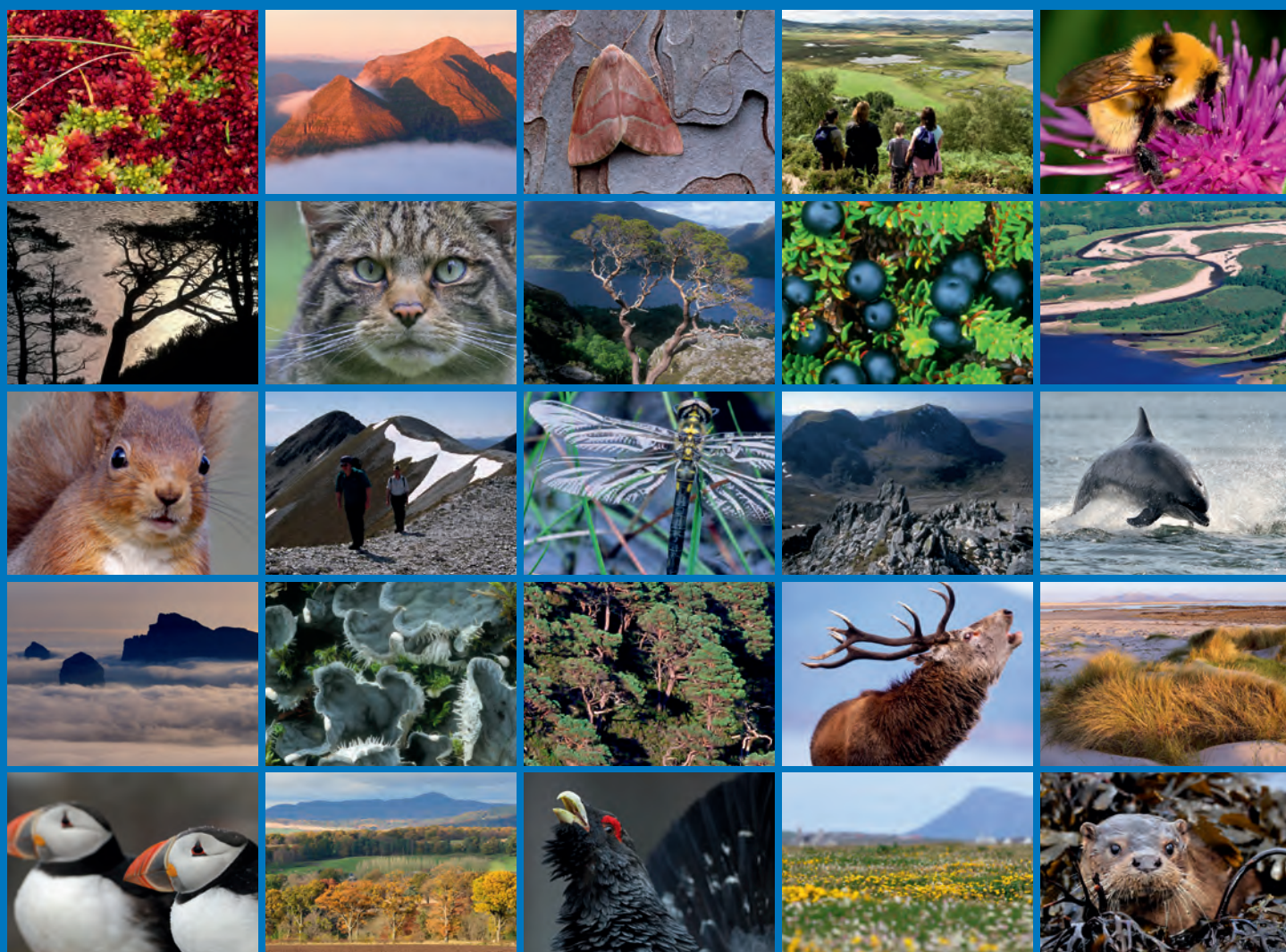


Baseline survey and mapping of intertidal features within selected Scottish SSSIs





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COMMISSIONED REPORT

Commissioned Report No. 754

Baseline survey and mapping of intertidal features within selected Scottish SSSIs

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COMMISSIONED REPORT

Summary

Baseline survey and mapping of intertidal features within selected Scottish SSSIs

Commissioned Report No. 754

Contractor: Aquatic Survey & Monitoring Ltd.

Year of publication: 2014

Keywords

SSSI; site condition monitoring; intertidal; sediment; lagoon; west coast.

Background

Site condition monitoring was required for intertidal sediment features (and one lagoon) in eight designated SSSIs on the west coast of Scotland. This project was designed to provide baseline data and guidance for future monitoring and assessment.

The eight sites are: Kames Bay SSSI, Ballochmartin Bay SSSI, Bogside Flats SSSI, Cree Estuary SSSI, Ulva, Danna and the McCormaig Isles SSSI, Tong Saltings SSSI, Luskentyre Banks and Saltings SSSI, Northton Bay SSSI.

Main findings

- A literature review of marine biological and site condition data was carried out for the eight sites. For most of the sites there was very limited available data on the intertidal sediment communities.
- Marine biological surveys of intertidal sediment biotopes were carried out at seven sites (all except Kames Bay) in April / May 2012. The survey methodology relied primarily on *in-situ* recording at spot locations, but some samples were taken from one site for laboratory analysis.
- The survey results provide descriptions of the sediment habitats and communities and use these to assign biotopes from the national marine biotope classification.
- Records of habitats or species of conservation importance are highlighted.
- Observations of any anthropogenic impacts or activities are noted.
- Generic and site specific recommendations for future monitoring and assessment are given.
- Appendices provide full tabulation of the survey data and a photo catalogue.

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1. INTRODUCTION

Site condition monitoring assessments are a mandatory requirement for all designated SACs and SSSIs within UK waters. Site condition monitoring is carried out to identify deterioration in the condition of the features for which the site has been established. Scottish Natural Heritage (SNH), in association with the other countryside agencies, has established a series of common standards for the monitoring of these sites of nature conservation interest (Anon, 1998). Before monitoring begins it is normally necessary to carry out a baseline assessment of site conditions. No baseline assessment had been completed for the designated intertidal features of the following eight SSSIs (see Figure 1):

Table 1. List of study sites

	Site name	Location	Features	Area (Ha)
1	Kames Bay	Isle of Cumbrae	Sandflats	4.6
2	Ballochmartin Bay	Isle of Cumbrae	Sandflats	18.9
3	Bogside Flats	Kilmarnock	Mudflats	254.72
4	Cree Estuary	Dumfries and Galloway	Mudflats	3441.88
5	Ulva, Danna and the McCormaig Isles (UDMI)	Mid Argyll	Saline lagoon Mudflats	736.78
6	Tong Saltings	Western Isles (Lewis)	Mudflats	441.24
7	Luskentyre Banks and Saltings	Western Isles (Harris)	Sandflats	1080.98
8	Northton Bay	Western Isles (Harris)	Sandflats	450.97

The aim of this project was to carry out baseline assessments of the designated features of the eight sites and develop cost effective and pragmatic methodologies for future site condition monitoring assessments that meet the requirements of the agreed standards.

Specific objectives of the project, focused on the designated features, were to:

- Prepare a literature review of existing information;
- Carry out baseline surveys and assessments in all sites for which the existing baseline data was inadequate;
- Prepare guidelines for the repeat monitoring of the features;
- Prepare a comprehensive report outlining all of the above, including maps indicating the location and boundaries of the features and component biotopes;
- Complete a site attribute table (SAT) for each site to ensure that all of the mandatory attributes are assessed.



Figure 1. Locations of the eight study sites. (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

2. REVIEW OF PREVIOUS DATA

2.1 Kames Bay

Table 2. Summary features of Kames Bay

Area of SSSI	4.57 ha
Location	NS 171 550 OS 1:50,000 Sheet No.63
Dimensions	300 m wide; 170 m deep
Physical characteristics	
Freshwater input	Streams; seepage from water channelled by fault
Salinity	Fully marine but with brackish areas
Tidal currents	Negligible
Tidal range	
Sediments	Sand
Exposure to wave action	Sheltered except from due south
Conservation status	
SSSI	
Human use	Recreation – sandy beach, research
Activities	
Water quality	
Effluent	Stream draining farmland
PMFs	
Species of interest	<i>Hediste diversicolor</i> population on marine beach

The Isle of Cumbrae lies on the western side of the Fairlie Channel in the Firth of Clyde, approximately 2 km from the mainland coast. Kames Bay is a small south facing bay at the head of Millport Bay on Cumbrae's south coast. It is the southern extension of the Great Cumbrae Fault which divides calciferous sandstones on the west side of Kames Bay and Millport Bay from the Old Red Sandstone of Farland Point. Although it is sheltered from most directions by Farland and Portachur Points, the Eileans in Millport Bay and the island of Little Cumbrae, it is exposed to winds from due south and is therefore subject to occasional storms. Kames Bay is Cumbrae's main sandy beach and is the only one on the island with a significant expanse of intertidal sand. The area of Kames Bay within the SSSI is approximately 300 m wide and 170 m from the top of the site (Mean High Water Springs MHWS) to the bottom (Mean Low Water Springs MLWS). Tidal streams are negligible and the tidal range varies from a minimum of approximately 1 m on neap tides to 4 m on springs.

Although the seawater in Millport Bay is fully marine, Smith (1955) observed that there was a significant interstitial input of freshwater creating permanently brackish conditions on part of the beach. He suggested this was due to rainwater collecting on a clay layer above the underlying rocks in the dip of the Great Cumbrae Fault and subsequently seeping through the sand. Other freshwater sources are a burn which flows down the centre of the beach from a culvert after draining agricultural land in the centre of the island, and an overflow sewage pipe on the west side of the bay. This was reported to be in poor condition (SNH Management Statement, 2000) and has not been used since 2005 (Tiwari, 2011). There was no significant change in salinity between 1988 and 2010 although the water table had become gradually deeper (Tiwari, 2011). Smith (1955), Cowie (2005) and Tiwari (2011) all note beach profile changes with the seasons, with increased wave action in autumn and winter reducing the angle of slope and the development of a small berm on the upper shore in spring.

The beach sediments range from fine sand to gravel, with the coarsest sand at the top of the shore and a few boulders on the lower shore. Bedrock on both sides of the beach is not included in the SSSI. Smith (1955) noted that gravel and stone layer is only about 10 cm beneath the overlying sand during the summer months whilst Tiwari (2011) reported an increase in median grain size in the centre of the beach during her analysis of UMBS student data. The Redox Potential Discontinuity (RPD) layer is a few centimetres below the surface on the upper shore but at a depth of up to 1 m on the lower shore (Cowie 2005, reported in Tiwari 2011).

The site was designated as an SSSI in 1978 and redesignated in 1985 (SNH, 1985). Its proximity to the University Marine Biological Station of Millport (UMBS) means that it has long been an important source of material for research studies and the SSSI citation states:-

“Kames Bay is the classic Scottish site for the study of intertidal marine biology, having contributed more to the understanding of marine biology than any other stretch of beach in Scotland.”

A large number of publications since the early 1900s have cited Kames Bay as a study site. One of the earliest pieces of work was that of Stephenson (1911) who recorded the nemertean worms found in the vicinity of Millport. The nemertean *Amphiporus elongatus* is still only known from Kames Bay and the Shetland Islands (Norenburg & Gibson, 2011). Brown (1938) carried out one of the site's earliest studies of polychaetes, looking at the anatomy of *Ophelia cluthensis*. Smith (1955) correlated the distribution of the ragworm *Nereis* (now *Hediste*) *diversicolor* with lowered salinity in interstitial sands. The role of another polychaete *Platynereis dumerilii* in the sublittoral decay of kelp debris was investigated by Bedford & Moore (1985). Lugworms *Arenicola marina* collected from Kames Bay were used as comparative material in the description of a new species from South Wales, *Arenicola defodiens* (Cadman & Nelson-Smith, 1993).

Bivalve populations including *Angulus tenuis*, the dominant bivalve on the beach, *Chamelea gallina* and *Donax vittatus* have been the subject of a number of research projects over many years. These include studies of their biology (Stephen, 1928, 1929, 1930, 1938), morphology and growth (Ansell, 1959, 1961, 1972; Ansell & Trevallion, 1968), burrowing behaviour (Wilson, 1979) and the dispersion of *A. tenuis* from Kames Bay (Wilson, 1976). Kames Bay is the type locality of two species of Coccidia found in *A. tenuis* (Buchanan, 1979). Ansell (1960) investigated the role of the gastropod *Natica alderi* (now *Euspira pulchella*) as a predator of *Venus striatula* (now *Chamelea gallina*) on Kames Bay.

Elmhirst (1931) described a diverse crustacean fauna, mainly composed of amphipods, from Kames Bay. The diurnal migration of crustaceans in the bay has been studied by Watkin (1939, 1942) who looked particularly at *Bathyporeia* spp. and Corey (1969, 1970a, 1970b) who considered this aspect of Cumacean ecology as well as the life history and distribution on the beach of three species cumaceans. Beare and Moore (1996, 1997, 1998) and Moore & Beare (1993) looked at the biology and taxonomy of a number of amphipods (*Pontocrates arenarius*, *Pontocrates altamarinus*, *Pontocrates arcticus*, *Synchelidium maculatum*, *Periculodes longimanus*). Mauchline (1967) compared the breeding season of mysids *Schistomysis spiritus* collected from Kames Bay with ones from Loch Ewe in the north of Scotland. Naked amoebae found in the sand of Kames Bay have been studied by Butler & Rogerson (2005), Cowie & Hannah (2003, 2007), Hannah *et al.* (1996) and Rogerson *et al.* (2000).

Watkin (1942, discussed by S. Álvarez, 2009) gave an early description of the macrofauna, noting that *Tellina* (now *Angulus*) *tenuis* was the dominant bivalve whilst the dominant polychaetes were *Nereis* (now *Hediste*) *diversicolor*, *Scolecopsis* sp., *Phyllodoce* (*Anaitides*) *groenlandica* and *Nephtys caeca*. According to RJA Atkinson (pers. comm. to S. Álvarez,

2009) there was confusion in the early literature between *N. caeca* and *Nephtys cirrosa*, both of which are present on the beach. In the 1940s (Watkin, 1942) *Eteone flava* and *Ophelia rathkei* were common on the upper half of the shore and *N. diversicolor* and *Scolelepis squamata* were most abundant at MHWN. *Arenicola marina* was distributed across the whole shore whilst *N. caeca* and *P. groenlandica* were most abundant on the lower half of the beach. Smith (1955) subsequently showed that the distribution of *N. diversicolor* in Kames Bay was related to the area's freshwater seepage. S. Álvarez (2009) observed that the polychaete infauna in Kames Bay is dominated by predators in contrast to deposit feeders in Ballochmartin Bay.

UMBS has run marine biology courses for undergraduates in the spring and autumn for many years. As part of the course, the students survey a transect down the centre of Kames Bay. The approach to this exercise has been standardised since 1988, resulting in a data sequence of over 20 years. Tiwari (2011) analysed 24 years of infaunal and physical data to look for seasonal and long term patterns.

The depth of the RPD layer had become shallower on the upper half of the transect since 2004/2005 but was deeper on the lower shore. North Ayrshire Council has carried out a summer programme of beach cleaning for a number of years. Around 2004 the method changed from raking up and removing drift algae to shifting it down the beach and either compacting it into the sand with the tractor or burying it, both in the hope that it would be carried away on the next tide (Tiwari, 2011). Tiwari (2011) speculates that the increasing load of decaying organic matter on the midshore is responsible for the decrease in oxygen levels in the sediment.

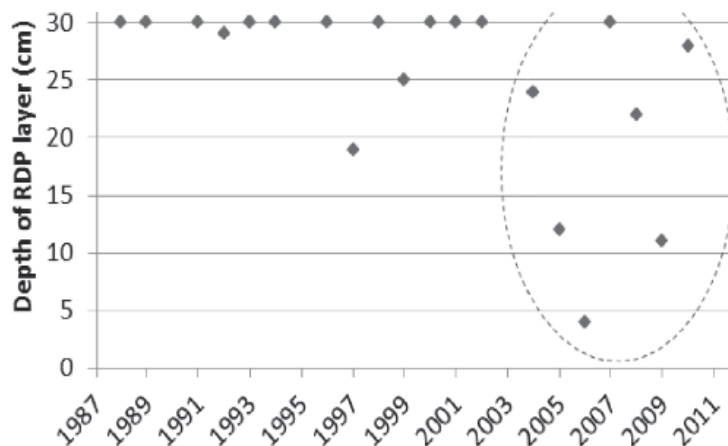


Figure 2. Shallowing in depth of RDP layer in spring from 2004 onwards, the point at which the burial of organic debris in the sediment of Kames Bay began. (Taken from Tiwari, 2011).

Tiwari's analyses of the macrofaunal data was restricted by the lack of sample replicates (Tiwari, 2011). She found that 87 species had been recorded in total. Sampling methods meant that some species were only recorded occasionally whilst others were recorded on every occasion and her analysis concentrated on this latter group. Species diversity was moderately rich, with little difference between the mean species diversity in spring and autumn except on the lower shore where the autumnal diversity was found to be lower. She observed a few changes in the populations of individual species over the 24 year period. The *Angulus tenuis* population had shifted down the shore since the late 1990s whilst *Arenicola marina*, based on counts of casts, had appeared to shift slightly up the shore. The abundance of the amphipod *Haustorius arenarius* had been patchy over the years but its distribution on the beach appeared unchanged. However the amphipod species *Pontocrates*

arenarius showed a significant reduction in numbers and both this species and the polychaete *Ophelia rathkei* had virtually disappeared from the beach.

Kames Bay was selected by the Scottish Marine Biological Association as a control site for studies of the effects of warm water discharge from the Hunterston Power Station because more is known about the composition and dynamics of this bay than any other in the Firth of Clyde (SNH, 2000). The recruitment, growth, and mortality of some of the principal infaunal species of Kames Bay and a beach affected by Hunterston were monitored through monthly studies over a 25 year period (Pearson & Barnett, 1987). Continuous records of water temperature were also collected. Pearson & Barnett (1987) illustrated the value of these long term studies in interpreting the complex interactions of the environmental and biotic factors. They related growth in *Angulus tenuis* populations to water temperature and phytoplankton availability, showing that the bivalves in the artificially warmer water of the Hunterston effluent were better able to utilise high levels of phytoplankton than those from the unheated site at Kames Bay.

S. Álvarez (2009) made comparisons between Kames Bay and the island's other intertidal SSSI at Ballochmartin Bay. He noted that there are more human impacts on Kames Bay which is used as a recreational beach and is subject to strandline cleaning by the council. He also pointed out that where the promenade is there would once have been a dune system and as a result the sand cycle has been stopped. There is less bird activity on the beach in Kames Bay than there is in Ballochmartin Bay; oystercatchers and redshanks have been recorded but only in small numbers. The distribution of *Arenicola marina* across the whole beach may be due to the absence of birds feeding in Kames Bay in contrast to Ballochmartin, where bird feeding pressure around low tide restricted *A. marina* to the upper shore (S. Álvarez, 2009).

SNH (2000) lists a number of impacts of varying significance that affect the site. The SNH Management Plan (SNH, 2000) comments that the council clears seaweed from the strandline during the winter months but Tiwari (2011) states that this occurs during the summer tourist season - Kames Bay is the main tourist beach on the island. Concern was expressed over the poor condition of the sewage pipe on the site (SNH, 2000) but this is no longer used (Tiwari, 2011). As discussed above, research work is one of the major activities on the site.

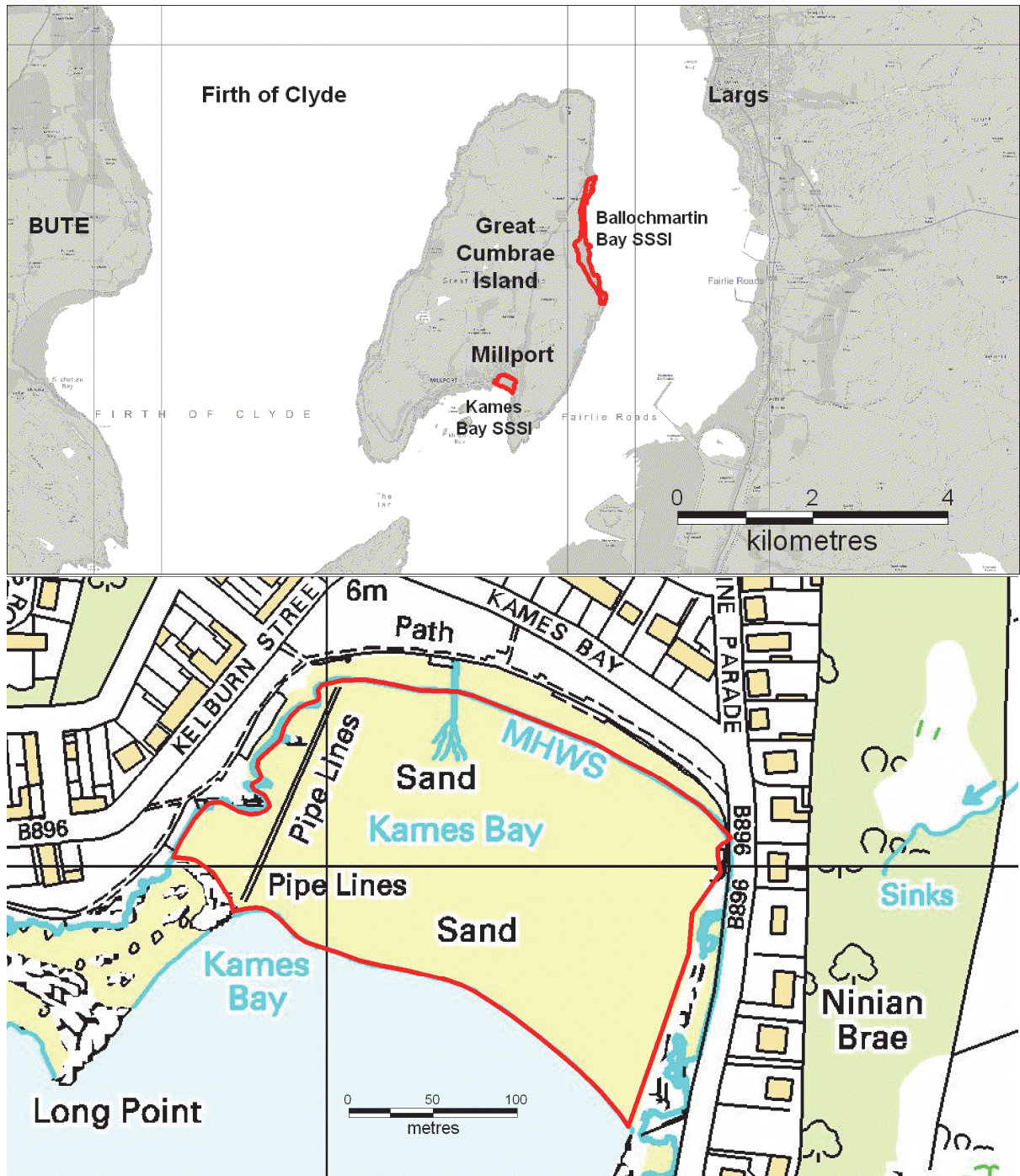


Figure 3. Kames Bay SSSI. (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

2.2 Ballochmartin Bay

Table 3. Summary features of Ballochmartin Bay

Area of SSSI	18.2 ha
Location	NS 182 570; OS 1:50,000 Sheet No.63
Length	2 km long 50 – 200 m wide
Physical characteristics	
Freshwater input	Runoff: Several streams and overflow pipes run across shore
Salinity	32.1 ‰ (Barnes, 1955)
Tidal currents	Slight
Tidal range	c. 1 m (neaps) to 4 m (springs)
Sediments	Mixed shingle and sand with underlying clay; scattered boulders
Exposure to wave action	Sheltered
Conservation status	
SSSI	Designated 1978, redesignated in 1985
Human use	Research (UMBS) Fish farm licences (not operational) Sewage overflow pipes Sea school with jetty for dinghies
Activities	Dinghy launching. Diving (Clashfarland Point)
Water quality	Some organic enrichment from agricultural run off
Effluent	Sewage overflow pipes in poor condition
PMFs	<i>Mytilus edulis</i> beds
Species of interest	<i>Phoronis muelleri</i> , intertidal <i>Cerianthus lloydii</i>

The Isle of Cumbrae lies on the western side of the Fairlie Channel in the Firth of Clyde, approximately 2 km from the mainland coast. Ballochmartin Bay is a wide bay on Cumbrae's east coast and is sheltered by the island's proximity to the mainland. The shore within the SSSI has a length of 2 km and ranges in width from 50 m at its narrowest point to 200 m in the centre of the bay. Tidal streams are slight and the tidal range varies from a minimum of approximately 1 m on neap tides to 4 m on springs. Salinity conditions are generally fully marine (average salinity at Millport is 32.1 ‰ (Barnes, 1955)) but the influence of the estuarine waters in the inner firth and freshwater runoff in streams that run across the beach, particularly in winter, can create conditions of reduced salinity. Freshwater runoff also creates areas of standing water whilst the Ordnance Survey map shows a substantial tide pool at the northern end of the site. There are a number of sewage overflow pipes running across the shore and a small jetty at the sea school at Fairhaven. A more substantial jetty at the Scottish National Watersports Centre forms the northern boundary to the site. The beach is backed by herb-rich grassland and the roadside verges are reported to support slow-worms (*Anguis fragilis*) (SNH Management Statement: SNH, 2000).

The site was designated as an SSSI in 1978 and redesignated in 1985. It is considered to be one of the most varied sediment beaches on the Isle of Cumbrae and its proximity to the University Marine Biological Station of Millport (UMBS) means that it has long been an important source of material for research studies and field courses. Many postgraduate studies have used Ballochmartin Bay as a study site with species investigated including barnacles, sandhoppers, hermit crabs (*Pagurus* spp.), the crab *Ebalia tuberosa*, the swimming crab *Necora puber*, limpets, bivalves including *Venerupis senegalensis*, brittlestars and the sea urchin *Echinus esculentus* (SNH, 2000). However, although there have been many studies of individual species, there appear to have been few faunal or floral surveys of the site.

The majority of the shore within the SSSI consists of mixed sediments with cobbles and pebbles and scattered small boulders overlying mixed muddy sand and gravel. There is steep bedrock at the southern end of the site at Clashfarland Point, an example of the carboniferous dykes which are an important geological feature of Cumbrae, and occasional small bedrock outcrops on the sediment beach. S. Alvarez (2009) described the substrata along a transect across the widest part of the beach. Grain size decreased from the top of the shore downwards, with more shingle at the top of the shore and finer sand on the lower shore. There was a layer of clay at 15 to 20 cm beneath the sand on the lower shore; towards the upper shore it was measured at over 0.5 m down before it could no longer be readily found. Alvarez noted that this prevents water percolation and thus promotes anoxic conditions in the sediment. In the upper half of the transect there was a layer of cobble and pebble between the overlying sand and the clay. Figure 4 shows the beach elevation along the Alvarez (2009) transect.

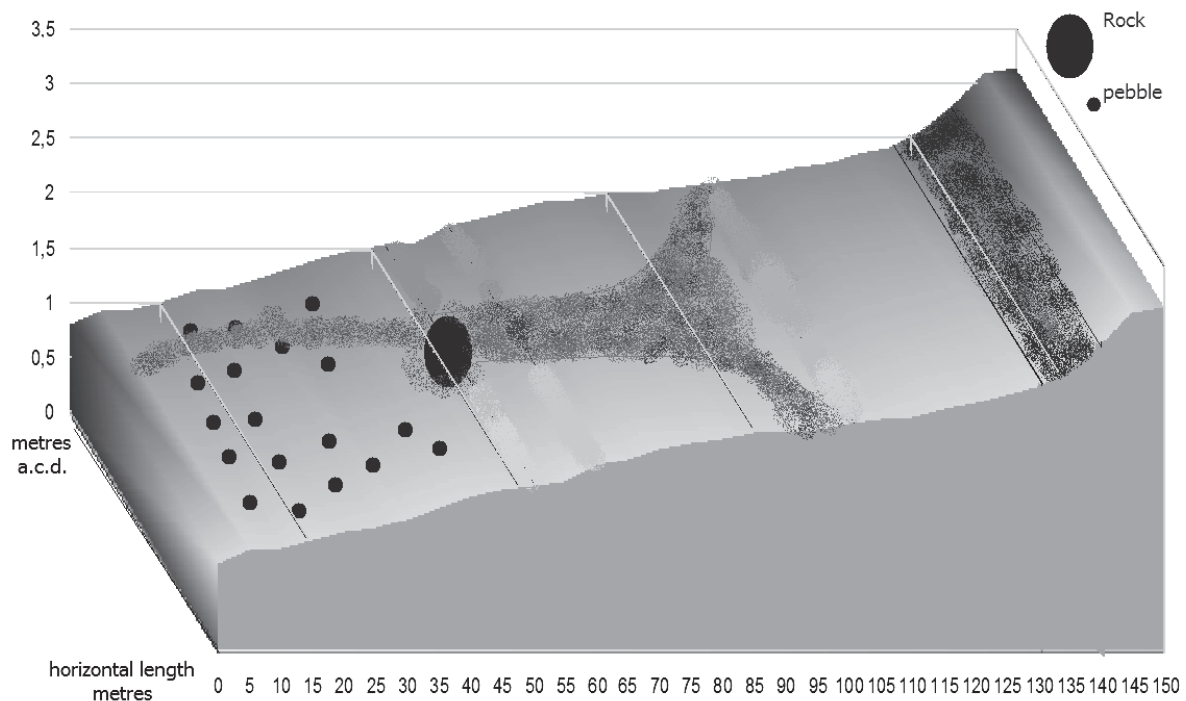


Figure 4. Shore profile representation showing the position of the transect stations, the strandline and the water runoff. X- axis represents horizontal distance and y-axis height above Chart Datum. (Figure from Alvarez, S., 2009)

S. Alvarez (2009) described the macro-infauna along the transect shown in Figure 4. He found that the amphipods *Orchestia gammarellus*, *Deshayesorchestia deshayesii* and *Apothyale prevostii* dominated the fauna on the upper shore above Mean High Water, where there was algal debris on the strandline, whilst annelid polychaetes dominated the mid and lower shore. The clay layer was important in creating hypoxic conditions in the sediment with standing water on the surface and this was reflected in community composition.

