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

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Castlemaine Waterbird Studies – II (Oysters & Mussels)

Preliminary assessment of the potential effects of oyster cultivation and additional intertidal mussel relay on the spatial distribution of waterbirds in Castlemaine Harbour

April 2011

Plan Design Enable

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Executive Summary

We carried out a study to assess the potential impact of intertidal oyster and mussel cultivation in the Douglas Strand-Cromane area on the waterbird populations of Castlemaine Harbour. There is a small amount (5.4 ha) of existing oyster cultivation, with 54 ha licensed and license applications for another 54 ha. These represent the only significant areas of existing or potential oyster cultivation in Castlemaine Harbour. There are also license applications for 71 ha of intertidal mussel cultivation. These represent the only areas of potential intertidal mussel cultivation outside the mussel order area in Castlemaine Harbour.

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 four counts of the Douglas Strand-Cromane area in January and Febraury 2011. For these counts, we divided the area into 12 sectors that reflected the configuration of the major tidal channels, differences in substrate type and the distribution of intertidal osier licenses and license applications.

Waterbird numbers in the Douglas Strand-Cromane area

Most intertidally feeding species were recorded in 2009/10 in lower numbers than would be predicted by the amount of intertidal habitat. The mean percentages of Sanderling and Bar-tailed Godwits were much higher than would be predicted by the availability of intertidal littoral habitat, but numbers of both these species were very variable between counts. Shelduck, Greenshank, Turnstone, Black-headed Gull and Lesser Black-backed Gull were recorded in numbers roughly in accordance with the availability of intertidal habitat. Of the subtidally feeding species, Scaup, Red-breasted Merganser and Cormorant all occurred in relatively high numbers in the Douglas Strand-Cromane area. In fact, the only records of Scaup from Castlemaine Harbour during the 2009/10 counts were from the Douglas Strand-Cromane area. Most Cormorants recorded during the counts in this area were roosting on intertidal habitat.

Taking account of the level of variation between counts within each winter, there were not clear differences in numbers of most species between the two winters. However, numbers of Mallard, Dunlin and Black-tailed Godwit were consistently higher in 2011 and Oystercatcher and Bar-tailed Godwit were consistently lower and Scaup did not occur in 2011.

The potential impact of intertidal mussel and oyster cultivation

We assessed the potential impact of intertidal mussel and oyster cultivation in the Douglas Strand-Cromane area by calculating the percentage displacement, as a proportion of the total Castlemaine Harbour population, if the activities cause complete exclusion from the areas they occupy. These are worst-case scenarios that make unrealistic assumptions, as many species show a neutral or positive response and even those that show a negative response are often not completely excluded, while full occupation of the licenses and license applications is unlikely. However, these scenarios have been used as a screening method to identify species that may be at risk.

The existing level of oyster cultivation within Castlemaine Harbour is very small. The percentage of intertidal habitat occupied by trestles is too small to detect avoidance of trestles. If any avoidance of trestles is occurring, it is highly unlikely that it is having a significant impact on the overall population levels within Castlemaine Harbour.

Under a worst case scenario, where waterbirds are completely excluded from areas occupied by oyster trestles, full occupation of the licensed plots would affect up to 1% of the total Castlemaine Harbour populations of various species, and possibly up to 2% of the Shelduck and Black-tailed Godwit populations and 4% of the Bar-tailed Godwit population. Similarly, under this scenario, full occupations of plots with

active applications, as well as the licensed plots would affect up to 3% of the total Castlemaine Harbour populations of various species, and possibly up to 4% of the Black-tailed Godwit population and 7% of the Bar-tailed Godwit population. Also under this scenario, full occupation of the mussel license applications would affect up to 3% of the total Castlemaine Harbour populations of various species, and possibly up to 5% of the Shelduck and Bar-tailed Godwit populations and 8% of the Black-tailed Godwit population. Finally, under this scenario, full occupation of the oyster license and of the mussel and oyster license applications would affect up to 4% of the total Castlemaine Harbour populations of various species, and possibly up to 5% of the Shelduck population, 10% of the Black-tailed Godwit population and 12% of the Bar-tailed Godwit population.

We used preliminary results from a larger scale study to identify species that may be negatively affected by intertidal oyster cultivation. For most species (apart from Bar-tailed Godwit) where we have some evidence of negative responses to trestles, the level of impact predicted under these scenarios would be less than 0.5%. This reflects the fact that these species tend to occur on the outer sandflats, while the most of the affected areas are close to the shore.

The predictions made above are based on limited data and combine datasets from two winters, and there is no data on species distribution within the Douglas Strand-Cromane area during the autumn/early winter period. Also, conclusions about species response to oyster cultivation are based on preliminary data analyses and may be subject to change.

Acknowledgements

We would firstly like to thank John Evans and Oliver Tierney, Marine Institute, 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. In particular we would like to thank NPWS / BWI for surveyors made available to the Marine Institute from the low tide count programme to assist with this work. Special thanks also to Michael O'Clery the counter at Castlemaine for the oyster study.

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.

1. Introduction

1.1 Atkins was commissioned by the Marine Institute to provide ornithological services in relation to the appropriate assessment of aquaculture activities on the Castlemaine Harbour Special Protection Area (SPA).

1.2 Only part of Castlemaine Harbour has been legally designated as a SPA, However, 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 will have to consider the entirety of the area covered by the existing designation and the proposed extension.

1.3 Oyster cultivation occurs along the southern side of Castlemaine Harbour, between Cromane Point and Douglas Strand. There are also license applications for intertidal mussel cultivation in this area (Figure 1.1).

1.4 Our brief for this report was to assess the potential impact of intertidal oyster and mussel cultivation (outside the mussel order area) on the waterbird populations of Castlemaine Harbour. The scope of this report includes:

- Review of the 2009/10 waterbird count data carried out under the NPWS Baseline Waterbird Survey Programme.
- Report on the studies carried out in January-February 2011.

1.5 The data analysis and report writing was done by Tom Gittings and was reviewed by Paul O'Donoghue. Data entry was carried out by Katie O'Hora.

1.6 Scientific names and British Trust for Ornithology (BTO) species codes of bird species mentioned in the text are listed in Appendix B

Oyster cultivation in Castlemaine Harbour

1.7 Oyster cultivation occurs along the southern side of Castlemaine Harbour, between Cromane Point and Douglas Strand. Cultivation began in 1993. Production levels were 145 tonnes in 2008 and 97 tonnes in 2009 (Appropriate Assessment, p. 13).

1.8 There are 14 licensed plots, covering an area of 53 ha. There are another 17 plots with current applications covering an additional area of 54 ha. There are also another eight plots with lapsed or withdrawn applications. These latter plots are not considered further in this report.

1.9 As noted, the licensed plots and those with current applications occur mainly along southern side of Castlemaine Harbour, between Cromane Point and Douglas Strand. There are outlying plots in Rossbehy Creek (licensed) and on the northern side of Castlemaine Harbour (application).

1.10 The actual extent of oyster cultivation in Castlemaine Harbour was mapped in February 2011 by the engineering staff from the Department of Agriculture, Fisheries and Food. There are a total of 34 separate blocks of trestles, occupying an area of 5.4 ha. The largest block covers an area of 1.1 ha and most blocks (21 of the 34 blocks are less than 0.1 ha in size. The trestle blocks only occupy a small proportion of the licensed area, although some blocks occur outside licensed plots (see Plates 1 and 2).

1.11 There are no trestle blocks in the outlying plots in Rossbehy Creek or on the northern side of Castlemaine Harbour. Because of the small areas of these plots, and the lack of any oyster cultivation, these areas are not considered further in this report.

Plate 1. Oyster trestles, visible as narrow black lines, along the edges of the tidal channels that form the boundary of sectors CAST-OY4.

Plate 2. Oyster trestles, visible as narrow black lines, behind mixed sediment shore habitat in sector CAST-OY1.

Intertidal mussel cultivation in Castlemaine Harbour

1.12 The main area licensed for mussel cultivation in Castlemaine Harbour occurs within the mussel order area to the west of Cromane. This includes a large area of intertidal mussel cultivation on the sandflat to the east of the dunes at Inch. The potential impacts of intertidal mussel cultivation in this area were studied in February-March 2010 and are discussed in a separate report (Gittings and O'Donoghue, 2011).

1.13 Outside, the mussel order area, there are four additional licensed plots, covering an area of 11 ha, and 14 license applications for mussel cultivation, covering an area of 201 ha, within Castlemaine Harbour. There are also another four plots with lapsed, withdrawn or surrendered licenses or license applications. These latter plots are not considered further in this report.

1.14 Detailed information on the status of cultivation within the existing licenses and the proposed cultivation within the license applications has not been made available to us. However, some of the plots are in largely subtidal habitat (as indicated by Ordnance Survey aerial photographs[1]) and can be assumed to refer to bottom mussel cultivation (Francis O Beirn, Maine Institute, pers. comm.). These plots are not considered further in this report.

1.15 The only plots that are in largely intertidal habitat are along the southern side of Castlemaine Harbour, between Cromane Point and Douglas Strand. These are all license applications. There are no currently licensed plots for intertidal mussel cultivation outside the mussel order area in Castlemaine Harbour.

Limitations to this study

1.16 The impact of cultivation of oysters on trestles within Castlemaine harbour on waterbirds using Castlemaine was one practice for which little information was available. However, a separate study to identify consistent patterns across sites of positive and/or negative associations between waterbird distribution and the presence of oyster trestles is also being undertaken by Atkins on behalf of the Marine Institute. This study is being carried out in six sites: Bannow Bay, Co. Wexford; Waterford Harbour & Dungarvan, Co. Waterford; Ballymacoda, Co. Cork; Castlemaine, Co. Kerry; and Poulnasherry, Co. Clare. These sites have been selected because: they have large areas of active trestles; suitable control habitat is available; reasonable views of the trestle areas are possible without disturbing birds; and the trestle zones support significant numbers of waterbirds. While data from this study has informed the assessment of impacts at Castlemaine it should be noted that only four counts were being carried out at each site during spring low tide periods in January and February 2011 due to tidal constraints and availability of surveyors who were made available to Atkins from the NPWS low tide count team (counts in December 2010 had to be postponed due to adverse weather).

1.17 See also paragraphs 3.52 to 3.55 (Conclusions) for further discussion of study limitations.

[1] Note that the representation of intertidal and subtidal habitat indicated on the Ordnance Survey Discovery Series mapping is very inaccurate.

