

Manx Marine Environmental Assessment
**Ecology/Biodiversity
Habitats**

Coastal Ecology



White Strand beach towards Peel Castle. Photo: P. McEvoy

MMEA Chapter 3.2

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Coastal Ecology

Introduction

The Manx coast

The Isle of Man has a relatively small land area (588km² or 227 sq. miles), and consequently the coastal ecosystems comprise a substantial proportion of the whole. Compared to the wider offshore marine areas, they provide the greatest and most immediate visual impact for the majority of residents and visitors. They have a key role in determining the attractiveness and the character of the Island.

The Island is rich in some coastal habitats, and poor in others. This pattern is largely defined by the convex shape of the Island, so that shorelines are predominantly exposed to wave action. The southern half consists mainly of rocky shores and cliffs, the northern half of exposed sand and shingle shores. There are a limited number of sheltered sandy beaches between the rocky headlands. As a result of the small land area, rivers are minor, and so are their estuaries: these all dry out at low water or they did before marina development. Typical sheltered-shore ecosystems such as mud flats and salt marshes are both scarce, and of limited extent.

The unequal areas of coastal habitats pose two challenges to marine and coastal management. One is to preserve the diversity and integrity of the widespread ecosystems, such as rocky shores. The other is to conserve the habitats of high importance, but limited abundance in order that the fullest diversity of coastal ecology may continue to be observed around our shores.

Coastal wetland makes up a significant part of those wetlands covered by the Ramsar Convention (Table 1).

Table 1. Wetland inventory showing the main wetland habitats (*coastal and marine).

Broad wetland habitat type	Area in hectares	% of total wetland area
Natural non-linear water bodies	7.32	0.04
Swamp	19.70	0.11
Man-made non-linear water bodies	132.40	0.71
Selected wet woodland and scrub	311.95	1.67
Wet heathland	342.35	1.83
Selected coastland*	570.55	3.06
Mire	637.89	3.42
Marshy grassland	1067.11	5.72
Intertidal (Including saltmarsh)*	1654.55	8.87
Shallow marine waters*	13915.40	74.58
TOTAL WETLAND:	18659.21	100

Source: Tomlinson 2007

The limits of 'Coastal Ecology'

This study of 'coastal ecology' aims to include all habitats within the intertidal range, from lowest astronomical tide (LAT) to highest astronomical tide (HAT), as well as adjacent habitats affected by the sea. Around the Isle of Man the intertidal areas can be substantial, since maximum tidal extent ranges from 4.5m to 6.5m. Sea bed areas below LAT are covered in MMEA Chapter 3.3 (Subtidal Ecology) with aspects of open water systems covered in other chapters, including MMEA Chapter 3.1 (Plankton in Manx Waters).

It is not always easy to delineate the areas where marine influence is strong. Some such areas are clear cut, such as the lichen communities on upper rocky shores, and sand dunes backing depositing shores. However, further inland, there are flowering-plant dominated 'maritime' communities, whose landward limits are difficult to determine (Lamb, 1999): these must still be considered an integral part of the 'coastal' ecosystem.

Habitat descriptions

Whole Island overview

The north/south division of coastal habitats around the Isle of Man was touched on in the introduction to this chapter: the southern half is mainly a rocky coastline, the northern half has sand and shingle dominated shores. The rocky shores extend from just north of Peel (about White Strand, approx. 54° 14.998N, 004° 38.478W), anticlockwise to just south of Ramsey, (about Port Lewaigue, approx. 54° 18.66N, 004° 21.10W), including the Calf of Man. However, within that stretch, there are a number of relatively sheltered fine sand beaches, important since they include the main bathing beaches on the Island. The rest of the coastline, north from White Strand round the Point of Ayre to Ramsey comprises exposed shores of coarse sand and shingle which are either depositing or eroding. There are also some small areas of saltmarsh, some of which are associated with the various small estuaries.

The coastal habitats will be reviewed in the following order: rocky shores; sandy beaches; exposed sand and shingle shores; salt marsh; muddy shores and estuaries; upper shore and adjacent terrestrial communities. The marine fauna of the Isle of Man is listed in Bruce *et al.* (1963).

Rocky shores

The rocky shores can be categorised on two grounds – geology and exposure to wave action.

Geology

The great majority of rocky shores are composed of Ordovician Manx slate which is heavily folded. This provides a very uneven topography, with steeply sloping faces, which can affect wave exposure on a local scale (see below). The rock surface is generally smooth, and pools are often deep and narrow. There is an area of

carboniferous limestone in the south with four headlands, (Lamplugh 1903). The three main ones are at Kallow Point, Port St Mary (Figure 1), Derbyhaven and Scarlett Point. These limestone shores tend to comprise sloping ledges separated by vertical faces, with shallow pools and boulder fields at the base of the ledges.



Figure 1. The limestone ledges at Kallow Point, Port St Mary, Isle of Man. Photo: J. Cubbon 2011.

Thus despite a superficially homogenous appearance, they provide a diversity of habitats. The limestone ledges are generally smooth, but some are highly pitted: this is either due to length of exposure, or to the nature of that stratum. There are also limestone shores on the western side of Langness, but these do not show the ledge-structure described above and have more in common with limestone pavement.