The polychaete *Scoloplos armiger* was dominant on the mid to lower shore; this is a species capable of utilizing oxygen in very hypoxic conditions. Spionids, particularly *Spio filicornis* and *Pygospio elegans* were also abundant whilst maldanid polychaetes were only found at the low shore stations (below 1.15m above CD). Alvarez noted that Stephen (1929) reported maldanids to be present in significant numbers throughout the muddy parts of Ballochmartin Bay although they were absent from the sandy areas in 2009. Other annelids present in small numbers included *Phyllodoce maculata*, *Glycera alba* and *Nephtys* spp. These species are all carnivores and less likely to be able to survive long periods of hypoxia than the filter

feeders due to the oxygen demands of their more active lifestyle. Two bivalve species *Cerastoderma edule* and *Angulus tenuis* were also present. *A. tenuis*, which had been reported by Stephen (1929) to reach numbers as high as 800 individuals per m² in this part of Ballochmartin Bay, was recorded at a maximum density of 65/m² by Alvarez. Oligochaetes and *Capitella* spp. were abundant at one station on the lower shore, accounted for by buried decaying algal debris altering the oxygen balance in the sediment.

The species composition of the sediments between mean high water neaps and mid tide level was strongly influenced by organic enrichment due to freshwater runoff from adjacent farmland. Oligochaetes and *Capitella* spp. were the dominant species with *Scoloplos armiger* abundant at one station where the clay layer kept the sediment permanently wet. *Spio* sp., *Arenicola marina*, *Angulus tenuis* and *Cerastoderma edule* were all frequent in this zone and the annelid *Eteone longa* was present.

J. Alvarez (2009) studied bird feeding behaviour on Ballochmartin Bay. The beach was selected for its variety of habitat, including lower shore beds of mussels *Mytilus edulis*. It was noted that the muddy sediments supported the island's only population of the amphipod *Corophium volutator*, an important bird food species. Three contrasting study plots on the beach were used: a sandy area, rock with mussel beds on the lower shore and a bouldery area. The rock and boulder plots both also had sections of sand. Of the 24 species identified making use of the beach, there were five waders, five gulls, two corvids, six species of wildfowl and 6 other species including grey herons, barn swallows, sand martins and rock pipits. Oyster catchers were the most common birds on the beach, feeding preferentially on mussels and cockles at low tide. Curlew followed the tide line across the lower shore where the sediment was finest, feeding on worms, assumed to be *Scoloplos armiger*, *Pygospio elegans* and *Spio martinensis*. Ringed plover also fed on *S. armiger*. Common and herring gulls used the beach mainly for roosting but were seen to feed on larger prey items particularly mussels. Their diet also included crabs, starfish and small fish. Mallard were recorded feeding mainly at ebbing and rising tides and were always associated with a patch of green algae at one of the discharge pipes. Their food items were not determined but may have been invertebrates associated with the algae. Jackdaws and rooks turned seaweed to find invertebrates but also fed on mussels, dropping these from a height to break them open.

The SNH Management Plan (SNH, 2000) makes a number of observations on species of interest on the shore. The saltmarsh fucoid *Fucus distichus* occurs on the site, presumably on small patches of saltmarsh at the top of the shore. There is a population of the tube dwelling phoronid *Phoronis muelleri* whilst the burrowing anemone *Cerianthus lloydii*, which is extremely common in subtidal sediments in the Clyde but is unusual in the intertidal, is found on the lower shore. The plan also comments that there are several mussel beds; *Mytilus edulis* beds are a Priority Marine Feature (Howson *et al.*, 2012). The brackish water amphipod *Gammarus duebeni*, which is present at several sites on the island, is found in the streams that cross the high tide mark at Ballochmartin (Ironsides *et al.*, 2003).

SNH (2000) lists a number of impacts of varying significance that affect the site. A section was cleared of boulders and stones in the early 1970s when aggregate was required during the laying of a waterpipe over the island. Roadside verges have been mechanically cut since the 1970s, resulting in the loss of much of the botanical interest and the presence of bracken on the verge is of some concern due to its invasive nature. A seabed lease was granted in 1988 for a sea-based rainbow trout farm and in 1990 a fish farming application was granted adjacent to the site; these had not been used when the management plan was written (SNH, 2000). Two houses were developed into a sea school for marine activities in 1990 and the school erected a dinghy landing jetty in the late 1990s. S. Alvarez (2009) describes Ballochmartin Bay as undisturbed but suggests that the high organic content of the freshwater runoff across the beach is likely to affect the infaunal communities. The Management Plan (SNH, 2000) considers that pollution would destroy the faunal interest of

the site and expresses concern about the poor condition of overflow sewage pipes that run across the shore. The plan stresses the importance of the UMBS use of Ballochmartin Bay as a research site for over a hundred years and recommends that significant unnatural change to the site should be prevented to enable long term comparisons of information.

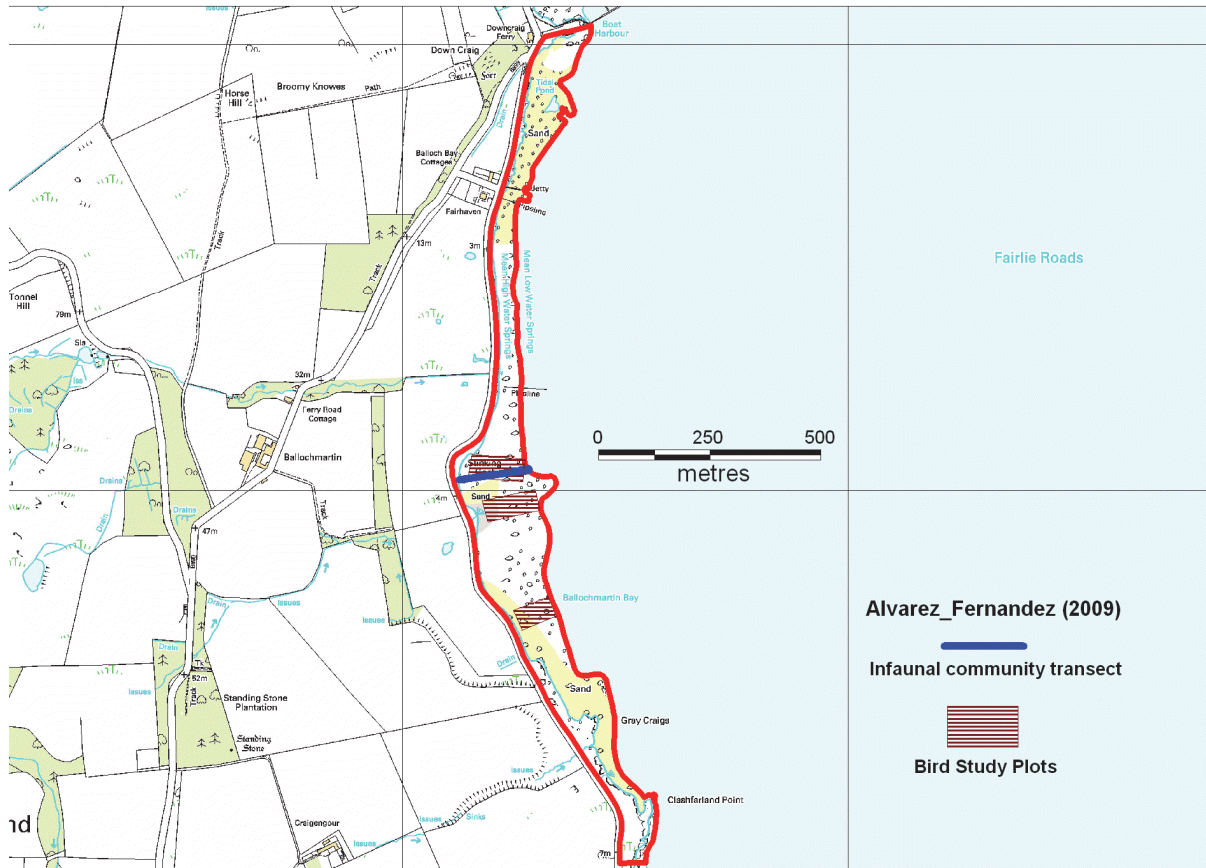


Figure 5. Ballochmartin Bay SSSI (For location map see Figure 3). (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

2.3 Bogside Flats

Table 4. Summary features of Bogside Flats

Area of SSSI	254.72 ha
Location	NS 305 394; OS 1:50,000 Sheet No.70
Dimensions	3.73 km long c. 1.3 km wide
Physical characteristics	
Freshwater input	Estuarine confluence of Rivers Garnock and Irvine
Salinity	?
Tidal currents	?
Tidal range	c. 1 m (neaps) to 4 m (springs) at harbour entrance
Sediments	Mud and sand; scattered boulders; artificial; mussel bed
Exposure to wave action	Extremely sheltered
Conservation status	
SSSI	Designated 1978, redesignated 30/01/1987 with 31 ha increase in area; notification reviewed 04/02/2011
Human use	Industry, tourism, housing developments around edges
Activities	Intermittent dredging in River Irvine; angling, walking, bird watching, horse riding; bait digging and crab collecting
Water quality	'Good' with 'high water quality' and a 'good overall ecological status'. (SEPA)
Effluent	
PMFs	Blue mussel bed
Species of interest	Important populations of wintering waterfowl and waders.

The Bogside Flats SSSI encompasses the estuarine confluence of the Rivers Garnock and Irvine between the towns of Irvine and Stevenston on the Ayrshire coast. The site includes extensive areas of saltmarsh, mudflats and adjacent coastal grassland and developing heath. The peninsula separating the two rivers and including the former Bogside Race Course forms the major part of the site and includes a transition from grassland through upper, middle and lower saltmarsh habitats to intertidal estuarine mud; the marsh is an example of floodplain grazing marsh (Land Use Consultants, 2009). The remainder of the site is narrow strips of intertidal habitat along the banks of both rivers and saltmarsh to the east of the River Irvine. A length of 3.6 km of the River Garnock is included within the SSSI and 2.2 km of the west bank of the River Irvine; the east bank of the Irvine lies within Irvine Harbour and, along with the harbour entrance, is excluded from the site. The width of the intertidal sediment flats ranges from a few metres to around 350 m. The tidal range at the entrance to the harbour varies from a minimum of approximately 1 m on neap tides to 4 m on springs.

Bogside Flats was designated as a SSSI in 1978 and was renotified in 1987 with a 31 ha increase in area (SNH, 2011). The notification was reviewed in February 2011. The site is the only extensive expanse of estuarine saltmarsh and mudflats between the Solway Firth and the Inner Clyde estuary. It is considered to be the best example of this habitat type in Ayrshire, with a variety of plant and animal communities representative of different degrees of tidal inundation. Unusually in Scotland, where lower saltmarsh is not a common habitat, all the possible saltmarsh habitat zones (upper, middle, and lower saltmarsh) are present. The site is one of the most important feeding and roosting areas for wildfowl and waders in Ayrshire. It is extensively used by migrant and wintering wildfowl and waders with nationally

significant wintering populations of eider, red breasted merganser and cormorant. There are regionally significant populations of golden plover, redshank, widgeon, lapwing, dunlin, oystercatcher, shelduck and whooper swans (SNH, 2011).

No survey work has been carried out on the intertidal mudflats although the Ordnance Survey maps show mussel beds (*Mytilus edulis*) on the lower shore on the east bank of the River Garnock. The remainder of the mudflats are marked predominantly as *Mud and Sand*. An exception is the area around and downstream of the McGowan Bridge, a disused railway bridge across the Garnock, which is shown as *Sand and mud* and may be firmer. Photographs on Google Earth of the lower estuary show scattered boulders with fucoids. A Phase 1 Habitat survey of the site carried out in the late 1980s mapped the saltmarsh communities and recorded the mudflats as shown on the OS map (Hand drawn maps provided by G. Walker, Area Officer). There are a number of manmade structures in places, with the remains of jetties, bridges and moorings. In the past, rock armouring has been installed on the banks of the River Garnock but the Management Plan (SNH, 2011) notes that this is now mostly vegetated.

The Bogside Flats have a long history of industrial impact and this is described in the SNH Management Plan (SNH, 2011). Historically, heavy and chemical industries in the Garnock catchment created very acid conditions with high levels of organic nutrients, copper and zinc. With the demise of industry, the chemical company ICI constructed a long sea outfall in 1981 and created a treatment system and closed special waste site to prevent contaminated groundwater reaching the estuary from former operational areas. Pollution in the estuary has consequently decreased and the Scottish Environment Protection Agency (SEPA) currently classifies the Garnock/Irvine Estuary as 'Good' with 'high water quality' and a 'good overall ecological status'.

The lower reach of the River Garnock, which was at one time dredged on a regular basis to allow shipping to reach the Garnock Wharf, has not been dredged since the early 1980s. The River Irvine requires intermittent dredging adjacent to the SSSI.

In recent years the area around the SSSI has attracted interest from industry, tourism and housing development. The Ardeer peninsula to the west of the River Garnock was the site of Alfred Nobel's explosive factory (established in the early 1870s) and more recently the site of 'the Big Idea' millennium building, which opened in 2000 but closed in 2003. This area is now being considered for redevelopment with new residential, industrial and recreational opportunities being cited. It is anticipated that when proposals are brought forward there may be a need to carry out restoration works (e.g. removal of bridges or pipes) within the SSSI. A number of different options have been proposed and some of these may lead to adverse impacts on the SSSI. Any future development requires careful consideration and planning (SNH, 2011).

The grassland area which once formed part of Bogside Racecourse was at one time mined for coal and during the Second World War it provided the site for a small anti-aircraft battery. It is currently reverting to heathland.

Part of the Garnock East area, to the north of the SSSI has planning approval for sand quarrying. This supersedes an expired approval for a 'waste disposal land raise' at the same location. Adjoining the southern edge of the site there is a leisure and harbour development near the mouth of the estuary at Irvine Harbour. Further mixed-use development of this area, part of the Irvine Bay Urban Regeneration Area, is planned. Care will be needed to ensure that disturbance within the SSSI is minimised.

In March 2009 the Royal Society for the Protection of Birds (RSPB) acquired the Marress Field on the eastern bank of the River Irvine within the SSSI. The Bogside RSPB reserve is

a 19 ha site, managed as a grazed floodplain for the benefit of birdlife in the area. The RSPB notes that the rough grassland is used as a foraging area by hen harrier and short-eared owl and that the silt provides a roost area for wintering wildfowl and waders ([RSPB, 2009](#)).

Leisure and recreational pursuits undertaken within the SSSI include angling, walking, bird watching, and horse riding. These are generally at low levels and cause no problems. Wildfowling is legal below the Mean High Water Spring tide level, however due to the nature of the location it seldom takes place (SNH, 2011).

Informal bait and crab collecting is a frequent occurrence, and may cause temporary and localised disturbance to roosting or feeding wildfowl. The SNH Area Officer noted that, in recent years, most of the problems at the site have been caused by crab trapping for bait on the mudflats. He comments that cars are occasionally burnt out on the race course but that this does not affect the intertidal habitats (G. Walker, pers. comm.). Land Use Consultants (2009) identified the use of off-road vehicles and poaching as problems on Bogside Flats.

The Management plan (SNH, 2011) specifies two major targets for maintaining the quality of the site:

1. To maintain the extent and condition of saltmarsh habitat by ensuring protection from damaging impacts.
2. To maintain the extent and forage value of intertidal mudflats by minimising or avoiding damaging impacts including harmful pollution.

In terms of the saltmarsh and grassland, the plan states that light grazing should be continued and encouraged to promote botanical diversity. Construction, dumping or coastal protection works should be avoided and, if deemed necessary, impacts on the saltmarsh should be minimised. SNH is also concerned that high water quality is maintained to protect the mudflats and that any development is sustainable. The plan also stresses that any land use changes should be carefully planned to avoid disturbance to wintering birds (SNH, 2011).

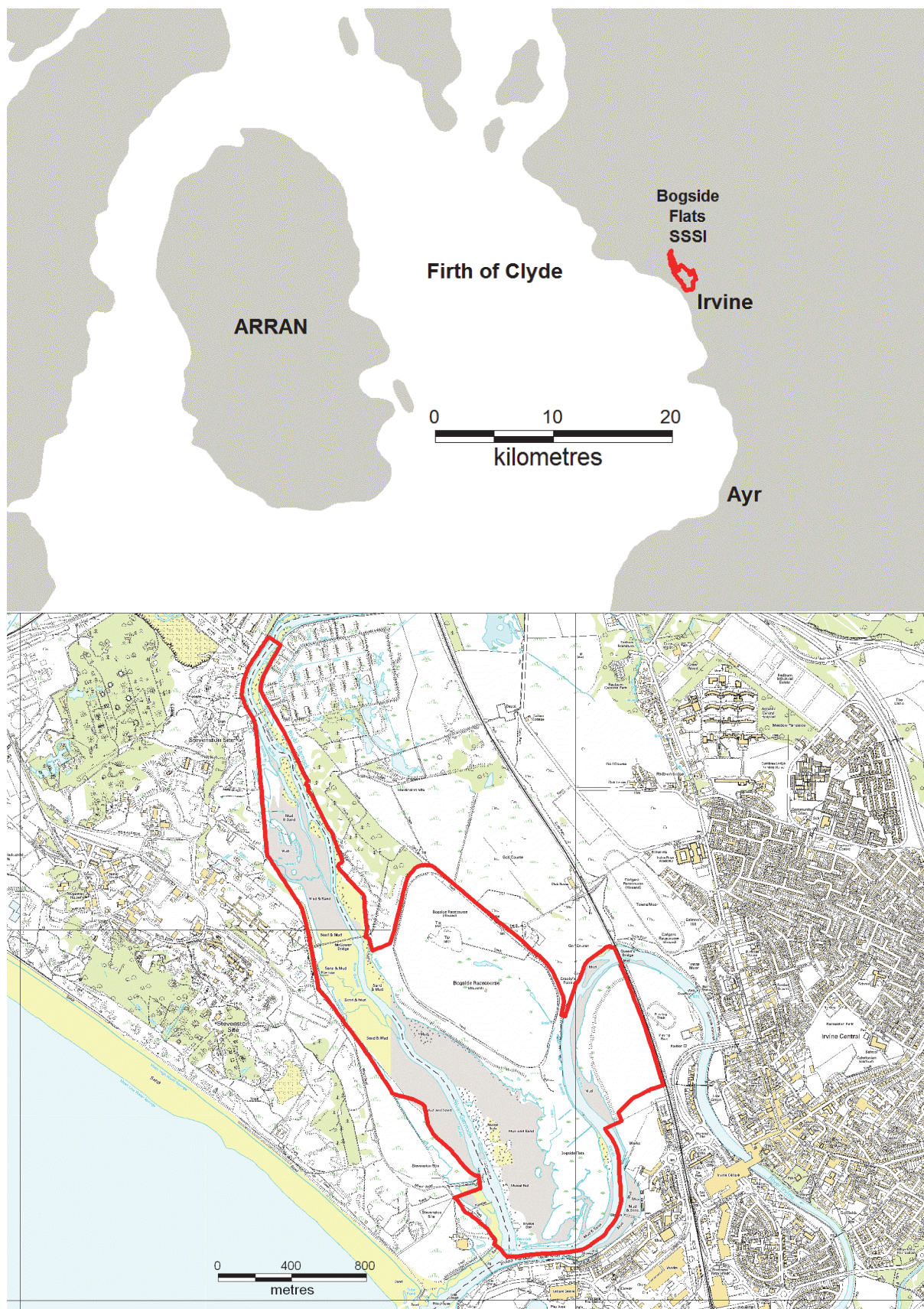


Figure 6. Bogside Flats SSSI. (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

2.4 Cree Estuary

Table 5. Summary features of Cree Estuary

Area of SSSI	3441.88 ha
Location	NX465 545; OS 1:50,000 Sheet No.83
Dimensions	12 km long c. 5 km wide
Physical characteristics	
Freshwater input	Rivers Cree and Bladnoch; runoff from surrounding land
Salinity	?
Tidal currents	?
Tidal range	c. 3 m (neaps) to 7.5 m (springs)
Sediments	Mud and sand; boulder breakwaters; flood defences;
Exposure to wave action	Very sheltered
Conservation status	
SSSI	Designated 1956, 1958, redesignated 31/03/1987 with 2864 ha increase in area; notification reviewed 28/09/2010 Most of Cree Estuary SSSI is declared as part of Wigtown Bay Local Nature Reserve. Overlaps part of the River Bladnoch SAC, designated for Atlantic salmon (<i>Salmo salar</i>). Adjacent to Lower River Cree SSSI. Fishing for salmon & migratory trout; Some military low-level flying; grazing. Site surrounded by agricultural land.
Human use	
Activities	Wildfowling, angling, bird watching
Water quality	?
Effluent	?
PMFs	Smelt or Sparling (<i>Osmerus eperlanus</i>), Atlantic salmon (<i>Salmo salar</i>)
Species of interest	Pink-footed goose (<i>Anser brachyrhynchus</i>), non-breeding

The Cree Estuary, south of Newton Stewart in Dumfries and Galloway, lies on the north shore of the Solway Firth. The SSSI, which covers an area of 3442 ha, includes around 12 km of the River Cree channel and estuary and is approximately 5 km across at its widest point. The tidal range varies from a minimum of approximately 3 m on neap tides to 7.5 m on springs. Whilst the main freshwater input is from the River Cree, the River Bladnoch empties into the estuary east of Wigtown and there are numerous streams draining the surrounding land. The site consists of mud and sand flats and fringing saltmarsh with creeks and salt pans; much of the saltmarsh has developed over the last 25 years (SNH, 2010a). There are sea defences around much of the estuary and the hinterland is farmed.

The site was first designated as an SSSI in 1956 and was redesignated in 1987 with the notification reviewed in 2010. The mudflats and saltmarsh are important bird feeding grounds and the site supports an internationally important population of wintering pink-footed geese. The marshes are of geomorphological and botanical interest and the estuary is one of only three Scottish locations where the nationally rare fish, the smelt or sparling *Osmerus eperlanus*, is known to spawn (SNH, 2010b). The adjacent Lower River Cree SSSI is also notified for smelt, a Priority Marine Feature (PMF). Part of the Cree Estuary site overlaps the River Bladnoch Special Area of Conservation (SAC), which is designated for the Atlantic salmon *Salmo salar*, also a PMF, and it is included within the Wigtown Bay Local Nature Reserve. Studies of the fish populations (eg. Maitland and Lyle, 2001) and surveys of the saltmarsh have been carried out (SNH, 2010a) but there has been very little work done on the intertidal mudflats.

SNH (2010a) describe the saltmarshes as showing a full succession of plants from pioneer species such as glasswort, on areas most frequently flooded by the tide, through common saltmarsh grass, rush communities and red fescue grassland to reedbeds that are influenced by freshwater run-off from adjacent agricultural land. Although the marshes are heavily grazed, there are a number of species of interest including the sea kale *Crambe maritima*, sea radish *Raphanus raphanistrum* ssp. *maritimus* and lax-flowered sea lavender *Limonium vulgare*. Grazing has had a major impact on the vegetation, with the sward short and flowers difficult to find (SNH, 2010a). As a result, the condition of the marshes was considered to be Unfavourable.

Angus (2004) reports on the concern of SNH and the local authority regarding the presence of cord grass *Spartina anglica* in the lower and pioneer saltmarsh zones along the shore near Wigtown, and discusses the most appropriate methods of eradication. The presence of *S. anglica* meant that those marsh features did not meet the site condition targets.

There appear to have been two visits to the estuary to sample the fauna and flora of the mudflats (Marine Recorder data, 2011). Four stations on the Wigtown Sands alongside the River Bladnoch were sampled in 1991 (Covey and Emblow, 1992). The sediment was muddy sand and mud with shell debris and supported *Corophium* sp., *Arenicola marina*, *Macoma balthica*, *Scrobicularia plana* and *Peringia ulvae*. At the lowest shore station, the black layer was immediately below the sediment surface and shell debris was abundant. At the station furthest from the river but amongst deep drainage channels *S. plana* was abundant on the channel sides with *P. ulvae* abundant in patches on the sediment surface. Three sediment biotopes were assigned: *Macoma balthica* and *Arenicola marina* in littoral muddy sand (MuSa.MacAre), *Hediste diversicolor* in littoral gravelly muddy sand and gravelly sandy mud (GvMu.HedMx) and *Hediste diversicolor*, *Macoma balthica* and *Scrobicularia plana* in littoral sandy mud shores (MEst.HedMacScr). Towards the top of the mudflats there was a small boulder breakwater along the river bank. This was covered with *Ascophyllum nodosum* and *Fucus vesiculosus* with barnacles *Semibalanus balanoides* and mussels *Mytilus edulis* beneath the algae (FVS.AscVS). A site further south on the Baldoon Sands was visited in 1989. The sediment here was fine muddy sand with standing water and creeks. *P. ulvae*, *Cerastoderma edule*, *M. balthica* and *S. plana* were common and *Corophium* sp. was present on the creek banks. Polychaetes in the sediment included *Nephtys* sp. and *Hediste diversicolor* and the site was classified as MEst.HedMacScr.

Internationally important numbers of pink-footed geese visit the estuary during the late winter. The birds roost on the mudflats and graze on the saltmarsh and in nearby fields. Pintail, oystercatcher, whooper swan and golden plover are found in nationally important numbers on the site (SNH, 2010a). The macrofauna of the mudflats provides an abundant supply of food for the wintering birds.

The SNH Management Plan describes the history of activities on and around the site (SNH, 2010a). Sea defences around the edge of the site and breakwaters on the mudflats were constructed in the 1800s and, at the same time, attempts were made at one time to improve the channel of the River Bladnoch for shipping. It is clear from aerial photographs that creeks have been straightened, particularly along the western shore. This may have been related to unsuccessful attempts to cultivate areas of saltmarsh. The Management Plan comments that, despite agricultural land-claim, the extent of natural features of fringing estuarine saltmarshes that remain are of a sufficient extent to make this large area of sandflat and saltmarsh of major biological and geomorphological conservation importance (SNH, 2010a).

Whitefish, migratory trout and salmon and smelt were all fished commercially at one time by fixed, boat-based and haaf nets. Shellfish have been collected by hand, as well as boat-based and tractor-drawn dredgers. There is some concern that the recovery of cockle stocks

might encourage further mechanical harvesting. The Management Plan comments that any such harvesting should be sustainable and cause minimal impact to the site features. Fishing for salmon and migratory trout continues and recreational fishing for whitefish, such as plaice and flounders, takes place at a low intensity. Wildfowling occurs over much of the site, with punt guns occasionally being used on the main channel and the River Bladnoch.

The smelt population on the River Cree was the subject of a study by Lyle and Maitland (1997) for Scottish Natural Heritage. This population is the only one remaining from several which previously existed in the Solway. It was found that spawning in February/March was initiated by the temperature in the lower river in the preceding weeks but that the prevailing temperature, tide and flow conditions determined exactly where and when spawning took place (Lyle & Maitland, 1997). The authors recommended that consideration should be given to the reintroduction of smelt to other rivers on the Solway Coast.

A number of management actions were recommended by SNH (2010a). They stated that the maintenance of any essential flood defences should take account of the impacts on natural erosion and accretion processes to protect the geomorphological interest of the estuary. The important smelt feeding, spawning and nursery areas in the estuary and adjacent River Cree should be protected by the management of activities such as fishing and the maintenance of high water quality (SNH, 2010a).



Figure 7. Cree Estuary SSSI location. (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

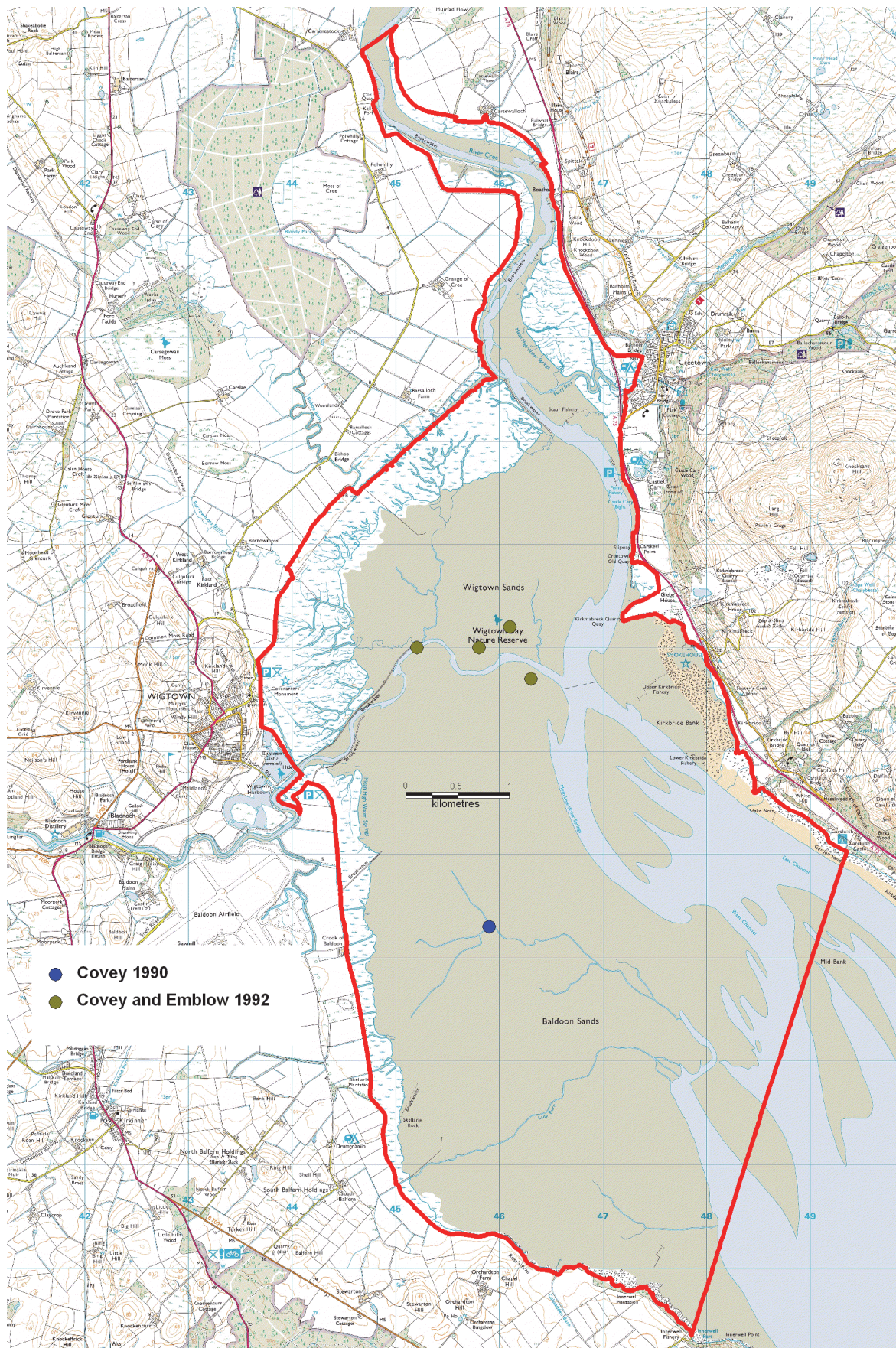


Figure 8. Cree Estuary SSSI. (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

2.5 Ulva, Danna and the McCormaig Isles

Table 6. Summary features of Ulva, Danna and the McCormaig Isles

Area of SSSI	736.78 ha
Location	NR 700799, NR 666753, NR 678758 OS 1:50,000 Sheet Nos. 55, 61 and 62 OS 1:25,000 Sheet No. 358
Dimensions	NE to SW: 10.25 km Max width: 1.6 km
Physical characteristics	
Freshwater input	Streams
Salinity	Fully marine but with brackish areas
Tidal currents	Ranging from negligible to strong in Linne Mhuirich
Tidal range	Unknown but small, probably less than 1.5 m. (No tide stations in vicinity and near an amphidromic point between Islay and the Mull of Kintyre).
Sediments	Mud and sand
Exposure to wave action	Varies between exposed on the open coast and sheltered in the shores around Ulva
Conservation status	SSSI
Human use	Recreation, grazing by livestock
Activities	Sailing and power-boating
Water quality	Good
Effluent	None directly into SSSI
PMFs	Intertidal mudflats, maerl beds, seagrass beds, Low or variable salinity habitats (saline lagoons)
Species of interest	Maerl and sponge growths in Linne Mhuirich rapids

This description of the Ulva, Danna and the McCormaig Isles Site of Special Scientific Interest (SSSI) is taken from information in the SSSI citation (SNH, 2011a, 2011b). The SSSI is situated on the Knapdale peninsula, approximately 15 km south-west of Lochgilphead. It encompasses the Ulva peninsula including the coastal lagoons leading into the Linne Mhuirich in the north east and the head of Loch na Cille on the west coast. It also includes the islands of Danna, Liath Eilean, Sgeir Bun an Locha, Sgeir Dhonncha, Eilean Mor, Dubh Sgeir, Corr Eilean and Eilean Ghamhna, which lie at the entrance to Loch Sween.