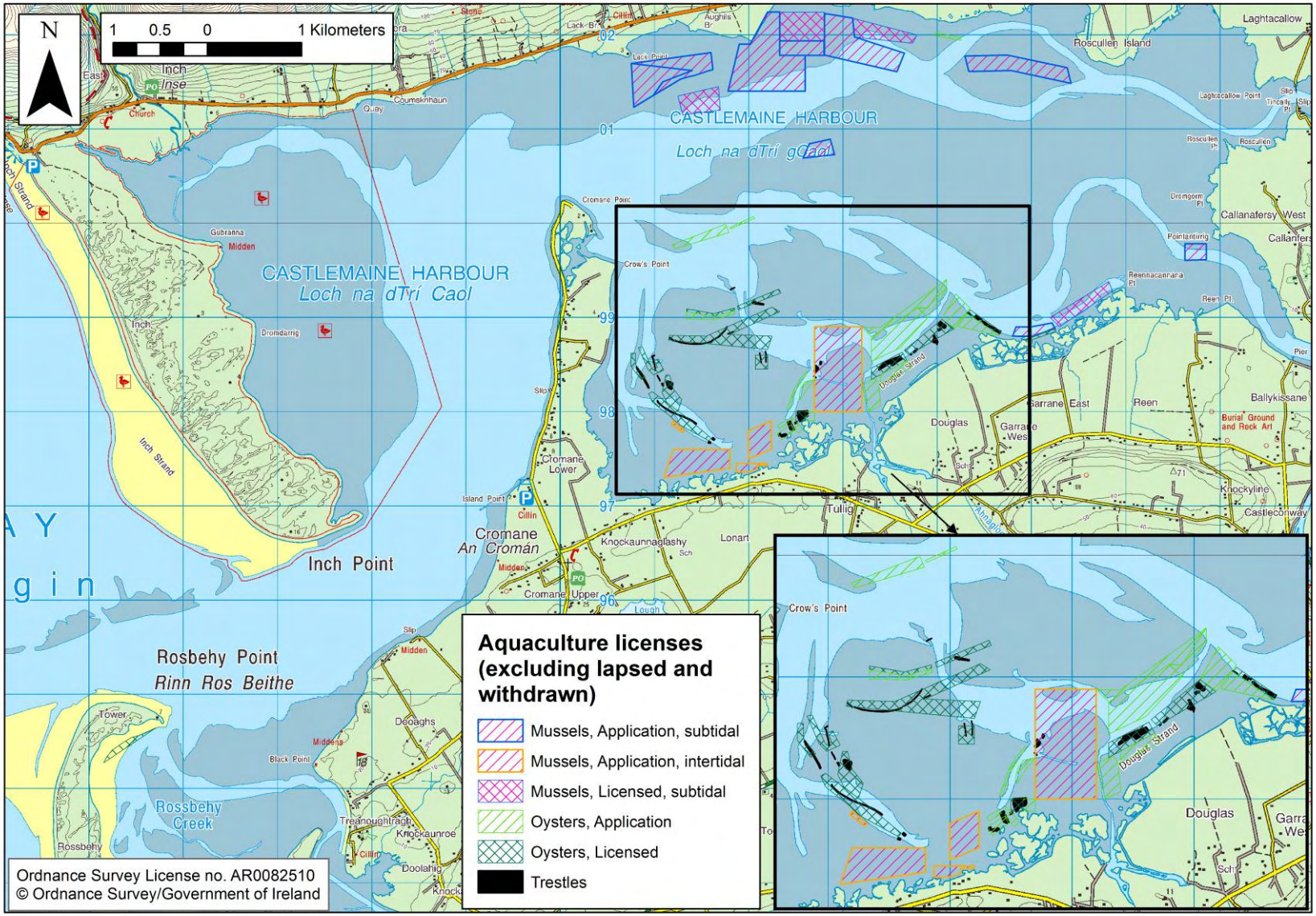

Figure 1.1 – Oyster and mussel licenses and license applications in Castlemaine Harbour.

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.

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).

Kelly *et al.* (1996)

2.3 Kelly *et al.* (1996) studied the distribution of waders in relation to intertidal oyster culture at Tomales Bay, California. They used two plots with oyster trestles and four control plots located on consolidated fine sands, silts, and clays. Each plot occupied 225 m of shoreline and around 2 ha of intertidal habitat. They carried out three counts per month across five winters (November-February).

2.4 They found that then abundances of Western Sandpiper and Dunlin were significantly lower in the aquaculture plots, while the abundance of Willet was significantly higher. There were no significant difference between aquaculture and control plots in the abundances of Grey Plover[2], Marbled Godwit, Sanderling and Least Sandpiper.

2.5 Oyster workers were present in the aquaculture plots on 62% of the counts but were not observed to cause movements of birds into or out of the plots. The distributions of shorebirds were not significantly related to the presence of the oyster workers.

2.6 The study design partly confounded treatment effects with spatial variation because the two aquaculture plots were next to each other. While various analyses indicated that there was not any underlying habitat gradient, the authors acknowledge that their study did not rule out the possibility “that observed differences between control and aquaculture areas resulted from underlying (pre-aquaculture) habitat conditions along a larger habitat gradient”.

2.7 Therefore, while this study provides some interesting results, the low number of replicates and the possibly confounding effects of spatial variation mean that its results should be treated with caution. Furthermore, it only deals with one species that is a SCI species at Castlemaine Harbour.

Hilgerloh *et al.* (2001)

2.8 Hilgerloh *et al.* (2001) studied the distribution and behaviour of waterbirds in relation to intertidal oyster culture at Cork Harbour. They used one plot with oyster trestles and one control plot (both 1 ha) located on mudflats in Saleen Creek on the eastern side of Cork Harbour. They carried out 64 scan counts and a series of focal observations on four days between 2nd and 7th March 1999.

[2] Referred to as Black-bellied Plover in Kelly *et al.* (2006).

2.9 Oystercatcher, Curlew, Black-headed Gull and Common Gull occurred in significantly lower numbers[3] in the trestle area compared to control plot, while there was no difference in the numbers of Dunlin and Redshank. There was no significant difference in the percentage of feeding birds of any of these species between the plots and the feeding rate of Oystercatchers did not differ between the plots. They also report various data on the behaviour of birds in areas of trestles with bags compared to areas without bags.

2.10 This study has no replication of treatments and the authors acknowledge that "the differences observed in the distribution of the other species [Oystercatcher, Curlew, Black-headed Gull and Common Gull] cannot only be explained by the presence of the trestles, since not all environmental parameters were identical in both areas. Furthermore, the very limited temporal range of the study (five days between the first and last count days) means that the results may not be very representative of overall distribution patterns.

[3] The authors present data on densities in the tables in the paper but refer to numbers in the text.

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 and Crowe, 2010).

3.2 Castlemaine Harbour was divided up into a number of count sectors for these counts. Two count sectors comprised most of the area with oyster licenses and with current oyster cultivation (Figure 3.1).

3.3 Four low tide counts and one high tide count were completed in Castlemaine Harbour under the NPWS Baseline Waterbird Survey Programme (Table 3.1). The count data was supplied to us by NPWS in spreadsheet format.

Table 3.1 – NPWS counts in the Cromane Point-Douglas Strand area.

Date	Tide	Tide time[1]	Tide height[1]	OK468[2]		OK469	
				Start	Finish	Start	Finish
5th October 2009	Low	12:24	0.7 m	10:31 10:37	11:09 13:40	12:46	13:18
21st November 2009	Low	13:40	1.4 m	11:52 11:42	13:09 13:30	12:09	14:05
4th January 2010[3]	Low	13:55	0.7 m	12:00 11:40	12:37 13:51	13:07	14:36
25th January 2010[4]	High	12:05	3.7 m	10:26 10:22	11:30 13:55	11:02	13:31
1st February 2010	Low	12:48	0.3 m	10:35 **11:05**	11:58 **11:55**	12:00	13:35

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

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

[3] Partial count in OK468

[4] Partial count in OK469

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).

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

Waterbirds counts of the southern side of Castlemaine Harbour, Jan-Feb 2011

3.6 Waterbird counts were carried out in the southern side of Castlemaine Harbour, as part of a broader study of the effects of oyster trestles on the spatial distribution of waterbirds. This study was designed and supervised by Atkins and carried out by counters assigned from the NPWS Baseline Waterbird Survey Programme.

Count sectors

3.7 We defined the count sectors for these counts using biotope maps of Castlemaine Harbour and field observations to cover the main areas of oyster trestles and areas of similar substrate type. Aquaculture license applications were also taken into account in defining the count sectors.

3.8 Count sectors C1 and C5 are largely outside the area covered by NPWS sectors OK468 and 469. To allow comparison between the 2009/10 and 2011 datasets, sectors C1 and C5 are excluded from the analyses in this report, unless otherwise stated.

3.9 There are two different versions of the biotope map of Castlemaine Harbour (Figure 3.2 and Figure 3.3). Neither of these versions correctly maps the configuration of the tidal channels and there are significant differences between the versions in terms of their classification of substrates within our study area. Based on our field observations, the 2008 ASU version has been used to help define divisions between count sectors along the southern side of the study area to reflect differences between sandier and muddier substrates. However, the distinctions in the ASU map between fine sand and muddy sand substrates in the outer part of our study area does not correspond to any obvious observed differences in sediment type in the field and has, therefore not been used to define sector boundaries.

3.10 The count sectors include areas of fine sand, muddy sand and mixed sediment substrate. Where count sectors extend up to the shoreline any distinct shoreline zones of different substrate (e.g., a shingle beach) were excluded.

3.11 The relationship between the count sectors and oyster and mussel licenses and license applications is shown in Figure 3.4.

3.12 The main boundaries between the sectors were major tidal channels. The configuration of these tidal channels differs from that shown on the OS Discovery maps. The mapping details used were validated in the field and should be regarded as superseding the OS maps.

3.13 Further details about the definition of the count sectors are included in Atkins (2010).

Count dates and methodology

3.14 Counts were carried out on four dates in January and February 2011 (Table 3.1). A count planned for December 2010 had to be abandoned due to adverse weather.

3.15 The counts were carried out by a counter assigned from the NPWS Baseline Waterbird Survey Programme 2010/11 under the supervision of Atkins.

Table 3.2 – Oyster study counts.

Date	Tide	Tide time (Cromane)[1]	Tide height (Cromane)[1]	Start	Finish
5th January 2011	Low	11:52	1.0 m	11:30	14:25
24th January 2011	Low	14:31	0.8 m	12:45	17:20
3rd February 2011	Low	11:37	0.9 m	10:50	14:18
23rd February 2011	Low	14:53	0.7 m	14:10	17:45

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

3.16 On each count day, one count covering all count sectors was carried out during the period of maximum exposure of the sectors around low tide.

3.17 There was limited visibility of sectors C1, C3 and OY3 from the vantage points, so birds may have been undercounted in these sectors.

3.18 The position of the birds in relation to the tideline (on the tideline or in intertidal habitat away from the tideline) and within or outside areas of oyster trestles was recorded. The behaviour of the birds was also recorded (Feeding, or Roosting/Other).

3.19 Birds recorded as on the tideline included birds in subtidal habitat within around 10 m of the tideline. Due to the objectives of the broader study, birds in subtidal habitat further away from the tideline were not recorded. However, according to the counter:

In reality, there were very few birds in mid channel, either within 10 m or beyond it. A few Mergansers ventured up the narrow channels, as did some fishing Cormorants, but I didn't count anything further out (though there were some Great Crested Grebes and Divers in the outer channels). Any waterfowl resting on the water were doing so very close to shore - there were no 'rafts' of birds further out (Michael O'Clery, pers. comm.)

3.20 The position of the tideline in each count sector was mapped. The detailed count methodology is described in Atkins (2010).

