | 0.97±0.02 |
| | Fe | 30.65±3.65 | 39.15±10.95 |
| | K | 94350.00±3150.00 | 46650.00±1550.00 |
| | Hg | <0.005 | 0.01±0.00 |
| | Mg | 12850.00±50.00 | 8285.00±335.00 |
| | Mn | 3.86±0.20 | 14.45±0.45 |
| | Ni | 0.60±0.00 | 2.65±0.05 |
| | Pb | 0.14±0.01 | 0.20±0.01 |
| | Rb | 0.11±0.02 | 0.08±0.02 |
| | Se | <0.2 | <0.2 |
| | Zn | 8.85±0.15 | 23.50±0.40 |
| Ferraria OS*** | Ca | 8660.00±280.00 | 11100.00±200.00 |
| UTM | Cd | 2.34±0.86 | 1.01±0.25 |
| W - 4190618.4 | Co | 0.47±0.01 | 1.14±0.05 |
| N - 600912.1 | Cs | 0.11±0.04 | 0.12±0.01 |
| | Cu | 0.96±0.29 | 1.11±0.18 |
| | Fe | 55.30±1.10 | 68.35±2.75 |
| | Hg | <0.005 | 0.01±0.00 |
| | K | 102950.00±16050.00 | 30800.00±300.00 |
| | Mg | 10850.00±650.00 | 7385.00±275.00 |
| | Mn | 5.77±0.00 | 98.05±2.95 |
| | Ni | 1.35±0.35 | 6.65±0.65 |
| | Pb | 0.16±0.02 | 0.16±0.04 |
| | Rb | 0.27±0.01 | 0.06±0.01 |
| | Se | <0.20 | <0.20 |
| | Zn | 411.00±126.00 | 740.00±350.00 |
| Porto Formoso*** | Ca | na | na |
| UTM | Cd | na | na |
| W - 4187175.0 | Co | na | na |
| N - 635802.4 | Cs | na | na |
| | Cu | na | na |
| | Fe | na | na |
| | Hg | na | na |
| | K | na | na |
| | Mg | na | na |
| | Mn | na | na |
| | Ni | na | na |
| | Pb | na | na |
| | Rb | na | na |
| | Se | na | na |
| | Zn | na | na |

# Appendix 14

Concentration of metals (ppm) in *F.spiralis* samples from the Azores and the British Isles (abbreviations as in Table 5.5).

**Appendix 14** - Concentration of metals (ppm) in *F. spiralis* samples from the Azores and the British Isles (Abbreviations as in Table 5.5).

| Sample | Cd | Cu | Fe | Mg |
|---|---|---|---|---|
| **AZORES** | | | | |
| Blank | ND | ND | 1,330.9 | 631.6 |
| Blank | ND | ND | 424.1 | 479.9 |
| Reference material | 0.330 | 11.1 | 1301.5 | 13310.1 |
| Reference material | 0.112 | 12.0 | 1580.8 | 14279.0 |
| Water Ferraria OS | 0.004 | 0.036 | 0.0 | 1,315.7 |
| Water Ferraria OS | 0.004 | 0.055 | 0.0 | 1,305.8 |
| Water Lagoa | 0.003 | 0.041 | 0.2 | 1,356.7 |
| Water Lagoa | 0.004 | 0.010 | 0.0 | 1,461.4 |
| **Untransplanted** | | | | |
| Lagoa T0 | 0.518 | 1.951 | 101.7 | 9,189.4 |
| Lagoa T0 | 0.530 | 2.246 | 101.0 | 9,065.5 |
| Lagoa T45 | n.a. | n.a. | n.a. | n.a. |
| Lagoa T45 | n.a. | n.a. | n.a. | n.a. |
| Lagoa T90 | n.a. | n.a. | n.a. | n.a. |
| Lagoa T90 | n.a. | n.a. | n.a. | n.a. |
| Mosteiros T0 | 0.497 | 3.491 | 78.3 | 9,275.9 |
| Mosteiros T0 | 0.490 | 4.058 | 85.1 | 10,004.5 |
| Mosteiros T45 | 0.745 | 3.471 | 161.7 | 9,533.3 |
| Mosteiros T45 | 0.817 | 2.964 | 173.0 | 8,958.9 |
| Mosteiros T90 | n.a. | n.a. | n.a. | n.a. |
| Mosteiros T90 | n.a. | n.a. | n.a. | n.a. |
| Ferraria OS T0 | 0.444 | 3.342 | 119.7 | 9,524.9 |
| Ferraria OS T0 | 0.418 | 3.906 | 141.4 | 9,637.4 |
| Ferraria OS T45 | 0.651 | 2.783 | 103.7 | 8,480.5 |
| Ferraria OS T45 | 0.620 | 3.144 | 97.5 | 7,981.9 |
| Ferraria OS T90 | n.a. | n.a. | n.a. | n.a. |
| Ferraria OS T90 | n.a. | n.a. | n.a. | n.a. |
| **Transplanted non-hydrothermal** | | | | |
| Mosteiros - Ferraria OS T45 | 0.701 | 3.383 | 86.8 | 8,364.0 |
| Mosteiros - Ferraria OS T45 | n.a. | n.a. | n.a. | n.a. |
| Ferraria OS - Lagoa T45 | 0.828 | 7.248 | 113.6 | 10,069.9 |
| Ferraria OS - Lagoa T45 | 0.824 | 5.045 | 96.0 | 9,831.0 |
| Lagoa - Mosteiros T45 | 0.938 | 3.379 | 158.5 | 10,006.7 |
| Lagoa - Mosteiros T45 | 0.825 | 3.783 | 151.8 | 9,746.4 |
| Mosteiros - Ferraria OS T90 | n.a. | n.a. | n.a. | n.a. |
| Mosteiros - Ferraria OS T90 | n.a. | n.a. | n.a. | n.a. |
| Ferraria OS - Lagoa T90 | n.a. | n.a. | n.a. | n.a. |
| Ferraria OS - Lagoa T90 | n.a. | n.a. | n.a. | n.a. |
| Lagoa - Mosteiros T90 | 0.583 | 4.206 | 114.3 | 10,009.0 |
| Lagoa - Mosteiros T90 | 0.575 | 3.425 | 100.1 | 9,437.0 |
| **Transplanted hydrothermal** | | | | |
| Mosteiros - Ferraria T45 | 1.157 | 7.340 | 134.1 | 7,421.8 |
| Mosteiros - Ferraria T45 | 0.734 | 3.889 | 92.7 | 8,278.9 |

**Appendix 14 (cont.)** - Concentration of metals (ppm) in *F. spiralis* samples from the Azores and the British Isles (Abbreviations as in Table 5.5).

| Sample | Cd | Cu | Fe | Mg |
|---|---|---|---|---|
| **AZORES (cont.)** | | | | |
| Ferraria OS - Ferraria T45 | 1.185 | 2.810 | 420.2 | 9,539.2 |
| Ferraria OS - Ferraria T45 | 1.223 | 2.960 | 468.4 | 10,489.4 |
| Lagoa - Ferraria T45 | 1.309 | 6.157 | 123.7 | 8,457.1 |
| Lagoa - Ferraria T45 | 0.820 | 3.340 | 85.7 | 3,995.4 |
| Mosteiros - Ferraria T90 | 1.133 | 7.085 | 639.4 | 7,621.4 |
| Mosteiros - Ferraria T90 | 2.080 | 8.193 | 656.2 | 12,881.0 |
| Ferraria OS - Ferraria T90 | 1.566 | 7.078 | 1,108.2 | 10,748.2 |
| Ferraria OS - Ferraria T90 | n.a. | n.a. | n.a. | n.a. |
| Lagoa - Ferraria T90 | 1.871 | 7.936 | 3,196.0 | 11,619.0 |
| Lagoa - Ferraria T90 | n.a. | n.a. | n.a. | n.a. |
| **BRITISH ISLES** | | | | |
| **Clean** | | | | |
| North Shian | 0.77 | 4.31 | 397.1 | 9288.2 |
| North Shian | 0.90 | 3.14 | 355.6 | 9430.8 |
| Seil Sound | 0.72 | 3.88 | 863.0 | 10540.7 |
| Seil Sound | 0.63 | 3.58 | 820.7 | 9862.6 |
| Featherbed Rocks | 0.66 | 3.15 | 119.4 | 10608.7 |
| Featherbed Rocks | 0.63 | 3.27 | 107.4 | 10875.8 |
| Kilchiaran | 0.85 | 1.49 | 160.9 | 10250.3 |
| Kilchiaran | 0.80 | 1.03 | 134.2 | 10037.0 |
| South Wick | 1.09 | 1.20 | 301.8 | 9836.1 |
| South Wick | 0.96 | 1.07 | 286.1 | 9830.9 |
| St. Margaret's Hope | 1.00 | 0.81 | 129.6 | 11074.9 |
| St. Margaret's Hope | 1.04 | 0.87 | 176.8 | 10299.6 |
| Bay of Skaill | 1.16 | 1.43 | 222.5 | 10481.8 |
| Bay of Skaill | 1.02 | 1.15 | 80.0 | 10250.2 |
| **Ports** | | | | |
| Port Ellen | 0.82 | 2.45 | 305.6 | 11071.2 |
| Port Ellen | 0.82 | 2.09 | 283.9 | 10827.6 |
| Port Charlotte | 0.70 | 2.39 | 129.1 | 10843.5 |
| Port Charlotte | 0.68 | 2.57 | 143.7 | 11087.7 |
| Portnahaven | 0.72 | 1.25 | 79.3 | 11639.0 |
| Portnahaven | 0.75 | 1.31 | 73.7 | 11432.0 |
| **Rivermouths** | | | | |
| Tynemouth | 0.71 | 1.57 | 186.2 | 10513.0 |
| Tynemouth | 0.73 | 1.71 | 199.0 | 11240.3 |
| Seaton Sluice | 0.64 | 2.37 | 145.7 | 9874.4 |
| Seaton Sluice | 0.62 | 2.48 | 168.1 | 9345.7 |
| **Distilleries** | | | | |
| Lagavulin (near) | 0.86 | 4.80 | 575.5 | 9798.9 |
| Lagavulin (near) | 0.81 | 4.45 | 600.1 | 10158.3 |
| Lagavulin (far) | 0.78 | 2.45 | 181.6 | 11410.2 |
| Lagavulin (far) | 0.73 | 2.50 | 166.9 | 10073.6 |

