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A long-term comparison of the benthic algal flora of Clare Island, County Mayo, western Ireland

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Abstract. The marine benthic algal flora of Clare Island, off County Mayo, western shore of Ireland, was investigated; collections of intertidal and subtidal marine algae were made at 16 sites along the eastern and southern shores in the years 1990, 1993 and 2000–2002. The data and observations obtained were compared with the results of a similar survey conducted by Arthur Disbrowe Cotton in 1910–1911. Considering the results of the original survey and the new survey together, the marine algal flora of the island currently totals 293 species; 224 species were recorded by Cotton in the original survey, whereas 223 species were identified in the present study. Most species are common to the original and the new list and the main differences are easily explainable; the new survey used SCUBA diving, which allowed the collection of several subtidal species not collected in 1910, and Cotton reported several microscopic green and brown algae, usually difficult to recognise in the field, which were not rediscovered. The most remarkable differences consist in the current presence of some large intertidal brown algae (*Bifurcaria bifurcata*, *Cystoseira foeniculacea* and *Cystoseira nodicaulis*) that were not reported in the survey of 1910. Two algae, *Codium fragile* subsp. *tomentosoides* and *Asparagopsis armata*, were introduced in Europe after the original survey. At present, the benthic algal assemblages of Clare Island still have basically the same structure and distribution as in 1910 and, if compared with other coastal areas of Europe, the intertidal marine environment of Clare Island appears remarkably well conserved.

Introduction

Occurring in virtually any type of coastal habitat where hard substrata are present, benthic marine macroalgae are a general component of shore ecosystems throughout the globe. The polyphyletic nature of marine algae implies that these organisms embrace a much wider range of diversity than many higher plant or animal groups (Norton et al. 1996). Studies on diversity of marine algae have encompassed a wide range of topics, mainly concerning taxonomic, genetic and ecological aspects. However, investigations of species numbers and their distribution in certain geographical areas have traditionally been a favoured topic in many studies of seaweed biodiversity.

It has been recognised for centuries that different geographical areas are characterised by different algal floras. On a global scale, many studies have acknowledged the existence of latitudinal trends in seaweed floras and a number of different biogeographical provinces, discussing in detail the causes of these patterns (van den

Hoek 1984; Hommersand 1986; Lüning 1990; Bolton 1994; Adey and Steneck 2001; Phillips 2001). Other floristic surveys of benthic marine algae have focused on more restricted spatial scales, often concerning areas with coastal extent from a few km to hundreds of km (see Ardré 1970; Lawson and John 1977; Lee and Lee 1981; Bird et al. 1983; Cecere et al. 1996; Huisman 1997; Stegenga et al. 1997; Schils et al. 2001; Verlaque 2001; Rindi et al. 2002). Not surprisingly, some of the most detailed studies have concerned zones with important field research stations, such as Helgoland, Germany (Bartsch and Kuhlenkamp 2000), Roscoff, northern France (Feldmann 1954), Banyuls-sur-Mer, Mediterranean France (Feldmann 1937) and the Gulf of Naples, western Italy (Funk 1955). Such studies are important to determine regional patterns of species diversity and highlight species-rich localities and habitats worthy of special attention for conservation. However, differences in overall extent of rocky shores and types of habitats, differences in sampling effort and differences in number and competence of algal taxonomists operating in different regions make the results of such studies generally difficult to compare. An important point is that, even in studies with good spatial coverage and sampling effort, only very rarely have temporal variations in the algal flora been considered. In some areas, introductions of new species have been noted and the consequences of their spread have been described (Carlton and Scanlon 1985; Critchley et al. 1990; Boudouresque et al. 1992; Piazzi et al. 1997; Verlaque 2001); but only for very few localities or regions (e.g., Faeröes Islands: see Børgesen 1902; Irvine 1982; County Durham, UK: see Edwards 1975) the benthic algal flora has been reinvestigated in detail after an extended time.

Most of the about 7000 km long coastline of Ireland is rocky and represents one of the most habitat-diverse shorelines in Europe. Due to extensive taxonomic work conducted in the 19th century and, subsequently, in the last 30 years, the benthic algal flora of Ireland is relatively well known, consisting of about 580 species of blue-green, green, brown and red algae (M.D.G., unpublished data). However, the sampling effort dedicated to different parts of the Irish shoreline is far from uniform. It is basically correct to state that the algal flora is much better known for three areas than for the other parts of the country; these are Galway Bay, the area of Lough Hyne (in the western part of county Cork), and Clare Island, County Mayo. For Galway Bay and Lough Hyne, this is mainly due to the presence of research facilities at the National University of Ireland, Galway, and at the 'Louis Renouf' Laboratory of University College Cork at Lough Hyne. For Clare Island, the main source of information is the report published by Cotton (1912) as part of the results of the Survey of Clare Island.

The Survey of Clare Island was a multidisciplinary study which concerned all aspects of the natural history of Clare Island, situated at the entrance of Clew Bay in County Mayo. In 1909 and 1910, under the sponsorship of the Royal Irish Academy and the guidance of Robert Lloyd Praeger, more than a hundred professional and amateur naturalists visited the island, collecting a bulk of observations on fauna, flora and geology (Guiry 1997). Arthur Disbrowe Cotton, subsequently Director of Kew Gardens in London, was the scientist most directly involved in the study of the marine algae; he visited the island six times, making large collections of intertidal and shallow subtidal seaweeds. The result of his study was an extensive report, with an extraordinary amount of information on the composition and ecology of the benthic algal assemblages, and a very detailed floristic list. Cotton (1912) described the benthic vegetation of Clare Island in terms of the most common algal associations and listed 224 species of green, red and brown algae (plus several intraspecific taxa), 66 of which were new to Ireland, 13 new to the British Isles and 2 new to science.

In 1990, recognising the value of a similar investigation, the Royal Irish Academy launched a New Survey of Clare Island. Despite funding problems which delayed the work, in the last few years we have visited the island several times and made extensive collections of seaweeds at the same sites visited by Cotton. For sampling effort, the data and observations obtained are now comparable with Cotton's (1912) results; this provides the exceptional opportunity of a comparison of the algal flora at the distance of almost a century, which is absolutely unique to this locality. We report here the results, highlighting variations in the algal flora of the island and discussing in detail some interesting peculiarities of the benthic algal vegetation of Clare Island.

Materials and methods

Study area and sampling sites

Clare Island is situated at the entrance of Clew Bay, County Mayo, on the western shore of Ireland (Figure 1). Roonagh Point, the nearest part of the Irish mainland, is about 4 km from the southern shore of Clare Island. With the exception of the bay in the vicinity of the harbour and few other sandy areas, the shores of Clare Island are rocky; long stretches, however, especially on the northwestern shore, grade very steeply, making access mostly impossible.

A complete list of the sampling dates and sites, numbered in a clockwise order along the shores of the island, is reported in Table 1 (see Figure 1 for the location of the sites); for each site the main characteristics and the type of habitats sampled are also reported. Most collections were made in two general phases. In June 1990, SCUBA divers visited several sites on the northwestern shore and made large collections of subtidal algae. Intertidal seaweeds were mainly collected in the period September 2000–May 2002, at several sites on the northeastern, eastern and southern parts of the island. These are the same sites at which Cotton made collections; several stretches of gently sloping bedrock occur there, making access possible. Directly facing Clew Bay, eastern and southeastern shores are partially wave-sheltered and in general host the richest and best-developed seaweed assemblages. The southern shore is more wave-exposed and benthic assemblages are less diverse there than on the northeastern and eastern shores. Still more exposed conditions appear to occur on the western and northwestern shores, but these areas were not visited because of the impossibility of access referred to above.