Results

Waterbird numbers in the Douglas Strand-Cromane area of Castlemaine Harbour

3.21 The area counted in 2011, broadly corresponds to the area included in Sectors OK468 and 469 from the NPWS Baseline Waterbird Survey Programme 2009/10. The 2011 sectors CAST-C1 and CAST-C4 are largely outside Sectors OK468 and 469. With the exclusion of CAST-C1 and CAST-C4, we consider that the 2011 dataset is comparable to the 2009/10 dataset.

3.22 Total waterbird numbers in the Douglas Strand-Cromane area of Castlemaine Harbour on each count day are shown in Table 3.3 and mean counts in each winter are shown in Table 2.4. Taking account of the level of variation between counts within each winter, there were not clear differences in numbers of most species between the two winters. However, numbers of Mallard, Dunlin and Black-tailed Godwit were consistently higher in 2011 and Oystercatcher and Bar-tailed Godwit were consistently lower.

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 most of the 2009/10 counts were earlier in the winter than the 2011 counts.

3.24 Also, 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.

Table 3.3 – Waterbird counts of the Douglas Strand-Cromane area.

	2009/10					2011			
	05-Oct	21-Nov	04-Jan	*25-Jan*	01-Feb	05-Jan	24-Jan	03-Feb	23-Feb
Light-bellied Brent Goose	2	39	87	*0*	211	16	41	40	146
Shelduck	0	4	7	*1*	98	105	55	39	46
Wigeon	0	6	47	*32*	125	63	71	88	47
Teal	26	0	156	*36*	33	41	33	12	12
Mallard	27	20	39	*2*	39	128	109	65	59
Shoveler	0	0	0	*0*	2	7	5	64	0
Scaup	0	0	10	*0*	14	0	0	0	0
Red-breasted Merganser	12	3	15	*1*	17	9	7	0	0
Great Northern Diver	0	0	0	*0*	1	0	0	0	0
Cormorant	10	6	13	*1*	23	9	9	7	13
Little Egret	36	13	8	*2*	5	10	0	1	2
Grey Heron	10	8	4	*0*	3	21	10	2	3
Spoonbill	0	1	1	*0*	0	0	0	0	0
Water Rail	1	0	0	*0*	0	0	0	0	0
Oystercatcher	223	340	221	*8*	171	233	122	54	77
Ringed Plover	0	5	1	*0*	0	6	0	0	5
Grey Plover	0	0	1	*0*	0	17	6	4	2
Lapwing	0	0	54	*50*	47	0	5	56	12
Knot	0	0	0	*0*	103	29	469	14	0
Sanderling	4	0	59	*0*	40	0	0	0	32
Dunlin	11	0	20	*3*	43	70	60	177	54
Snipe	0	1	1	*2*	0	0	0	2	0
Black-tailed Godwit	4	0	0	*80*	5	79	41	35	2
Bar-tailed Godwit	17	13	131	*0*	203	0	0	0	0
Curlew	273	86	170	*69*	136	179	117	115	61
Spotted Redshank	0	0	0	*0*	1	0	0	0	0
Greenshank	9	15	12	*1*	13	15	16	5	11
Redshank	75	72	91	*19*	173	222	118	34	90
Turnstone	22	14	19	*5*	31	36	20	13	50
Black-headed Gull	636	68	242	*12*	174	427	288	68	239

	2009/10					2011			
	05-Oct	21-Nov	04-Jan	*25-Jan*	01-Feb	05-Jan	24-Jan	03-Feb	23-Feb
Common Gull	87	16	40	*0*	9	51	33	61	53
Lesser Black-backed Gull	27	1	1	*0*	0	0	0	1	4
Herring Gull	26	55	37	*0*	12	63	68	16	31
Great Black-backed Gull	23	14	1	*0*	0	21	25	36	28

2009/10 data is from the NPWS Baseline Waterbird Survey Programme and represent the combined counts of sectors OK468 and 469. These counts were carried out at low tide, except for the count on 25 Jan (shown in italics), which was carried out at high tide.

2011 data is from counts carried out by for the oyster study and represent the combined counts of all the sectors excluding sectors OK468 and 469. These counts were all carried out at low tide.

Table 3.4 – Mean low tide counts in the Douglas Strand-Cromane area in 2009/10 and 2011.

	2009/10		2011	
	Mean	SD	Mean	SD
Light-bellied Brent Goose	85	91	61	58
Shelduck	27	47	61	30
Wigeon	45	58	67	17
Teal	54	70	25	15
Mallard	31	9	90	34
Shoveler	1	1	19	30
Scaup	6	7	0	0
Red-breasted Merganser	12	6	4	5
Great Northern Diver	0	1	0	0
Cormorant	13	7	10	3
Little Egret	16	14	3	5
Grey Heron	6	3	9	9
Spoonbill	1	1	0	0
Water Rail	0	1	0	0
Oystercatcher	239	72	122	80
Ringed Plover	2	2	3	3
Golden Plover	0	0	0	0
Grey Plover	0	1	7	7
Lapwing	25	29	18	26
Knot	26	52	128	228
Sanderling	26	29	8	16
Dunlin	19	18	90	58
Snipe	1	1	1	1
Black-tailed Godwit	2	3	39	32
Bar-tailed Godwit	91	93	0	0
Curlew	166	79	118	48
Spotted Redshank	0	1	0	0
Greenshank	12	3	12	5
Redshank	103	48	116	79
Turnstone	22	7	30	17
Black-headed Gull	280	248	256	148
Common Gull	38	35	50	12
Lesser Black-backed Gull	7	13	1	2
Herring Gull	33	18	45	25
Great Black-backed Gull	10	11	28	6

Importance of the Douglas Strand-Cromane area of Castlemaine Harbour

3.25 The mean percentages of the total Castlemaine Harbour count in the Douglas Strand-Cromane area in 2009/10 are shown in Table 3.1.

3.26 The total area of littoral sediment habitat in the Douglas Strand-Cromane area is 852 ha. This represents around 21% of the total area of littoral sediment habitat in Castlemaine Harbour. 735 ha of this habitat is included in the count sectors used in the 2011 study. Most intertidally feeding species were recorded in 2009/10 in lower numbers than would be predicted by the amount of intertidal habitat. The mean percentages of Sanderling and Bar-tailed Godwits were much higher than would be predicted by the availability of intertidal littoral habitat, but numbers of both these species were very variable between counts. Shelduck, Greenshank, Turnstone, Black-headed Gull and Lesser Black-backed Gull were recorded in numbers roughly in accordance with the availability of intertidal habitat.

3.27 However, these are very crude comparisons because there is significant variation in the intertidal habitat within the Douglas Strand-Cromane area. The actual area used by particular waterbird species may be much smaller than the total availability of intertidal habitat. In particular, Turnstone is likely to have been largely restricted to the mixed sediment habitat along the shoreline.

3.28 The total area of tidal channel habitat the Douglas Strand-Cromane area is 227 ha. This represents around 3% of the total area of subtidal habitat in Castlemaine Harbour and 15% of the area of subtidal habitat in the inner part of the harbour. Of the subtidally feeding species, Scaup, Red-breasted Merganser and Cormorant all occurred in relatively high numbers in the Douglas Strand-Cromane area. In fact, the only records of Scaup from Castlemaine Harbour during the 2009/10 counts were from the Douglas Strand-Cromane area. Most Cormorants recorded during the counts in this area were roosting on intertidal habitat. Red-breasted Merganser mainly occurs in the inner harbour (70-100% of total count in the inner harbour sectors on each count).

3.29 Light-bellied Brent Goose, Mallard and Wigeon can feed both intertidally and subtidally, In the Douglas Strand-Cromane area, most Light-bellied Brent Goose were on intertidal habitat during the counts, while Mallard and Wigeon varied in their usage of intertidal and subtidal habitats between counts.

3.30 Scaup[4] and Bar-tailed Godwit were not recorded from this area in the 2011 counts. The other main differences in numbers between 2009/10 and 2011 (see paragraph 3.22) would not substantially affect the above assessment of importance, assuming that the total Castlemaine Harbour population of these species was similar in the two winters.

[4] Although the count methodology in 2011 did not cover all the subtidal habitat, the counter has confirmed that no Scaup were seen anywhere in this area during the counts.

Table 3.5 - Mean percentages of the total Castlemaine Harbour count in the Douglas Strand-Cromane area during the 2009/10 low tide counts.

	Low tide		Individual counts				
	Mean	SD	05-Oct	21-Nov	04-Jan	*25-Jan*	01-Feb
Light-bellied Brent Goose	11%	12%	0%	3%	13%	*0%*	27%
Shelduck	17%	19%	0%	24%	4%	*1%*	42%
Wigeon	8%	8%	0%	5%	9%	*6%*	19%
Teal	12%	12%	12%	0%	28%	*22%*	9%
Mallard	6%	3%	2%	10%	5%	*1%*	7%
Shoveler	25%	50%	0%	0%	0%	*0%*	100%
Scaup	50%	58%	0%	0%	100%	*0%*	100%
Red-breasted Merganser	31%	12%	29%	17%	44%	*7%*	35%
Great Northern Diver	1%	2%	0%	0%	0%	*0%*	3%
Cormorant	23%	17%	7%	10%	38%	*3%*	36%
Little Egret	27%	9%	33%	34%	24%	*14%*	16%
Grey Heron	19%	11%	16%	35%	13%	*0%*	11%
Oystercatcher	13%	4%	13%	18%	13%	*1%*	9%
Ringed Plover	3%	5%	0%	11%	0%	*0%*	0%
Grey Plover	0%	1%	0%	0%	1%	*0%*	0%
Lapwing	2%	2%	0%	0%	3%	*4%*	3%
Knot	4%	8%	0%	0%	0%	*0%*	17%
Sanderling	35%	45%	100%	0%	29%	*0%*	12%
Dunlin	3%	3%	8%	0%	1%	*0%*	2%
Black-tailed Godwit	2%	2%	5%	0%	0%	*46%*	1%
Bar-tailed Godwit	49%	35%	33%	7%	83%	*0%*	71%
Curlew	14%	3%	18%	12%	16%	*11%*	12%
Greenshank	21%	9%	15%	34%	16%	*2%*	17%
Redshank	9%	5%	6%	6%	8%	*2%*	17%
Turnstone	21%	6%	29%	15%	20%	*5%*	23%
Black-headed Gull	28%	5%	27%	35%	26%	*2%*	23%
Common Gull	9%	9%	22%	6%	7%	*0%*	2%
Lesser Black-backed Gull	25%	16%	32%	33%	33%	*0%*	0%
Herring Gull	11%	9%	3%	23%	11%	*0%*	6%
Great Black-backed Gull	8%	9%	11%	20%	2%	*0%*	0%

High tide roosts

3.31 The waterbird numbers in sectors OK468 and 469 during the high tide count, and the summed totals of the roosts recorded in these sectors (and in the adjacent part of OK467) are compared in Table 3.6

3.32 The high tide roosts in the vicinity of intertidal mussel and oyster licenses and license applications, recorded during the roost survey on 26 February 2010, are shown in Figure 3.5. One major roost, with 200 Knot and 300 Bar-tailed Godwit was recorded on a small saltmarsh island in sector OY2. However, no Knot or Bar-tailed Godwit were recorded in this area during the high tide count on 25th January 2010 (Table 3.6). Several other roosts were also recorded along the southern shore. These were all minor roosts, mainly with small groups of dabbling ducks, Oystercatcher, Curlew, Redshank and gulls.