**Appendix 14 (cont.)** - Concentration of metals (ppm) in *F. spiralis* samples from the Azores and the British Isles (Abbreviations as in Table 5.5).

| Sample | Cd | Cu | Fe | Mg |
|---|---|---|---|---|
| **BRITISH ISLES (cont.)** | | | | |
| **Coal Mines** | | | | |
| Blackhall | 0.84 | 6.49 | 807.2 | 11122.7 |
| Blackhall | 0.87 | 7.68 | 814.1 | 12455.9 |
| St. Monans (100m) | 0.78 | 2.69 | 1847.8 | 10053.5 |
| St. Monans (100m) | 0.84 | 2.63 | 1979.1 | 9935.5 |
| St. Monans (50m) | 2.26 | 2.00 | 10307.7 | 8198.0 |
| St. Monans (50m) | 3.08 | 2.63 | 14968.3 | 10744.8 |
| St. Monans (0m) | 3.07 | 1.70 | 16416.1 | 9797.8 |
| St. Monans (0m) | 3.21 | 2.13 | 16721.5 | 10297.6 |

**Appendix 14 (cont.)** - Concentration of metals (ppm) in *F. spiralis* samples from the Azores and the British Isles (Abbreviations as in Table 5.5).

| Sample | Mn | Ni | Zn |
|---|---|---|---|
| **AZORES** | | | |
| Blank | ND | 0.12 | 1.94 |
| Blank | ND | 0.08 | 0.51 |
| Reference material | 1919.8 | 12.15 | 44.16 |
| Reference material | 2181.3 | 13.64 | 50.57 |
| Water Ferraria OS | 0.3 | 0.01 | 0.05 |
| Water Ferraria OS | 0.3 | 0.02 | 0.08 |
| Water Lagoa | 0.0 | 0.01 | 0.12 |
| Water Lagoa | 0.0 | 0.01 | 0.11 |
| **Untransplanted** | | | |
| Lagoa T0 | 31.4 | 6.204 | 18.181 |
| Lagoa T0 | 29.9 | 6.106 | 17.788 |
| Lagoa T45 | n.a. | n.a. | n.a. |
| Lagoa T45 | n.a. | n.a. | n.a. |
| Lagoa T90 | n.a. | n.a. | n.a. |
| Lagoa T90 | n.a. | n.a. | n.a. |
| Mosteiros T0 | 45.5 | 7.240 | 17.299 |
| Mosteiros T0 | 46.5 | 7.924 | 17.833 |
| Mosteiros T45 | 64.9 | 14.032 | 17.469 |
| Mosteiros T45 | 70.1 | 14.286 | 23.355 |
| Mosteiros T90 | n.a. | n.a. | n.a. |
| Mosteiros T90 | n.a. | n.a. | n.a. |
| Ferraria OS T0 | 124.0 | 12.720 | 21.498 |
| Ferraria OS T0 | 124.1 | 7.047 | 21.059 |
| Ferraria OS T45 | 183.5 | 12.768 | 58.431 |
| Ferraria OS T45 | 168.7 | 11.878 | 48.748 |
| Ferraria OS T90 | n.a. | n.a. | n.a. |
| Ferraria OS T90 | n.a. | n.a. | n.a. |
| **Transplanted non-hydrothermal** | | | |
| Mosteiros - Ferraria OS T45 | 80.6 | 11.222 | 26.806 |
| Mosteiros - Ferraria OS T45 | n.a. | n.a. | n.a. |
| Ferraria OS - Lagoa T45 | 121.3 | 12.294 | 38.244 |
| Ferraria OS - Lagoa T45 | 107.8 | 10.767 | 33.741 |
| Lagoa - Mosteiros T45 | 52.3 | 9.134 | 43.946 |
| Lagoa - Mosteiros T45 | 56.8 | 9.976 | 45.747 |
| Mosteiros - Ferraria OS T90 | n.a. | n.a. | n.a. |
| Mosteiros - Ferraria OS T90 | n.a. | n.a. | n.a. |
| Ferraria OS - Lagoa T90 | n.a. | n.a. | n.a. |
| Ferraria OS - Lagoa T90 | n.a. | n.a. | n.a. |
| Lagoa - Mosteiros T90 | 52.8 | 7.235 | 35.831 |
| Lagoa - Mosteiros T90 | 52.4 | 6.509 | 30.222 |
| **Transplanted hydrothermal** | | | |
| Mosteiros - Ferraria T45 | 1,538.1 | 16.417 | 63.980 |
| Mosteiros - Ferraria T45 | 91.8 | 12.395 | 28.548 |

**Appendix 14 (cont.)** - Concentration of metals (ppm) in *F. spiralis* samples from the Azores and the British Isles (Abbreviations as in Table 5.5).

| Sample | Mn | Ni | Zn |
|---|---|---|---|
| **AZORES (cont.)** | | | |
| Ferraria OS - Ferraria T45 | 2,416.3 | 17.946 | 47.851 |
| Ferraria OS - Ferraria T45 | 2,680.8 | 19.344 | 49.062 |
| Lagoa - Ferraria T45 | 1,895.2 | 15.610 | 88.045 |
| Lagoa - Ferraria T45 | 947.5 | 8.139 | 60.203 |
| Mosteiros - Ferraria T90 | 2,228.7 | 12.417 | 45.483 |
| Mosteiros - Ferraria T90 | 3,012.8 | 19.545 | 97.033 |
| Ferraria OS - Ferraria T90 | 36.7 | 17.416 | 65.711 |
| Ferraria OS - Ferraria T90 | n.a. | n.a. | n.a. |
| Lagoa - Ferraria T90 | 44.6 | 21.616 | 67.960 |
| Lagoa - Ferraria T90 | n.a. | n.a. | n.a. |
| **BRITISH ISLES** | | | |
| **Clean** | | | |
| North Shian | 117.9 | 4.95 | 41.6 |
| North Shian | 124.6 | 3.99 | 31.7 |
| Seil Sound | 126.8 | 3.18 | 36.3 |
| Seil Sound | 118.4 | 3.16 | 32.9 |
| Featherbed Rocks | 66.3 | 3.71 | 59.3 |
| Featherbed Rocks | 56.2 | 3.33 | 45.4 |
| Kilchiaran | 52.2 | 4.92 | 28.1 |
| Kilchiaran | 54.6 | 3.96 | 26.6 |
| South Wick | 60.6 | 3.22 | 33.8 |
| South Wick | 58.7 | 2.98 | 30.5 |
| St. Margaret's Hope | 94.4 | 2.71 | 20.7 |
| St. Margaret's Hope | 92.2 | 3.03 | 22.5 |
| Bay of Skaill | 44.3 | 4.67 | 20.4 |
| Bay of Skaill | 40.0 | 4.60 | 20.5 |
| **Ports** | | | |
| Port Ellen | 150.9 | 3.67 | 54.4 |
| Port Ellen | 145.6 | 3.55 | 55.0 |
| Port Charlotte | 93.4 | 3.43 | 29.7 |
| Port Charlotte | 98.1 | 3.80 | 30.0 |
| Portnahaven | 43.6 | 2.84 | 24.8 |
| Portnahaven | 40.6 | 2.66 | 23.6 |
| **Rivermouths** | | | |
| Tynemouth | 118.5 | 3.29 | 134.5 |
| Tynemouth | 148.3 | 3.50 | 149.0 |
| Seaton Sluice | 85.0 | 4.39 | 48.5 |
| Seaton Sluice | 86.2 | 4.92 | 43.4 |
| **Distilleries** | | | |
| Lagavulin (near) | 249.2 | 3.88 | 46.6 |
| Lagavulin (near) | 270.6 | 3.67 | 43.9 |
| Lagavulin (far) | 119.5 | 4.51 | 32.3 |
| Lagavulin (far) | 108.8 | 4.43 | 30.3 |

**Appendix 14 (cont.)** - Concentration of metals (ppm) in *F. spiralis* samples from the Azores and the British Isles (Abbreviations as in Table 5.5).

| Sample | Mn | Ni | Zn |
|---|---|---|---|
| **BRITISH ISLES (cont.)** | | | |
| **Coal Mines** | | | |
| Blackhall | 142.3 | 10.78 | 44.4 |
| Blackhall | 164.9 | 12.00 | 50.1 |
| St. Monans (100m) | 152.9 | 12.04 | 60.4 |
| St. Monans (100m) | 118.5 | 12.65 | 65.4 |
| St. Monans (50m) | 171.4 | 13.72 | 92.4 |
| St. Monans (50m) | 203.4 | 15.58 | 128.5 |
| St. Monans (0m) | 203.7 | 14.92 | 144.3 |
| St. Monans (0m) | 202.1 | 14.17 | 139.2 |

# Appendix 15

Published papers within the scope of the Present thesis:

Wallenstein, F. M., Couto, R. P., Amaral, A. S., Wilkinson, M., Neto, A. I. and Rodrigues, A. S., 2009a. Baseline metal concentrations in marine algae from São Miguel (Azores) under different ecological conditions – Urban proximity and shallow water hydrothermal activity. *Marine Pollution Bulletin*, **58**: 424-455.

