Marine Institute Bird Studies (in support of Castlemaine Harbour Appropriate Assessment)

Castlemaine Waterbird Studies – III (Clams)

Preliminary assessment of the effects of clam cultivation on the spatial distribution of waterbirds in Castlemaine Harbour

April 2011

Plan Design Enable

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Notice

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Executive Summary

We carried out a study to assess the potential impact of intertidal clam cultivation on the waterbird populations of Castlemaine Harbour. Clam cultivation occurs at only one location in Castlemaine Harbour; in the Rossbehy Creek area at the south western end of the harbour. Cultivation began in 2003/2004. The current production level is ca. 40 tonnes per year. There are two licensed plots covering an area of approximately 22 ha. The current extent of clam cultivation (mapped on 25th January 2011) is much smaller (6.0 ha) and is mainly outside the licensed area. In addition, there is another 0.8 ha between the foreshore and the clam beds that are being used as an access route and for storage.

The study included a review of the 2009/10 waterbird count data carried out under the NPWS Baseline Waterbird Survey Programme. We also carried out three counts of the Rossbehy Creek area in February and March 2011, and collected some bird count data on an additional visit in January 2011. For these counts, we divided the area into three broad zones (the Main Bay, Caragh Creek and Faha). The Main bay is the zone where clam cultivation occurs and comprises the entire intertidal area north of the mouth of Caragh Creek and east of the cause way that joins the dunes to Kilnabrack. We divided the Main Bay into ten sectors that reflected the configuration of the major tidal channels, differences in substrate type and the distribution of the clam cultivation and the clam licenses.

Waterbird numbers in the Rossbehy Creek area

In the first two counts in the 2009/10 dataset, very few waders were recorded: no waders on 5th October and only Oystercatcher on 21st November. Also on 21st November, only three species of waterbirds in total were recorded. This is rather surprising for a large (nearly 700 ha) and varied area of intertidal habitat and suggests that these counts may not be representative of the typical usage of this area. Therefore, our analysis of the importance of the Rossbehy Creek area focused on the three counts from January and February 2010.

Most species were recorded in 2009/10 in lower numbers than would be predicted by the amount of intertidal habitat. Turnstone was the only species that appears to show a marked positive association with this count sector. Ringed Plover, Sanderling and Greenshank were recorded in numbers roughly in accordance with the availability of intertidal habitat, although, in the case of Sanderling this is due to a single high count.

Numbers of Light-bellied Brent Goose, Oystercatcher, Ringed Plover, Sanderling, Dunlin, Curlew and Redshank were approximately two to three times higher in 2011, compared to January-February 2010. Therefore, if the total Castlemaine Harbour population of these species was similar in the two winters, the relative importance of the Rossbehy Creek area would increase commensurately (although the total area included in the counts was larger). In particular, the Rossbehy Creek area would support important components of the Castlemaine Harbour populations of Ringed Plover and Sanderling. Furthermore, the mean number of Sanderling in the Rossbehy Creek area in 2011 exceeded the threshold for national importance.

Spatial distribution of waterbirds within the Rossbehy Creek area

Light-bellied Brent Goose, Ringed Plover, Sanderling and Dunlin occurred almost exclusively in the Main Bay. Oystercatcher and Curlew occurred mainly in Faha and the Main Bay during the falling and rising tide counts, apparently moving into Caragh Creek during low tide. Redshank occurred across all three zones with variable patterns of distribution during the three counts.

Within the Main Bay, the general progression of tidal exposure is from the north to the south. The clam beds are exposed for a relatively short period: between 3h 15 min and 4h 45 min around low tide with the period of full exposure varying from 1h to 3h. The southernmost part of the Main bay is the last area to become exposed and can remain largely flooded throughout the low tide.

Oystercatcher, Curlew, Common Gull and Herring Gull were generally widely distributed throughout the Main Bay, usually without large concentrations. These species all occurred frequently in the clam beds.

Light-bellied Brent Goose mainly occurred around the mouth of Caragh Creek, moving to the outer sandbanks as the tide fell. On one of the count days, a large flock moved through the clam beds on the falling tide.

Wigeon, Mallard and Redshank mainly occurred in the muddy sediments of the southernmost part of the Main Bay. Small numbers of Wigeon and Mallard occurred in the clam beds on some counts. On two of the count days 25 or more Redshank fed in the clam beds on the ebbing and/or flooding tides.

Ringed Plover, Sanderling and Dunlin showed a marked preference for one count sector (partially within the licensed area) with very muddy sand habitat and to a lesser extent for an area of cockle sands (within the licensed area). These species were never recorded in the clam beds during the counts. On two of the count days birds were observed feeding up to within a few metres of the edge of the clam bed but did not move inside.

Turnstones were almost exclusively recorded in the clam bed. However, birds in the southernmost part of the Main Bay could have been missed due to poor visibility and it seems likely that the flock from the clam beds moved to this sector when the clam beds were covered by the tide.

The potential impact of clam aquaculture on waterbirds

We analysed the patterns of distribution of the above species, in relation to the availability of habitat across the tidal cycle. Our main conclusions are described below.

Turnstone

The clam beds clearly have a positive impact on Turnstone as they have converted an area of unsuitable habitat into suitable habitat.

Oystercatcher, Curlew and Redshank

The current level of clam aquaculture is not having a negative impact on these species and may be having a positive impact.

Extension of clam cultivation into the full extent of the licensed area is not likely to have a negative impact on these species and may have a positive impact.

Ringed Plover, Sanderling and Dunlin

The impact of the current level of clam aquaculture on these species will depend on how suitable the habitat was for these species before the start of clam cultivation. Their overall pattern of distribution indicates that the area now occupied by the clam beds was, at least in part, not optimum habitat for these species. Therefore, any impact from the current level of clam cultivation is probably relatively minor.

Extension of clam cultivation into the full extent of the licensed area would remove around 25% of the combined extent of the areas favoured by these species. As the Rossbehy Creek area may support around 30% of the total Castlemaine Harbour population of these species, extension of clam cultivation and may cause displacement of 8% of these the total Castlemaine Harbour populations of these species. However, there is a high level of uncertainty about this assessment because of the lack of data on total numbers in Castlemaine Harbour in 2010/11. It should also be noted that this assessment is based on only three counts in February and March 2011. A full season of counts is therefore recommended to ensure that these data are representative of impacts across seasons and years.

Other species

Most other species that occurred in the Main bay were recorded within the clam beds. From their behaviour and general patterns of distribution within the Main Bay, it is unlikely that Light-bellied Brent Goose, Wigeon, Mallard, Common Gull and Herring Gull were avoiding the clam beds. Other species occurred too infrequently and/or in too low numbers for it to be possible to reach any conclusions.

Disturbance

While our data is very limited, the presence of tractors working in the clam bed did not appear to affect the waterbird usage of the clam beds, or adjacent areas. The period when tractors are likely to be working in the clam beds, around the lowest point of the tide, is the period when there is least use of the clam beds by waterbirds. The latter usage pattern appears to be independent of the presence of tractors, occurring on days when no tractors were working.

Other activities are not causing significant levels of disturbance to waterbirds in the vicinity of the clam beds.

Acknowledgements

We would firstly like to thank Dr. David Tierney and Dr. Lesley Lewis, National Parks & Wildlife Service Dr. Sinead Cummins and Dr. Olivia Crowe, BirdWatch Ireland for their time, assistance and many a useful discussion during the course of the Castlemaine Waterbird Studies.

We would also like to thank Ms. Catherine Butler and Ms. Gráinne O'Brien, Bord Iascaigh Mhara and the aquaculture farmers in Castlemaine Harbour for their assistance throughout.

We would like to thank Mr. Paul O'Sullivan and Mr. Michael O'Sullivan (clam farmers) for their kind co-operation in facilitating this work.

1. Introduction

1.1 Atkins Ecology was commissioned by the Marine Institute to a) provide ornithological services in relation to the Appropriate Assessment under Article 6(3) of the EU Habitats Directive (92/43/EEC; and as amended) of aquaculture activities on the Castlemaine Harbour Special Protection Area (SPA) and b) to more generally undertake a series of studies on the impacts of shellfish aquaculture on waterbirds (looking at bottom mussels, pacific oyster and clam cultivation).

1.2 Only part of Castlemaine Harbour has been legally designated as a SPA, However, it is our understanding that NPWS intend to extend the designation to cover the whole of Castlemaine Harbour and plan to advertise this extension in the near future (David Tierney, NPWS, pers. comm.). The appropriate assessment of the impacts of shellfish aquaculture at Castlemaine Harbour will therefore have to consider the entirety of the area covered by the existing designation and the proposed extension.

1.3 Clam cultivation occurs at only one location in Castlemaine Harbour; in the Rossbehy Creek area at the south western end of the harbour. There is no existing information on the potential impacts of this activity on the waterbird populations in Castlemaine Harbour, and little relevant comparable work elsewhere in the peer reviewed or grey literature. Therefore, Atkins has carried out preliminary field studies to assess the potential effects of clam cultivation on the spatial distribution of waterbirds in Castlemaine Harbour.

1.4 Our brief for this report was to:

- Review relevant studies carried out elsewhere on the interactions between clam cultivation and waterbird populations.
- Review the 2009/10 waterbird count data carried out under the NPWS Baseline Waterbird Survey Programme.
- Report on the preliminary studies carried at Rossbehy out in January-March 2011.