Table 3.6 – High tide waterbird counts in the Douglas Strand-Cromane area.

Species	25th Jan High tide count	26th Feb Roost survey
Light-bellied Brent Goose		124
Shelduck	1	31
Wigeon	32	24
Teal	36	23
Mallard	2	6
Red-breasted Merganser	1	
Cormorant	1	12
Little Egret	2	2
Spoonbill		1
Oystercatcher	8	98
Lapwing	50	13
Knot		200
Dunlin	3	
Black-tailed Godwit	80	
Bar-tailed Godwit		300
Curlew	69	21
Greenshank	1	8
Redshank	19	39
Turnstone	5	
Black-headed Gull	12	44
Common Gull		56
Lesser Black-backed Gull		1
Herring Gull		36
Great Black-backed Gull		29

Behaviour

3.33 For most species the majority (usually 80-100%) of the birds recorded were feeding (Table 3.7 and Table 3.8). The only consistent exceptions were Cormorant; small numbers regularly roost on the outer sandbanks. In 2009/10, Wigeon, Teal, Lesser and Great Black-backed Gulls had high percentages of roosting birds. In 2011, Lapwing had high percentages of roosting birds.

3.34 For most species the majority of the birds recorded were on intertidal habitat, away from the tideline (Table 2.8). The exceptions were fish-eating species (Red-breasted Merganser and the herons), Greenshank and Common Gull. Cormorant, while being a fish-eating species, mainly occurred away from the tideline because of their use of the outer sandbanks for roosting.

Table 3.7 – Percentage of birds feeding in the Douglas Strand-Cromane area during the 2009/10 counts.

	05-Oct	21-Nov	04-Jan	*25-Jan*	01-Feb	Mean	SD
Light-bellied Brent Goose	100%	64%	46%	*100%*	83%	73%	23%
Shelduck		75%	71%	*83%*	100%	82%	16%
Wigeon		33%	47%	*0%*	30%	37%	9%
Teal	23%		71%	*39%*	58%	50%	25%
Mallard	100%	10%	64%	*0%*	72%	61%	38%
Scaup			70%		100%		
Red-breasted Merganser	17%	100%	27%	*0%*	100%	61%	45%
Cormorant	0%	17%	8%	*13%*	4%	7%	7%
Little Egret	97%	77%	75%	*0%*	100%	87%	13%
Grey Heron	90%	50%	75%	*0%*	100%	79%	22%
Oystercatcher	100%	86%	96%	*0%*	96%	95%	6%
Lapwing			81%	*14%*	100%	91%	13%
Knot				*0%*			
Sanderling	100%		100%		100%	100%	0%
Dunlin	100%		95%	*0%*	100%	98%	3%
Black-tailed Godwit	100%			*0%*	100%	100%	0%
Bar-tailed Godwit	100%	100%	99%	*0%*	100%	100%	0%
Curlew	100%	92%	98%	*22%*	100%	98%	4%
Greenshank	100%	93%	100%	*50%*	100%	98%	3%
Redshank	100%	100%	99%	*28%*	100%	100%	1%
Turnstone	100%	86%	100%	*31%*	100%	96%	7%
Black-headed Gull	99%	78%	49%	*17%*	92%	80%	22%
Common Gull	93%	38%	65%	*22%*	78%	68%	24%
Lesser Black-backed Gull	52%	0%	0%			17%	30%
Herring Gull	96%	31%	100%	*0%*	83%	78%	32%
Great Black-backed Gull	100%	14%	0%			38%	54%

Only species with a total count of at least 10 on at least one count day are included. All counts were carried out at low tide, except for the count on 25 Jan (shown in italics), which was carried out at high tide. Mean and standard deviations are shown for the low tide counts.

Table 3.8 – Percentage of birds feeding in the Douglas Strand-Cromane area during the 2011 counts.

	05-Jan	24-Jan	03-Feb	23-Feb	Mean	SD
Light-bellied Brent Goose	100%	100%	100%	85%	96%	8%
Shelduck	100%	100%	100%	100%	100%	0%
Wigeon	71%	77%	89%	74%	78%	8%
Teal	76%	100%	100%	92%	92%	11%
Mallard	100%	93%	100%	86%	95%	7%
Shoveler	100%	40%	100%		80%	35%
Red-breasted Merganser	100%	100%				
Cormorant	67%	16%	0%	6%	22%	31%
Little Egret	100%		100%	100%	100%	0%
Grey Heron	100%	80%	50%	67%	74%	21%
Oystercatcher	99%	100%	100%	92%	98%	4%
Ringed Plover	100%			100%	100%	0%
Grey Plover	100%	100%	100%	100%	100%	0%
Lapwing		0%	5%	0%	2%	3%
Knot	100%	100%	100%		100%	0%
Sanderling				100%		
Dunlin	100%	100%	100%	100%	100%	0%
Black-tailed Godwit	100%	100%	100%	100%	100%	0%
Curlew	98%	99%	100%	100%	99%	1%
Greenshank	100%	100%	100%	100%	100%	0%
Redshank	100%	100%	100%	100%	100%	0%
Turnstone	100%	100%	100%	72%	93%	14%
Black-headed Gull	99%	99%	91%	100%	97%	4%
Common Gull	94%	100%	95%	100%	97%	3%
Lesser Black-backed Gull			100%	100%		
Herring Gull	97%	99%	100%	94%	97%	3%
Great Black-backed Gull	90%	92%	100%	43%	81%	26%

Table 3.9 – Percentage of birds on the tideline.

	05-Jan	24-Jan	03-Feb	23-Feb	Mean	SD
Light-bellied Brent Goose	0%	0%	0%	36%	9%	18%
Shelduck	0%	16%	0%	0%	4%	8%
Wigeon	32%	37%	22%	30%	30%	6%
Teal	20%	33%	0%	8%	15%	14%
Mallard	9%	23%	17%	15%	16%	6%
Shoveler	29%	0%	0%		10%	16%
Red-breasted Merganser	100%	57%			79%	30%
Cormorant	67%	22%	43%	23%	39%	21%
Little Egret	60%		100%	100%	87%	23%
Grey Heron	67%	60%	100%	67%	73%	18%
Oystercatcher	14%	14%	20%	25%	18%	5%
Ringed Plover	0%			0%		
Grey Plover	0%	0%	0%	0%	0%	0%
Lapwing		0%	0%	25%	8%	14%
Knot	0%	4%	0%		1%	3%
Sanderling				0%		
Dunlin	0%	0%	0%	0%	0%	0%
Black-tailed Godwit	1%	34%	23%	0%	15%	17%
Curlew	21%	24%	18%	11%	19%	5%
Greenshank	87%	75%	80%	45%	72%	18%
Redshank	26%	22%	9%	21%	19%	7%
Turnstone	47%	25%	15%	0%	22%	20%
Black-headed Gull	51%	27%	43%	15%	34%	16%
Common Gull	51%	61%	57%	66%	59%	6%
Lesser Black-backed Gull			0%	75%	38%	53%
Herring Gull	21%	37%	25%	39%	30%	9%
Great Black-backed Gull	19%	28%	25%	32%	26%	6%

Spatial distribution

3.35 Waterbird numbers and densities in each count sector on each count day are shown in Appendix A.

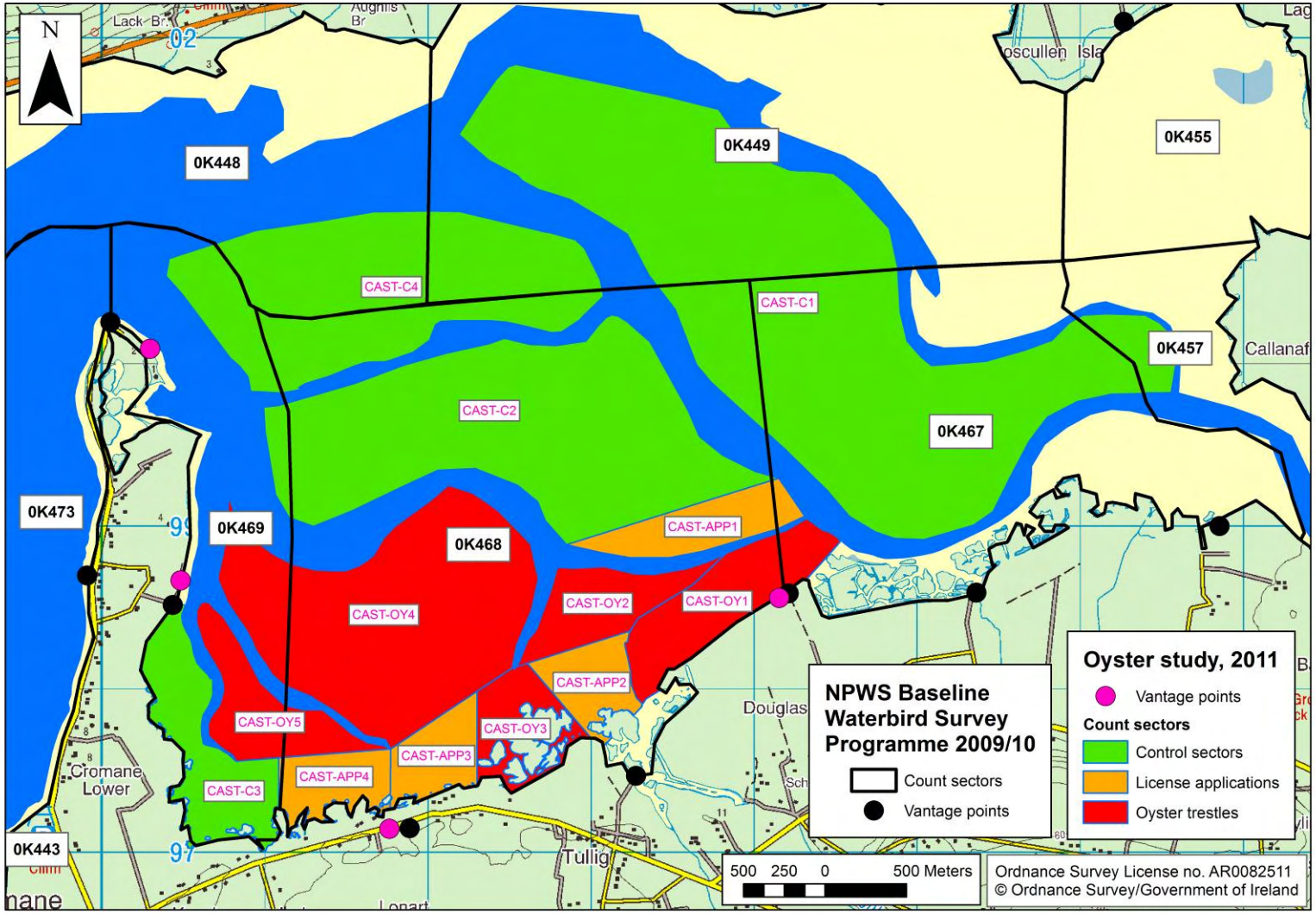

Figure 3.1 – Coverage of the southern side of Castlemaine Harbour by count sectors used in the 2009/10 NPWS Baseline Waterbird Survey Programme and by count sectors used in the 2011 oyster study.

