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Benthic marine ecosystems of Great Britain and the north-east Atlantic

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Part 2

Reviews within MNCR Coastal Sectors

Chapter 14: Outer Hebrides (MNCR Sector 14)*

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Synopsis

The Outer Hebrides including the offshore rocks of the St Kilda archipelago, Sula Skeir, North Rona and, far to the west, the isolated outcrop of Rockall include locations ranging from exceptionally exposed to exceptionally sheltered to wave action. Although there are no marine research stations in the area, the special features of the islands have attracted significant research studies. The islands of North and South Uist are especially characterised by extensive shallow marine and brackish-water fjardic sealochs and obs connected to each other and to the sea by rapids. These lagoonal features include highly specialised communities. On Lewis and Harris, fjordic sealochs are present and hold communities similar to those on mainland Scotland. The open coast of the islands includes rocky areas and some extensive sediment beaches. The offshore rocks are extremely exposed. St Kilda has communities and species characteristic of these exposed conditions and extensive cave, arch and tunnel habitats mainly colonised by encrusting animals. Rockall is remarkable for the extent of the *Alaria esculenta* forest and for the absence of intertidal species with a pelagic larva but has a rich fauna on underwater rock.

14.1 Introduction

The Outer Hebrides or Western Isles (Figures 14.1, 14.2 and 14.5) form the largest and most westerly offshore island group in Britain. They are divided roughly in two by the Sound of Harris, with the Uists, including North and South Uist, Benbecula, Barra and Mingulay, to the south, and Lewis and Harris to the north. The St Kilda island group lies some 65 km to the west of the Sound of Harris, and the isolated outcrops of Sula Sgeir and North Rona about 65 km north of the Butt of Lewis. Rockall, the most exposed and isolated rock in the British Isles, lies a further 265 km west of St Kilda.

Mean surface temperatures in the area range from about 7.5 °C in winter to 13–13.5 °C in the summer. Many of the shallow basins in the area experience ranges much greater than this. Surface salinity is in the region of 34.5–34.75‰, but there are a number of lagoons and obs, particularly in the Uists, with a full range of salinities from fresh to brackish and fully marine conditions (Nicol 1936a, 1936b). Most of the islands are subject to a mean spring tidal range of about 4 m. (All open coast data from Lee & Ramster 1981.)

The Outer Hebrides are subject to some of the most severe and frequent storms which affect the British Isles. The islands' west coasts are fully exposed to the prevailing westerly winds, and have no protection from the full force of the Atlantic. However, the large Atlantic swells are dampened somewhat as the seabed shelves gradually along the west side of the islands, with the 50 m depth contour some 12–16 km offshore. Much deeper water is present close inshore around St Kilda and Rockall, which are constantly subject to severe Atlantic swells and rate among the most wave-exposed coasts in the British Isles. In contrast to the western side of the Outer Hebrides, the eastern seaboard shelves steeply close inshore and, particularly at the southern and northern approaches to the Minch, is also affected

* This review was completed from published and, where available, unpublished sources of information on benthic habitats and communities including the results of interviews with relevant workers undertaken up to 1991. That work was published in Connor (1991a). The review has been revised to take account of major additional studies up to the end of 1994 by the second author and up to the end of 1996 by the series editor. It does not include benthic survey information summarised for or published in the MNCR *Regional Reports* series or work now being undertaken to describe and map biotopes in candidate Special Areas of Conservation. For information on conservation status and an analysis of rare and scarce seabed species, the reader is referred to the *Coastal Directories* series.

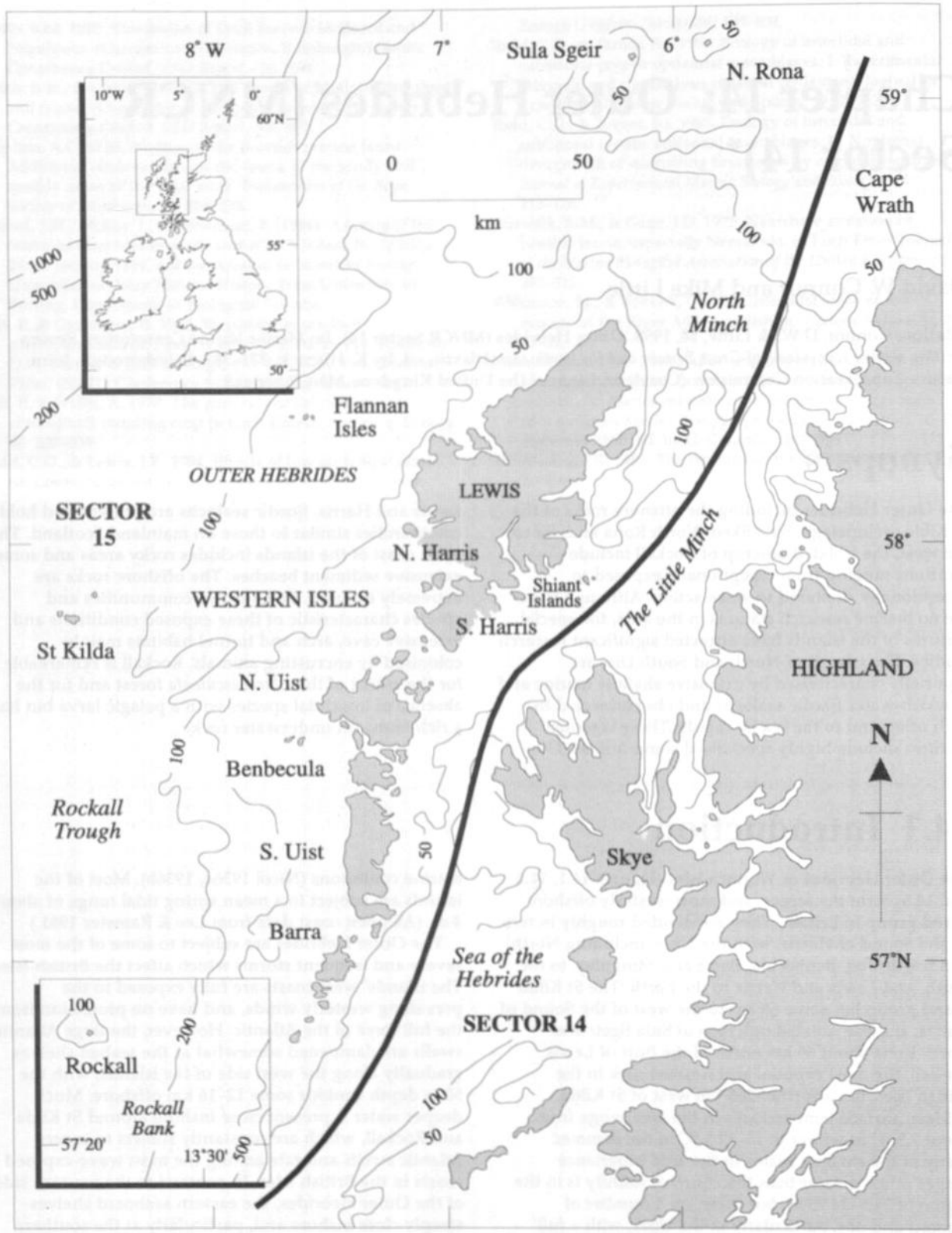

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Figure 14.1 The Outer Hebrides (MNCR Sector 14).

by the Atlantic swell. As with much of the rest of Scotland's west coast, the islands are highly indented by a series of sealochs which provide areas of extreme shelter from wave action, and a wide range of tidal stream strengths through the many narrow channels and rapids.

The Western Isles, particularly the Uists, have a very varied topography giving rise to a complex of land, water, islands and rocks. The highly indented coastline is formed into a series of sealochs many of which are further divided. These lochs range from fully marine to brackish and freshwater. Earll & Pagett (1984), in a catalogue of the sealochs, classified the lochs on the basis of salinity, with a secondary division based on water chemistry for freshwater and brackish lochs and on physiographic features for marine lochs. Marine lochs were distinguished from open bays by the presence of a sill, and divided into ob-like, fjardic, fjardic with fjordic features and truly fjordic sealochs. Earll & Pagett (1984) noted that obs, fjards and fjards with fjordic features are well represented in the Western Isles, but that fjordic sealochs are not as common as on the mainland. Loch Bee was considered to be the only machair-type brackish loch and Loch Obisary was rated as an outstanding brackish loch. Much of the recent information for sealochs in Sector 14 is based on surveys undertaken for the MNCR by the University Marine Biological Station, Millport, the results of which were described in Howson, Connor & Holt (1994) and in a series of separate survey reports cited below.

Connor (1991b) compared Scottish sealochs with Norwegian fjords and concluded that some of the extensive shallow systems in the Western Isles were of particularly high conservation interest. Connor (1994) considered the sublittoral zone of Loch Maddy to be one of the richest and most interesting in the British Isles. Buck (1993) included nine Outer Hebridean sites in her inventory of UK estuaries. Some of the obs of the Hebrides and north-west Scotland were surveyed by Smith (1987), and more recently by the MNCR. Harvey *et al.* (1980) regarded a number of rocky shores in the Western Isles as being of national importance while Bishop & Holme (1980) provided an assessment of the conservation value of sediment shores. A compilation of studies relating to the environment of the Outer Hebrides, including a number covering marine aspects, was brought together by Boyd (1979).

The Western Isles lie in the path of the Gulf Stream, which helps maintain winter sea temperatures above those on the mainland, and encourages the growth of warm-water species at a higher latitude than farther east on the Scottish mainland. Species such as the algae *Carpomitra costata*, *Meredithia microphylla* and *Rhodymenia ardissonei* have their most northerly known locations in the Western Isles or St Kilda (Maggs 1986). Maggs suggested that these species may also be restricted to these offshore islands because they require offshore water quality and hence cannot survive in the coastal and less saline inshore waters of mainland Scotland. The inshore water from the Clyde is known to mix with Atlantic water on the shelf west of Islay, and from there diverges to flow north through the Little Minch or around Barra Head and along the west coast of the Outer Hebrides (Ellett 1979). St Kilda however receives unmixed Atlantic water direct from the Rockall Channel. The influence of the North Atlantic Drift appears to be stronger on the Outer Hebrides, with southern species, such as the anemone *Bunodactis verrucosa*, the brown alga *Cystoseira tamariscifolia* (Harvey *et al.* 1980), and the red alga *Meredithia microphylla* (Maggs 1986) extending farther north than they do on the Scottish mainland. The northern brown alga *Fucus distichus edentatus* has its southern limit on North Rona and another subspecies *anceps* is found on the extremely exposed shores at the north end of Lewis, North Rona, Sula Sgeir, the Flannan Isles and St Kilda (Powell 1957, 1958). Powell *et al.* (1979) considered the islands, because of their offshore location, to have a slightly reduced littoral fauna and flora compared with mainland Scotland. The outlying islands of the Shiant Islands, Monach Islands, Flannan Islands, North Rona, Sula Sgeir, St Kilda and Rockall have a further reduced complement of shore species as a result of greater isolation and more severe exposure to wave action (Dipper & Mitchell 1980).

Stornoway is the principal fishing port for the Western Isles with the area being an important fishing ground for sprat *Sprattus sprattus*, Norway pout *Trisopterus esmarkii*, blue whiting *Micromesistius poutassou*, mackerel *Scomber scombrus*, Norway lobster *Nephrops norvegicus* and shrimps. There are also major spawning grounds for haddock *Melanogrammus aeglefinus*, whiting *Merlangius merlangus* and cod *Gadus morhua* in the area, which provide the principal demersal fisheries for the Sea of the Hebrides (Bailey, Hislop & Mason 1979). Dogfish and sand-eels (Ammodytidae) are caught seasonally. Recently, oil exploration companies have investigated the Hebridean Sea as a possible source of oil, with promising finds off Barra.