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# Baseline metal concentrations in marine algae from São Miguel (Azores) under different ecological conditions – Urban proximity and shallow water hydrothermal activity

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Algae are amongst the more suitable organisms for studies of heavy metal contamination in aquatic ecosystems. They have often been used as bioindicators for metal pollution in seawater because of their sessile nature, longevity, metal accumulation capacity and presence at sites prone to pollution (Abdallah et al., 2005; Mohamed and Khaled, 2005; Misheer et al., 2006; Chaudhuri et al., 2007). The Azores archipelago comprises nine islands and is located in the North Atlantic Ocean at the triple junction of the Eurasian, African and North American plates. São Miguel Island (Fig. 1) is the largest and the more populated island. Although remote from heavy industrial activity, São Miguel Island's expanding tourism has led to strong urban development in the last 20 years, thus increasing the potential sources of seawater contaminants (e.g. marinas, commercial harbours and sewage treatment facilities). In the less urbanized areas there is intensive agricultural exploitation of soils, and pasture for cattle dominates the rural landscape and strongly depends on the use of fertilizers and pesticides, which in turn contribute to the input of metals into seawater during rainy seasons (Cunha et al., 2008). A striking feature of these islands, however, is the presence of active shallow water hydrothermal activity as a result of their volcanic nature. The Azores thus provide a natural laboratory for studies, not only on heavy metal enriched environments, but also on environments with increased acidity and temperature. Such habitats are naturally enriched in terms of heavy metals, and thus provide valuable examples of naturally polluted sites to compare with those that are affected by human pollution. Although there have been other studies on the availability of trace metals in this type of environment (Weeks et al., 1995; Amaral et al., 2006, 2007; Zaldibar et al., 2006; Cunha et al., 2008), intertidal macroalgae communities have not been the main object of study.

The aim of this study was to provide baseline levels of a selected pool of elements for intertidal algae that occur abundantly on rocky shores around São Miguel Island (Azores), and compare results from non-urban sites with those affected by urban development or by shallow water hydrothermal activity. Coastal shallow water hydrothermally active sites are not common around the Globe. Consequently, information on macroalgal communities occurring in such specific environments provides a valuable tool for future research, not only to compare with sites that are artificially enriched with heavy metals (polluted), but also to assess

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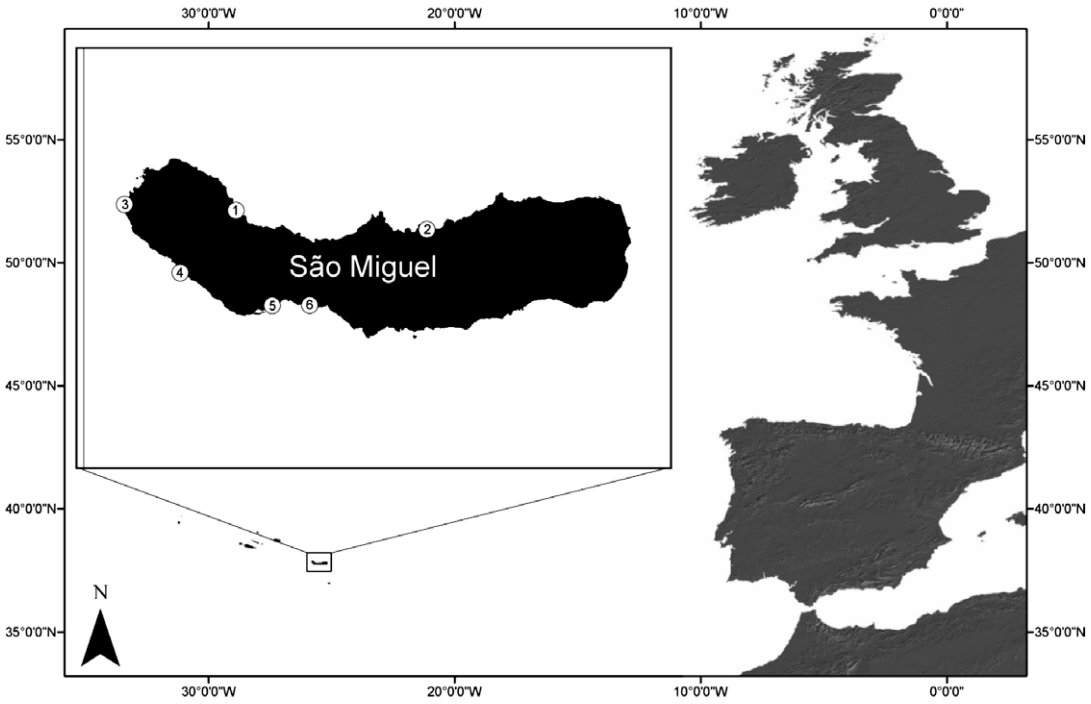


**Fig. 1.** São Miguel Island, Azores and location of the sampling sites: 1 – Santo António; 2 – Porto Formoso; 3 – Ferraria; 4 – Feteiras; 5 – Ponta Delgada; 6 – Lagoa (see Table 1 for geographic coordinates).

the impact of increased temperature and acidity on such communities.

Sampling stations were selected to represent three different ecological conditions: (i) non-urban – away from major urban development; (ii) urban – next to major urban development; and (iii) hydrothermal – adjacent to shallow water hydrothermal activity (Table 1). At each station the selection of biological material was carried out according to the following criteria: (a) abundant throughout the area of study and (b) taxonomically easy to identify and collect. Two samples of approximately 300 g wet weight of each species were collected from two distinct areas at each sampling site on one occasion from February to April 2007. Samples were taken to the laboratory, washed with seawater collected at the sampling site to remove particulate matter, scrubbed with a soft nylon brush to remove epiphytes and epifaunal species and rinsed very briefly with distilled water to remove traces of salt. They were then dried at 80 °C to constant weight, stored in sterile Eppendorf tubes, labelled and shipped to "Activation Laboratories Ltd." (Ancaster, Canada) for analysis by high resolution inductively coupled plasma mass spectrometry (HR-ICP-MS). Each sample was split into 10 microwave digestion vessels (0.5 g of dried sample in each) to which 5 ml of optima $HNO_3$ and 3 ml of $H_2O_2$ were added. After one hour in the fume hood to let the foaming subside, vessels were closed and subject to the microwave digestion program VEG1 (Table 2), then cooled down to room temperature, opened, 0.1 HF and 3.5 ml HCl added, closed and subject to the digestion program VEG2 (Table 2). One empty vessel was used in each batch of digestion for blank measurement and one vessel with 0.5 g of NIST SRM 1575a (Pine needles reference material) for validation of digestion methods. Microwave digestion vessels, caps and accessories were washed with detergent, rinsed with DI water, cleaned with 5 ml of concentrated $H_2NO_3$ and 3 ml $H_2O_2$ in the microwave (CLEAN program; Table 2), and rinsed again with DI water. Species for trace metal load analysis were selected only when present at least in one sampling site of each ecological condition. Concentrations of Ca, Cd, Co, Cs, Cu, Fe, Hg, K, Mg, Mn, Ni, Pb, Rb, Se and Zn were determined and results expressed in $\mu g\ g^{-1}$.

For each element, values were standardized as a proportion of the maximum concentration in all samples using the software PRIMER v6 (Clarke and Gorley, 2006). Species presence and abundance differed greatly among sites, thus resulting in a pool of data that is unbalanced regarding the factor "ecological condition". Consequently, ANOSIM tests were not significant due to a low number of possible permutations on which the test is based, and nMDS was used instead to visualize patterns of metal accumulation according to the ecological condition classes considered. Principal coordinate analysis (PCO) was used to visualize patterns of metal concentration associated with the different species sampled.

Due to the need to satisfy all selection criteria, only four species of Rhodophyta (*Corallina elongata* J. Ellis and Solander, *Gelidium microdon* Kützing, *Osmundea truncata* (Kützing) K.W. Nam and Maggs, and *Porphyra* sp. C. Agardh) and two Phaeophyta (*Cystoseira humilis* Schousboe ex Kützing, and *Fucus spiralis* Linnaeus) were included in the present study. *Corallina elongata* was the only species present at all sampling sites (Table 1). *Fucus spiralis* and *G. microdon* were present at five sites, *C. humilis* and *Porphyra* sp. at four sites and *O. truncata* occurred only at three sites. For each ecological condition there was only one site where all species occurred. The second hydrothermal site presented only one of the selected species, while both the non-urban and the urban sites presented four of the selected species, most of them in common.

Although metal load values in all species across all sites were highly variable (Table 1), Ca, Fe and Mg concentrations were generally the highest, with Mn and Zn the next highest. Se and Hg were in most cases below the detection limit.