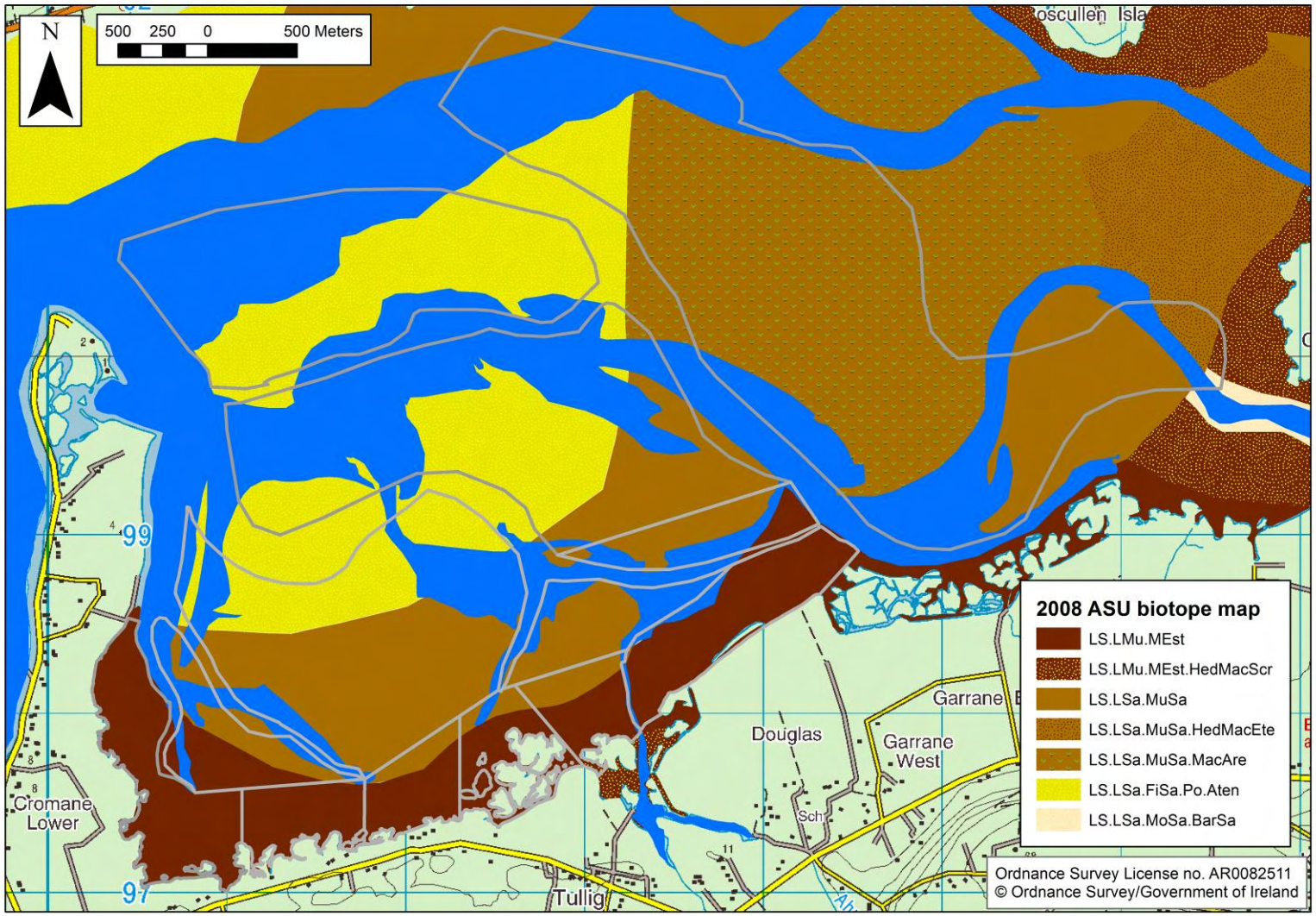

Figure 3.2 – Count sectors used in the 2011 oyster study and the ASU biotope map.

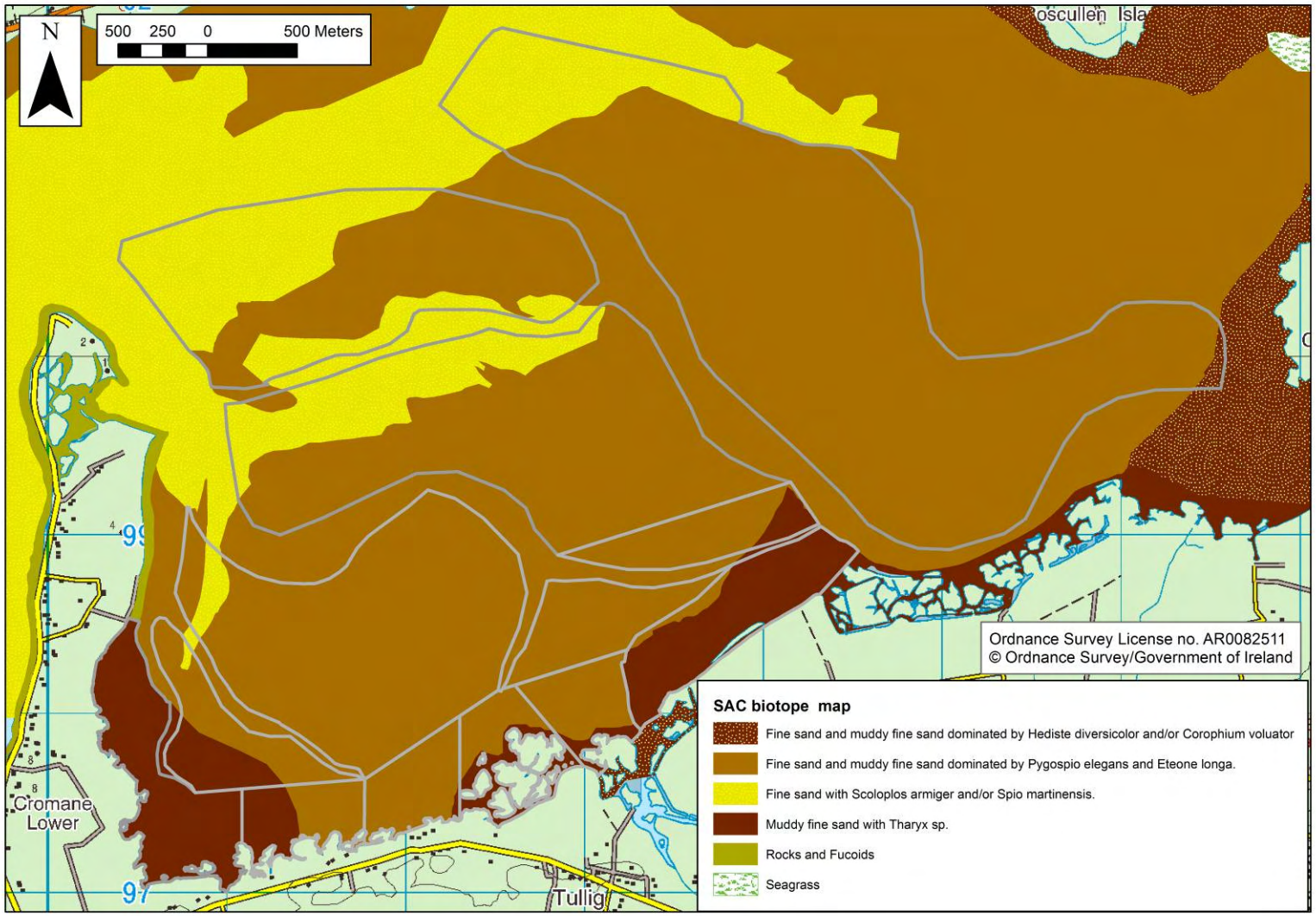

Figure 3.3 - Count sectors used in the 2011 oyster study and the SAC biotope map.

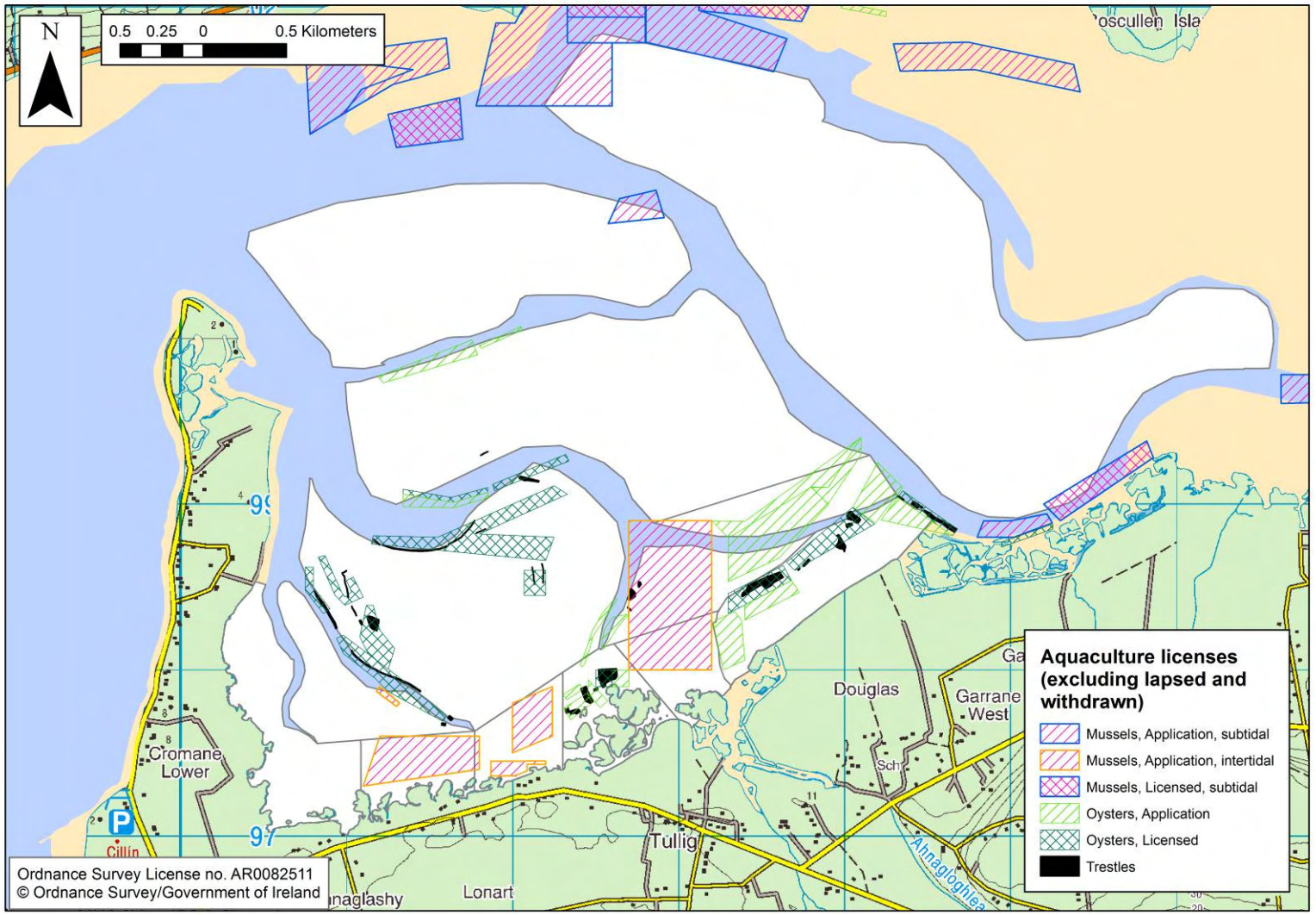

Figure 3.4 - Count sectors used in the 2011 oyster study and oyster and mussel licenses and license applications.