The underlying geology of the site (both acidic and basic rocks) has a significant influence on the plant communities and their distribution throughout the site. A series of northeast /southwest orientated ridges and valleys provide an important range in maritime exposure and soil moisture conditions. This landscape and the influence of the oceanic climate combine to produce a very diverse mosaic of habitat types with many species of flora and fauna, which make this one of the richest areas of conservation importance in the Argyll area. The coastal habitats within the SSSI support a rich diversity of vascular plants, with over 500 species recorded. There are several species of national importance and the site has been notified for the assemblage of these plant species (SNH, 2011a).

Several areas of calcareous grassland occur within the mosaic of habitat types and reflect the distribution of underlying base-rich limestone. Plant diversity is high in these areas and typically supports a range of calcicoles including lady's bedstraw *Galium verum* and common bird's-foot-trefoil *Lotus corniculatus*. These grassland areas are also one of the best in the region for orchids, with several notable species such as the frog orchid *Coeloglossum viride*.

In contrast, heath communities exist in patches of more acidic rock types, such as quartzite and quartz-mica schists. Wet heath communities occur in poorly drained areas with characteristic species such as common heather *Calluna vulgaris*, purple moor-grass *Molinia caerulea* and *Sphagnum* moss species. Along ridges, dry heath communities develop with sheep's fescue and other grasses frequently in association with ancient juniper *Juniperus communis* scrub. The growth form and extent of juniper scrub in these areas is highly unusual in Argyll. The site is also important for bryophytes with over 200 species having been recorded within the SSSI, including 10 nationally scarce species (SNH, 2011a).

Along the coastal fringes, the vegetation is strongly influenced by the sea with species such as sea plantain *Plantago maritima*, buck's-horn plantain *Plantago coronopus*, thrift *Armeria maritima* and sea campion *Silene uniflora* occurring. Fringing saltmarsh communities occur along the edges of the sea lochs with upper saltmarsh vegetation dominated by red fescue *Festuca rubra*, saltmarsh rush *Juncus gerardii* and sea milkwort *Glaux maritima*. At the edge of the shoreline, species typical of middle saltmarsh occur, dominated by saltmarsh-grass *Puccinellia maritima*. Below this, pioneer saltmarsh species such as common glasswort *Salicornia europaea* and annual sea blite *Suaeda maritima* sometimes occur (SNH, 2011a).

The marine environment of the site is rich with intertidal communities of national importance. The site is near an amphidromic point that results in an unusually small tidal range and a compressed intertidal zonation (Lewis and Powell, 1960).

In the 1980s the Nature Conservancy Council proposed the Loch Sween area as a Statutory Marine Nature Reserve and commissioned a series of survey reports. The marine life around Ulva, Danna and the McCormaig Isles is described in Lewis and Powell, 1960, Smith (1982, 1985 and 1986), Earll (1982), Rostron and Hiscock (1982) and Lumb and Hiscock (1990). Subsequent work includes a study of the Linne Mhuirich by Bunker (1999) and a review of the nature conservation value of the area by Allen and Birkett (*in prep*).

The marine features highlighted in the various surveys which relate to the Ulva, Danna and the McCormaig Isles SSSI are described below.

No information on the littoral zone of the McCormaig Isles could be found but it can be assumed from available maps and charts that the beaches are primarily rocky. A sandy beach by Eilean nan Uan on Danna was studied by Smith (1982) and was noted to contain a '*Cerastoderma – Tellina*' community.

Intertidal sediments once separated the islands of Danna and Ulva although a causeway bearing a road now bisects this channel (Smith 1985). To the west of the causeway is the beach at the head of Loch Na Cille, which faces southwest into the Sound of Jura. Smith (1986) described three habitats on this beach. The first and most southerly was Rubha na Garbhaird where the upper shore was formed from mud with several stone-built shooting hides and the lower shore was boulders on muddy gravel. The boulders were described as being dominated by *Fucus serratus* and the muddy gravel by *Amphitrite johnstoni*. In the sublittoral fringe the habitat was mixed with boulders, pebbles, gravel, sand and mud with a rich biota. *Laminaria digitata* and *Saccharina latissima* grew on boulders with abundant *Anemonia viridis* and ascidians. The second habitat described by Smith (1986) was the head of Loch Na Cille, which was a mixed sediment flat composed of shell, dead maerl, sand, gravel and mud. Here the upper shore contained *Cerastoderma edule* and *Macoma balthica* and there were patches of *Zostera noltei* with *Vaucheria*. Associated molluscs included *Limapontia depressa*, *Akera bullata* and *Retusa obtusa*. On the lower shore, clumps of *Fucus serratus* were attached to stones. The third habitat described was 'Loch na Cille lagoon' at the northern most limit of the beach. Here, a long narrow channel was crossed by several tumble-down walls upon which there were small amount of small algae

and large *Fucus serratus* plants with *Littorina saxatilis*¹. There were also pools up to 0.5m depth with a large healthy population of *Cerastoderma glaucum*.

On the east side, opening up into Loch Sween is the beach of Ceann an t-Sailein. Smith (1982) describes the sediments here as sandy with pebbles and some mud and including an 'Arenicola – Cerastoderma' community. Here, *Mya arenaria* was reported from the lower shore. The beach at Ceann an t-Sailein was studied in more detail in 1985 (Smith, 1986) where two habitats were described. The first was the narrow channel, which led to Loch na Cille before the road was built. The channel is described as being formed by mud and boulders and fringed by saltmarsh. The boulders were colonised by *Ascophyllum nodosum* and *Fucus vesiculosus*. Pools in the mud were described as containing a 'Hydrobia – Corophium' community which graded into a 'Macoma – Scrobicularia' community. The Saccoglossan mollusc, *Limapontia depressa* was found to be abundant but was apparently difficult to find amongst the alga *Vaucheria*. The second habitat described in Ceann an t-Sailein was further out into the bay where fine mud or muddy sand overlays clay and the 'Arenicola – Cerastoderma' community was found. There were also boulders with clumps of *Fucus serratus* and with *Mytilus edulis*. Smith (1986) also describes the habitats of Rudha Bhreatanich, which is a small bay, separated from Ceann an t-Sailein by a rocky spur. The bay of Rudha Bhreatanich was formed from boulders in the upper part and gravel towards the lower shore. There were no surveys of the biota here apart from an observation that the boulders were colonised by *Fucus serratus*.

The Ulva Islands border Linne Mhurich rapids on the south side and Loch Sween to the east occupying an area of approximately 500m x 800m. Smith (1982) reports the islands to be mostly saltmarsh on the west side and low rocky hummocks to the east. The rock is formed into elongated ridges running northeast to southwest and the islands are dissected by tidal channels.

The channel which runs from An Grianan to Port Linne Mhurich and then into Loch Sween is described by Smith (1982) as a slope with boulders bearing a covering of furoids and other algae, under which was a bed of *Modiolus modiolus* and ascidians. This bed of *Modiolus* had declined to a single specimen three years later (Smith, 1985). Port Linne Mhurich is described in Smith (1982) as muddy sand surrounded by short steep rocky shores with clear patterns of zonation. On the lower shore of Port Linne Mhurich a fringe of *Laminaria digitata* was described and also small ledges with a thick algal turf containing many species amongst which *Colpomena peregrine* was very abundant. Smith (1982) described several indentations in Port Linne Mhurich each of which was different but only two were described. One had a very muddy upper part with *Macoma balthica* and another was reported as being gravelly. This site was further surveyed by Smith (1985) and the south and west shore of Port Linne Mhurich was described as being composed of rock ridges and muddy or boulder gullies with a heavy cover of furoids. This area was described as rich in small Porifera and a wide variety of ascidians. Polychaetes were found to be few with *Syllis prolifera* featuring on the furoid covered boulders and *Arenicola marina* in the mud.

The Ulva Islands shores bordering Loch Sween were described by Smith (1982) as steep and rocky in the upper shore giving way to boulders and gravel towards low water. This habitat was reported to be rich in species, especially algae and ascidians.

The north shores of the Ulva Islands border the narrow entrance to Linne Mhurich, which results in accelerated tidal streams forming tidal rapids. The Linne Mhurich rapids have been described by various workers including Lewis and Powell (1960), Earll (1982), Lumb (1986), Lumb and Hiscock (1990) and Bunker (1999) as supporting the most diverse flora

¹ In the Loch na Cille lagoon, *Littorina saxatilis* was described as *Littorina tenebrosa*, a form of *L. saxatilis* once thought to be a separate species.

and fauna in the whole of the Loch Sween area (see Figure 9). Exceptionally large growths of the sponge *Hymeniacidon perleve* and *Halichondria bowerbanki* occur on the lower shore and shallow subtidal rocks bordering the rapids (SNH, 2011a) whilst a maerl bed formed by the species *Phymatolithon calcareum* (Bunker, 1999) dominates the seabed. Also present are large growths of the green seaweed *Codium fragile* subsp. *fragile*² (Bunker unpublished).

FIG. 20. COMMUNITIES OF LINNE MHUIRICH RAPIDS

This shows the wide range of habitat and community types present within Linne Mhuirich Rapids. These cover the central and eastern rapids section (Sites 17 & 21 mainly). The kelp stipe epiphytes are shown in Fig. 21.

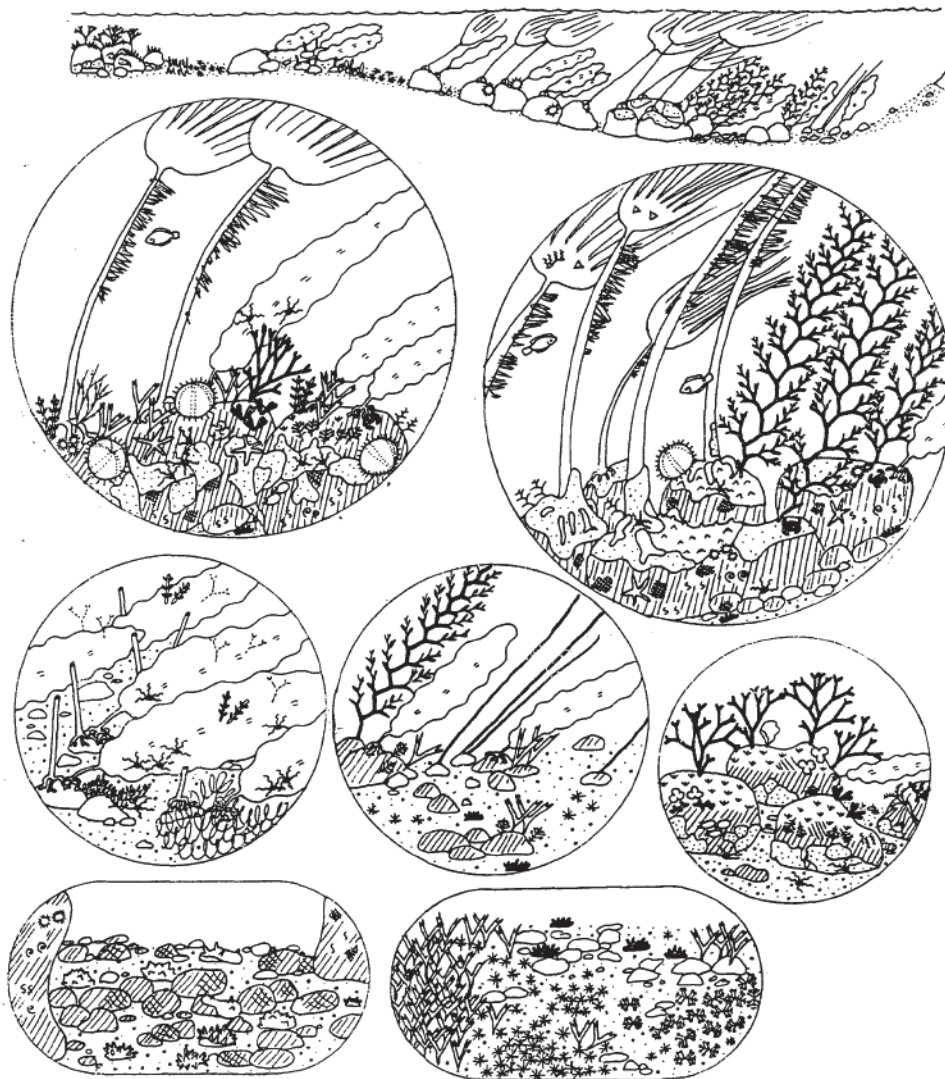


Figure 9. Diagrams to represent various communities found in the Linne Mhuirich rapids, from Lumb and Hiscock (1990).

Rostron and Hiscock (1985) describe the south shore of the Linne Mhuirich rapids as being steep rock being a zonation of fucoids and at the low water the substratum changed to small

² The large growths of *Codium* in Linne Mhuirich are the introduced species *Codium fragile* (Suringar) Hariot subsp. *fragile*. There is some confusion in the literature where it has been called *Codium fragile* and *Codium fragile* subsp. *tomentosoides*. An explanation of the naming British *Codium* species is given in Brodie *et al* (2007).

boulders with patches of gravel. A dense turf of algae was reported at low water with species including *Codium fragile* subsp. *fragile* and a mat of red seaweeds described as 'Trailliella / Falkenbergia' with large sponge growths. Smith (1982) described Sgeir an Feoir, a rocky reef jutting out northwards into the Linne Mhuirich rapids and forming a constriction at the bend of the channel leading into Loch Sween. Smith (1982) reports the upper part of the rocks here as bare and the lower part as being fringed with fucoids and *Saccharina latissima*. Just below low water, Smith (1982) noted a bank of maerl, which was largely dead. To the west of Sgeir an Feoir, Smith (1982) describes flattish rock up to 1m deep at low water, with large loose boulders and where sponges were unusually abundant and large. The shores of the Ulva Islands bordering the Linne Mhuirich rapids were also described by Rostron and Scott (1982).

On the west side of the Ulva Islands is a channel leading from Linne Mhuirich to An Grianan which was reported by Smith (1982) to be composed of sand and gravel and pools at the top of this channel were reported to contain *Limapontia depressa*, amongst the alga *Vaucheria*. The sands here were reported to be colonised by *Cerastoderma edule* and *Venerupis decussata*.

The shores of the Ulva Islands at the entrance of this channel were described by Smith (1982) as being formed of boulders and gravel with *Modiolus* and *Venerupis*. Further up the channel to the south the west shore of the Ulva islands were low-lying saltmarsh leading down to gravel and gently sloping sand. Here, beds of *Venerupis corrugata* and *Dosinia exoleta* were described with *Zostera* dominating the shallow subtidal. Sandy patches between clumps of *Zostera* were colonised by *Arenicola* with *Ophiocomina nigra*. Many *Buncina coronata* were recorded from the *Zostera*, a record noted by Smith (1982) as being unusual as this gastropod is typical of exposed coralline pools.

The intertidal mudflats on the shores of Loch na Cille and enclosed brackish lagoon within An Grianan bay are described by SNH (2011a) as having rich seagrass communities supporting the nationally scarce eelgrass *Zostera marina* and dwarf eelgrass *Zostera noltii*.

An Grianan lagoon was studied by Sheila Smith in 1982 (Smith, 1982) and again in 1985 (Smith, 1985). This lagoon is described (Smith, 1982) as being bordered by bog and saltmarsh and with almost no tide³. The lagoon was estimated to be approximately 450m across and over much of its extent less than 2m deep. According to Smith (1982), drainage ditches led into the lagoon and during the time of her survey (summer 1982) there was little flow of fresh water and the salinity was measured to be 29 parts per thousand. Smith (1982) describes how the lagoon was originally an arm of Linne Mhuirich, which was cut off by an artificial embankment leaving a narrow artificial channel, which at one time had a sluice gate. The channel floor was boulders and dropped about 1m to the level of Linne Mhuirich at low tide. The entrance to the lagoon was described as being scoured, with boulders colonised by *Fucus serratus* and *Fucus vesiculosus*. In Smith (1985) *Mytilus edulis* was recorded as being dominant in this location.

Smith (1982) reported the sandy bed of An Grianan to have a sparse fauna composed chiefly of *Arenicola* with a few specimens of *Cerastoderma glaucum* and small *Mya arenaria*. Both *Cerastoderma edule* and *C. glaucum* were recorded in 1985 but neither was found to be abundant. Many dead *Cerastoderma glaucum* shells were reported by Smith (1982) and she postulated how they were probably killed when the lagoon froze during the early part of 1982. The part of the lagoon furthest away from the sluice was found by Smith (1985) to be

³ As a general rule for lagoons with restricted exchange, the lowest tidal levels are during neaps (Hill, 1994)

dominated by the brackish water amphipod *Corophium lacustre*⁴ with *Potamogeton* sp. dominating the shallows. No *Zostera* was reported by Smith (1982) but a few 'whispy' growths were recorded in 1985 (Smith 1985). Large individuals of the thick-lipped grey mullet, *Chelon labrosus*, were recorded in the shallows of the lagoon.

Smith (1985) describes a high concentration of cowpats from grazing cattle around An Grianan and postulates how this could lead to the nitrogen enrichment of the lagoon.

The outer islands of the SSSI Corr Eilean and Eilean Ghamhna have particularly important seabird colonies and support the largest breeding populations of cormorant *Phalacrocorax carbo* and shag *P. aristotelis* in the Mid Argyll district. The site supports internationally important wintering populations of the Greenland races of barnacle geese *Branta leucopsis* and white-fronted geese *Anser albifrons* ssp. *flavirostris*. The barnacle geese utilise improved pastures on Danna Island as their core feeding zone, whilst the white-fronted geese range more widely, and utilise the saltmarsh communities to a greater extent. The offshore islands, notably Eilean Mor and Eilean Ghamhna, provide goose refuges and roosting sites. Over 1% of the British whooper swan *Cygnus cygnus* population also utilise An Grianan and Loch na Cille areas in the autumn before dispersing more widely.

Scottish Natural Heritage have management agreements to help conserve and protect the features of this SSSI (Scottish Natural Heritage, 2011b). These are summarized as follows:

1. Maintain and enhance the rich mosaic of habitat types within Ulva, Danna and the McCormaig Isles SSSI.
2. Maintain viable populations of notable bryophyte and vascular plant species within the SSSI and where possible encourage the expansion of their range.
3. Maintain the high quality and species rich marine environment within Ulva, Danna and the McCormaig Isles SSSI.
4. Maintain suitable habitat for all of the notified, wintering and breeding bird species within the SSSI.
5. Maintain suitable habitats for the overlapping marsh fritillary and otter features of Tayvallich Juniper and Coast Special Area of Conservation.

⁴ There is some uncertainty about this record as it is the only record of *C. lacustre* on the west coast of Scotland (according to the NBN Gateway), there is no voucher specimen in the NMS collection and other records of *Corophium* from the lagoon are all *C. volutator* and *C. arenarium* (Stewart Angus pers. comm.)

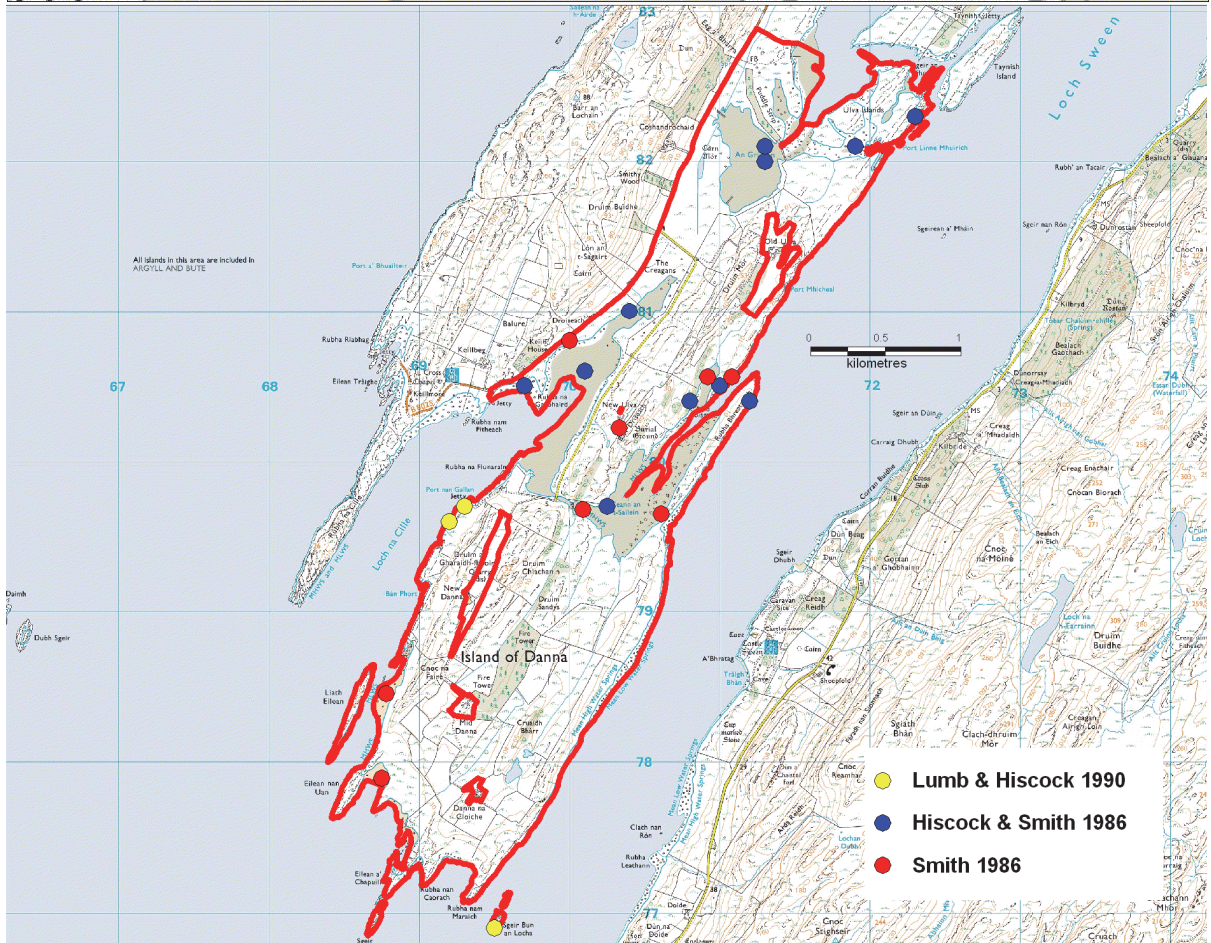
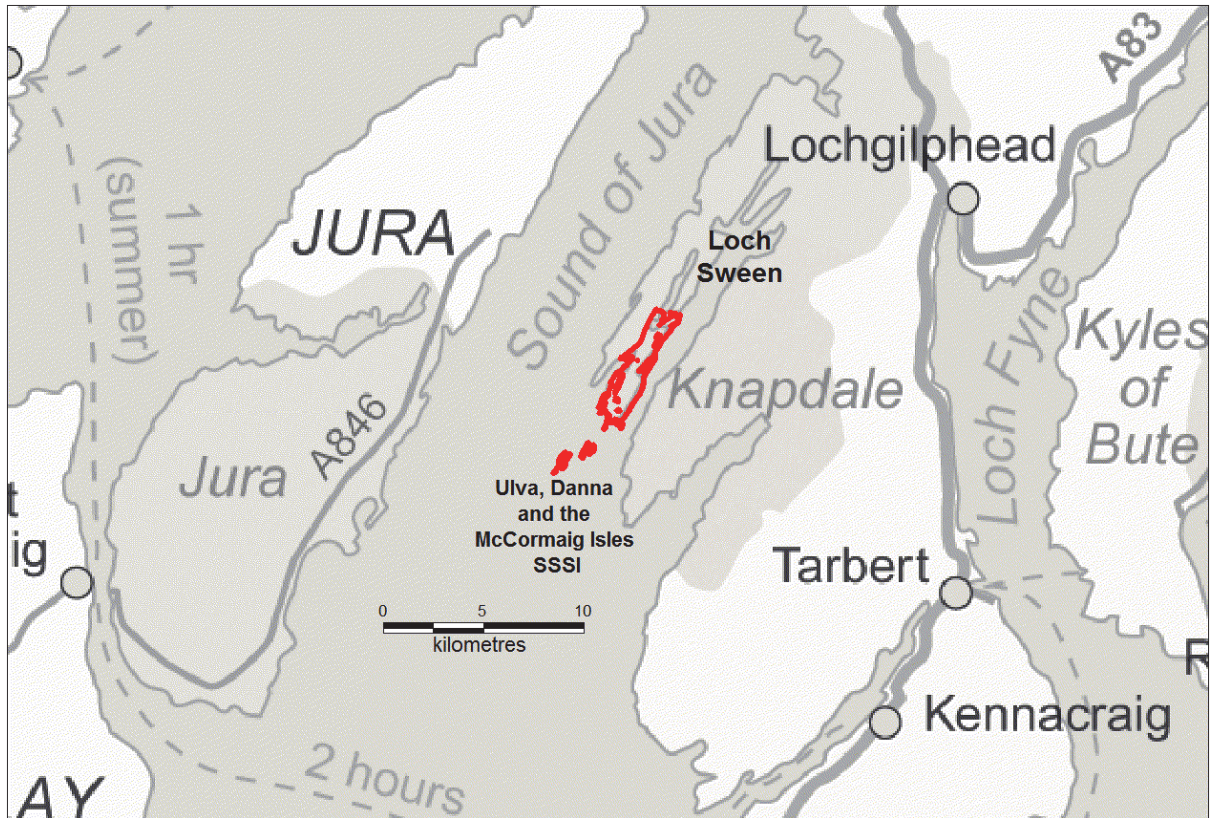


Figure 10. Ulva, Danna and the McCormaig Isles SSSI. (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

2.6 Tong Saltings

Table 7. Summary features of Tong Saltings.

Area of SSSI	441.24 ha
Location	NB 440 358 OS 1:50,000 Sheet No. 8 OS 1:25,000 Sheet No. 459
Dimensions	2.87 km at entrance c. 2.85 km maximum width east to west
Physical characteristics	
Freshwater input	River Laxdale and various streams which join
Salinity	?
Tidal currents	?
Tidal range	c. 1.5 m (neaps) to 3 m (springs)
Sediments	Mud and sand
Exposure to wave action	The seaward facing sandy beach is exposed to wave action from the northwest. Dunes provide a ridge of shelter for the sediments and saltmarsh at the back of the beach
Conservation status	
SSSI	Designated January 1974, redesignated 14/03/1984; notification reviewed 30/03/2011
Human use	Grazing of sheep and cattle, fishing, recreation
Activities	Angling, use of all terrain vehicles (ATVs)
Water quality	?
Effluent	?
PMFs	Intertidal mudflats
Species of interest	?

Tong Saltings is located on the east of the Isle of Lewis, at the head of Loch a Tuath (Broad Bay) to the northeast of Stornoway. SNH (2011a) describe this site as containing one of the largest areas of saltmarsh and tidal flats in the Outer Hebrides. SNH (2011a) states that Tong Saltings is considered to be the best representative intertidal system on the eastern seaboard (presumably of the Outer Hebrides). Conglomerate rock outcrops mark the north of the site at Sron Ruadh and the south of the site at Rubha Mhealaboist.

Estuarine waterways are a characteristic of this site. Streams coalesce at the northwest corner of the site to form a small estuarine river which runs south behind the sand and shingle spit of Teanga Tunga (Tong spit) and Melbost Spit and joins the River Laxdale which enters the site from the west. These two estuarine water systems join at Steinish Pools (Pool of Tong). From here, the estuarine flow turns north along the east side of Teanga Tunga as Abhainn Lacasdail which runs up Tràigh Mhealaboist (Melbost Sands) to enter the sea by the rocky headland of Sron Ruadh.

SNH (2011a) describes the sheltered intertidal flats on the west side of Teanga Tunga and Melbost Spit as having plentiful invertebrate fauna and how the sediments grade into saltmarsh and then into Calluna heath.

Limited data have been found on the sediment characteristics and fauna. Angus (1979) sampled five stations in this site (which he incorrectly named Steinish SSSI). One station was located at LWST on the open coast beach and was dominated by the bivalve *Donax vittatus* (145 per m²), with lower densities of the polychaetes *Nephtys* and *Lanice conchilega*. The other stations were located within the sheltered bay where there were large numbers of Capitellid polychaetes and numerous cockles *Cerastoderma edule* plus large mounds of the lugworm *Arenicola marina* at one station. Other species found in the sediment and within pools included *Tellina* (now *Angulus*) *tenuis*, the shrimp *Crangon*

vulgaris, juvenile plaice, the isopod *Idotea linearis*, the shore crab *Carcinus maenas* and the mud snail *Hydrobia* (now *Peringia*) *ulvae*.