There was no evident pattern of metal accumulation associated to a specific ecological condition class (Fig. 2). However, hydrothermal activity appears to increase Mn, Rb and Zn levels in *C. elongata*, Pb in *G. microdon*, Cd, Cu and Zn in *C. humilis*, Se in *O. truncata* and Zn in *F. spiralis* (Table 1). Proximity to urban areas seemed to raise

**Table 1**
Element concentration (mean ± SE; μg $g^{-1}$, dry weight) in algae species collected at each sampling site, their respective geographic coordinates and ecological condition ( * – non-urban; ** – urban; *** – hydrothermal; na – not available; a – one sample only).

| Sample site | Element | *Corallina elongata* | *Gelidium microdon* | *Osmundea truncata* | *Porphyra* sp | *Cystoseira humilis* | *Fucus spiralis* |
|---|---|---|---|---|---|---|---|
| Santo | Ca | 257000.00 ± 10000.00 | 1087.50 ± 312.50 | na | 2175.00 ± 155.00 | na | 10750.00 ± 150.00 |
| António* | Cd | 0.15 ± 0.00 | 0.29 ± 0.10 | na | 0.41 ± 0.00 | na | 1.19 ± 0.05 |
| N37° 51' 48.5" | Co | 0.05 ± 0.01 | 0.11 ± 0.03 | na | 0.08 ± 0.01 | na | 0.25 ± 0.04 |
| W25° 41' 59.6" | Cs | 0.02 ± 0.00 | 0.02 ± 0.01 | na | 0.01 ± 0.00 | na | 0.12 ± 0.00 |
| | Cu | 1.23 ± 0.69 | 1.34 ± 0.32 | na | 3.26 ± 0.09 | na | 0.95 ± 0.08 |
| | Fe | 45.75 ± 10.95 | 48.80 ± 3.80 | na | 53.25 ± 8.65 | na | 24.40 ± 1.10 |
| | Hg | <0.005 | 0.01 ± 0.00 | na | <0.005 | na | 0.01 ± 0.00 |
| | K | 5210.00 ± 250.00 | 14585.00 ± 5315.00 | na | 32350.00 ± 650.00 | na | 31950.00 ± 950.00 |
| | Mg | 26550.00 ± 350.00 | 1805.00 ± 525.00 | na | 5785.00 ± 585.00 | na | 7900.00 ± 80.00 |
| | Mn | 8.32 ± 0.54 | 12.10 ± 1.40 | na | 11.45 ± 0.15 | na | 27.95 ± 5.35 |
| | Ni | 0.60 ± 0.00 | 4.45 ± 0.45 | na | 1.00 ± 0.00 | na | 6.65 ± 0.85 |
| | Pb | 0.17 ± 0.03 | 0.09 ± 0.00 | na | 0.17 ± 0.01 | na | 0.18 ± 0.00 |
| | Rb | 0.08 ± 0.00 | 6.12 ± 2.36 | na | 5.12 ± 0.04 | na | 0.18 ± 0.01 |
| | Se | <0.20 | 0.20[a] | na | 0.20[a] | na | <0.20 |
| | Zn | 12.90 ± 0.00 | 17.60 ± 5.30 | na | 9.85 ± 0.65 | na | 15.20 ± 0.80 |
| Feteiras* | Ca | 241500.00 ± 5500.00 | 1280.00 ± 10.00 | 6315.00 ± 215.00 | 3085.00 ± 515.00 | 9745.00 ± 355.00 | 11300.00 ± 700.00 |
| N37° 46' 54.6" | Cd | 0.34 ± 0.00 | 0.34 ± 0.02 | 0.68 ± 0.03 | 1.01 ± 0.03 | 1.08 ± 0.02 | 1.46 ± 0.22 |
| W25° 46' 24.7" | Co | 0.37 ± 0.29 | 0.18 ± 0.01 | 0.21 ± 0.04 | 0.24 ± 0.04 | 0.24 ± 0.02 | 2.19 ± 1.90 |
| | Cs | 0.03 ± 0.01 | 0.03 ± 0.00 | 0.05 ± 0.00 | 0.01 ± 0.00 | 0.03 ± 0.00 | 0.13 ± 0.02 |
| | Cu | 1.11 ± 0.11 | 4.19 ± 0.60 | 4.14 ± 0.29 | 6.74 ± 0.04 | 0.89 ± 0.06 | 2.42 ± 0.13 |
| | Fe | 797.15 ± 772.85 | 72.95 ± 6.45 | 168.00 ± 58.00 | 322.50 ± 87.50 | 86.85 ± 52.15 | 1205.60 ± 1174.40 |
| | Hg | <0.005 | 0.01 ± 0.00 | <0.005 | <0.005 | <0.005 | 0.01 ± 0.00 |
| | K | 4125.00 ± 25.00 | 15600.00 ± 0.00 | 39150.00 ± 250.00 | 26700.00 ± 300.00 | 78350.00 ± 3550.00 | 30100.00 ± 300.00 |
| | Mg | 25400.00 ± 400.00 | 2060.00 ± 60.00 | 3035.00 ± 565.00 | 4485.00 ± 195.00 | 11300.00 ± 400.00 | 9810.00 ± 2590.00 |
| | Mn | 28.83 ± 22.37 | 10.65 ± 0.25 | 20.20 ± 1.10 | 23.45 ± 0.95 | 5.46 ± 1.32 | 37.25 ± 16.05 |
| | Ni | 1.30 ± 0.90 | 8.40 ± 0.70 | 8.15 ± 0.15 | 1.25 ± 0.15 | 1.00 ± 0.00 | 19.85 ± 12.85 |
| | Pb | 0.40 ± 0.22 | 0.25 ± 0.15 | 0.17 ± 0.01 | 0.10 ± 0.01 | 0.18 ± 0.04 | 0.26 ± 0.04 |
| | Rb | 0.19 ± 0.16 | 6.70 ± 0.02 | 18.40 ± 0.30 | 5.71 ± 0.00 | 0.12 ± 0.00 | 0.25 ± 0.02 |
| | Se | <0.20 | <0.20 | 0.20[a] | <0.20 | <0.20 | <0.20 |
| | Zn | 8.35 ± 1.55 | 29.20 ± 4.70 | 14.30 ± 0.40 | 13.25 ± 0.95 | 7.50 ± 0.00 | 116.30 ± 101.70 |
| Ponta | Ca | 231500.00 ± 3500.00 | 1845.00 ± 135.00 | na | na | 9030.00 ± 80.00 | 10350.00 ± 150.00 |
| Delgada** | Cd | 0.07 ± 0.00 | 0.21 ± 0.00 | na | na | 0.16 ± 0.03 | 1.06 ± 0.11 |
| N37° 44' 26.4" | Co | 0.23 ± 0.08 | 0.27 ± 0.05 | na | na | 0.06 ± 0.00 | 0.41 ± 0.06 |
| W25° 39' 01.1" | Cs | 0.02 ± 0.00 | 0.03 ± 0.00 | na | na | 0.02 ± 0.00 | 0.10 ± 0.02 |
| | Cu | 1.18 ± 0.15 | 6.60 ± 0.09 | na | na | 1.24 ± 0.21 | 2.22 ± 0.08 |
| | Fe | 513.50 ± 161.50 | 336.50 ± 119.50 | na | na | 34.70 ± 3.50 | 281.30 ± 233.70 |
| | Hg | <0.005 | 0.01 ± 0.00 | na | na | 0.01 ± 0.00 | 0.01 ± 0.00 |
| | K | 5060.00 ± 10.00 | 19550.00 ± 550.00 | na | na | 74050.00 ± 250.00 | 38650.00 ± 350.00 |
| | Mg | 22400.00 ± 700.00 | 2025.00 ± 65.00 | na | na | 11900.00 ± 500.00 | 8145.00 ± 295.00 |
| | Mn | 15.30 ± 2.90 | 18.60 ± 2.70 | na | na | 3.54 ± 0.16 | 29.20 ± 3.00 |
| | Ni | 0.85 ± 0.15 | 7.60 ± 0.60 | na | na | 0.60 ± 0.00 | 3.80 ± 0.00 |
| | Pb | 0.50 ± 0.01 | 0.41 ± 0.05 | na | na | 0.20 ± 0.01 | 0.38 ± 0.01 |
| | Rb | 0.02 ± 0.01 | 7.88 ± 0.07 | na | na | 0.09 ± 0.01 | 0.14 ± 0.08 |
| | Se | <0.20 | <0.20 | na | na | <0.20 | <0.20 |
| | Zn | 29.25 ± 1.35 | 105.00 ± 1.00 | na | na | 10.95 ± 0.25 | 55.60 ± 1.80 |
| Lagoa** | Ca | 234000.00 ± 4000.00 | 1620.00 ± 180.00 | 14050.00 ± 2550.00 | 8550.00 ± 10.00 | 9420.00 ± 440.00 | 9160.00 ± 260.00 |
| N37° 44' 31.8" | Cd | 0.26 ± 0.07 | 0.45 ± 0.03 | 0.53 ± 0.04 | 1.05 ± 0.00 | 0.38 ± 0.01 | 0.86 ± 0.07 |
| W25° 35' 19.3" | Co | 0.21 ± 0.10 | 0.20 ± 0.02 | 0.62 ± 0.10 | 0.15 ± 0.00 | 0.10 ± 0.00 | 0.23 ± 0.01 |
| | Cs | 0.02 ± 0.00 | 0.03 ± 0.00 | 0.05 ± 0.00 | 0.01 ± 0.00 | 0.02 ± 0.00 | 0.08 ± 0.00 |
| | Cu | 0.98 ± 0.17 | 4.11 ± 0.39 | 3.41 ± 0.27 | 7.49 ± 0.15 | 0.76 ± 0.03 | 0.97 ± 0.02 |
| | Fe | 335.00 ± 167.00 | 107.70 ± 24.30 | 971.50 ± 38.50 | 116.00 ± 1.00 | 30.65 ± 3.65 | 39.15 ± 10..95 |
| | K | 3305.00 ± 305.00 | 21050.00 ± 950.00 | 55700.00 ± 2500.00 | 40450.00 ± 550.00 | 94350.00 ± 3150.00 | 46650.00 ± 1550.00 |
| | Hg | <0.005 | 0.01 ± 0.00 | <0.005 | <0.005 | <0.005 | 0.01 ± 0.00 |
| | Mg | 21750.00 ± 250.00 | 2045.00 ± 55.00 | 7545.00 ± 525.00 | 4235.00 ± 165.00 | 12850.00 ± 50.00 | 8285.00 ± 335.00 |
| | Mn | 11.83 ± 2.38 | 13.70 ± 1.10 | 25.45 ± 0.55 | 22.85 ± 0.75 | 3.86 ± 0.20 | 14.45 ± 0.45 |
| | Ni | 0.80 ± 0.20 | 7.35 ± 0.85 | 10.60 ± 0.80 | 1.10 ± 0.00 | 0.60 ± 0.00 | 2.65 ± 0.05 |
| | Pb | 0.45 ± 0.05 | 0.17 ± 0.02 | 0.56 ± 0.09 | 0.18 ± 0.01 | 0.14 ± 0.01 | 0.20 ± 0.01 |
| | Rb | 0.49 ± 0.08 | 7.69 ± 0.41 | 20.65 ± 0.85 | 5.63 ± 0.03 | 0.11 ± 0.02 | 0.08 ± 0.02 |
| | Se | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| | Zn | 14.40 ± 3.30 | 42.35 ± 3.15 | 22.55 ± 1.05 | 28.90 ± 0.10 | 8.85 ± 0.15 | 23.50 ± 0.40 |
| Ferraria*** | Ca | 251500.00 ± 5500.00 | 1385.00 ± 95.00 | 4955.00 ± 325.00 | 2800.00[a] | 8660.00 ± 280.00 | 11100.00 ± 200.00 |
| N37° 51' 26.8" | Cd | 0.10 ± 0.01 | 0.32 ± 0.02 | 0.73 ± 0.03 | 0.79[a] | 2.34 ± 0.86 | 1.01 ± 0.25 |
| W25° 51' 10.3" | Co | 0.18 ± 0.04 | 0.79 ± 0.04 | 0.39 ± 0.15 | 0.66[a] | 0.47 ± 0.01 | 1.14 ± 0.05 |
| | Cs | 0.01 ± 0.00 | 0.03 ± 0.00 | 0.06 ± 0.00 | 0.06[a] | 0.11 ± 0.04 | 0.12 ± 0.01 |
| | Cu | 0.71 ± 0.14 | 4.18 ± 0.20 | 3.20 ± 0.13 | 5.21[a] | 0.96 ± 0.29 | 1.11 ± 0.18 |
| | Fe | 263.50 ± 13.50 | 1060.50 ± 159.50 | 489.50 ± 113.50 | 157.00[a] | 55.30 ± 1.10 | 68.35 ± 2.75 |
| | Hg | <0.005 | 0.01 ± 0.00 | <0.005 | <0.005 | <0.005 | 0.01 ± 0.00 |
| | K | 3660.00 ± 330.00 | 16850.00 ± 1950.00 | 42150.00 ± 2650.00 | 46400.00[a] | 102950.00 ± 16050.00 | 30800.00 ± 300.00 |
| | Mg | 22200.00 ± 200.00 | 2215.00 ± 25.00 | 6205.00 ± 875.00 | 6500.00[a] | 10850.00 ± 650.00 | 7385.00 ± 275.00 |
| | Mn | 26.30 ± 4.20 | 29.10 ± 1.40 | 24.20 ± 0.30 | 30.70[a] | 5.77 ± 0.00 | 98.05 ± 2.95 |
| | Ni | 0.45 ± 0.05 | 15.05 ± 1.85 | 7.40 ± 0.60 | 1.80[a] | 1.35 ± 0.35 | 6.65 ± 0.65 |
| | Pb | 0.29 ± 0.03 | 0.83 ± 0.20 | 0.26 ± 0.03 | 0.17[a] | 0.16 ± 0.02 | 0.16 ± 0.04 |
| | Rb | 0.41 ± 0.04 | 7.83 ± 1.07 | 18.40 ± 0.50 | 12.40[a] | 0.27 ± 0.01 | 0.06 ± 0.01 |
| | Se | <0.20 | 0.30[a] | 1.10[a] | <0.20 | <0.20 | <0.20 |