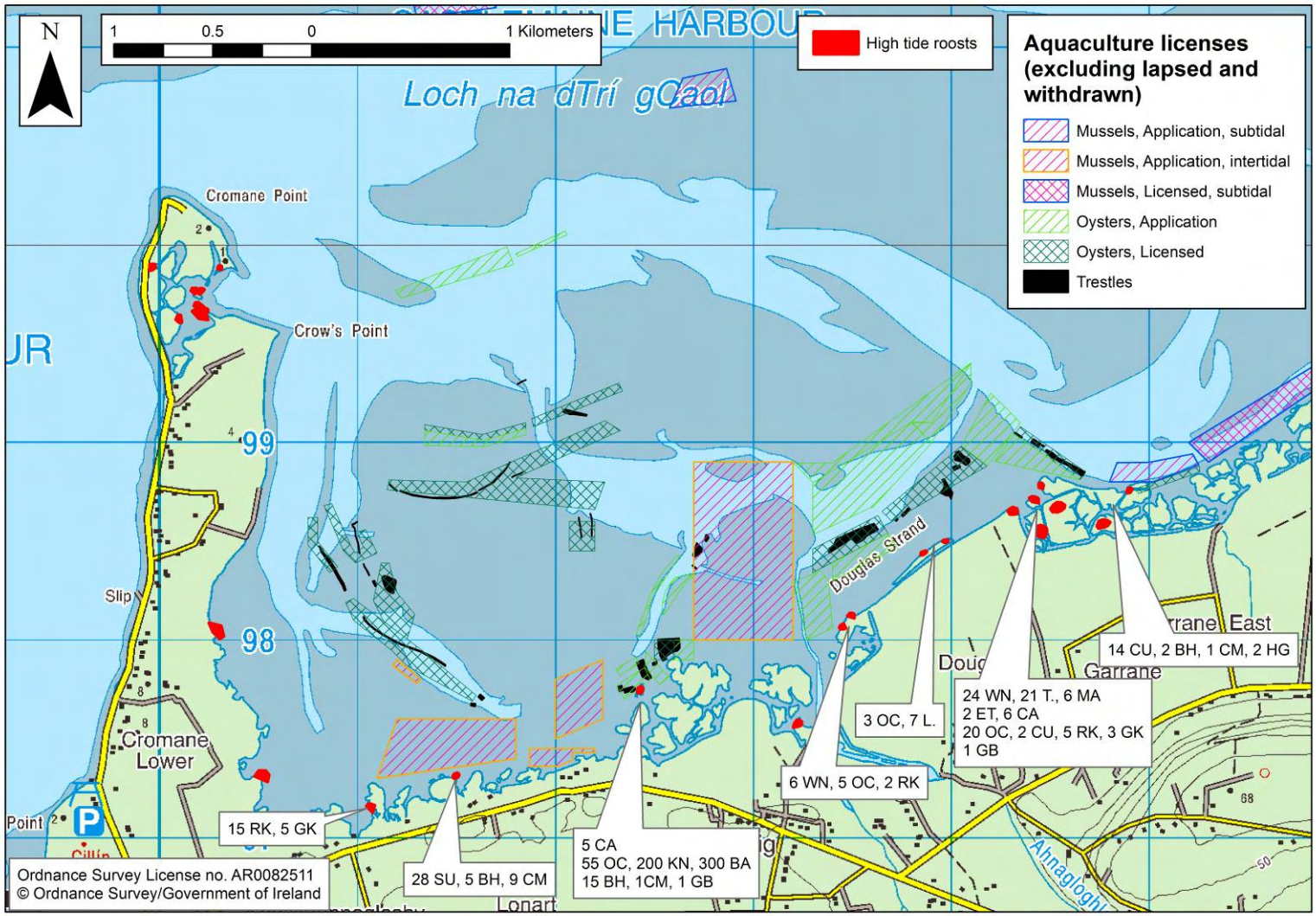

Figure 3.5 – High tide roosts in the vicinity of intertidal mussel and oyster licenses and license applications, recorded during the roost survey on 26 February 2010

4. Assessment of potential impact of intertidal mussel and oyster cultivation in the Douglas Strand-Cromane area

Scope of the assessment

4.1 The main focus of this assessment is on the potential impacts of intertidal oyster and mussel cultivation on intertidal habitat as a feeding resource for waterbirds.

4.2 Some species may also use intertidal habitat for low tide roosts. However, the only species that shows a consistent pattern of low tide roosting in the Douglas Strand-Cromane area is Cormorant. These roosting birds occur on the outer sandbanks (C2 and C4) outside areas that have significant amounts of licenses or license applications. The potential impacts on roosting Cormorant are considered under the sections on disturbance. For most other species, most incidences of non-feeding birds probably were of birds resting or engaging in other activities for short periods of time, in between bouts of feeding. Therefore, we have used the total numbers recorded for the assessments and have not separated feeding and roosting birds.

4.3 A number of high tide roosts occur along the southern shore of the Douglas Strand-Cromane area (see Figure 3.5). These occur on saltmarsh islands outside any of the licenses or license applications. Husbandry activities associated with intertidal mussel and oyster cultivation mainly take place at low tide, particularly during spring low tides, and will not therefore cause disturbance to high tide roosts. Dredging of mussels for relay into subtidal plots typically takes place in spring/early summer (in 2010, it occurred in April and early May) when waterbird numbers are low. Therefore, intertidal oyster and mussel cultivation will not have any significant impacts on the utilisation of high tide roosts in the Douglas Strand-Cromane area, and high tide roosts are not considered further in this section.

4.4 Fish-eating species that feed in subtidal habitat are unlikely to be affected by these habitat changes. Therefore, fish-eating species are not considered further in this section, apart from potential disturbance impacts.

Waterbird responses to intertidal mussel and oyster cultivation

Habitat changes

4.5 Intertidal mussel and oyster cultivation cause changes to the intertidal habitat, both through alteration of the structure of the habitat and changes to the intertidal fauna. These habitat changes may affect herbivorous and invertebrate feeding waterbird species that feed on the intertidal habitat when it is exposed around low tide, and/or feed in shallow water long the tideline. Impacts on these waterbird species may be caused by changes in prey availability and/or behavioural responses to the altered habitat structure.

Intertidal mussel cultivation

4.6 We have previously studied waterbird responses to intertidal mussel cultivation in the nursery area at Castlemaine Harbour (Gittings and O'Donoghue, 2011).

4.7 Oystercatcher and Redshank were positively associated with mussel cover at both large and small spatial scales and there was also some evidence to suggest that Light-bellied Brent, Curlew, Turnstone and Herring Gull were positively associated with mussel cover at small spatial scales.

4.8 There was some evidence to suggest that Sanderling, Dunlin and Bar-tailed Godwit were negatively associated with mussel cover at small spatial scales. However, mussel cover within the nursery area was very patchy (mean cover 12%) and these species fed in clear areas between patches of mussels. Therefore, it is not clear whether this level of mussel cover would significantly affect the utilisation of intertidal mussel nursery areas by these species.

4.9 In addition, there was some evidence to suggest complete avoidance of the nursery area by Ringed Plover and Grey Plover.

4.10 Other species that tend to feed in open intertidal habitats include Shelduck and Black-tailed Godwit. These species may, therefore, also be negatively affected by intertidal mussel cultivation.

4.11 Grey Heron, Little Egret and Greenshank often feed in mussel beds and are, therefore, unlikely to be negatively affected by intertidal mussel cultivation.

Intertidal oyster cultivation

4.12 We have recently completed fieldwork for an extensive study across six sites (including Castlemaine Harbour) and a detailed study within one site (Dungarvan Harbour) of the relationship between oyster cultivation and waterbird distribution. We have completed some preliminary analyses of the results of these studies. The following is a summary of the main conclusions of these preliminary analyses. **These conclusions are provisional and may be subject to change following completion of the full analyses**.

4.13 Grey Plover, Ringed Plover and Sanderling appear to show almost complete avoidance of trestles.

4.14 We have found strong evidence of negative association between Bar-tailed Godwits and oyster trestles. At Ballymacoda and Dungarvan, large flocks of Bar-tailed Godwit appear to completely avoid the oyster trestles. At Dungarvan, utilisation of trestle areas by birds in smaller groups (< 100) is on average 30% lower than predicted by the availability of suitable habitat.

4.15 Dunlin (and possibly Knot) may show similar patterns to Bar-tailed Godwit, but the data for these species is more complex to analyse. Black-tailed Godwit is behaviourally similar to Bar-tailed Godwit and so may also avoid trestles (and there is some limited evidence of this at Castlemaine, see paragraph 4.23).

4.16 Oystercatcher, Redshank, Greenshank and Turnstone and the gull species appear to generally show a neutral or positive association with trestles, although we have not completed any formal data analysis for these species yet. Oystercatcher and Turnstone regularly feed on the trestles.

4.17 At some sites, Light-bellied Brent regularly feed on the trestles. However, it is not clear from the pattern of the data whether this species shows a consistent response to trestles across the sites; they may respond positively in some sites and negatively in other sites.

Disturbance

4.18 Intertidal mussel cultivation does not generate much human activity during the low tide period. We have previously studied waterbird responses to potential disturbance from intertidal mussel cultivation in the nursery area at Castlemaine Harbour (Gittings and O'Donoghue, 2011). During

out study, mussel-related disturbance activities affected a mean of up to 7% of the available habitat resource. We consider that this overestimates the actual disturbance impacts for a number of reasons and that the actual mean disturbance impact per low tide period would be reduced by at least 50-75%, and probably lower than even the lower end of that range.

4.19 Intertidal oyster cultivation generates a high level of human activity during the low tide period, including the use of tractors. As part of our studies of the relationship between oyster cultivation and waterbird distribution, we will be examining the impacts of disturbance from these activities. The preliminary results reported above include the effects of disturbance, if any, as we have not yet tried to separate the effects of disturbance from the effects of habitat changes. Our observations during the study suggest that waterbirds using trestle areas show a high level of habituation to human activity within the trestles.

