Intertidal Survey of Cuskinny Bay, Co. Cork

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1.0 Introduction

The managers of Cuskinny Nature Reserve commissioned a survey of the intertidal zone of Cuskinny Bay. Cuskinny Nature Reserve is set on the lower reaches of the Ballyleary Stream and consists of twelve hectors of mixed habitat. Given its proximity to the coastline, there are a number of marine influences on the Nature Reserve, including salt-water incursions and influxes of marine species. Therefore, a deeper understanding of the health and functioning of Cuskinny Bay would lead to a more complete view of the Nature Reserve as an ecosystem.

The main objectives of this survey were to determine the habitat types within the intertidal zone of Cuskinny Bay, their community compositions, health, and relative importance both locally and nationally. This survey was also used to establish a baseline dataset for continued long-term monitoring within Cuskinny Bay.

Site Description:

Cuskinny Bay is situated on the southern shore of Great Island, along the south coast of Ireland. The bay itself is approximately 98 km^2 in size and consists predominantly of soft sediment substrates. Intertidally, the shore is dominated by course mixed substrata, which is exposed by a strong inshore current that is forced across the bay and along the shore. The ecology of this site is also influenced by freshwater outflow from the Ballyleary Stream and Cuskinny Marsh, which enter the sea at this site.

Cuskinny Bay is set within the Special Protection Area of Cork Harbour, site number 004030 (NPWS 2004). Under the European Habitats Directive (79/409/EEC) this designation protects the annual influx of approximately 20,000 wintering waterfowl that rely on this internationally important site every year (NPWS 2004). Cuskinny Bay itself is noted specifically for its importance to salmonid populations (Halcrow 2007) and is boarded by Cuskinny Marsh Nature Reserve, which is a designated a proposed Natural Heritage Area (site number 001987).

The waters surrounding Cuskinny Bay are highly influenced by anthropogenic activity, due to local industry and maritime traffic associated with the two nearby ports of Cobh and Ringaskiddy. Although Cuskinny Bay is known for bait collecting, it is more commonly utilised as a recreation beach, especially during the summer given its proximity to Cobh. Cobh is a large town with a population of approximately 11,303 local inhabitants (Government of Ireland, 2007), which number doubles during the summer season.

2.0 Materials and Methods

The objectives of this survey were to:

- Map the habitat within the intertidal zone of Cuskinny Bay
- Establish a baseline dataset describing the structure of the communities present.

These objectives were achieved using the following methodology.

2.1 Biotope Mapping

A biotope is the unit used in the mapping of intertidal zones. The mapping of biotopes, as opposed to habitats, allows for the complexity of the intertidal environment to be explained in more detail. A biotope refers to a physical environment and its distinct assemblage of conspicuous species (Hiscock 1996), as opposed to a habitat, which refers to a specific species or population. The biotopes of the shore were mapped using the standards set out by the Joint Nature Conservation Committee (JNCC) (Connor *et al*. 2004) and adapted to Ireland by Emblow *et al.* 1998 and Davies *et al.* 2001. The biotopes were identified using the classification developed under the LIFE funded Biomar project (Connor *et al*. 1997).

To map the biotopes of the intertidal zone at Cuskinny Bay a surveyor walked the shore at spring low tide. Biotopes were identified and mapped directly onto a wireframe map of the area made from a simplified Ordnance Survey Ireland map. The surveyor also complied a species list within each identified biotope to ensure that the species present corresponded with that described by the JNCC (Connor *et al.* 2004).

Within the loose substrate biotopes the infauna was sampled using the methods set out by Davies *et al*. 2001. Two spade loads (approximately $0.02m^2$) of sediment that were dug to a depth of 20 – 25 cm and sieved through a 0.5mm sieve on site using seawater, the remainder of the sample was preserved in 70% alcohol and later identified back in the lab (Davies *et al*. 2001). This procedure was replicated 10 times across the biotope.

2.2 Community Composition

A community composition completed using a SACFOR scale along a line transect. This survey is semi quantitative and gives a better resolution of the community structure then a biotope map. Unfortunately, the results of such a survey are not amenable to statistical analysis. However, if conducted regularly as part of a long-term monitoring programme, this type of survey can be effectively used to detect changes within a community.

The transect lines on which the survey was conducted were selected by refereeing to the biotope map. From the biotope survey it was determined that the shore could be divided up into four general sections of zonation. Within each section a transect survey was conducted at a randomly selected point. Each transect began at the high water mark (HWM) and ran down along the shore to the shoreline at a spring low tide. This starting point for each transect was marked using a hand held Garmin GPS unit.

At each station three quadrates were dropped randomly and the associated communities within were recorded. Each station was determined by a 50cm change in the vertical shore height, which was determined using the two-stick method. All survey work was carried out on the spring tides to ensure that as much of intertidal shore was surveyed as possible. Within each $25cm^2$ quadrate the species were recorded using a modified version of the SACFOR scale from Hawkins & Jones (1992)(Table 1). For analysis this data was presented in tables and used to describe the general community composition of the survey area.

Table 1: Shows the breakdown of the SACFOR scale used to describe the community structure of the species on the shore. This scale has been modified from Hawkins & Jones (1992)

Species	Abundance category				
	Abundant	**Common**	**Frequent**	**Occasional**	**Rare**
Barnacles *Chthalamus stellatus* *Chthalamus montagui* *Semibalanus balanoides* *Austraminius modestus*	>250 per $0.5m^2$ quadrat.	25-250 per $0.5m^2$ quadrat.	2.5-25 per $0.5m^2$ quadrat.	0.025-2.5 per $0.5m^2$ quadrat.	Only a few found per per $0.5m^2$ in 30min search.
Limpets *Patella vulgata* *Patella ulyssiponensis*	12.5 per $0.5m^2$ or >50% of limpets at certain levels.	2.5-12.5 per $0.5m^2$, 10% to 50% at certain levels	0.25-2.5 per $0.5m^2$, 1% to 10% at certain levels	<0.25 per $0.5m^2$ on average, <1% of population	Only a few found in 30min. search.
Topshells *Osilinus lineatus* *Gibbula umbilicalis* *Gibbula cineraria*	Exceeding 2.5 per $0.5m^2$ generally.	0.25-2.5 per $0.5m^2$ sometimes very locally over 5 per $0.5m^2$	<0.25 per m^2, locally sometimes more	Always <0.25 per $0.5m^2$.	Only a few found in 30min. search.
Periwinkles *Littorina littorea*	>12.5 per $0.5m^2$.	2.5-12.5 per $0.5m^2$	0.25-2.5 per $0.5m^2$		Only a few found in 30min search.
Anenomes *Actina equina*	Many in almost every pool and damp place	Groups in pools and damp places	Isolated specimens in few pools		A small number under 5 found after 30min search.
Algae and *Mytilus sp.*	>30%	5-30%	<5%	Scattered individuals.	Few plants 30min search.

2.2.2 Barnacle Survey

As an abundant, persistent and sessile community, along the intertidal zone of Cuskinny Bay, barnacles were selected a bioindicator species that could be easily utilised for long-term monitoring dataset. This competitive and sensitive group of organisms can describe a lot about a shore, including exposure, temperature, and levels of disturbance. This survey was conducted along the eastern section of Cuskinny Bay where the substrate type is predominantly hard. A transect line was randomly laid out along the rocky outcrop which dominates the eastern shore. Along the transect, ten $0.15cm^2$ quadrates were randomly dropped at each station height for all four species of barnacle present. Station heights were determined by a drop of 30 cm in the vertical shore height, which was determined using the two-stick method. The results of this survey would then be depicted in a kite diagram showing the vertical distribution of the species across the shore.