1.5 The project was conceived by Dr. Paul O'Donoghue and Dr. Tom Gittings; field counts were undertaken by Tom Gittings. Data entry was carried out by Katie O'Hora. Data analysis and report preparation was undertaken by TG and reviewed by Paul O'Donoghue.

1.6 Scientific names and British Trust for Ornithology (BTO) species codes of bird species mentioned in the text are listed in Appendix A. The BTO species codes are also used in some of the figures included in this report.

Clam cultivation in Castlemaine Harbour

1.7 Clam cultivation occurs in the Rossbehy Creek area of Castlemaine Harbour. Cultivation began in 2003/2004 (Mr. Paul O'Sullivan[1], pers comm.). The current production level is ca. 40 tonnes per year. It is our understanding that the Rossbehy site was selected as it was known locally to have been a good site for hand picking cockles (Mr. Paul O'Sullivan, pers comm.).

1.8 There are two licensed plots covering an area of approximately 22 ha. The current extent of clam cultivation (mapped on 25th January 2011) is much smaller (6.0 ha) and is mainly outside the

[1] Mr. O'Sullivan is the farmer currently operating the clam farm at Rossbehy.

licensed area (Figure 1.1). In addition, there is another 0.8 ha between the foreshore and the clam beds that are being used as an access route and for storage, etc (mapped on 24 February 2011). We understand that various parts of the licenced block have been used, with different levels of success, since use of the site began in 2003/2004. The current location provides good growing conditions for clams (Mr. Paul O'Sullivan, pers comm.).

1.9 The clam beds consist of alternating strips of around ca. **1 m** wide of bags of clams and intervening clear strips; these are known in the industry as clam *parcs*. The clam bags are raised slightly (a few cms.) above the level of the clear areas. The bags are usually covered with fine sands, and those parcs that have not been recently cleaned can also be covered with seaweed.

1.10 There are two 20 m wide gaps in the clam bed, which are clear of clam bags. These are at a slightly lower elevation than the surrounding clam beds and act as tidal channels through the clam beds.

1.11 Two areas that have been harvested could be clearly distinguished. These areas have a smooth surface to the sediment with traces of the positions of the clam bags still visible.

1.12 There is also a licensed plot for oyster cultivation in the outer part of Rossbehy Creek. However, this plot is not currently being used. We did not observe any evidence of oyster cultivation in the Rossbehy Creek area, apart from a couple of discarded trestles on the foreshore (within the area mapped as *Access routes and storage areas* in Figure 1.1.

Plate 1.1 - Clam beds at Rossbehy, Castlemaine Harbour.

Plate 1.2 - Individual *parcs* and intervening tracks within the clam beds at Rossbehy.

Plate 1.3 - Mesh bags (*parcs*) within which clams are on-grown, with attached *Fucus* sp.

Limitations to this study

1.13 In considering the impacts of shellfish aquaculture on waterbirds as part of the appropriate assessment process a review of current shellfish aquaculture practices within the bay was undertaken. The clam farm at Rossbehy was one practice for which little information was available. The site was visited by Paul O'Donoghue and Tom Gittings to gain a better understanding of the mechanisms of clam farming; examine the benthic habitat types within and in the environs of the farm and look at the suitability of these areas for birds.

1.14 We immediately designed and commenced a preliminary study to look at the spatial distribution of waterbirds relative to the clam farm. While we maximised the number of counts that could be undertaken, it should be noted that the main limitation to this work is the small number of counts (3) undertaken in a quite limited time period (February to March 2011; i.e. late winter).

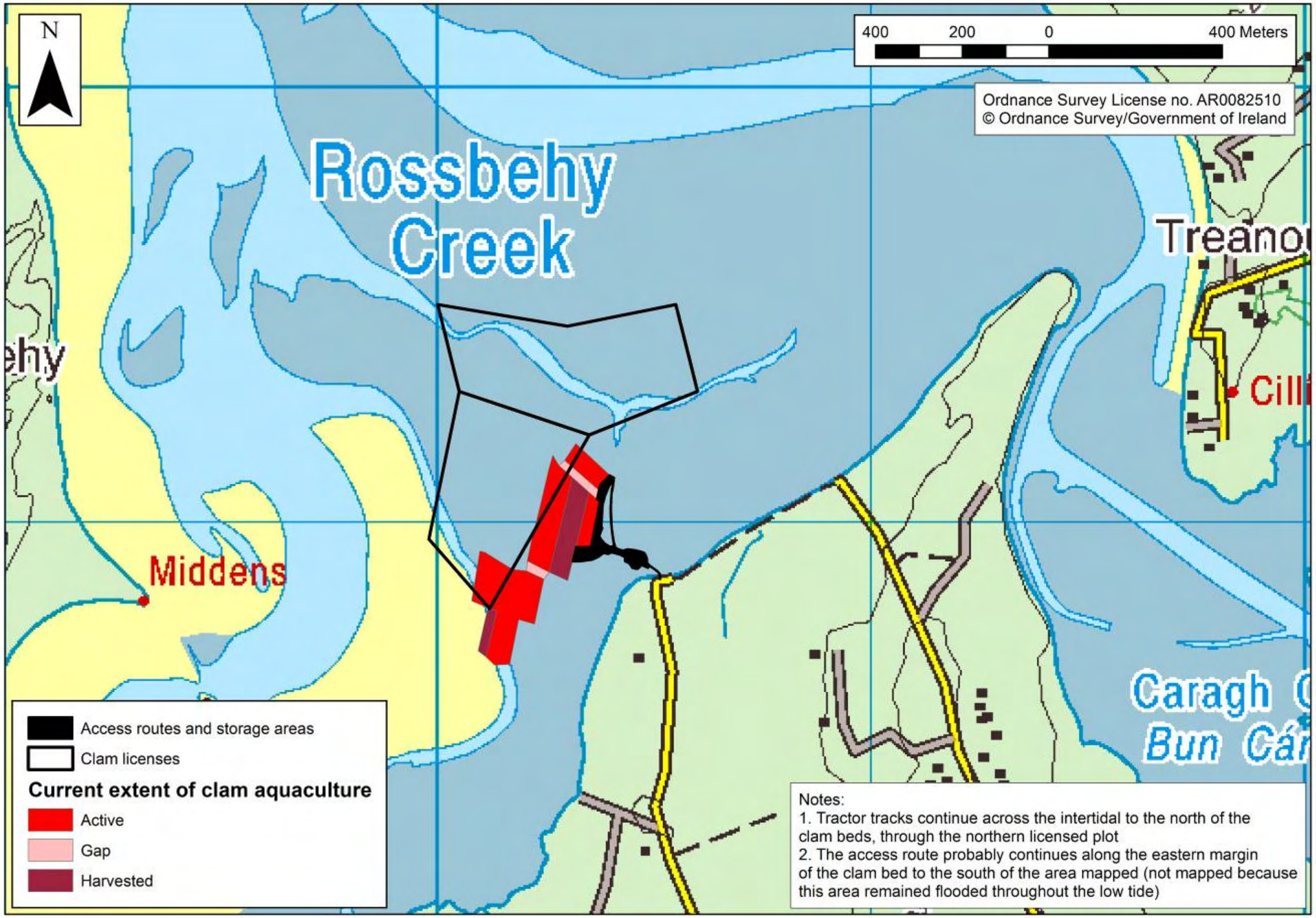

Figure 1.1 – Clam licenses and clam cultivation in Castlemaine Harbour.

2. Literature review

2.1 There is little published information available on the effects of intertidal aquaculture on waterbird populations in Ireland. Hilgerloh *et al*. (2001) undertook a preliminary investigation of the effect of oyster trestles on intertidal birds at a site in Cork Harbour, while Roycroft *et al*. (2004) examined the impact of suspension culture of mussels on birds and seals in Bantry Bay, a non-seaduck area in the southwest of Ireland. There have, however, been no studies looking at the relationship between the culture of manila clam (*Ruditapes philippinarum*) and intertidal birds in Ireland.

2.2 This trend is repeated aboard with few detailed studies of effects of intertidal aquaculture on waterbird populations having being published in the peer reviewed literature. A number of significant exceptions include studies of intertidal mussel cultivation (Caldow *et al*., 2003), oyster trestles (Kelly *et al*., 1996; Hilgerloh *et al*., 2001) and intertidal clam cultivation (Godet *et al*., 2009).

2.3 With respect to clams, Godet *et al*., (2009) examined the effects of the degradation of *Lanice conchilega* beds by shellfish farming on the spatial distribution of shorebirds in the Chausey archipelago, France. They found that clam farming has a negative effect on Oystercatcher populations. This was due to the loss of *Lanice conchilega* beds, which were a favoured feeding habitat for Oystercatcher. At sites where clam farming does not affect *Lanice conchilega* beds (like Castlemaine), the relevance of Godet *et al*.'s (2009) work is limited. Equally, the effects of aquaculture activities are likely to vary between sites, depending upon the scale of the activity, the intertidal biotopes affected and the waterbird species present; thus even if relevant to Castlemaine application of findings in studies such as Godet *et al*., (2009) must be undertaken cautiously.

2.4 Ideally, a large body of published work across a range of site types is required before robust generalisations can be made about the potential impact of aquaculture activities on waterbird populations. In the absence of such a body of work, targeted studies are required to provide an evidence base for the appropriate assessment of the potential impact of aquaculture activities on waterbird populations. This report presents the findings of such a (preliminary) study undertaken to fill this data gap and allow a more informed assessment of the potential impacts of clam farming at Rossbehy, Castlemaine Harbour to be undertaken.