Sand dune vegetation and maritime grassland have developed on the sand and shingle spit of Teanga Tunga and Melbost Spit and to the south of the site on Steinish Island. Scottish Natural Heritage (2011b) describes these spits as being of geomorphological importance.

The site is important for wintering, breeding and feeding birds, including terns, waders and wildfowl. The breeding bird assemblage includes the largest Arctic tern colony on the Outer Hebrides (SNH, 2011b).

The SSSI forms part of several common grazings and is currently used for the grazing of sheep and cattle (SNH, 2011b). It has proven challenging to manage the grazing regime in the past, as stock can circumvent fencing at low tide. Recreational use of all terrain vehicles (ATVs) has caused some damage to salt marsh habitats as well as causing disturbance to breeding birds.

Cockles *Cerastoderma edule* are occasionally collected on a commercial basis from the 'mudflats' of the sheltered bay and stock assessment surveys have been carried out in recent years. The last survey, in November 2009 (Ross and Mackenzie, 2010), estimated that 193 tonnes of cockles were present (averaging 91 cockles per m² across 0.71 km² of the flats).

Scottish Natural Heritage aims to work with the site owner (the Stornoway Trust) to protect the site and to maintain and where necessary enhance its features of special interest (SNH, 2011b). They aim to carry out survey, monitoring and research as appropriate to increase knowledge and understanding of the site and its natural features. The management aims are to maintain the extent and quality of saltmarsh habitats by appropriate management of grazing and to maintain breeding bird populations by avoiding significant disturbance.

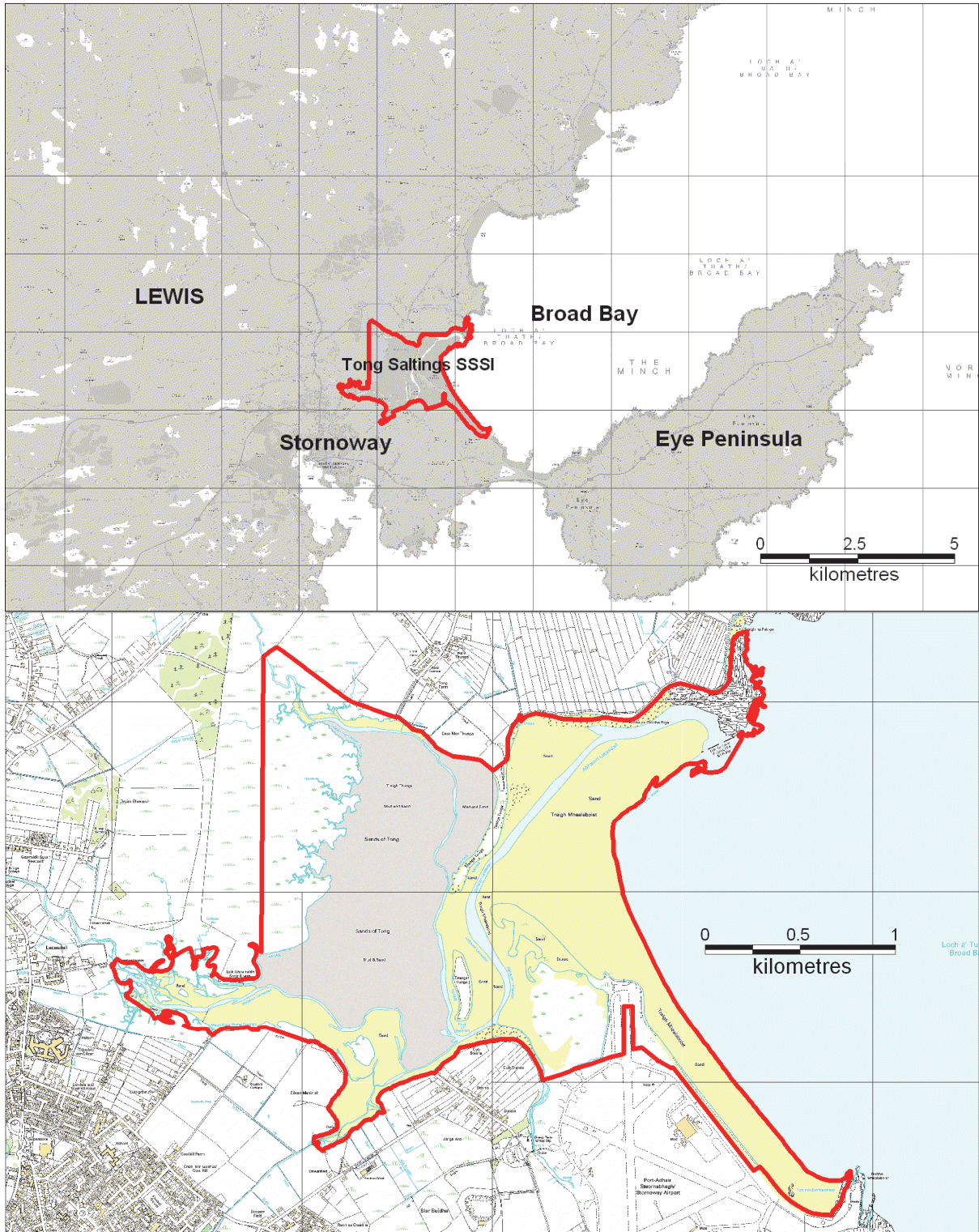


Figure 11. Tong Saltings SSSI. (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

2.7 Luskentyre Banks and Saltings

Table 8. Summary features of Luskentyre Banks and Saltings

Area of SSSI	1080.98 ha
Location	NB 080 973; OS 1:50,000 Landranger Series 18 1:25,000 Explorer Series 455
Length	4.43 km (NE to SW) along seaward edge 7.59 km (SE to NW) from inland extent to seaward edge
Physical characteristics	
Freshwater input	Freshwater streams from hills drain onto main beach where they join the main estuarine channel (Fahail Losgaintir) which enters the the sea at Os Losgaintir. Loch Fincastle at the head of Tràigh Losgaintir overflows to join the freshwater run off.
Salinity	Full salinity over most of the sediment flats, reduced salinity in the channel and freshwater in the feeder streams and Loch Fincastle. No actual measurements of salinity available.
Tidal currents	Tidal currents accelerated in the channel between Luskentyre and Taransay. No data on current speed is available.
Tidal range	c. 4 m Springs/ c. 1.2 m Neaps
Sediments	Sand
Exposure to wave action	Moderately exposed at seaward end with shelter increasing towards the westward end.
Conservation status	
SSSI	Designated 1974, re-notified 1984 and 2011
Human use	Common grazings for sheep and cattle. Recreational use around Horgaost and surrounding beaches Sand extraction occurs outwith the site, but does not affect the features of the SSSI.
Activities	Camping, caravanning and surfing
Water quality	Good
Effluent	Limited sewage effluent from local housing IR.LIR.Lag
PMFs	Submerged fucoids, green or red seaweeds (low salinity infralittoral rock). Eels are likely to occur in Loch Fincastle
Species of interest	Dense communities of <i>Donax vittatus</i> , <i>Nemalion helminthoides</i>

The Luskentyre Banks & Saltings SSSI is situated on the southwest side of Harris, adjacent to and sheltered by the small islet of Taransay. The area is notified as an SSSI because it exhibits one of the best transitional sequences in the Western Isles and possibly Western Scotland from the coastal environment through to calcareous grassland to acid moorland. The SSSI citation (SNH, 2011) describes the features of the site, concentrating on geomorphological features. The beach, dune and machair landforms together form a single geomorphological system considered to be of the highest importance for its physiographical and botanical features. The site is also important for feeding, breeding, wintering and migrating birds, especially waders and wildfowl.

Bruaichean Losgaintir (Luskentyre Banks) is an unusual promontory setting for machair development. The juxtaposition of erosional and depositional features, include some of the highest sand hills in the Outer Hebrides.

Corran Sheilebost is significant as a dynamic spit and has representative examples of Harris dune and machair landforms. However, it is the integral nature of the total landform complex, incorporating Bruaichean Losgaintir, Corran Sheilebost and the extensive intertidal sand of

Tràigh Losgaintir and adjacent saltmarsh that is of prime geomorphological significance. The system appears to represent the reshaped remnants of a much larger area of machair fragmented by postglacial submergence and it has outstanding potential for studies in coastal evolution.

On the east of the site, the extremely gentle slope of the intertidal sandflats of Tràigh Luskentyre extends inland. The western coastal edge is backed by a nearly continuous foredune ridge of up to 10 m high, except in the south where the foreshore is backed by an undercut old and stable machair surface. Towards the north of the peninsula, a healthy and prograding foredune ridge with extensive marram *Ammophila arenaria* cover has developed. There is a well-marked zonation from open shell sand beach and intertidal sandflats, through areas of saltmarsh or sand dunes and dry machair to rough pasture and hillside moorland over granite.

The beach system is the largest in Lewis and Harris, with Tràigh Sheilebost and Tràigh Rosamol adjacent to the sea with the semi-estuarine basin of Losgaintir lying behind them. There has been little work on the marine fauna and flora of the beach although the infauna was studied by Angus (1979) and Ansell *et al.* (1984) and the following description is derived from these references.

Tràigh Sheilebost is a flat and wide beach sheltered by the offshore island of Taransay. The infauna is typical of semi-exposed sand flats with a fauna dominated by the banded wedge shell *Donax vittatus* and large numbers of the thin tellin *Angulus tenuis* and catworms, *Nephtys* sp(p). Other species found here included Nemertea indet., *Gammarus* spp. and sand eels *Ammodytes* spp.. There was a single specimen of the polychaete *Sigalion mathildae*. No infauna was recorded at the south end of Tràigh Sheilebost at High Water Neaps (HWN).

At Tràigh Rosamol the dominant members of the fauna were *Donax vittatus*, *Angulus tenuis*, *Nephtys* sp. and the isopod *Eurydice pulchra*. Ansell *et al.* (1984) found populations of *Donax vittatus* to be extremely abundant at Tràigh Rosamol with densities up to 2,240 per m².

Tràigh Losgaintir is separated from Tràigh Sheilebost by the dunes of Corran Sheilebost and little overlap was found between the faunas of the two areas. The beach of Tràigh Losgaintir is bisected by the estuarine waterway of Fadhail Losgaintir and grades from an estuarine environment upstream to one that is fully marine. To the west, the fauna was found to be dominated by estuarine species. Ragworms *Hediste diversicolor*, Capitellidae, the Baltic tellin *Macoma balthica* and the amphipod *Corophium volutator* were the most numerous species, but there were also small numbers of the laver spire shell *Peringia ulvae* and the peppery furrow shell *Scrobicularia plana*.

Towards the sea, the fauna becomes progressively more marine with *Angulus tenuis*, the bristleworm *Scoloplos armiger* and juvenile *Travisia forbesi* joining the semi-estuarine edible cockle *Cerastoderma edule* and shore crab *Carcinus maenas*. At the seaward end, the fauna was predominantly marine, with large numbers of very young *A. tenuis* and small numbers of polychaetes.

Fresh water cascades down the surrounding hills to the beach where the streams join to form a brackish water estuary. SNH (2011a) describe the SSSI as having oligotrophic and dystrophic lochs with associated fens and an estuarine *Phragmites* swamp grows at Liana Horgabost. At the head of Tràigh Losgaintir is Loch Fincastle, whose peaty waters empty into Fadhail Losgaintir creating a dramatic colour contrast of brown water over white sand (Bunker, unpublished).

Bunker (unpublished, 2007) noted submerged populations of furoid seaweeds growing on the stones in Tràigh Losgaintir (see Figure 12). The rocks at the south end of Tràigh Sheileboist were noted to be dominated by small mussels *Mytilus edulis* with abundant growth of the red seaweed *Aglaothamion sepositum*. Also present was the uncommon red seaweed *Nemalion helminthoides*.

In its Management Statement, Scottish Natural Heritage (2011b) expounds a policy of trying to work with the site owner to protect the site and to maintain and where necessary enhance its features of special interest. Specific aims of the current management policy are to maintain the extent of saltmarsh habitats by appropriate management of grazing and to maintain breeding bird populations by avoiding significant disturbance and maintaining habitats. The SSSI forms part of several common grazings and is currently used for grazing sheep and cattle. The habitats within the site are managed by different townships and sand dunes and machair in the different townships are subject to different grazing regimes. The saltmarsh is not fenced so it is not possible to exclude sheep for a summer grazing break.

Cockles *Cerastoderma edule* are occasionally collected on a commercial basis from the 'mudflats' of the sheltered bay and stock assessment surveys have been carried out in recent years. The last survey, in November 2009 (Ross and Mackenzie, 2010), estimated that 319 tonnes of cockles were present (averaging 49 cockles per m² across 1.76 km² of the flats).

Horgabost is one of the most used recreational areas in the Outer Hebrides. Its beaches are close to the road, and relatively sheltered, so they are popular with campers and caravanners during the summer. In the past, the scientific interest of the site had been damaged by recreational use of the machair. The creation of an official campsite may have limited this damage by restricting vehicular access to sensitive areas, although the construction of the road by Comhairle nan Eilean Siar unintentionally enabled re-establishment of the campsite and therefore greater access (Stewart Angus pers. comm.). There is sand extraction from areas outside the site but this does not affect the features of the SSSI (SNH, 2011b).



Figure 12. Tràigh Losgaintir with brown peaty water from Loch Fincastle and submerged fucoïds. Photo copyright Francis Bunker, September 2007.

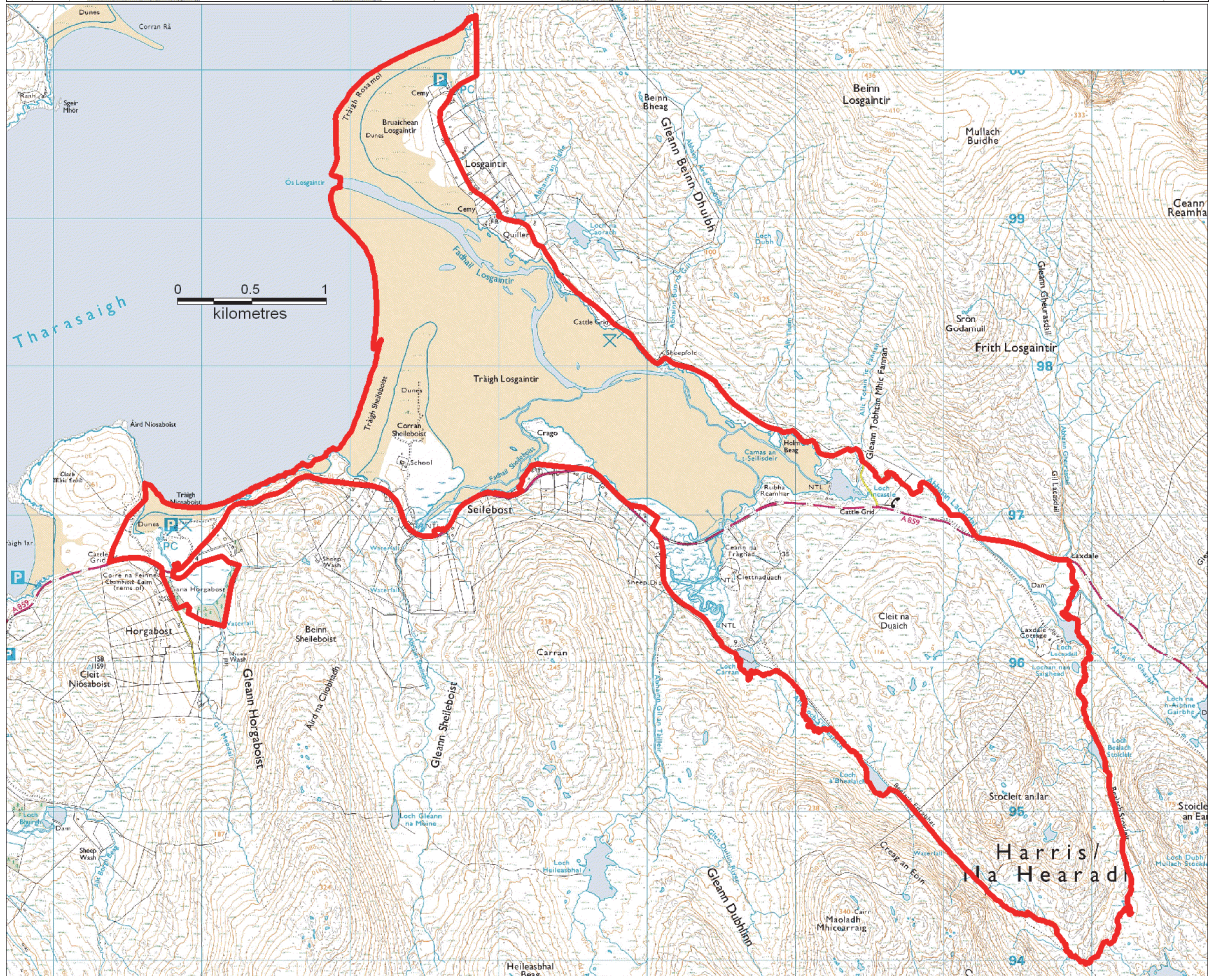
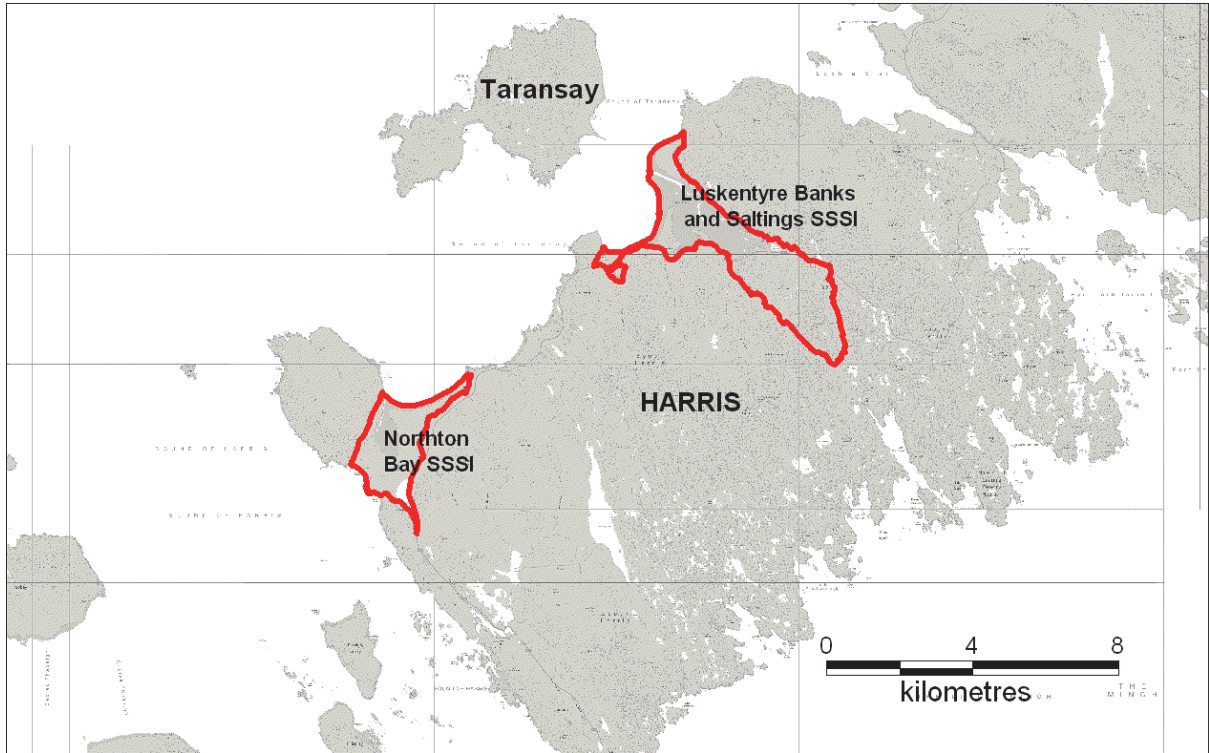


Figure 13. Luskenytre Banks and Saltings SSSI. (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

2.8 Northton Bay

Table 9. Summary features of Northton Bay

Area of SSSI	450.97 ha
Location	NF 990 920; OS 1:50,000 Sheet No.18 1:25,000 Sheet No. 455
Dimensions	4.66 km long (NE to SW) 1.75 km at widest point
Physical characteristics	
Freshwater input	Freshwater streams from surrounding hills and Loch Iosal Vassary to the south of Taobh Tuath
Salinity	Fully saline apart from a stream fed upper shore pool by Taobh Tuath (no measurements available).
Tidal currents	Unknown
Tidal range	c. 4 m Springs/ c. 1.2 m Neaps
Sediments	Sand and mud
Exposure to wave action	Exposed to extremely sheltered
Conservation status	
SSSI	Designated 1974, re-designated 27/09/1984; notification reviewed 30/03/2011
Human use	Housing developments at Taobh Tuath and some at Scarista.
Activities	Grazing of machair and saltmarsh
Water quality	Good, possibly some eutrophication of the lagoon from housing, cattle and sheep
Effluent	Housing developments
PMFs	? ['saline lagoon' now considered to be a tide pool]
Species of interest	Breeding site for a variety of wading birds and wildfowl

Available information on the Northton Bay site of special scientific interest (SSSI) is limited but the main features of interest for which the site was designated are contained within the SSSI citation and Management Statement (Scottish Natural Heritage 2011a, 2011b).

Northton Bay is located in the south west of the Isle of Harris and the site consists of an isthmus of beaches, dunes and machair connecting the ridge of Chaipaval to the mainland of Harris. An extensive and low-lying area of sediment habitats occur on the eastern side of the isthmus. Adjacent to the settlement at the south end of the site is a large area of grazed saltmarsh machair and an extensive saline lagoon. This grades into the large sand flat of Traigh an Taoibh Thuath which extends northwards to the open sea and is backed along its eastern edge by dunes and machair. To the west are the steep slopes of Chaipaval. The south-western shore of the isthmus is marked by two small beaches, Tràigh na Cleabhaig and Tràigh na h-Uidhe. Dunes and machair separate the small beach at Tràigh na Cleabhaig from the large beach of Traigh an Taoibh Thuath.

The fauna of the main beach, Traigh an Taoibh Thuath was described by Angus (1979). No animals were found despite extensive sampling, except for a few lugworms *Arenicola marina*. Small numbers of sand-hoppers *Talitrus saltator* found to be present around the high water mark.

A large upper shore tide pool by Taobh Tuath was described as a saline lagoon (see Thorpe *et al.*, 1998), but seawater incursion is not restricted and it is no longer considered to be a lagoon (Stewart Angus, pers. comm.). The pool is backed on the eastern side by the A859 road, on the northern and western sides by a sandy beach and to the south by the village of Northton. The pool was described in Thorpe *et al.* (1998) as a large shallow fully marine

lagoon located set back in the beach about 1 km from the high water mark of Northton Bay SSSI. The pool was described as being microtidal, about 1 km long, with a maximum depth of 0.5 m and an average depth of around 0.2 m.

Thorpe *et al.* (1998) stated that Northton 'lagoon' appears to be prone to disturbance by weather, which can move sediment or alter the salinity regime. Its shallow nature and large surface area were considered to make it susceptible to large fluctuations in temperature and salinity (depending on air temperature, sunlight and rainfall). Thorpe *et al.* (1998) stated that high salinity appeared to be maintained by seawater percolating through the sand and overtopping the sand flat during high spring tides and storms. It is noted that a small freshwater stream enters the southern end of the lagoon via an area of saltmarsh.

The 'lagoon' bed was described by Thorpe *et al.* (1998) as consisting of sand with a few isolated large cobbles close to the eastern edge. Description of the biota is rudimentary and Thorpe *et al.* (1998) stated that cobbles were colonised by filamentous green algae and blue-green algae with a few scattered spiral wrack, *Fucus spiralis* plants. The sediment was described as containing tubeworms and sparse bivalves while numerous mysid shrimps in the water column. A map of the main biotopes is shown in Figure 14.

The area is renowned for its breeding bird assemblage including a variety of waders and wildfowl typical of coastal habitats. The site is also important for passage and wintering birds.

In its management statement, Scottish Natural Heritage (2011b) outlines how the SSSI forms part of several common grazings and is currently used for grazing sheep and cattle. The saltmarsh is not fenced so it is not possible to exclude sheep for a summer grazing break. Although the condition of the saltmarsh could be improved if there were a summer grazing break, it would be difficult to achieve this; a fence, which would be required to exclude stock, would have to be erected in the sea and this is unfeasible.

SNH (2011b) state how they aim to work with the owner⁵ to protect the site and to maintain and where necessary enhance its features of special interest. SNH aims to carry out site survey, monitoring and research as appropriate to increase knowledge and understanding of the site and its natural features.

Specific aims of the current management policy are:

1. To maintain the extent of saltmarsh habitats, appropriate management of grazing, to enable plants to set seed and minimise poaching.
2. To maintain breeding bird populations by avoiding significant disturbance and maintaining habitats.

⁵ But as this is a crofting township, in practice SNH works with the occupiers (Stewart Angus, pers. comm.)

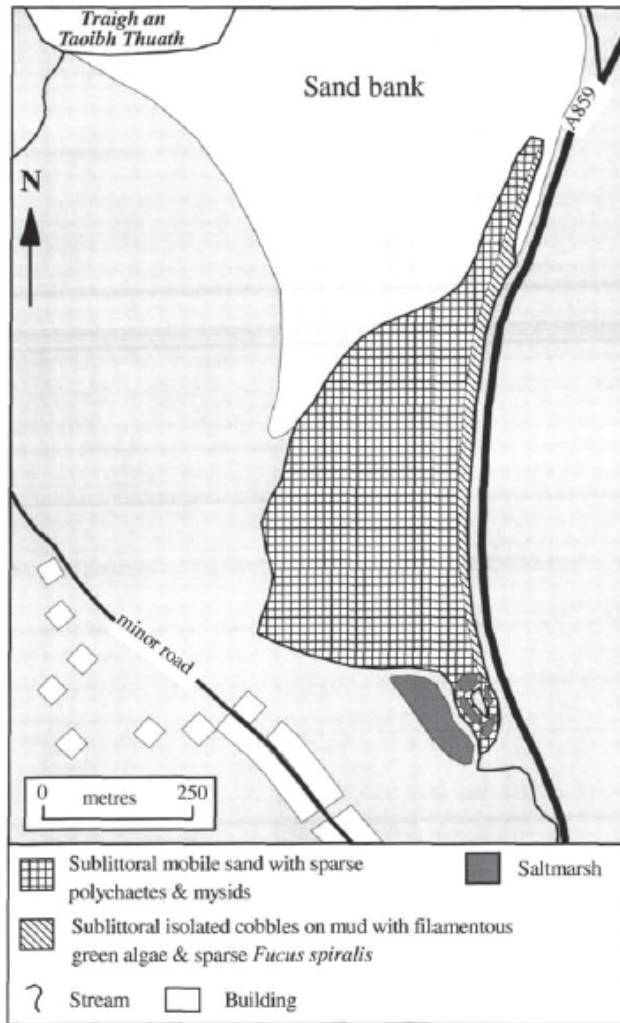


Figure 14. Indicative distribution of the main biotopes of Northton Lagoon (based on field survey information). From Thorpe et al., 1998.

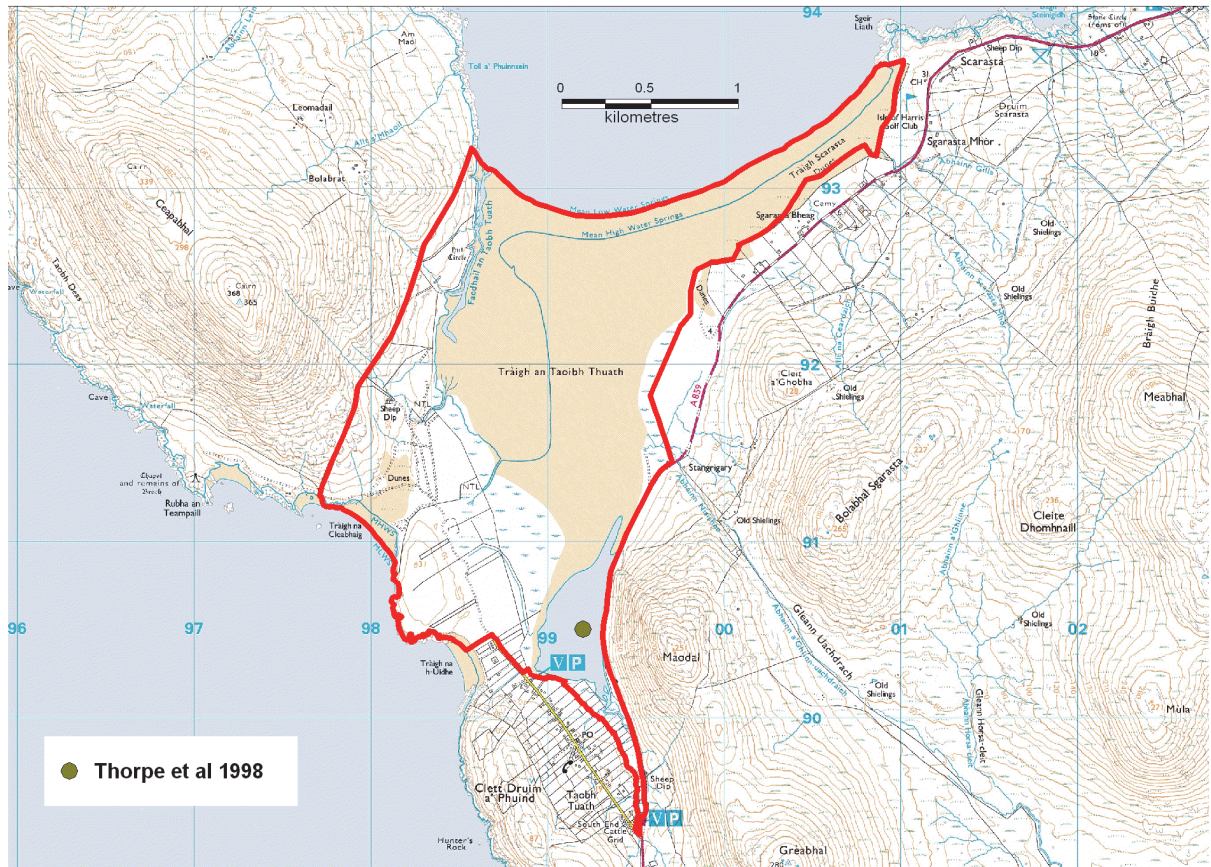


Figure 15. Northton Bay SSSI. (For location map see Figure 13). (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

3. METHODS

3.1 Survey planning, logistics and risk assessment

Development of the survey strategy and methodology was based on the SNH contract specification, ASML's proposed approach and discussions at the inception meeting in December 2011.