The Manx slate and limestone shores, both hard rocks, do not support different species (although the burrowing bivalve *Hiatella striata* only burrows into limestone (Bruce *et al.* 1963), but is only found very low in the intertidal. Nevertheless, the even topography of the three limestone ledge shores renders patterns of zonation and discrimination of communities much clearer and characteristic communities of species occur. As a result they are more amenable to scientific study, and have increased educational value. This is especially the case for Kallow Point, Port St Mary, where the intensive history of scientific research was an important factor in its designation as an Area of Special Scientific Interest in 2011 (DEFA 2011). These limestone ledges consequently have a significance which is disproportionate to their small area. Now that a substantial portion of the Derbyhaven limestone ledges has now been covered by the Ronaldsway runway extension, this renders the remaining two areas even more important. There are small areas of sandstone at the north end of Peel Bay and at White Strand. A few igneous intrusions occur, such as the volcanic cone at Scarlett.

The majority of the rocky coastline is Manx slates and shales which vary in its folding and the angle of the bedding planes (Figures 2 and 3). At The Sugarloaf, off the Chasms, the bedding planes are horizontal making the rock ideal for nesting colonies of seabirds: guillemots, kittiwakes and razorbills. For further information refer to MMEA Chapter 2.3 (Coastal and Offshore Geology).



Figure 2. Steeply shelving Manx slates near the Dhoon Glen, on which native oaks maintain a roothold. Photo: DEFA.



Figure 3. Folds of slate create caves that are important for nesting coughts. Photo: DEFA.

Wave exposure

Wave exposure is a more important factor than geology in determining the community of plants and animals on rocky shores in the Isle of Man. The convex outline of the Island, and its general alignment from SW to NE, combine to give limited shelter from the prevailing SW winds. So most shores are wave exposed, though on UK scales they would only rate as semi-exposed. This is because the 'fetch' in the Irish Sea is generally short, and cannot develop the wave power characteristic of the open Atlantic west facing coasts of Britain. On an eight point exposure scale from 1=exposed to 8=sheltered (Ballantine 1961), Manx shores rarely fall below level 3. The major effect of wave action is to determine the algal/animal balance in the community, with decreasing seaweed dominance as wave exposure increases (Ballantine 1961). Very exposed shores are devoid of large seaweed species, very sheltered shores are blanketed by a continuous cover of fucoid seaweeds. So the majority of Manx rocky shores exhibit a mosaic of fucoid seaweeds, barnacles and limpets, in keeping with their semi-exposed status. The balance on a shore changes with time, due to biological interactions and variations in recruitment (Hartnoll and Hawkins 1985). A feature of Manx rocky shores is a dearth

of the common mussel *Mytilus edulis*, which is rare except in the area from Peel Bay to White Strand, on the piles of Ramsey's Queen's Pier, Ramsey Harbour and to the north of Ramsey Bay. Very exposed shores devoid of seaweed do not occur on the Isle of Man, except on some vertical faces. Likewise very sheltered rocky shores, characterised by dense and continuous seaweed, notably of knotted wrack *Ascophyllum nodosum* on the midshore, are restricted. Small patches of this vegetation type occur on many shores, where irregular terrain provides local shelter. Larger areas are scarce and found at Castletown, Derbyhaven, Langness and Port St Mary.

For further information on wave exposure please refer to MMEA Chapter 2.1 (Physical Environment – Hydrology etc.).

Intertidal rocky shores

The Phase 1 habitat surveys (Wynn *et al.* 2000) of the Island's intertidal zones, identified four rocky shore biotopes which are classified as rare in the UK (CMACS 2002). This survey of biotope richness indicates that areas north of Peel, and around Derbyhaven and Scarlett are particularly species-rich. The more detailed Phase 2 surveys show areas on the west side of Langness, and at Scarlett Point, to be particularly species-rich (CMACS 2002). The Ronaldsway Runway end site (now covered by the runway extension) was found to have the highest diversity score (PEML 2003).

An example of the information available from the 2002 Phase 1 intertidal survey is provided in Figure 4.