3. Waterbird distribution

Methods

NPWS Baseline Waterbird Survey Programme

3.1 The methodology used in the NPWS Baseline Waterbird Survey Programme is described in *Baseline Waterbird Surveys within Irish Coastal Special Protection Areas – Draft Survey Methods and Guidance Notes* (National Parks and Wildlife Service, 2009). Details of the results of the counts and any constraints/limitations experienced are described in *Collection of baseline waterbird data for Irish Coastal Special Protection Areas 1: Castlemaine Harbour, Tralee Bay, Lough Gill & Akeragh Lough, Dundalk Bay, Bannow Bay, Dungarvan Harbour & Blackwater Estuary* (Cummins & Crowe, 2010).

3.2 Castlemaine Harbour was divided up into a number of count sectors for these counts. One count sector comprised most of the Rossbehy Creek area. However, sections of the Rossbehy Creek area were not included in this, or any other, count sector, and were, therefore, not covered by the counts (Figure 3.1).

3.3 Four low tide counts and one high tide count were completed at Castlemaine Harbour under the NPWS Baseline Waterbird Survey Programme (NPWS, 2009). The count data was supplied to Atkins / Marine Institute by NPWS in excel spreadsheet format.

Table 3.1 – NPWS counts at Rossbehy Creek.

Date	Tide	Tide time (Cromane)[1]	Tide height (Cromane)[1]
5th October 2009	Low	12:24	0.7 m
21st November 2009	Low	13:40	1.4 m
4th January 2010	Low	13:55	0.7 m
25th January 2010	High	12:05	3.7 m
1st February 2010	Low	12:48	0.3 m

[1] Admiralty EasyTide (http://easytide.ukho.gov.uk/) tidal data for Cromane

[2] Partial count

[3] Covered by two counters; separate start/finish times shown for each counter

3.4 The NPWS Baseline Waterbird Survey also included recording the location of major flocks of foraging and/or roosting birds on field maps (National Parks and Wildlife Service, 2009). However, no flock maps were available for the Rossbehy Creek area.

3.5 In addition to the above counts, a high tide roost survey was carried out on 26 February 2010.

Waterbirds counts of the Rossbehy Creek area, Jan-March 2011

3.6 Waterbird counts were carried out on three dates in February and March 2011. In addition, we also recorded some waterbird count data during a preliminary visit to assess the habitat and map the clam beds in January 2011. On 7th February 2011, the clam farmers were active in the clam beds. Because we wanted to separate the effects of habitat changes caused by clam farming from the effects of disturbance, we arranged the subsequent visits, with the co-operation of the clam farmers, for days when no activity was taking place in the clam beds.

Table 3.2 – Atkins counts at Rossbehy Creek.

Date	Tide	Tide time (Cromane)[1]	Tide height (Cromane)[1]	Purpose of visit
25th January 2011	Low	15:18	1.0 m	Habitat assessment and mapping clam beds; some count data recorded
7th February 2011	Low	13:37	1.1 m	Waterbird counts
24th February 2011	Low	15:42	1.0 m	Waterbird counts
4th March 2011	Low	11:15	0.5 m	Waterbird counts

[1] **Source:** Admiralty EasyTide (http://easytide.ukho.gov.uk/)

Count zones and sectors

3.7 The Rossbehy Creek area was divided into three zones: Caragh Creek, Faha and the Main Bay (Figure 3.2). The Main Bay is the area containing the clam beds. We divided the Main Bay into count sectors that broadly discriminated between areas currently occupied by clam beds, unused licensed areas and unused unlicensed areas (Figure 3.2). The boundaries of the count sectors did not precisely follow the boundaries of the licensed areas, because of this requirement to use clearly identifiable habitat features (mainly tidal channels) to demarcate the count sectors.

3.8 The outer boundary of Sector A is defined by a visible change in sediment type (from cockle sands to clear sands). The south-eastern corner of the sector is an isolated patch of mussels. The boundaries of count sectors C, D and E are defined by tidal channels and the clam beds, except for the north-eastern boundary of E.

3.9 The distribution of the count sectors in relation to the mapped biotopes (NPWS, 2010) is shown in Figure 3.3). The outer count sectors (G, H and I) are mainly occupied by slightly raised sandbanks that dry out at low tide. These are classified as *Mixed fine sand and medium sand with Nephtys cirrosa* in the NPWS biotope map. Muddier sediments occur in the southern part of the Main Bay, occupying most of Sector D and much of Sectors C and E, as well as the southern part of the clam beds. These are classified as *Fine sand and muddy fine sand dominated by Pygospio elegans and Eteone longa* in the NPWS biotope map.

3.10 The northern part of Sector B and C and the clam beds are mapped as *Mixed fine sand and medium sand with Nephtys cirrosa* in the NPWS biotope map, but are muddier than the areas of this biotope further out in the Main Bay.

3.11 Sector A occupies an area with abundant cockle shells on the surface. According to local information, this is a traditional area for cockle harvesting. This area is included in the *Mixed fine sand and medium sand with Nephtys cirrosa* biotope in the NPWS biotope map.

3.12 Extensive areas of mixed sediment shore (LS5; Fossitt, 2000) occur along the western and southern sides of Sector E and over much of Sector F (and continue along the southern shore of the Faha count zone. The NPWS biotope map does not map any areas of mixed sediment shore

3.13 A small area of seagrass is mapped in the NPWS biotope map at the boundary between Sectors F and G, adjacent to the shore. However, our observations indicate that his area of seagrass extends further into Sector F than mapped.

3.14 The amount of intertidal habitat in each count sector is listed in Table 3.3.

Table 3.3 – Area of intertidal habitat in each count sector

Count zone	Count sector/grouping	Area of intertidal habitat (ha)
Main Bay	A	12
	B	4.4
	C	25
	CLAM	6.0
	D	8.2
	E	35
	F	20
	G	149
	H	64
	I	133
	Main Bay total	457
	Licensed plots and adjoining areas (LIC)	76
Faha		93
Caragh		97

Count methodology

3.15 On each count day, we carried out a complete count of the Rossbehy Creek area, and a series of counts in the Main Bay and the clam beds (

Table 3.4). In addition to the complete count, we carried out two-four counts of the entire main bay and five-seven counts of the clam bed only. On 4th March 2011, because of the longer duration of the low tide period, we were also able to carry out an additional five counts of the count sectors covering the licensed plots and adjoining areas (sectors A-D, F and CLAM).

Table 3.4 – Counts completed on each count day.

Date	Coverage	Time relative to low tide	Number of counts[1]
7th February 2011	Complete	-00:10	1
	Main Bay	-02:37 to +01:30	5
	Clam beds	-01:43 to +01:58	10
24th February 2011	Complete	-02:07	1
	Main Bay	-02:07 to +00:02[2]	3
	Clam beds	-01:28 to +01:40	10
4th March 2011	Complete	+ 2:31	1
	Main Bay	-01:47 to +02:31	4
	Licensed plots and adjoining areas	-01:47 to +02:00	8
	Clam beds	-02:14 to +02:25	14

[1] The number of Main Bay counts includes the complete counts. The number of licensed plots and clam bed counts include the Main Bay counts when clam beds were exposed. The number of clam bed counts includes the licensed plots counts.

[2] Main bay counts not carried out after low tide, due to poor visibility of the outer bay.

3.16 On each count, we recorded the number and activity (feeding or roosting/other) of all waterbird species in each zone and/or count sector. We also mapped the position of significant flocks and made notes on the position of the tideline and the degree of exposure of various count sectors.

3.17 Counts of the Main Bay were mainly carried out from vantage points on the shore above the clam bed (see Figure 3.2). These provided good visibility over nearly all of the Main Bay. The vantage points provided only distant views of the outer part of sectors G, H and I, but the views were still generally adequate for counting. It is possible that small groups of small waders could have been missed at this distance. On 4th March 2011, during the 1-1.5 hour period around low tide, the tideline along parts of the outer edge of Sector H and I, and parts of tidal channels within sectors G, H and I were not visible from these vantage points.

3.18 Count sector E includes areas of mixed sediment shore and, on many counts, was counted looking south into the sun. Some birds (particularly Turnstone) were probably missed during some of the counts of this sector.

Results

Waterbird numbers in the Rossbehy Creek area

3.19 Total waterbird numbers in the Rossbehy Creek area on each count day are shown in

Table 3.5.

Table 3.5 – Waterbird counts of the Rossbehy Creek area.