Draft Survey Plans and Risk Assessments were prepared by ASML and then reviewed and approved by SNH prior to the survey. They included information on the survey location (maps), personnel, work scope and plan (summary of features, methods, priorities and outline schedule), logistics (travel, accommodation and subsistence, equipment, budget etc.), tide tables, potential hazards, assessment of risk from those hazards, actions/asures to minimise risk, contact details for emergency services, personnel and next of kin.

The survey programme was in three parts (see field log in Appendix A8 for more details):

- Ballochmartin Bay and Bogside Flats, 20-22 April 2012, two ASML surveyors.
- The Hebrides sites (Tong Saltings, Luskentyre Banks & Northton Bay), 3-10 May 2012, two ASML surveyors.
- Cree Estuary and UDMI, 3-10 May 2012, three ASML and two SNH surveyors.

No fieldwork was carried out in the Kames Bay SSSI as it was agreed with SNH, following the literature review, that there was already sufficient data available.

The individual survey teams managed their own survey logistics and survey schedules. Accommodation was arranged in suitable B&Bs near to the survey sites, with space for field laboratories and equipment etc. An inflatable boat (coded) was used in the Cree Estuary and a kayak was used in the An Grianan lagoon (UDMI SSSI) for access to some survey stations.

Field survey equipment included handheld GPS navigators (various makes and models), digital cameras (various makes and models, all set to high resolution and local time), gridded quadrats (various sizes), tape measures, first aid kits, microscopes, identification guides, laptop computers, laser printer and other field laboratory equipment. GIS mapping software (MapInfo), Microsoft Office software and various other utilities were used for daily survey planning, data entry, downloading GPS data and digital photographs and cataloguing files.

3.2 Intertidal sediment biotopes – *in-situ* surveys

3.2.1 Rationale

The majority of the sites are dominated by large areas of sand and mud with very little in the way of hard substrata. This means that identifying and mapping biotopes would require relatively little complicated and time-consuming digitising of conspicuous features or descriptions of target features and biotope mosaics. However, standard ('Phase 2') methods of surveying intertidal sediment communities to provide species data and identify biotopes present would require the collection of core samples followed by laboratory analysis of macrofauna and granulometry. However, use of these methods to provide adequate data for biotope mapping and long term monitoring would require very large numbers of samples and a large budget for laboratory analysis, which was not available.

ASML therefore proposed an *in-situ* survey methodology, developed in Wales as a basis for broadscale mapping and monitoring of large sediment features in marine SACs. The methodology was first established by Wyn and Brazier 2001 (Procedural Guideline No. 3-1

in the JNCC Marine Monitoring Handbook) and further developed by Jon Moore (2009) of ASML to standardise descriptions and improve consistency.

The method requires *in-situ* identification of key species and species groups, from both surface features and in sieved samples, and description of physical characteristics. It has been found that this can normally provide adequate data for identification of biotopes to level 4 or 5 of the national biotope classification and some semi-quantitative data for monitoring changes over time.

To adequately represent the range and distribution of sediment biotopes at the site, within the survey time available and without bias to any particular area or feature, the sediment survey locations are based on a pre-determined grid of stations.

More conventional biotope mapping of conspicuous features (e.g. boundary with saltmarsh, *Zostera* beds, notable creeks, stable shingle ridges, fringing upper shore rock etc) provides additional descriptive information of the site.

A description of the revised methodology, as applied to the seven SSSIs, is given in the following sections.

3.2.2 *Site and station locations*

SNH provided GIS maps (Ordnance Survey) and aerial imagery of each SSSI. These were used to define the survey areas – i.e. the intertidal sediment habitat within the SSSI boundaries. Information on site conditions for survey work, including access and sediment character, was gathered from the literature review, maps and aerial imagery. The number of stations that could be surveyed per day, in different sediment conditions, taking account of walking distances between stations and access points, was derived from previous surveys of this type that had been carried out in Wales. The number of stations that could reasonably be surveyed each day at each site was then calculated. The number of days of survey work to assign to each site was then worked out, considering spatial extent, expected diversity of habitats, species richness, conservation value and logistical issues. This was an iterative process, which resulted in an outline schedule that was different from the original SNH specification but approved by SNH after consultation.

The 'Grid Maker' tool in the MapInfo GIS package was used to create grids of points across the defined survey areas with different distances between the points. After some trial and error, grids of points were created for each site which provided the appropriate numbers of stations. Placement of some additional stations was made to better represent lower shore habitats if the grid did not provide that, and to represent habitats in areas where the intertidal was a relatively narrow band.

Each point on the grid (= station) was given a unique code (e.g. BF01 to BF15 for Bogside Flats; CE01 to CE65 for Cree Estuary), and an Ordnance Survey grid reference (output from the MapInfo database). These were then uploaded into Garmin GPS units. Maps of the station grid were also printed on waterproof paper, showing the station codes, for use during the survey.

3.2.3 *Survey procedures*

For each site, the surveyors worked out a survey plan for the allocated period, taking account of all logistical issues – transport, access, site and weather conditions, distances, safety etc. GPS units were then used to navigate to each station in turn. To minimise bias, a strict rule was applied for placement of the core sampler: as soon as the GPS showed that the position had been reached (within the available accuracy of the GPS at the time - often

indicated by a sudden swing of the direction arrow) the navigator stopped and the corer was placed at the end of his/her toe, without looking at the sediment features. Thus, unbiased sampling of representative locations within the site had a much higher priority than accurately locating the exact position of the pre-defined station.

Once on station, the surveyors carried out the following:

- Took a single core sample, sieved it and described the contents (see Section 3.2.4)
- Took photographs of the habitat (i.e. the sediment surface), the core and the sieve contents, and recorded the photo numbers.
- Visually inspected a small representative sample of the sediment, with the aid of a grain-size comparator, and recorded the main characteristics.
- Made notes on the conspicuous epibiota and other features of the habitat (see Section 3.2.5)
- Recorded all details on the printed (waterproof paper) proforma, including station number, time and any other relevant information.

If a station was in accessible or otherwise not surveyed then a note was made to explain the reasons (e.g. in drainage channel, on rock or below low tide level). For some such stations, particularly those that happened to fall in a drainage channel, the surveyors moved the station to a nearby area of sediment, taking care to minimise bias in placing the corer and then recording the waypoint and new grid reference from the GPS.

The survey protocol, agreed with SNH, allowed provision for additional sampling in locations where the sediment community was found to be particularly biodiverse and potentially of notable nature conservation value. In the event, this was only carried out within the UDMI SSSI. See section 3.4 for more details on the methodology.

3.2.4 *Species in core samples*

Where possible, a single 0.01 m² core sample was taken at each survey station. If the station happened to lie on a rocky outcrop, in a drainage channel or in a pool greater than ~5 cm deep, then a core sample was not taken.

The core sample was then sieved using a 1 mm mesh sieve in a nearby pool. The contents of the sieve were then inspected closely, with the aid of a magnifying glass. All visible animals were identified and counted, to the extent achievable, by the most experienced surveyor in the pair. A simple photographic guide to the most likely species / taxa present was available to the surveyors for use as an aide memoire. Specimens of animals that a surveyor could not recognise, but which were distinctly marked/shaped and fairly frequently occurring, were collected for later inspection under microscopes at the survey base. The names and counts of all species / taxa were recorded on the printed proforma. A copy of the recording form used for this survey is provided in Appendix A2.

The quality and thoroughness of the species records and counts was generally high, but was reduced when large amounts of coarse sediment (mainly shell material, with coarse sand in some stations) were present in the sieve.

More detailed and specific recording protocols for species or features on the forms are given in Appendix A2 (Instructions for completing the forms).

3.2.5 *Conspicuous species / features*

Records of conspicuous species and surface sediment features were made from each station; defined as the area lying within a circle of 5 m radius around the core sample position. Key features to record were:

- Sediment description, with the aid of a grain size comparator and magnifying glass (e.g. well sorted Medium Sand, muddy very fine Sand, gravelly medium Sand, fine Sand / very fine Sand)
- Sediment softness - on a scale of 1 to 5 (1 = v.hard / rock, 5 = ankle depth or more)
- Percentage cover of standing water
- Depth of black layer (redox layer)
- Counts per m² of *Cerastoderma* (adults and juveniles), *Arenicola* casts, *Lanice* tubes, *Hediste* and any other conspicuous animals.
- Percentage cover of *Zostera noltei*, *Enteromorpha* (now renamed *Ulva* (tubular)), green algal staining / coat and any other conspicuous algae.
- Semi-quantitative (SACFOR) abundance or Presence of any other species / taxa that could not easily be quantified more accurately.

Any other notable features were also recorded and photographs were taken to illustrate the substrata/habitat features.

More detailed notes on specific recording protocols for species or features on the forms are given in Appendix A2 (Instructions for completing the forms).

3.3 Mapping of other intertidal features – *in-situ* surveys

Intertidal rocky habitats that are present within the SSSIs were mainly restricted to some narrow fringing upper shore areas (except at UDMI, where rocky shore habitats are common). As those habitats are not identified as features of interest for the sites and therefore not a priority of the survey, they were not recorded in any detail and only in passing as the surveyors moved around the sediment areas. Typically they were recorded as a single station with a brief description of the notable biotopes present.

3.4 Sediment sampling for laboratory analyses

Additional sampling of sediments for laboratory analysis of infauna and granulometry was carried out within the UDMI SSSI; due to the apparent high biodiversity and potential nature conservation interest of the biotopes present. The core sampling stations were selected in the field, to represent the biodiverse sediment biotopes found within the SSSI.

Five core samples were taken from each of the selected sampling stations, using a 0.01 m² corer. The cores were taken within a radius of approximately 5 m from the central mark; and randomly placed without reference to the surface features (with eyes closed). Each core was then sieved over a 0.5 mm mesh and the sieve contents transferred to suitable labelled pot or plastic bag. These samples were then taken back to the field survey base and preserved in 10% formalin.

A sample of the sediment was also taken from each station for granulometry analysis. The sample was usually taken from the side of one of the corer holes, to a depth of at least 5 cm, and placed in a labelled plastic bag.

Biological analysis of the infauna samples was carried out by ASML (Tom Mercer). Granulometry analyses on sediment samples was carried out by Hebog, Bangor. All analyses were carried out using standard laboratory methods and protocols. More details on those methodologies are available on request.

3.5 An Grianan lagoon – *in-situ* surveys

Survey in the *An Grianan* lagoon (UDMI SSSI) used three *in-situ* methods plus laboratory analysis of four samples:

- Rapid survey of habitats and species present at locations (=stations) distributed around the lagoon. Locations were selected on site to represent the visible habitats / communities present. Epibiota and infauna identified *in-situ*. Photographs taken to illustrate each habitat. Salinity measurements were taken by Stewart Angus of SNH using a temperature/conductivity salinometer (a portable Hydrolab Quanta unit configured for temperature, conductivity (and salinity) & depth).
- Quantitative counts of sediment bivalves at four of those stations. Counts of *Cerastoderma glaucum* and *Macoma balthica* per m² using a randomly placed 0.25m² quadrat.
- Non-quantitative samples of sediment (approximately 1 litre) in surface scrapes from the upper 10cm of the lagoon bed were taken at four of the lagoon stations. 30cm diameter core tubes were pushed horizontally through the surface sediment, until they were half full. This took place while standing in approximately 30-50cm of water. The core contents were sieved over 0.5mm mesh *in situ* and fixed and buffered at the survey's field base. Laboratory analysis of infauna was carried out by ASML (Tom Mercer).
- Establishment of a transect (approx 250m long) across the lagoon, between two large isolated boulders. Quantitative recording of *Cerastoderma glaucum*, *Zostera noltei* shoots and *Arenicola marina* casts at intervals (0, 50, 100, 150, 200 and 242m) along the transect. *C. glaucum* and *Z. noltei* were quantified using the top rim of a small round sieve (20cm diameter = 0.0314m²) to mark the sediment surface and then digging the sediment out from the marked area and sieving it to extract and count the cockles and seagrass shoots. Five (or six) replicate counts, randomly placed, were made from each transect station. *A. marina* casts were quantified by counting the number of casts within a single randomly placed 0.25m² quadrat. Photographs taken to aid relocation of the boulders marking the ends of the transect.

Distinguishing lagoon cockle *C. glaucum* from the common marine cockle *C. edule* was aided by applying the pin-method described by Brock (1978). Then, once the surveyors had 'got their eye in', they found that the shape of the *C. glaucum* was distinctive.

As the majority of the lagoon stations were underwater, the surveyors used a combination of kayaking and snorkelling to access and survey the stations. GPS fixes were taken on all locations, including the boulders marking the start and end of the transect. Photographs were taken to illustrate various features around the lagoon.

3.6 Data collation, management and mapping

All data were entered into Microsoft Excel spreadsheet files during the course of the surveys, usually by the individual surveyors who had collected them. A spreadsheet file was created for each site (SSSI), each containing multiple spreadsheets to accommodate the different types of data. Two files were created for the UDMI SSSI, one for the *An Grianan* lagoon and one for the rest of the site. Standardised template spreadsheets, designed for the methodologies described above and including a number of auto-verification features and conditional formatting, were used to maintain consistency of data entry by the surveyors.

Each spreadsheet file typically contains the following sheets:

- MEDIN metadata – based on MEDIN Discovery Metadata Standard 2.3.2
- Spreadsheet metadata - explanations of all data fields in each individual spreadsheet
- Station data – table of survey station numbers, positions and associated data
- Conspicuous spp – species and abundances from epibiota surveys
- In-situ core spp – species and abundances from *in-situ* analysis of sieved cores

- Waypoints – positions and notes on additional waypoints, for photos and features
- Photolog – catalogue of digital photographs

Waypoints and tracks captured during the surveys were downloaded from the handheld GPS units and converted to MapInfo Tab files. All positions were captured as Latitude / Longitude coordinates (WGS84 datum) (the native format of the GPS units) and later converted to OS grid references within MapInfo. OS grid references and Lat/Long coordinates were then exported from MapInfo and collated with the rest of the data in the Excel spreadsheets.

Data verification procedures, to maintain consistency and accuracy and ensure that all relevant details had been captured, were carried out during the surveys and on the completed spreadsheets soon after the end of the surveys, while details were still fresh in the minds of the surveyors. These procedures included GIS mapping and cross checking of all recorded GPS fixes to make sure they were in valid locations; checking all recorded species against known geographic range and habitats; checking records for accuracy and validity of station numbers, dates and times, recorded method types, abundance codes/numbers, photo filenames etc. All spreadsheet data fields were formatted as appropriate to the data type.

Digital photographs taken during the surveys were downloaded from the cameras and the jpg files were renamed using the following naming convention:

YYYYMMDD_ABC_XXXX.JPG

where YYYY=4 digit year, MM=2 digit month, DD=2 digit day, ABC=3 letter photographers initials, XXXX=4 digit unique number from camera; e.g.:

20100902_CMH_5890.JPG

Photographs were catalogued in a spreadsheet, including filename, date/time, photographer, station numbers and a description. A hyperlink field in the spreadsheet allows the photograph to be opened direct from the catalogue (when stored in the appropriate sub-directory). Where possible, the catalogue also includes the positions (OS grid references and Lat/Long coordinates) from which the photographs were taken, derived from the survey station and waypoint positions.

Taxonomic nomenclature is according to the World Register of Marine Species (www.marinespecies.org), with taxonomic order based on Howson and Picton (1997).

All areas given in this report are Cartesian Areas, measured with the features in MapInfo Professional GIS software (version 8.0).

All relevant species and habitat data have been entered into Marine Recorder.

Maps for this report were prepared in a MapInfo (version 10.1) GIS database. All relevant GIS data were then exported to ESRI Shape files and imported into ArcGIS 9.3.1. However, the spatial data produced by this project was restricted to points (the survey stations) with simple OS grid coordinates (Eastings & Northings) which are provided in the Excel data spreadsheets with all associated attribute data.

4. RESULTS

4.1 Kames Bay

Following literature review it was decided that existing baseline data for Kames Bay were adequate. Therefore, no survey work was carried out for this site.

4.2 Ballochmartin Bay

Surveys of stations in Ballochmartin Bay were carried out during low spring tides on the 19th and 20th April 2012. Figure 16 shows the locations and numbers of the survey stations visited. Of the 10 stations on the planned grid 1 (BB08) was not surveyed because it was covered by the tide at low water. Three additional stations were added (BB11-13) to represent areas of sediment and habitats that had not been covered.

4.2.1 Biotopes and species

Tables 10a, b, c and d summarise the data collected. The full data is tabulated in Appendices A3, A4, A5, A6 and A7.

Biotopes from the national classification of marine biotopes (Connor *et al.* 2004) have been assigned to each survey station after close inspection of the detailed physical and biological data collected. Table 10b lists the biotopes and Figure 17 shows their distribution.

Table 10a. Summary data for surveyed stations

No. of stations surveyed	12
No. of <i>in-situ</i> core stations	12
Total No. of epibiota species	38
Total No. of <i>in-situ</i> core species	16
No. of biotope types	7

Table 10b. Biotope types at surveyed stations, based on classification of Connor et al. 2004.

Biotope code	Stns	Biotope name
LR.LLR.F.Fves.X	1	<i>Fucus vesiculosus</i> on mid eulittoral mixed substrata
LR.MLR.BF.Fser.Bo	3	<i>Fucus serratus</i> and under-boulder fauna on exposed to moderately exposed lower eulittoral boulders
LS.LCS	1	Littoral coarse sediment
LS.LSa.FiSa	2	Polychaete / amphipod dominated fine sand shores
LS.LSa.FiSa.Po.Aten	2	Polychaetes and <i>Angulus tenuis</i> in littoral fine sand
LS.LSa.MoSa	3	Barren or amphipod-dominated mobile sand shores
LS.LSa.St.Tal	2	Talitrids on the upper shore and strand-line

Table 10c. Conspicuous epibiota (most frequently recorded species only) recorded in-situ from surface of substrata. Survey methods: Presence (P), density (M) or percentage cover (%) estimated over 5 m radius. Stns = No. of stations (out of 12) in which taxon was recorded. Full data in Appendix A4.

Name	Method	Stns
<i>Arenicola marina</i>	M	8
<i>Lanice conchilega</i>	M	4
Spirorbinae	P	3
<i>Semibalanus balanoides</i>	P	6
Talitridae	P	3
Gammaridae	P	3
<i>Pagurus bernhardus</i>	P	3
<i>Patella</i>	P	3
<i>Littorina littorea</i>	P	8
<i>Porphyra purpurea</i>	%	4
<i>Dumontia contorta</i>	%	4
<i>Heterosiphonia japonica</i>	%	5
Ectocarpaceae	%	4
<i>Fucus vesiculosus</i>	%	7
<i>Ulva</i>	%	3
<i>Verrucaria mucosa</i>	%	4

Table 10d. Species / taxa recorded in-situ from sieved core samples (most frequently recorded species only). Stns = No. of stations (out of 12) in which taxon was recorded. Full data in Appendix A5.

Name	Stns
Polychaeta	6
<i>Scoloplos armiger</i>	2
Talitridae	3
<i>Corophium</i>	2
<i>Littorina littorea</i>	2
<i>Angulus tenuis</i>	4

4.2.2 Habitats and species of conservation importance

Native oysters - *Ostrea edulis* were recorded.

No other Priority Marine Features, Biodiversity Action Plan habitats, BAP species or other rare species recorded.

4.2.3 Impacts and activities noted during the survey

- Research and education - students from the marine station at Millport use the shore for a variety of fieldwork activities, ranging from ornithological surveys (winter wader usage etc.) to rocky shore studies.
- Local anglers collect bait (lugworm, ragworm etc.) from the sandy areas along the shore and there appear to be several areas where launching of small boats occurs.
- Walkers and minor beach recreation activities occurring at low levels particularly in the summer months.

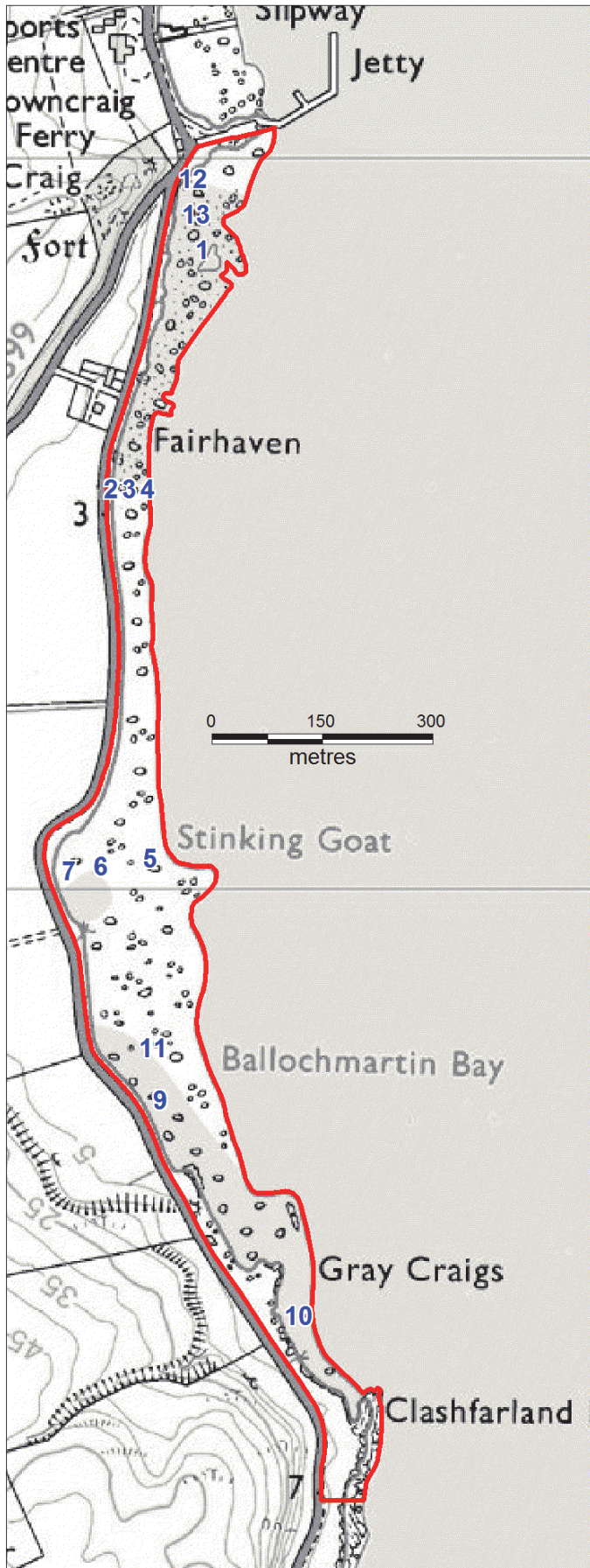


Figure 16. Survey stations in Ballochmartin Bay SSSI (For location map see Figure 3). (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

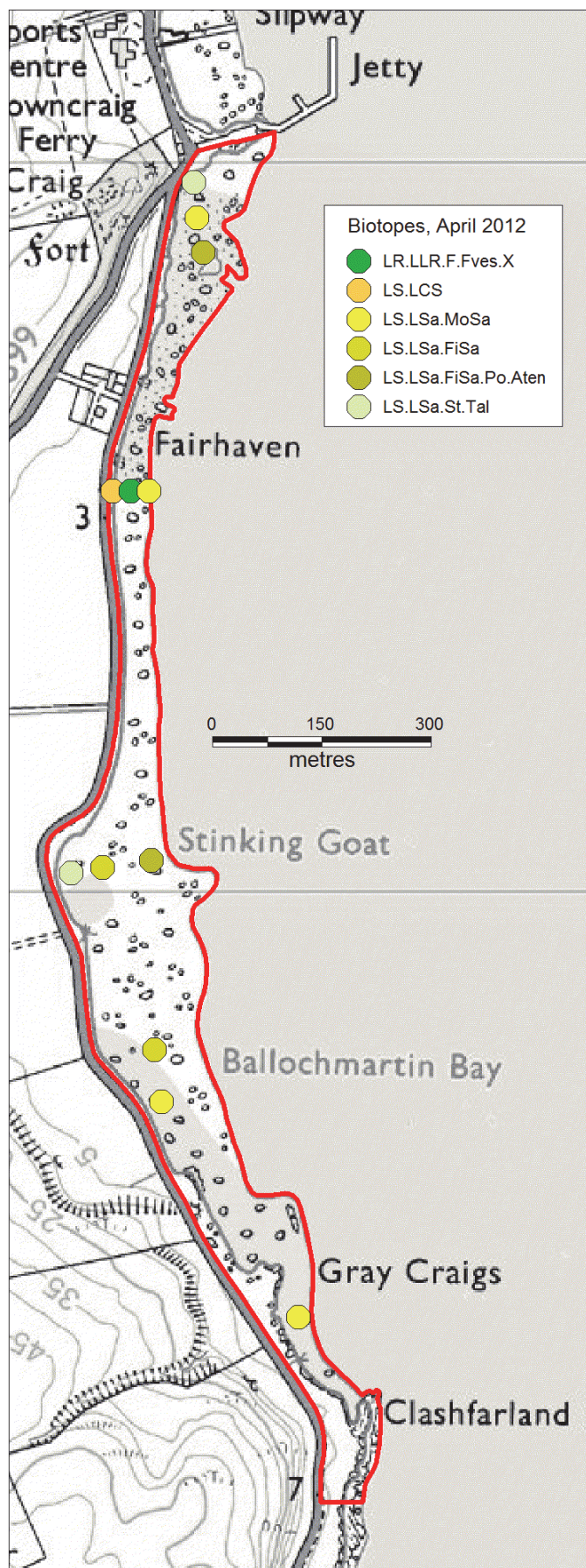


Figure 17. Distribution of intertidal biotopes in Ballochmartin Bay, April 2012. (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

4.3 Bogside Flats

Surveys of stations in Bogside Flats SSSI were carried out during low spring tides on the 21st and 22nd April 2012. Figure 18 shows the locations and numbers of the survey stations visited. Of the 15 stations on the planned grid 1 (BB08) was not surveyed because it was covered by the tide at low water. Three additional stations were added (BB11-13) to represent areas of sediment and habitats that had not been covered.

4.3.1 Biotopes and species

Tables 11a, b, c and d summarise the data collected. The full data is tabulated in Appendices A3, A4, A5, A6 and A7.

Biotopes from the national classification of marine biotopes (Connor et al. 2004) have been assigned to each survey station after close inspection of the detailed physical and biological data collected. Table 10b lists the biotopes and Figure 19 shows their distribution.

Table 11a. Summary data for surveyed stations

No. of stations surveyed	15
No. of <i>in-situ</i> core stations	15
Total No. of epibiota species	13
Total No. of <i>in-situ</i> core species	11
No. of biotope types	7

Table 11b. Biotope types at surveyed stations, based on classification of Connor et al. 2004.

Biotope code	Stns	Biotope name
LR.LLR.FVS.Fcer	1	<i>Fucus ceranoides</i> on reduced salinity eulittoral rock
LS.LBR.LMus.Myt.Mx	1	<i>Mytilus edulis</i> beds on littoral mixed substrata
LS.LMu.MEst.HedMacScr	2	<i>Hediste diversicolor</i> , <i>Macoma balthica</i> and <i>Scrobicularia plana</i> in littoral sandy mud shores
LS.LMu.UEst.Hed	4	<i>Hediste diversicolor</i> in littoral mud
LS.LSa.MuSa	8	Polychaete / bivalve dominated muddy sand shores

Table 11c. Conspicuous epibiota (most frequently recorded species only) recorded in-situ from surface of substrata. Survey methods: Presence (P), density (M) or percentage cover (%) estimated over 5 m radius. Stns = No. of stations (out of 15) in which taxon was recorded. Full data in Appendix A4.

Name	Method	Stns
<i>Arenicola marina</i> (casts)	M	3
<i>Corophium</i>	P	7
<i>Littorina littorea</i>	P	3
<i>Fucus ceranoides</i>	%	12
<i>Fucus vesiculosus</i>	%	4
<i>Ulva</i>	%	7

Table 11d. Species / taxa recorded in-situ from sieved core samples (most frequently recorded species only). Stns = No. of stations (out of 15) in which taxon was recorded. Full data in Appendix A5.

Name	Stns
<i>Hediste diversicolor</i>	12
Spionidae	9
<i>Corophium</i>	12

4.3.2 Habitats and species of conservation importance

Blue mussel beds - recorded at one station, but in fairly low abundance.

Intertidal mudflats – LS.LMu biotopes, characterised by *Hediste diversicolor* and *Corophium* spp., were recorded from 6 stations and dominated much of the upper and middle estuary. The biotopes that comprise much of the lower estuary were predominantly muddy sands (LS.LSa.MuSa). The latter may be described as mudflats for the purposes of the SAC, but are not mudflats within the definitions of Priority Marine Features or Biodiversity Action Plan habitats.

No other Priority Marine Features, Biodiversity Action Plan habitats, BAP species or other rare species recorded.

4.3.3 Impacts and activities noted during the survey

- Bogside Flats is surprisingly isolated from the general public. This isolation is brought about by both the natural morphology of the estuary complex, the Garnock and Irvine rivers and the location and type of land use that surround it, the golf course and the explosives factories both acting to reduce public access.
- The estuary complex naturally catches a considerable amount of driftwood and flotsam originating both from the sea and via the two rivers. There is consequently a considerable amount of stranded litter lining the shoreline and strandlines up to 20m wide were encountered particularly on the Garnock.
- There is obviously a major problem with fly tipping into both the rivers upstream. For example at least 5 computer screens were noted in the strandlines during the survey, along with a similar number of Wheelie Bins and propane gas cylinders.
- The mudflats in the lower estuaries are 'fished' for 'peeler crabs' in several places and some bait digging occurs there as well.
- The uppershore flats are also constantly impacted by trail bikers, who frequently ride all over the site when the tide is out and use the disused railway bridge over the Garnock that links the western and eastern sides of the site. Several sets of bikers were encountered during the survey.
- However outside human recreation hours, the site is obviously also well used by wildlife. Roe deer were seen during the survey and many fox and otter tracks were also noted criss-crossing the Garnock Estuary.