3.0 Results

3.1 Biotope Mapping

Fifteen biotopes were identified along the littoral zone of Cuskinny Bay, within which a total of 85 species were recorded. The locations of these biotopes can be seen in the biotope map below (fig. 1). A brief description of each biotope, based on the JNCC standards, can be found in appendix 2. During the mapping process it became clear that the biotopes of the shore could be divided into four general sections of zonation. These sections, along with their respective species richness (n)(appendix 3), have been described in the following paragraphs.

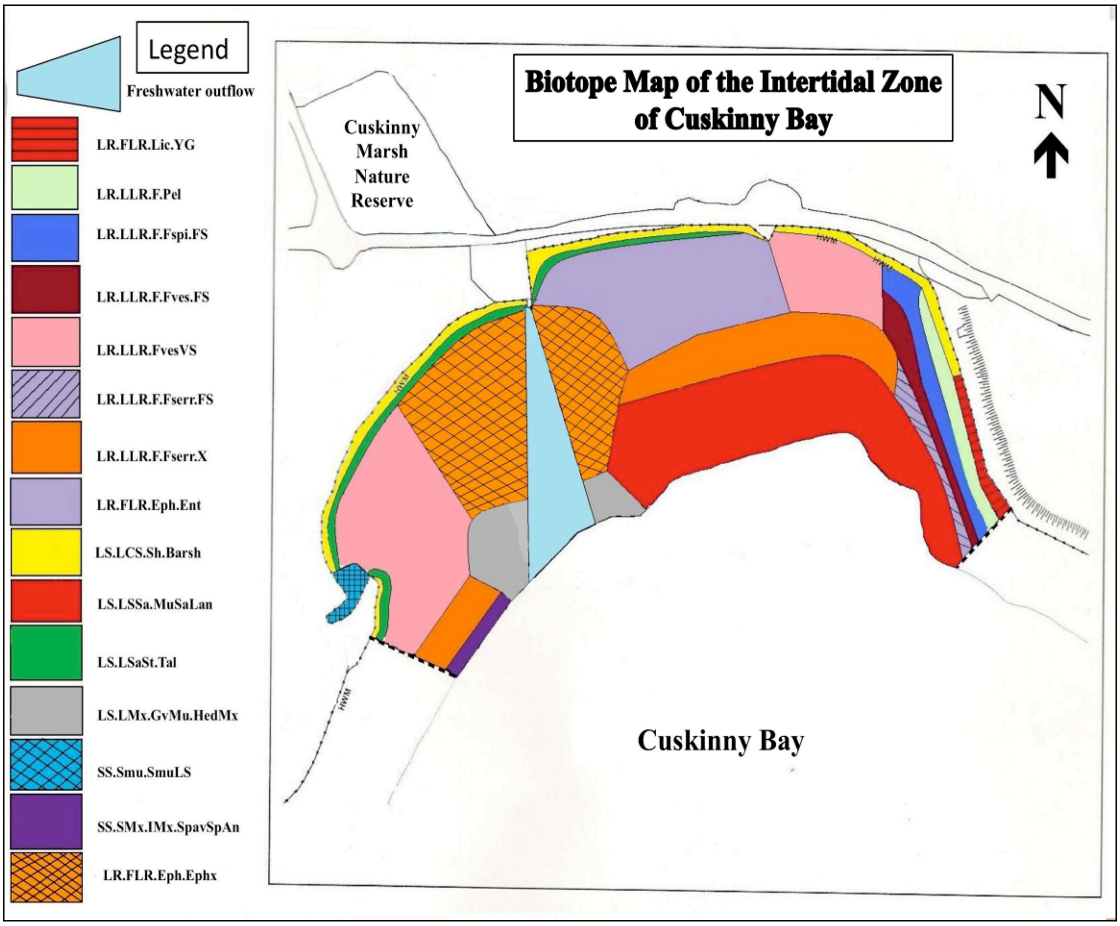

Figure 1: This map shows the location and extent of the fifteen biotopes found along the intertidal section of Cuskinny Bay. The scale of the map is 1:5000m. The legend shows the short code of the biotopes present. Full descriptions of these short codes can be found in appendix 1

Section one begins at the eastern side of the bay and is characterised by a rocky outcrop. This section demonstrates a clear pattern of zonation that begins, at the high water mark (HWM), in a zone of yellow and green lichens on supralittoral rock (LR.FLR.Lic.YG)(n=7). Below this biotope, moving towards the low water mark (LWM), the following biotopes occur; *Pelvetia canaliculata* on sheltered littoral fringe (LR.LLR.F.Pel)(n=16), *Fucus sprialis* on full salinity sheltered upper eulittoral rock (LR.LLR.F.Fspi.FS)(n=18), *Fucus vesiculosus* on full salinity moderately exposed to sheltered mid eulittoral rock (LR.LLR.F.Fves.FS)(n=31) and ending in a biotope dominated by *Lancie conchilega* in littoral sand (LS.LSSa.MuSaLan)(n=22). As can be seen in figure 1, this eastern section of the shore, demonstrated the largest variability of biotopes of all four sections.

Further west along the shore, we move into the second section in which the biotopes are characterised by unstable mixed course sediments. The upper shore in this section is dominated by species barren littoral shingle (LS.LCS.Sh.Barsh)(n=0). Below which forms a species poor biotope of *Fucus vesiculosus* zone that is characterised by variable salinity and mixed substrata (LR.LLR.FvesVS)(n=16). Further west along the shore this biotope shifts into a biotope of further reduced species richness that is dominated by *Ulva* spp (previously known as *Entramorpha* spp.). and characterised by a even greater freshwater influence on unstable substrate (LR.FLR.Eph.Ent)(n=7). Below both of these biotopes is a biotope that is dominated by *Fucus serratus* that is influenced by unstable substrate (LR.LLR.F.Fserr.X)(n=31). Finally, as this section meets the low water mark (MLWS) it moves into a biotope dominated by the bristle worm *Lancie conchilega* (LS.LSSa.MuSaLan)(n=22).

West of section two we move into the third section in which the full influence of the freshwater outlet can be seen in the biotopes present. As with the previous section, the high shore is characterised by a barren littoral shingle biotope (LS.LCS.Sh.Barsh)(n=0), followed by a species poor *Talitridae* dominated upper shore (LS.LSaSt.Tal)(n=1). As we move towards the low water mark the biotope shifts to a community characterised by ephemeral green and red seaweeds, variable salinity and unstable substrate (LR.FLR.Eph.Ephx)(n=5). Lower on the shore a mixed gravel substrate community develops. This biotope is dominated by the polychaete *Hediste diversicolor* (LS.LMx.GvMu.HedMx)(n=2). Within both of these species poor habitats it is important to not that the redox level was close to the surface at approximately 2-4cm.

The western, fourth and final section of the shore, is characterised by the shingle substrate, in which we see the continuation of the species poor barren littoral shingle biotope (LS.LCS.Sh.Barsh)(n=0) and *Talitridae* dominated community (LS.LSaSt.Tal)(n=1). As we move down towards the lower shore another species poor biotope of *Fucus vesiculosus* occurs. This biotope is characterised by variable salinity and mixed substrata (LR.LLR.FvesVS)(n=16). Towards the low shore of this section we move into a biotope dominated by *Fucus serratus* and unstable substrate (LR.LLR.F.Fserr.X)(n=31). Finally this section ends in a species rich biotope dominated of *Sabella pavonina* and sponges, on infra littoral mixed sediment (SS.SMx.IMx.SpavSpAn)(n=10).