	2009/10 (NPWS)					2011 (Atkins)		
Species	**05-Oct**	**21-Nov**	**04-Jan**	***25-Jan***	**01-Feb**	**07-Feb**	**24-Feb**	**04-Mar**
Light-bellied Brent Goose	44		42	*37*		51	184	119
Shelduck				*24*	12	15	29	18
Wigeon	36		7	*56*	28	88	51	59
Teal								11
Mallard	47			*16*	14	26	40	26
Red-breasted Merganser					4	11	6	26
Great Northern Diver							2	
Cormorant				*4*		1		1
Little Egret	4			*1*	4	1	3	3
Grey Heron	2						1	1
Oystercatcher		54	62	*59*		76	119	217
Ringed Plover				*39*	32	70	74	54
Lapwing				*1*				
Knot				*40*		6	13	
Sanderling				*162*		80	173	265
Dunlin				*90*		320	340	180
Bar-tailed Godwit					14	3	2	59
Curlew			20	*35*	32	33	62	65
Greenshank			9	*9*	10	4	4	18
Redshank			25	*37*	37	101	16	139
Turnstone			43	*39*	45	23		22
Black-headed Gull	34	34		*18*		6	9	10
Common Gull	14		9	*16*	34	56	93	44
Lesser Black-backed Gull	9						2	21
Herring Gull		10	2		9	16	43	42
Great Black-backed Gull	7			*2*		3	3	18

2009/10 data is from the NPWS Baseline Waterbird Survey Programme and represent single counts of the Rossbehy Creek count sector. These counts were carried out at low tide, except for the count on 25th January (shown in italics), which was carried out at high tide.

2010/11 data is from counts carried out by Atkins and represent the maximum counts on each count day. These counts were carried out from 2-3 hours before low tide to 2-3 hours after low tide.

3.20 In the first two counts in the 2009/10 dataset, very few waders were recorded: no waders on 5th October and only Oystercatcher on 21st November. Also on 21st November, only three species of waterbirds in total were recorded. This is rather surprising for a large (nearly 700 ha) and varied area of intertidal habitat and suggests that these counts may not be representative of the typical usage of this area.

3.21 The highest numbers of waders in the 2009/10 dataset were recorded during the high tide count on 25th January 2010. However, this count was carried out 2.5-3 hours after high tide, and during neap tide conditions. It is likely that a substantial amount of intertidal habitat was exposed and most of the waders, apart from the Turnstone, were recorded as foraging. During the high tide roost survey on 26th February 2010, no roosting waders were recorded in the Rossbehy Creek sector.

3.22 Numbers of Light-bellied Brent Goose and most species of waders and gulls were generally higher in the 2010/11 counts compared to the 2009/10 counts. The comparison in

Table 3.5 is biased somewhat by using maximum counts from multiple counts on each count day in 2010/11. However, for most species the maximum count was from the single complete count of the entire Rossbehy Creek area, or was not much higher than that count (Table 3.6). The main exceptions were Ringed Plover, Dunlin and Sanderling, where the complete counts on 24th February and 4th March 2011 were carried out on the falling or rising tide and parts of the flocks had left the area.

Table 3.6 – Comparisons of the single complete counts of the entire Rossbehy Creek area and the maximum count in the Main Bay on each count day in 2011.

	Complete count			Maximum count		
	07-Feb	24-Feb	04-Mar	07-Feb	24-Feb	04-Mar
Light-bellied Brent Goose	46	93	119	51	184	119
Shelduck	15	29	18	15	29	18
Wigeon	50	51	52	88	51	59
Teal			11	0	0	11
Mallard	25	28	19	26	40	26
Red-breasted Merganser	2	6	26	11	6	26
Great Northern Diver		2		0	2	0
Cormorant	1		1	1	0	1
Little Egret	1	3	2	1	3	3
Grey Heron		1		0	1	1
Oystercatcher	76	119	217	76	119	217
Ringed Plover	60		50	70	74	54
Knot		5		6	13	0
Sanderling	48	52	240	80	173	265
Dunlin	220	220	150	320	340	180
Bar-tailed Godwit	3	2	1	3	2	59
Curlew	33	62	65	33	62	65
Greenshank		4	18	4	4	18
Redshank	101	16	139	101	16	139
Turnstone			1	23	0	22
Black-headed Gull	6	9	10	6	9	10
Common Gull	15	93	28	56	93	44
Lesser Black-backed Gull		2	1	0	2	21
Herring Gull	1	43	42	16	43	42
Great Black-backed Gull	2		6	3	3	18

3.23 It is possible that the differences between the 2009/10 counts and the 2011 counts reflect differences in seasonal patterns of spatial distribution, as all the 2009/10 counts were earlier in the winter than the 2011 counts. In particular, the number of Sanderling increased across the duration of the four 2011 counts (including a count of 40 Sanderling on the preliminary visit on 25 January 2011).

3.24 The incomplete coverage in the 2009/10 counts (see paragraph 3.2) might also explain some of the differences, although the areas that were not covered generally held few birds.

3.25 Finally, some of the differences may be due to annual variation in total numbers in Castlemaine Harbour. I-WeBS monitoring data from 2010/11 is not yet available, so this explanation cannot be investigated further.

Importance of the Rossbehy Creek area

3.26 The mean percentages of the total Castlemaine Harbour count in the Rossbehy Creek count sector in 2009/10 are shown in Table 3.6. Four low tide counts and one high tide count were completed at Castlemaine Harbour under the NPWS Baseline Waterbird Survey Programme (NPWS, 2009). The count data was supplied to Atkins / Marine Institute by NPWS in excel spreadsheet format.

3.27 Table 3.1Separate percentages are shown excluding the October and November counts because these counts appear to be unrepresentative (see paragraph 3.20). The total area of intertidal habitat in the Rossbehy Creek sector is 470 ha. This represents around 12% of the total area of intertidal habitat in Castlemaine Harbour. Most species were recorded in 2009/10 in lower numbers than would be predicted by the amount of intertidal habitat. Turnstone was the only species that appears to show a marked positive association with this count sector. Ringed Plover, Sanderling and Greenshank were recorded in numbers roughly in accordance with the availability of intertidal habitat, although, in the case of Sanderling this is due to a single high count.

3.28 Numbers of Light-bellied Brent Goose, Oystercatcher, Ringed Plover, Sanderling, Dunlin, Curlew and Redshank were approximately two to three times higher in 2011, compared to January-February 2010. Therefore, if the total Castlemaine Harbour population of these species was similar in the two winters, the relative importance of the Rossbehy Creek area would increase commensurately (although the total area included in the counts was larger). In particular, the Rossbehy Creek area would support important components of the Castlemaine Harbour populations of Ringed Plover and Sanderling. Furthermore, the mean number of Sanderling in the Rossbehy Creek area in 2011 exceeded the threshold for national importance.

3.29 However, these are very crude comparisons because a large part of the intertidal habitat in the Rossbehy Creek area consists of outer sandflats that support low numbers of waterbirds. The actual area used by the majority of waterbirds is much smaller than the total availability of intertidal habitat.

Table 3.7 - Mean percentages of the total Castlemaine Harbour count in the Rossbehy Creek count sector during the 2009/10 counts.

	All 5 counts		Jan and Feb 2010	
	Mean	SD	Mean	SD
Light-bellied Brent Goose	3%	3%	4%	3%
Shelduck	4%	6%	6%	6%
Wigeon	3%	4%	5%	4%
Mallard	2%	2%	2%	2%
Red-breasted Merganser	2%	4%	3%	5%
Cormorant	2%	4%	3%	5%
Little Egret	5%	5%	6%	6%

	All 5 counts		Jan and Feb 2010	
	Mean	SD	Mean	SD
Grey Heron	1%	1%	0%	0%
Oystercatcher	2%	2%	3%	3%
Ringed Plover	6%	9%	10%	10%
Lapwing	0%	0%	0%	0%
Knot	4%	9%	7%	12%
Sanderling	8%	17%	13%	22%
Dunlin	1%	2%	1%	2%
Bar-tailed Godwit	1%	2%	2%	3%
Curlew	2%	2%	3%	2%
Greenshank	9%	8%	15%	4%
Redshank	2%	2%	3%	1%
Turnstone	21%	20%	35%	9%
Black-headed Gull	4%	7%	1%	2%
Common Gull	5%	5%	8%	6%
Lesser Black-backed Gull	2%	5%	0%	0%
Herring Gull	2%	2%	2%	3%
Great Black-backed Gull	11%	22%	17%	29%

Spatial distribution of waterbirds within the Rossbehy Creek area

3.30 The spatial distribution of waterbirds between count zones within the Rossbehy Creek area during the Atkins counts in February and March 2011 is shown in Table 3.8 (counts zones are illustrated in Figure 3.2). Light-bellied Brent Goose, Ringed Plover, Sanderling and Dunlin occurred almost exclusively in the Main Bay (MB). Oystercatcher and Curlew occurred mainly in Faha and the Main Bay during the falling and rising tide counts, apparently moving into Caragh Creek during low tide.

3.31 Redshank occurred across all three zones with variable patterns of distribution during the three counts. On the rising tide count Redshank in sectors D, E and F of the main bay during the low tide period appear to have moved to Faha by the time of the complete count. The Redshank in Caragh Creek during this count were roosting on a saltmarsh peninsula.

Table 3.8 – Spatial distribution of waterbirds between count zones during complete counts of the Rossbehy Creek area in February and March 2011.