4.20 Both types of intertidal cultivation may also generate disturbance to areas outside the occupied areas due to access to/from these areas. The majority of oyster growers access the oyster trestles by boat from Cromane point (Marine Institute Fisheries Science Service, 2010). No details are available of proposed access routes to any future expansion of oyster trestles into unoccupied licensed areas or license application plots, and to intertidal mussel cultivation in mussel license application plots.

Impact of existing oyster trestles

4.21 The current (February 2011) extent of oyster trestles in Castlemaine Harbour is shown in Figure 1.1. These occupy a total area of 5.4 ha, which amounts to less than 1% of the total area of intertidal habitat in the Douglas Strand-Cromane area of Castlemaine Harbour.

4.22 The amount of intertidal habitat and oyster trestles exposed during each count in 2011 is shown in Figure 4.1. During these counts, the trestles occupied between 0.5-0.7% of the available intertidal habitat in the Douglas Strand-Cromane area and 0.7-1.2% of the available intertidal habitat in the southern sectors of this area.

4.23 The percentage occurrence of waterbirds within areas of oyster trestles during these counts is summarised in Table 3.1 and Table 3.2. Several species did not occur within the trestles but, because of the low percentage occupied by trestles, this does not necessarily mean that these species were avoiding the trestles. However, in the two sectors (OY1 and OY3) with the highest percentage occupancy of trestles (2.8-4.3%), Light-bellied Brent Goose, Teal and Black-tailed Godwit each occurred on three of the counts but did not occur within the trestles on any of these counts.

Table 4.1 - Percentage occurrence of waterbirds within areas of oyster trestles relative to the total counts in the Douglas Strand-Cromane area in 2011.

	Mean	SD	05-Jan		24-Jan		03-Feb		23-Feb	
			Out	In	Out	In	Out	In	Out	In
Light-bellied Brent Goose	0%	0%	16	0	41	0	40	0	146	0
Shelduck	0%	0%	117	0	74	0	65	0	48	0
Wigeon	2%	2%	69	0	104	2	143	0	45	2
Teal	0%	0%	41	0	33	0	18	0	12	0
Mallard	7%	10%	128	0	103	6	121	2	48	13
Shoveler	0%	0%	7	0	5	0	64	0	0	0
Little Egret	8%	14%	9	3	0	0	1	0	2	0
Grey Heron	8%	9%	18	3	10	2	3	0	3	0
Oystercatcher	5%	3%	299	14	203	7	130	4	84	9
Ringed Plover	0%	0%	6	0	0	0	0	0	5	0
Grey Plover	0%	0%	23	0	12	0	10	0	2	0
Lapwing	0%	0%	0	0	5	0	176	0	12	0
Knot	0%	0%	369	0	589	0	474	0	0	0
Sanderling	0%	0%	15	0	15	0	30	0	32	0
Dunlin	0%	0%	86	0	140	0	357	0	57	0
Black-tailed Godwit	0%	0%	102	1	83	0	70	0	2	0
Curlew	4%	2%	206	16	248	11	261	9	91	3
Greenshank	1%	2%	15	0	20	1	10	0	11	0
Redshank	3%	2%	259	14	164	4	76	3	99	0
Turnstone	33%	13%	21	17	17	3	8	5	34	16
Black-headed Gull	2%	2%	621	8	517	23	238	2	328	12
Common Gull	18%	14%	72	6	21	12	66	18	75	4
Lesser Black-backed Gull	0%	0%	0	0	0	0	1	0	3	1
Herring Gull	3%	5%	89	10	106	1	84	2	33	0
Great Black-backed Gull	5%	3%	29	3	48	3	51	1	43	1

Table 4.2 - Percentage occurrence of waterbirds within areas of oyster trestles relative to the total counts in the southern sectors (OY1-OY3, OY5, APP1-APP4, C3) of the Douglas Strand-Cromane area in 2011.

	Mean	SD	05-Jan		24-Jan		03-Feb		23-Feb	
			Out	In	Out	In	Out	In	Out	In
Light-bellied Brent Goose	0%	0%	12	0	41	0	40	0	138	0
Shelduck	0%	0%	7	0	9	0	39	0	22	0
Wigeon	3%	4%	57	0	43	2	37	0	25	2
Teal	0%	0%	41	0	33	0	12	0	5	0
Mallard	9%	9%	54	0	67	6	41	2	39	11
Shoveler	0%	0%	2	0	3	0	0	0	0	0
Little Egret	13%	22%	5	3	0	0	1	0	2	0
Grey Heron	10%	11%	13	3	8	2	2	0	2	0
Oystercatcher	11%	5%	113	11	76	7	39	4	40	9
Ringed Plover	0%	0%	6	0	0	0	0	0	5	0
Grey Plover	0%	0%	15	0	6	0	1	0	2	0
Lapwing	0%	0%	0	0	5	0	53	0	12	0
Knot	0%	0%	7	0	29	0	0	0	0	0
Sanderling	0%	0%	0	0	0	0	0	0	32	0
Dunlin	0%	0%	30	0	60	0	92	0	54	0
Black-tailed Godwit	0%	1%	52	1	22	0	35	0	2	0
Curlew	11%	4%	106	14	73	11	60	9	38	2
Greenshank	2%	4%	12	0	12	1	5	0	9	0
Redshank	6%	5%	166	13	87	4	25	3	68	0
Turnstone	33%	14%	19	17	17	3	8	5	34	16
Black-headed Gull	10%	8%	218	6	86	23	26	2	56	6
Common Gull	22%	10%	24	6	21	12	32	8	28	4
Lesser Black-backed Gull	0%	0%	0	0	0	0	0	0	1	0
Herring Gull	13%	13%	27	10	25	1	7	2	23	0
Great Black-backed Gull	10%	11%	8	3	21	1	18	1	21	1

Table 4.3 – Percentage occurrence of waterbirds within areas of oyster trestles relative to the total counts in sectors OY1 and OY3 of the Douglas Strand-Cromane area in 2011.

	Mean	SD	05-Jan		24-Jan		03-Feb		23-Feb	
			Out	In	Out	In	Out	In	Out	In
Light-bellied Brent Goose	0%	0%	0	0	6	0	8	0	60	0
Wigeon	33%	47%	26	0	4	2	6	0	0	2
Teal	0%	0%	12	0	14	0	12	0	0	0
Mallard	11%	12%	5	0	14	4	6	0	8	2
Oystercatcher	60%	32%	0	7	9	5	6	3	3	8
Black-tailed Godwit	0%	0%	12	0	14	0	0	0	0	0
Curlew	39%	28%	6	12	15	10	6	6	2	0
Redshank	45%	44%	8	12	8	2	0	2	2	0
Turnstone	63%	48%	0	7	3	3	0	5	4	0
Black-headed Gull	60%	26%	0	0	2	17	2	2	7	5
Common Gull	54%	44%	1	3	14	9	1	0	0	2

Potential impact of full occupation of the licensed plots and the license applications

Assessment method

4.24 We have used data on the percentage occurrence of waterbird species within the Douglas Strand-Cromane area of Castlemaine Harbour (from 2009/10) and the percentage occurrence of waterbird species within sectors with licensed plots and/or license applications (from 2011) to assess the worst-case scenario that licensed plots and/or license applications are fully occupied and species are completely excluded from these areas. This is probably an unrealistic scenario, both in terms of patterns of aquaculture activity and (for most species) waterbird responses to aquaculture activity.

4.25 The licensed areas appear to extend into subtidal habitat within deep tidal channels. However, the extent of these tidal channels has not been precisely mapped, and the actual positions of oyster trestles do not always exactly coincide with the areas that have been licensed. Therefore, we have assumed, for the purposes of this assessment, that all the licensed areas occupy intertidal habitat. For the purposes of calculating areas within count sectors, we have allocated subtidal portions of licensed plots to adjacent count sectors.

4.26 If X% of the Castlemaine Harbour population of a species occurs in the Douglas Strand-Cromane area, and the relevant plots occupy Y% of the intertidal habitat in the Douglas Strand-Cromane area, and assuming that the species population is uniformly distributed throughout the Douglas Strand-Cromane area, then complete exclusion from areas occupied by oyster trestles could reduce the total Castlemaine Harbour population by X*Y%.

4.27 However, for many species, their distribution within the Douglas Strand-Cromane area is concentrated within certain parts of the area. If their distribution is concentrated within sectors containing high percentage cover of licensed plots and/or license applications, then complete exclusion from areas occupied by oyster trestles and/or intertidal mussel cultivation would reduce the total Castlemaine Harbour population by a greater percentage than predicted from their percentage occurrence within the Douglas Strand-Cromane area. Conversely, if their distribution is concentrated outside these sectors, then complete exclusion from areas occupied by oyster trestles would reduce the total Castlemaine Harbour population by a lower percentage than predicted from their percentage occurrence within the Douglas Strand-Cromane area

4.28 Therefore, to assess the potential impact of full occupation of the licensed areas, we have calculated the proportion of the 2011 Douglas Strand-Cromane counts within the sectors where the licensed plots and/or license applications are concentrated (Y_1%) and the percentage occupation of these sectors by licensed plots and/or license applications (Y_2%). We calculated the overall potential worst-case scenario impact, assuming complete exclusion from areas occupied by oyster trestles and/or intertidal mussel cultivation as X%* Y_1%* Y_2%.

4.29 The worst-case scenario is highly unlikely to apply but is used as a screening method to identify species that may be at risk. Where species have a positive response to the presence of trestles, the worst-case scenario does not indicate a potential negative impact.

4.30 In all the following four scenarios are considered: -

1) Oyster licences;

2) Oyster licences & licence applications;

3) **Intertidal mussel applications;**

4) **Oyster licences & licence applications & Intertidal mussel applications.**

Oyster licenses [Scenario 1]

4.31 The total extent of areas currently licensed for oyster cultivation within the Douglas Strand-Cromane area of Castlemaine Harbour is 49 ha, which occupies around 7% of the total area of intertidal habitat. These areas are concentrated in sectors OY1 and OY4, where they occupy 23% and 18% of the total area, respectively (Table 4.4) and 19% of the combined total area of these sectors. There are 4 ha of licensed plots outside these sectors occupying less than 1% of the total area of the remaining sectors.

Table 4.4 – Areas of oyster licenses and license applications in the 2011 count sectors.

Sector	Total area/ha	% licensed	% applied for	% licensed and applied for
CAST-APP1	33	1%	63%	64%
CAST-APP2	24	0%	0%	0%
CAST-C2	241	0%	3%	4%
CAST-OY1	52	23%	23%	46%
CAST-OY2	35	1%	20%	21%
CAST-OY3	23	4%	16%	20%
CAST-OY4	187	18%	1%	19%
CAST-OY5	39	5%	0%	5%

4.32 The overall worst-case scenario level of impact is less than 1% for most species, and less than 0.5% for species with a known negative response to the presence of trestles (Table 3.5). However, these calculations assume that the relative occurrence within the Douglas Strand-Cromane area was the same in 2011 as in 2009/10. Some species occurred in considerably higher numbers in the Douglas Strand-Cromane area in 2011 compared to 2009/10. Overall count data for Castlemaine Harbour is not available yet for the 2010/11 season. However, if we assume that overall numbers in Castlemaine Harbour were similar in 2011 to those in 2009/10, then the overall level of impact would increase to 1.8% for Shelduck, 1% for Wigeon, 0.6% for Mallard, 1% for Dunlin and 2% for Black-tailed Godwit.