3.2 Community Composition

The results of the transect survey confirm the presence four general sections of zonation along the shore of Cuskinny Bay. The transect showing the highest complexity in community structure was that of transect 1 (N 51° 51' 27.01", W 08° 15' 38.55") , which was taken along the eastern shore of Cuskinny Bay. As can be seen from SACFOR abundances recorded in table 2 and 3, the substrate that dominated this community was rock. This rocky substrate supported medium to high abundances of all eleven groups of organisms in this survey (table 2 and 3).

Transect four (N 51° 51' 25.50", W 08° 15' 57.69"), on the western shore of Cuskinny Bay showed the second highest community complexity. From table 3, it can be seen that the upper reaches of the transect were dominated by shingle. This shingle was characterised by a low species diversity. However, as the substrate type shifted to a rock within the lower reaches of the transect, the community composition diversified with seven groups being recorded.

Finally, the two transects which showed the lowest complexity were transects 2 (N 51° 51' 31.65", W 08° 15' 41.76") and 3 (N 51° 51' 31.82", W 08° 15' 50.63"), along the northern shore of Cuskinny Bay. Both transects were dominated by soft sediments and showed low diversity of life. As with transect 4, a species barren shingle bank occurred close to the high water mark along transect 2 and 3. Although the lower reaches of these transects were abundant in bristle worms they showed little diversity of other groups such as producers, grazers and predators.

Table 2: Community compositions recorded along transect 1 and 2 using the SACFOR abundance scale (S=superabundant, A=abundant, C=common, F=Frequent, O=Occasional, R=Rare). The average abundances for each station along transects are shown.

	Transect 1					Transect 2			
	ST1	ST2	ST3	ST4	ST5	ST1	ST2	ST3	ST4
Algae		S	C	A	A			R	C
Anemones				R	R				
Barnacles		R	A	A	O				
Bristle Worms					R			C	A
Dog Whelk					O				
Lichens	O								
Limpets			C	C					
***Mytilus* sp.**			O	O					
Periwinkles		O	C	O	C				
Rock	A	A	A	S	A				
Shingle				O		S	S		
Sediment								S	S
Terrestrial Plants	R								
Topshells			O	C	A				

Table 3: Community compositions recorded along transect 3 and 4 using the SACFOR abundance scale (S=superabundant, A=abundant, C=common, F=Frequent, O=Occasional, R=Rare). The average abundances for each station along transects are shown.

	Transect 3				Transect 4				
	ST1	ST2	ST3	ST4	ST1	ST2	ST3	ST4	ST5
Algae		A	A	R		R	C	C	A
Anemones									
Barnacles								O	A
Bristle Worms			O	C					
Dog Whelk								R	R
Lichens									
Limpets								R	
***Mytilus* sp.**									
Periwinkles								A	C
Rock								S	A
Shingle	S	O			S	S	S	O	O
Sediment		S	S	S					O
Terrestrial Plants									
Topshells								C	C

3.2 Barnacle Survey

The four species of barnacle found along the intertidal zone of Cuskinny Bay were represented along this transect; *Austrominius modestus*, *Chthalamus montagui*, *Chthalamus stellatus* and *Semibalanus balanoides*. The kite diagram in figure 2 shows the vertical distribution of these four species across the transect. Along this transect the barnacle band began approximately 3m above chart datum and continued down the shore to the last station which was 0.25m above chart datum. The two Chthamalidae species recorded along this transect occupied the upper reaches of the transect, with *C. montagui* occurring more frequently then *C. stellatus*. As can be seen in figure 2 *S. balanoides*, showed the highest abundance of all four barnacles along the transect, however its distribution was restricted to the lower section of the transect, starting at approximately 2.3 m above chart datum. Unlike the three native species found along the transect, the invasive barnacle *Austrominius modestus* occurs along the length of this transect, however it only showed dominance along a narrow band of the mid shore approximately 2 – 2.5 meters above chart datum.

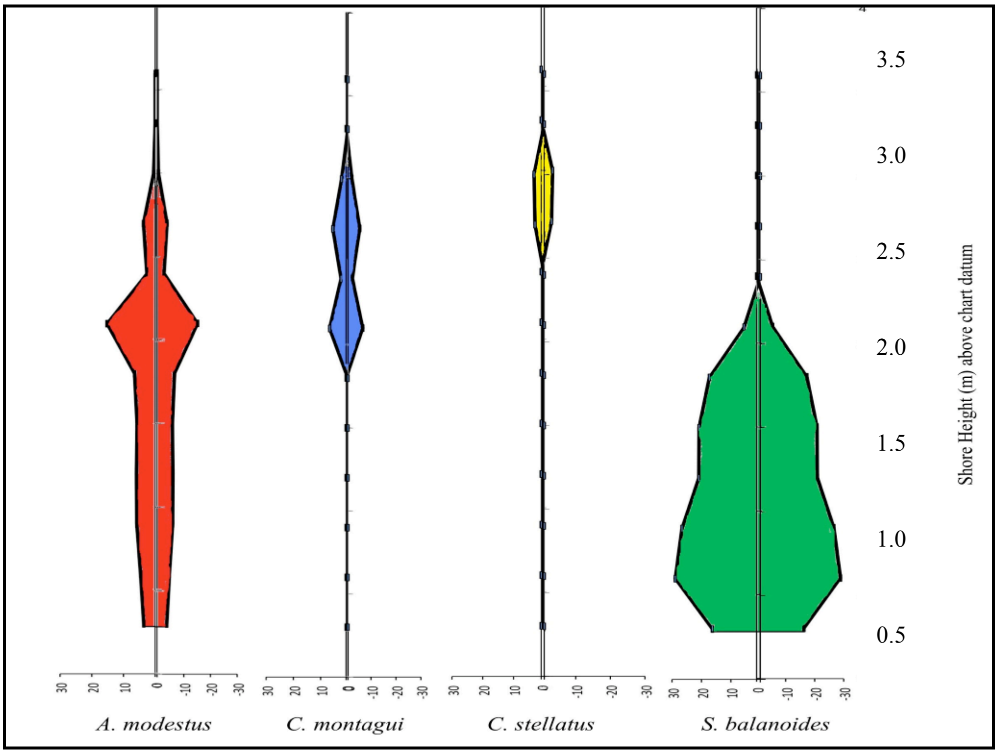

Figure 2: Shows the vertical distribution of intertidal barnacles at Cuskinny Bay. Abundance data (linear scale from 0 to 60 barnacles per $15cm^2$; shore height from 0 to 4.0m) are presented as kite diagrams.

4.0 Discussion

The fifteen biotopes found along the intertidal zone of Cuskinny Bay are characteristic of semi-sheltered, freshwater influenced, mixed substrate communities. The results of the survey showed a number of trends in community composition and species richness across the shore. While the species richness recorded for each biotope is lower then that described by the JNCC as characteristic, there are a number of indicators of a healthy community, including the presence of two species with local and national importance.

4.1 Variation in species richness across the site

The intertidal zone of Cuskinny Bay consists of areas of rock face, shingle, course sediments and fine mud. As the substrate composition changed along the shore, so to did the species richness (n). Across the site high species richness was associated with stable surfaces such as rock face and fine-grained substrates, and a low species richness, with medium sized substrates. This trend was more obvious along the mid to upper section of Cuskinny Bays' intertidal zone. Evidence of this trend can be seen in both the biotope map (fig 1), and the community composition survey (table 2 and 3).

During the mapping of the biotopes the highest species richness recorded was of 31, and this was found along a rock face in a community dominated by the algae *Fucus vesiculosus* on full salinity (LR.LLR.F.Fves.FS). The two lowest species richness were found along sections of unstable medium sized substrates of shingle with species barren littoral shingle (LS.LCS.Sh.Barsh) and a *Talitridae* dominated community with a species richness of 1 (LS.LSaSt.Tal). This trend was also mirrored within the community composition survey where the occurrence of multiple groups was associated with the high abundance of rock or sand and mud (table 2 and 3), and the low number of groups was associated with the occurrence of shingle (table 2 and 3). When rock was recorded as superabundant (S) it was associated with the occurrence of up to 7 other groups of organisms (table 2 and 3). Whereas the when shingle was recorded as superabundant it was associated with no other groups of organisms along some stations (table 2 and 3).