Date	07th February Low tide				24th February Falling tide				04th March Rising tide			
Zone[1]	**C**	**F**	**MB**	**Tot**	**C**	**F**	**MB**	**Tot**	**C**	**F**	**MB**	**Tot**
Light-bellied Brent Goose			46	**46**			93	**93**		6	113	**119**
Shelduck	3	12		**15**	24	5		**29**	12	2	4	**18**
Wigeon	19	2	29	**50**	1	8	42	**51**	2		50	**52**
Teal									11			**11**
Mallard		1	24	**25**	3	9	16	**28**	5	2	12	**19**
Red-breasted Merganser	2			**2**			6	**6**	6		20	**26**
Great Northern Diver							2	**2**				
Cormorant	1			**1**					1			**1**
Little Egret	1			**1**	1		2	**3**	2			**2**
Grey Heron							1	**1**				
Oystercatcher	49	23	4	**76**		66	53	**119**		89	128	**217**
Ringed Plover			60	**60**							50	**50**
Knot							5	**5**				
Sanderling			48	**48**			52	**52**			240	**240**
Dunlin			220	**220**			220	**220**			150	**150**
Bar-tailed Godwit		3		**3**		1	1	**2**		1		**1**
Curlew	10	13	10	**33**	2	36	24	**62**	4	47	14	**65**
Greenshank					4			**4**	12	4	2	**18**
Redshank	68	4	29	**101**	3	5	8	**16**	42	74	23	**139**
Turnstone									1			**1**
Black-headed Gull	3	2	1	**6**	3	5	1	**9**	4	6		**10**

Date	07th February Low tide				24th February Falling tide				04th March Rising tide			
Zone[1]	**C**	**F**	**MB**	**Tot**	**C**	**F**	**MB**	**Tot**	**C**	**F**	**MB**	**Tot**
Common Gull		6	9	**15**	8	63	22	**93**		17	11	**28**
Lesser Black-backed Gull						2		**2**		1		**1**
Herring Gull			1	**1**		3	40	**43**	1	26	15	**42**
Great Black-backed Gull	2			**2**						2	4	**6**

[1] C = Caragh Creek; F = Faha; MB = Main Bay; Tot=Total.

Spatial distribution of waterbirds within the Main Bay

Patterns of tidal exposure

3.32 Waterbird distribution in intertidal habitat is strongly affected by the patterns of tidal exposure. Therefore, we first discuss how the exposure of intertidal habitat varies across the low tide period, before considering the spatial distribution of waterbirds.

3.33 The general progression of tidal exposure is from the north to the south. Sectors G, H and I are largely exposed before the sectors around the clam beds become exposed.

3.34 Sector C starts to become exposed shortly before the clam beds start to become exposed. On all three counts, sector C was fully exposed during the middle of the count period.

3.35 The middle section of the clam beds are the first part of the clam bed to become exposed, followed by the northern section. The southern section is the last area to become exposed and on 24th February remained shallowly flooded, but accessible to intertidally feeding waterbirds, throughout the low tide. The slight elevation of the rows of clams in the clam beds mean that they become exposed 10-15 minutes earlier than the adjoining intertidal habitat.

3.36 Sector D and the northern part of Sector E are the last areas to become exposed. On 7th and 24th February these areas remained largely flooded throughout the low tide.

3.37 The clam beds were exposed for between 3h 15 min and 4h 45 min around low tide with the period of full exposure varying from 1h to 3h (Table 3.8). The ebb and flood periods during which the tide is receding / advancing across the clam beds last for around 45-70 minutes. The exposure period was shortest on 24th February, even though the predicted tidal height was lower on that date than on 7th February. Strong south-westerly winds on 24th February may have held the tide in. The exposure period was asymmetrical around the low tide time for Cromane with the midpoint of the exposure period occurring 10-15 minutes later than the low tide time.

Table 3.9 – Duration of tidal exposure of the clam beds.

	7th February	24th February	04th March
Maximum duration of exposure	03:55	03:15	04:45
Duration of full exposure	02:15	01:00	03:00
Duration of ebb period	00:50	01:05	01:00
Duration of flood period	00:50	01:10	00:45

Spatial distribution across the Main Bay and use of the clam beds

3.38 The following sections discuss the main spatial and temporal patterns of usage of waterbird species that regularly occurred in the Main Bay. For each species, the general patterns across the Main Bay are discussed first, followed by the patterns of usage of the clam beds.

3.39 Waterbirds counts in sector CLAM, covering the clam beds, are shown in Table 3.12.

Light-bellied Brent Goose

3.40 Main feeding area in Sector G, moving to outer part of sector as tide falls, and passing through Sector A. On 24th February a large flock of over 100 geese flew into Sector D when it was still flooded and moved up through the clam beds as the tide receded. On 4th March, a flock of up to 57 were in the outer part of sector H.

3.41 Apart from the flock on 24th February, the only other record from the clam beds was of three geese on a single count on the ebbing tide on 4th March.

Wigeon and Mallard

3.42 Wigeon and Mallard mainly occurred in Sector E and adjacent parts of Sectors D and F.

3.43 Small numbers occurred in the clam beds on some counts.

Plate 1.4 - Wigeon, Mallard, gulls and Light-bellied Brent geese at the boundary between Sectors D and E.

Oystercatcher

3.44 Oystercatcher were generally widely distributed throughout the Main Bay, usually without large concentrations, but rarely occurred in Sector C. In Sector G, they followed the tide with few birds in the inner part of the sector at low tide. On 4th March, a roosting flock of around 75 appeared in the outer part of Sector H at low tide and remained here on the rising tide. Apart from this flock, most birds recorded were feeding

3.45 Small numbers (up to 10) occurred in the clam beds on nearly all the counts. On 7th February and 4th March, numbers dropped at the midpoint of the low tide. This pattern was not evident on 24th

February, probably because the southern part of the clam bed remained shallowly flooded throughout the low tide on this date. Birds moved into the clam beds as soon as the first tops of the clam rows became exposed, and remained until the last tops were flooded. They generally followed the tide through the clam beds moving to the southern parts as the tide receded.

Ringed Plover, Sanderling and Dunlin

3.46 These species showed a marked preference for Sector C. On 25th January, 7th and 24th February, the entire flock remained within Sector C for virtually the entire time it was exposed. On 4th March, the flock was more mobile usually being split between Sector C and Sector A and the south-western part of Sector G. The flock appears to move to Sector H as the tide rises, but observations were not continued long enough to identify the high tide roost. Most birds recorded on all counts were feeding.

3.47 These species were never recorded in the clam beds during the counts. On 24th February and 4th March, while parts of the flock were in Sector A, birds were feeding up to within a few metres of the edge of the clam bed but did not move inside.

Curlew

3.48 Curlews were generally widely distributed throughout the Main Bay, usually without large concentrations, apart from a flock of 25 in Sector E during one count on 4th March. Most birds recorded on all counts were feeding.

3.49 Small numbers (up to 5) occurred in the clam beds on most of the counts. Unlike Oystercatcher, Curlew numbers did not show any obvious pattern in relation to the tidal cycle. Like Oystercatcher, Curlews moved into the clam beds as soon as the first tops of the clam rows became exposed, and remained until the last tops were flooded and generally followed the tide through the clam beds moving to the southern parts as the tide receded.

Redshank

3.50 Redshank mainly occurred in the southernmost sectors (CLAM, D, E and F), with Sectors D and E being generally the most favoured. Their feeding area seems to largely coincide with the *Fine sand and muddy fine sand dominated by Pygspio elegans* biotope.On 7th February, 9 Redshank were feeding across the inner part of Sector G as the tide began to fall. On most counts, most birds recorded were feeding. However, on 4th March, around low tide, up to 26 Redshank were recorded roosting in Sectors D and F along the edge of the clam beds and along tidal channels.

3.51 On 7th February, up to 27 Redshank were fed in the clam beds on the ebbing and flooding tide, with small numbers remaining present at the lowest point of the tide. On 24th February, Redshank were not recorded within the clam beds, but overall numbers present in the Rossbehy Creek area were very low on this date. On 4th March, up to 25 were feeding in the clam beds on the ebbing tide with small numbers remaining present through the lowest point of the tide and on the flooding tide. Redshank moved into the clam beds on the ebbing tide later than Oystercatcher and Curlew and left on the flooding tide earlier. On 7th February, Redshank appeared to be mainly feeding in the clear strips between the raised rows of clam bags.

Turnstone

3.52 Turnstones were almost exclusively recorded in the clam bed, apart from occasional birds in Sector E. However, birds in the southern part of Sector E could have been missed due to poor visibility (see paragraph 3.18) and it seems likely that the flock from the clam beds moved to this sector when the clam beds were covered by the tide. Most birds recorded on all counts were feeding.

3.53 Up to 23 Turnstone were feeding in the clam beds on 7th February and 4th March. A Turnstone flock of similar size was also recorded in the clam beds during the preliminary visit on 25th January. On 24th February, Turnstone were not recorded within the clam beds. Overall numbers recorded in the Rossbehy Creek area were very low on this date, but it is possible that the Turnstone flock remained in the southern part of Sector E and were missed due to poor visibility. On 4th March, the Turnstone flock occurred in the clam beds during the period when it was fully exposed. The pattern of usage on 7th February is less clear, perhaps due to disturbance from clam farming activities. Turnstone appeared to feed on the rows of clam bags, particularly those covered with seaweed.

Common and Herring Gulls

3.54 These gulls were generally widely distributed throughout the Main Bay, but with roosting flocks occurring on some counts in Sector E. Overall around two-thirds of the birds recorded were roosting.

3.55 Small numbers of these gulls were frequent in the clam beds, with, exceptionally, a flock of up to 22 Common Gulls feeding on the flooding tide on 7th February.

Table 3.10 – Waterbird counts in the clam beds on 7th February 2011.