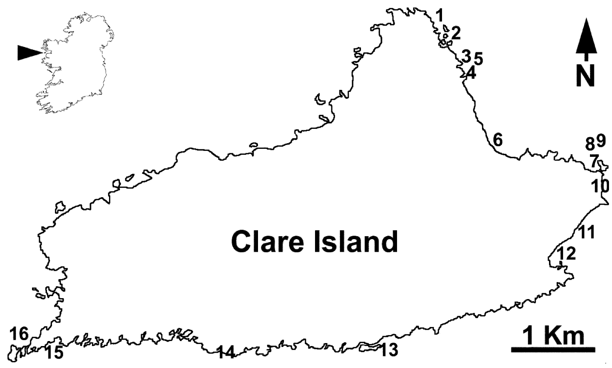

Figure 1. Map of Clare Island showing the location of the sampling sites.

Methods

The material collected was examined by light microscopy a few days after collection; identifications to the best possible level of taxonomic discrimination were obtained. Voucher specimens were prepared as dried material mounted on herbarium sheets, or as permanent slides mounted in 80% Karo corn syrup. The specimens are deposited in the Phycological Herbarium of the Department of Botany, National University of Ireland, Galway (GALW), currently housed in the Martin Ryan Institute.

Results and discussion

Number of species

We collected 227 taxa of benthic marine algae (Table 2), belonging to 223 species (24 Chlorophyta, 56 Phaeophyceae and 143 Rhodophyta). In the original survey, Cotton (1912) listed 233 taxa belonging to 224 species (35 Chlorophyta, 75 Phaeophyceae and 114 Rhodophyta). Considering the results of the original survey and the new survey together, the marine algal flora of the island currently totals 293 species. Although most seaweeds are common to our floristic list and that of the original survey, some differences are evident. We recorded a number of algae (especially red) that Cotton did not report; conversely, we could not rediscover a number of species (mainly brown and green) found during the original survey.

Differences between the floristic lists of the original and new survey

Differences between the floristic lists of the original and new survey are due to a number of reasons that in most cases are reasonably clear. For example, in 1990 the use of SCUBA diving allowed access to some subtidal species not reported in the

Table 1. Sampling sites and sampling dates.

Number	Site	Sampling dates	Characteristics of the site
1	Deasy's Rock, subtidal	23/6/90	Boulder slope between 20 and 27 m depth, with a battered kelp forest between 20 and 24 m. Material was collected from rock and kelp stipes.
2	North of Doonallia Island, subtidal	22/6/90	Gully walls ending at 11 m on a mixed bottom, formed by sand and stones of different sizes. Collections were made between 7 and 11 m depth; algae growing on the walls and the largest stones were collected and examined.
3	Ooghnamara, intertidal	28/4/01	Rocky shore, irregular and degrading quite steeply. When the site was visited, intertidal assemblages were mainly represented by mussel beds; relatively few large perennial seaweeds were observed (mainly scattered plants of *Fucus*). *Enteromorpha* and *Porphyra* were abundant, occurring both on rock and mussels. Collections were mainly made from rockpools.
4	Cove at Ooghcorragaun, intertidal and subtidal	22/6/90, 25/6/90, 19/9/01	Sheltered cove with rock mixed to sand. In June 1990, collections were made from sandy and pebble bottom and from the walls of the harbour, between 0 and 3 m depth. In September 2001, collections were made on intertidal bedrocks around the cove; on that occasion, the main intertidal erect algae observed were small plants of *Fucus*, *Palmaria palmata* and *Mastocarpus stellatus*.
5	Amphiteatre rocks, subtidal	24/6/90, 25/6/90	Bottom formed by bedrocks, partially buried by sand in some spots, and cliffs; some areas were occupied by large boulders. Collections were made between 6 and 16 m depth, in a variety of habitats.
6	Portlea, intertidal	22/6/90, 17/9/00, 28/4/01, 21/7/01, 4/11/01, 16/2/02	Large, northeast facing beach; the mid and low intertidal were formed by gently sloping rock, buried in sand in some stretches, with numerous rockpools. The upper intertidal was mainly formed by large boulders (50–80 cm); only the largest of them host perennial seaweeds (scattered plants of *Fucus spiralis* and *Fucus vesiculosus*). In the mid-intertidal, algal cover was in general more abundant towards the eastern part of the beach, which was the most sheltered; a canopy of fucoids (*Fucus vesiculosus* and *Fucus serratus*) occupied large stretches of rock. Several spots, however, were more or less completely covered by sand; there, *Rhodothamniella floridula* was particularly flourishing, forming thick cushions. In the low intertidal and in the pools, *Himantalia elongata* was particularly common and abundant.
7	Lacknacranny, intertidal	24/6/90, 1/10/93, 20/9/01, 20/10/01	Stretch of gently sloping rocky shore; when the site was visited, the main intertidal algae were species of *Fucus*, *Palmaria palmata* and *Mastocarpus stellatus*; species of *Codium* were very common in the pools.

Table 1. (*continued*)

Number	Site	Sampling dates	Characteristics of the site
8	Reef north of Lacknacranny, subtidal	23/6/90	Rocky bottom with forest of *Laminaria hyperborea*; collections were made around 14 m depth.
9	Northeast of Lacknacranny, subtidal	22/6/90	Area consisting of bedrock and cliffs alternated to sandy areas; large boulders occurred in some spots at the edge of sand. Large forests of *Laminaria hyperborea* occupied the rocky bottom, in particular at 3–6 m depths. The material examined was collected at depths ranging from 3 to 17 m on horizontal rock, cliffs, large boulders and stipes of kelps.
10	Alnahaskilla, intertidal	17/9/00, 20/10/01	Gently sloping rocky shore; collections were mainly made in some large, shallow rockpools that occupy some portions of the mid and low intertidal. In these pools, *Gelidium pulchellum* was particularly abundant; at the time of the visits, it was virtually the only erect macroalga occurring in pools hosting dense populations of limpets and urchins. *Codium* spp. were also common.
11	Shore between harbour and Kinnacorra, intertidal	23/6/90, 28/4/01, 9/6/01, 10/6/01, 21/7/01, 20/9/01, 20/10/01, 4/11/01, 16/2/02, 24/5/02	Gently sloping rocky shore, with many intertidal rockpools; seaweed assemblages were generally rich, but with a strong variability in small-scale distribution (stretches with abundant coverage of fucoids and other large seaweeds were alternated to stretches of almost bare rock). At Kinnacorra the shore was mainly formed by large boulders, on which no macroscopic marine algae were observable.
12	Harbour bay, intertidal	23/6/90, 18/9/00, 20/9/01, 20/10/01, 4/11/01, 16/2/02, 24/5/02	Collections were mainly made in some lower intertidal rockpools in an area located in the northern part of the bay; the area consisted of an isolated bedrock, the lower parts of which were largely buried in sand.
13	Portnakilly, intertidal	25/6/90, 19/10/93, 29/4/01, 10/6/01, 20/7/01, 18/9/01, 21/10/01, 4/11/01, 15/2/02	As the whole southern shore in general, this site was very exposed; on the most exposed stretches, intertidal assemblages were mainly formed by mussel beds, with some scattered plants of *Fucus vesiculosus* v. *evesiculosus*; in spring and summer, some filamentous and laminar species were common (*Ceramium shuttleworthianum*, *Aglaothamnion sepositum*, *Porphyra umbilicalis*). In coves and more sheltered areas other large species of seaweeds occurred. Rockpools were frequent and relatively deep; they were characterised by an extensive development of large brown algae, such as *Himanthalia elongata*, *Halydris siliquosa* and several species of *Cystoseira*. Encrusting corallines covered large portions of the bottom, especially in rockpools with large populations of limpets and sea urchins.
14	Tonabrickill, intertidal	16/9/00	Similar to Portnakilly, with the difference that the shore degrades more steeply. Rockpools were deep and mainly dominated by kelps (*Laminaria digitata*).
15	Lackwee, intertidal	16/9/00, 17/9/01	Same characteristics as Tonabrickill.
16	Beetle Rock, subtidal	24/6/90	A rocky bottom area between 20 and 27 m depth was visited, with a forest of *Laminaria hyperborea* down to 25 m; algae were collected from horizontal and vertical rocky surfaces, boulders and stipes of kelps.