The sheltered shores of the east coast lochs have been extensively used for the commercial harvesting of the knotted wrack *Ascophyllum nodosum*. Walker (1947) estimated that 70% of Scotland's *Ascophyllum* and fucoid biomass occurred in the Outer Hebrides, with the bulk of this being in the Uists and Benbecula. Its harvesting in the Outer Hebrides since the Second World War has yielded the largest production of alginates in the world (Norton & Powell 1979). Norton & Powell (1979) also discussed the use of kelp *Laminaria* spp. as fertiliser and as a source of soda, potash and iodine.

There are no marine biological research stations in the Western Isles, but the area has attracted much attention because of its relative remoteness, its natural beauty and its wide variety of marine habitats. Consequently, the marine communities have been reasonably well studied, and the islands are perhaps better known than the less remote coast of north-west Scotland. Many surveys were initiated by the Nature Conservancy Council, including shore surveys by the Intertidal Survey Unit (SMBA/MBA) (Powell *et al.* 1979) and Smith (1978, 1982), surveys on the impact of fish-farms (Earll & Pagett 1984) and more recently MNCR surveys of sealochs (Holt 1991; Howson 1989, 1991) and subsequent MNCR surveys of isolated saline waters.

Powell *et al.* (1979) gave a description of the main shore communities in the Western Isles from the wide-ranging survey of rocky and sedimentary shores

undertaken by the NCC-commissioned Intertidal Survey Unit. Powell *et al.* (1979) selected 17 areas as of biological interest, including Loch Roag, which they considered to be of outstanding quality for its variety and richness. Six other areas (north-west Lewis, Griminish Point on North Uist, Rubha Ardvule on South Uist, Eoligarry off Barra, Bagh nam Faoileann off South Uist, and Loch Maddy on North Uist) were highly rated and are discussed below under the relevant sections. Angus (1979) described 20 sediment beaches around the island group, splitting the faunas into similar categories to those of Powell *et al.* (1979), from the exposed crustacean-dominated sands to the finer sediments with bivalves and lugworm *Arenicola marina* in sheltered conditions. He concluded that the abundance and composition of the fauna was principally determined by variation in wave exposure and found there to be a well developed zonation on most beaches. Norton & Powell (1979) gave a checklist of marine algae for the islands. Waterston *et al.* (1979) provided a useful summary of the biology of brackish lochs, which they considered together with freshwater systems on the islands. They noted that 25‰ appeared to be a critical salinity for marine species and 5‰ for freshwater species. Campbell & Williamson (1979) reviewed the fish populations of these brackish and freshwater systems. Rostron (1984) gave brief descriptions of sites surveyed by the Nature Conservancy Council from many of the fully saline sealochs in connection with pollution monitoring near salmonid fish-farms. Bryan (1994) provided a summary of current knowledge of the marine and coastal environment of Sector 14, and human influences affecting it.

14.2 The Uists

14.2.1 Introduction

Interest in the marine biology of the Uists and Barra (Figure 14.2) dates back to the last century when M'Intosh (1866) noted the littoral fauna of North Uist to be particularly rich and varied. The islands since then have attracted much attention with a number of studies in the 1930s, particularly on the extensive brackish-water systems of the island group, and more recently with surveys for NCC (e.g. Dipper & Mitchell 1980). General accounts of the molluscan fauna of the Uists were given by Angus (1977) and Smith (1978) who included species lists from a wide range of sites.

14.2.2 Barra

Sandy shores on Vatersay, at the southern end of the island group, and on neighbouring Barra, were first described by Stephen (1930). The Vatersay shores were rather barren, but a 5 km stretch of coast on Barra at Traigh Mhor, known as 'cockle shore', had a rich and very extensive bed of commercially fished *Cerastoderma edule*. Here Stephen (1930) was surprised not to find the tellin *Macoma balthica*, a common associate of *Cerastoderma edule*. Further attention to this shore and the formation of shell-banks from dead cockle shells was given by Farrow (1974). Indeed, the importance of the cockle shore at Traigh Mhor is recorded in the old writings of Dean Munro quoted (but without a date) in Gosse (1865): "This ile is full of grate cokills, and aledgit be the auncient countremen that the same cokills comes down out of the foresaid hill throw the said strype in the first smalle forme that wee have spokyn of, and aftir theyr comying down to the sandes growis gate cockills allways. Ther is no fayer and more profytable sandes for cokills in all the worlde". The Traigh Mhor shore was classed as 'sheltered' by Eleftheriou & McIntyre (1976) in their appraisal of Scotland's sandy beaches. Traigh Eais, on the west side of Barra fell into their 'exposed' category, and from there to Traigh Mhor was one of the most highly-rated sites described in Powell *et al.* (1979).

Forrest, Waterston & Watson (1936) gave an account of Barra's flora and fauna, including species lists for most marine groups, and Sinclair (1938) described the marine algae of the island. Both authors give records for Loch Obe on the east side of the island. Gunning, Pate & Crosset (1966) gave a description of the algal zonation along the long narrow gorge-like entrance channel to this small sealoch. This steep-sided entrance, with a rich fauna and flora (Powell *et al.* 1979), is a unique feature in the Outer Hebrides. Consequently, Loch Obe was promoted as an MCA (Nature Conservancy Council 1990).

Littoral and sublittoral sites on Barra and surrounding islands were surveyed by the MNCR in 1996. The southernmost islands of Berneray and Mingulay have deep water close inshore and so wave action from Atlantic swell and during strong onshore winds is severe. Very steep bedrock shores are characterised by very wide bands of lichens above typical wave-exposed communities of mussels and barnacles and red algae. In the sublittoral, the kelp *Alaria esculenta* dominates the sublittoral fringe. Below this lies a very rich forest and park of *Laminaria hyperborea* with dense red algae, sponges and a turf of bryozoans. The west-facing coast farther north, around Barra and Vatersay, is also characterised by steep barnacle-dominated rocky shores with kelp forests in the sublittoral zone. The kelp forest and park in this area extend several kilometres offshore on the flat bedrock plain that characterises this area. Surge gullies, caves and arches occur in several places around the islands especially on the west coast. Although varying with local conditions, the walls of these gullies and tunnels was characterised by a robust fauna of sponge crusts, anemones and colonial ascidians. Between the islands, there are shallow sounds where tidal streams are strong and the kelp plants are colonised by dense growths of sponges, colonial ascidians, anemones and brittlestars. Wherever sheltered conditions occur, shores were dominated by fucoid algae.

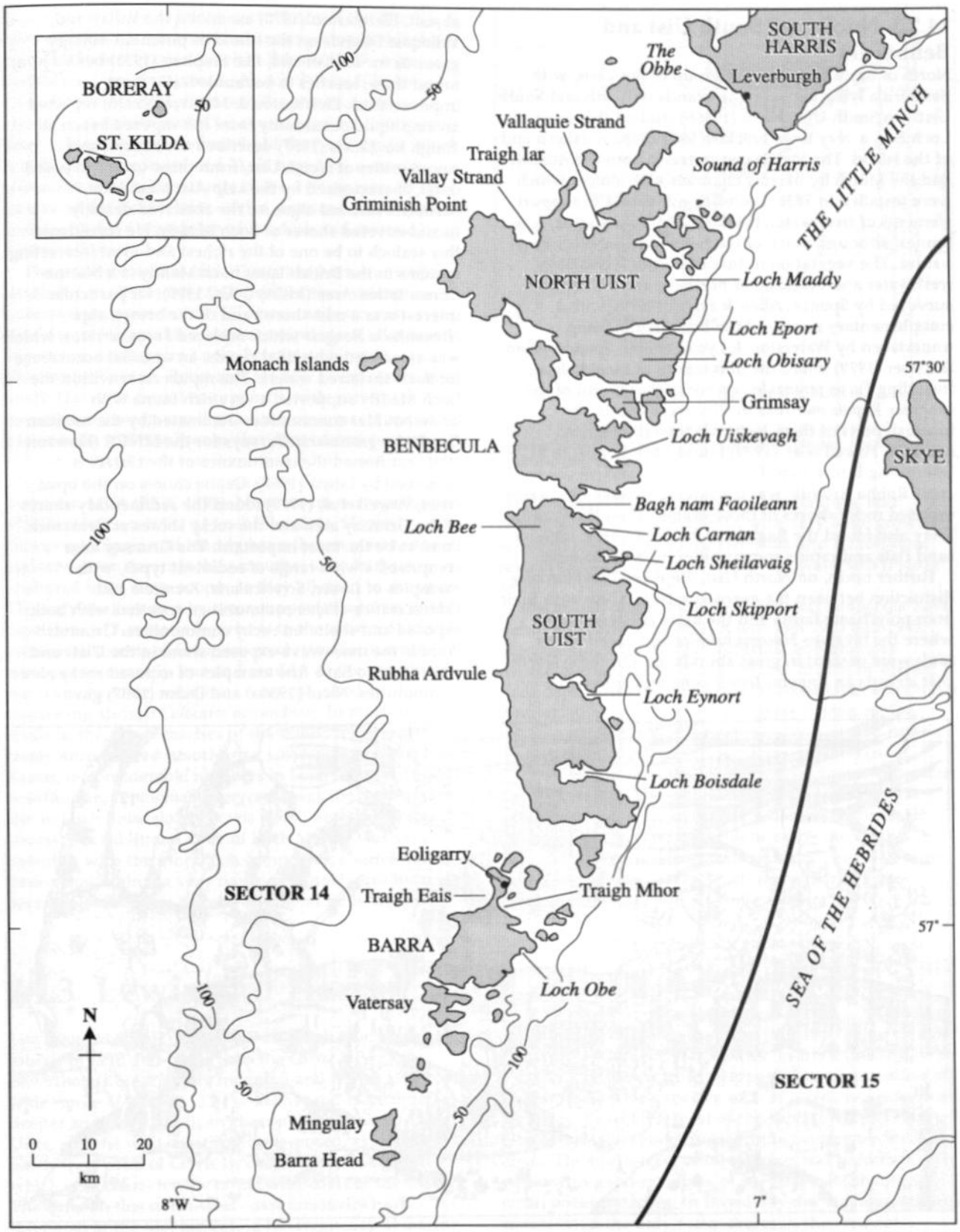

Figure 14.2. The Uists, Barra and St Kilda, showing places mentioned in the text.

14.2.3 North and South Uist and Benbecula

North of Barra lies the main group of the Uists, with Benbecula lying between the islands of North and South Uist. On South Uist, Nicol (1936b) studied the fauna of Loch Bee, a very large brackish loch at the northern end of the island. The loch is connected to both the Atlantic and the Minch by narrow channels with sluices which were installed in 1836. Loch Bee was found to support elements of freshwater, brackish and fully marine faunas, although much of the fauna was brackish in nature. The vegetation of this and other lochs, both freshwater and brackish, of northern South Uist was surveyed by Spence, Allen & Fraser (1979), with a complementary survey of the macrofauna being undertaken by Waterston & Lyster (1979). Spence, Allen & Fraser (1979) noted the dominance of fucoid algae, including *Fucus ceranoides*, on rocky shores and of the seagrass *Ruppia maritima* in silty areas within the brackish parts of these lochs. Of the fully marine sealochs, Powell *et al.* (1979) found Loch Eynort to have interesting littoral rapids communities, and on the west coast Rubha Ardvule was considered to have the richest exposed rocky shores of those examined on the island. They also found the Bagh nam Faoileann area, with its sand flats and rapids communities, to be of interest.