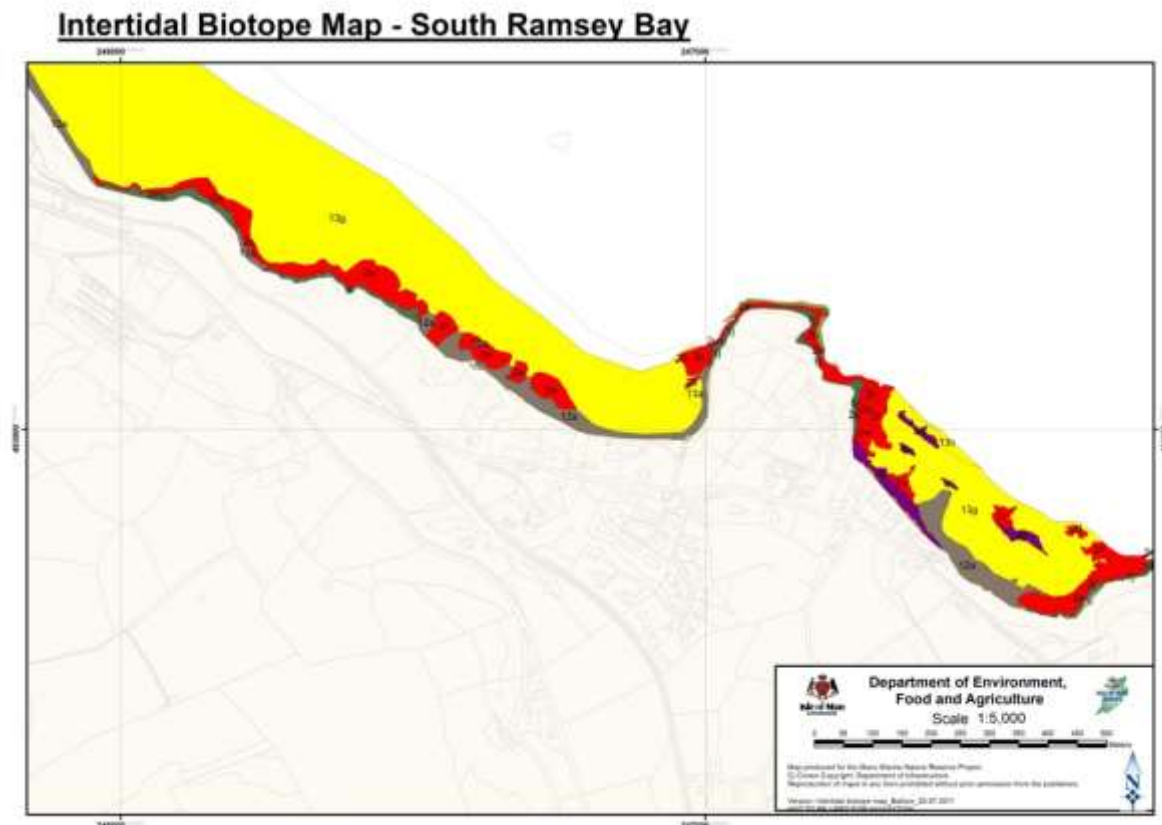


Figure 4. Example of the available Phase 1 intertidal information. Date source: CMACS 2002.

Sandy beaches

This section relates to the relatively sheltered sandy beaches located within bays around the otherwise rocky coastline.



The beach at Port Erin. Photo: Isle of Man Government.

Sandy beaches are small in extent, but have a high importance due to their shelter and comprise the main bathing beaches on the Island. They are of major importance to the tourist industry, and they are also important as fishery nursery grounds (Geffen *et al.* 1990), particularly for flat fish such as plaice. Such beaches occur at Peel, Port Erin, Port St Mary, Castletown, Derbyhaven, Laxey and Ramsey (Figure 5).

The beaches support populations of isopods and amphipods, and of polychaete worms, particularly the lugworm *Arenicola marina*. The rarer species of lugworm *Arenicola defodiens* can also be found at some beaches. Near low water a more diverse assemblage occurs, including the burrowing sea urchin *Echinocardium cordatum* and various bivalves and the sandy shore at Derbyhaven is particularly rich in these. At high tide they provide feeding grounds for shrimp, juvenile flatfish and gadoids (cod and hake family). These areas attract feeding waders at low tide and flocks of oystercatchers, curlews and plovers can be seen, depending on the time of year.

Significant studies of these beaches include Pirrie *et al.* (1932), Southward (1953), and Hastings (1980).