Table 2. Floristic list of the benthic marine algae of Clare Island. For the numbers of the sites where individual species have been recorded, see Table 1.

Species	Recorded in the new survey	Recorded in the original survey	Sites	Abundance
Chlorophyta				
Acrochaete viridis (Reinke) R. Nielsen	+	+	13	R
Acrochaete wittrockii (Wille) R. Nielsen		+		
Acrosiphonia arcta (Dillwyn) Gain	+	+	11	U
Blidingia minima (Nägeli ex Kützing) Kylin	+	+	11, 14	C
Bolbocoleon piliferum Pringsheim		+		
Bryopsis plumosa (Hudson) C. Agardh	+	+	1, 8, 9, 10, 16	C
Chaetomorpha linum (O.F. Müller) Kützing	+	+	13	S
Chaetomorpha melagonium (F. Weber et D. Mohr) Kützing		+		
Cladophora albida (Nees) Kützing	+	+	6	S
Cladophora flexuosa (O.F. Müller) Kützing		+		
Cladophora pellucida (Hudson) Kützing		+		
Cladophora rupestris (Linnaeus) Kützing	+	+	7, 10, 11, 13, 15	W
Cladophora sericea (Hudson) Kützing	+	+	13	S
Cladophora vagabunda (Linnaeus) Van den Hoek	+		6	R
Codium adhaerens C. Agardh		+		
Codium fragile subsp. *atlanticum* (A.D. Cotton) P.C. Silva	+	+	6	L
Codium fragile subsp. *tomentosoides* (van Goor) P.C. Silva	+		10, 11, 13	W
Codium tomentosum Stackhouse	+	+	6, 13	C
Codium vermilara (Olivi) Delle Chiaje	+	+	6	U
Derbesia marina (Lyngbye) Solier	+	+	1, 9, 16	U
Enteromorpha clathrata (Roth) Greville	+	+	6	U
Enteromorpha compressa (Linnaeus) Nees	+	+	6, 13, 14, 15	W
Enteromorpha intestinalis (Linnaeus) Nees	+	+	6, 10, 11	W
Enteromorpha linza (Linnaeus) J. Agardh		+		
Epicladia flustrae Reinke		+		
Monostroma grevillei (Thuret) Wittrock		+		
Monostroma grevillei var. *cornucopiae* Carmichael ex Batters		+		
Percursaria percursa (C. Agardh) Rosenvinge		+		
Phaeophila dendroides (P.L. Crouan et H.M. Crouan) Batters	(+)		13	R
Prasiola stipitata Suhr ex Jessen	+	+	11, 12	S
Rhizoclonium riparium (Roth) Harvey		+		
Rhizoclonium riparium v. *implexum* (Dillwyn) Rosenvinge		+		
Rhizoclonium tortuosum (Dillwyn) Kützing	+	+	6, 10	C
Rosenvingiella polyrhiza (Rosenvinge) P.C. Silva	+	+	12	R
Spongomorpha aeruginosa (Linnaeus) van den Hoek	+	+	4	U
Tellamia contorta Batters		+		
Ulothrix flacca (Dillwyn) Thuret	+	+	10, 13	U
Ulva lactuca Linnaeus		+		
Ulva rigida C. Agardh	+		4, 6, 11, 13	W
Ulvella lens P.L. Crouan et H.M. Crouan	+		13	R
Urospora penicilliformis (Roth) Areschoug		+		
Urospora wormskioldii (Mertens ex Hornemann) Rosenvinge		+		
Phaeophyceae				
Alaria esculenta (Linnaeus) Greville	+	+	4, 5, 6, 7, 11, 14, 15	C
Ascophyllum nodosum (Linnaeus) Le Jolis	+	+	13	R
Asperococcus bullosus J.V. Lamouroux		+		

Table 2. (*continued*)

Species	Recorded in the new survey	Recorded in the original survey	Sites	Abundance
Asperococcus fistulosus (Hudson) W.J. Hooker	+	+	6, 11, 13	R
Bifurcaria bifurcata Ross	+		13	R
Chilionema ocellatum (Kützing) Kornmann		+		
Chorda filum (Linnaeus) Stackhouse	+		4, 12	R
Chordaria flagelliformis (O.F. Müller) C. Agardh	+	+	4, 13	U
Cladostephus spongiosus f. *verticillatus* (Lightfoot) Prud'homme van Reine	+	+	2, 5, 6, 10	C
Compsonema microspongium (Batters) Kornmann		+		
Compsonema saxicolum (Kuckuck) Kornmann		+		
Corynophlaea crispa (Harvey) Kuckuck		+		
Cutleria multifida (J.E. Smith) Greville	+		1, 2, 5, 9, 16	C
Cystoseira baccata (S.G. Gmelin) P.C. Silva	+	+	6, 11, 13	C
Cystoseira foeniculacea (Linnaeus) Greville	+		13	R
Cystoseira nodicaulis (Withering) M. Roberts	+		6, 11, 13	C
Cystoseira tamariscifolia (Hudson) Papenfuss	+	+	6, 7, 11, 13	C
Desmarestia aculeata (Linnaeus) J.V. Lamouroux	+	+	2, 4, 5	U
Desmarestia dresnayi J.V. Lamouroux ex Leman	+		5	R
Desmarestia ligulata (Lightfoot) J.V. Lamouroux	+	+	2, 5, 6	U
Desmarestia viridis (O.F. Müller) J.V. Lamouroux	+	+	4, 5	U
Dichosporangium chordariae Wollny		+		
Dictyopteris polypodioides (De Candolle) J.V. Lamouroux	+		1, 2, 4, 5, 8, 9	C
Dictyosiphon foeniculaceus (Hudson) Greville		+		
Dictyota dichotoma (Hudson) J.V. Lamouroux	+	+	1, 2, 4, 5, 6, 8, 9, 10, 11, 13, 16	W
Dictyota dichotoma v. *intricata* (C. Agardh) Greville	+	+	10, 11	C
Ectocarpus fasciculatus Harvey	+	+	13	L
Ectocarpus fasciculatus var. *draparnaldioides* P.L. Crouan et H.M. Crouan	+		13	L
Ectocarpus siliculosus (Dillwyn) Lyngbye	+	+	14	R
Elachista flaccida (Dillwyn) Fries	+	+	6, 13	U
Elachista fucicola (Velley) Areschoug	+	+	6, 11, 13	C
Elachista scutulata (J.E. Smith) Duby	+	+	13	U
Eudesme virescens (Carmichael ex Harvey) J. Agardh	+	+	4, 11	U
Feldmannia paradoxa (Montagne) Hamel	+	+	13	R
Feldmannia simplex (P.L. Crouan ex H.M. Crouan) Hamel	+	+	11	U
Fucus serratus Linnaeus	+	+	3, 4, 6, 7, 10, 11, 12, 13, 14, 15	W
Fucus serratus var. *angustifrons* Stackhouse		+		
Fucus spiralis Linnaeus	+	+	3, 6, 11, 12, 13	W
Fucus vesiculosus Linnaeus	+	+	3, 6, 7, 11, 12	W
Fucus vesiculosus var. *angustifrons* Turner		+		
Fucus vesiculosus var. *evesiculosus* A.D. Cotton	+	+	13, 14, 15	C
Halosiphon tomentosus (Lyngbye) Jaasund	+	+	4	R
Halidrys siliquosa (Linnaeus) Lyngbye	+		6, 11, 13, 14, 15	W