Farther north, on North Uist, Stephen (1935) found a distinction between the exposed sandy shores with their poor polychaete fauna and the more sheltered sites where the bivalves *Macoma balthica* and *Cerastoderma edule* were present in great abundance. On these North Uist strands an *Angulus tenuis* zone was apparently absent. Eleftheriou (1970) examined the Vallay and Vallaquie Strands on the island as potential nursery grounds for flatfish and, like Stephen (1935) before him, found these beaches to be faunistically quite impoverished. Eleftheriou & McIntyre (1976) reported an amphipod community from the exposed beach at Traigh Iar. Lewis (1957) described the rocky shore communities of North Uist, from those on the exposed coast, characterised by the kelp *Alaria esculenta*, barnacles and red algae, to the sheltered densely fucoid-covered shores of Loch Maddy. He considered this sealoch to be one of the richest and most interesting systems in the British Isles; Loch Maddy is a Marine Consultation Area (MCA) (NCC 1990). Of particular interest was a mid-shore band of the brown alga *Himanthalia elongata* which replaced *Fucus serratus*, which was associated with tidal rapids, an unusual occurrence for such sheltered waters. The rapids areas within the Loch Maddy supported a very rich fauna with underboulder communities dominated by the ascidian *Dendrodoa grossularia*. Surveys for the MNCR (Howson 1991) confirmed the continuance of the situation described by Lewis (1957). Of the shores on the open coast, Powell *et al.* (1979) found the sedimentary shores of the Grimsay area and the rocky shores at Griminish Point to be the most important. The Grimsay area comprised a wide range of sediment types, with examples of *Lanice*, *Scrobicularia*, *Arenicola* and *Echinocardium-siliqua* communities, together with both exposed and sheltered rocky communities. Griminish Point is the most wave-exposed shore in the Uists and was found to have fine examples of exposed rocky shore communities. Nicol (1936a) and Dunn (1937) gave

Figure 14.3. A tidal rapids community. Species illustrated include: 1. *Laminaria hyperborea*, 2. *Halidrys siliquosa*, 3. *Anemonia viridis*, 4. *Scypha ciliata*, 5. *Leucosolenia botryoides*, 6. *Antedon bifida*, 7. *Alcyonium digitatum*, 8. *Delesseria sanguinea*, 9. *Laminaria saccharina*, 10. *Halichondria panicea*, 11. *Echinus esculentus*, 12. *Necora puber*, 13. *Sagartia elegans*, 14. *Urticina felina*, 15. *Pomatoceros triqueter*, 16. *Ophiothrix fragilis*, 17. *Saccorhiza polyschides*, 18. *Asterias rubens*, 19. *Cancer pagurus*, 20. *Metridium senile*, 21. Encrusting Corallinacea, 22. *Lepidochitona cinerea/Tonicella rubra*, 23. *Pagurus bernhardus*, 24. *Galathea* sp., 25. *Phymatolithon calcareum*. From Howson, Connor & Holt (1994). (Drawing by Sue Scott.)

descriptions of the brackish-water lochs of the North Uist, and these were given further attention by Mitchell *et al.* (1980) and Dipper, Lumb & Palmer (1987) who highlighted the importance of Loch Obisary (Figure 14.4). Edwards (1989) discussed the physical and chemical nature of Loch Obisary, suggesting that there is deep saline water at the bottom of the north basin which is only slowly replaced and likely to produce anoxic sediments. The hydrography of the loch appears to be unique in the British Isles, with a permanent halocline giving a vertical separation of brackish and marine communities.

The sublittoral zone of the Uists has been less well studied than the shores, and much of the existing information comes from NCC-sponsored surveys. Rostron (1984) provided brief descriptions of sites from surveys undertaken in Lochs Boisdale, Skipport, Sheilavaig, Carnan, Eport and Maddy. Loch Eynort, in South Uist, was found to support a wide variety of communities for its small size, including maerl beds, gravel beds with the brown alga *Asperococcus turneri*, rich circalittoral rock communities with the sea fan *Swiftia pallida* and a rich rapids area (Dipper 1985). The loch is an MCA (NCC 1990). More recent surveys for the MNCR (Howson 1991) of Lochs Boisdale, Skipport, Uiskevagh, Eport and Maddy have shown most of the sealochs, even towards their mouths, to be fairly sheltered from wave action, as they all open to the east The very sheltered rocky areas supported a forest of the cape form of *Laminaria hyperborea* to the seaward side of areas with forests of *Laminaria saccharina*. Sediments were predominantly fine and muddy. At the mouths of the sealochs these sediments were colonised by the burrowing shrimp *Calocaris macandreae*. In much softer muds in the upper reaches of the sealochs the very rarely encountered holothurian *Labidoplax media* was found, in considerable numbers in Loch Maddy. Another holothurian, *Leptosynapta bergensis*, was common at one site in Loch Boisdale. As Lewis (1957) found with the shores, the sublittoral zone of Loch Maddy was very complex, with the inner loch comprising a series of basins that drain via very narrow channels and form several waterfalls on the ebb and flood tides. Maerl beds

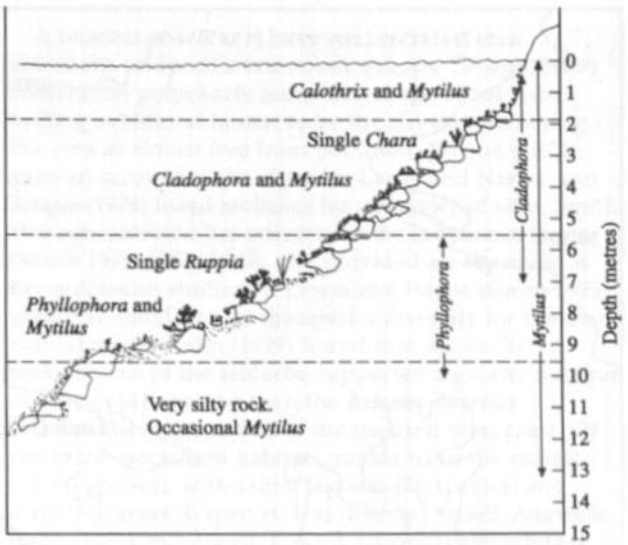

Figure 14.4. Vertical distribution of the main zones and communities in the south basin of Loch Obisary. (From Dipper, Lumb & Palmer 1987.)

were present in the numerous tidal channels, and exceptionally long kelp plants, with very large growths of the sponges *Leucosolenia botryoides* and *Halichondria panicea* on their stipes, grew near the waterfalls (Figure 14.3).

The obs on North and South Uist and Benbecula have been surveyed by the MNCR between 1993 and 1995. They included a variety of substrata and biotopes depending especially on salinity, the degree of shelter, their depth and type of lagoon. Shallow areas were often dominated by macrophytes (seagrass *Zostera marina*, dwarf seagrass *Zostera noltii*, beaked tasselweed *Ruppia maritima* and spiral tasselweed *Ruppia spiralis* (now *Ruppia cirrhosa*), and the lagoon species foxtail stonewort *Lamprothamnium papulosum*. Filamentous green algae often dominated the surface of rocks and sediments. Sediments were especially colonised by the worms *Arenicola marina* and *Hediste diversicolor*. The tide-swept rapids included coralline crusts and often rich commmunities of sponges and ascidians.

14.3 Lewis and Harris

Lewis and Harris (Figure 14.5), although much less a mosaic of land and water than the Uists, are nevertheless quite highly indented and have a very wide range of habitats. The sealochs tend to be much deeper and more fjordic in character than those in the Uists, and the west coast is more exposed, as the north-west coast of Lewis lacks the wide shallow shelf which is so characteristic of the west coast of the Uists. The cliffs on this north-west coast unusually have saltmarsh at the top, indicating the frequency of marine influence up to 50 m above sea level.

Powell *et al.* (1979) provided an overall appraisal of the shores, choosing seven areas to give a representative selection of habitats for the islands. Of these, Loch Roag was considered to be of outstanding importance because of its wide range of communities. In the loch there were a number of rapids which supported large quantities of suspension-feeding species such as ascidians, and some shores had species typical of the sublittoral, such as the alga *Nitophyllum punctatum* and the featherstar *Antedon bifida*. The north-west coast of Lewis was predominantly rocky with good examples of very exposed shores and small pocket beaches. In Broad Bay the sandstone shores represented the only rocky shores in the area not composed of gneiss. The Bay had rock and sediment habitats in both exposed and sheltered conditions. The shores at the entrance to Loch Erisort were representative of the east coast of Lewis and Harris, and

Figure 14.5. Lewis and Harris, showing places mentioned in the text.

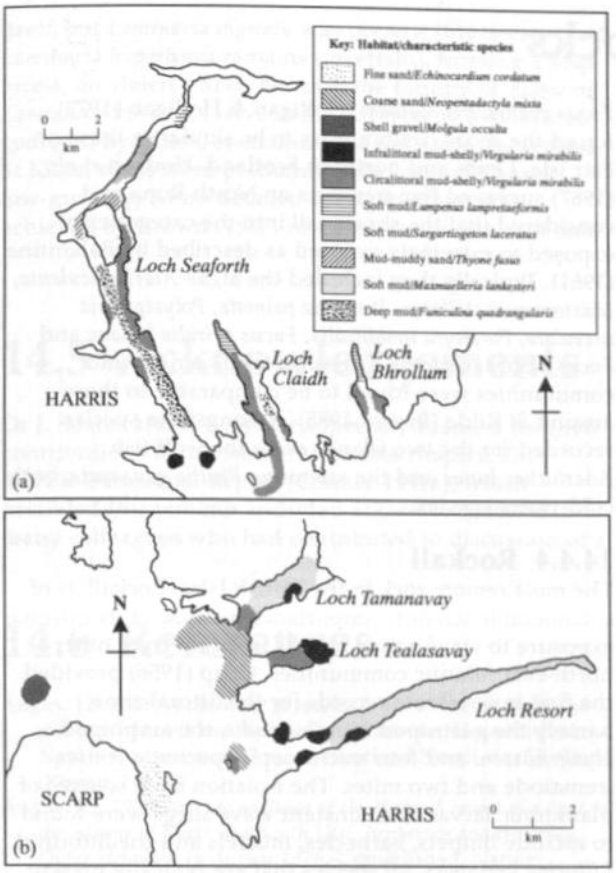

Figure 14.6. Distribution of sediment communities in (a) Lochs Seaforth, Claidh and Bhrollum (east Lewis) and (b) Lochs Tamanavay, Tealasavay and Resort (west Lewis) (re-drawn from Howson 1989).

notable for the presence of the non-native barnacle *Elminius modestus*. For sheltered habitats, and shores subject to brackish conditions, the small tidal inlet of the Obbe at Leverburgh was found to have moderately rich fauna and a variety of communities. The Luskentyre area of Harris supported the richest and most varied sediment shores in the area. The offshore island group of the Shiants was found to have rich cave habitats and an exceptionally well developed lichen *Xanthoria parietina* zone. Loch Roag and the Obbe have been promoted as MCAs (NCC 1990).

In an overview of Britain's coastal lagoons, Barnes (1988) considered Scotland to have only two proper lagoons, both of which are situated in Lewis, at Loch Ordais and Loch Arnol on the north-west coast. This rarity of true saline lagoons (as opposed to lagoonal definitions of other workers) places considerable importance on these sites. Both sites fall into the category of 'streams damned by sand and/or shingle bars', and Loch Arnol is only temporarily a brackish lagoon, being for the most time freshwater, whilst Loch Ordais is permanently brackish, supporting the seagrass *Ruppia* spp. (MNCR, unpublished data).

A number of workers have concentrated their attentions on specific taxonomic groups. George (1979) studied the polychaete fauna at a range of habitats, finding sublittoral faunas to be the richest and noting the area as almost free from pollution. Norton (1972) gave an account of the algae for Lewis and Harris, and Angus (1976) listed molluscs for a number of sites. Smith also concentrated her surveys on the molluscan fauna (Smith 1979, 1982, 1983). She provided an overview of her molluscan studies on Lewis and Harris (Smith 1979), giving an indication of the species diversity for the main habitat types. Smith (1979) found that the sheltered rocky shores of the sealochs supported a greater number of species (47 species) than the *Balanus–Mytilus* communities (15 species) of the exposed west coast. Of the more specialised habitats, rapids were the richest (50–65 species), with saline lagoons (26 species) and estuarine areas (6 species) less diverse. Ansell, Angus & Robb (1985) and Ansell, Robb & Powell (1988) studied populations of the bivalve *Donax vittatus*, including work on their mass mortality following dislodgement from the sediment because of excessive algal growth on the shells.