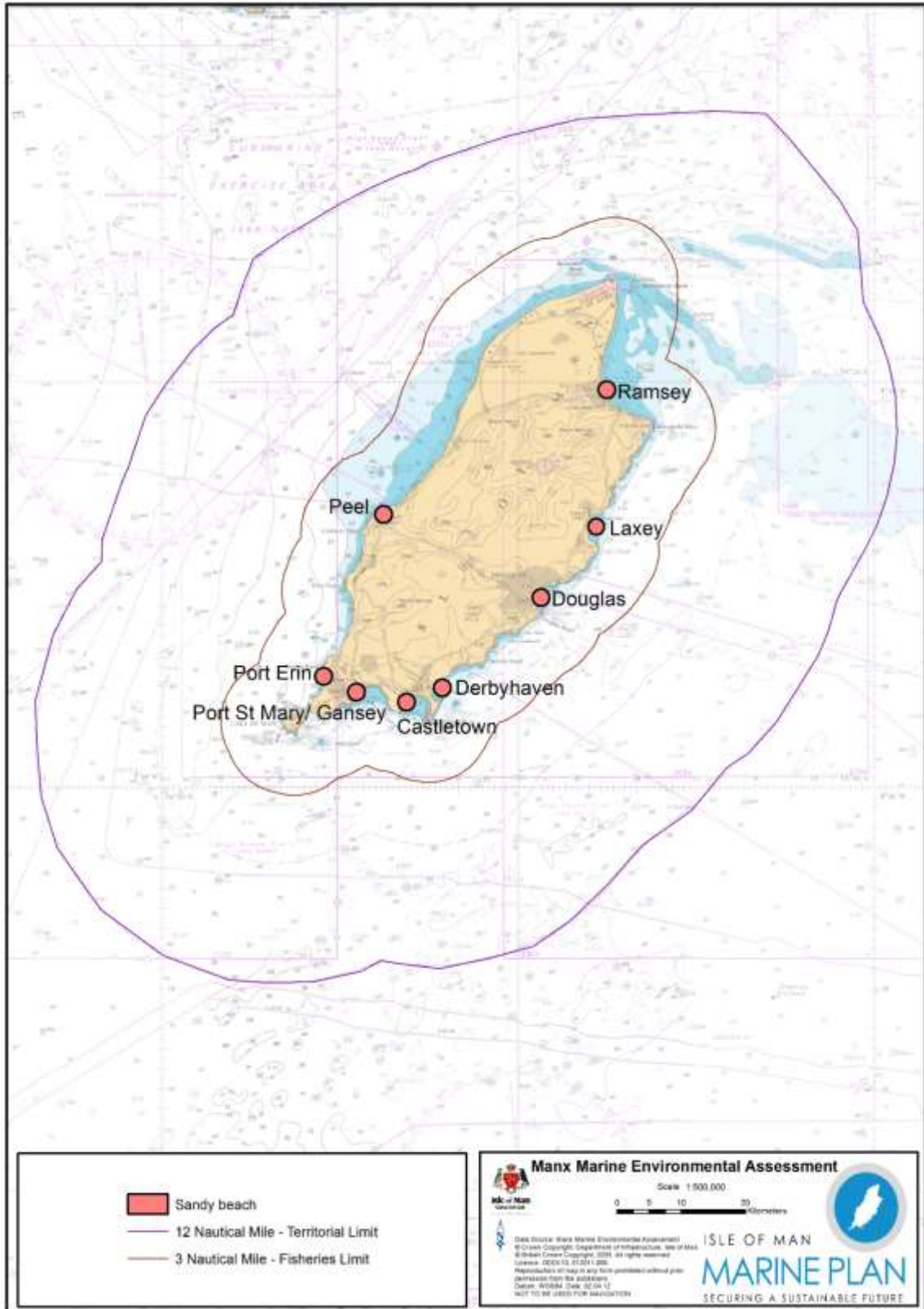


Figure 5. The main sandy beaches of the Isle of Man.

Exposed sand and shingle shores

Nearly half of the Manx coastline comprises exposed depositing shores of coarse sand, gravel and shingle, typified by the shore north of Ramsey (Figure 6), yet they have been very little studied. They comprise accumulated storm beaches backed by glacial deposits, often forming soft cliffs. The faunal status of these shores is summarised by Holt (1996-1999): “the sandy shores around the north of the Island are relatively barren, generally appearing to be dominated by small crustaceans (amphipods)”. Where the sediments are very coarse and mobile, such as around the Ayres, they are effectively lifeless intertidally: these are classified as ‘barren shingle or gravel shores’ in terms of biotope (CMACS 2002). However, the strandline does support amphipod populations, and attracts feeding birds. In other areas the sediments are finer and more stable, classed as the biotope ‘burrowing amphipods and polychaetes in clean sand shores’. The lugworm *Arenicola marina* is a prominent component. Waders and other seabirds are abundant, and feed intertidally in these areas. Ringed plovers, terns and oystercatchers nest above the high tide line.



Figure 6. Sand and shingle coastline north of Ramsey. Photo: J Cubbon.

All locations within this area have low biotope diversity (CMACS 2002). The few Phase 2 samples indicate low species diversity (PEML 2003). However, given the wide extent of these habitats around the Isle of Man, they require further study.

Saltmarsh

Saltmarsh is an atypical intertidal community dominated by salt tolerant or halophytic flowering plants, predominantly grasses and rushes, which possess adaptations which enable them to withstand periods of tidal submergence. Coastal saltmarsh occupies the interface between land and sea and has features of both in its flora and fauna. Saltmarshes develop in areas where there is some degree of shelter, a gentle gradient in the topography of the near shore, suitable substrate and a supply of suspended sediment. These conditions are not common around the Isle of Man. The total area is less than 7 hectares, 0.01% of the Island's land mass (Sayle *et al.* 1995). This was Phase 1 of all terrestrial habitats surveyed in 1991-94 using terrestrial Phase 1 survey techniques (JNCC 2010).

There are five main areas (Lamb 1999): Sulby River, Ramsey (Lamb 1995); Port Cornaa; St Michael's Isle; the western side of Langness (the largest at 3.44 ha); and Poyllvaish. Saltmarsh communities are relatively poor in species diversity, but the majority of species are restricted to this habitat and therefore have limited distribution, and are therefore of interest. These include a number of rare species in the Isle of Man, and consequently the "main areas should receive statutory designation in order to recognise their importance and afford them some degree of protection" (Lamb 1999, Spencer 2005). This was also indicated in the Site Selection Guidelines for Biological Areas of Special Scientific Interest (ASSIs) (DAFF, 2008). The process of designating terrestrial ASSIs, (down to lowest astronomical tide), is continuing and the full suite of sites is expected to be completed by 2020 as part of the Island's Convention on Biological Diversity commitment.

Due to the specialised nature of saltmarsh species many of them are restricted or rare in the Isle of Man, such as the chestnut sedge *Blysmus rufus*, which occurs at Langness and is near to the edge of its southern range (Rodwell, 2000); grass-leaved orache (*Atriplex littoralis*) and sea purslane (*Halimione portulacoides*), which are both on Schedule 7 (plants which are protected at all times) of the Isle of Man Wildlife Act 1990.

The Sulby River saltmarsh exhibits a diverse saltmarsh creek system, which has facilitated the formation of small, isolated pools or salt pans, fed by rising Spring tides and often drying out and, consequently, becoming colonised by vascular plants, such as glasswort (*Salicornia europaea*), which are tolerant of the extreme salinity of the exposed mud. Algal mats have formed in these wet salt pans and creeks, which contain communities of nematodes, flatworms and copepods and small fishes such as small mullet fry and sand gobies.

Cornaa is the most dynamic and variable saltmarsh with natural interfaces with woodland and marsh. Whilst Langness is the largest saltmarsh with its distinctive saltwater pools, such as the 'stinking dub'. These saltmarshes on the south coast, on bare rock, have more in common with Scottish loch saltmarshes than lowland British marshes.