Table 2. (*continued*)

Species	Recorded in the new survey	Recorded in the original survey	Sites	Abundance
Hecatonema terminale (Kützing) Kylin		+		
Herponema velutinum (Greville) J. Agardh	+	+	13	U
Himanthalia elongata (Linnaeus) S.F. Gray	+	+	6, 11, 13, 15	W
Hincksia granulosa (J.E. Smith) P.C. Silva		+		
Hincksia mitchelliae (Harvey) P.C. Silva	(+)	+	13	R
Hincksia hincksiae (Harvey) P.C. Silva	+	+	13	U
Isthmophlea sphaerospora (Carmichael ex Harvey) Kjellman		+		
Kuetzingiella holmesii (Batters) Kornmann		+		
Laminaria digitata (Hudson) J.V. Lamouroux	+	+	3, 6, 7, 11, 12, 13, 14, 15	W
Laminaria digitata v. *stenophylla* (Harvey) Kleen		+		
Laminaria hyperborea (Gunnerus) Foslie	+	+	2, 4, 5, 6, 9, 11, 13, 14, 15, 16	W
Laminaria saccharina (Linnaeus) J.V. Lamouroux	+	+	4, 5, 6, 13	W
Laminaria saccharina v. *phyllitis* Le Jolis		+		
Laminariocolax aecidioides (Rosenvinge) Burkhardt et Peters		+		
Laminariocolax tomentosoides (Farlow) Kylin		+		
Leathesia difformis (Linnaeus) Areschoug	+	+	6, 13	S
Litosiphon laminariae (Lyngbye) Harvey	+	+	6, 11, 13	C
Mesogloia vermiculata (J.E. Smith) S.F. Gray		+		
Microspongium globosum Reinke		+		
Myriactula areschougii (P.L. Crouan et H.M. Crouan) Hamel		+		
Myriactula clandestina (P.L. Crouan et H.M. Crouan) J. Feldmann		+		
Myriactula haydenii (Gatty) Levring		+		
Myriactula rivulariae (Suhr) J. Feldmann	+	+	13	R
Myriactula stellulata (Harvey) Levring		+		
Myrionema corunnae Sauvageau	+	+	13	R
Myrionema papillosum Sauvageau		+		
Myrionema strangulans Carmichael ex Greville	+	+	13	U
Myriotrichia clavaeformis Harvey	+	+	13, 14	U
Pelvetia canaliculata (Linnaeus) Decaisne et Thuret	+	+	6, 10, 11, 12, 13, 14, 15	W
Petalonia fascia (O.F. Müller) Kuntze		+		
Petalonia zosterifolia (Reinke) Kuntze		+		
Petrospongium berkeleyi (Greville) Nägeli ex Kützing		+		
Phaeostroma pustulosum Kuckuck		+		
Phycocelis crouani Athanasiadis	+		13	U
Phycocelis foecunda Strömfelt		+		
Protectocarpus speciosus (Børgesen) Kuckuck ex Kornmann		+		
Pseudolithoderma extensum (P.L. Crouan et H.M. Crouan) S. Lund	+		1	R
Punctaria latifolia Greville	+	+	13	R
Pylaiella littoralis (Linnaeus) Kjellman	+	+	6, 11	C
Ralfsia verrucosa (Areschoug) Areschoug	+	+	11	U
Saccorhiza polyschides (Lightfoot) Batters	+	+	4, 5, 8, 11, 13	C
Scytosiphon lomentaria (Lyngbye) Link	+	+	10, 11	U
Sphacelaria cirrosa (Roth) C. Agardh	+	+	4, 10, 11, 13	W

Table 2. (*continued*)

Species	Recorded in the new survey	Recorded in the original survey	Sites	Abundance
Sphacelaria nana Nägeli ex Kützing		+		
Spongonema tomentosum (Hudson) Kützing	+	+	6, 11, 13	S
Sporochnus pedunculatus (Hudson) C. Agardh	+	+	2	R
Stictyosiphon griffithsianus (Le Jolis) Holmes et Batters		+		
Stragularia clavata (Harvey) Hamel		+		
Stypocaulon scoparium (Linnaeus) Kützing	+	+	3	R
Taonia atomaria (Woodward) J. Agardh	+		5	R
Ulonema rhizophorum Foslie		+		
Rhodophyta				
Acrochaetium alariae (Jónsson) Bornet	+	+	15	L
Acrochaetium caespitosum (J. Agardh) Nägeli	+		7, 11, 13, 15	C
Acrochaetium daviesii (Dillwyn) Nägeli	+		4, 7, 13	U
Acrochaetium secundatum (Lyngbye) Nägeli		+		
Acrochaetium virgatulum (Harvey) Bornet	+		4, 6, 10, 11, 13	W
Acrosorium venulosum (Zanardini) Kylin	+	+	1, 2, 4, 5, 8, 9, 10, 11, 16	C
Aglaothamnion gallicum (Nägeli) L'Hardy-Halos ex Ardré	+		6	R
Aglaothamnion hookeri (Dillwyn) Maggs et Hommersand	+	+	11, 12, 13	C
Aglaothamnion priceanum Maggs, Guiry et Rueness	+		5	R
Aglaothamnion sepositum (Gunnerus) Maggs et Hommersand	+	+	7, 13, 14, 15	L
Aglaothamnion tenuissimum (Bonnemaison) G. Feldmann-Mazoyer	+		5	R
Ahnfeltia plicata (Hudson) Fries	+	+	2, 4, 6, 12	U
Antithamnion cruciatum (C. Agardh) Nägeli	+	+	8, 9	R
Antithamnion densum (Suhr) M. Howe	+		5	R
Antithamnionella spirographidis (Schiffner) E.M. Wollaston	+		8, 9	R
Apoglossum ruscifolium (Turner) J. Agardh	+	+	2, 5, 8, 9, 16	C
Asparagopsis armata Harvey	+		11, 13	L
(sporophyte '*Falkenbergia rufolanosa*')	+		7, 10, 11	C
Asterocolax erythroglossi J. Feldmann et G. Feldmann-Mazoyer	+		2, 4	U
Bangia atropurpurea (Roth) C. Agardh	+	+	11	L
Boergeseniella fruticulosa (Wulfen) Kylin	+	+	7, 10, 11, 13	W
Boergeseniella thuyoides (Harvey) Kylin	+	+	6, 11, 13	C
Bonnemaisonia asparagoides (Woodward) C. Agardh	+	+	1, 2, 5, 8, 9, 16	C
Bonnemaisonia hamifera Hariot		+		
(sporophyte '*Trailliella intricata*')	+		5, 6, 8, 9	U
Bornetia secundiflora (J. Agardh) Thuret		(+)		
Bostrychia scorpioides (Hudson) Montagne ex Kützing		+		
Brongniartella byssoides (Goodenough et Woodward) F. Schmitz	+		2, 4, 5, 9, 16	C
Calliblepharis ciliata (Hudson) Kützing	+	+	5	R
Calliblepharis jubata (Goodenough et Woodward) Kützing	+	+	13	R
Callithamnion granulatum (Ducluzeau) C. Agardh	+	+	11, 13	U
Callithamnion tetragonum (Withering) S.F. Gray	+	+	13	S
Callithamnion tetricum (Dillwyn) S.F. Gray	+		7	R