	Ebbing tide				Fully exposed				Flooding tide		
Time before/ after low tide	-1:43	-1:37	-1:26	-1:16	-0:51	-0:13	+0:28	+1:13	+1:23	+1:39	+1:58
Shelduck					1						
Wigeon	4	4	1		1						
Mallard					6		1				
Oystercatcher	5	4	3	5	4	2	3	2	6	9	2
Knot		3	3		1						
Bar-tailed Godwit				1	2						
Curlew	1		1	1	3	4	1		3	2	1
Greenshank			1		1			2	1		
Redshank	3	12	9	13	21	1	2	6	11	27	11
Turnstone			1	5	7			11	13	23	2
Black-headed Gull		1						1	4	1	
Common Gull								3	20	22	13
Herring Gull		1							3	1	1
Hooded Crow									9		

Table 3.11 - Waterbird counts in the clam beds on 24th February 2011.

	Ebbing tide				Fully exposed		Flooding tide			
Time before/ after low tide	01:28	01:17	00:59	00:37	00:03	00:23	01:13	01:23	01:33	01:40
Light-bellied Brent Goose		121	79	68	27	20	18			
Oystercatcher	8	8	3	12	6	8	2	3	3	2
Curlew	2	1	3	5	5	4		1	2	1
Black-headed Gull					1	1				
Common Gull	1	5	7	5	4	8				
Herring Gull	4			2	5	6		1	1	
Great Black-backed Gull				1	1					
Hooded Crow				1						

Table 3.12 - Waterbird counts in the clam beds on 4th March 2011, before low tide.

	Ebbing tide				Fully exposed			
Time before low tide	02:14	01:56	01:39	01:27	01:09	00:48	00:25	00:07
Light-bellied Brent Goose				3				
Mallard			2	2	2	2	2	2
Oystercatcher	1	2	4	5	1	1	1	1
Bar-tailed Godwit			2					
Curlew			3	1	2	4	3	4
Greenshank				1	1			
Redshank			25	2	22	2	1	1
Turnstone					1	22	20	20
Common Gull		2						1
Herring Gull	4	1	2	1				
Hooded Crow			2	5	4	1	4	1

Table 3.13 - Waterbird counts in the clam beds on 4th March 2011, after low tide.

	Fully exposed			Flooding tide		
Time after low tide	00:32	01:07	01:33	02:04	02:14	02:25
Light-bellied Brent Goose						
Mallard						
Oystercatcher	1		3	5	6	3
Bar-tailed Godwit						
Curlew	1	5	4	3	2	1
Greenshank				1		
Redshank	1	3	3	2		
Turnstone	9	1	1	2		
Common Gull	1	3	3	5	2	
Herring Gull			1	1	2	1
Hooded Crow	1	3	10	1	4	

Relative usage of the clam beds and the licensed area

3.56 The maximum counts in the clam beds and the sectors covering the licensed area are compared to the maximum counts across the entire Main Bay in Table 3.13 and Table 3.14. Apart from Turnstone (see paragraphs 3.52 and 3.53), the clam beds support relatively low percentages of the waterbird populations in the Main Bay.

3.57 The clam bed supported, at some point during the tidal cycle, 14-26% of the total Main Bay populations of Oystercatcher, Curlew, Common Gull and Herring Gull, with relatively little variability between count days in these percentages.

3.58 Two other species were more variable in their usage of the clam beds. On one count day, the clam bed supported, at some point during the tidal cycle, 65% of the Main Bay Light-bellied Brent Goose population. On two of the count days, the clam beds supported, at some point during the tidal cycle, 30-60% of the Main Bay Redshank population.

3.59 On all three counts, the sectors covering the licensed plots and adjoining areas supported, for much of the tidal cycle, virtually the entire Main Bay populations of Ringed Plover, Sanderling and Dunlin. These sectors also consistently supported 65-70% of the Mallard and Curlew populations and 30% of the Oystercatcher population. Other species were more variable in their use of these sectors.

Table 3.14 – Mean percentages of the maximum Main Bay counts in the clam beds (CLAM) and in the sectors covering the licensed plots and adjoining areas (LIC).

	CLAM		LIC	
	Mean	SD	Mean	SD
Light-bellied Brent Goose	23%	37%	33%	36%
Wigeon	2%	3%	24%	18%
Mallard	10%	12%	71%	5%
Oystercatcher	19%	13%	29%	17%
Oystercatcher (excl. roosting flock)[1]	21%	9%	33%	9%
Ringed Plover	0%	0%	100%	0%
Sanderling	0%	0%	96%	4%
Dunlin	0%	0%	100%	0%
Curlew	14%	3%	65%	10%
Redshank	31%	32%	46%	44%
Common Gull	26%	13%	37%	20%
Herring Gull	19%	4%	53%	42%

The data in this table show the mean and standard deviations across count days of the maximum counts in the clam beds and in sectors covering the licensed area expressed as a percentage of the maximum count across the entire main bay.

[1] Excluding the roosting flock of 75 on the outer part of Sector H on 4 March

Table 3.15 – Maximum counts in the clam beds (CLAM), the sectors covering the licensed plots and adjoining areas (LIC) and the entire Main Bay (MB) on each count day.

	07-Feb			24-Feb			04-Mar		
	Clam	LIC	MB	Clam	LIC	MB	Clam	LIC	MB
Light-bellied Brent Goose	0	7	51	121	137	184	3	12	113
Shelduck	1	2	2	0	2	5	0	3	6
Wigeon	4	18	88	0	4	49	0	26	59
Teal	0	0	0	0	0	0	0	0	0
Mallard	6	18	26	0	27	40	2	20	26
Red-breasted Merganser	0	0	11	0	0	6	0	3	20
Great Northern Diver	0	0	0	0	0	2	0	0	0
Cormorant	0	1	1	0	0	0	0	1	1
Little Egret	0	0	0	0	0	2	0	2	3
Grey Heron	0	0	0	0	0	1	0	1	1
Oystercatcher	9	13	31	12	18	53	6	13	128
Ringed Plover	0	70	70	0	74	74	0	54	54
Knot	3	3	6	0	13	13	0	0	0
Sanderling	0	80	80	0	160	173	0	250	265
Dunlin	0	320	320	0	340	340	0	180	180
Bar-tailed Godwit	2	2	2	0	0	1	2	22	59
Curlew	4	17	24	5	23	33	5	25	47
Greenshank	2	3	4	0	0	0	1	2	5
Redshank	27	37	42	0	0	8	25	42	85
Turnstone	23	23	23	0	0	0	22	22	22
Black-headed Gull	4	4	4	1	1	1	0	4	10
Common Gull	22	33	60	8	11	28	5	7	44
Lesser Black-backed Gull	0	0	0	0	0	0	0	0	21
Herring Gull	3	16	16	6	8	40	4	7	18
Great Black-backed Gull	0	0	3	1	1	3	0	12	18

The potential impact of clam aquaculture on waterbirds

Impact of change in habitat

3.60 In principle, the potential impact of the existing clam beds on waterbird spatial distribution can be assessed by comparing the proportion of the Main Bay population occurring in the clam bed, with the proportion of the Main Bay intertidal habitat in the clam beds.

Turnstone

3.61 Turnstones were generally only recorded in the clam beds during these counts, apart from a few recorded in Sector E and F. However, birds in the southern part of Sector E could have been missed due to poor visibility (see paragraph 3.18) and it seems likely that the flock from the clam beds moved to this sector when the clam beds were covered by the tide.

3.62 The clam beds clearly have a **positive impact on Turnstone** as they have converted an area of unsuitable habitat into suitable habitat.

Oystercatcher, Curlew and Redshank

3.63 The existing clam beds cover an area of 6.0 ha out of a total area of 460 ha of intertidal habitat in the Main Bay. However, a simple comparison of the proportion of intertidal habitat occupied by the clam beds with the proportion of the waterbird population using the clam bed is misleading: by the time that the clam beds are exposed, large areas of intertidal habitat at higher elevations in the Main Bay are not being used by waterbirds, presumably because the sediment has become too dry.

3.64 During the period when the tide is ebbing and flooding in the clam beds, we estimate that around 70 ha of intertidal habitat in the area around the clam beds is in a similar tidal condition. However, during this period, Oystercatcher and Curlew also feed in the outer parts of Sector G and Sector I. Because of the effects of foreshortening over the distances at which we were viewing, it was not possible to map the extent of tidal exposure, or the areas occupied by Oystercatcher and Curlew in the outer part of the Main Bay. But the above would suggest that the clam beds occupy 5-10% or less of the area suitable for feeding Oystercatcher and Curlew during this period. Therefore, although the total numbers of Oystercatcher and Curlew in the clam beds are low, there is some evidence that they preferentially select this habitat during the ebb and flood tide periods. The behaviour of individual birds that arrive as the first tiny patches are exposed and sit on the clam bags waiting for the sediment to become accessible supports this conclusion.

3.65 Redshank are largely restricted to the southern part of the Main Bay. The clam beds appear to be the northernmost limit of their main feeding area. As the clam beds are one of the first areas of intertidal soft sediment to become exposed within their feeding area, it is not surprising that concentrations occur in the clam beds during the ebb and flood tide periods. During this period around 30 ha of intertidal habitat is exposed within their feeding area. On 7 February, over 60% of the Redshank in the Main Bay occurred in the clam beds during the ebb and flood tide periods, while on 4 March around 20% occurred in the clam beds during the ebb tide period but only a few birds occurred during the flood tide. Therefore, while it appears that Redshank do not avoid the clam beds; it is not clear whether they show an active preference for the clam beds.