In addition to the main saltmarshes, there are dozens of smaller ones on rocky coasts where vegetated upper rock pools have mini saltmarshes. Some of the most

interesting saltmarsh diversity exists in these areas, such as Scarlett, Port Mooar, and the Dalby coast.

Manx saltmarshes provide important feeding grounds for many overwintering birds such as wigeon, teal and shelducks, this is partly due to the presence of algal mats (alga unlike other flowering plants grow all year round) but mostly due to a large supply of invertebrates.

Manx saltmarshes are important habitat types within a European context. A high proportion of European temperate saltmarsh lies within the British Isles and has been afforded statutory protection under the UK's Wildlife and Countryside Act 1981. Saltmarsh is also a UK Biodiversity Action Plan priority habitat and its benefits as natural flood defence are beginning to be acknowledged, especially at a time when climate change is likely to increase the risk to our environment through increased rain fall and tidal erosion. The Island is currently developing its own Action Plan for saltmarshes as part of its Biodiversity Strategy.



The muddy shore at Derbyhaven. Photo: J Cubbon.

Muddy shores and estuaries

Muddy shores are scarce around the Island, occurring only in a few sheltered locations. The only sizeable area of muddy shore outside the estuaries is at Derbyhaven, inside the shelter of the breakwater. It has been studied in detail by Southward (1953). It has an interesting population of the bivalve *Loripes lucinalis*, which depends upon symbiotic sulphur bacteria for its nutrition.

Manx estuaries are all small, and originally they all emptied of sea water at low water leaving the freshwater flow restricted to a small channel. The main estuaries are at Peel (River Neb), Castletown (Silverburn), Douglas (River Dhoo/Glass), Laxey (Laxey River) and Ramsey (Sulby River) (Figure 7). They all contain (or contained, see below) a variety of euryhaline species, including typical estuarine species such as the alga *Fucus ceranoides*, the polychaete *Nereis diversicolor*, crustaceans *Jaera* spp., several amphipods, and the goby *Pomatoschistus microps*. Furthermore they provide passage to and from freshwater for migratory salmon, sea trout and eels. Estuarine sediments at Peel and Laxey have enhanced levels of heavy metals (copper, lead and zinc) as a legacy of geology and past mining activity within the watersheds. High metal levels are recorded in some of the estuarine organisms, particularly bivalves (Southgate *et al.* 1984), but no species seem to be excluded as a consequence.

Although various estuarine species have been studied, there are no comprehensive studies of Manx estuaries. Peel harbour was known to have held important populations of bivalve molluscs, including *Mya arenaria*, *Scrobicularia plana* and *Cerastoderma edule* on the area of mudflat exposed at low tide (see below)(Geffen *et al.* 1990, Gubbay 2000), although these are thought to have been destroyed as a result of Peel marina construction.



**Peel harbour still showing tidal mud, during construction of the water retention scheme.
Photo: September 2004, DEFA.**

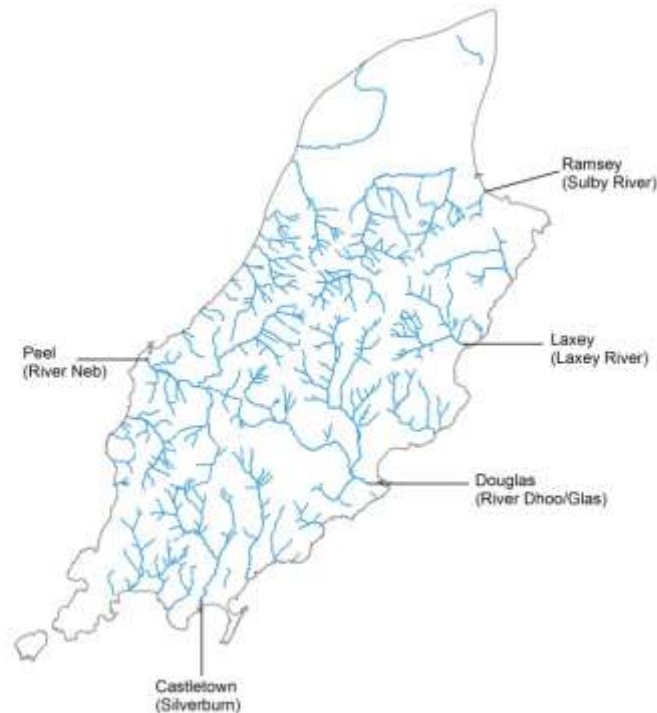


Figure 7. The main estuaries of the Isle of Man.

These estuaries are all at the same time active harbours and over the years have been extensively modified in consequence by dredging and harbour works. More radically, however, in recent years Douglas and Peel harbours have been fitted with flap-gate water retention systems to enable marina developments. As a result they no longer drain at low water. A similar scheme has been under discussion for Ramsey and Port St Mary. However, they have not been progressed.

Brackish water environments also occur in some high level shore pools that are reached only by exceptionally high tides. They occur at Scarlett, Langness and elsewhere, and contain interesting brackish water species. The isopod *Idotea chelipes* is found only in this habitat. The pools at Scarlett were studied in some detail by Naylor and Slinn (1958).