The low species richness associated with medium sized intertidal substrates is influenced by two major factors. Firstly, medium sized substrate is highly mobile and prone to disturbance, with stones being constantly overturned by wave action, thus crushing both sessile and mobile organisms that live on or under them (Sousa 1980). Secondly, shingle and cobble substrates are small objects and are not buffered from the sun as large outcrops of rock face would be therefore cobbles can heat up dramatically in sunlight during low tide exposure, thus creating thermal instability (Bertness 1989).

The variation biotopes and species richness across the site was further influenced by the presence of the freshwater outflow form Cuskinny Marsh and the Ballyleary Stream. While all intertidal species are, to varying degrees, tolerant to changes in salinity, few can tolerate persistent low salinity levels created by a year round freshwater influence such as this. For this reason the species richness of the two biotopes surrounding the outflow area are low. The mid to upper shore around the outflow area is dominated by a community of ephemeral green and red seaweeds (LR.FLR.Eph.Ephx) that have a species diversity of 5 (fig. 1). Along the lower shore this community shifts into a biotope dominated by the annelid *Hediste diversicolor* Müller 1776 (LS.LMx.GvMu.HedMx) with a species richness of only 2 (fig1).

Aside from the freshwater influenced zone, the lower shore of Cuskinny Bay has a high biodiversity. This high biodiversity is due to the presence of two bioengineering species, *Lancie conchilega* Pallas 1766 and *Sabella pavonina* Savigny 1822, that both define their respective biotopes. The bristle worm *Lancie conchilega* defines a biotope in littoral mud (LS.LSSa.MuSaLan)(fig. 1) with a species richness of 22. *Sabella pavonina* defines a biotope of sponges and on mixed littoral sediment (SS.SMx.IMx.SpavSpAn)(fig. 1) with a species richness of 10. Both of these species have local, national and international importance.

4.2 Species of importance

Lancie conchilega Pallas 1766 is designated as an Annex V species under Ospar as it is both threatened and declining species (Tyler-Walters and Hiscock 2005). The presence of extensive bed of *L. conchilega*, such as those along lower sections of the shore, are an indication of the health of the site as they are considered to prefer clean sediments (Agar 2008). This is an important fact as Cuskinny Bays' waters have been noted as important waters for local populations of salmonids that require clean water (Halcrow 2007).

L. conchilega acts as a bioengineer by consolidating the sediment around it, and obstructing the activities of predatory burrowers and enabling other sedentary animals to establish themselves (Wood, 1987). As stable habitat is a limiting resource within the marine environment (Little and Kitching 1996), *L. conchilega* are functionally very important for increasing biodiversity locally (Godet *et al*. 2008), even expanding the niche of several species (Rabaut *et al*. 2007). This increase of biodiversity does not only have a localized impact but also has an important impact within the wider ecosystem. Additionally, *L. conchilega* is an important food source for wading birds. As Cork Harbour is a Special Protection area, of internationally importance due to the 20,000 wading birds which winter there every year (NPWS 2004), such as the curlew which are one of the main predators of (Goss-Custard *et al*. 1977) *L. conchilega* numbers have an international importance.

Another important species found along the shore of Cuskinny Bay is *Sabella pavonina* Savigny 1822. *S. pavonina*, commonly known as the peacock fan worm, has been recorded as widespread around the coasts of Britain and Ireland (Avant 2008). However, high densities this species are rare and hugely important as they form biodiversity hot spots (Dyryndam 2005). Though the population of *S. pavonina* found at the site could only be described as a community of moderate density, it appears to be associated with an increased species richness (n=10). Although the importance of *S. pavonina* is noted by organisations such as the NPWS (2006) and MarLIN, information on the intertidal impact and biology of this species is limited.

Internationally, the importance of habitat engineers such as *L. conchilega* and *S. pavonina* are widely agreed upon. However, despite the importance of these species being recognised by organisations such as MarLIN (Marine Life Information Network), intertidal communities of these two species are not currently protected under the EU Habitats Directive (79/409/EEC). Under the Habitats Directive a species must have a certain longevity and persistence in order to be defined and protected as a biogenic species. Unfortunately, there are conflicting records as to the longevity and persistence of communities of both *L. conchilega* and *S. pavonina*. But there is currently a push to change the definition of a biogenic reef within the Habitats directive, so that intertidal populations of these important species can be protected (Raubaut *et al*. 2007, 2008, Callaway *et al*. 2010).

This conservation status is also mirrored within Irish legislation where the importance of these species is only noted but not defined. In particular reference to the large shallow bay of Cork Harbour SPA (site code 004030), the NPWS have classed subtidal communities of *L. conchilega* and *S. pavonina* as ecologically significant and infrequent to rare (NPWS 2006). Along with the importance of these communities their weaknesses have also been noted. In 2006 the NPWS stated the importance of ensuring the availability of large areas of habitat for the long-term survival of the species subtidally. It is becoming increasingly more obvious that the health and functioning of protected areas such as Cork Harbour, and the species that they contain, depends more heavily on the import and export of larvae from the area then the size of it (Jessop and MacAllen 2008). Therefore, given that species such as *L. conchilega* are noted to have a dispersal potential of more then 10km (Agar 2008), healthy sites such as Cuskinny Bay may have a role in maintaining the flow of larvae within the SPA. Given that the outlook for Large Shallow Bays such as Cork Harbour was noted as poor from a conservation perspective, in the most recent survey by the NPWS in 2007, the importance of sites such as Cuskinny Bay may increase over time.

Figure 3: A *Lancie conchilega* individual growing on a rocky section of Cuskinny Bay under a canopy of algae

Figure 4: A community of *Lancie conchilega* on a soft sediment section of Cuskinny Bay

Figure 5: The upper section of a *Sabella pavonina* tube found on a section of mixed substrate along Cuskinny Bays' intertidal zone

4.3 Current and Potential Disturbance

Cuskinny Bay is located within an area of high human activity. Therefore it was not surprising that a number of indicators of disturbance were recorded during this survey. One of these indicators can be clearly seen on arrival to the shoreline, where a thin mat of ephemeral green algae can clearly been across the mid to upper sections of the shore (see cover photo). This group of primary producers play an important role in the food web of every shore and typically define biotopes that have are effected by a strong environmental factors such as low salinity. A biotope defined by this group of algae was noted along the banks of the freshwater outflow that runs across a section of the site (LR.FLR.Eph.Ephx). Normally, ephemeral green algae like this are limited in their development by the physical, chemical and biological characteristics of the intertidal environment. Yet a thin but noteworthy band of algal mat stretches across the mid to upper shore of much of the site with *Ulva spp*. (previously known as *Entramorpha* spp.) being recorded in 10 of the 15 biotopes along the shore. The three major anthropogenic factors that may lead to an increase of algal mats like those at Cuskinny Bay are eutrophication, global warming and food web alteration (Lotze and Worm 2002). As the growth of these mats can disrupt local ecology (Worm *et al*. 1999) it would be advisable to monitor their development and impact at this site. Algal mats are not an issue isolated to east Cork, in fact, large-scale blooms of these ephemeral green algal have been reported in shallow coastal waters worldwide (Fletcher 1996, Raffaelli 1999).