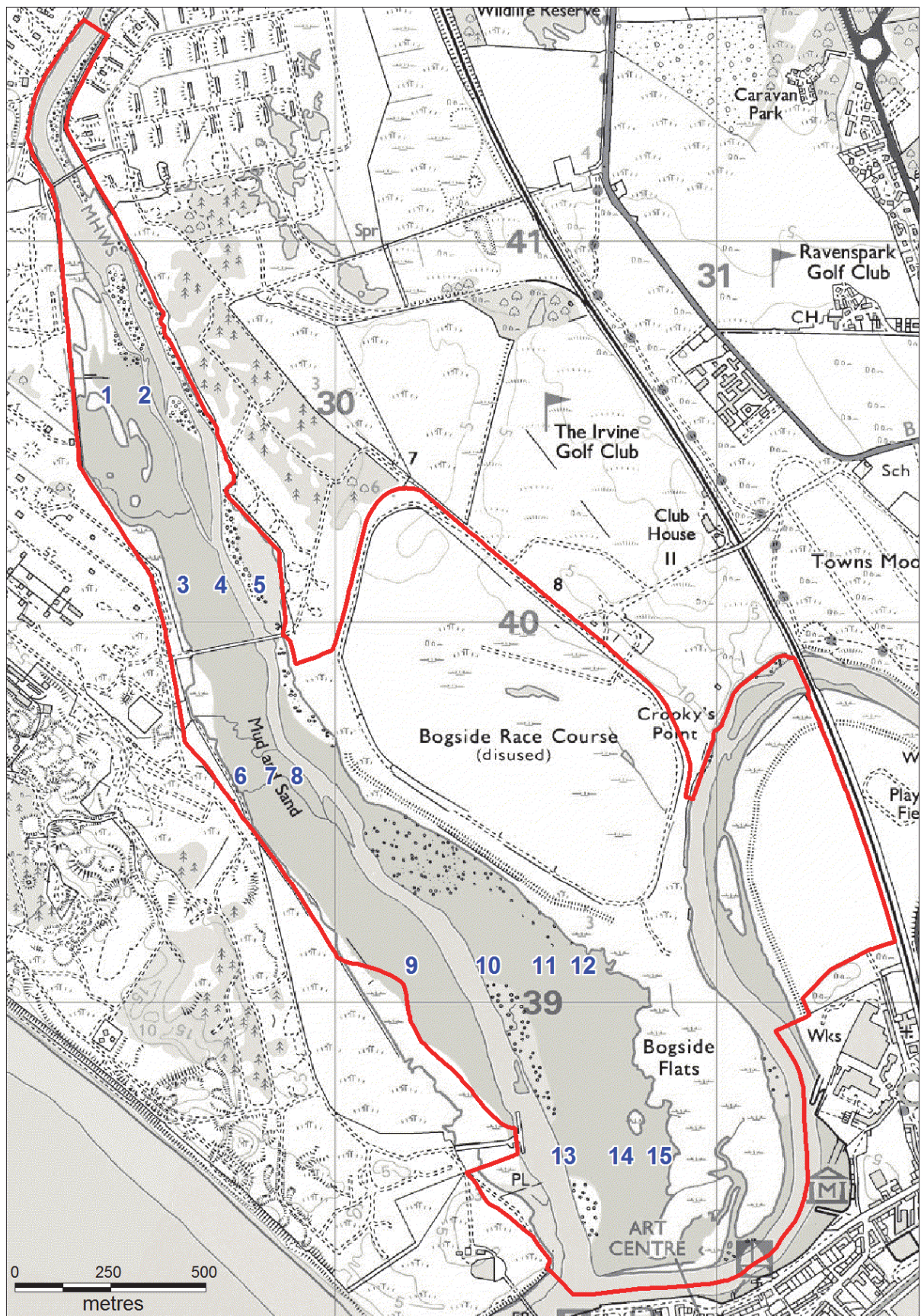


Figure 18. Survey stations in Bogside Flats SSSI (For location map see Figure 6). (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

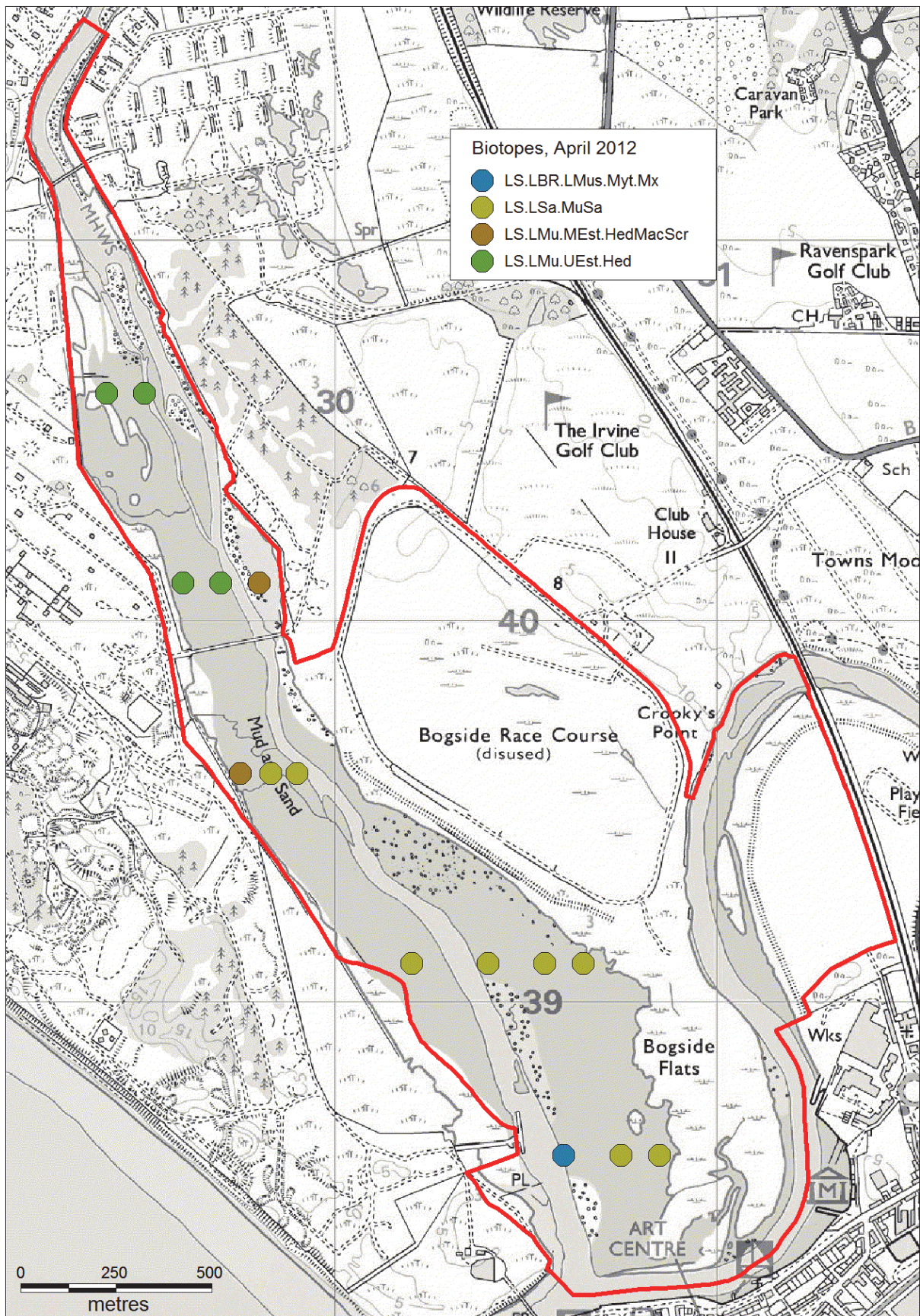


Figure 19. Distribution of intertidal biotopes in Bogside Flats, April 2012. (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

Cree Estuary

Surveys of stations in Cree Estuary SSSI were carried out during low spring tides on the 3rd to 6th May 2012. Figure 20 shows the locations and numbers of the survey stations visited. Of the 65 stations on the planned grid 3 (CE44, 50 & 59) were not surveyed because they were either in the saltmarsh or underwater at low tide. One other station was not cored because the substrata consisted of heavy clay.

4.3.4 Biotopes and species

Tables 12a, b, c and d summarise the data collected. The full data is tabulated in Appendices A3, A4, A5, A6 and A7.

Biotopes from the national classification of marine biotopes (Connor *et al.*, 2004) have been assigned to each survey station after close inspection of the detailed physical and biological data collected. Table 10b lists the biotopes and Figure 21 shows their distribution.

Table 12a. Summary data for surveyed stations

No. of stations surveyed	62
No. of <i>in-situ</i> core stations	61
Total No. of epibiota species	22
Total No. of <i>in-situ</i> core species	17
No. of biotope types	12

Table 12b. Biotope types at surveyed stations, based on classification of Connor et al. 2004.

Biotope code	Stns	Biotope name
LS.LSa.FiSa.Po	1	Polychaetes in littoral fine sand
LS.LSa.MoSa.Ol	3	Oligochaetes in littoral mobile sand
LS.LSa.MuSa	10	Polychaete / bivalve dominated muddy sand shores
LS.LSa.MuSa.CerPo	19	<i>Cerastoderma edule</i> and polychaetes in littoral muddy sand
LS.LSa.MuSa.HedMacEte	2	<i>Hediste diversicolor</i> , <i>Macoma balthica</i> and <i>Eteone longa</i> in littoral muddy sand
LS.LSa.MuSa.Lan	1	<i>Lanice conchilega</i> in littoral sand
LS.LSa.MuSa.MacAre	15	<i>Macoma balthica</i> and <i>Arenicola marina</i> in littoral muddy sand
LS.LMu	1	Littoral mud
LS.LMu.MEst.HedMacScr	9	<i>Hediste diversicolor</i> , <i>Macoma balthica</i> and <i>Scrobicularia plana</i> in littoral sandy mud shores
LS.LMu.UEst.Hed	1	<i>Hediste diversicolor</i> in littoral mud
LS.LMx	2	Littoral mixed sediment

Table 12c. Conspicuous epibiota (most frequently recorded species only) recorded in-situ from surface of substrata. Survey methods: Presence (P), density (M), SACFOR abundance (A) or percentage cover (%) estimated over 5 m radius. Stns = No. of stations (out of 62) in which taxon was recorded. Full data in Appendix A4.

Name	Method	Stns
<i>Hediste diversicolor</i>	M	7
Spionidae (tubes)	A	33
<i>Arenicola marina</i> (casts)	M	36
Corophium	A	8
<i>Crangon</i>	P	4
<i>Carcinus maenas</i>	P	8
<i>Littorina littorea</i>	P	4
<i>Peringia ulvae</i>	M	32
<i>Cerastoderma edule</i> (adults >20mm)	M	14
<i>Cerastoderma edule</i> (juvs <20mm)	M	13
<i>Macoma balthica</i>	P	4
<i>Scrobicularia plana</i> (marks)	M	9
<i>Mya arenaria</i>	M	3
<i>Ulva</i>	%	24
<i>Zostera</i> (<i>Zosterella</i>) <i>noltei</i>	%	11

Table 12d. Species / taxa recorded in-situ from sieved core samples (most frequently recorded species only). Stns = No. of stations (out of 61) in which taxon was recorded. Full data in Appendix A5.

Name	Stns
Polychaeta	6
<i>Hediste diversicolor</i>	8
Nephtys	4
Spionidae (tubes)	41
Corophium	4
<i>Peringia ulvae</i>	16
<i>Cerastoderma edule</i> (juvs <20mm)	10
<i>Cerastoderma edule</i> (adults >20mm)	6
<i>Angulus tenuis</i>	3
<i>Macoma balthica</i>	12
<i>Scrobicularia plana</i> (juvs)	4
<i>Scrobicularia plana</i>	3

4.3.5 Habitats and species of conservation importance

Intertidal mudflats – LS.LMu biotopes, characterised by *Scrobicularia plana*, *Mya arenaria*, *Peringia ulvae* (old name *Hydrobia ulvae*), *Hediste diversicolor* and *Corophium* spp., were recorded from 10 stations and dominated much of the upper intertidal of Wigtown Bay. The biotopes that comprise much of the rest of the Bay were predominantly muddy sands (LS.LSa.MuSa). The latter may be described as mudflats for the purposes of the SAC, but are not mudflats within the definitions of Priority Marine Features or Biodiversity Action Plan habitats.

Seagrass beds - *Zostera noltei* was recorded in a few stations but not in high enough abundance to be considered as a bed.

No other Priority Marine Features, Biodiversity Action Plan habitats, BAP species or other rare species recorded.

4.3.6 Impacts and activities noted during the survey

- Walkers and minor beach recreation activities occurring at a very low levels on the Cree estuary, due to the remote location and poor access to much of the estuary

from the surrounding farmland. Most activity was seen originating from the Crook of Baldoon Reserve car park and the Innerwell Port access road. There is very poor access from Wigtown and the sediments here are very soft and treacherous.

- Little boating activity occurs in the vicinity due to the shallow nature of the bay and estuary and the constantly shifting channels.
- Fish traps line the shores of the Cree on both sides of the main estuary. Most of these are disused and falling down.
- Patches of cobbles with what appeared to be building waste were noted south of the old jetty for Fell Quarries (OS Grid Ref: NX 47388 55301) but this area was not extensive.
- Rip-rap sea defences were in place in several areas of the River Cree north of Creetown to prevent erosion of the land behind but are creating steep eroded and current washed river banks.
- Heavy trampling by livestock (including cattle) was noticed on the saltmarsh at the Crook of Baldoon and cowpats were present on the saltmarsh and in salt pans causing eutrophication.

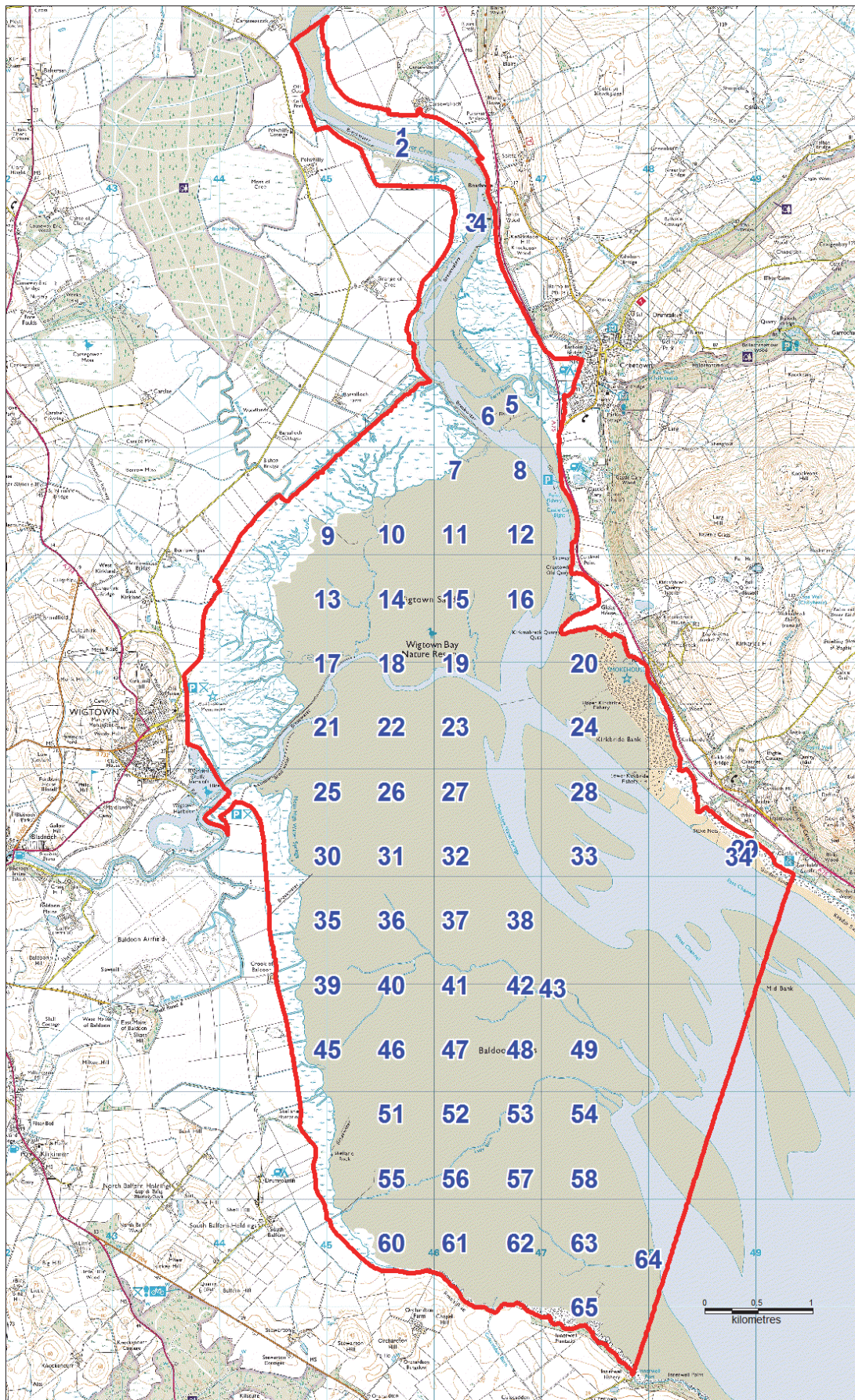


Figure 20. Survey stations in Cree Estuary SSSI (For location map see Figure 7). (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

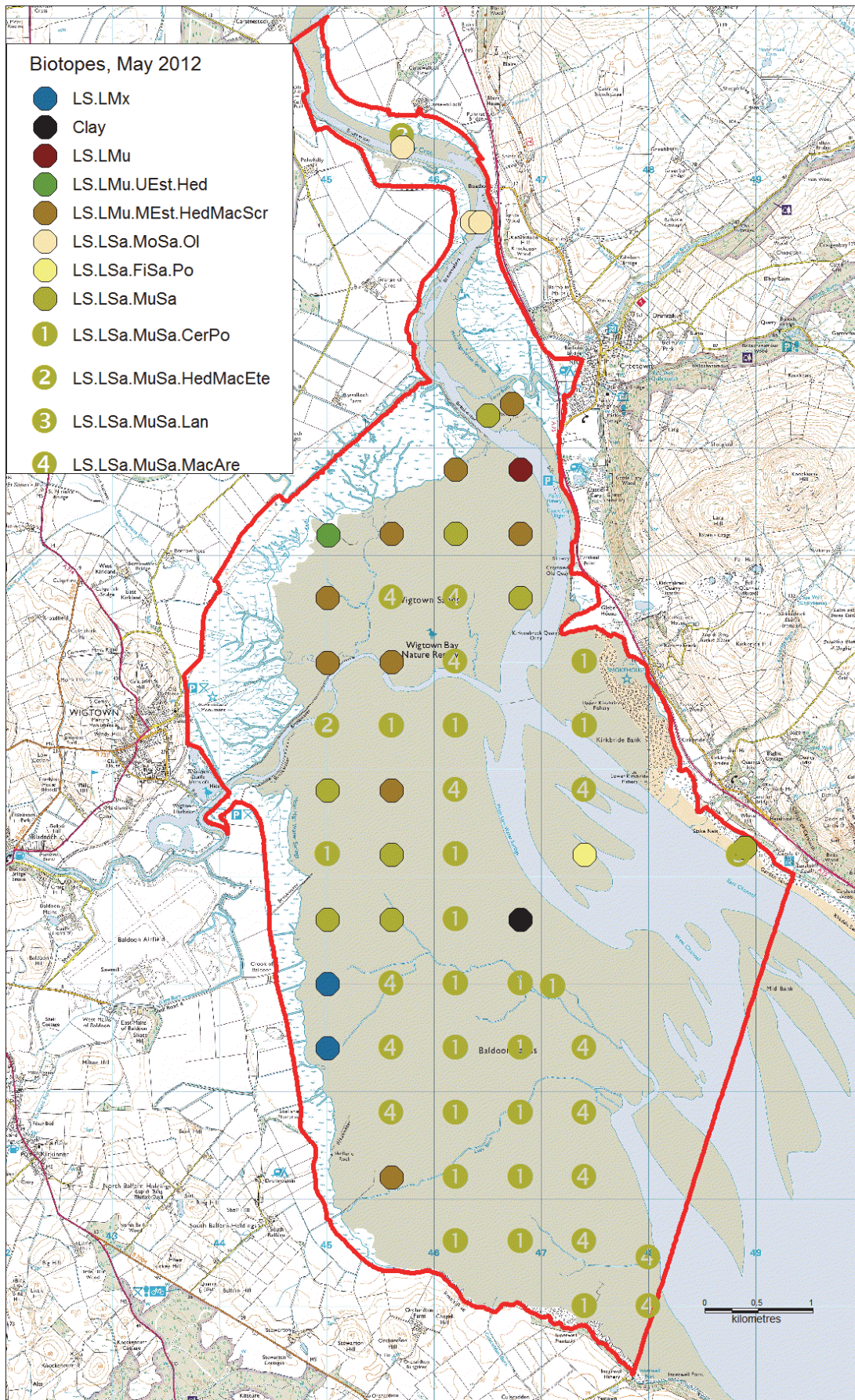


Figure 21. Distribution of intertidal biotopes in Cree Estuary, May 2012. (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

4.4 Ulva, Danna and the McCormaig Isles

Surveys of stations in UDMI SSSI (including An Grianan lagoon) were carried out during low spring tides on the 8th to 10th May 2012. Figure 22 shows the locations and numbers of the survey stations visited. A variety of survey methods were used in An Grianan lagoon (see methodologies in Section 3.5), so the data are tabulated separately from those of the UDMI main site.

Three sediment stations (2, 11 and 29) from UDMI main site were also sampled for laboratory analysis, using the methodologies described in Section 3.4. Five core samples were taken from each of these three stations followed by detailed analysis of the fauna and sediment granulometry.

4.4.1 Biotopes and species

Tables 13a to 13i summarise the data collected. The full data is tabulated in Appendices A3, A4, A5, A6 and A7. Biotopes from the national classification of marine biotopes (Connor et al. 2004) have been assigned to each survey station after close inspection of the detailed physical and biological data collected. Table 10b lists the biotopes and Figure 23 shows their distribution.

Table 13a. Summary data for surveyed stations

	Main site	Lagoon
No. of stations surveyed	35	13
No. of <i>in-situ</i> scrape stations	23	11
Total No. of epibiota species	43	43
Total No. of <i>in-situ</i> scrape species	17	4
No. of biotope types	15	2

Table 13b. Biotope types at surveyed stations, based on classification of Connor et al. 2004.

Biotope code	Stns	Biotope name
Main site		
LR.FLR.Lic	1	Lichens or small green algae on supralittoral and littoral fringe rock
LR.LLR.FVS.PeIVS	2	<i>Pelvetia canaliculata</i> on sheltered variable salinity littoral fringe rock
LR.LLR.FVS.FspiVS	1	<i>Fucus spiralis</i> on sheltered variable salinity upper eulittoral rock
LR.HLR.FT.AscT	1	<i>Ascophyllum nodosum</i> , sponges and ascidians on tide-swept mid eulittoral rock
LR.HLR.FT.FserT	1	<i>Fucus serratus</i> , sponges and ascidians on tide-swept lower eulittoral rock
LS.LBR.LMus.Myt.Mx	1	<i>Mytilus edulis</i> beds on littoral mixed substrata
LS.LMx	6	Littoral mixed sediment
LS.LMx.Mx.CirCer	1	Cirratulids and <i>Cerastoderma edule</i> in littoral mixed sediment
LS.LSa.FiSa	1	Polychaete / amphipod dominated fine sand shores
LS.LSa.MuSa	5	Polychaete / bivalve dominated muddy sand shores
LS.LSa.MuSa.CerPo	3	<i>Cerastoderma edule</i> and polychaetes in littoral muddy sand
LS.LSa.MuSa.HedMacEte	2	<i>Hediste diversicolor</i> , <i>Macoma balthica</i> and <i>Eteone longa</i> in littoral muddy sand
LS.LSa.MuSa.MacAre	9	<i>Macoma balthica</i> and <i>Arenicola marina</i> in littoral muddy sand
LS.LMp.Sm	1	Saltmarsh
SS.SSa.SSaLS	1	Sublittoral sand in low or reduced salinity (lagoons)
An Grianan lagoon		
SS.SSa.SSaLS	11	Sublittoral sand in low or reduced salinity (lagoons)
SS.SMP.SSgr	7	Sublittoral seagrass beds
IR.LIR.IFaVS.MytRS	1	<i>Mytilus edulis</i> beds on reduced salinity tide-swept infralittoral rock

Table 13c. Conspicuous epibiota (most frequently recorded species only) recorded in-situ from surface of substrata. Survey methods: Presence (P), density (M), SACFOR abundance (A) or percentage cover (%) estimated over 5 m radius. Stns = No. of stations (out of 35) in which taxon was recorded. Full data in Appendix A4.

Name	Main site		Lagoon	
	Method	Stns	Method	Stns
<i>Hediste diversicolor</i>	M	7		
Spionidae (tubes)	A	15	P	3
<i>Arenicola marina</i> (casts)	M	33	P/M	8
<i>Lanice conchilega</i>	M	6		
Spirobranchus	P	5		
<i>Semibalanus balanoides</i>	P	5		
Mysidae	P	1	P	5
Corophium	P	7		
Idotea			P	6
<i>Carcinus maenas</i>			P	3
<i>Littorina littorea</i>	M	4		
<i>Peringia ulvae</i>	A	8		
<i>Mytilus edulis</i>	P	6	P	8
<i>Cerastoderma edule</i> (adults >20mm)	M	10		
<i>Cerastoderma glaucum</i>			P/M	7
<i>Scrobicularia plana</i> (marks)	A	6		
Chironomidae			P	7
<i>Chondrus crispus</i>			P	9
<i>Ascophyllum nodosum</i>	%	4		
<i>Fucus serratus</i>	P	1	P	3
<i>Fucus vesiculosus</i>	P	5		
<i>Pelvetia canaliculata</i>	P	3		
<i>Ulva intestinalis</i>	P	1	P	4
<i>Zostera</i> (<i>Zosterella</i>) <i> noltei</i>	%	1	P	5
Saltmarsh	P	3		

Table 13d. Species / taxa recorded in-situ from sieved core samples (most frequently recorded species only) at UDMI (main site) stations. Cores = No. of core samples (out of 35) in which taxon was recorded. Full data in Appendix A5.

Name	Cores
Polychaeta	21
Nephtys	9
Spionidae (tubes)	12
<i>Notomastus latericeus</i>	5
<i>Arenicola marina</i>	3
Corophium	8
<i>Peringia ulvae</i>	5
<i>Cerastoderma edule</i> (juvs <20mm)	3
<i>Cerastoderma edule</i> (adults >20mm)	3
<i>Scrobicularia plana</i> (juvs)	5
<i>Scrobicularia plana</i>	5

Table 13e. Bivalves recorded in-situ in An Grianan lagoon stations. Abundances are counts per m².

Name	Station			
	1	4	5	6
<i>Cerastoderma glaucum</i> (juvs.)	4	24	124	72
<i>Cerastoderma glaucum</i> (adults)		12	8	8
<i>Macoma balthica</i>			4	

Table 13f. Abundance of selected species recorded in-situ at stations along a transect in An Grianan lagoon. Abundances are counts per m². Full data in Appendix A5.

Name	Distance along transect (m)					
	0	50	100	150	200	242
<i>Cerastoderma glaucum</i>	134	197	90	45	102	38
<i>Zostera noltei</i> shoots	363	96	239	369	38	140
<i>Arenicola marina</i>	32	40	28	52	60	80

Table 13g. Species / taxa recorded from laboratory analysed core samples (most frequently recorded species only), UDML main site. Cores = No. of core samples (out of 15) in which taxon was recorded. Abundances in Station columns are No. per m² (calculated from 5 x 0.01m² cores at each station). Full data in Appendix A6.

Name	Cores	Station		
		2	11	29
Nematoda	5	1040	0	0
<i>Exogone</i> (<i>Exogone</i>) <i>naidina</i>	4	0	140	0
<i>Nephtys hombergii</i>	6	0	40	120
<i>Scoloplos</i> (<i>Scoloplos</i>) <i>armiger</i>	8	0	160	80
<i>Scolecopsis fuliginosa</i>	3	140	0	0
<i>Dipolydora quadrilobata</i>	3	0	120	0
<i>Pygospio elegans</i>	14	1660	360	80
<i>Capitella capitata</i>	6	140	60	0
<i>Heteromastus filiformis</i>	5	0	80	20
<i>Mediomastus fragilis</i>	3	0	60	20
<i>Notomastus</i>	5	0	260	0
<i>Arenicola marina</i>	3	140	0	0
<i>Fabricia stellaris</i>	6	2160	20	0
<i>Tubificoides benedii</i>	7	40	260	0
<i>Tubificoides pseudogaster</i> (agg.)	6	2800	20	0
Enchytraeidae	5	640	0	0
<i>Corophium volutator</i>	6	3080	0	20
<i>Peringia ulvae</i>	5	740	0	0
<i>Macoma balthica</i>	3	80	0	0
<i>Scrobicularia plana</i>	4	140	0	0

Table 13h. Sediment granulometry and organic matter content from laboratory analysed samples of sediment from UDML main site stations. All values are percentages of the total dry weight. LOI = Loss on ignition.

Sediment category	Size range	Station		
		2	11	29
Medium pebble (gravel)	> 8 mm	0	23.73	0
Small pebble (gravel)	4-8 mm	0	17.62	0
Granule	2-4 mm	0.08	7.20	0
Sand - very coarse	1-2000 µm	0.43	6.83	0.07
Sand - coarse	500-1000 µm	3.58	4.08	0.76
Sand - medium	250-500 µm	20.35	10.33	4.38
Sand - fine	125-250 µm	58.61	27.71	22.30
Sand - very fine	63-125 µm	14.23	1.69	48.50
Silt & Clay	< 63 µm	2.71	0.82	23.99
% Organic Matter (by LOI)		0.76	0.95	1.95

Table 13i. Species / taxa recorded from laboratory analysed samples (all species), collected from stations in An Grianan lagoon. Values are counts of each taxon in individual (non-quantitative) scrapes.

Name	Station			
	1	4	5	6
Nemertea	2	1	1	3
Nematoda	1	3	2	3
<i>Scoloplos (Scoloplos) armiger</i>	16	16	1	12
<i>Scolecopsis fuliginosa</i>			3	
<i>Pygospio elegans</i>	12		14	
<i>Capitella capitata</i>	1		1	
<i>Tubificoides benedii</i>	6	2	150	3
<i>Tubificoides pseudogaster</i>	3			
Corophium				1
<i>Neomysis integer</i>				1
<i>Idotea chelipes</i>	1	3		1
<i>Cylichna cylindracea</i>		1		
<i>Peringia ulvae</i>	3		1	
<i>Macoma balthica</i>		1		
<i>Cerastoderma glaucum</i>	1	5	4	
<i>Abra tenuis</i>	1			
Chironomidae	103	612	3	101

4.4.2 Habitats and species of conservation importance

Saline lagoon – An Grianan lagoon.