Upper shore and adjacent terrestrial communities

Areas above Extreme High Water Spring tides are nevertheless affected by marine influences as a result of splash and spray, particularly during storm conditions. Consequently, they must be considered part of the coastal ecosystem (Pritchard 1975). These communities are described in detail by Lamb (1999), and only a brief overview is presented here. These higher communities differ between rocky and depositing shores.

On rocky shores the immediately adjacent habitat is comprised of maritime lichen communities with a distinct zonation pattern up shore of black, yellow and grey lichens. The vertical extent of the lichen zone increases with exposure to wave action (Lewis 1964). Most recent lichen work (Seaward and Hawkins 2011) identified two

rare or unusual lichens on Ancient Ordovician rocks of the Manx group at the Calf Sound: *Acarospora benedarensis* (occurring in 7 squares in British Isles on the NBN map) and *Anaptychia ciliata* subsp. *Mamillata* (the western sub-species with 39 squares on the NBN map). There may be other sites of significance for lichen species on the Manx shoreline, which are an under-recorded group. Man-made structures can be valuable lichen habitats too, such as the old Peel swimming pool.

Above the lichen zone flowering plant communities occur, initially of specialised species, but then grading into coastal grassland and heath (See Geffen *et al.* 1990; Lamb 1999 for details). The landward limit of maritime communities is not easily defined.

On depositing shores the strandline supports a variety of salt tolerant plants – such as sea rocket, sea sandwort, sea holly, prickly saltwort, oraches, sea beet and rare species including Oysterplant (*Mertensia maritima*). Shingle beaches have long established colonies of sea kale (*Crambe maritima*) (Figure 8) and yellow horned poppy (*Glucium flavum*).



Figure 8. Sea kale in Derbyhaven bay. Photo: DEFA.

There are extensive dune systems, above the strandline, along the northwest coast up to the Point of Ayre, which support pyramidal orchid, dune fescue and the common lizard (all are protected under the Isle of Man Wildlife Act 1990). The Isle of Man Cabbage (*Coincya monensis*) is also found in a few locations. Purple rampion-fumitory (*Fumaria purpurea*), a UK Biodiversity Action Plan (BAP) priority species, has been recorded on the soft cliffs. Sand martins can also be found on eroding sand cliffs. Elsewhere the strandline is backed by coastal grassland or heath, some of which is protected. See MMEA Chapter 3.7 (Marine and Coastal Conservation) for further information on site designation. Coastal reed beds are very uncommon and recorded at 6 sites, including on the Dalby Coast (a designated site) and at Scarlett.

There is a limestone coastline in the south between Santon Gorge ASSI and Port St Mary Ledges and Kallow Point ASSI. Another BAP priority species, purple milk vetch (*Astragalus danicus*) grows on the short turf on this limestone section of coast. Other important coastal grassland and saltmarsh areas on limestone, at Langness and Scarlett support chestnut rush (*Blysmus rufus*), parsley water dropwort (*Oenanthe lachenalii*), strawberry clover (*Trifolium fragiferum*), common sea lavender (*Limonium vulgare*) and grass-leaved orache (*Atriplex littoralis*) (all protected under the Wildlife Act schedule 7).

Much of the coastal grassland is diverse with kidney vetch, spring squill and rock species: *Spergularia* spp, thrift, rock samphire and sea campion.

In places, particularly on the east coast there are remnants of native oak/hazel woodland; Bulgham, Dhoon, Cornaa, Glen Maye, Santon and Skincoe (Dubbeldam 2011). In ungrazed coastal flushes royal fern, brookweed, hemp agrimony and other wetland plants thrive. While in grazed flushes there are diverse communities with many sedge species, including bristle clubrush and spike rushes.

Maidenhair fern (*Adiantum capillus-veneris*) is near its northern limit and grows on wet tufa deposits and rock cracks just above the splash zone between Port Erin and Peel.

Current research and surveys

Current surveys include plant recording for the new Flora of the Isle of Man and repeat Phase 2 surveys of terrestrial sites identified as having conservation value in 1994-2000.

Following the closure of the Port Erin Marine Laboratory in 2006, very little locally based intertidal research has continued, with the exception of surveys for Environmental Impact Assessment and student projects. However, time series monitoring has continued under the supervision of Prof Stephen Hawkins of Southampton University, working with the DEFA. This is important in the context of the effects of global warming on changes in species distributions. For further information see MMEA Chapter 2.2 (Climate Change in Manx Waters).

Sargassum muticum surveys have been completed in 2016 (Naldrett 2016) replicating the work undertaken in 2013 by Giesler, looking at abundance and distribution. The latest finding revealed that *S. muticum* has spread, since the initial survey, from 19 sites to 23. In addition to this survey, Ramsey harbour wall has been monitored since 2013 for invasive species *Crassostrea gigas* and *Austrominius modestus*. The findings have revealed that *C. gigas* is declining whilst *A. modestus* is increasing in abundance. Supporting this work is the Non-Native Species Public Sightings Scheme set up by Manx Wildlife Trust (MWT) where members of the public can report any invasive species they find.