Table 1 (*continued*)

| Sample site | Element | *Corallina elongata* | *Gelidium microdon* | *Osmundea truncata* | *Porphyra* sp | *Cystoseira humilis* | *Fucus spiralis* |
|---|---|---|---|---|---|---|---|
| | Zn | 34.80 ± 28.20 | 39.35 ± 8.25 | 261.70 ± 213.30 | 15.80[a] | 411.00 ± 126.00 | 740.00 ± 350.00 |
| Porto Formoso *** N37° 49' 18.8" W25° 27' 25.2" | Ca | 260500.00 ± 500.00 | na | na | na | na | na |
| | Cd | 0.03 ± 0.00 | na | na | na | na | na |
| | Co | 0.05 ± 0.01 | na | na | na | na | na |
| | Cs | 0.01 ± 0.00 | na | na | na | na | na |
| | Cu | 0.24 ± 0.00 | na | na | na | na | na |
| | Fe | 94.75 ± 8.25 | na | na | na | na | na |
| | Hg | <0.005 | na | na | na | na | na |
| | K | 2945.00 ± 525.00 | na | na | na | na | na |
| | Mg | 22350.00 ± 250.00 | na | na | na | na | na |
| | Mn | 59.55 ± 9.05 | na | na | na | na | na |
| | Ni | 0.30 ± 0.00 | na | na | na | na | na |
| | Pb | 0.14 ± 0.02 | na | na | na | na | na |
| | Rb | 0.51 ± 0.20 | na | na | na | na | na |
| | Se | <0.2 | na | na | na | na | na |
| | Zn | 38.80 ± 7.10 | na | na | na | na | na |

**Table 2**
Microwave digestion programs.

| Program | Stage | Power (Watts) | Pressure (PSI) | Time (min) | Time at pressure (min) | Fan speed ($m^3$ per min) |
|---|---|---|---|---|---|---|
| CLEAN | 1 | 190 | 20 | 15 | 10 | 3.6 |
| | 2 | 513 | 50 | 15 | 10 | 3.6 |
| | 3 | 513 | 100 | 15 | 10 | 3.6 |
| | 4 | 513 | 100 | 15 | 10 | 3.6 |
| | 5 | 190 | 20 | 15 | 10 | 3.6 |
| VEG1 | 1 | 190 | 20 | 15 | 10 | 3.6 |
| | 2 | 522.5 | 50 | 15 | 10 | 3.6 |
| | 3 | 570 | 75 | 15 | 10 | 3.6 |
| VEG2 | 1 | 190 | 20 | 15 | 10 | 3.6 |
| | 2 | 522.5 | 50 | 15 | 10 | 3.6 |
| | 3 | 665 | 80 | 15 | 10 | 3.6 |
| | 4 | 760 | 100 | 15 | 10 | 3.6 |

**Fig. 2.** nmMDS plot (stress 0.16) for all samples labelled according to the ecological condition of the site where they were collected (circles – urban; triangles – non-urban; squares – hydrothermal).

the Pb levels in *C. elongata*, Hg in *C. humilis*, Fe, Pb and Rb in *O. truncata*, and Cu in *Porphyra* sp. (Table 1).

Differences between species appeared to reflect their affinities with different elements (Fig. 3): *C. humilis* was the only species scoring along the Cd axis; *F. spiralis* and *C. elongata* the two species scoring higher along the Mg, Ca, Zn, and Mn axes; and *O. truncata*, *G. microdon* and *Porphyra* sp. were the species that score highest on the Cu and Rb axes.

Unlike Northern European sheltered and moderately exposed shores characterised by large canopy-forming brown algae, rocky intertidal communities of the Azores are dominated by compact mats of turf forming algae with foliose and frondose algae present only at the lowest level, in the transition to the subtidal (Neto, 2000, 2001). It is thus not surprising to have a reduced pool of species that are exuberant enough to be easily identified and collected in sufficient amount for metal analysis. The fact that a larger proportion of red algae rather than brown algae were selected reflects the dominance of red algae over the remaining flora, which is a general characteristic of warm water areas of the North Atlantic (Neto et al., 2005).