Blue mussel beds - recorded at two stations - fairly patchy clumps on mixed sediment and in the outflow to the lagoon. Likely present in many other locations within the SSSI, but the survey was not designed to adequately describe the distribution of this habitat.

Seagrass beds - *Zostera noltei* was widespread in the lagoon and abundant in places. As the survey was carried out early in the growing season, it is likely that it would be even more prominent in the summer. However, it was recorded as a sub-biotope of the main SS.SSa.SSaLS biotope. It was also recorded in a few stations elsewhere in the SSSI, but not in high enough abundance to be considered as a bed.

Tide-swept algal communities – tide-swept *Ascophyllum nodosum* and *Fucus serratus* recorded from one location. Likely present in many other locations within the SSSI, but the survey was not designed to adequately describe the distribution of this habitat.

Native oysters - *Ostrea edulis* were recorded.

No other Priority Marine Features, Biodiversity Action Plan habitats, BAP species or other rare species recorded.

4.4.3 Impacts and activities noted during the survey

- Trampling by cattle was noted on the saltmarshes fringing the An Grianan lagoon together with cowpats which would be a source of eutrophication.
- The man-made dam between An Grianan lagoon and Linne Mhuirich was in disrepair. If it were to be washed away it would seriously affect the integrity of the lagoon.

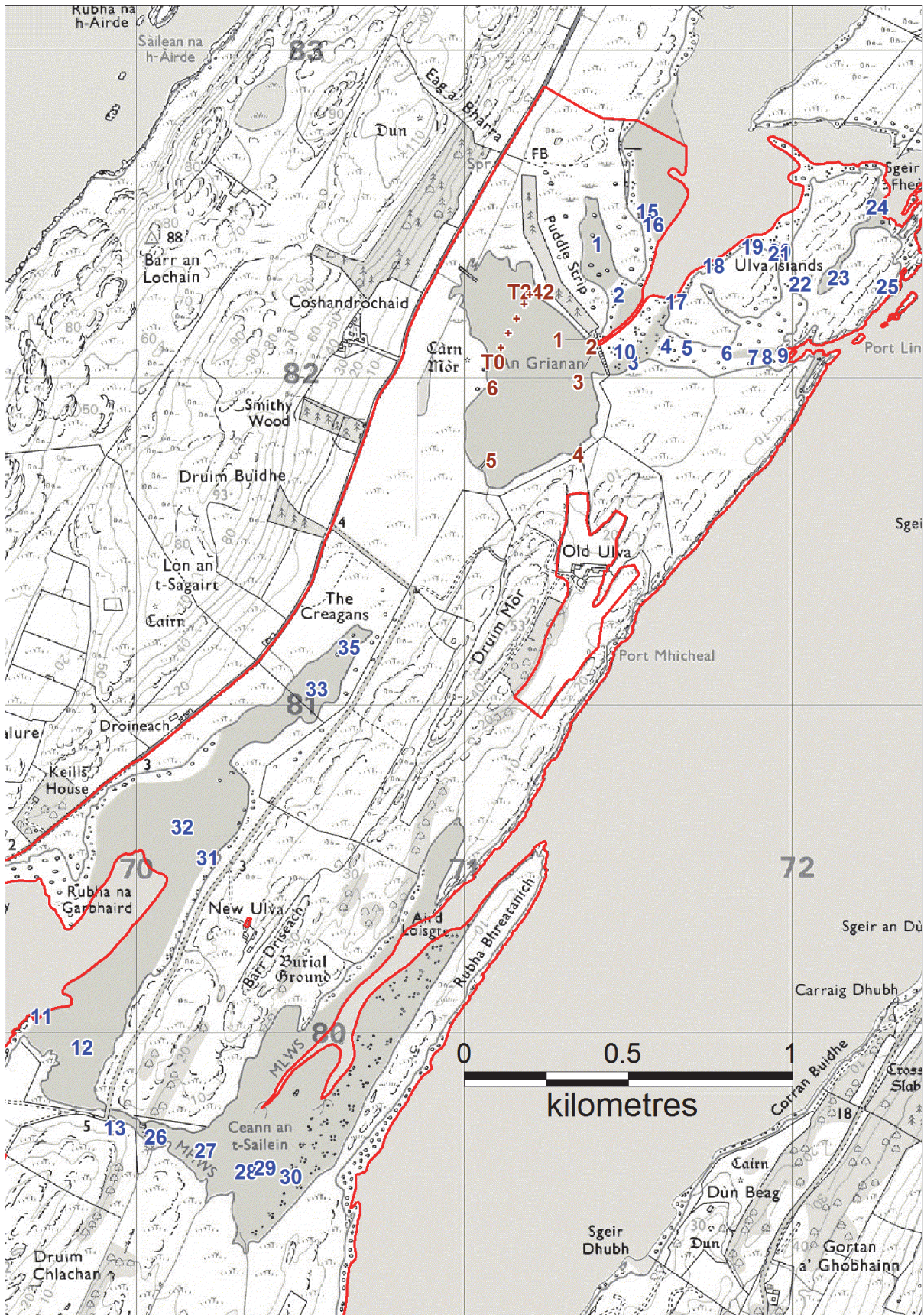


Figure 22. Survey stations in UDMI SSSI (including An Grianan lagoon) (For location map see Figure 10). (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

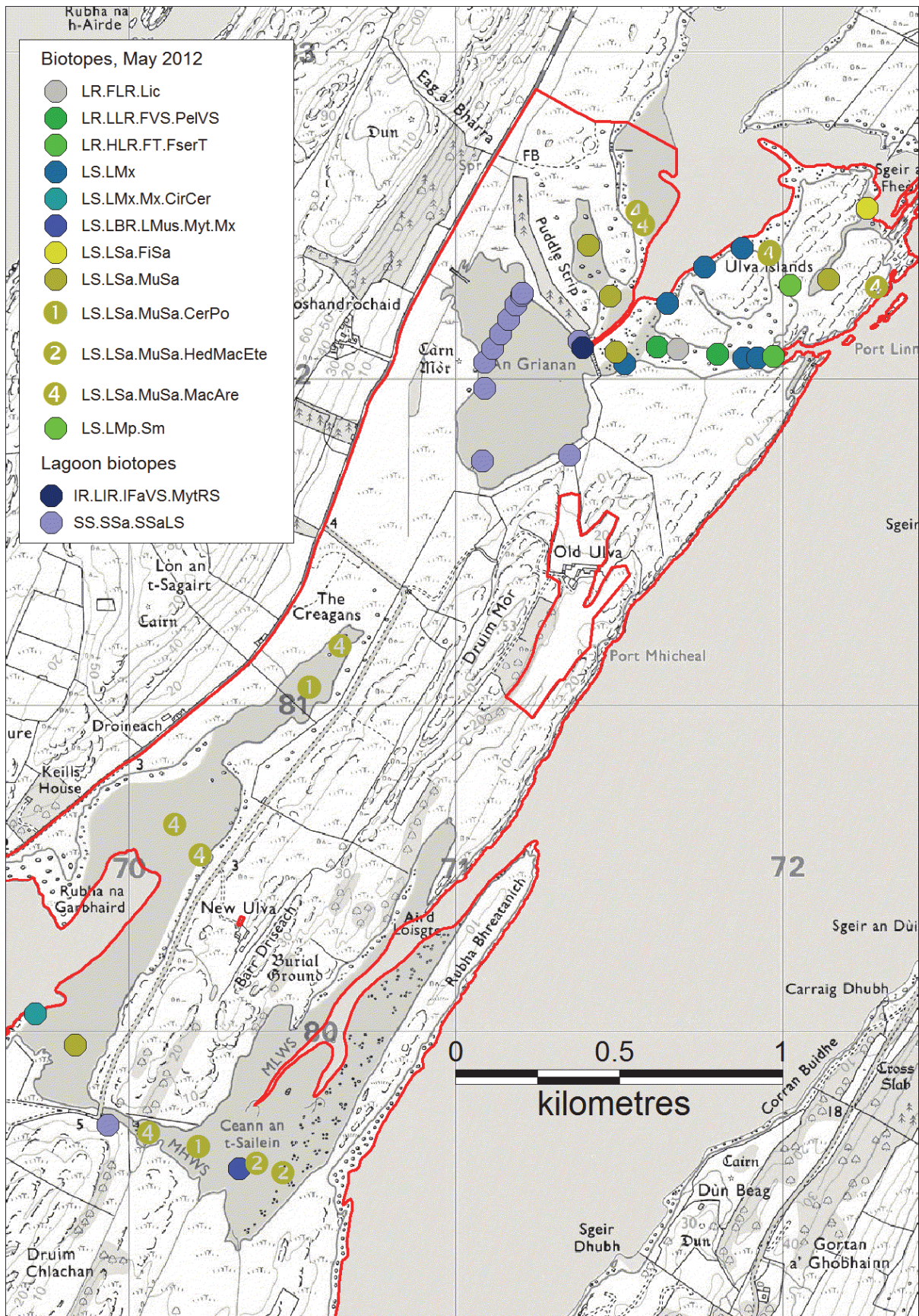


Figure 23. Distribution of intertidal biotopes in UDMI May 2012. (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

4.5 Tong Saltings

Surveys of stations in Tong Saltings SSSI were carried out during low spring tides on the 3rd to 5th May 2012. Figure 24 shows the locations and numbers of the survey stations visited. Of the 35 stations on the planned grid 2 (TS30 & TS32) were not surveyed because of difficult access. Five additional stations were added (TS36-40) to represent areas of sediment and habitats that had not been covered.

4.5.1 Biotopes and species

Tables 14a, b, c and d summarise the data collected. The full data is tabulated in Appendices A3, A4, A5, A6 and A7.

Biotopes from the national classification of marine biotopes (Connor et al. 2004) have been assigned to each survey station after close inspection of the detailed physical and biological data collected. Table 10b lists the biotopes and Figure 25 shows their distribution.

Table 14a. Summary data for surveyed stations

No. of stations surveyed	40
No. of <i>in-situ</i> core stations	38
Total No. of epibiota species	22
Total No. of <i>in-situ</i> core species	22
No. of biotope types	6

Table 14b. Biotope types at surveyed stations, based on classification of Connor et al. 2004.

Biotope code	Stns	Biotope name
LS.LSa	2	Littoral sand
LS.LSa.FiSa	5	Polychaete / amphipod dominated fine sand shores
LS.LSa.MoSa	1	Barren or amphipod-dominated mobile sand shores
LS.LSa.MoSa.AmSco	6	Amphipods and <i>Scolecopsis</i> spp. in littoral medium-fine sand
LS.LSa.MuSa	18	Polychaete / bivalve dominated muddy sand shores
LS.LMu.MEst.HedMacScr	6	<i>Hediste diversicolor</i> , <i>Macoma balthica</i> and <i>Scrobicularia plana</i> in littoral sandy mud shores

Table 14c. Conspicuous epibiota (most frequently recorded species only) recorded in-situ from surface of substrata. Survey methods: Presence (P), density (M), SACFOR abundance (A) or percentage cover (%) estimated over 5 m radius. Stns = No. of stations (out of 40) in which taxon was recorded. Full data in Appendix A4.

Name	Method	Stns
Spionidae (tubes)	A	18
Arenicola marina (casts)	M	29
Corophium	A	5
Peringia ulvae	A	7
Cerastoderma edule (adults >20mm)	M	8
Cerastoderma edule (juvs <20mm)	M	3
Scrobicularia plana (marks)	M	5
Scrobicularia plana (marks)	P	3
Ectocarpaceae	%	8
Fucus spiralis	%	4
Fucus vesiculosus	%	11
Ulva (tubular)	%	27

Table 14d. Species / taxa recorded in-situ from sieved core samples (most frequently recorded species only). Stns = No. of stations (out of 38) in which taxon was recorded. Full data in Appendix A5.

Name	Stns
<i>Hediste diversicolor</i>	3
Nephtys	4
Spionidae (tubes)	22
<i>Arenicola marina</i>	7
Corophium	3
<i>Peringia ulvae</i>	4
<i>Cerastoderma edule</i> (juvs <20mm)	9
<i>Cerastoderma edule</i> (spat)	8
<i>Cerastoderma edule</i> (adults >20mm)	4
<i>Angulus tenuis</i>	3

4.5.2 Habitats and species of conservation importance

Intertidal mudflats – LS.LMu biotopes, characterised by *Scrobicularia plana*, *Hediste diversicolor* and *Corophium* spp., were recorded from 6 stations and were observed as a narrow band along the upper shore, adjacent to the saltmarsh, around most of the inner bay. The biotopes that comprise much of the rest of the inner bay were predominantly muddy sands (LS.LSa.MuSa). The latter may be described as mudflats for the purposes of the SAC, but are not mudflats within the definitions of Priority Marine Features or Biodiversity Action Plan habitats.

No other Priority Marine Features, Biodiversity Action Plan habitats, BAP species or other rare species recorded

4.5.3 Impacts and activities noted during the survey

- Sewage pipe across shore into channel near station 18, but no obvious sign of discharge
- Some signs and observations of bait collecting
- Hose riding across muddy sand flats
- Fairly newly installed (?<1 year ago) agricultural stock fence, with deeply embedded strong posts, across upper shore and edge of saltings along whole west side of bay. Installation will have resulted in disturbance of the muddy sediments, but there was no obvious sign of that disturbance at the time of the survey.

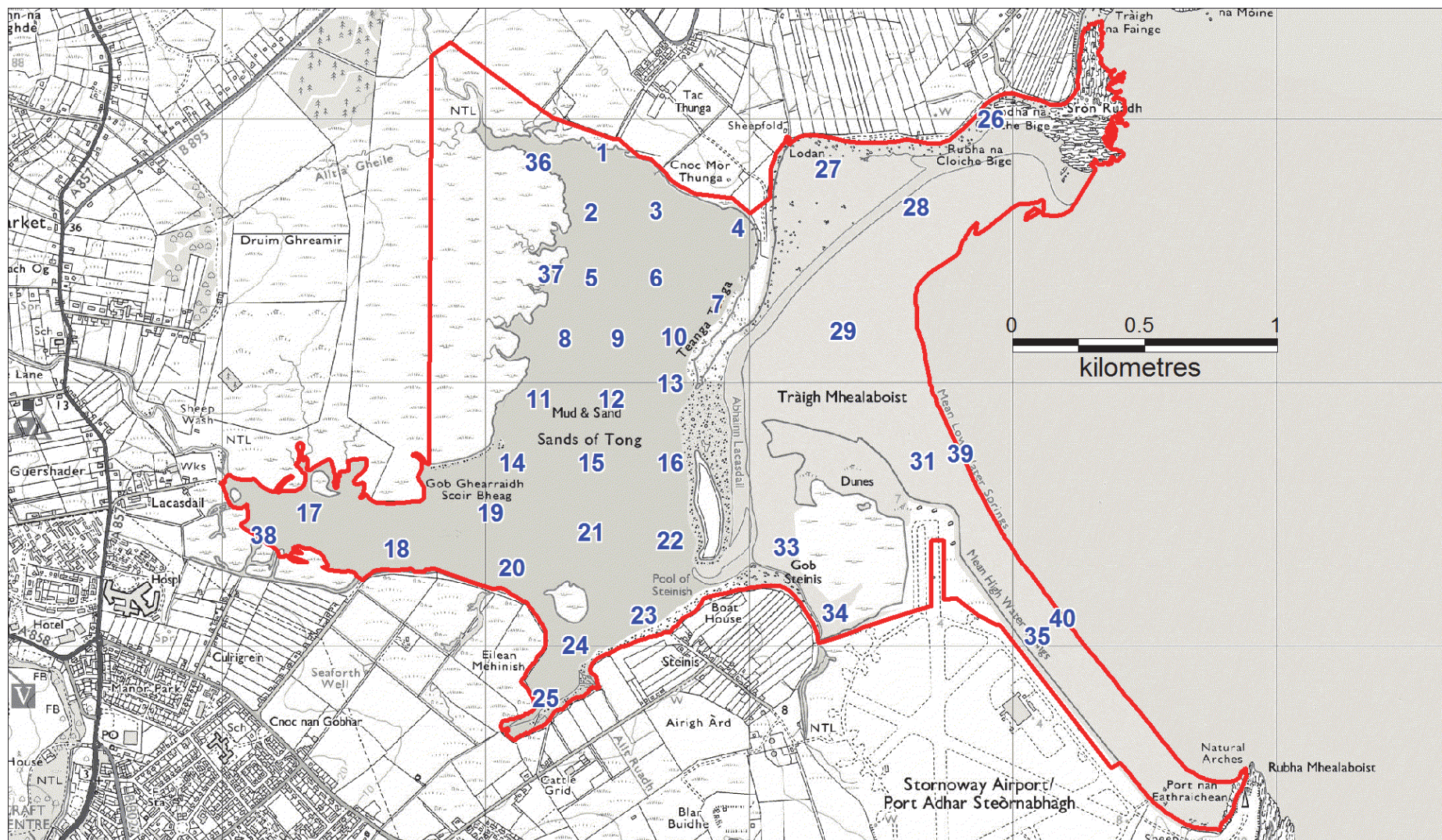


Figure 24. Survey stations in Tong Saltings SSSI (For location map see Figure 11). (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

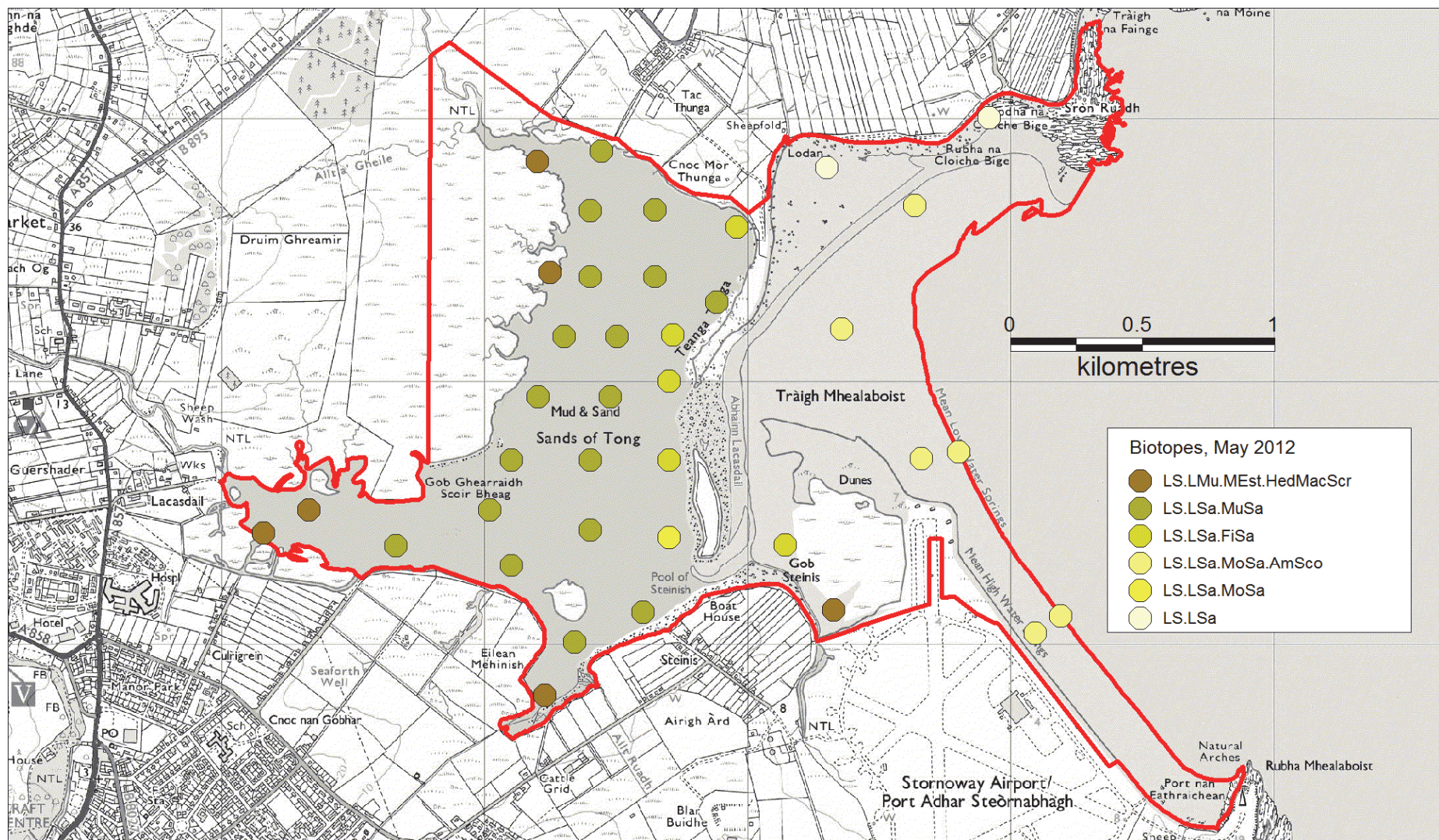


Figure 25. Distribution of intertidal biotopes in Tong Saltings, May 2012. (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

4.6 Luskentyre Banks and Saltings

Surveys of stations in Luskentyre Banks and Saltings SSSI were carried out during low spring tides on the 6th, 7th and 10th May 2012. Figure 26 shows the locations and numbers of the survey stations visited. Of the 46 stations on the planned grid 4 (LB8, 9, 44 and 45) were not surveyed because they were situated above high tide level. Four additional stations were added (LB47-50) to represent areas of sediment and habitats that had not been covered.

4.6.1 Biotopes and species

Tables 15a, b, c and d summarise the data collected. The full data is tabulated in Appendices A3, A4, A5, A6 and A7.

Biotopes from the national classification of marine biotopes (Connor et al. 2004) have been assigned to each survey station after close inspection of the detailed physical and biological data collected. Table 10b lists the biotopes and Figure 27 shows their distribution.

Table 15a. Summary data for surveyed stations

No. of stations surveyed	50
No. of <i>in-situ</i> core stations	46
Total No. of epibiota species	18
Total No. of <i>in-situ</i> core species	24
No. of biotope types	5

Table 15b. Biotope types at surveyed stations, based on classification of Connor et al. 2004.

Biotope code	Stns	Biotope name
LS.LSa.St.Tal	5	Talitrids on the upper shore and strand-line
LS.LSa.FiSa	12	Polychaete / amphipod dominated fine sand shores
LS.LSa.MoSa.AmSco	15	Amphipods and <i>Scolecopsis</i> spp. in littoral medium-fine sand
LS.LSa.MuSa	12	Polychaete / bivalve dominated muddy sand shores
LS.LMu.MEst.HedMacScr	2	<i>Hediste diversicolor</i> , <i>Macoma balthica</i> and <i>Scrobicularia plana</i> in littoral sandy mud shores

Table 15c. Conspicuous epibiota (most frequently recorded species only) recorded in-situ from surface of substrata. Survey methods: Presence (P), density (M), SACFOR abundance (A) or percentage cover (%) estimated over 5 m radius. Stns = No. of stations (out of 50) in which taxon was recorded. Full data in Appendix A4.

Name	Method	Stns
Spionidae (tubes)	A	12
<i>Arenicola marina</i> (casts)	M	21
<i>Carcinus maenas</i>	P	3
<i>Peringia ulvae</i>	A	7
<i>Cerastoderma edule</i> (adults >20mm)	A	10
<i>Cerastoderma edule</i> (juvs <20mm)	A	8
<i>Scrobicularia plana</i> (marks)	P	4
<i>Ulva</i> (tubular)	%	11

Table 15d. Species / taxa recorded in-situ from sieved core samples (most frequently recorded species only). Stns = No. of stations (out of 46) in which taxon was recorded. Full data in Appendix A5.

Name	Stns
<i>Hediste diversicolor</i>	3
<i>Nephtys</i>	3
Spionidae (tubes)	10
<i>Pygospio elegans</i>	3
<i>Scolelepis squamata</i>	4
<i>Bathyporeia pilosa</i>	6
<i>Peringia ulvae</i>	3
<i>Cerastoderma edule</i> (spat)	7
<i>Cerastoderma edule</i> (adults >20mm)	4
<i>Cerastoderma edule</i> (juvs <20mm)	3
<i>Angulus tenuis</i> (juvs)	7
<i>Angulus tenuis</i>	3
<i>Scrobicularia plana</i>	3

4.6.2 Habitats and species of conservation importance

Intertidal mudflats – LS.LMu biotopes, characterised by *Scrobicularia plana*, were recorded from 2 stations and were observed to extend up into both creeks on the south side of the inlet.

No other Priority Marine Features, Biodiversity Action Plan habitats, BAP species or other rare species recorded

4.6.3 Impacts and activities noted during the survey

- Sewage pipe (?disused) across sandflats, ending near station 22, but no obvious sign of discharge
- Commercial cockle picking – observed on one day
- Recreation – dog walking and some beach users (particularly at Horgabost)

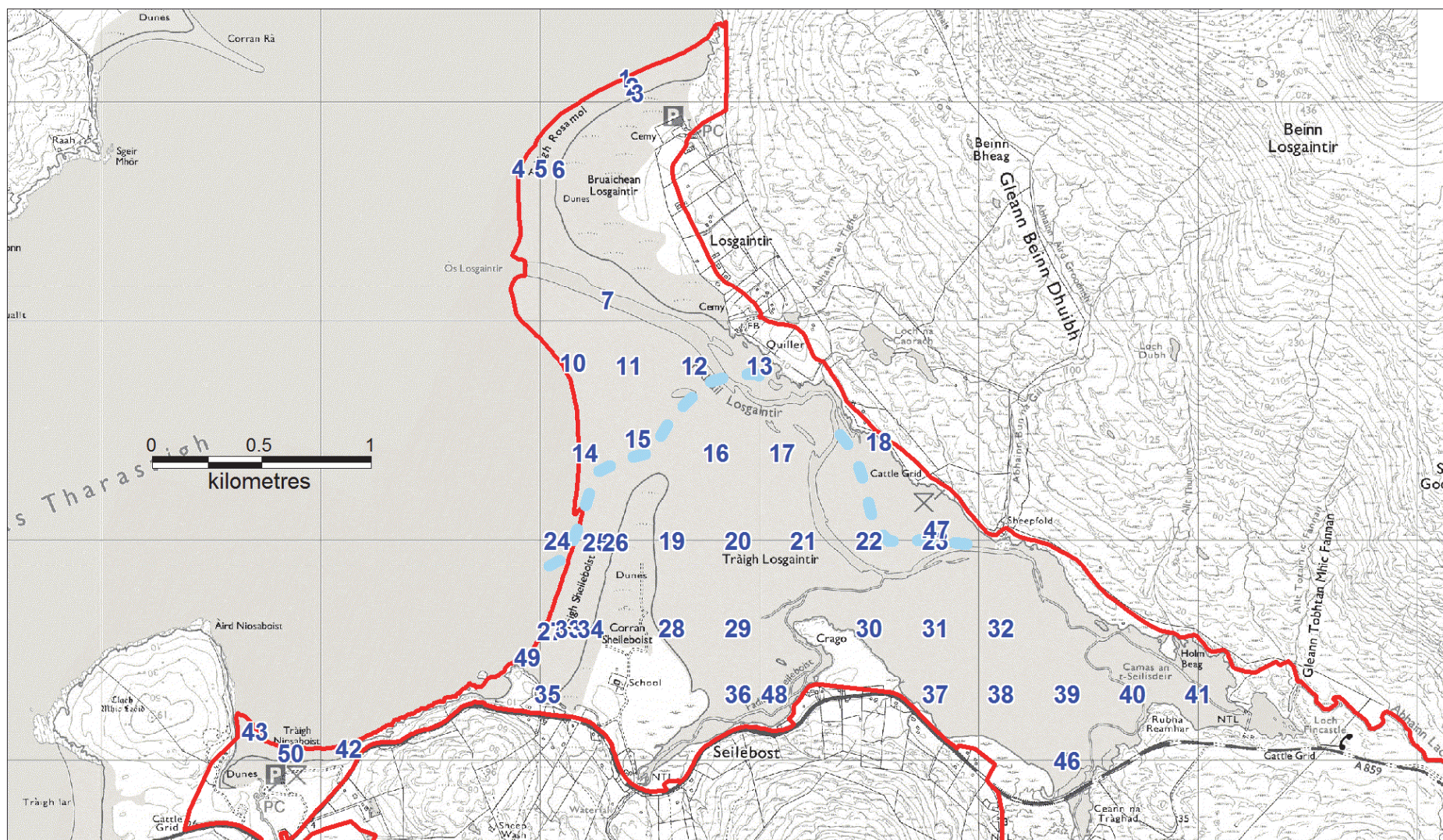


Figure 26. Survey stations in Luskenyrtre Banks and Saltings SSSI (For location map see Figure 13). (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

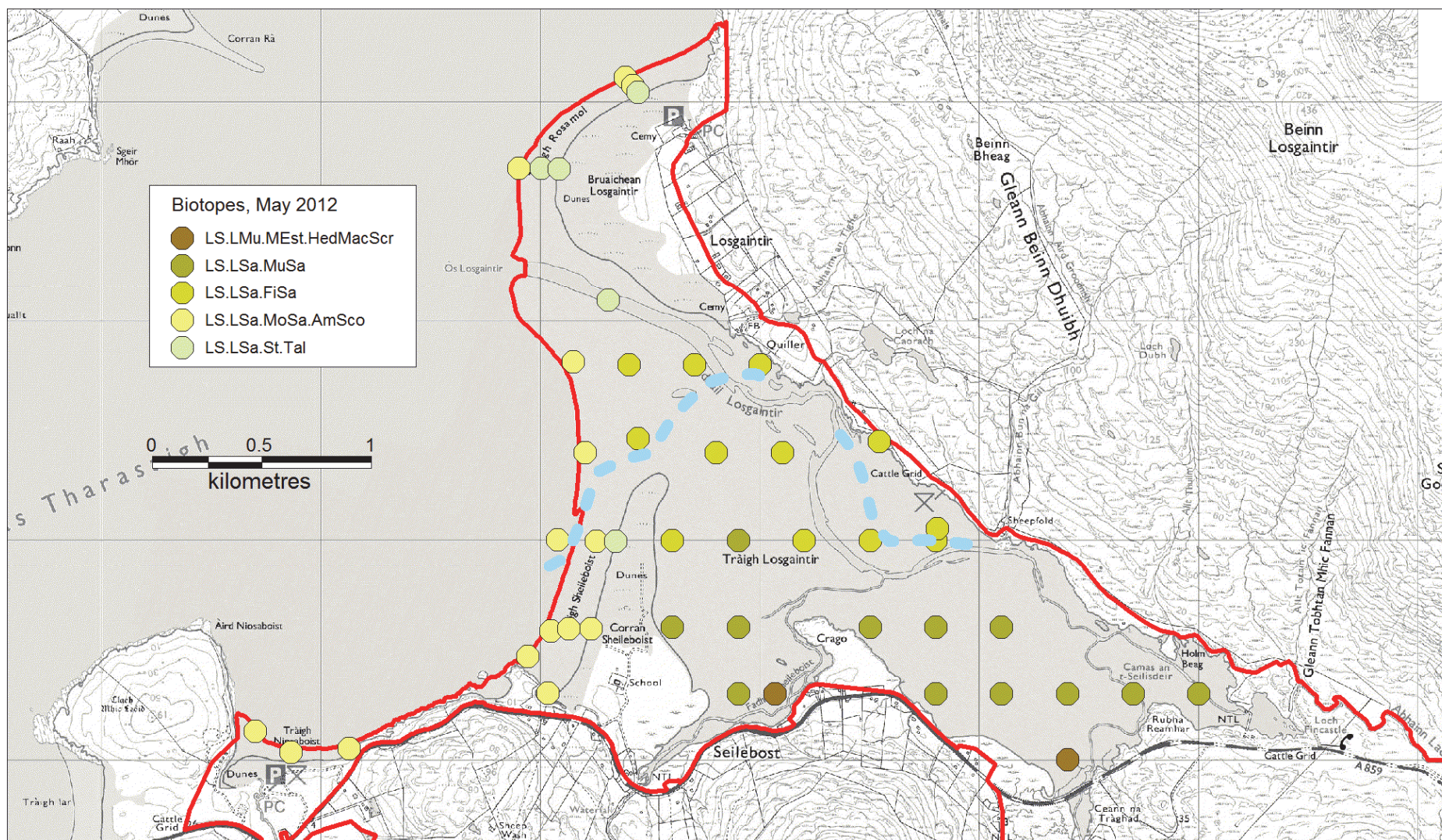


Figure 27. Distribution of intertidal biotopes in Luskentyre Banks and Saltings, May 2012. (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

4.7 Northton Bay

Surveys of stations in Northton Bay SSSI were carried out during low spring tides on the 8th and 9th May 2012. Figure 28 shows the locations and numbers of the survey stations visited. Of the 26 stations on the planned grid 4 (NB01, 16, 25 & 26) were not surveyed because they were covered by the tide at low water, too high on the shore or too deep in the tide pool. Four additional stations were added (NB27-30) to represent areas of sediment and habitats that had not been covered.