Data availability: collection & ownership

The coastal ecology of the Isle of Man has been surveyed in considerable detail. A comprehensive general overview is provided by Geffen *et al.* (1990), and the references in that work list many important earlier studies. It also covers some subtidal habitats, but nevertheless presents a clear summary of intertidal and maritime communities. Detailed Phase 1 (mapping of broadly defined community/habitat combinations or biotopes) intertidal surveys are reported in Holt (1996-1999). These are the results of surveys commissioned by the MWT, and were based upon the methods of the BioMar Lifeform classification (Connor *et al.* 2004:

this is the latest version of the classification, which has replaced the 1997 version used for these studies). These intertidal surveys have been supplemented by a study of the supra-tidal coastal communities also commissioned by the MWT (Lamb 1999). This survey extends inland “as far as there was a significant coastal influence”. The above studies by Holt and Lamb were integrated to produce a series of detailed maps of coastal habitats (MWT 1999). More detailed intertidal surveys were conducted in 1999-2002. The Phase 1 surveys were repeated for the entire coastline, incorporating ArcView GIS mapping. In addition, a number of more detailed Phase 2 (species lists within specific biotopes, with semi-quantitative species assessments (Hiscock 1996)) surveys were carried out, focussed on rocky shores around the south of the Isle of Man. The detailed data is held on CD-ROM (including aerial photographs) by DEFA and a summary of the methodology and results is available (CMACS 2002). Subsequent additional Phase 2 surveys are reported in PEML (2003).

Some important coastal habitats have been highlighted in surveys of sites of potential marine conservation areas (Gubbay 2000; Koskinen 2004). Detailed intertidal surveys have been carried out in relation to coastal developments (actual or proposed): the Ronaldsway runway extension (CMACS 2007), with a report on follow-up studies in submission to the Department of Infrastructure; IRIS sewage project (Holt et al. 1994); Ramsey marina (Nadasen 1993).

There is also a very substantial body of work on Isle of Man coastal communities in the scientific literature, predominantly resulting from activities of the Liverpool University Port Erin Marine Laboratory (closed in 2006) and associated workers.

Initial considerations for future marine development

Coastal ecosystems are susceptible to major anthropogenic impacts, as well as to natural environmental impacts. Generally coastal communities and species are resistant to natural environmental variations. The highly fluctuating environment which they experience on a tidal, diurnal and lunar basis requires physiological flexibility and tolerance: consequently, the effects of climate change and extreme weather may be mitigated. Nevertheless, unusual seasonal temperatures can result in significant mortality (e.g. Hawkins and Hartnoll 1985). Toxic phytoplankton blooms can also damage coastal ecosystems, though it is usually debatable whether these are of natural or anthropogenic origin (Sellner et al. 2003). Likewise temperature rise due to climate change results in a progressive northward movement of species boundaries. Thus the northern limpet (*Collisella tessulata*), previously common around the Island, appears to have disappeared in recent years as has the tortoiseshell limpet (*Tectura testudinalis*). This was not found in the Isle of Man in the 2000s having been recorded in the 1970s and early 1980s (SJ Hawkins pers. ob.). However, the loss of northern species is being compensated for by the incursion of southern warm-water species. Poli's stellate barnacle (*Chthamalus stellatus*) has recently arrived in Manx waters, first recorded in 2004 (Mieszkowska et al, 2006). See also, MMEA Chapter 2.2 (Climate Change in Manx waters). This increase in temperature may also increase the presence of non-native species resulting in their distribution and abundance.

Global warming may also result in a modest sea level rise, between 0.24 m and 0.54 m, (Acclimatise 2006). This will not seriously impact most of the coastline, with communities having the capacity to make compensating up shore migrations. The exception is where the upper shore is constrained by sea walls and promenades, as in many of the sandy beaches. Potentially this could result in a loss of intertidal area, with deleterious consequences for recreation and tourism. Climate change is also predicted to increase storm events, wind strengths and wave action: this may affect communities in various ways and could certainly affect erosion rates. See also, MMEA Chapter 2.1 (Hydrology, Weather, Climate & Climatology).

Coastal erosion is a natural phenomenon along the northwest and northeast coasts of the Island, and in historical times the shoreline in places has receded by at least a mile. The main eroding areas are from Glen Wyllin to Jurby Head on the northwest coast, and from Port Cranstall to Dog Mills on the northeast. Erosion will only increase as a result of sea level rise and increased storm action associated with global warming. The accepted wisdom is to allow erosion to take its course: preventative measures would be prohibitively costly, and only likely to divert the erosive action to other areas. See also MMEA Chapter 2.1 (Hydrology, Weather, Climate & Climatology).

Anthropogenic Impacts

The major overt anthropogenic impacts on coastal ecosystems are the various forms of coastal development. These comprise diverse forms of hard engineering – such as harbours, water-retention systems, breakwaters and coastal protection. Recent examples in the Isle of Man are the construction of the airport runway extension at Ronaldsway, which has overlain a limestone shore of considerable environmental interest. A second example is the rock protection over the upper shore at Gansey Beach. These developments have twofold effects. Most obviously they destroy the habitats which they overlie. Secondary effects include changes in sediment transport and deposition regimes, potentially leading to beach erosion or accretion. Water-retention systems have recently been established in Douglas and Peel harbours, with substantial, but undocumented effects upon their ecology.

There are also pollution risks to coastal ecosystems. Previously, raw sewage discharge occurred around the coast, though due to its limited scale the impacts appeared to be on health and aesthetic grounds, rather than on the ecosystems (no anoxic events occurred as in some other areas – see Pearson & Rosenberg, 1978). However the implementation of the IRIS scheme in Douglas and around the south of Island, and more recently Ramsey in 2017, resulting in the treatment of most discharges, has limited this problem. Estuarine sediments at Peel and Laxey have enhanced levels of heavy metals (copper, lead and zinc) as a legacy of past mining activity within the watersheds. As a result of dredging within certain harbours, coastal waters are now showing elevated levels of heavy metals and Poly aromatic hydrocarbons (PAHs) in sediments and biota. This is being closely monitored and discussions are being had how best to address this issue.