As Cuskinny Bay is a popular local recreational beach, it is important to consider the impact this may have on the community present. The current disturbance create by recreational activity at the site include bait digging and trampling of habitat. Bait digging is a traditional activity along the shore of Cuskinny Bay, with three of the eleven species of annelids recorded during the survey being commonly used as fishing bait (Hayward and Ryland 2004); *Marphysa sanguinea* Montagu 1815, *Arenicola marina* Lamarck 1801, *Hediste diversicolor* Müller 1776. For intertidal communities trampling is a major issue, whether they are composed of a hard or soft substrate the impacts are similar, resulting in a shift in community composition. Along rocky sections of the intertidal zone, studies show no small scale spatial variation, but a significant shift in community composition, with a typical increase in herbivores such as limpets and decreases in fragile organisms such as coralline algae (Addessi 1994, Keough and Quinn 1998). Along soft substrate section, such as mud, trampling has been shown to have negative impacts on population structures, including a reduction in numbers of bivalves such as clams and cockles (Rossi *et al*. 2007). In the United Kingdom there is substantial qualitative evidence that many rocky shores that are extensively walked by tourists and school/university educational visitors have lower levels of biodiversity than they did in the 19th Century when such usage was negligible (Davenport and Switalski 2006).

There have also been large-scale disturbances to the substrate along the intertidal zone of Cuskinny Bay. In the winter of 2009, an ESB line running from Aghada Power Station in the south across Cork Harbour to Cows Cross, was brought on shore via Cuskinny Bay and buried at the site. This construction involved the disturbance of a large area of sand and mud at the shore and has resulted in an obvious beach scar at the site. Although this beach scar is not permanent physical feature, these activities may have had implications for the species along the shore, in particular the two bioengineers found along the soft sections of this shoreline. *Lancie conchilega* and *Sabella pavonina* are both species are sensitive substrate disturbances of this nature, which if prolonged can result in population decline (Tyler-Walters and Hiscock 2005, Ager 2008). As both these species are associated with biodiversity hot spots this sensitivity should be considered in further activity along the shore.

Cuskinny Bay like all marine environments is under constant threat of invasion (e.g. Streftaris *et al*. 2005, Chapmen *et al.* 2006), however due to the sites proximity to the busy international ports of Ringaskiddy and Cobh this threat is intensified. The invasive barnacle *Austrominius modestus* (Darwin 1854) was recorded across the site during this survey. *A. modestus* was found to have a higher frequency of occurrence then the three native species present, being recorded in seven of the fifteen biotopes along the shore. Whereas the native species of barnacle *Semibalanus balanoides* Pilsbry 1916 in just 6 biotopes, and *Chthalamus montagui* Southward 1976 and *Chthalamus stellatus* Poli 1791 in 4 and 3 biotopes respectively.

This trend was further explored within the barnacle survey. The invasive *A. modestus* was only found to have marginal dominance within the barnacle community along the upper mid shore. However, as can be seen in the kite diagram in figure 2, *A. modestus*, unlike the three native species, has a continuous presence from high to low shore. It is clear from the results in both the biotope and the barnacle survey that *A. modestus* has a foothold within the intertidal community of Cuskinny Bay. Although there is no way of knowing from a single survey whether or not *A. modestus* is having an impact on the community at Cuskinny Bay, it is important to note the potential impacts of this invasive. Worldwide the invasive potential of this *A. modestus* has been well documented (e.g. Crisp & Southward, 1959; Simkanin *et al*., 2005; Allen *et al*., 2006) and once established it has the potential to out compete native species (Lawson *et al*., 2004). *A. modestus* has number of adaptations which have allowed it to achieve this, including a tolerance of reduced salinity (Fish & Fish, 1996), and both higher and lower temperatures then native Irish species, allowing it to survive at all shore levels (Hui & Moyse, 1987). Invasive species typically initially settle within vacant niches where disturbance regime or resource availability have recently changed (e.g. Davis *et al*. 2000, Facon *et al*. 2006). For this reason disturbance events, which may effect native populations are worth discussing as they may create an opportunity for an invasive such as *A. modestus* to become dominant (e.g. Dawes 1998, Stachowicz *et al*. 1999). Worldwide the distribution of species is being effected by the major disturbance event of global warming (Chapmen *et al*. 2006). In the United Kingdom long-term studies show the shift in community structure of the barnacle community and an increase in the invasive *A. modestus*, associated with increase water temperature due to climate change (Southward and Crisp 1954, Southward *et al.* 1995, Hawkins *et al*. 2003). In Ireland historical data has been used to detect temporal changes in the abundance of intertidal species. Although the increase in *A. modestus* cannot be directly linked to climate change, it does show the need for continued monitoring (Simkanin *et al*. 2005)

4.5 Recommendations

Cuskinny Bay is a popular recreational beach for locals and visitors to the area, therefore continued maintenance of its quality and beauty are not only of ecological importance, but also has an invaluable social extrinsic value.

This survey described the intertidal section of Cuskinny Bay using three simple methodologies. The results showed that although this typical, semi sheltered, intertidal community contains healthy populations of two nationally important, there is evidence of disturbance at the site. To gain a better understanding of the true impact of this disturbance a repeated monitoring over a long period would be essential. As all the methodology used in this survey is easily and cheaply replicated, it could be used as a structure for a long-term monitoring program at the site. Each section of the methodology has its strengths and weaknesses, and allows for varying levels of resolution in the detection of disturbances. The mapping of biotopes is essential yet the borders of the biotopes themselves are subjective. Therefore any shifts in community structure, unless major, may not be detected. While the community composition survey would detect more detailed community shifts in the groups of organisms present. Additionally, continued monitoring of the barnacle community as a bioindictor species, would allow for a more detailed view of the healthy and functioning of the shore.

Finally, it should be considered, that further studies include a nutrient and chemical analysis of the substrates and water present. Cuskinny Bay is set within the highly disturbed area of Cork Harbour, where human activity is a constant. This activity can result in a number of types of pollution, including industrial and agricultural waste, all of which can have a major impact on the communities present. Previous studies in the area show the necessity for this addition, with three authors noting that high levels of TBT had led to the development of imposex in the population of periwinkles along the shore (Minchin *et al*. 1996, Casey *et al*. 1998, Harding *et al*. 1998). This may explain why periwinkles only occur as abundant at one station along one transect of the community composition survey at Cuskinny Bay despite the high levels of grazing available at the shore (table 2 and 3). However without the addition of nutrient and chemical analysis it would be impossible to confirm.

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Appendix

Appendix 1:

This list shows the descriptions of the biotopes recorded during the survey of Cuskinny Bays intertidal zone as defined by the Joint Nature Conservation Committee (JNCC)(Connor *et al*. 2004).