As with other parts of the Outer Hebrides, the sublittoral zone of Lewis and Harris is not well studied. Rostron (1984) provided a brief description of sites in the Obbe and in Lochs Roag and Mharabhig. Dipper (1983) described in more detail the communities of Loch Roag, which included the seagrass *Zostera marina* and horse mussel *Modiolus modiolus* beds. The area was noted for its range of sediment types and for the variety of communities in the many rapids of the sealoch complex. Lochs Seaforth, Claidh and Bhrollum on the east of Lewis and Harris and Lochs Tamanavay, Tealasavay and Resort on the west coast were surveyed by Howson (1989) as part of NCC's sealoch survey. Loch Seaforth, the only large fjordic sealoch in the Western Isles, was found to contain typical fjordic communities such as the *Neocrania anomala/Protanthea simplex* association of sheltered bedrock (Figure 14.6a), and has been given MCA status (NCC 1990). The deep muds of Loch Seaforth and Loch Claidh had populations of the tall sea pen *Funiculina quadrangularis*, as do many of the mainland fjordic lochs. In contrast, the soft muds of Lochs Resort and Tamanavay supported large numbers of the echiuran *Maxmuelleria lankesteri*, a species found in only a few other sealochs. At the exposed mouths to the west coast sealochs, shell-gravel was colonised by the large and uncommon ascidian *Molgula occulta* (Figure 14.6b). The NCC's sealoch survey was continued by Holt (1991) who carried out mainly sublittoral surveys of Lochs Stockinish, East and West Tarbert, Erisort, Leurbost and Grimshader. The infralittoral bedrock communities ranged from *Laminaria hyperborea* in wave- and tide-exposed areas to dense *Laminaria saccharina* in the most sheltered areas. *Leptometra celtica, Swiftia pallida* and *Diazona violacea* were typically found at the entrances to the east coast sealochs. Loch Erisort held a particularly wide range of sediment communities including undisturbed sediment with the sea pen *Virgularia mirabilis* and the opisthobranch *Philine aperta*.

14.4 Outlying islands and rocks

14.4.1 Introduction

The offshore islands and rocks of St Kilda, Sula Sgeir, North Rona and Rockall have attracted much attention because of their isolation and remoteness. Such areas often offer extremes of wave exposure which are of interest to ecological studies and provide ground for the discovery of new records of species. Their remoteness is also useful in the study of speciation and biogeographic trends.

14.4.2 St Kilda

The St Kilda group has predominantly very exposed rocky shores, many of which are vertical and broken by sea-caves. Hiscock (1992) considered these cave systems to be special features of the Scottish marine environment. Gauld, Bagenal & Connell (1953) found the shores to be remarkably uniform, with three distinct zones: a supralittoral fringe of bare rock with limpets *Patella vulgata* and the red alga *Porphyra umbilicalis*; a midlittoral zone dominated by barnacles, and a sublittoral fringe with the kelp *Alaria esculenta* and calcareous algae. The single sediment beach of the islands, in Village Bay, is a sandy beach which is completely washed away in winter, leaving a storm beach of boulders. This shore, also described by Scott (1960), supported a sparse fauna of amphipods, the worm *Nephtys cirrosa* and the isopod *Eurydice pulchra*. The extreme exposure to wave action has brought about records of marine species at very high altitudes. Bagenal (1957) noted *Littorina saxatilis* and *Enteromorpha* sp. at 95 feet (29 m) above sea level and the amphipod *Orchestia gammarellus* at 350 feet (107 m). Watling, Irvine & Norton (1970) gave an account of the marine algae of the St Kilda group.

The sublittoral zone of St Kilda is renowned for its clear oceanic waters, extensive vertical rock faces and complex system of caves and tunnels. The combination of high wave exposure and constant surge produces a rich marine life which comprises mainly encrusting or low-growing species, such as sponges, polyclinid ascidians and anemones (Howson & Picton 1985). The caves and tunnels, which are probably the best-developed in Britain, and the extensive wave-exposed communities, resulted in MCA status for the island group (NCC 1990). St Kilda is owned by the National Trust for Scotland and is recognised as a site of international importance, being designated a World Heritage Site, a Biosphere Reserve, a National Nature Reserve and a National Scenic Area.

14.4.3 North Rona and Sula Sgeir

The islands to the north of the Butt of Lewis are isolated and have required dedicated expeditions to reach their shores. Powell (1958) visited the islands in the 1950s as part of his work on fucoid algae, in this case the two subspecies of *Fucus distichus* which occur on the islands. Rice & Chapman (1985) also used samples of fucoids from the region in a taxonomic study of *Fucus distichus* subspecies. On the basis of morphology they determined that there were actually two species; *Fucus distichus* and *Fucus evanescens*. Gilbert, Holligan & Holligan (1973) found the shore communities to be similar to those on Fair Isle, Lewis and northern Scotland. Hodson *et al.* (1987) surveyed five transects on North Rona and considered that the shores fell into the categories of exposed to extremely exposed as described by Ballantine (1961). Typically they included the algae *Alaria esculenta*, *Mastocarpus stellatus*, *Palmaria palmata*, *Polysiphonia urceolata*, *Porphyra umbilicalis*, *Fucus spiralis* f. *nana* and *Fucus distichus anceps*. The sublittoral scenery and communities were found to be comparable to those around St Kilda (Brown 1985). Amongst the species recorded for the two islands were the wolf fish *Anarhichas lupus* and the anemone *Phellia gausapata*, both cold-water species.

14.4.4 Rockall

The most remote rock in the British Isles, Rockall, is of considerable scientific importance because of its extreme exposure to wave action and its isolation from other north-east Atlantic communities. Crisp (1956) provided the first invertebrate records for the littoral zone, namely the gastropod *Littorina rudis*, the amphipod *Hyale nilssoni* and four microscopic species; a rotifer, trematode and two mites. The isolation from sources of planktonic larvae and constant wave surge were found to exclude limpets, barnacles, mussels and the littorinid *Littorina neritoides*, all species that are typically present on other very exposed shores. Moore (1977) listed a further 11 microscopic littoral species, and confirmed Crisp's (1956) view that none of the littoral fauna has a pelagic dispersal phase. This has prompted the idea that the rock is too remote and too small to receive recruitment of larvae from larger land masses. Powell & Chamberlain (1956) gave an account of the plant life on the rock, describing an *Alaria esculenta* zone in the sublittoral fringe, a narrow band of red algae, and then wide bands of black and green algae/lichens above in the splash zones. This zonation was considered to be similar to other very exposed coasts, although species diversity was perhaps lower and the vertical extent of the zones was extended considerably due to wave action.

Brown (1987) provided the first description of sublittoral communities around Rockall from an amateur expedition. He reported a total lack of kelp *Laminaria* spp., with the sublittoral fringe species *Alaria esculenta* extending down to 35 m, considerably deeper than at any other very exposed location in the British Isles. Rock surfaces were covered by species typical of wave surge conditions, and the expedition failed to find any soft coral *Alcyonium digitatum*, ascidians or fish. An MNCR team added considerably to these findings in 1988 (Laffoley & Hiscock 1988) in the first scientific expedition to survey both the littoral and sublittoral communities and to include the adjacent reefs of Hasselwood Rock and Helen's Reef. The survey yielded the first records of a barnacle (*Verruca stroemia*) and a limpet (*Tectura virginea*) from the littoral zone of Rockall. Again *Laminaria* was found to be absent from Rockall

itself, but *Laminaria digitata* was present (the presence of *Laminaria hyperborea* remains uncertain), forming a kelp forest, on Helen's Reef. Beneath the canopy of *Alaria* or *Laminaria* the rocks were richly covered by a mosaic of sponges, hydroids, anemones and red algae. As around St Kilda, these were predominantly encrusting and low-growing. More detailed surveying than was achieved by Brown (1987) revealed the presence of fish, ascidians and *Alcyonium digitatum*, although the latter appeared to be confined to the deeper rock at about 45 m. Although the rocks were very richly colonised, species diversity was not particularly high, as might be expected in such an extreme environment and remote location. The oceanography, including biotic aspects, of the Rockall Trough and adjacent waters was discussed in a symposium volume (Mauchline 1986).

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Chapter 15: North-west Scotland (MNCR Sector 15)*

David W. Connor and Mike Little

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Synopsis

Descriptions of the marine biology of north-west Scotland including the northern isles of the Inner Hebrides are predominantly found in limited circulation publications commissioned by the nature conservation agencies. The coastline is greatly indented and predominantly rocky, although with some extensive sandy beaches in a few places. Rocky shore and sublittoral biotopes present range from those characteristic of very exposed coasts to those found only in extreme shelter. The sealochs, which are most intensively studied, hold some of the most extensive and richest examples of sealoch biotopes. The Loch Duich, Alsh and Long complex holds deep mud and rock communities in extreme shelter from wave action and tidal streams but with narrows areas having typical tidal stream-swept communities. Loch Long is notable for the presence of extensive rocky areas in low salinity. On the open coast, the Summer Isles include a particularly wide range of biotopes with some rare or unusual species present. Of the localised areas of intertidal sediments the sands of Kentra Bay and Loch Moidart are noted as amongst the most extensive littoral estuarine sediments in western Scotland.

15.1 Introduction

The coast of north-west Scotland, from the Point of Ardnamurchan to Cape Wrath (Figure 15.1), includes perhaps the most remote and rugged stretch of coast on mainland Britain. It is highly dissected by a series of sealochs, with the Inner Hebridean islands of Skye, Raasay and the Small Isles (Canna, Rum, Eigg and Muck) lying offshore.

Sector 15 encompasses a similar range of physical conditions to western Scotland (Sector 13) and consequently includes a wide range of habitats. While much of the open coast is fairly exposed to wave action, it is sheltered from the full force of the Atlantic swells by the broad protection offered by the Western Isles. Even so, the southern and northern approaches to the Minches are exposed and can be subject to considerable swell. At the other extreme many of the sealochs are protected by sills or narrows and are very sheltered from wave action. The narrows and some of the tidal sounds, such as the Sound of Sleat, generate strong tidal streams, reaching 6–8 knots (3–4 m s^{-1}) in places and providing further diversity of habitats.

Mean surface temperatures in the area range from about 7 °C in the winter to 13–13.5 °C in the summer. Surface salinity is in the region of 34.25–34.5‰, increasing slightly in summer months. Most of the region is subject to a mean spring tidal range of about 4 m. (All data from Lee & Ramster 1981.)

The fauna and flora of the north-west coast show a slight decrease in species richness compared with more southern parts of the Scottish west coast, as some of the warm-water species find their most northerly limits on or south of this stretch of coast. For instance, the algal flora for north-west Scotland is reduced by 25 species compared with waters south of the Firth of Lorn (Maggs

* This review was completed from published and, where available, unpublished sources of information on benthic habitats and communities including the results of interviews with relevant workers undertaken up to 1991. That work was published in Connor (1991). The review has been revised to take account of major additional studies up to the end of 1994 by the second author and up to the end of 1996 by the series editor. It does not include benthic survey information summarised for or published in the MNCR *Regional Reports* series or work now being undertaken to describe and map biotopes in candidate Special Areas of Conservation. For information on conservation status and an analysis of rare and scarce seabed species, the reader is referred to the *Coastal Directories* series.