Persistent Tri-butyl-tin (TBT) residues as a result of their use in antifouling paints (now banned in the Isle of Man) are a persistent problem. The most overt effect is on the dog whelk *Nucella lapillus* resulting in the 'imposex' condition: this was observed notably in Port Erin and Port St Mary (Spence 1989). More recently, Howe (2010)

reported elevated levels of TBT in Ramsey and Port St Mary inner harbour sediments, although imposex assessments could not be made due to a lack of dog whelks. Other mollusc species may be affected, but without further input effects should decline with time. It is hoped that future monitoring will be undertaken as a result of OSPAR suggesting the need for greater protection for *N. lapillus* and will follow earlier work by Spence (1989) and Howe (2010).

Other anthropogenic impacts are of less local origin. Oil spills are a high-profile risk to coastal systems, both in respect of the toxicity of the oil, and the potential damage resulting from clean-up efforts. The Torrey Canyon spill is well documented in these respects (Southward and Southward 1978), though current methods of oil dispersal should be much less damaging.

Offshore sediment extraction has been implicated in coastal erosion. This was recently mooted for Manx waters, but currently not approved or implemented although licences for aggregate prospecting were issued to two companies for Manx waters in 2007-2008. An example is the speculation that erosion on Horton Beach on the Gower Peninsula has increased as a consequence of dredging on Helwick Bank two miles offshore, (discussed in Phillips 2008). Radioactive discharge from the Sellafield works has been a cause for concern, but there has been no evidence of health or environmental impacts in the Isle of Man. See MMEA Chapter 2.4 (Marine Pollution).

Sensitivity of receptors

As stated above, generally coastal communities and species have an inbuilt tolerance to environmental variation. In general rocky shore species and communities are more robust, and quicker to recover from impacts such as pollution events. Soft shore communities, especially those in sheltered environments such as estuaries and mud flats, are more sensitive.

Notwithstanding this general resilience, coastal communities will nevertheless respond to environmental trends. There is ample past evidence of species abundance increasing or decreasing in response to temperature fluctuations (Southward and Crisp 1954). If temperatures rise in the course of global warming it is inevitable that more species will disappear, and that new species will replace them. There is evidence that this is happening already.

Likelihood of occurrence

Several changes seem certain to occur. Erosion around the north of the Island will continue, and as a result of the increased storm activity associated with global warming, may well intensify. There will be the loss and gain of species. Some will spread naturally. Others may introduce non-native aliens that take advantage of the changed conditions. These may have detrimental impacts on natural communities. There may also be impacts on the reproductive patterns and growth rates of species. There is expected to be a rise in sea level. With the measures in place, water quality should steadily improve although a concern remains for ocean acidification.

Pressure to develop the coastal areas is certain to continue, and it is essential that full consideration is given to the environmental impacts and the appropriate mitigation measures put in place.

Mitigation

Nothing done on a local scale will prevent the processes of global climate change. The attendant sea level rise could be mitigated by modifications to the top-shore protection systems. To allow the landward extension of sandy beaches would in most cases be impractical and or costly, due to the developments along the immediate shore. Increasing the height of existing protection to prevent flooding is a more practicable, and perhaps essential, measure in sensitive areas.

Erosion is an ongoing process that is only likely to become more severe with sea-level rise and increased storm action. Prevention would be extremely expensive, and if implemented on a local scale, likely to increase erosion in other areas. The rational policy is to allow erosion to take its course.

It has been emphasised above that the major threat to coastal ecosystems is coastal development, and the major mitigation in this respect would be an enlightened and protective approach by the planning authorities. An understanding of the human and economic benefits of coastal habitats and the risks involved in cutting corners with environmental assessments will assist in this.

In all such developments early stakeholder engagement is essential as local experts and residents hold local and detailed knowledge in many cases.

The Island Government expects best practice standards and industry standard guidelines to be followed, such as the Guidelines on Ecological Impact Assessment in the United Kingdom (IEEM 2006; IEEM 2010). Strategies of avoidance, mitigation and compensation will need to be employed as appropriate to the impacts involved and the level of significance of the species and habitats affected.

Residual effects (post-mitigation)

The major effects post-mitigation have resulted from the absence of effective mitigation measures. Valuable areas of coastal ecosystem have been lost, and others have not been given the protection which they merit.

Regular monitoring of sites, including good provision for post-construction monitoring will assist in this, in addition to understanding lessons learnt from other similar developments.

Confidence and knowledge gaps

The coastal ecosystems of the Isle of Man are in general well studied. Indeed, in the southern area, studies resulting from the activity of the Port Erin Marine Laboratory have generated a baseline of information in excess of most of the UK coastline (though not always quantitatively repeatable). In contrast, the exposed depositing

shores in the north of the Island have not been examined in the same detail. This should be remedied if future changes are to be identified.

Whilst there are extensive Phase 1 surveys around the Island, a resurvey on that basis is likely to reveal modest changes in species composition or abundance resulting from climate change or other variables. Phase 2 surveys are restricted in number, and biased to the southern rocky shores. A resurvey on this scale can reveal subtle changes in community structure. Hence there is a strong case for further Phase 2 studies, especially in the northern parts of the Island.

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