Biotope no.	Biotope code	Biotope description
1	LR.FLR.Lic.YG.	**- Yellow and green lichens on supralittoral rock** Vertical to gently sloping bedrock and stable boulders in the supralittoral (or splash zone) of the majority of rocky shores are typically characterised by a diverse maritime community of yellow and grey lichens, such as *Xanthoria parietina*, *Caloplaca marina*, *Lecanora atra* and *Ramalina* spp. The black lichen *Verrucaria maura* is also present, but usually in lower abundance than in the littoral fringe zone. In wave exposed conditions, where the effects of sea-spray extend further up the shore, the lichens generally form a wide and distinct band. This band then becomes less distinct as wave exposure decreases, and in sheltered locations, cobbles and pebbles may also support the biotope. Pools, damp pits and crevices in the rock are occasionally occupied by winkles such as *Littorina saxatilis* and halacarid mites may also be present.
2	LR.LLR.F.Pel	**- *Pelvetia caniculata* on sheltered littoral fringe:** Lower littoral fringe bedrock or stable boulders and mixed substrata in sheltered to extremely sheltered conditions characterised by a dense cover of the wrack *Pelvetia canaliculata*. The biotope may be present in localised sheltered patches on moderately exposed shores. *P. canaliculata* overgrows a crust of black lichens *Verrucaria maura* or the non-calcified red algae *Hildenbrandia rubra* on very sheltered shores. Individuals of the wrack *Fucus spiralis* can usually be found among the *P. canaliculata* and/or in lower part of the biotope. This biotope lacks the density of barnacles found amongst the *P. canaliculata* on more exposed shores. The winkle *Littorina saxatilis* occurs, as do a variety of amphipods. The red alga *Catenella caespitosa* can be present especially in more shaded areas while the green seaweed *Enteromorpha* spp. can be present in moist areas.
3	LR.LLR.F.Fspi.FS	**- *Fucus sprilalis* on full salinity sheltered upper eulittoral rock:** Moderately exposed to sheltered full salinity upper eulittoral mixed substrata characterised by a band of the wrack *Fucus spiralis*. Occasional clumps of the wrack *Pelvetia canaliculata* can be overgrowing the black lichen *Verrucaria maura* and the olive green lichen *Verrucaria mucosa*. On the more stable boulders underneath the fronds the red crust *Hildenbrandia rubra* can be found along with the barnacle *Semibalanus balanoides* and the limpet *Patella vulgata*. The winkles *Littorina littorea* and *Littorina saxatilis* can be found on and

		among the boulders and cobbles, while amphipods and the crab *Carcinus maenas* can be present either underneath the boulders or among the brown seaweeds. The green seaweed *Enteromorpha intestinalis* can occur in some abundance especially during the summer.
4	LR.LLR.F.Fves.FS	**- *Fucus vesiculosus* on full salinity moderately exposed to sheltered mid eulittoral rock:** Moderately exposed to sheltered mid eulittoral bedrock and large boulders characterised by a dense canopy of the wrack *Fucus vesiculosus* (Abundant to Superabundant). Beneath the seaweed canopy the rock surface has a sparse covering of the barnacle *Semibalanus balanoides* and the limpet *Patella vulgata*. The mussel *Mytilus edulis* is confined to pits and crevices. A variety of winkles including *Littorina littorea, Littorina saxatilis* and the whelk *Nucella lapillus* are found beneath the seaweeds, whilst *Littorina obtusata/mariae* graze on the fucoid fronds. The calcareous tube-forming polychaete *Spirorbis spirorbis* may also occur epiphytically on the fronds. In areas of localised shelter the wrack *Ascophyllum nodosum* may occur, though never at high abundance. Damp cracks and crevices often contain patches of the red seaweed *Mastocarpus stellatus* and even the wrack *Fucus serratus* may be present. The crab *Carcinus maenas* may be present in pools or among the boulders.
5	LR.LLR.FvesVS	**- *Fucus vesiculosus* on variable salinity mid eulittoral boulders and stable mixed substrata** Sheltered to extremely sheltered mid eulittoral pebbles and cobbles lying on sediment subject to variable salinity and characterised by the wrack *Fucus vesiculosus*. The wrack *Ascophyllum nodosum* can occasionally be found on larger boulders, while the barnacles *Semibalanus balanoides* and *Elminius modestus* and the mussel *Mytilus edulis* can be present on cobbles. Winkles, particularly *Littorina littorea*, commonly graze on the seaweeds, while *Littorina saxatilis* can be found in crevices. Ephemeral seaweeds such as *Enteromorpha intestinalis* can occupy available space. Patches of sediment found between the hard substrata often contains the lugworm *Arenicola marina* or the sand mason *Lanice conchilega*, while the crab *Carcinus maenas*, gammarids and amphipods occur on and under cobbles.
6	LR.LLR.F.Fserr.FS	**- *Fucus serattus* on full salinity sheltered lower eulittoral rock:** Sheltered lower eulittoral rock subject to fully marine conditions characterised by a dense canopy of the wrack *Fucus serratus*. There is a wide range of associated species found on the surface of the rock underneath the canopy, including the barnacle *Semibalanus balanoides*, limpets *Patella vulgata*, winkles *Littorina littorea*, and even mussels *Mytilus edulis* can be present in cracks and crevices. These species are usually found in higher abundance further up on the shore. There may also be a number of other seaweeds present, including the red *Corallina officinalis* and *Mastocarpus stellatus*, the wrack *Fucus vesiculosus* and the green *Enteromorpha intestinalis*, *Ulva lactuca* or *Cladophora rupestris*, though these usually are present in low numbers if present at all. The sponge *Halichondria panicea* can be present underneath the *F. serratus* canopy in moist cracks or minor overhangs. Polychaetes such as *Pomatoceros triqueter* and *Spirorbis* spp. are present in their white calcareous tubes on the rock.

7	LR.LLR.F.Fserr.X	**- *Fucus serattus* on full salinity lower eulittoral mixed substrata:** Sheltered to extremely sheltered full salinity lower eulittoral mixed substrata with dense stands of the wrack *Fucus serratus*. The crab *Carcinus maenas* and a large number of winkles such as *Littorina littorea* and *Littorina obtusata/mariae* can be found amongst the pebbles and cobbles as well as large individuals of the mussel *Mytilus edulis*, commonly occurring in clumps. On these mussels and on larger cobbles are the barnacle *Semibalanus balanoides* and the limpet *Patella vulgata*. Red algae such as coralline crusts including *Lithothamnion* spp. and the tube-forming polychaetes *Pomatoceros triqueter* and *Spirorbis* spp. can be found on cobbles and boulders. *Spirorbis* spp. can also be found on the *F. serratus* fronds. Sediment in the spaces between the loose substrata may support infauna including the polychaete *Arenicola marina*. The red seaweed *Mastocarpus stellatus* and the wrack *Ascophyllum nodosum* can occur in patches, while the green seaweeds *Enteromorpha intestinalis* and *Cladophora* spp. can be found among the mussels and underneath the *F. serratus* canopy.
8	LR.FLR.Eph.Ent	**- *Entramorpha* spp. on freshwater influenced and unstable eulittoral:** Upper shore hard substratum that is relatively unstable (e.g. soft rock) or subject to considerable freshwater runoff is typically very species poor and characterised by a dense mat of *Enteromorpha* spp. (now know as *Ulva* spp.), though *Ulva lactuca* can occur as well. It occurs in a wider zone spanning from the supralittoral down to the upper eulittoral, across a wide range of wave exposures range. This biotope is generally devoid of fauna, except for occasional limpets *Patella vulgata*, winkles *Littorina littorea* or *Littorina saxatilis* and barnacles *Semibalanus balanoides*.
9	LR.FLR.Eph.Ephx	**- Ephemeral green and red seaweeds on variable salinity and/or disturbed eulittoral mixed substrata:** Eulittoral mixed substrata (pebbles and cobbles overlying sand or mud) that are subject to variations in salinity and/or siltation, characterised by dense blankets of ephemeral green and red seaweeds. The main species present are *Enteromorpha intestinalis*, *Ulva lactuca* and *Porphyra* spp., along with colonial diatoms covering the surface of the substratum. Small numbers of other species such as barnacles *Semibalanus balanoides* and *Elminius modestus* are confined to any larger cobbles and pebbles or on the shells of larger individuals of the mussel *Mytilus edulis*. The crab *Carcinus maenas* and the winkle *Littorina littorea* can be present among the boulders, cobbles and seaweeds, while gammarids can be found in patches underneath the cobbles. In common with the other biotopes found on mixed substrata, patches of sediment are typically characterised by infaunal species including bivalves, for example, *Cerastoderma edule* and the polychaete *Arenicola marina* and the polychaete *Lancie conchilega*.
10	LS.LCS.Sh.Barsh	**- Barren littoral shingle:** Shingle or gravel shores, typically with sediment particle size ranging from 4 - 256 mm, sometimes with some coarse sand mixed in. This biotope is normally only found on exposed open coasts in fully marine conditions. Such shores tend to support virtually no macrofauna in their very mobile and freely draining substratum. The few individuals that may be found are those washed into the habitat by the ebbing tide, including the occasional amphipod or small polychaete.