Table 2. (*continued*)

Species	Recorded in the new survey	Recorded in the original survey	Sites	Abundance
Callocolax neglectus F. Schmitz ex Batters	+	+	9	R
Callophyllis laciniata (Hudson) Kützing	+	+	1, 2, 5, 9, 11, 12, 16	C
Catenella caespitosa (Withering) L.M. Irvine		+		
Ceramium atlanticum H.E. Petersen		+		
Ceramium boergesenii H.E. Petersen		+		
Ceramium ciliatum (J. Ellis) Ducluzeau	+	+	4, 11	U
Ceramium deslongchampsii Chauvin ex Duby		+		
Ceramium echionotum J. Agardh	+	+	4, 13	S
Ceramium gaditanum (Clemente) Cremades		+		
Ceramium pallidum (Nägeli ex Kützing) Maggs et Hommersand	+		7	R
Ceramium secundatum Lyngbye	+	+	15	U
Ceramium shuttleworthianum (Kützing) Rabenhorst	+	+	3, 7, 13, 14, 15	C
Ceramium strictum sensu Harvey	+	+	9, 11	U
Ceramium virgatum Roth	+	+	2, 7, 10, 11, 13	W
Champia parvula (C. Agardh) Harvey	+	+	10, 11, 12	U
Chondracanthus acicularis (Roth) Fredericq	+		12	R
Chondria dasyphylla (Woodward) C. Agardh	+		12	R
Chondrus crispus Stackhouse	+	+	3, 4, 5, 6, 11, 13, 14, 15	W
Choreocolax polysiphoniae Reinsch	+		13	U
Choreonema thuretii (Bornet) F. Schmitz		+		
Chylocladia verticillata (Lightfoot) Bliding	+	+	6, 11	U
Coccotylus truncatus (Pallas) M.J. Wynne et J.N. Heine	+		12	R
Compsothamnion gracillimum De Toni	+		2, 4, 9	U
Compsothamnion thuyoides (J.E. Smith) Nägeli	+		1, 2, 4, 5, 8, 9, 16	C
Corallina elongata J. Ellis et Solander	+		6, 11	C
Corallina officinalis Linnaeus	+	+	2, 4, 6, 11, 13	W
Cruoria pellita (Lyngbye) Fries	+	+	1, 2, 5, 8, 9	
Cryptopleura ramosa (Hudson) Kylin ex L. Newton	+	+	1, 2, 4, 5, 8, 9, 11, 13, 16	W
Cystoclonium purpureum (Hudson) Batters	+	+	4, 12	R
Dasya hutchinsiae Harvey	+	+	4, 5, 6, 11	U
Delesseria sanguinea (Hudson) J.V. Lamouroux	+	+	1, 2, 4, 5, 6, 8, 9, 11, 16	W
Dilsea carnosa (Schmidel) Kuntze	+	+	2, 4, 5, 6, 13	C
Drachiella spectabilis Ernst et J. Feldmann	+		5, 16	R
Dudresnaya verticillata (Withering) Le Jolis		+		
Dumontia contorta (S.G. Gmelin) Ruprecht	+	+	11, 13	C
Erythroglossum laciniatum (Lightfoot) Maggs et Hommersand	+		2, 4, 5, 8, 9, 16	C
Erythrotrichia carnea (Dillwyn) J. Agardh	+	+	10, 11, 13	U

Table 2. (*continued*)

Species	Recorded in the new survey	Recorded in the original survey	Sites	Abundance
Erythrotrichia welwitschii (Ruprecht) Batters		+		
Furcellaria lumbricalis (Hudson) J.V. Lamouroux	+	+	2, 4, 6, 11, 12	C
Gastroclonium ovatum (Hudson) Papenfuss	+	+	4, 6, 11, 13	W
Gelidium pulchellum (Turner) Kützing	+	+	6, 7, 10, 11, 13, 15	W
Gelidium pusillum (Stackhouse) Le Jolis	+	+	13	U
Gelidium spinosum (S.G. Gmelin) P.C. Silva		+		
Gloiosiphonia capillaris (Hudson) Carmichael ex Berkeley	+	+	2, 4	U
Gonimophyllum buffhamii Batters	+	+	8, 9	U
Gracilaria gracilis (Stackhouse) Steentoft, L.M. Irvine et Farnham	(+)		12	R
Gracilariopsis longissima (S.G. Gmelin) Steentoft, L.M. Irvine et Farnham	+		12	R
Grateloupia filicina (J.V. Lamouroux) C. Agardh	+		2, 5	R
Gymnogongrus crenulatus (Turner) J. Agardh	+		4, 12	R
Halarachnion ligulatum (Woodward) Kützing	+	+	2, 5, 8, 9	U
Haliptilon squamatum (Linnaeus) H.W. Johansen, L.M. Irvine et A. Webster	+	+	11, 13	U
Halurus equisetifolius (Lightfoot) Kützing	+	+	13	R
Halurus flosculosus (J. Ellis) Maggs et Hommersand	+	+	9, 13	R
Haraldiophyllum bonnemaisonii (Kylin) A.D. Zinova	+		8, 9, 16	U
Harveyella mirabilis (Reinsch) F. Schmitz et Reinke		+		
Helminthora divaricata (C. Agardh) J. Agardh		+		
Heterosiphonia plumosa (J. Ellis) Batters	+	+	4, 5, 8, 9, 11	C
Hildenbrandia rubra (Sommerfelt) Meneghini	+	+	13	U
Hypoglossum hypoglossoides (Stackhouse) Collins et Hervey	+	+	1, 2, 5, 6, 8, 9, 11, 16	C
Jania rubens (Linnaeus) J.V. Lamouroux	+	+	13	L
Kallymenia reniformis (Turner) J. Agardh	+	+	1, 2, 8, 16	U
Laurencia obtusa (Hudson) J.V. Lamouroux	+		7, 13	S
Lithophyllum corallinae (P.L. Crouan et H.M. Crouan) Heydrich		+		
Lithophyllum incrustans Philippi	+	+	13	L
Lithophyllum pustulatum (J.V. Lamouroux) Foslie	+	+	13	U
Lomentaria articulata (Hudson) Lyngbye	+	+	4, 6, 11, 12, 13, 15	W
Lomentaria clavellosa (Turner) Gaillon	+	+	2, 4, 5, 6, 8, 9, 12	C
Lomentaria orcadensis (Harvey) Collins ex W.R. Taylor	+		8, 9	R
Mastocarpus stellatus (Stackhouse) Guiry	+	+	4, 6, 7, 11, 13, 15	W
(sporophyte '*Petrocelis cruenta*')	+		6, 11, 13	C
Meiodiscus spetsbergensis (Kjellman) Saunders et McLachlan	+		8	R
Melobesia membranacea (Esper) Heydrich	+	+	13	R
Membranoptera alata (Hudson) Stackhouse	+	+	4, 6, 9, 11, 16	C

Table 2. (*continued*)