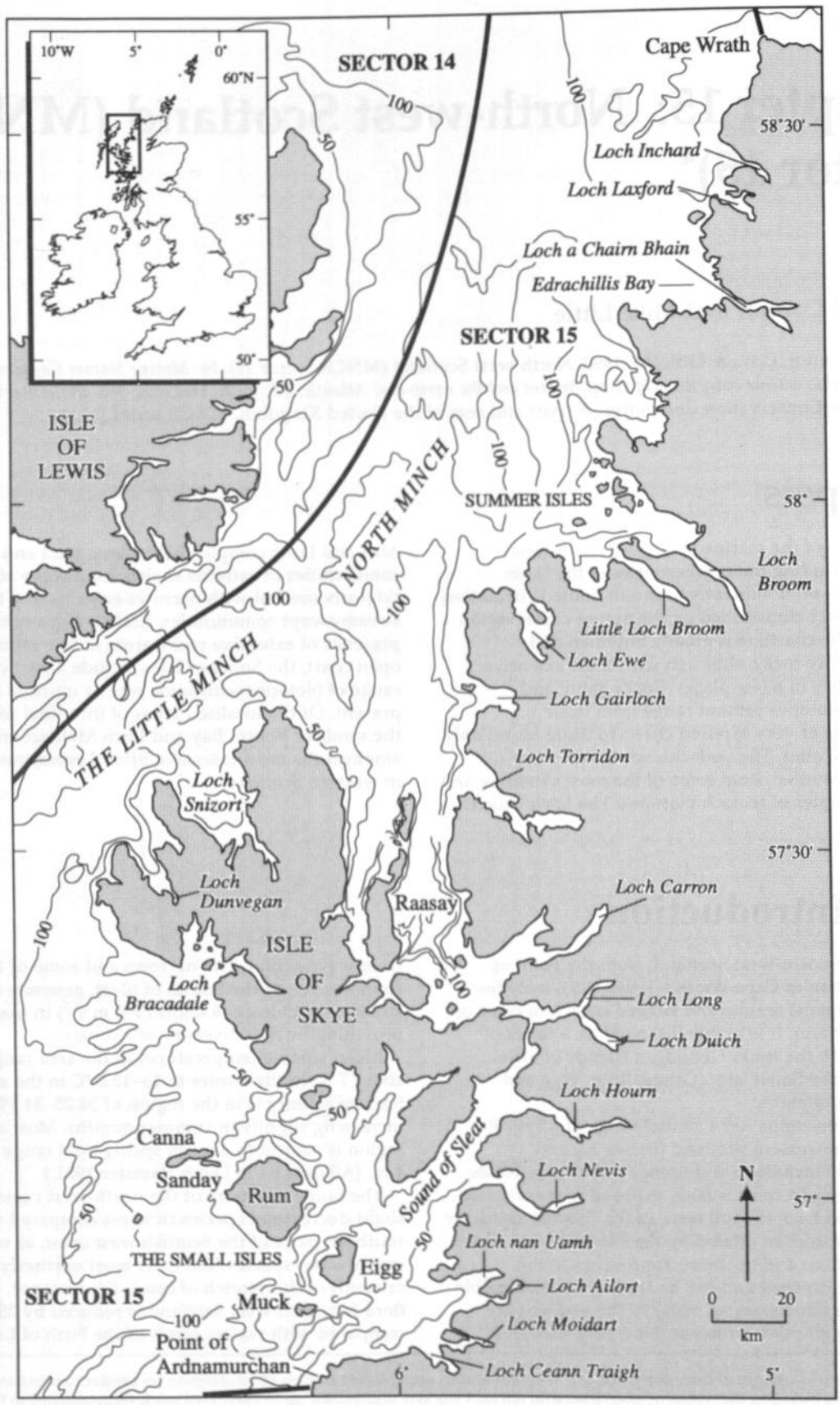

Figure 15.1. North-west Scotland (MNCR Sector 15).

1986). On the shores, the abundance of *Chthamalus* spp. is very much reduced as *Semibalanus balanoides* becomes the dominant barnacle, while northern algae such as *Odonthalia dentata* and *Ptilota plumosa* become more abundant in appropriate habitats compared with farther south (Harvey *et al.* 1980). In the sublittoral, the effect of urchin grazing is suggested as a major factor in reducing species richness in rocky areas (Dipper 1981a; Davies 1989).

The seabed of The Minch has been surveyed mainly as a part of fisheries investigations and a programme of studies using acoustic survey and ground-truthing by video and grab sampling was initiated by the SOAEFD Marine Laboratory in 1995. Surveys were carried out over an area extending throughout the Greater Minch, from off Kinlochbervie to east of Barra Head. The RoxAnn® acoustic seabed discrimination system was used to map the seabed sediments and the data collected were ground-truthed. Benthic samples, both epifaunal and infaunal, were collected from the sedimentary zones defined by the acoustic system using a combination of grabbing, closed-circuit television and still photography. Statistical analysis of these data revealed four broad groupings which could be related to the sediment types suggesting that these groups may represent differing biotopes. Community A was characterised by a gravel substratum and was dominated by the featherstar *Antedon bifida* while the soft mud substratum of Community B was dominated by burrowing decapods such as *Calocaris macandreae* and *Nephrops norvegicus*. Community C was characterised by mixed sediments with a variable fauna and, finally, Community D was represented by boulders and bedrock dominated by echinoderms.

Bryan (1994) provided a summary of current knowledge of the marine and coastal environment of the Minch, and human influences affecting it. The Minch and Sea of the Hebrides are important inshore fishing grounds, particularly for sprat *Sprattus sprattus*, mackerel *Scomber scombrus*, shrimps and Norway lobster *Nephrops norvegicus*. Mallaig and Ullapool support large fishing fleets, with Ullapool used extensively in recent years for the mooring of factory ships. As elsewhere in Scotland, mariculture of salmon and shellfish developed considerably during the 1980s. In response, Highland Regional Council (HRC) produced framework plans to facilitate control of these developments in a number of sealochs (e.g. Lochs Ewe, Nevis, Inchard, Torridon and Hourn) (HRC 1988a; 1988b; 1988c; 1988d; 1989)

The only centres for biological research in the region are the Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD) (formerly the Department of Agriculture and Fisheries for Scotland (DAFS) and Scottish Office Agriculture and Fisheries Department (SOAFD)) field stations at Loch Ewe and the Sea Fish Industries Authority laboratory at Ardtoe. Their work is primarily oriented towards inshore fisheries research, including shellfish and fish-farming. Sector 15 has therefore been relatively little-used for detailed autecological studies and the bulk of research effort has been directed towards descriptions of the shores and seabed. Much of this was initiated by the Nature Conservancy Council and concentrated in the sealochs, and there remain large stretches of coast, particularly in the nearshore and offshore sublittoral zones, for which little is known of the flora and fauna.

15.2 Mainland coast

The mainland coast of north-west Scotland (Figures 15.2 and 15.3) was a major study area for Lewis's (1957) work on the ecology of rocky shores, from which he described general zonation patterns in relation to wave exposure and tidal movement (for instance, Figure 15.4). The well developed exposed coast communities characterised by mussels *Mytilus edulis* and red algae, so widespread on the Caithness coast (Lewis 1954), were not found to be so prevalent on the west coast. Nor did Lewis & Powell (1960) find the wide range of communities recorded in Loch Sween, Argyll, repeated in any of the lochs in north-west Scotland, although many included a proportion of Loch Sween's features together with characteristics of their own.

Further widespread surveys of shores on the north-west coast were undertaken by Eleftheriou & McIntyre (1976) and by Powell *et al.* (1980). The former, a survey of sandy beaches, concentrated on the moderately exposed and sheltered shores between Gruinard Bay and Gairloch. The moderately exposed shores were numerically dominated by crustaceans (mainly *Bathyporeia* spp. on the upper shore) and polychaetes, together with large numbers of the bivalve *Angulus tenuis* on the lower shore. The more sheltered beaches revealed an increase in the numbers of polychaetes, fewer crustaceans and often large populations of bivalves.

Within north-west Scotland the SMBA/MBA Intertidal Survey Unit investigated a wide range of shore types (Bishop & Holme 1980; Powell *et al.* 1980). Four areas were selected as of highest marine biological importance, together with a number of other sites of lesser interest. Lochs Ailort and nan Uamh were notable for their wide range of communities and the most northerly known occurrence of the green alga *Codium adhaerens*. The sediment beaches at Samalaman Bay and Eilean nan Trom had rich communities. The Arisaig area had a rich flora and fauna with several uncommon species and a seagrass *Zostera* bed, while the head of Loch Duich held a prime example of an *Ascophyllum nodosum* ecad *mackaii* bed. The Point of Stoer coast farther north, with its exposed boulder and bedrock shores and the more sheltered Oldany Island area included a wide variety of richly colonised habitats. The range of sediment shores in Loch Ewe and at Rubha Coigeach was also highly rated.

A series of further studies on the shores, with particular emphasis on the molluscan fauna, were

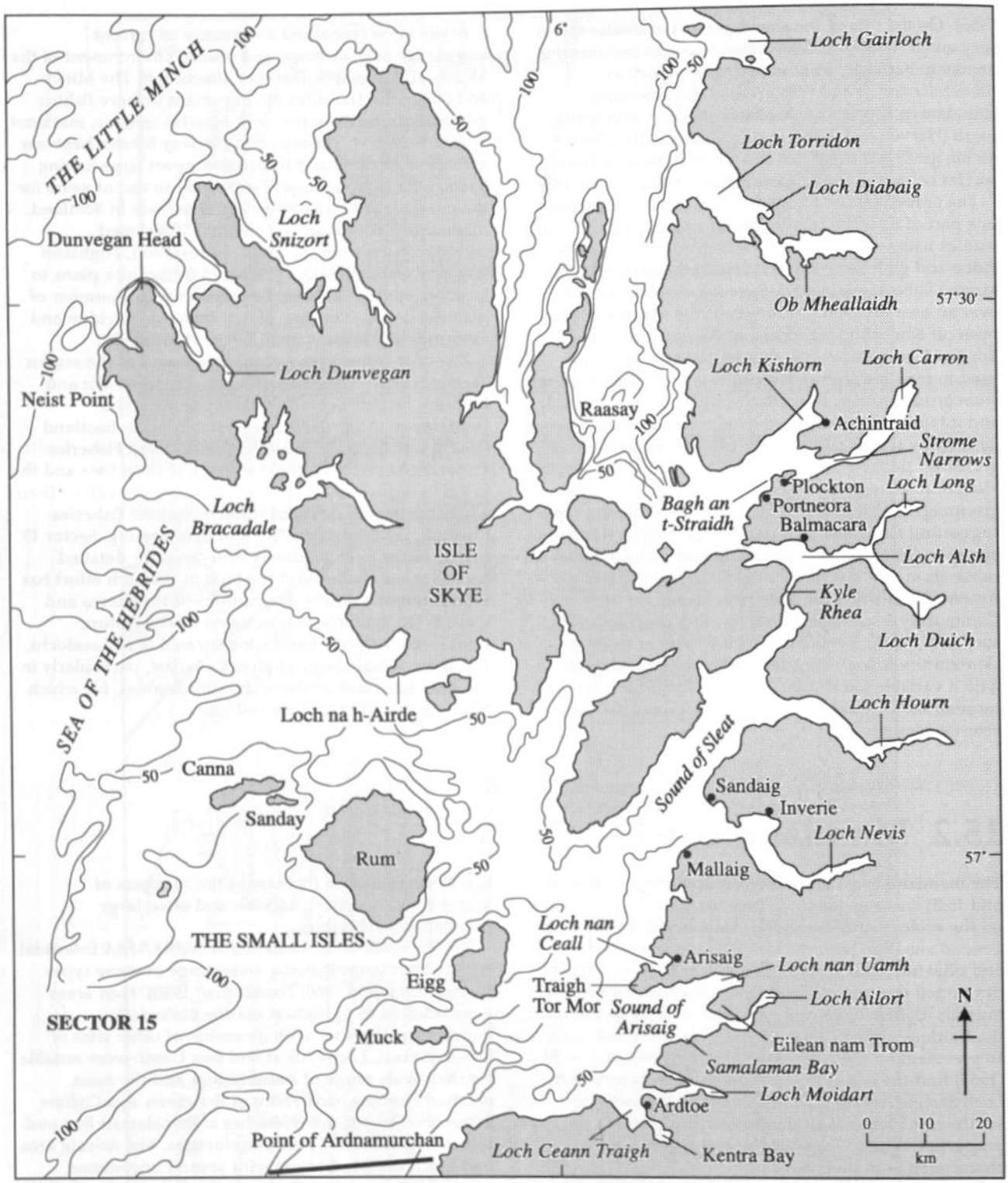

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Figure 15.2. The coast of north-west Scotland (southern part), including Skye and the Small Isles, showing places mentioned in the text.