11	LS.LSSa.MuSaLan	**- *Lancie conchilega* in littoral sand:** This biotope usually occurs on flats of medium fine sand and muddy sand, most often on the lower shore but sometimes also on waterlogged mid shores. The sand may contain a proportion of shell fragments or gravel. Lan can also occur on the lower part of predominantly rocky or boulder shores, where patches of sand or muddy sand occur between scattered boulders, cobbles and pebbles. Conditions may be tide-swept, and the sediment may be mobile, but the biotope usually occurs in areas sheltered from strong wave action. The sediment supports dense populations of the sand mason *Lancie conchilega*. Other polychaetes present are tolerant of sand scour or mobility of the sediment surface layers and include the polychaetes *Anaitides mucosa*, *Eumida sanguinea*, *Nephtys hombergii*, *Scoloplos armiger*, *Aricidea minuta*, *Tharyx* spp. and *Pygospio elegans*. The mud shrimp *Corophium arenarium* and the cockle *Cerastoderma edule* may be abundant. *Macoma balthica* may be present. On boulder shores, and where pebbles and cobbles are mixed in with lower shore tide-swept sand with dense *L. conchilega* between the cobbles, the infaunal component is rarely sampled. The infaunal community under these circumstances, provided that the cobbles are not packed very close together, is likely to be similar to that in areas without the coarse material.
12	LS.LSaSt.Tal	**- Talitrids in the upper shore and strandline:** A community of sandhoppers (talitrid amphipods) may occur on any shore where drift lines of decomposing seaweed and other debris accumulate on the strandline. The biotope occurs most frequently on medium and fine sandy shores, but may also occur on a wide variety of sediment shores composed of muddy sediment, shingle and mixed substrata, or on rocky shores. The decaying seaweed provides cover and humidity for the sandhopper *Talitrus saltator*. In places on sand that regularly accumulate larger amounts of weed, *Talorchestia deshayesii* is often present. Oligochaetes, mainly enchytraeids, can occur where the stranded debris remains damp as a result of freshwater seepage across the shore or mass accumulation of weed in shaded situations. On shingle and gravel shores and behind saltmarshes the strandline talitrid species tend to be mainly *Orchestia* species. Abundances of the characterising species tend to be highly patchy. Two characterising species lists are presented below. They are derived from two sets of data, which were analysed separately. The first shows data from infaunal samples, the second shows data from epifaunal samples. The epifaunal lists contains no counts per square metre, as the data were collected on the SACFOR scale.Tal may occur on the same shore as a range of sediment (especially sandy) biotopes, where drift lines of algae and other debris accumulate on the upper shore. These biotopes include BarSh, BarSa, Ol, AmSco, and Po. The biotope also occurs at the back of boulder, cobble and pebble shores, above mixed sediment and rocky biotopes. This biotope varies in its position between spring and neap tides, and as a result of changing weather. After storms, it may extend into the fore dunes, during spring tides it will occur high on the shore, and during neaps the greatest numbers of talitrids may be found at or just below MHWN level. The amount of debris washed up on strandlines, and hence the extent of this biotope, may also vary significantly depending on factors such as recent storms or high tides.

13	LS.LMx.GvMu.HedMx	**- Hediste diversicolor in littoral gravelly muddy sand and gravelly sandy mud:** Sheltered gravelly sandy mud, subject to reduced salinity, mainly on the mid and lower shore. The infaunal community is dominated by abundant ragworms *Hediste diversicolor*. Other species of the infauna vary for the sub-biotopes described. They include polychaetes such as *Pygospio elegans*, *Streblospio shrubsolii*, and *Manayunkia aestuarina*, oligochaetes such as *Heterochaeta costata* and *Tubificoides* spp., the mud shrimp *Corophium volutator*, the spire shell *Hydrobia ulvae*, *Macoma balthica* and the peppery furrow shell *Scrobicularia plana*. Sub-biotopes described in HedMx have equivalent communities in soft muddy sediments, but the sediment here is much firmer due to the gravel component. There are relatively few records in each sub-type, leading to uncertainty over the precise nature of the habitat, particularly regarding sediment type and salinity regime.
14	SS.Smu.SmuLS	**- Sublittoral mud in low or reduced salinity (lagoon):** Shallow, typically anoxic, muddy and sandy mud sediments in areas of low or reduced, although stable, salinity (may vary annually) with largely ephemeral faunal communities. Characterised by *Arenicola marina* and blue-green algae with other species, including mysids, *Carcinus maenas* and *Corophium volutator* which commonly occur in lagoons. Important infaunal species may include *Hediste diversicolor*, *Heterochaeta costata* and chironomids; however infaunal records for this biotope are limited.
15	SS.SMx.IMx.SpavSpAn	**- *Sabbella pavonina* with sponges and anemnones on infralittoral mixed sediment:** Muddy gravelly sand with pebbles off shallow, sheltered or moderately exposed coasts or embayments may support dense populations of the peacock worm *Sabella pavonina*. This community may also support populations of sponges such as *Esperiopsis fucorum*, *Haliclona oculata* and *Halichondria panicea* and anemones such as *Sagartia elegans*, *Cerianthus lloydii* and *Urticina felina*. Hydroids such as *Hydrallmania falcata* and the encrusting polychaete *Pomatoceros triqueter* are also important. This biotope may have an extremely diverse epifaunal community. Less is known about its infaunal component, although it is likely to include polychaetes such as Nephtys spp., *Harmothoe* spp., *Glycera* spp., syllid and cirratulid polychaetes, bivalves such as *Abra* spp., Aoridae amphipods and brittlestars such as *Amphipholis squamata*.

Appendix 2:

This list shows the species recorded present (P) in the biotopes mapped along Cuskinny Bay's intertidal zone. The biotope numbers correspond to those marked in Appendix 1.