Species	Recorded in the new survey	Recorded in the original survey	Sites	Abundance
Meredithia microphylla (J. Agardh) J. Agardh	+		2, 4, 5, 16	U
Mesophyllum lichenoides (J. Ellis) M. Lemoine	+	+	6, 11, 13	L
Monosporus pedicellatus (J.E. Smith) Solier		+		
Naccaria wiggii (Turner) Endlicher	+		5, 9	U
Nemalion helminthoides (Velley) Batters	+	+	13, 14, 15	L
Nitophyllum punctatum (Stackhouse) Greville	+		1, 2, 5, 8, 9, 11, 16	C
Osmundea hybrida (De Candolle) Nam	+	+	6, 10, 11, 13	C
Osmundea osmunda (S.G. Gmelin) Nam et Maggs	+		11	U
Osmundea pinnatifida (Hudson) Stackhouse	+	+	4, 6, 10, 11, 13	W
Palmaria palmata (Linnaeus) Kuntze	+	+	3, 4, 6, 7, 9, 10, 11, 13	W
Peyssonnelia dubyi P.L. Crouan et H.M. Crouan	+		4	R
Phycodrys rubens (Linnaeus) Batters	+	+	6, 8, 9, 11, 16	C
Phyllophora crispa (Hudson) P.S. Dixon	+	+	2, 4, 5, 6, 11, 12, 13, 15, 16	W
Phyllophora pseudoceranoides (S.G. Gmelin) Newroth et A.R.A. Taylor	+	+	11	R
Phymatolithon brunneum Y.M. Chamberlain	+		13	R
Phymatolithon laevigatum (Foslie) Foslie		+		
Phymatolithon lenormandii (J.E. Areschoug) W.H. Adey		+		
Phymatolithon purpureum (P.L. Crouan et H.M. Crouan) Woelkerling et L.M. Irvine	+	+	13	U
Pleonosporium borreri (J.E. Smith et Sowerby) Nägeli	+		4	R
Plocamium cartilagineum (Linnaeus) P.S. Dixon	+	+	2, 4, 5, 6, 8, 11, 13, 16	W
Plumaria plumosa (Hudson) Kuntze	+	+	4, 6, 11, 13	C
Polyides rotundus (Hudson) Greville	+		4, 6, 12	R
Polysiphonia atlantica Kapraun et J.N. Norris	+	+	4, 12	L
Polysiphonia brodiei (Dillwyn) Sprengel	+	+	4, 6, 7, 11, 13, 14, 15	W
Polysiphonia elongata (Hudson) Sprengel	+	+	2, 13	S
Polysiphonia fibrata (Dillwyn) Harvey	+	+	5, 6, 11, 15	C
Polysiphonia fibrillosa (Dillwyn) Sprengel	+		11	R
Polysiphonia fucoides (Hudson) Greville	+		2, 3, 4, 6, 10, 11, 12	C
Polysiphonia furcellata (C. Agardh) Harvey		+		
Polysiphonia harveyi J. Bailey	+		10, 12	R
Polysiphonia lanosa (Linnaeus) Tandy	+	+	6, 11, 13	L
Polysiphonia nigra (Hudson) Batters	+	+	2, 12	R
Polysiphonia stricta (Dillwyn) Greville	+	+	1, 4, 5, 6, 8, 9, 13, 15	C
Porphyra dioica Brodie et L.M. Irvine	+		12	R

Table 2. (*continued*)

Species	Recorded in the new survey	Recorded in the original survey	Sites	Abundance
Porphyra leucosticta Thuret	+	+	3, 7, 11	C
Porphyra linearis Greville	+	+	11	S
Porphyra umbilicalis (Linnaeus) Kützing	+	+	7, 13, 14, 15	C
Porphyropsis coccinea (J. Agardh ex Areschoug) Rosenvinge	+	+	2	R
Pophyrostromium boryanum (Montagne) Trevisan		+		
Porphyrostromium ciliare (Carmichael) M.J. Wynne	+		4	R
Pterocladiella capillacea (S.G. Gmelin) Santelices et Hommersand	+	+	13	L
Pterosiphonia parasitica (Hudson) Falkenberg	+	+	1, 2, 5, 6, 8, 9, 13, 16	C
Pterothamnion crispum (Ducluzeau) Nägeli		+		
Pterothamnion plumula (J. Ellis) Nägeli	+		2, 5	U
Ptilota gunneri P.C. Silva, Maggs et L.M. Irvine	+	+	1, 2, 5, 8, 9, 11	C
Ptilothamnion pluma (Dillwyn) Thuret	+	+	1, 5, 8, 9	C
Radicilingua thysanorizans (Holmes) Papenfuss	+		1, 2, 4, 5, 9	C
Rhodochorton membranaceum (Magnus) Hauck	+		8	R
Rhodochorton purpureum (Lightfoot) Rosenvinge		+		
Rhodomela confervoides (Hudson) P.C. Silva	+	+	2, 4, 5, 6, 9	C
Rhodophyllis divaricata (Stackhouse) Papenfuss	+	+	5, 8, 9, 13, 16	C
Rhodothamniella floridula (Dillwyn) J. Feldmann	+	+	6, 7, 11, 12, 13	W
Rhodymenia ardissonei J. Feldmann	+		1, 2, 5	U
Rhodymenia delicatula P.J.L. Dangeard	+		1, 5	R
Rhodymenia pseudopalmata (J.V. Lamouroux) P.C. Silva	+		16	U
Schizymenia dubyi (Chauvin ex Duby) J. Agardh		+		
Schmitzia hiscockiana Maggs et Guiry	+		5, 9	U
Schmitziella endophloea Bornet et Batters		+		
Schottera nicaeënsis (J.V. Lamouroux ex Duby) Guiry et Hollenberg	+		1, 5, 8, 9, 13, 16	C
Scinaia turgida (De Candolle) M.J. Wynne	+		2, 5	U
Spermothamnion repens (Dillwyn) Rosenvinge	+	+	2, 4, 6, 12	L
Sphaerococcus coronopifolius Stackhouse	+	+	1, 5	U
Sphondylothamnion multifidum (Hudson) Nägeli	+	+	2, 8, 16	U
Stylonema alsidii (Zanardini) K.M. Drew	+		10	R

For the species recorded in the new survey, a general estimate of the abundance is provided according to the following scale: W = widespread species (occurring at many sites and on many sampling dates, forming large populations); C = common species (occurring at several sites and on several sampling dates, but usually not producing large populations); U = uncommon species (occurring at one or a few sites, usually not producing large populations); L = local species (generally uncommon, occurring at one or few sites but locally producing large populations); S = seasonal species (generally rare but locally abundant on some sampling dates, apparently with considerable seasonal variation); R = rare species (occurring at one or a few sites, only as individual specimens or very limited populations). The mark (+) indicates species for which the identification is doubtful. For each species the currently accepted name is used; synonymies and taxonomic arrangement follow Hardy and Guiry (2003).

original survey. These include the brown algae *Desmarestia dresnayi*, *Dictyopteris polypodioides*, *Taonia atomaria* and the red algae *Aglaothamnion tenuissimum*, *Antithamnion densum*, *Brongniartella byssoides*, *Erythroglossum laciniatum*, *Naccaria wiggii*, *Pterothamnion plumula*, *Radicilingua thysanorhizans* and *Schottera nicaeënis*; furthermore, at the time of the original survey some of these species were unknown to science (*Aglaothamnion priceanum*, *Drachiella spectabilis*, *Phymatolithon brunneum*, *Rhodymenia ardissonei* and *Schmitzia hiscockiana*). Probably in subtidal habitats around the island these algae are not rare and there is no reason to believe that they were not present in 1910; the impossibility for Cotton to collect them is presumably the only reason why they did not appear in his report.