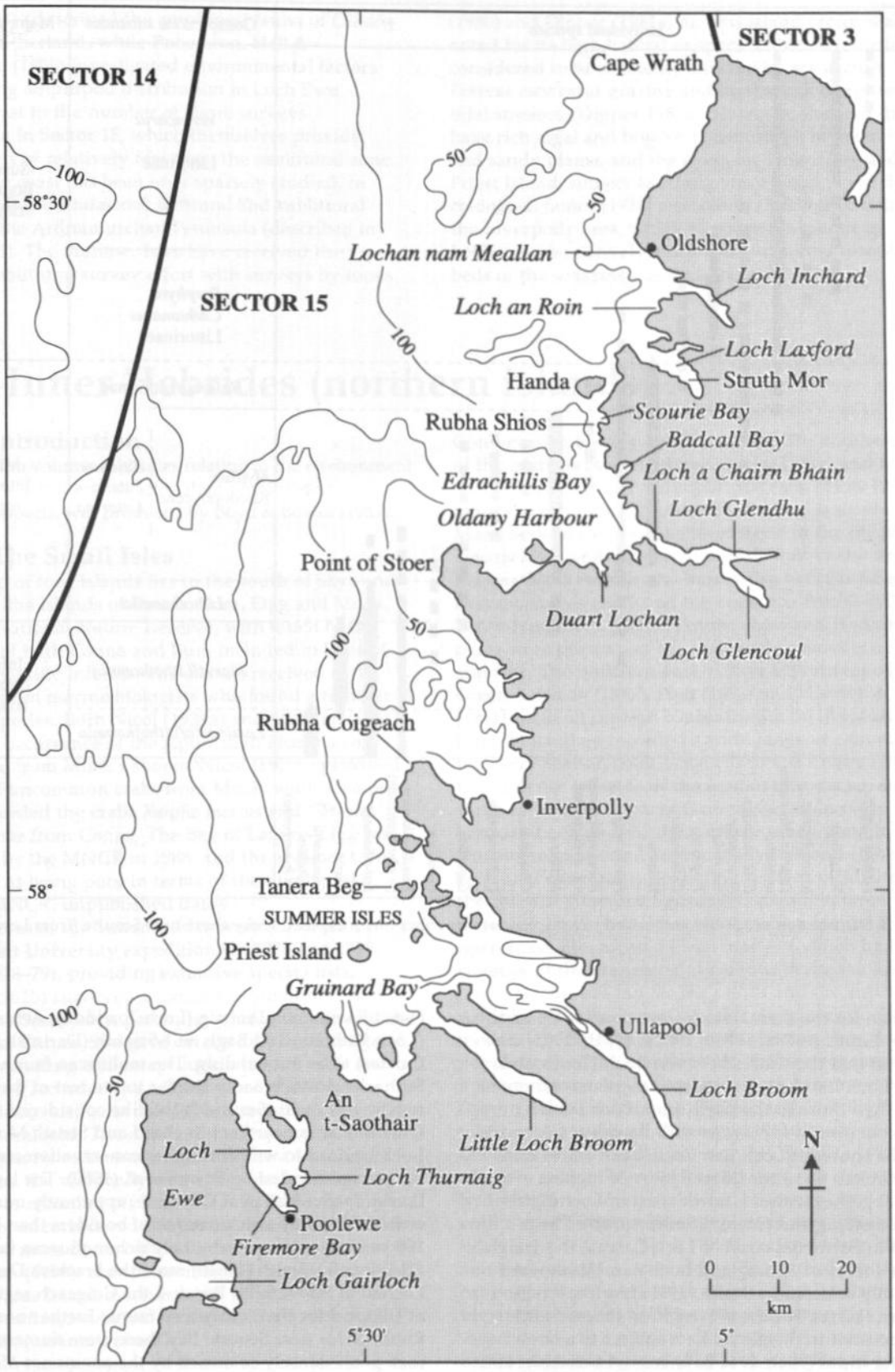

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Figure 15.3. The coast of north-west Scotland (northern part), showing places mentioned in the text.

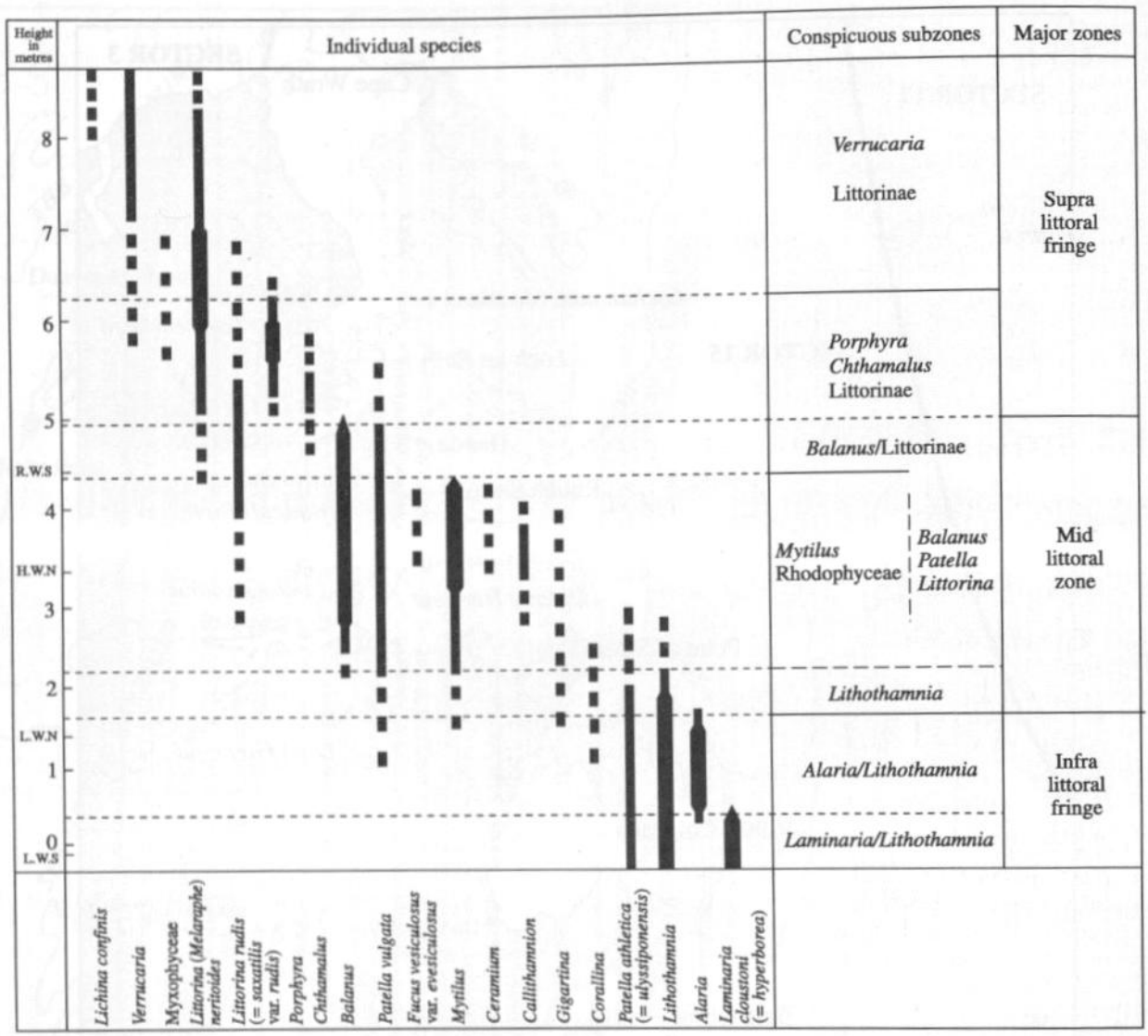

Figure 15.4. Distribution of species and extent of conspicuous sub-zones on an exposed rocky shore near Scourie (from Lewis 1957).

undertaken for the then Nature Conservancy Council (NCC) by Smith (1978a, 1978b, 1981a, 1981b, 1985). She considered that the shores between Loch Hourn and south to Loch Linnhe encompassed a greater variety of habitats than those to the north from Loch Hourn to Loch Broom (Smith 1978a). As with Powell *et al.*'s work (1980), the shores of Loch nan Ceall, Loch Ailort and Ardnamurchan were considered to be of highest interest, together with the north coast of Loch Nevis between Sandaig and Inverie (Smith 1978b). The Plockton to Portneora coast of Loch Carron, the Traigh Torr Mor shores of Arisaig and Loch nan Uamh were additionally selected by Smith (1981a) for their rich molluscan faunas. For the Wester Ross shores Smith (1978a) pointed to the gravel flats subject to a large freshwater input (such as at Balmacara, Loch Alsh) as a habitat common on the mainland but lacking from similar situations in the Western Isles. Of the Wester Ross shores Smith (1978a) found those at Ob Mheallaidh (Loch Torridon), An t-Saothair (Gruinard Bay), Loch Thurnaig (Loch Ewe), Loch Diabaig (Loch Torridon), Achintraid (Loch Kishorn) and Bagh an t-Straidh (Darinish, Loch Carron) to be outstanding. The molluscan fauna of Sutherland was broadly similar to the rest of the north-west coast (Smith 1981b). She considered the Oldshore area near Loch Inchard and Struth Mor in Loch Laxford to warrant higher conservation status than that recommended by Powell *et al.* (1980). The lagoonal Lochan nam Meallan at Oldshore, apparently more enclosed now by a storm beach of boulders than it was 100 years ago, has an extremely rich molluscan fauna. Additionally, Smith (1981b) rated the brackish Duart Lochan in Eddrachillis Bay and the Coigeach region north of Ullapool for their molluscan fauna. Farther north at Rubha Shios near Scourie Bay there were numerous small rock pools densely colonised by the anemones *Metridium senile* and *Sagartia elegans*, and a thick growth of red algae, barnacles and mussels *Mytilus edulis* on open rock faces (Smith 1985).

Reid (1941) described the amphipod fauna of Oldany harbour, Sutherland, while Roberston, Hall & Eleftheriou (1989) investigated environmental factors determining amphipod distribution in Loch Ewe.

In contrast to the number of shore surveys undertaken in Sector 15, which themselves provide descriptions of relatively few sites, the sublittoral zone of the open coast has been only sparsely studied. In 1994, the MNCR undertook a littoral and sublittoral survey of the Ardnamurchan Peninsula (described in Chapter 13). The Summer Isles have received the greatest sublittoral survey effort with surveys by Jones (1980) and Dipper (1981a, b). This island group was not noted for its high habitat or species diversity, the latter considered to be markedly affected by sea urchin *Echinus esculentus* grazing and by the lack of appreciable tidal streams. (Dipper 1981a). However, the area did have rich algal and bivalve communities in maerl beds and sandy plains, and the caves on Tanera Beg and Priest Island, subject to strong wave surge, were richly colonised. James [1978] and White (1988) gave details of the Inverpolly area, which supported a mosaic of habitats in a relatively small area, including extensive beds of the seagrass *Zostera marina*.

15.3 Inner Hebrides (northern islands)

15.3.1 Introduction

A symposium volume of studies relating to the environment of the Inner Hebrides, including their physical and biological aspects, was produced by Boyd & Bowes (1983).

15.3.2 The Small Isles

This group of four islands lies to the south of Skye and comprises the islands of Canna, Rum, Eigg and Muck. Rum is a National Nature Reserve, with much of the shoreline of both Canna and Rum included in Sites of Special Scientific Interest. The islands received early attention from marine biologists who found a number of unusual species. Both Nicol (1939a) and Stephen (1961) noted the occurrence of the sipunculan *Phascolosoma granulatum* from Muck's shores. Nicol (1939b) provided records of uncommon crabs from Muck, while Campbell (1948) recorded the crabs *Xantho incisus* and *Corystes cassivelaunus* from Canna. The Bay of Laig on Eigg was surveyed by the MNCR in 1988, and the sediment was described as being poor in terms of the number of species (MNCR, unpublished data).