3.66 The above indicates that the current level of clam aquaculture is not having a negative impact on Oystercatcher, Curlew and Redshank and may be having a positive impact.

3.67 None of these species showed strong preferences for licensed areas outside the current extent of clam cultivation. Therefore, extension of clam cultivation into the full extent of the licensed area is not likely to have a negative impact on these species and may have a positive impact.

Ringed Plover, Sanderling and Dunlin

3.68 Ringed Plover, Sanderling and Dunlin showed a strong apparent preference for two of the sectors adjoining the clam beds (Sector A and, particularly C). The favoured area of Sector C is largely across the tidal creek from the current area used for clam cultivation (Plate 3.1). They never occurred within the clam beds, despite feeding up to within a few metres of the edges of the clam beds in Sector A. These observations strongly indicate that these species avoid the clam beds. As the Rossbehy Creek area may support around 30% of the total Castlemaine Harbour population of these species, clam aquaculture has the potential to cause displacement of a significant proportion of these populations.

Plate 3.1 - Part of Sector C, the sector favoured by Ringed Plover, Sanderling and Dunlin (note tidal creek in the foreground).

3.69 The impact of the current level of clam aquaculture on these species will depend on how suitable the habitat was for these species before the start of clam cultivation. If all of the area currently occupied by clam aquaculture was previously suitable for these species then the development of clam aquaculture would have removed 14% of the main area of habitat used by these species in Rossbehy Creek, and may have caused displacement of 4% of the total Castlemaine Harbour population of these species. However, the fact that these species also did not occur in Sectors B and D may suggest that the area now occupied by the clam beds was, at least in part, not optimum habitat for these species. Therefore, any impact from the current level of clam cultivation is probably relatively minor, although there is some uncertainty about this assessment due to lack of knowledge of the nature of the habitat before the start of clam cultivation.

3.70 Extension of clam cultivation into the full extent of the licensed area would remove around 2.2 ha (9%) of the intertidal habitat in Sector C and 9 ha (75%) of the intertidal habitat in Sector A. The area of intertidal habitat that would be removed in Sector C is along the edge of a tidal channel. It is exposed for a shorter period, and is, therefore, used less by these species than areas in the centre of Sector C (i.e. north of the tidal channel). However, overall, the extension of clam cultivation would remove 25% of the combined areas of Sectors A and C and may cause displacement of 8% of the total Castlemaine Harbour populations of these species. However, there is a high level of uncertainty about this assessment because of the lack of data on total numbers in Castlemaine Harbour in 2010/11. It should also be noted that this assessment is based on only 3 counts in February and March 2011. A full season of counts is therefore recommended to ensure that these data are representative of impacts across seasons and years.

Other species

3.71 Most other species that occurred in the Main bay were recorded within the clam beds. From their behaviour and general patterns of distribution within the Main Bay, it is unlikely that Light-bellied Brent Goose, Wigeon, Mallard, Common Gull and Herring Gull were avoiding the clam beds. Other species occurred too infrequently and/or in too low numbers for it to be possible to reach any conclusions.

Impact of disturbance

Activities

3.72 According to information provided by the clam farmers, on average they spend one day per week working in the clam beds, harvesting clams or cleaning the bags.

3.73 Other activities in the area include hand collection of shellfish and recreation. Hand collection of cockles has taken place in the past in Sector A. The current status of this activity is not known. A single winkle picker was present on 7th February and 4th March in the upper (south-eastern part) of Sector G and adjacent part of Sector F. No winkle pickers were present on 25th January or 24th February.

3.74 The main focus of recreation in the Rossbehy Creek area is the dunes at Faha. On each of our visits we noted occasional instances of people walking along the beach above the clam bed, but they kept to the shoreline and did not venture on to the intertidal.

Impact assessment

3.75 Our observations elsewhere, during studies of oyster farms, indicate that waterbirds habituate to the presence of tractors in aquaculture sites. Our observations during the present study also indicate that the presence of tractors was not affecting the waterbird usage of the clam beds, or adjacent areas.

3.76 The period when tractors are likely to be working in the clam beds, around the lowest point of the tide, is the period when there is least use of the clam beds by waterbirds. The latter usage pattern appears to be independent of the presence of tractors, occurring on days when no tractors were working.

3.77 On 7th February, a tractor was working in the clam beds from around 10 minutes before low tide to 1 hour 20 minutes after low tide. Numbers of waterbirds within the clam beds had already dropped very low before the tractor began working (00:13 count in Table 3.10). They remained low in a subsequent count shortly after the tractor had begun working. However, as the tide begun flooding lower-lying areas in the Main Bay, waterbird numbers increased in the clam beds while the tractor was still working (01:13 count in Table 3.9). Overall, while the data is very limited, the pattern of waterbird usage of the clam beds across the entire count period on 7th February does not indicate any obvious response to the presence of the tractor during the middle of the period.

3.78 Therefore, it seems unlikely that disturbance levels associated with the current level of clam cultivation is adversely affecting waterbird populations.

3.79 Other activities are not causing significant levels of disturbance to waterbirds in the vicinity of the clam beds.

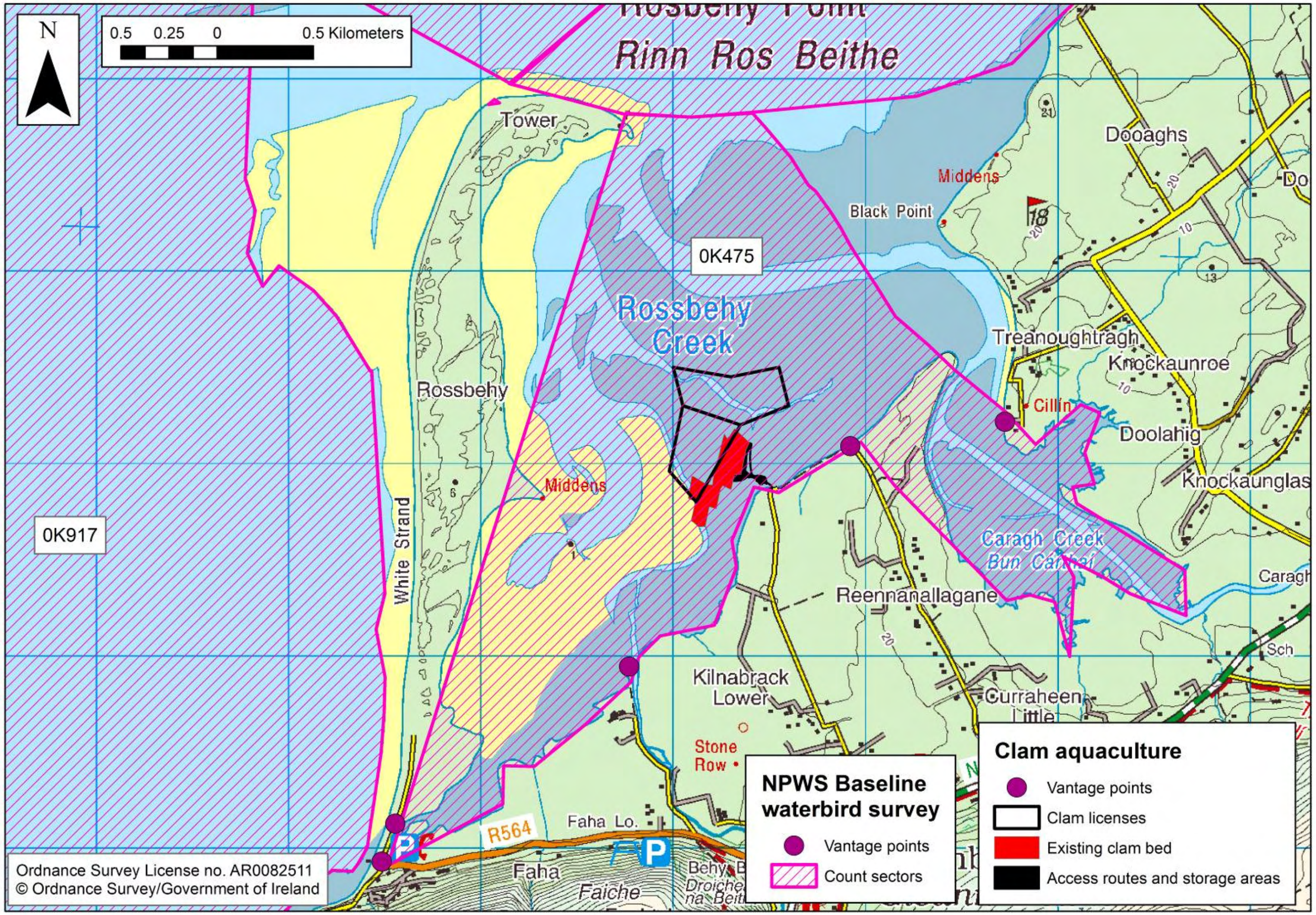

Figure 3.1 – Coverage of the Rossbehy Creek area by count sectors used in the NPWS Baseline Waterbird Survey Programme.