4.7.1 Biotopes and species

Tables 16a, b, c and d summarise the data collected. The full data is tabulated in Appendices A3, A4, A5, A6 and A7.

Note: Sediment macrofauna in Northton Bay was characterised by low species richness, abundances and small body sizes, in the sheltered inner bay as well as on the wave exposed beach.

Biotopes from the national classification of marine biotopes (Connor et al. 2004) have been assigned to each survey station after close inspection of the detailed physical and biological data collected. Table 10b lists the biotopes and Figure 29 shows their distribution.

Table 16a. Summary data for surveyed stations

No. of stations surveyed	26
No. of <i>in-situ</i> core stations	26
Total No. of epibiota species	13
Total No. of <i>in-situ</i> core species	11
No. of biotope types	4

Table 16b. Biotope types at surveyed stations, based on classification of Connor et al. 2004.

Biotope code	Stns	Biotope name
LS.LSa.St.Tal	3	Talitrids on the upper shore and strand-line
LS.LSa.MoSa.AmSco	14	Amphipods and <i>Scolecopsis</i> spp. in littoral medium-fine sand
LS.LSa.MoSa.BarSa	1	Barren littoral coarse sand
LS.LSa.FiSa	8	Polychaete / amphipod dominated fine sand shores

Table 16c. Conspicuous epibiota (most frequently recorded species only) recorded in-situ from surface of substrata. Survey methods: Presence (P), density (M), SACFOR abundance (A) or percentage cover (%) estimated over 5 m radius. Stns = No. of stations (out of 26) in which taxon was recorded. Full data in Appendix A4.

Name	Method	Stns
Spionidae (tubes)	A	3
<i>Arenicola marina</i> (casts)	M	3
Bathyporeia	A	3
<i>Ulva</i> (tubular)	%	3

Table 16d. Species / taxa recorded in-situ from sieved core samples (most frequently recorded species only). Stns = No. of stations (out of 26) in which taxon was recorded. Full data in Appendix A5.

Name	Stns
<i>Hediste diversicolor</i>	4
<i>Scolecopsis squamata</i>	4
<i>Bathyporeia pilosa</i>	3

4.7.2 Habitats and species of conservation importance

No Priority Marine Features, Biodiversity Action Plan habitats, BAP species or other rare species recorded. The large upper shore tide pool at the head of the Bay by Taobh Tuath is no longer considered to be a lagoon (see Section 2.8).

4.7.3 Impacts and activities noted during the survey

- Recreation – dog walking
- Strandline litter, primarily seaborne

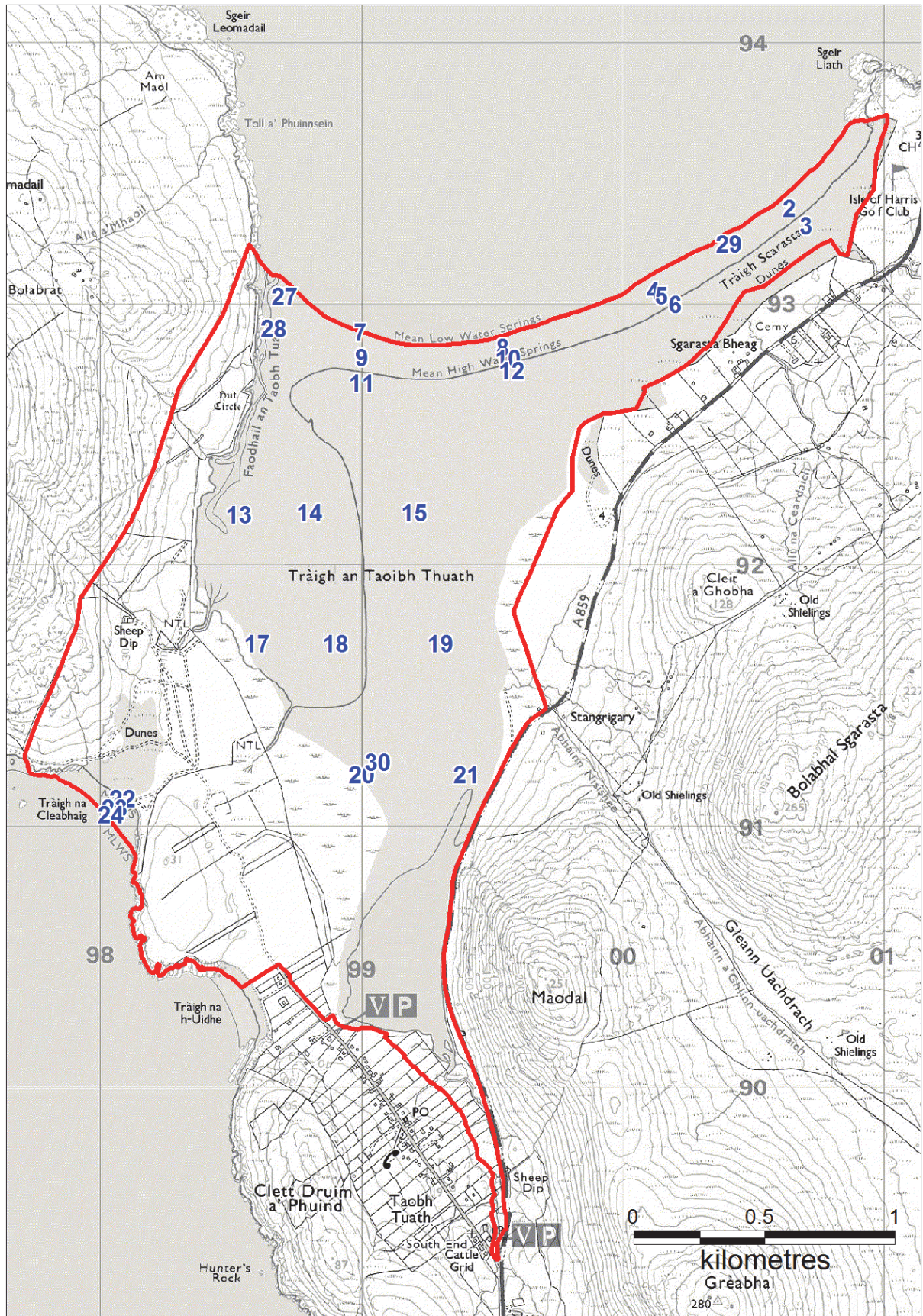


Figure 28. Survey stations in Northton Bay SSSI (For location map see Figure 13). (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

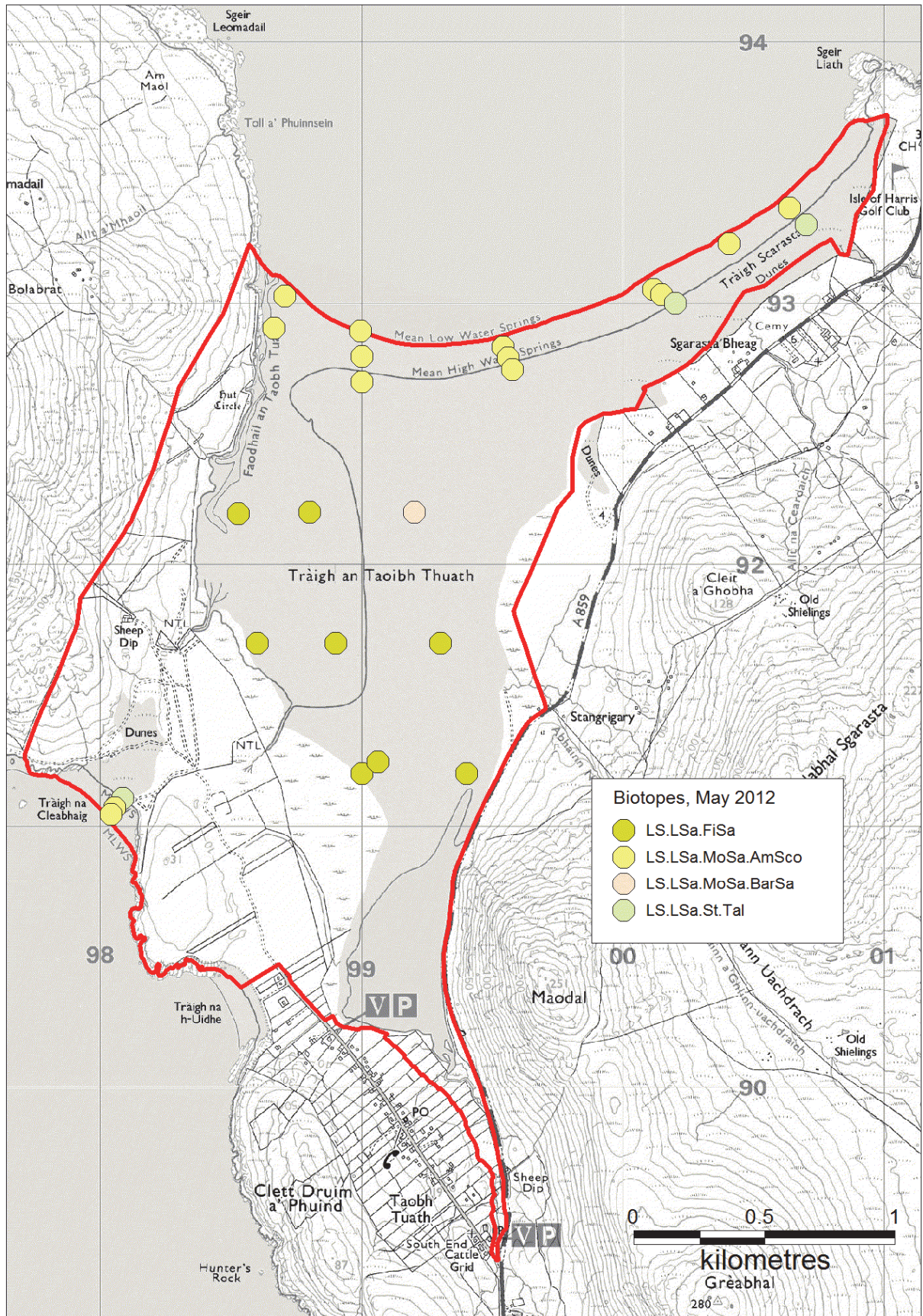


Figure 29. Distribution of intertidal biotopes in Northton Bay, May 2012. (© Crown copyright and database rights 2014. Ordnance Survey 100017908).

5. DISCUSSION AND RECOMMENDATIONS

5.1 Comparison with previous data

The following sections highlight any notable differences in the sediment habitats and communities between this survey and any previous survey work (see Section 2). Direct comparisons are not possible due to the considerable differences in methods and sampling locations. The notes are mainly confined to apparent differences in the presence and abundance of bivalves and other species that are large or easily identified *in-situ*.

5.1.1 Kames Bay

No 2012 data to compare with previous data.

5.1.2 Ballochmartin Bay

Cerianthus lloydii was previously recorded in the intertidal within the SSSI, but was not found in 2012. This is probably purely due to the logistics of the 2012 survey, which to all intents and purposes was a mapping survey and hence only a small piece of shoreline will have been surveyed at the exact time of low water. Hence any beds of *C. lloydii* may well have already been covered by the tide as they were passed by the surveyors. Conversely *Echinocardium cordatum*, was recorded in a small dense bed at the north end of the SSSI in 2012 (BB01) and this taxon had gone un-noticed until now. As stated in Section 2.2, there appear to have been few broadscale surveys of the SSSI and so this particular bed of heart urchins has remained un-recorded. The presence of native oysters are also of interest.

5.1.3 Bogside Flats

No previous data to compare.

5.1.4 Cree Estuary

As there has been little published data on the flora and fauna of the intertidal mud and sand, the scope for comparisons with previous data are limited. The saltmarshes were reported in SNH (2010a) to be in unfavourable condition and judging by the extensive trampling and grazing by livestock observed by the Crook of Baldoon this was still the case at the time of the survey.

Cord grass *Spartina anglica* has previously been recorded along the shore near Wigtown (Angus 2004) and is a negative indicator for the saltmarsh habitats. The 2012 survey was not designed to look for *S. anglica*, but the surveyors reviewed their notes and photographs after the survey and had no record of its presence anywhere in the Cree Estuary. However, this is obviously not a reliable record of its absence.

Possible effects of the rip-rap sea defences on smelt spawning areas of the River Cree were raised by Lyle and Maitland (1997). The steep eroded banks of the River Cree noted in the region of sea defences during this survey could be a cause for concern for well-being health of the smelt spawning area if the geomorphology and flow of the river are being adversely affected in this regard.

The nature of the sediment flats and the biota recorded during a brief survey in 2011 generally concurs with that recorded in 2012. The 2012 survey took many more samples over a larger area and as would be expected, the number of biotopes described was greater.

The biotope LS.LMx.GvMu.HedMx was recorded in 2011 but not in 2012. However, it is thought that this is probably a case of data interpretation as the muddy gravel biotope LS.LMx was recorded in 2012 but was not shoe-horned into a higher level biotope because

none were thought to match satisfactorily. The only other biotope recorded during 2011 which was not recorded in 2012 was LR.LLR.FVS.ASCVS. The 2012 survey concentrated on sediments rather than rocky biotopes and it will be for this reason that the fucoid biotopes did not feature.

At the time of the survey there were no sightings or signs of shell fish harvesting, mechanical or otherwise and was raised as a concern by SNH (2010a). The occurrence of *Zostera marina* on the more sheltered region of Baldoon sands was of interest and not mentioned in previous surveys. This species would undoubtedly suffer if mechanical harvesting of cockles was employed in this area.

5.1.5 *Ulva, Danna and the McCormaig Isles*

This study identified *Zostera noltei* from An Grianan lagoon whereas Smith (1986) identified both *Z. noltei* and *Zostera marina*. As the 2012 survey took place early in the growing season, identification of small plants was difficult and it may be that *Z. marina* did occur in the lagoon but that it was not spotted.

Whereas Smith (1982) recorded only a few *Cerastoderma glaucum* in the An Grianan lagoon, in 2012 they were found to be plentiful. The pattern observed in 2012 was of both *C. glaucum* and *Cerastoderma edule* occurring around the entrance channel, but *C. glaucum* dominated the inner part of the lagoon and were the only species of cockle found on the transect. Smith (1982) did not record *Zostera* from the An Grianan lagoon and only a few 'whisky' growths were reported by Smith (1985). It would seem that there has been an increase in *Zostera* in this lagoon in 2012 as *Zostera* was found to be widespread and abundant in places. Grey mullet were recorded in the An Grianan lagoon by Smith (1985) but not in 2012.

Modiolus modiolus was recorded on the An Grianan lagoon side of the entrance channel in 2012, but not in large numbers. *Modiolous* had previously been recorded as forming a bed by Smith (1982) but had since declined (Smith, 1985).

On the west side of the Ulva Islands, the sand and gravel shores with *Cerastoderma edule* were as described by Smith (1982) although the bivalve *Venerupis decussata* was not found in the samples but this may have been due to the tide not going low enough during the 2012 survey. There was not enough time to study the northwest shores of the Ulva Islands and so no comparisons of habitats and biota can be made with previous surveys.

At the head of Loch Na Cille, Smith (1986) recorded *Zostera noltei* and *Vaucheria* patches in the upper shore and SNH (2011a) reported the presence of rich seagrass communities in this area with both *Z. marina* and *Z. noltei* present. Although this area was sampled in 2012 at stations 33 and 35 (see Figure 22), there were no records of *Zostera*. This may be because it was early in the growing season and therefore very small. Smith, (1986) also sampled some pools in this region and found *Cerastoderma glaucum*. These pools were not sampled in 2012.

The beach to the east of the causeway, Ceann an t-Sallein, was sampled both by the 2012 survey and Smith (1982). The small lagoon with a population of *Cerastoderma glaucum* described in 2012 to the east of the causeway bridge between Ulva and Danna was not noted by Smith (1982 and 1986). Smith described the sediments of Ceann an t-Sallein as having an '*Arenicola - Cerastoderma*' community. The 2012 survey described the sediments as biotopes according to Connor *et al.* (2004) and the ones described for Ceann an t-Sallein (see Figure 23) relate well with Smith's description but an exact match cannot be made. *Mytilus edulis* dominated communities were found by both Smith (1982) and the 2012 survey.

5.1.6 Tong Saltings

Previous survey data is limited and does not describe all of the areas and habitats present on the site (particularly the dense *Scrobicularia plana* beds), but the sediment communities described by Angus (1979) at five stations are similar to those found in the same general areas in 2012. A notable difference is that the large densities of *Donax vittatus* that he recorded in 1977 were not found on the main beach in 2012 (see notes below for Luskentyre Banks and Saltings).

5.1.7 Luskentyre Banks and Saltings

The distribution and composition of sediment habitats and infaunal communities present in May 2012 were generally very similar to those described by Angus (1979) with one notable exception. The high densities of *Donax vittatus* that were present in 1977 (and even higher densities in 1984, Ansell *et al.*, 1984) were not found, after extensive searching, in the 2012 survey. Only a single individual was recorded from the *in-situ* core samples, but a sign of previous large numbers was an accumulation of dead shells (not recent) above the strandline at the end of the Corran Sheileboist dunes.

Large natural fluctuations in *D. vittatus* populations have been recorded from other sites around UK (e.g. Moore, 2012) and a cyclical pattern in a population in Kames Bay, Millport, was described by Ansell (1972). Any site condition targets that incorporate data on *D. vittatus* populations will need to take such fluctuations into account.

5.1.8 Northton Bay

Previous data are very limited, but the overall distribution of sediment habitats and very sparse infauna present in 2012 is similar to that described by Angus (1979) and Thorpe *et al.* (1998).

5.2 Generic discussion and recommendations on future monitoring

The following sub-sections discuss and provide generic recommendations. Appendices 1 and 9 provide site specific guidance and Site Attribute Tables (SATS).

5.2.1 Background

JNCC (2004) provides standards for monitoring of marine features, many of which are relevant to the sites described in this report (Table 17).

Table 17. Generic attributes and targets for marine features found within SSSIs. Adapted from JNCC (2004), to include only those features relevant to the study sites in this report.

Attribute	Target	Feature
Extent	No change in extent of feature	Littoral sediment, lagoon
Isolating barrier – presence, nature and integrity	No change in measures from established baseline	Lagoon
Biotope composition of the feature	Maintain the variety of biotopes identified for the site, allowing for natural succession or known cyclical change.	Littoral sediment, lagoon
Salinity regime	Average seasonal salinity, and seasonal maxima and minima, does not deviate significantly from an established baseline.	Lagoon
Sediment character: sediment type	No change in composition of sediment type across the feature, allowing for natural succession / known cyclical change.	Littoral sediment, lagoon

** Distribution and spatial pattern of biotopes	Maintain the distribution and/or spatial arrangement of biotopes, allowing for natural succession/known cyclical change.	Littoral sediment, lagoon
* Extent of sub-feature or representative / notable biotopes	No change in the extent of the biotope(s) identified for the site allowing for natural succession / known cyclical change	Littoral sediment, lagoon
* Extent of water	At least 60% of the water of the lagoon persisting at all times of the year and states of tide.	Lagoon
* Species composition of representative or notable biotopes	No decline in biotope quality due to change in species composition or loss of notable species allowing for natural succession / known cyclical change.	Littoral sediment, lagoon
Species population measures – population structure of a species	Maintain age / size class structure of a (named) species	Littoral sediment, lagoon
* Species population measures – presence and / or abundance of specified species	Maintain presence and / or abundance of the specified species. Absence of the specified species (such as an undesirable non-native species)	Littoral sediment, lagoon
* Topography	No change in topography of the littoral sediment, allowing for natural responses to hydrodynamic regime.	Littoral sediment, lagoon
* Sediment character: organic carbon content	Organic carbon content should not increase in relation to an established baseline.	Littoral sediment
* Sediment character: oxidation reduction profile (Redox layer)	Average depth to the top of the black layer should not increase in relation to baseline.	Littoral sediment
* Water depth	Average water depth should not deviate significantly from an established baseline subject to natural variation.	Lagoon

* Not a compulsory attribute.

** Not a compulsory attribute for lagoons.

Application of those standards to the intertidal sediment and lagoon features of the eight study sites is not straightforward for a number of reasons, particularly when budgets and staff time are limited. ERT (2009) discuss options for rapid assessment of site condition and their limitations. They highlight the difficulties of distinguishing natural and anthropogenic changes in biotopes and populations without a considerable quantitative baseline and knowledge of the normal levels of natural variation. They also highlight the value of local knowledge of activities and uses of the site, including the adjacent areas, for such assessments

5.2.2 Extent

Sandflats and to a lesser degree mudflats are dynamic systems and may be subject to notable natural change in extent within the time scale of the regular review periods. Such changes could include expansion or regression of adjacent maritime habitats, like saltmarsh. In some locations, particularly where invasive cord grass *Spartina anglica* colonises pioneer saltmarsh, this could result in an undesirable reduction in the extent of mudflats. In such locations it will be appropriate to carry out regular, 2 or 3 yearly, surveillance of pioneer saltmarsh condition and to check for the presence and expansion of *S. anglica*.

Notable anthropogenic change in extent is only likely in the event of a major activity on site or in the vicinity that results in reclamation, extraction, dumping or coastal development construction. Local SNH staff should be aware of any such activities and should assess their influence on site conditions whenever they occur. Detailed measurement of extent, which would require comparison of remote images, should only be necessary in those situations. A regular, 6 yearly, review of extent should consist of little more than a reminder to local staff to review the use of the site and its environs.

The same can be said for saline lagoons, although lagoons are more vulnerable to notable anthropogenic change. This is because lagoons are relatively small in extent so relatively small scale activities (e.g. reclamation and dumping) could notably affect them. A review of the use of the site and its environs should be carried out relatively frequently; e.g. annually.

None of the eight sites considered in this report contain sub-features of the intertidal features that can be easily mapped (e.g. well developed *Zostera* or *Ascophyllum nodosum* ecad *mackayi* beds). The intertidal sediment communities present have no easily visible surface characteristics, so accurate mapping would require considerable digging. This would be too destructive and time consuming, so is not recommended. Assessment of the extent of those sediments supporting dense *Scrobicularia plana* populations would be valuable, but those communities are particularly sensitive to physical damage, so accurate mapping is not sustainable. However, broad scale mapping, using the star pattern feeding marks of *S. plana*, with occasional digging to confirm their presence, may be appropriate for selected well defined high density beds.

5.2.3 *Biotope composition*

Measurement of the variety of biotopes (or habitats or communities) present within a site feature is an attribute that would be very valuable for monitoring if it was not so sensitive to recorder error and subjective application of the biotope classification. Assigning biotopes to sediments can be particularly inconsistent as most of the characterizing species are hidden from view and not necessarily present at any particular sample point.

However, a broad assessment of the range of biotopes present within the site is appropriate. The methodology used for the 2012 surveys described in this report provides a good basis for a less subjective application of the biotope classification, but is time consuming. Alternatively, a rapid assessment can be made; looking for biotopes that are the same or similar to those previously recorded and only carrying out a more detailed assessment if the rapid assessment suggests a notable change.

Realistically, the likelihood that anthropogenic activity would cause an ecologically significant change in the variety of biotopes is small, without some major extraction or reclamation; while natural storm events could result in greater fluctuations. As noted in the sub-section above, it is suggested that no great attention needs be made to this attribute unless local SNH staff become aware of a major development.

5.2.4 *Distribution of biotopes*

Monitoring the distribution of intertidal sediment biotopes and setting reliable criteria of notable change is even more difficult than for biotope composition. Natural fluctuations are high, anthropogenic activities would need to be considerable to cause similar levels of change, and consistency in mapping and assigning biotopes is poor.

A similar approach to that described for monitoring *extent* in Section 5.1.1 is therefore recommended, with the initiation of detailed survey work triggered by major anthropogenic development or activity.

5.2.5 *Presence of representative / notable biotopes*

Intertidal mudflats (LS.LMu) are the only sediment biotopes recorded from these surveys that are defined as Priority Marine Features (and BAP habitat). Many others are considered representative and some are potentially sensitive to anthropogenic activities. Of the mudflat biotopes, LS.LMu.MEst.HedMacScr (*Hediste diversicolor*, *Macoma balthica* and *Scrobicularia plana* in littoral sandy mud shores) is considered notable, particularly where it includes high densities of the long lived / slow growing peppery furrow shell *Scrobicularia*

plana. This biotope is naturally relatively stable and would be good for monitoring if it was easier to identify and describe without physically damaging it in the process. The *S. plana* make a fairly distinctive star pattern feeding mark that gives a visible clue to its presence, although occasional confirmation by digging is necessary. Surface marks made by high densities of the amphipod *Corophium*, which are also often associated with this biotope, also provide a further visual clue. The presence of this biotope may therefore be assessed with a rapid walkover survey

5.2.6 *Sediment character and topography of mud flats and sand flats*

A detailed assessment of sediment character and topography is beyond the scope of the current report and would require specialist expertise and methodologies. A gross assessment of change may be appropriate on a periodic basis, but it is assumed that notable change would most likely be associated with a major activity on site or in the vicinity that results in reclamation, extraction, dumping or coastal development construction.

5.2.7 *Species composition of representative / notable biotopes*

Intertidal mudflats (LS.LMu) are the only sediment biotopes recorded from these surveys that are defined as Priority Marine Features (and BAP habitat). Many others are considered representative and some are potentially sensitive to anthropogenic activities, including pollution; but all of them will also be subject to notable unpredictable natural fluctuations in their species composition. Survey and assessment of species composition of sediment communities also requires specialist skills and methodologies that are time consuming and expensive.

The methodologies applied in most of the surveys described in this report were relatively rapid and designed to give relatively coarse data on species composition. Re-surveys, using the same *in-situ* methodologies and suitably trained surveyors, would provide similarly coarse species composition data that could be compared with the baseline data from these surveys. Assessment of changes would require considerable knowledge and experience of intertidal sediment communities and species and their typical levels of natural fluctuations. It would also need to take account of the potential inaccuracies of the *in-situ* methodology. Such an assessment would necessarily be fairly subjective, with no simple criteria to indicate when conditions may not be favourable. Unfavourable conditions may be indicated by gross changes in species composition, including relatively low species richness and / or very low abundances over a notable proportion of the habitat.

More detailed laboratory analysis of species composition has been carried out in recent years at some of the sites (e.g. at Ballochmartin Bay by Alvarez (2009)) and was carried out on samples from three stations in the UDMI SSSI in this survey. Re-surveys, using the same *in-situ* methodologies, would provide detailed species composition data that could be directly compared with the baseline data from these surveys. Assessment of changes would be carried out in much the same way as described for *in-situ* data, but with more detail and confidence in the species data. Assessment of change would also be similarly subjective and lacking in simple criteria. In addition, the relatively few stations sampled would reduce confidence in the extent of any described changes.

5.2.8 *Species population measures*

Native oysters *Ostrea edulis* were the only PMF (and BAP) species recorded in any of these surveys. Many others are considered representative and some are potentially sensitive to anthropogenic activities, but all of them will also be subject to notable unpredictable natural fluctuations in their populations. Notwithstanding such fluctuations, populations of some of the uncommon and representative species are conspicuous and easily recognised and may be usefully monitored. If large and potentially deleterious changes are recorded then further

detailed assessment may be appropriate. Examples of such species include the bivalves *Scrobicularia plana*, *Angulus tenuis*, *Cerastoderma glaucum*, *Ostrea edulis* and the seagrass *Zostera noltei*.

The surveys described in this report did not provide sufficient data on the abundance of any individual species for use as a baseline for detailed monitoring. No data were recorded on any other population measures for any species. However, the survey data do provide broad scale distribution information and indicative abundances for many species that could be used to develop a more detailed population study. For example, this might be appropriate for the native oysters at Ballochmartin Bay or UDMI.

5.2.9 Lagoon specific attributes

The condition of a lagoon's isolating barrier and the salinity regime and water depth created by it are key to the lagoon's integrity. However, the former can be difficult to assess and the latter attributes require frequent measurements over a period of time, which is difficult to achieve at a remote site. The recommended guidance here is therefore to use the presence and abundance of characteristic lagoonal species as a proxy for the physical condition of the lagoon. The survey at An Grianan lagoon (UDMI SSSI) described in this report focussed primarily on the lagoon cockles *Cerastoderma glaucum*, which are relatively easy to sample, count and measure.

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