The shores of the Summer Isles were surveyed by Heriot-Watt University expeditions in 1978 and 1979 (Anon. 1978–79), providing extensive species lists. Dipper (1981b) surveyed a number of sublittoral sites around the Small Isles, particularly around Rum and the east side of Canna. She gave details for a wide range of habitats including tide-swept rock, offshore reefs and gravels, and recorded the tall sea pen *Funiculina quadrangularis*, a species more characteristic of the sheltered sealochs. The nationally rare sea cucumber *Parastichopus tremulus* was present in the area (Dipper 1981b), and the nationally rare anemone *Actinauge richardi* was recorded off Eigg (MNCR, 1988 unpublished data). Dipper considered the Canna, Sanday and Muck areas to be more diverse than Rum. In a later survey by Mackinnon (1989), the spectacular south-eastern corner of Canna was found to have dense growths of dead-man's fingers *Alcyonium digitatum* on sublittoral buttresses of columnar basalt.

15.3.3 Island of Skye

Skye has remained remarkably little studied, not attracting surveys by NCC and by the Marine Conservation Society until the 1980s. The southern half of the island was studied by Dipper (1981c) and Smith (1983). Dipper found the sublittoral rock below kelp forests to be intensely grazed by *Echinus esculentus*. Maerl beds in the area sheltered nests of the file shell *Limaria hians* and supported populations of the urchin *Psammechinus miliaris*, the burrowing sea cucumber *Neopentadactyla mixta* and the anemone *Peachia cylindrica*. Loose-lying beds of filamentous algae and *Phyllophora crispa* were present on the sheltered sediments of the sealochs. The northern part of Skye was surveyed by Green & Green (1987), Holt (1988) and Hiscock & Covey (1991), with all surveys concentrating on the sealochs, from which they recorded a wide range of communities typical of sheltered sealochs. Hiscock & Covey (1991) found dense growths of the seagrass *Ruppia* sp. and three-spined sticklebacks *Gasterosteus aculeatus* in the brackish Loch na h-Airde; a coarse sandy plain in Loch Dunvegan supported an unusually rich and stable epifaunal community, including solitary ascidians and the colonial anemone *Epizoanthus couchii* in large numbers. Hiscock & Covey (1991) also examined some open coast sites around Skye, many of which had large colonies of the branching calcareous bryozoan *Porella compressa*, the sea fan *Swiftia pallida* and the cup sponge *Axinella infundibuliformis*, species characteristic of moderately exposed coasts in this Sector. Very dense populations of the anemone *Hormathia coronata*, an uncommon species in Scotland, were present at Neist Point, while a wide range of algae and animals in the tide-swept gravels off Dunvegan Head justified the selection of this small area as an MCA (NCC 1990). The narrows at Kyle Rhea supported very rich growths of hydroids, anemones, barnacles, bryozoans and sponges, with a species composition typical of very strongly tide-swept bedrock. Scott (1991) surveyed five littoral and two sublittoral sites along the route of the then proposed Skye road bridge as part of an environmental impact assessment and described communities associated with a mixture of substrata including brittlestar, horse mussel (*Modiolus modiolus*) and maerl (*Lithothamnion corallioides*) beds and extensive areas of tide-swept algal communities.

15.4 Mainland sealochs

15.4.1 Introduction

Much of the recent information for sealochs in Sector 15 is based on surveys undertaken for the MNCR by the University Marine Biological Station, Millport, the results of which were described in Howson, Connor & Holt (1994) and in a series of separate survey reports cited below.

15.4.2 Sound of Arisaig sea lochs

Lochs Ceann Traigh (Kentra Bay), Moidart, Ailort, nan Uamh and nan Ceall were surveyed for the MNCR in 1989 (Howson 1990), following surveys of shores in the area by the SMBA/MBA Intertidal Survey Unit and Smith (see Section 15.2). The littoral sands of Kentra Bay and Loch Moidart are amongst the most extensive littoral estuarine sediments in western Scotland, with those in Kentra Bay considered to be particularly rich (Powell *et al.* 1980). The shores in Loch Moidart were also examined by Wilkinson & Scanlan (1987), who paid particular attention to the algae, and found the area to be unspoilt but less rich in species than open coast sites. The conservation status of Kentra Bay and Loch Moidart was summarised by Buck (1993). Howson's (1990) survey revealed rich littoral sediments in Loch Ailort, with populations of the sipunculan *Golfingia vulgaris*, and extensive fucoid communities at the entrance to Loch nan Ceall on the complex of rocky outcrops. In the sublittoral, the area was most notable for its maerl beds which were widespread in the entrance channels to each of the sealochs, with particularly rich beds in Loch Ailort and Loch nan Ceall. The communities in the Sound of Arisaig were more typical of the open coast than sealochs because of the greater exposure to wave action, with the sea cucumber *Neopentadactyla mixta* common in coarse sediments in shallow water. In contrast, the shallow fine sediments of Loch nan Ceall had populations of the small holothurian *Labidoplax media*, a species previously known in the British Isles only from Loch Eynort in South Uist and one location in Ireland (Dipper 1985).

15.4.3 Sound of Sleat sealochs

Lochs Nevis and Hourn are amongst the most inaccessible of the mainland sealochs, with restricted road access along the loch sides. Loch Duich and Loch Long, both opening into Loch Alsh at the northern end of the Sound of Sleat, have easier access, and although each of these lochs had been little studied prior to 1989 they now have MCA status (NCC 1990). The deep mud faunas of Loch Nevis were compared with those of the Fladen grounds in the North Sea (McIntyre 1961), the former area having a foraminiferan-dominated community which typically included the brittlestar *Amphiura chiajei*. McIntyre (1961) found a greater biomass in the Loch Nevis benthos which he considered may be due to more stable sea temperatures and higher primary production than are present in the North Sea. The shallower parts of Loch Nevis and Loch Hourn were surveyed by Breen, Connor & MacKenzie (1986), with

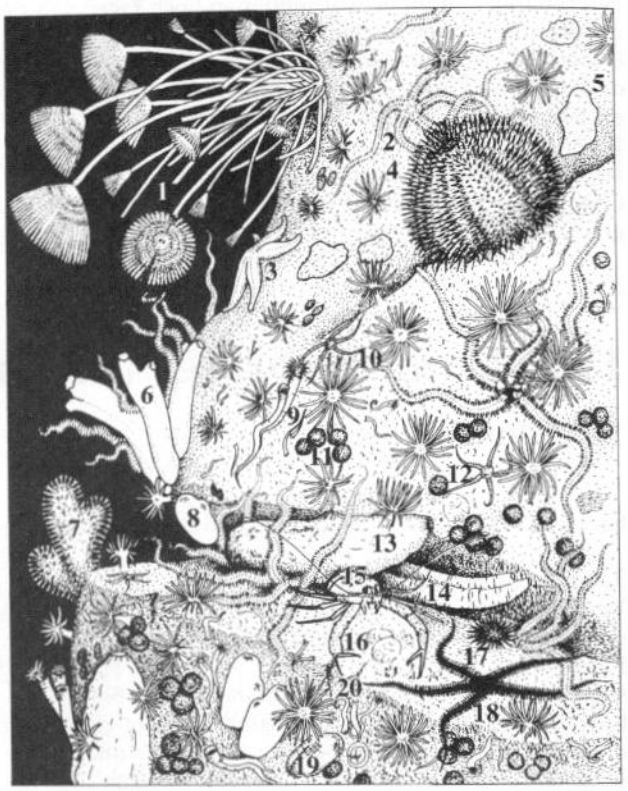

Figure 15.5. Rock wall circalittoral community typical of fjordic sea lochs. The illustration is based on locations in Loch Duich. Species illustrated include: 1. *Sabella pavonina*, 2. *Ophiothrix fragilis*, 3. *Asterias rubens*, 4. *Echinus esculentus*, 5. *Parasmittina trispinosa*, 6. *Ciona intestinalis*, 7. *Alcyonium digitatum*, 8. *Ascidia virginea*, 9. *Serpula vermicularis*, 10. *Protanthea simplex*, 11. *Neocrania anomala*, 12. *Ophiura albida*, 13. *Ascidia mentula*, 14. *Chaetopterus variopedatus*, 15. *Munida rugosa*, 16. *Terebratulina retusa*, 17. *Psammechinus miliaris*, 18. *Ophiocomina nigra*, 19. *Corella parallelograma*, 20. *Pomatoceros triqueter*. From Howson, Connor & Holt (1994). (Drawing by Sue Scott.)

Loch Nevis receiving more detailed attention in 1988 and 1990 (MNCR, unpublished). The brackish upper reaches of the sealochs supported dense populations of the urchin *Psammechinus miliaris*, with the anemone *Protanthea simplex* and the brachiopod *Neocrania anomala* typically present on sheltered bedrock. Forests of the sea pen *Funiculina quadrangularis* lined the lochs in sediments below about 25 m, as they do in Loch Duich (Connor 1989). Although Connor's (1989) survey revealed broadly similar communities in Lochs Duich, Long and Alsh to those in Nevis and Hourn, the Duich system also held more unusual communities. Most important of these were the brackish communities in Loch Long, dense populations of the fireworks anemone *Pachycerianthus multiplicatus* and rich sublittoral cliff communities (Figure 15.5, 15.6). On the shore, the head of Loch Duich supported perhaps the most extensive bed of the brown alga *Ascophyllum nodosum* ecad *mackaii* known in Scotland. These features of Lochs Duich and Long were important in the MCA designations for the

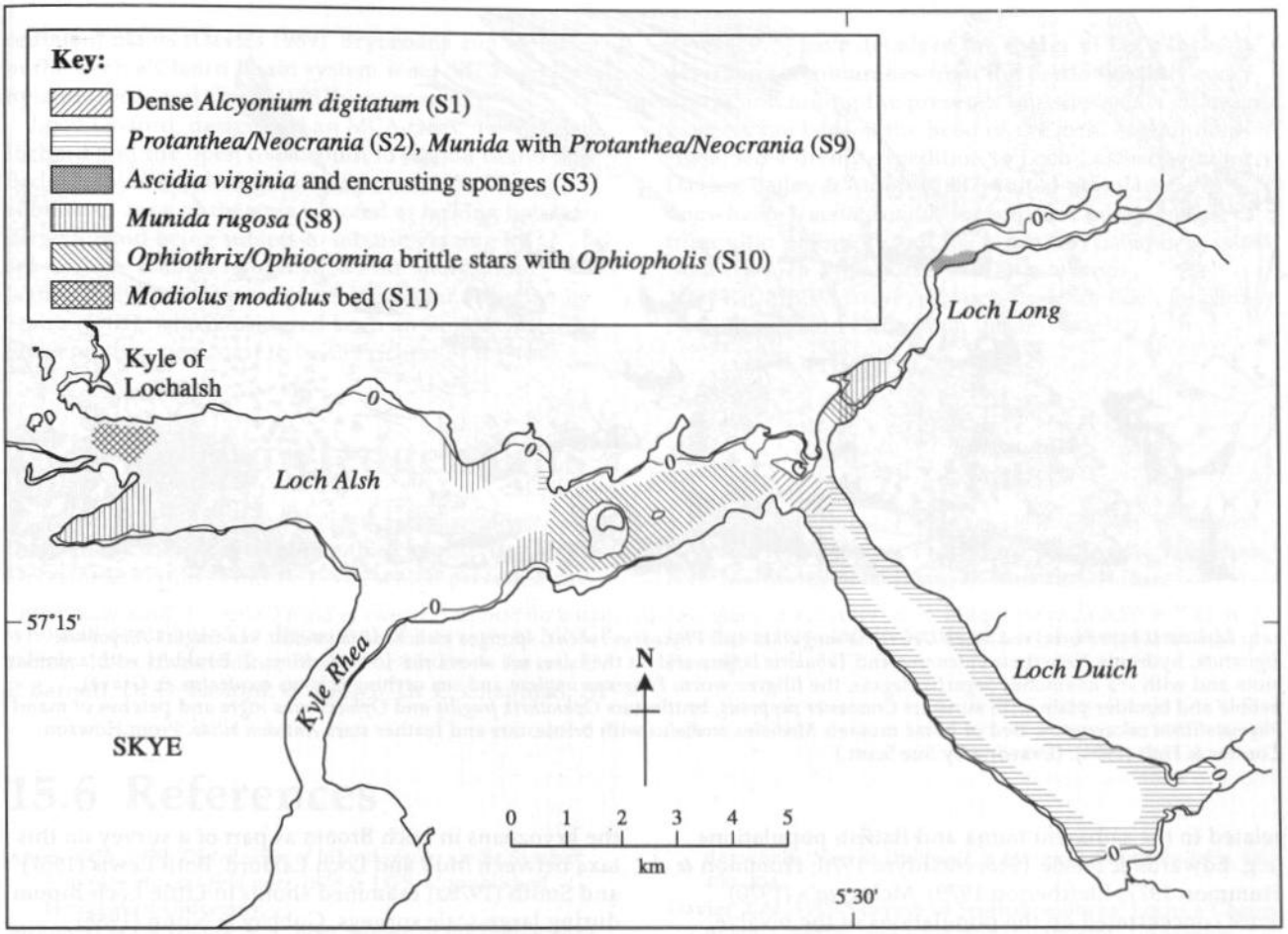

Figure 15.6. Predicted distribution of circalittoral rocky communities in Lochs Duich, Long and Alsh (re-drawn from Connor 1989).

two lochs (NCC 1990). Intertidal surveys of Loch Long and Loch Duich were carried out by the MNCR (Hiscock 1991).