		Biotope Numbers														
	Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Plants	*Armeria maritima*	P	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lichens	*Caloplaca* spp.	P	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Ochrolechia parella	P	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Tephromela atra	P	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Verrucaria maura	P	P	–	–	–	–	–	–	–	–	–	–	–	–	–
	Xanthoria parietina	P	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Algae	*Ahnfeltia plicata*	–	P	P	P	–	P	–	–	–	–	–	–	–	–	–
	Ascophyllum nodosum	–	–	P	P	P	–	P	–	–	–	–	–	–	–	–
	Ceramium shuttleworthianum	–	–	P	P	–	–	–	–	–	–	–	–	–	–	–
	Ceranium spp.	–	–	P	P	–	P	–	–	–	P	–	–	–	–	–
	Chaetomorpha linum	–	–	P	P	P	P	P	P	–	–	–	–	–	–	–
	Chondrus crispus	–	–	–	P	–	P	–	–	–	–	–	–	–	–	–
	Cladophora rupestris	–	–	–	P	–	P	P	–	–	–	P	–	–	–	–
	Ectocarpus agg.	–	P	P	P	P	P	P	–	–	–	–	–	–	P	–
	Fucus serratus	–	–	–	–	–	P	P	–	–	–	–	–	–	–	–
	Fucus spiralis	–	P	P	P	–	–	–	–	–	–	–	–	–	–	–
	Fucus vesiculosus	–	–	–	P	P	–	–	–	–	–	–	–	–	P	–
	Gelidium pusillum	–	–	–	P		P	–	–	–	–	–	–	–	–	–
	Hildenbrandia rubra	–	P	–	P	–	P	P	–	–	–	–	–	–	–	–
	Himantalia elongata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P
	Laminaria digitata	–	–	–	–	–	–	–	–	–	–	P	–	–	–	–
	Laminaria saccharina	–	–	–	–	–	–	–	–	–	–	P	–	–	–	–
	Lithothmnia spp.	–	–	P	–	–	P	P	–	–	–	–	–	–	–	–
	Lomentaria articulata	–	–	–	–	–	–	–	–	–	–	P	–	–	–	P
	Mastocarpus stellatus	–	–	–	P	–	P	P	–	–	–	–	–	–	–	–
	Osmundea pinnatifida	–	–	–	–	–	P	–	–	–	–	P	–	–	–	P
	Pelvita canalicuata	–	P	–	–	–	–	–	–	–	–	–	–	–	–	–
	Polsiphonia lanosa	–	–	P	P	–	–	–	–	–	–	–	–	–	–	–
	Porphyra spp.	–	–	–	–	–	–	–	–	P	–	–	–	–	–	–
	Ralfsia verrucosa	–	–	P	–	–	P	P	–	–	–	–	–	–	–	–
	Scyosiphon lomentaria	–	–	–	–	–	–	–	–	–	–	P	–	–	–	P
	Ulva compressa	–	–	P	P		P	–	P	P	–	–	–	–	P	–
	Ulva intestinalis	–	P	P	P	P	P	P	P	P	–	–	–	–	P	–
	Ulva lactuca	–	–	–	–	P	–	P	P	P	–	P	–	–	P	–
	Ulva spp.	–	–	P	P	P	P	P	P	P	–	–	–	–	P	–
	Verrucaria mucosa	–	–	P	–	–	–	P	–	–	–	–	–	–	–	–

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Annelids	*Arenicola marina*	–	–	–	–	–	–	–	–	–	–	–	–	–	P	–
	Hediste diversicolor	–	–	–	–	–	–	–	–	–	–	–	–	P	P	–
	Lancie conchilega	–	–	–	–	P	P	P	–	–	–	P	–	–	–	P
	Lumbrineris latreilli	–	–	–	–	–	–	–	–	–	–	P	–	–	–	–
	Marphysa sanguinea	–	–	–	–	–	–	–	–	–	–	P	–	–	–	–
	Nematonereis unicornis	–	–	–	–	–	–	–	–	–	–	P	–	–	–	–
	Pomatoceros spp.	–	–	–	P		P	P	–	–	–	P	–	–	–	P
	Sabella pavonina	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P
	Scoloplos armiger	–	–	–	–	–	–	–	–	–	–	P	–	–	–	–
	Spirorbis spirorbis	–	–	–	–	–	P	–	–	–	–	P	–	–	–	–
	Spirorbis spp.	–	–	–	–	–	P	P	–	–	–	P	–	–	–	–
Ascidiacea	*Botrylloides leachi*	–	–	–	–	–	–	P	–	–	–	–	–	–	–	–
Bryozoa	*Alcyonidium diaphanum*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P
	Alcyonidium gelatinosum	–	–	–	–	–	P	P	P	–	–	–	–	–	–	–
	Electra pilosa	–	–	–	–	–	P	–	–	–	–	P	–	–	–	–
	Membranipora membranacae	–	–	–	–	–	P	–	–	–	–	P	–	–	–	–
Crustaceans	*Austrominius modestus*	–	P	P	P	P	P	P	–	–	–	P	–	–	–	–
	Carcinus menus	–	P	P	–	P	–	P	–	–	–	–	–	–	P	P
	Chthamalus montagui	–	P	P	P	P	–	–	–	–	–	–	–	–	–	–
	Chthamalus stellatus	–	–	P	P	P	–	–	–	–	–	–	–	–	–	–
	Corophium spp.	–	–	–	–	–	–	–	–	–	–	P	–	–	P	–
	Gammerus spp.	–	–	–	P	P		P	P	–	–	–	–	–	–	–
	Ligia oceanica	–	P	–	–	–	–	–	–	–	–	–	–	–	–	–
	Pagurus bernhardus	–	–	–	–	–	P	–	–	–	–	–	–	–	–	P
	Semibalanus balanoides	–	–	–	P	P	P	P	–	–	–	P	–	–	–	–
	Talitridae spp.	P	P	–	–	–	–	–	–	–	–	–	P	P	–	–
Cnidaria	*Actinia equina*	–	–	–	P	–	P	–	–	–	–	–	–	–	–	–
Collembola	*Anuridella marnia*	–	P	–	–	P	–	–	–	–	–	–	–	–	–	–
Molluscs	*Anomia ephippium*	–	–	–	–	–	P	P	–		–	P	–	–	–	–
	Cerastoderm edule	–	–	–	–	–	–	–	–	–	–	P	–	–	–	–
	Littorina littorea	–	–	–	P	P	P	P	–	–	–	–	–	–	–	–
	Littorina neritoides	–	P	–	–	–	–	–	–	–	–	–	–	–	–	–
	Littorina obtusata	–	P	–	–	–	–	P	–	–	–	–	–	–	–	–
	Littorina saxatilis	–	P	P	P	–	P	–	–	–	–	–	–	–	–	–
	Nucella lapillus	–	–	–	–	–	P	P	–	–	–	–	–	–	–	–
	Mytilus edulis	–	–	P	P	–	–	–	–	–	–	–	–	–	–	–
	Patella depressa	–	–	P	–	–	P	P	–	–	–	–	–	–	–	–
	Patella vulgata	–	–	P	P	–	P	–	–	–	–	–	–	–	–	–
	Gibbula umbilicalis	–	–	P	P	–	P	P	–	–	–	–	–	–	–	–
	Monodonta lineata	–	–	–	P	–	P	P	–	–	–	–	–	–	–	–
	Lepidochitona cinereus	–	–	–	–	–	P	P	–	–	–	–	–	–	–	–
Pisces	*Lipophrys pholis*	–	–	–	–	–	P	–	–	–	–	–	–	–	–	–
Porifera	*Halichondria panice*	–	–	–	–	–	P	P	–	–	–	–	–	–	–	P
	Hymeniacidon perleve	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P

Appendix 3:

This is a summary table of appendix 2, showing the total species richness (n) recorded for each biotope mapped along the intertidal zone of Cuskinny Bay.

Biotope no.	Biotope code	Biotope description
1	LR.FLR.Lic.YG.	7
2	LR.LLR.F.Pel	16
3	LR.LLR.F.Fspi.FS	18
4	LR.LLR.F.Fves.FS	31
5	LR.LLR.FvesVS	16
6	LR.LLR.F.Fserr.FS	39
7	LR.LLR.F.Fserr.X	31
8	LR.FLR.Eph.Ent	7
9	LR.FLR.Eph.Ephx	5
10	LS.LCS.Sh.Barsh	0
11	LS.LSSa.MuSaLan	22
12	LS.LSaSt.Tal	1
13	LS.LMx.GvMu.HedMx	2
14	SS.Smu.SmuLS	9
15	SS.SMx.IMx.SpavSpAn	10

Appendix 4:

This table shows the metadata for fieldwork conducted during this survey.

	Biotope mapping and Transect 1	Biotope mapping and Transect 2	Biotope mapping and Transect 3	Biotope mapping and Transect 4	Barnacle Transect
Date	15-May-10	15-May-10	16-May-10	16-May-10	30-May-10
Tide height	0.22 m	0.22 m	0.32m	0.32m	0.30 m
Surveyors	Claire and John Moore	Claire and John Moore	Claire Moore and Nicolas Denis	Claire Moore and Nicolas Denis	Claire Moore and Nicolas Denis