However, a few of the species not recorded by Cotton (1912) are large, distinctive intertidal algae that we collected in pools or on bedrocks; the brown *Bifurcaria bifurcata*, *Cystoseira nodicaulis* and *Cystoseira foeniculacea* are perhaps the most remarkable examples. *B. bifurcata* and *C. nodicaulis* are relatively common on the shores of northern and western Ireland, where they most frequently occur in intertidal pools (De Valéra 1962). *C. foeniculacea* is comparatively much rarer, having been reported in scattered localities in the southwestern counties of Clare, Kerry and Cork (Guiry 1978). The morphology of these species is very distinctive and Cotton could not have missed or confused them. In fact, he mentioned explicitly that he could not find a single specimen of *B. bifurcata* (as *Bifurcaria tuberculata* Stackhouse) despite a careful search; at the same time, he reported the occurrence of *C. nodicaulis* (as *Cystoseira granulata* Agardh) in Clew Bay but not on Clare Island. This is remarkable for *C. nodicaulis*, since it is now relatively common on Clare Island. During visits in the spring and summer of 2000 and 2001 many large specimens were observed in intertidal pools at the sites 6, 11 and 13, so for this species it is difficult to propose an immediate explanation of its absence in 1910. Conversely, the current distribution of *B. bifurcata* and *C. foeniculacea* on Clare Island appears much more localised. They occur at a single site, Portnakilly (site 13), where these algae are present only in two mid-lower intertidal pools (*B. bifurcata*) and a few mid-upper intertidal pools (*C. foeniculacea*). For *B. bifurcata*, it is also interesting to note that De Valéra (1962) confirmed the absence of the species on Clare Island in August 1960. Evidently, the general conditions of Clare Island must not be suitable for settlement, growth and dispersal of these species; in such an unfavourable environment, their presence and abundance possibly undergo significant variations not only in space, but also in time. These temporal fluctuations probably take place on a scale of years or tens of years and do not seem to be seasonal. In fact, De Valéra (1962) suggested the possibility that climatic fluctuations may affect the abundance of *B. bifurcata* on western Irish shores (and the same might apply to *C. foeniculacea* and *C. nodicaulis*); we agree with her that experimental studies on the effect of abiotic factors on critical stages of the life history might be of great help to elucidate this phenomenon. In this regard, it is also interesting to compare the distribution of *B. bifurcata* and *C. foeniculacea* with that of another fucalean brown alga, *Ascophyllum nodosum*. Remarkably, still today *A. nodosum* occurs only at a single site (a mid-intertidal bedrock at Portnakilly, partially sheltered by a long cement pier), which is precisely the same place where Cotton (1912) reported the alga.

Some species of red algae, such as *Chondracanthus acicularis*, *Chondria dasyphylla*, *Coccotylus truncatus*, *Gracilaria gracilis* and *Porphyra dioica* also have a very limited distribution on Clare Island, at least in the intertidal zone. We only found them in some lower littoral pools in an isolated rocky area situated in the northern part of the bay of the harbour (site 12). These species were also not reported by Cotton and, in this case too, we consider this unlikely to be the result of overlooking or misidentifications; in fact, Cotton (1912) cited *C. acicularis* (as *Gigartina acicularis*) as one of the notable absentees in the area. For these species, such a limited distribution is probably attributable to the type of habitat in which they occur. Although reported in a variety of intertidal and subtidal habitats in Britain and Ireland, these algae are well known to be very tolerant of sand cover (Dixon and Irvine 1977; Maggs and Hommersand 1993; Brodie and Irvine 1997). The rockpools in which we collected these algae are typically subjected to heavy sand burial; presumably, such a tolerance must be an advantage that they do not have in other parts of the island's shore, in which a combination of biotic and abiotic factors evidently prevents their colonisation and development.

As we found some species not collected during the original survey, in the same way there is a number of species recorded by Cotton (1912) that have not been found. Many of these are microscopic entities, usually impossible to recognise in the field and generally subject to serendipitous discovery, such as the green *Acrochaete* spp. and *Urospora* spp. and the brown *Compsonema* spp., *Laminariocolax* spp., *Myrionema* spp. and *Myriactula* spp. Other species must be actually uncommon, restricted to particular habitats, or very seasonal on Clare Island, as Cotton (1912) cited them as rare or local (e.g., the red algae *Bostrychia scorpioides*, *Choreonema thuretii*, *Gelidium spinosum*, *Helminthora divaricata*, *Monosporus pedicellatus*, *Polysiphonia furcellata*). It is possible that, similarly to *B. bifurcata*, *C. nodicaulis* and *C. foeniculacea*, the abundance of these species may undergo considerable temporal fluctuations and that future collections will rediscover them; in any case, at present, there is no reason to believe that they have disappeared in the last 90–100 years. We also suspect that the current absence of a few of the species recorded by Cotton (1912) is only apparent, probably due to different taxonomic concepts followed in the two studies. For example, we identified as *Ulva rigida* the only species of *Ulva* that we found on Clare Island; all the specimens that we collected and examined microscopically are in good agreement with the morphology of this species as described by Burrows (1991). Conversely, *Ulva lactuca* is the only species recorded by Cotton (1912), who perhaps regarded *U. lactuca* and *U. rigida* as conspecific or the latter as a variety of the former. Most probably, the algae cited as *U. rigida* by us and *U. lactuca* by Cotton (1912) are the same. A similar problem might be involved in the case of *Enteromorpha linza*, for which we did not find with certainty any specimens. These few doubtful records can be reassessed by checking Cotton's voucher specimens (conserved in the Natural History Museum, London), that we are planning to examine soon. A few species were also probably misidentified by Cotton. For example, Guiry (1978) and Maggs and Hommersand (1993) indicated that Cotton's record of *Bornetia secundiflora* is most probably incorrect and the presence of this species on Clare Island is very unlikely.

On the basis of the previous discussion, we consider that no substantial long-term change has taken place in the floristic composition of the algal assemblages of Clare Island between 1910 and 2002; the differences between the list of the original survey and the list of the new survey appear in general easily explainable. Consequently, the estimate of 293 species (of which confirmation for 10–12 species is desirable), obtained from the results of the original and new survey, must be very close to the actual number of species. However, it is important to stress a point that has never been discussed in this type of surveys. Most floristic studies of marine algae simply report presence or absence of a species in a more or less extended geographical area, without making any mention of temporal patterns of distribution (and only rarely discussing spatial patterns in some detail). The comparison of this study with Cotton's report shows clearly that the presence of some marine algae on Clare Island is characterised by marked temporal fluctuations: these are probably present on the island only periodically or occasionally (e.g., *Bifurcaria bifurcata*, *Cystoseira foeniculacea*, *Chondracanthus acicularis*, etc.). How should these species be considered? We suggest the term 'ephemeral members' or 'non-permanent members'. Species of marine algae for which the distribution shows such irregularities in space and time are probably common on small islands such as Clare Island. We expect that the relative abundance of non-permanent members of the flora will be more important in environments characterised by strong biotic or abiotic disturbance (a generally very wave-exposed environment, in the case of Clare Island). This phenomenon can be expected to be even more marked for species which are at the limits of their geographical distribution (for Clare Island, this may be the case for *Cystoseira foeniculacea*).