15.4.4 Sealochs in Wester Ross and Cromarty

The Ross and Cromarty sealochs comprise Lochs Carron, Kishorn, Torridon, Gairloch, Ewe, Little Loch Broom and Broom. Of these, the first three have been most well surveyed, with Loch Torridon and Loch Carron achieving MCA status (NCC 1990). Loch Ewe has also received much attention from workers at the SOAFD research laboratory at Firemore Bay, Poolewe.

A number of shores in Lochs Carron, Kishorn and Torridon were examined by Smith (1978a) and Powell *et al.* (1980), as discussed above, before Smith & Hiscock (1985) made a more thorough investigation of the area, including the sublittoral zone. Loch Carron is notable for having a number of sublittoral communities which extend onto the shores, in particular beds of the horse mussel *Modiolus modiolus* and maerl *Lithothamnion corallioides*. Strome Narrows supports a 'nursery' of urchins *Echinus esculentus* and has rich and diverse bedrock communities, whilst in other tide-swept areas the encrusting alga *Aglaozonia* sp. binds pebbles on the seabed, unusual for this species. Figure 15.7 illustrates some of these communities. Continuing studies of Strome Narrows (S. Scott pers. comm.) have revealed a particularly wide range of biotopes present in the area including seagrass *Zostera marina* beds, dense file shells *Limaria hians*, comparatively large numbers of the anemone *Aureliania heterocera*, and species-rich rock wall communities. In Loch Torridon the shallow lagoonal Ob Mheallaidh was considered to be exceptionally rich (Smith & Hiscock 1985), with abundant hydroids, bryozoans, molluscs, maerl and seagrass *Zostera* found in a complex array of communities. Together with the characteristic communities in Loch Torridon of sea pens, brittlestars and burrowing megafauna, the Torridon narrows has dense stands of hydroids, and the rare northern starfish *Hippasteria phrygiana* has been recorded within the loch (Smith & Hiscock 1985). Loch Carron has been used for environmental assessment studies around fish farms (Gowen *et al.* 1988), and Miller, Rice & Johnstone (1973) noted a population of leopard-spotted gobies *Thorogobius ephippiatus* in upper Loch Torridon; a very northern record for this cryptic species.

Sandy beaches in both Gairloch and Loch Ewe were surveyed by Eleftheriou & McIntyre (1976) as part of the large-scale survey in western Scotland described in Section 15.2. Firemore Bay in Loch Ewe was the focus of a number of other studies by SOAFD workers, mainly

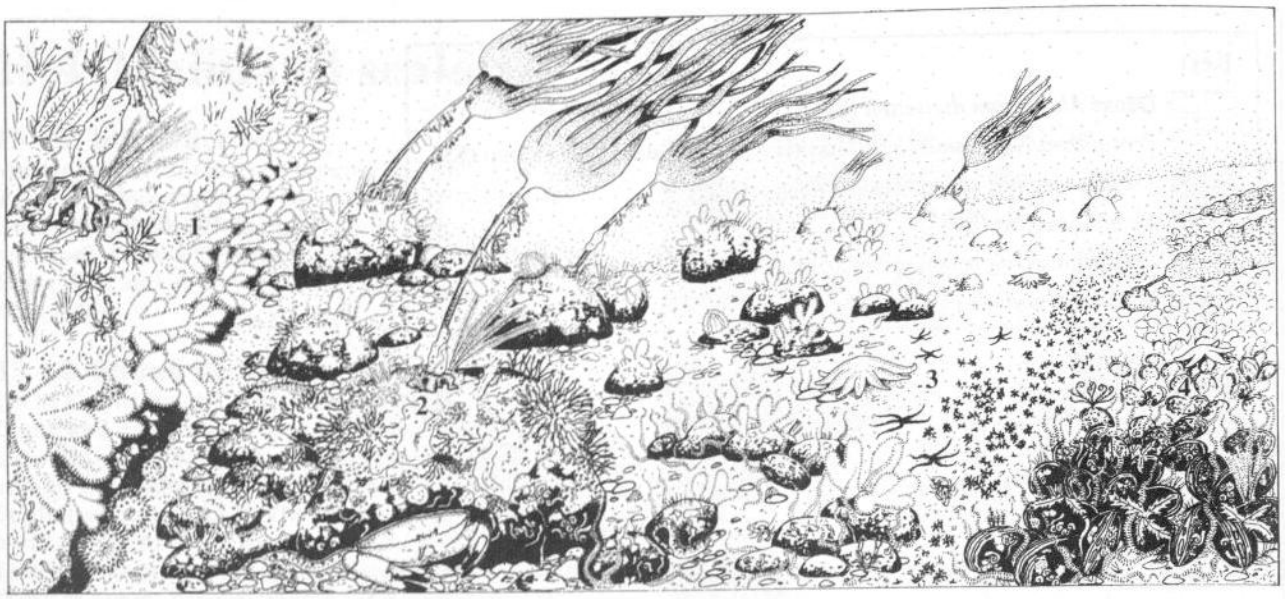

Figure 15.7. A tidal narrows typical of the entrance to some sealochs (based on Strome Narrows in Loch Carron). 1. Rock walls with kelp *Laminaria hyperborea*, red algae *Delesseria sanguinea* and *Phycodrys rubens*, sponges *Halichondria panicea*, sea fingers *Alcyonium digitatum*, hydroids *Nemertesia antennina* and *Tubularia larynx* and, at the base, sea anemones *Urticina felina*. 2. Boulders with a similar biota and with sea anemones *Sagartia elegans*, the filigree worm *Filograna implexa* and sea urchins *Echinus esculentus*. 3. Gravel, pebble and boulder plain with sunstars *Crossaster papposus*, brittlestars *Ophiothrix fragilis* and *Ophiocomina nigra* and patches of maerl *Phymatolithon calcareum*. 4. Bed of horse mussels *Modiolus modiolus* with brittlestars and feather stars *Antedon bifida*. From Howson, Connor & Holt (1994). (Drawing by Sue Scott.)

related to the sediment fauna and flatfish populations (e.g. Edwards & Steele 1968; McIntyre 1970; Hummon & Hummon 1977; Eleftheriou 1979). McIntyre's (1970) work concentrated on the populations of the bivalve *Tellina* (now *Angulus*) *tenuis* which were found to be affected by predation, plankton dispersal and wave exposure during larval settlement. The laboratory facility at Firemore Bay has also attracted external workers to the area for a variety of studies, e.g. kelp ecology (Kain 1962), mysid breeding cycles (Mauchline 1967) and nematode taxonomy (Warwick & Platt 1973).

In 1989 a Marine Conservation Society (MCS) *Seasearch* team surveyed the habitats in Gairloch, Loch Ewe and Gruinard Bay (Gubbay 1990) with more detailed community studies being undertaken in the two sealochs for the MNCR in 1990 (Howson 1991). The broad and open aspect of the two sealochs reduces the amount of shelter from wave action within the lochs compared with many other mainland sealochs. Consequently, communities in sands and gravels were found well into each of the lochs, with only limited areas of finer sediments. In early June, dense stands of foliose algae flourished in some rocky sublittoral areas despite very high densities of urchins *Echinus esculentus* (Howson 1991). However, by late summer the urchins appeared to have a marked effect on communities with many rock surfaces very well grazed (Gubbay 1990).

Little Loch Broom and Loch Broom remained poorly studied until an MCS *Seasearch* expedition in 1988 (Gubbay & Nunn 1988). Prior to this, Thomas (1950) recorded Fries's goby *Gobius* (now *Lesueurigobius*) *friesii* from Little Loch Broom. Walker (1955) undertook a survey of the kelps in this loch, and Ryland (1963) listed the bryozoans in Loch Broom as part of a survey on this taxa between Mull and Loch Laxford. Both Lewis (1957) and Smith (1978a) examined shores in Little Loch Broom during large-scale surveys. Gubbay & Nunn (1988) described sublittoral habitats in the area on intensely grazed bedrock and boulders, maerl, horse mussel *Modiolus modiolus* and file shell *Limaria hians* beds and a variety of sandy and muddy plains; they depicted the predicted distribution of each habitat within the lochs.

15.4.5 Sealochs in west Sutherland

Lochs a'Chairn Bhain, Laxford and Inchard, because of their remoteness in the extreme north-west of Scotland, have attracted the attention of a number of 'amateur' expeditions as well as NCC-sponsored surveys. The Loch a'Chairn Bhain complex, including Lochs Glencoul and Glendhu, was found to have communities reflecting a variety of exposures to both wave-action and tidal streams (Davies 1989). In the outer part of the loch complex, coarse sediment had populations of the heart urchin *Spatangus purpureus* and the brittlestar *Amphiura securigera*, while increasing shelter within the lochs produced finer sediments supporting populations of the echiuran worm *Amalosoma eddystonense* and the large bivalve *Arctica islandica*, together with more typical and widespread sheltered loch species. *Amalosoma eddystonense* has recently been recorded from a number of sealochs (Connor 1990) in north-west Scotland though it was previously recorded only from Plymouth and Galway Bay, Ireland. Accelerated tidal movement through the narrows at Kylestrome and Glencoul produced dense stands of *Alcyonium digitatum* and hydroids on rocky substrata, and beds of brittlestars, *Modiolus modiolus* and *Limaria hians* on the coarse

sediment plains (Davies 1989). Bryozoans and molluscs in the Loch a'Chairn Bhain system were discussed by Ryland (1963) and Smith (1981b) respectively.

Loch Laxford, designated an MCA (NCC 1990), Loch Inchard and the open coast south to Handa Island and Badcall Bay were described by Smith (1985). The sublittoral zone of the area is noted as lacking habitat diversity and being subject to intense grazing by sea-urchins *Echinus esculentus*. Of the shores, four lagoonal enclosures were given particular attention by Smith (1985), who considered Loch an Roin and Rudha Shios on the open coast to be the richest of the four.

Jones [1975] gave details of the shores in Loch Inchard, describing communities from the predominantly rocky shores and noting the presence of *Ascophyllum nodosum* ecad *mackaii* beds at the head of the loch. Mackinnon (1986) led a diving expedition to Loch Laxford, while Davies, Bailey & Moore (1987) tested populations of dogwhelks *Nucella lapillus* for imposex in relation to tributyltin pollution, and Ryland (1963) listed bryozoans from the loch. Holt (1991) and a team from MNCR/UMBSM surveyed Loch Laxford, Loch Inchard, Loch Broom and Little Loch Broom.

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