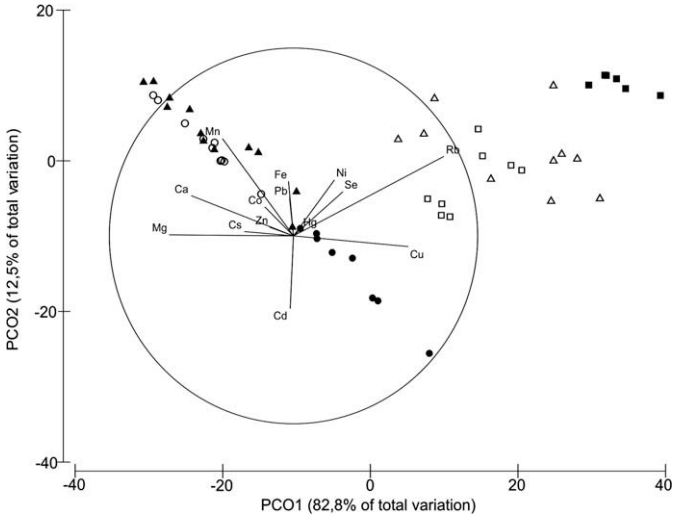


**Fig. 3.** Correlations of several chemical elements with the two PCO axes and with samples of several species (black triangles – *Corallina elongata*; white triangles – *Gelidium microdon*; black circles – *Cystoseira humilis*; white circles – *Fucus spiralis*; black squares – *Osmundea truncata*; white squares – *Porphyra* sp.).

Shallow water hydrothermal activity does not occur widely along the shores of the island, and sampling designs that consider this factor are thus restricted to a reduced number of sites. Consequently, it is not possible to control other factors affecting the occurrence of macroalgae on the shore, such as the substratum type and/or the geographical aspect of the sites. Uneven occurrence of the species included in the present study across all sampling sites might be the result of such contingency. Cobbles are the dominant type of substratum at Porto Formoso, the sampling site where the only species collected was *C. elongata*, which is located on the north coast where the sea is rougher throughout most of the year. The conjunction of both factors poses adverse conditions to the attachment of macroalgae, and it is thus not surprising to observe the dominance of the most resistant species (*C. elongata*) over the remaining ones. Where bedrock is the dominant substratum type (all other sites besides Porto Formoso) species richness is higher than at cobble or boulder sites (Wallenstein and Neto, 2006; Wallenstein et al., 2008), thus it is not surprising to observe the occurrence of most of the selected pool of species at all sampling sites. The absence of one or more species at bedrock sites is more likely to occur due to local and/or seasonal conditions rather than any anthropogenic factor.

Metal concentrations vary in different portions of the plant, and are generally higher in the older parts of the algae and lower in fast growing tips (Farías et al., 2002; Volterra and Conti, 2000), which might explain the variability found within each sample, since there was no separation of younger and older parts of the algae in the present study. There are no previous studies on metal contents in intertidal macroalgae from the Azores, and the intention was to assess baseline values to compare with future studies. Additionally, and although care was taken to assure an efficient cleaning process for all samples, variability in the results might arise due to some interference of extra-cellular polymers of epiphytic bacteria rather than the algae under investigation (Holmes et al., 1991).

High concentrations of Ca, Fe, Mg, Mn and Zn in macroalgae collected in the present study are consistent with several studies conducted elsewhere with a great variety of species (Chaudhuri et al., 2007; Colaço et al., 2006; Kut et al., 2000; Mohamed and Khaled, 2005), and reflect the structural and functional importance of these elements as major cell constituents and/or intervenients in important physiological processes. However, Mn, Rb and Zn which are metals that can be associated with volcanic activity (Amaral et al., 2006, 2007, 2008; Zaldibar et al., 2006; Cunha et al., 2008) show higher concentrations in algae present at both hydrothermally active sites – Ferraria and Porto Formoso especially for *O. truncata*, *Cystoseira abies-marina* and *F. spiralis*.

The accumulation of metals in macroalgae can occur either within the apparent free space between cells (rapid physicochemical reversible process of uptake on the external surface), or inside cellular compartments (Volterra and Conti, 2000). Consequently different algae exhibit different affinities towards different metals, which in turn depend on the chemical structure of the biosorbent part of the plant (Riget et al., 1997; Volterra and Conti, 2000; Stengel et al., 2004; Abdallah et al., 2005; Mohamed and Khaled, 2005).

Brown algae, including *Cystoseira* species, are usually reported as good indicators for metals (Caliceti et al. 2002; Al-Masri et al., 2003; Lozano et al., 2003; Abdallah et al., 2005). In accordance with such evidence *C. humilis* in the present study showed a special affinity with Cd, Cu and Zn. It is noteworthy the higher concentration of Cd in the samples of *C. humilis* from Ferraria (one of the hydrothermally active sites) compared with all other sites. Studies on barnacles and amphipods from the Azores also report high levels of Cd, Cu and Zn associated to hydrothermally active environments (Moore et al., 1995; Weeks et al., 1995). Coincidently, studies comparing metal concentrations in macroalgae from contaminated and uncontaminated sites report low Cd and Zn concentrations at unimpacted sites when compared with contaminated areas (Amado Filho et al., 1999; Al-Masri et al., 2003; Abdallah et al., 2005). Reduced sample size did not allow us to statistically test the significance of differences between ecological conditions in the present study. However, results suggest that hydrothermal activity increases metal accumulation in most of the species considered. Different species tend to accumulate different metals, thus meaning that each species could be used as an indicator of the effect of hydrothermal activity on a specific metal accumulation.

*Fucus spiralis* showed a highly variable accumulation capacity of most metals considered in the present study and does not respond to the ecological condition factor considered. The variability of metal concentrations in samples of *F. spiralis* might be related to: (1) the fact that it accumulates less in its propagules (Munda, 1986), which was not considered in the sampling procedures; and (2) the cell wall composition of brown algae (alginate polysaccharide) that is responsible for their ion-exchange capacity, giving rise to a selective metal binding (Davis et al., 2003). The fact that *F. spiralis* is apparently less responsive to the ecological condition of the sampling site might be connected with the fact that it occurs on the high shore and is subject to shorter immersion periods. This also applies to *Porphyra* sp. and *G. microdon* that show a common tendency for the accumulation of Cu and Rb. The species that appears to be more responsive to any impact (urban and hydrothermal) is *O. truncata* which occurs lower on the shore, and the one with the highest water content from the pool of species considered in the present study, factors that might favour exchanges of elements with the surrounding seawater. According to Villares et al. (2002) levels of metals in macroalgae vary depending on several environmental factors, and therefore caution should be used when comparing metals levels between distant areas with very different characteristics. Thus, such comparison is not provided in the present study. However, higher metal concentrations at impacted sites are a common feature worth noticing, which enables us to establish a parallelism between naturally contaminated areas (hydrothermal activity) and anthropogenically contaminated areas (pollution). The existence of hydrothermally active sites in the Azores provides a means of studying the effects of pollution arising form a natural source on the accumulation of metals in macroalgae. Increased levels of Pb, Hg, Cu, Fe and Rb in samples taken in the vicinity of urban areas may reflect the responsiveness of macroalgae to some unknown input, which may be rich in certain heavy metals.

The present study is a first approach to the accumulation of a selected pool of chemical elements in macroalgae that occur abundantly at the rocky intertidal of the Azores archipelago. As such, the results here presented are to be considered as baseline values for future general studies on metal accumulation in macroalgae in the Azores. Additionally, some insights were given regarding the influence of urban proximity and hydrothermal activity on the levels of some trace metals in some of the selected species. Shallow water hydrothermal activity adjacent to rocky shores of the Azores are a rare and useful scenario to study not only the impact of heavy metal enrichment, but also of temperature and pH increase, both at the community level and at the species and cellular levels.

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# Occurrence and distribution of hydrocarbons in surface sediments from Marseille Bay (France)

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Hydrocarbons are widespread contaminants in the marine environment. Among these ubiquitous compounds, some are carcinogenic and mutagenic and may have an important impact on the marine life. Recent data concerning hydrocarbon levels in coastal Mediterranean sediments are available for Cretan sea surficial sediments (Gogou et al., 2000; Gogou and Stephanou, 2004), for pristine sediments of the Eastern Mediterranean (Tsapakis et al., 2003), for sediments of the Porto Torres and Olbia harbours in Sardinia (De Luca et al., 2004, 2005), for coastal sediments from Tunisia (Louati et al., 2001; Zaghden et al., 2007), for sediments of Naples harbour (Sprovieri et al., 2007), for sediments of Stagone coastal lagoon (Culotta et al., 2006) for sediments from the Mar Piccolo (Cardellicchio et al., 2007) and for sediments from French coastal zones (Mille et al., 1992; Tolosa et al., 1996; Benlahcen et al., 1997; Baumard et al., 1999). Recently, we determined the levels and the origins of hydrocarbons in surface sediments from the Gulf of Fos (Mille et al., 2007) and found that petroleum inputs or combustion of petroleum derived products were not the main source of contamination. In order to (i) implement the data relative to French Mediterranean coasts and (ii) know the influence and impact of the industrial and petrochemical complex of Fos, we undertook a study of the hydrocarbons in surface sediments from Marseille Bay. No data dealing with hydrocarbons are available for this area which represents forty kilometers of coast on which industrial, nautic, harbour and tourism activities can be found. Several islands (Maire, Planier, Frioul) are close to the coast. Marseille Bay is an important tourist attraction and an important

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ORIGINAL ARTICLE

# Macroalgal turfs in the Azores

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## Abstract

Studies on macroalgal communities of the Azores report algal turfs as one of the most conspicuous ecological entities occurring on the rocky shores of these islands. The present study investigates the influence of shore height and substratum on turf composition. Data were analysed using the software PRIMER and results confirmed the previous distinction between calcareous, dominated by articulated coralline algae, and non-calcareous turfs, characterized mainly by small red algae. However, no differences in species composition were found in either type of turf occurring on different substrata or at different shore levels.