Introduced algae

Despite the general absence of long-term variation, there are at least two species which are now permanent members of the algal flora of Clare Island that certainly appeared there after the original survey. These are the green alga *Codium fragile* subsp. *tomentosoides* and the red alga *Asparagopsis armata*. Their status of species introduced to Europe is well known and has been documented in detail. This might also be the case for another red alga, *Polysiphonia harveyi*.

Codium fragile subsp. *tomentosoides* is one of the most widely distributed introduced seaweeds on a global scale (Trowbridge 1998). This alga is probably a native of Japan and adjacent seas (Silva 1955), but in the last century it has spread to most temperate seas of the world (Silva 1957; Carlton and Scanlon 1985; Burrows 1991; Trowbridge 1998). In Europe, it was first observed in The Netherlands around 1900 and subsequently it spread to most of the Atlantic and Mediterranean shores of the continent (Trowbridge 1998). The first documented records for Ireland date back to 1941 (Silva 1955; Trowbridge 1998) and since then the alga has been a common member of the algal assemblages of lower intertidal pools and bedrock (Parkes 1975; Burrows 1991; Trowbridge 2001). In Ireland, the distribution of *C. fragile* subsp. *tomentosoides* has overlapped that of another subspecies, *Codium fragile* subsp. *atlanticum*. This is also generally considered an introduced alga, which appeared on Irish shores before 1808 and subsequently spread around the British Isles and to Norway (Silva 1955, 1957; Trowbridge 1998). At the time of the original survey, the subsp. *atlanticum* was abundant on Clare Island and Cotton (1912) remarked that on the first day spent on the island the alga attracted his attention because of the obvious morphological difference from the native *Codium tomentosum*; he reported both entities as common, highlighting some ecological differences (Cotton 1912). Our collections and observations suggest that nowadays the subsp. *tomentosoides* is the most common *Codium* on Clare Island. During the period of this study, plants of *Codium* have been rarely observed on intertidal bedrocks; these algae mainly occurred in intertidal pools and, although subsp. *atlanticum*, *C. tomentosum* and *Codium vermilara* were also recorded, the majority of the specimens examined microscopically was readily attributed to subsp. *tomentosoides*. There is some speculation that interspecific competition by introduced *Codium* may result into exclusion of native algae (Parkes 1975; Farnham 1980; Eno et al. 1997), suggesting that the spread of subsp. *tomentosoides* on Clare Island may have had a negative effect on the congeners previously present. Further studies, however, are necessary to assess this with certainty; a recent investigation by Trowbridge (2001) showed that, at four coastal sites on the Irish mainland, no decline of subsp. *atlanticum* and *C. tomentosum* attributable to dominance of subsp. *tomentosoides* could be detected in the last 30 years.

Asparagopsis armata was introduced to Europe in the early years of the last century. This species was reported more or less at the same time at several localities on Atlantic and Mediterranean shores around 1940 (De Valéra 1942; Feldmann and Feldmann 1942; Guiry and Dawes 1992). In Ireland the alga was first recorded in the area of Galway Bay, where in 1939 De Valéra collected the sporophytic *Falkenbergia* phase (Drew 1950; De Valéra and Folan 1964) and subsequently the gametophyte (De Valéra 1942). Since then the alga has spread along Irish shores, but the two phases seem to have different distribution patterns and have probably mainly spread independently, by vegetative fragmentation (Guiry et al. 1979; Guiry and Dawes 1992). The sporophyte has been reported for the whole of Ireland, except the eastern shores (Dixon and Irvine 1977). The gametophyte is most abundant in late spring and summer, and it is rarely observed in autumn and winter (Guiry and Dawes 1992); its occurrence has been reported only on southern and southwestern shores, County Mayo being its northern distribution limit (Dixon and Irvine 1977; Guiry et al. 1979). Interestingly, a marked difference in the abundance of the gametophyte was observed on Clare Island between collections in 1990 and 2001. In spring and summer 2001 large gametophytes were common in the lower intertidal and shallow subtidal at the sites 11 and 13, whereas the alga was not observed in June 1990, neither subtidally nor at intertidal sites (only a few drift specimens were collected). We consider this more likely to be an effect of different climatic situations between the two periods, with the conditions of 2001 favouring an earlier vegetative development, rather than the result of a recent spread of *A. armata* on Clare Island. For a detailed discussion of the factors influencing growth and reproduction in this species, see Guiry and Dawes (1992).

The presence of *Polysiphonia harveyi* in Britain and Ireland has been recognised only relatively recently (Maggs and Hommersand 1990), because of its close similarity with indigenous species of *Polysiphonia*. Recent studies based on molecular techniques showed that this morphologically and physiologically polymorphic alga has undergone several cryptic introductions (McIvor et al. 2001); the first documented record for the British Isles dates back to 1908 (Maggs and Hommersand 1993). However, at present it is not possible to state with certainty whether or not this species occurred on Clare Island at the time of the original survey.

General consideration of the benthic algal flora of Clare Island

From the floristic point of view, the collections made during the study led to some interesting findings. *Antithamnion densum*, *Aglaothamnion priceanum* and *Phymatolithon brunneum* were interesting records; details on taxonomy and distribution of these species are reported elsewhere (Guiry and Maggs 1991; Maggs et al. 1991; Maggs and Hommersand 1993; O'Flynn 2000). Despite these few peculiarities, however, the composition of the algal flora of Clare Island does not show any marked differences or distinctive characters from that of the western Irish shores. As remarked by Guiry and Hession (1998), unlike other coastlines around the world, it is not possible to find major discontinuities in floral composition along Irish shores; this clearly applies to Clare Island too. It is noteworthy, however, that at least 293 species of benthic marine algae have been recorded. This should be regarded as a considerable number for an island with a coastal extent of about 30 km, considering that, with its extensive shoreline and large differentiation of coastal habitats, the Irish mainland is known to host about 580 species of benthic marine algae (including Cyanophyta).

Finally, it seems appropriate to conclude with some considerations on the general status of the benthic algal assemblages of Clare Island. This study was primarily floristic, aimed at compiling a catalogue comparable with Cotton's report. We did not study in detail the temporal and spatial patterns of distribution of individual species and we did not examine experimentally the effect of particular factors on the structure of the benthic communities. Consequently, it is not possible to make generalisations about the spatial and temporal dynamics of algal assemblages and to state if long-term changes took place. However, our observations suggest that in general the marine algal assemblages of Clare Island are remarkably well conserved. Although spatial patterns of distribution are fairly variable for many species, most types of vegetation described by Cotton are still easily recognisable (in particular the types occurring on exposed shores, such as the 'Fucaceae association', the '*Porphyra umbilicalis* association' and the '*Callithamnion arbuscula* association'). The only two major introduced algae, *Codium fragile* subsp. *tomentosoides* and *Asparagopsis armata*, occur in the form of scattered individuals; their influence on the native species has clearly none of the deleterious effects reported for other introductions on the Atlantic and Mediterranean shores of Europe (Rueness 1989; Boudouresque et al. 1992; Piazzi et al. 2001). Our experience leads us to conclude that these considerations can be generalised to many parts of the Irish western coast. In the last 200 years the western shore of Ireland has experienced a much lower human impact than many other coastal areas in Europe. The collapse of population which followed the Great Famine of the 1840s reduced large parts of western Ireland (including Clare Island) to a very low population density for a long time; furthermore, the scanty local population has traditionally found most of its resources in farming or agriculture rather than in activities associated with the sea. We therefore regard Clare Island and many similar coastal zones of western Ireland as areas worthy of special and vigorous efforts for conservation.

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