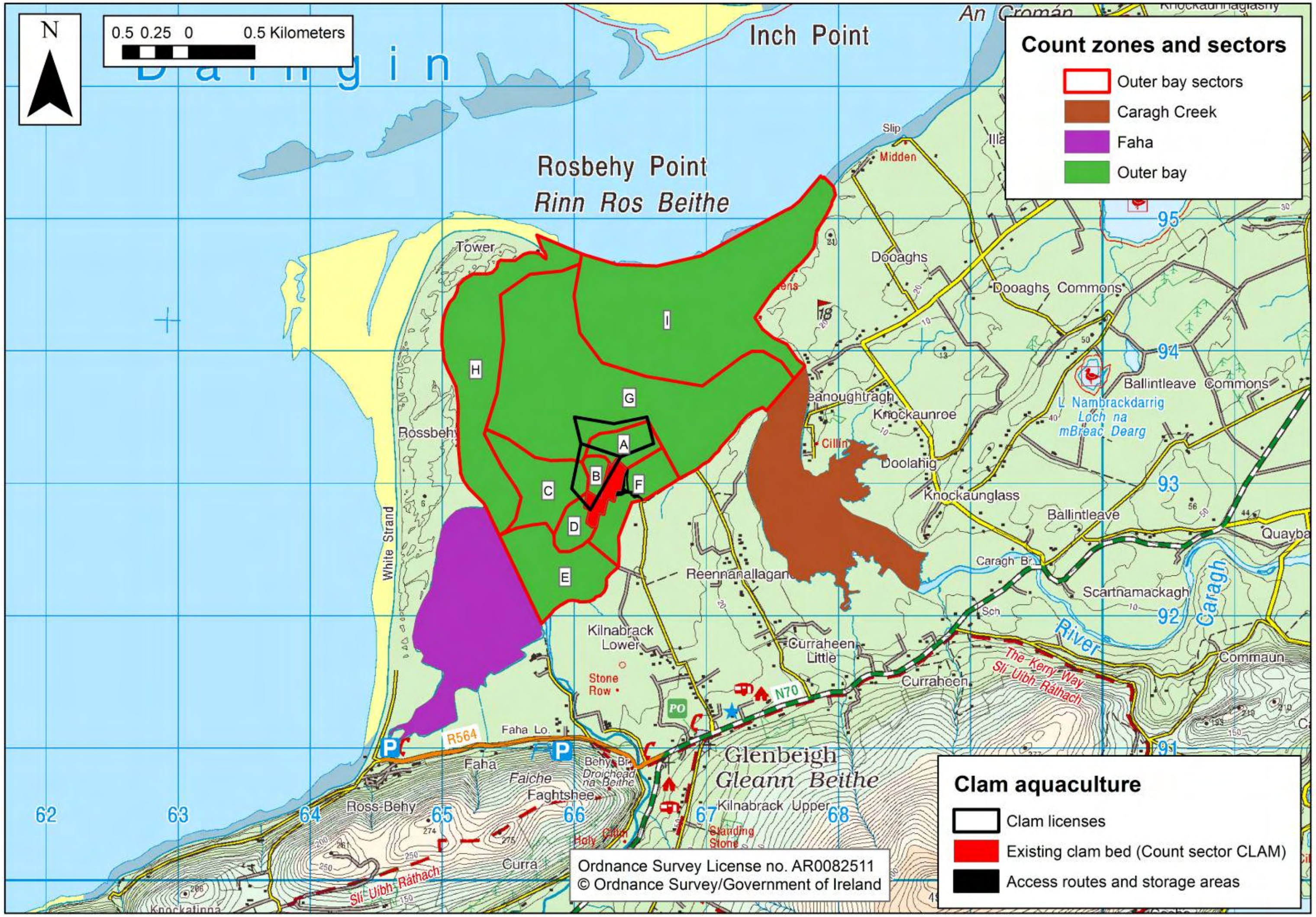

Figure 3.2 – Count zones and sectors used in the 2011 Atkins waterbird counts of the Rossbehy Creek area.

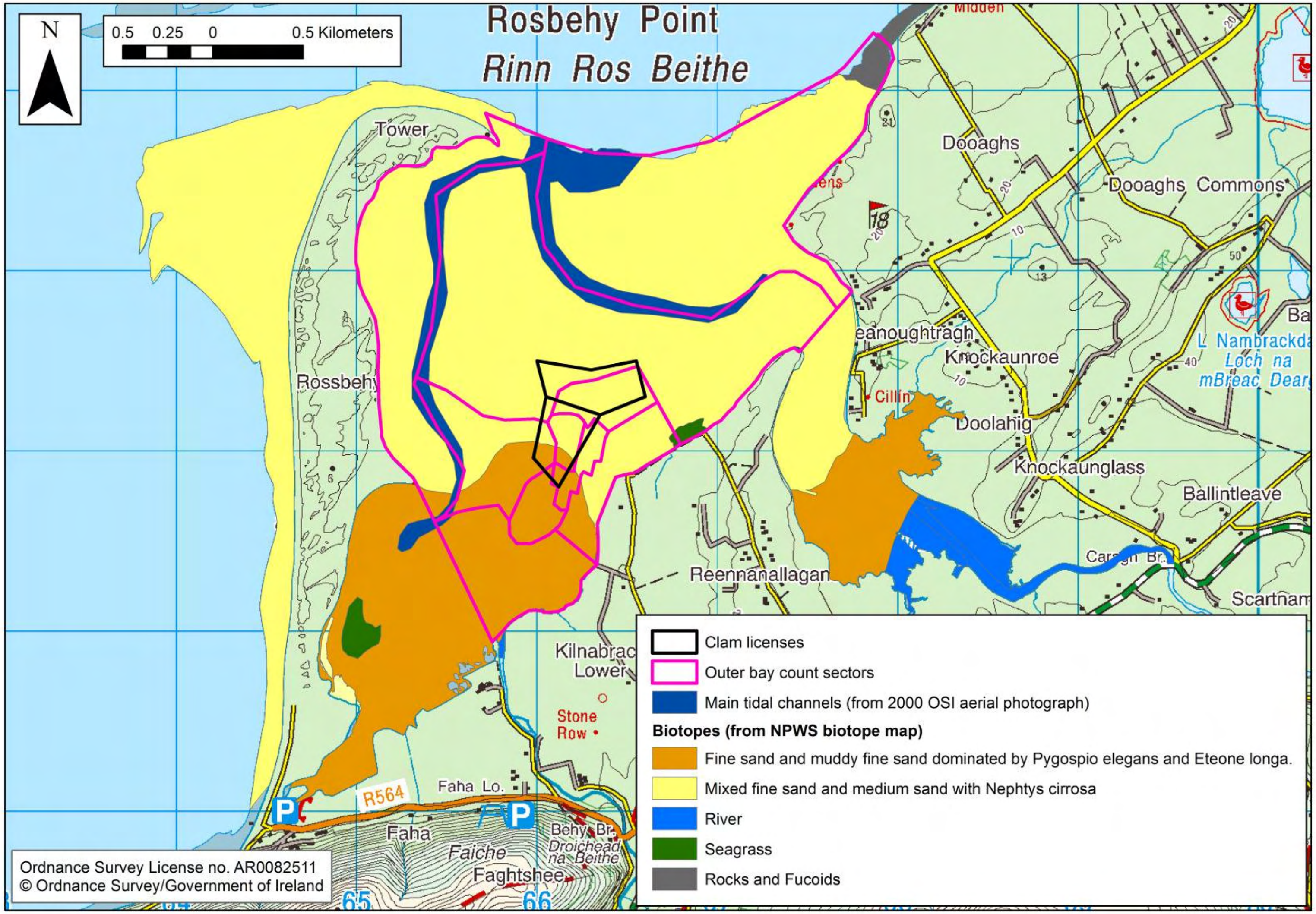

Figure 3.3 – Intertidal biotopes in the Rossbehy Creek area of Castlemaine Harbour.

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Appendix A – Species codes and scientific names of bird species mentioned in the text.

A.1.1 The following table lists the BTO species codes and the scientific names of the bird species mentioned in the text. The nomenclature follows Cramp & Simmons (2004).

Code	Name	Scientific name
PB	Light-bellied Brent Goose	*Branta bernicla hrota*
SU	Shelduck	*Tadorna tadorna*
WN	Wigeon	*Anas penelope*
T.	Teal	*Anas crecca*
MA	Mallard	*Anas platyrhynchos*
RM	Red-breasted Merganser	*Mergus serrator*
RH	Red-throated Diver	*Gavia stellata*
ND	Great Northern Diver	*Gavia immer*
GG	Great Crested Grebe	*Podiceps cristatus*
CA	Cormorant	*Phalacrocorax carbo*
SA	Shag	*Phalacrocorax aristotelis*
ET	Little Egret	*Egretta garzetta*
H.	Grey Heron	*Ardea cinerea*
OC	Oystercatcher	*Haematopus ostralegus*
RP	Ringed Plover	*Charadrius hiaticula*
L.	Lapwing	*Vanellus vanellus*
KN	Knot	*Calidris canutus*
SS	Sanderling	*Calidris alba*
DN	Dunlin	*Calidris alpina*
BA	Bar-tailed Godwit	*Limosa lapponica*
CU	Curlew	*Numenius arquata*
GK	Greenshank	*Tringa nebularia*
RK	Redshank	*Tringa totanus*
TT	Turnstone	*Arenaria interpres*
BH	Black-headed Gull	*Larus ridibundus*
CM	Common Gull	*Larus canus*
LB	Lesser Black-backed Gull	*Larus fuscus*
HG	Herring Gull	*Larus argentatus*
GB	Great Black-backed Gull	*Larus marinus*

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