## Problem

A suite of studies undertaken during the past 15 years has investigated the intertidal and subtidal algal communities of the Azores (Neto 1992, 2000, 2001; Neto & Tittley 1995; Tittley *et al.* 1998; Tittley & Neto 2000). Algal turfs are generally described as complex assemblages of macroalgae with compact growth, 5 cm in height and well developed entangled prostrate axes (Price & Scott 1992). Turfs are conspicuous features of warm temperate intertidal communities, and have been widely studied (Chapman 1955; Pryor 1967; Lawson & Norton 1971; Oliveira & Mayral 1976; Lawson & John 1977; Rogers & Salesky 1981; Stewart 1982; Neto & Tittley 1995; Morton *et al.* 1998). Some studies have classified communities systematically as biotopes based on broad ecological/taxonomic categories, such as green algae, calcareous and non-calcareous turfs and crusts (*e.g.* Neto & Tittley 1995; Tittley *et al.* 1998, Tittley & Neto 2000; Wallenstein & Neto 2006; Wallenstein *et al.* 2008). Turfs classified as calcareous or coralline occur with increasing abundance towards the low-shore and are usually not very conspicuous on less stable substrata such as cobbles, whereas turfs classified as non-calcareous are more evenly distributed across the intertidal with higher abundances at mid-shore (Neto & Tittley 1995; Wallenstein & Neto 2006; Wallenstein *et al.* 2008). Classification of turfs into these two broad categories has been based on the abundance of erect coralline algae (recognizable by the naked eye) and can thus be subjective and artificial. To evaluate whether such a classification is artificial we have tested differences between species composition in samples of turf provisionally identified *in situ* as calcareous (*i.e.* dominated by erect coralline algae) or non-calcareous turf.

## Material and Methods

Data for analysis were gathered in the course of intertidal biotope surveys undertaken on three islands of the archipelago – São Miguel, Santa Maria and Graciosa (Fig. 1) in the summer periods of 2004, 2005 and 2006, respectively. As macroalgae communities are not evenly distrib-

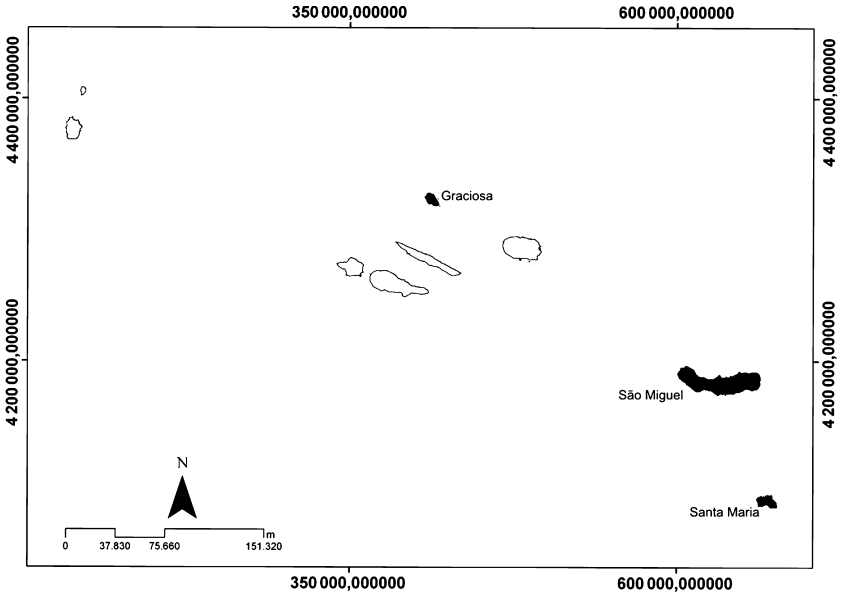


**Fig. 1.** Schematic representation of the Azores archipelago with the sampled islands in dark.

uted across the intertidal, both in terms of species composition and substratum coverage, they pose a difficulty in sampling designs that require the collection of an equal number of samples at differing 'substratum × shore level' combinations. Although the original aim was to acquire quantitative data for macroalgal communities at high-, mid- and low-shore, on three substrata (cobbles, boulders and bedrock), high-shore samples had to be excluded from the pool of data because there were several sites where calcareous turf was absent. At mid- and low-shore, whenever possible two 10 × 10 cm areas (minimal intertidal scraping area defined by Neto 1997) of each type of turf (calcareous and non-calcareous) were cleared (scraped with a chisel into a nylon mesh bag) from the upper facing surfaces of three different substrata and brought to the laboratory for examination. Additionally, owing to an irregular distribution of substrata along the shores of the surveyed islands, an uneven sampling design had to be adopted (Table 1).

Turf constituents were identified with the help of a microscope and species abundances recorded using a semi-quantitative DAFOR scale (Dominant; Abundant; Frequent; Occasional; Rare). To test for differences between types of turfs (calcareous *versus* non-calcareous), substrata (cobbles *versus* boulders *versus* bedrock) and shore levels (low-shore *versus* mid-shore), PERMANOVA analyses were run on species richness (as presence/absence data) and species relative abundance data with the software PRIMER (Anderson *et al.* 2008). PERMANOVA combines the best of traditional test-statistics (ANOVA designs) and flexible multivariate nonparametric methods, and can thus be based on symmetric dissimilarity or distance measures (or their ranks) providing probability values (P; significant if <0.05; not significant if ≥0.05) using appropriate permutation methods. The greater the number of possible permutations, the stronger the result of the tests. The island where samples were collected was set as a random factor, as there was no hypothesis regarding differences between islands. Furthermore, SIMPER analysis on relative abundance data was used to identify the species responsible for the differences found between both types of turf.

**Table 1.** Number of samples collected according to the surveyed islands, turf types, substrata and shore level.

| | Graciosa | Santa Maria | São Miguel | Total |
|---|---|---|---|---|
| Turf type | | | | |
| Calcareous | 32 | 27 | 39 | 98 |
| Non-calcareous | 34 | 47 | 48 | 129 |
| Substrata | | | | |
| Cobbles | 22 (3 sites) | 14 (4 sites) | 28 (5 sites) | 64 (12 sites) |
| Boulders | 20 (3 sites) | 19 (3 sites) | 22 (4 sites) | 61 (10 sites) |
| Bedrock | 24 (3 sites) | 41 (9 sites) | 37 (6 sites) | 102 (18 sites) |
| Shore level | | | | |
| Low | 32 | 40 | 40 | 112 |
| Mid | 34 | 34 | 47 | 115 |
| Total | 66 (9 sites) | 74 (16 sites) | 87 (15 sites) | 227 (40 sites) |

## Results

### Species present

The turf samples contained 139 species of algae from 24 orders; the Ceramiales contained 60 species, the Gigartinales 11 species, and the Corallinales 9 species. These

**Table 2.** PERMANOVA analysis of differences in turfs according to substratum type (fixed factor with three levels: cobbles, boulders and bedrock) and to shore level (fixed factor with two levels: low-shore and mid-shore).

| Source | df | PSpp. composition data/PA data | Permutations |
|---|---|---|---|
| All turfs | | | |
| Turf type | 1 | 0.001/0.001[a] | 999 |
| Residual | 225 | | |
| Total | 226 | | |
| Calcareous turf | | | |
| Substratum | 2 | 0.321/0.23 | 998 |
| Shore level | 1 | 0.278/0.468 | 998 |
| Island | 2 | 0.001/0.001[a] | 998 |
| Island × Substratum | 4 | 0.001/0.001[a] | 998 |
| Island × Shore level | 2 | 0.114/0.069 | 999 |
| Substratum × Shore level | 2 | 0.846/0.625 | 997 |
| Island × Substratum × Shore level | 4 | 0.01/0.001[a] | 999 |
| Residual | 100 | | |
| Total | 117 | | |
| Non-calcareous turf | | | |
| Substratum | 2 | 0.393/0.289 | 998 |
| Shore level | 1 | 0.11/0.077 | 998 |
| Island | 2 | 0.001/0.001[a] | 998 |
| Island × Substratum | 4 | 0.001/0.001[a] | 998 |
| Island × Shore level | 2 | 0.006/0.037[a] | 998 |
| Substratum × Shore level | 2 | 0.724/0.821 | 998 |
| Island × Substratum × Shore level | 4 | 0.001/0.001[a] | 999 |
| Residual | 91 | | |
| Total | 108 | | |

[a]Significant test; df = degrees of freedom; P = probability value associated to the test; PA data = presence/absence data; Permutations = number of permutations on which the test was based.

three orders are all in the red algae (Rhodophyta). Other orders present had fewer species.

### Numerical analysis

PERMANOVA tests on species composition and relative abundance upheld the basic separation into calcareous and non-calcareous turfs (Table 2).

When analysing data separately for each turf type there were no significant differences in turfs associated with substratum or shore level (Table 2).

Dissimilarity between calcareous and non-calcareous turfs is greater when comparing these using the relative abundance of its constituents (87.62) rather than using species richness (78.32). Differences between the two types of turf are mainly due to the co-dominant, erect calcareous species within one type of turf and *Gelidium* (dominant) and *Ceramium* spp. within the other (Table 3).

## Discussion

The present study validates the empirical classification of two types of turf, calcareous, and non-calcareous, based on the presence of species of *Corallina*, *Jania* and *Haliptilon* that occur in such abundance that they are visually recognizable (*cf.* Neto & Tittley 1995). Although differences between the two types of turf are mainly due to the dominance of calcareous species within calcareous turfs, *Corallina elongata* can also be an important constituent of non-calcareous turfs; likewise, *Laurencia* spp. are a noticeable component of both communities. The few other major constituents of these two types of turf differ slightly, but there is a long list of minor constituents that are common to both (Table 3) and these are mainly filamentous red algae. The definition of both turfs in the present study is in accordance with the provisional biotope definition study of Tittley & Neto (2000). However, regarding non-calcareous turf in the present study we add *Gelidium microdon* to the species list defined as 'soft algal turf' by Tittley & Neto (2000). This is the main structuring species in our non-calcareous turf samples, which is certainly due to the fact that it occurs mainly in the mid-to-low eulittoral, which coincides with the distribution reported for the association of *Gelidium microdon* and *Fucus spiralis* by Tittley & Neto (2000). Approximately 30% of the total flora of the Azores was identified within the turfs sampled for the present study.

Highly mobile substrata tend to inhibit the attachment and growth of macroalgae and favour thin, turf-like growths that are resistant to abrasion, namely fast-growing, opportunistic algae (mainly green algae and filamentous red and brown algae) that comprise non-calcareous turfs. Our finding of the absence of substratum specificities in non-calcareous turfs with increasing substratum stability (cobbles to boulders to bedrock) was unexpected (Table 2). Increased stability was expected to allow the development of more mature communities, namely turfs with a greater number of species. However, unusual stability conditions in cobble beaches as a result of reduced wave action in the summer might have allowed non-calcareous turf communities on less stable substrata to develop towards those common on more stable substrata. Accordingly, sampling at other times of year might have detected changes in communities on different types of substrata.

Species composition of both types of turf does not vary significantly in the narrow mid- to low-shore range, probably because of the limited shore extension in the Azores. Steep shores and small tidal ranges provide very little space for macroalgae to attach. A turf-like life form may present an advantage in the competition for space and help resist the strong wave action prevalent on most

**Table 3.** Species that contribute to 90% of the differences between calcareous and non-calcareous turfs (SIMPER analysis) and their respective occurrence rate in all turf samples and abundance scores (DAFOR; in bold the most common category for each species).

| Spp. | Contribution% | Occurrence | DAFOR categories |
|---|---|---|---|
| Calcareous turf | | | |
| *Corallina elongata* | 56.73 | 0.73 | **D**A |
| *Haliptilon virgatum* | 9.63 | 0.32 | **D**A |
| *Jania* spp.[a] | 10.83 | 0.46 | D**A**FO |
| *Laurencia* spp.[b] | 7.37 | 0.51 | A**F**O |
| *Chondria* spp.[c] | 2.17 | 0.29 | A**F**O |
| *Gelidium* spp.[d] | | 0.25 | A**F**O |
| *Stypocaulon scoparium* | | 0.27 | F**O** |
| *Chondracanthus acicularis* | | 0.25 | F**O** |
| *Ceramium* spp.[e] | 4.08 | 0.51 | F**O**R |
| *Chaetomorpha* spp.[f] | | 0.26 | **O**R |
| Other spp.(see below) | | <0.25 | **R** |
| Total | 90.81 | | |
| Non-calcareous turf | | | |
| *Gelidium* spp.[d] | 32.44 | 0.43 | D**A**F |
| *Corallina elongata* | 13.15 | 0.46 | A**F**O |
| *Laurencia* spp.[b] | 7.71 | 0.35 | A**F**O |
| *Ceramium* spp.[e] | 14.28 | 0.51 | A**F**OR |
| *Jania* spp.[a] | 2.66 | 0.26 | **F**O |
| *Ulva* spp.[g] | 2.48 | 0.28 | **O**R |
| *Chaetomorpha* spp.[f] | 3.22 | 0.35 | **R** |
| *Herposiphonia* sp. | 3.32 | | |
| *Polysiphonia* spp.[h] | 2.68 | | |
| *Gymnogongrus* spp.[i] | 2.52 | | |
| *Ahnfeltia plicata* | 1.77 | | |
| *Osmundea* spp.[j] | 1.57 | | |
| *Centroceras clavulatum* | 1.53 | | |
| *Caulacanthus ustulatus* | 1.4 | | |
| Other spp. (see below) | | <0.25 | R |
| Total | 90.73 | | |

[a]*Jania capillacea*, *Jania longifurca*, *Jania pumila*, *Jania rubens.*

[b]*Laurencia viridis*, *Laurencia* sp.

[c]*Chondria coerulescens*, *Chondria dasyphylla*, *Chondria capillaris.*

[d]*Gelidium microdon*, *Gelidium pusillum*, *Gelidium spinosum.*

[e]*Ceramium ciliatum*, *Ceramium circinatum*, *Ceramium diaphanum*, *Ceramium echionotum*, *Ceramium flaccidum*, *Ceramium virgatum.*

[f]*Chaetomorpha linum*, *Chaetomorpha pachynema.*

[g]*Ulva compressa*, *Ulva intestinalis*, *Ulva clathrata*, *Ulva rigida.*

[h]*Polysiphonia brodiei*, *Polysiphonia denudata*, *Polysiphonia elongata*, *Polysiphonia furcellata.*

[i]*Gymnogongrus griffithsiae*, *Gymnogongrus crenulatus.*

[j]*Osmundea hibrida*, *Osmundea pinnatifida.*

Other spp.: *Acrosorium venulosum*, *Aglaothamnion* sp., *Aglaozonia parvula*, *Ahnfeltia* sp., *Ahnfeltiopsis intermedia*, *Amphiroa* spp. (*Amphiroa beauvoisii*, *Amphiroa* sp.), *Anotrichium* spp. (*Anotrichium furcellatum*, *Anotrichium tenue*), *Antithamnion* sp., *Asparagopsis armata*, *Bachelotia antillarum*, *Boergeseniella* spp. (*Boergeseniella fruticulosa*, *Boergeseniella* sp.), *Bonnemaisonia asparagoides*, *Bryopsis* spp. (*Bryopsis cupressina*, *Bryopsis hypnoides*, *Bryopsis plumosa*), *Callithamnion* spp. (*Callithamnion corymbosum*, *Callithamnion tetragonum*, *Callithamnion* sp.), *Catenella caespitosa*, *Caulacanthus ustulatus*, *Centroceras clavulatum*, *Chondracanthus acicularis*, *Chondrophycus* sp., *Cladophora* spp. (*Cladophora albida*, *Cladophora coelothrix*, *Cladophora prolifera*, *Cladophora* sp.), *Cladophoropsis membranacea*, *Cladostephus spongiosus*, *Codium adhaerens*, *Compsothamnion decompositum*, *Cryptopleura ramosa*, *Cystoseira* spp. (*Cystoseira abies-marina*, *Cystoseira humilis*, *Cystoseira* sp.), *Dasya* spp. (*Dasya corymbifera*, *Dasya hutchinsiae*, *Dasya* sp.), *Dictyota* sp., *Diplothamnion* sp., *Dipterosiphonia* sp., *Drachiella minuta*, *Endarachne binghamiae*, *Erythrocystis montagnei*, *Falkenbergia rufolanosa*, *Fucus spiralis*, *Gastroclonium* spp. (*Gastroclonium ovatum*, *Gastroclonium reflexum*), *Gelidiella* sp., *Gelidiopsis* sp., *Gigartina pistillata*, *Grateloupia* spp. (*Grateloupia filicina*, *Grateloupia dichotoma*), *Griffithsia corallinoides*, *Halopteris filicina*, *Herposiphonia* sp., *Heterosiphonia crispella*, *Hypnea* spp. (*Hypnea arbuscula*, *Hypnea musciformis*), *Lomentaria articulata*, *Lophosiphonia* spp. (*Lophosiphonia obscura*, *Lophosiphonia reptabunda*), *Nemoderma tingitanum*, *Platysiphonia* sp., *Pleonosporium* sp., *Plocamium cartilagineum*, *Porphyra* sp., *Pterocladiella capillacea*, *Pterosiphonia* spp. (*Pterosiphonia pennata, Pterosiphonia* sp.), *Rhodymenia holmesii*, *Sargassum* spp. (*Sargassum cymosum*, *Sargassum vulgare*), *Sphacelaria* spp. (*Sphacelaria cirrosa*, *Sphacelaria plumula*), *Sphondylothamnion multifidum*, *Stylonema alsidii*, *Stypocaulon scoparium*, *Symphyocladia marchantioides*, *Valonia* spp. (*Valonia macrophysa*, *Valonia utricularis*).

shores of the Azores. Other advantages of the turf life form are the retention of water, the increased surface areas for attachment of admixed algae, increased resistance to herbivory, and increased ability in vegetative propagation (Price & Scott 1992).

No hypothesis was set regarding differences in turfs sampled on different islands. Sampling was done in different years on each island and differences in species composition might reflect variations in population dynamics of the turf constituents.

The turf life form may be an ecological response to severe environmental conditions, notably wave action. Although this life form is resistant to the prevailing harsh conditions, more delicate/fragile algae, such as the filamentous species of *Callithamnion* and *Dasya*, are able to survive as minor constituents within the turf community. Turfs are an important feature of the warm temperate shore communities that dominate intertidal communities in the Azores. They thus deserve special attention, not as major features of an ecosystem, but as a local ecosystem in their own right.

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