4.33 Bar-tailed Godwit did not occur in the Douglas Strand-Cromane area in the 2011 counts. If it was uniformly distributed throughout the Douglas Strand-Cromane area in 2009/10, then complete exclusion from areas occupied by oyster trestles would reduce the total Castlemaine Harbour population by 3.4%. However, the flock maps from 2009/10 indicate that it mainly occurs on the outer mud/sandflats across Castlemaine Harbour. Therefore, it is unlikely to have occurred in significant numbers within sector OY1.

Table 4.5 – Potential worst-case scenario of full occupation of the oyster licenses and license applications, assuming complete exclusion from areas with oyster trestles.

	% of 2009/10 LT counts in the Douglas Strand-Cromane area		% of 2011 counts in sectors OY1 and OY4		Worst-case scenario impact[1]	Response to trestles[2]
	Mean	SD	Mean	SD		
Light-bellied Brent Goose	11%	12%	15%	17%	0.5%	Uncertain
Shelduck	17%	19%	17%	20%	0.8%	Uncertain
Wigeon	8%	8%	29%	15%	0.7%	Uncertain
Teal	12%	12%	40%	42%	1.4%	Uncertain
Mallard	6%	3%	12%	2%	0.2%	Uncertain
Shoveler	25%	50%	10%	17%	0.7%	Uncertain
Little Egret	27%	9%	3%	6%	0.2%	Uncertain
Grey Heron	19%	11%	16%	24%	0.9%	Uncertain
Oystercatcher	13%	4%	12%	11%	0.5%	**Positive**
Ringed Plover	3%	5%	0%	0%	0.0%	**Negative**
Grey Plover	0%	1%	4%	9%	0.0%	**Negative**
Lapwing	2%	2%	10%	16%	0.1%	Uncertain
Knot	4%	8%	1%	1%	0.0%	Negative
Sanderling	35%	45%			0.0%	**Negative**
Dunlin	3%	3%	19%	33%	0.2%	Negative
Black-tailed Godwit	2%	2%	18%	21%	0.1%	Negative
Bar-tailed Godwit	49%	35%			0.0%	**Negative**
Curlew	14%	3%	13%	7%	0.5%	Uncertain
Greenshank	21%	9%	3%	6%	0.2%	Positive
Redshank	9%	5%	8%	4%	0.2%	Positive
Turnstone	21%	6%	18%	16%	1.1%	**Positive**
Black-headed Gull	28%	5%	9%	4%	0.7%	Positive
Common Gull	9%	9%	33%	24%	0.9%	Positive
Lesser Black-backed Gull	25%	16%	38%	53%	2.8%	Positive
Herring Gull	11%	9%	14%	10%	0.4%	Positive
Great Black-backed Gull	8%	9%	3%	6%	0.1%	Positive

[1] For details of calculation method, see paragraphs 4.26-4.28.

[2] See paragraphs 4.12-4.17. Species where there is a high level of confidence about the response are indicated in bold.

Oyster licenses and license applications [Scenario 2]

4.34 The total extent of areas either with active applications, or currently licensed, for oyster cultivation within the Douglas Strand-Cromane area of Castlemaine Harbour is 104 ha, which occupies around 14% of the total area of intertidal habitat within the Douglas Strand-Cromane area. These areas are particularly concentrated in sectors APP1 and OY1, but also occupy around 20% of three other sectors (Table 4.4) and occupy 28% of the combined total area of these five sectors. There are 12 ha of licensed plots and license applications outside these sectors occupying 3% of the total area of the remaining sectors.

4.35 The overall worst-case scenario level of impact varies from 0-3% for most species, but is less than 0.5% for species with a known negative response to the presence of trestles (Table 4.6). However, these calculations assume that the relative occurrence within the Douglas Strand-Cromane area was the same in 2011 as in 2009/10. Some species occurred in considerably higher numbers in the Douglas Strand-Cromane area in 2011 compared to 2009/10. Overall count data for Castlemaine Harbour is not available yet for the 2010/11 season. However, if we assume that overall numbers remained the same, then the overall level of impact would increase to 2.5% for Shelduck, 1.5% for Wigeon, 1.7% for Mallard, 1.9% for Dunlin and 3.9% for Black-tailed Godwit.

4.36 Bar-tailed Godwit did not occur in the Douglas Strand-Cromane area in the 2011 counts. If it was uniformly distributed throughout the Douglas Strand-Cromane area in 2009/10, then complete exclusion from areas occupied by oyster trestles would reduce the total Castlemaine Harbour population by 6.9%. However, the flock maps from 2009/10 indicate that it mainly occurs on the outer mud/sandflats across Castlemaine Harbour. Therefore, it is unlikely to have occurred in significant numbers within sector OY1 and OY3.

Table 4.6 - Potential worst-case scenario of full occupation of the oyster licenses and license applications, assuming complete exclusion from areas with oyster trestles.

	% of 2009/10 LT counts in the Douglas Strand-Cromane area		% of 2011 counts in sectors APP1 and OY1-OY4		Worst-case scenario impact[1]	Response to trestles[2]
	Mean	SD				
Light-bellied Brent Goose	11%	12%	34%	28%	1.0%	Uncertain
Shelduck	17%	19%	22%	20%	1.1%	Uncertain
Wigeon	8%	8%	43%	13%	1.0%	Uncertain
Teal	12%	12%	53%	44%	1.8%	Uncertain
Mallard	6%	3%	37%	10%	0.6%	Uncertain
Shoveler	25%	50%	39%	18%	2.8%	Uncertain
Little Egret	27%	9%	33%	29%	2.6%	Uncertain
Grey Heron	19%	11%	37%	25%	2.0%	Uncertain
Oystercatcher	13%	4%	26%	5%	1.0%	**Positive**
Ringed Plover	3%	5%	0%	0%	0.0%	**Negative**
Grey Plover	0%	1%	40%	36%	0.0%	**Negative**
Lapwing	2%	2%	13%	22%	0.1%	Uncertain
Knot	4%	8%	16%	25%	0.2%	Negative

	% of 2009/10 LT counts in the Douglas Strand-Cromane area		% of 2011 counts in sectors APP1 and OY1-OY4		Worst-case scenario impact[1]	Response to trestles[2]
	Mean	SD				
Sanderling	35%	45%	0%	0%	0.0%	**Negative**
Dunlin	3%	3%	47%	46%	0.4%	Negative
Black-tailed Godwit	2%	2%	34%	25%	0.2%	Negative
Bar-tailed Godwit	49%	35%			0.0%	**Negative**
Curlew	14%	3%	35%	12%	1.4%	Uncertain
Greenshank	21%	9%	15%	16%	0.9%	Positive
Redshank	9%	5%	31%	14%	0.8%	Positive
Turnstone	21%	6%	43%	4%	2.6%	**Positive**
Black-headed Gull	28%	5%	19%	6%	1.5%	Positive
Common Gull	9%	9%	45%	28%	1.2%	Positive
Lesser Black-backed Gull	25%	16%	38%	53%	2.8%	Positive
Herring Gull	11%	9%	24%	18%	0.8%	Positive
Great Black-backed Gull	8%	9%	25%	17%	0.6%	Positive

[1] For details of calculation method, see paragraphs 4.26-4.28.

[2] See paragraphs 4.12-4.17. Species where there is a high level of confidence about the response are indicated in bold.

Intertidal mussel applications [Scenario 3]

4.37 Intertidal mussel cultivation does not currently occur within the Douglas Strand-Cromane area. However, there are several applications for licenses. These occupy a total area of 71 ha amounting to around 10% of the total area of intertidal habitat within the Douglas Strand-Cromane area (Table 4.7). The mussel licenses are mainly concentrated in sectors APP2-APP4 and OY2 and occupy 60% of the combined area of these sectors. There are 6 ha of mussel license applications outside these sectors occupying 1% of the total area of the remaining sectors.

Table 4.7 – Areas of intertidal mussel license applications in the 2011 count sectors.

Sector	Total area/ha	% with mussel license applications	% with oyster and mussel licenses and license applications
APP1	33	14%	77%
APP2	24	56%	56%
APP3	24	41%	41%
APP4	24	63%	63%
C2	241	0%	4%
OY1	52	0%	46%
OY2	35	75%	96%
OY3	23	1%	21%
OY4	187	1%	19%
OY5	39	2%	7%

4.38 The overall worst-case scenario level of impact varies from 0-3% for most species, but is less than 0.5% for species with a known negative response to the presence of intertidal mussel cultivation (Table 4.8). Some species occurred in considerably higher numbers in the Douglas Strand-Cromane area in 2011 compared to 2009/10. Overall count data for Castlemaine Harbour is not available yet for the 2010/11 season. However, if we assume that overall numbers remained the same, then the overall level of impact would increase to 4.7% for Shelduck, 2.1% for Wigeon, 2.9% for Mallard, 0.5% for Dunlin and 7.8% for Black-tailed Godwit.

4.39 Bar-tailed Godwit did not occur in the Douglas Strand-Cromane area in the 2011 counts. If it was uniformly distributed throughout the Douglas Strand-Cromane area in 2009/10, then complete exclusion from areas occupied by intertidal mussel cultivation would reduce the total Castlemaine Harbour population by 4.9%. However, the flock maps from 2009/10 indicate that it mainly occurs on the outer mud/sandflats across Castlemaine Harbour. Therefore, it is unlikely to have occurred in significant numbers within sectors APP2-APP4.

Table 4.8 - Potential worst-case scenario of full occupation of the mussel license applications, assuming complete exclusion from areas with intertidal mussel cultivation.

	% of 2009/10 LT counts in the Douglas Strand-Cromane area		% of 2011 counts in sectors APP2-APP4 and OY2		Worst-case scenario impact[1]	Response to intertidal mussel cultivation[2]
	Mean	SD	Mean	SD		
Light-bellied Brent Goose	11%	12%	68%	13%	4.5%	Uncertain
Shelduck	17%	19%	21%	18%	2.1%	Uncertain
Wigeon	8%	8%	29%	22%	1.4%	Uncertain
Teal	12%	12%	30%	21%	2.2%	Uncertain
Mallard	6%	3%	29%	13%	1.0%	Uncertain
Shoveler	25%	50%	0%	0%	0.0%	Uncertain
Little Egret	27%	9%	47%	50%	7.6%	Uncertain
Grey Heron	19%	11%	23%	27%	2.6%	Uncertain
Oystercatcher	13%	4%	23%	17%	1.8%	**Positive**
Ringed Plover	3%	5%	0%	0%	0.0%	**Negative**
Grey Plover	0%	1%	9%	18%	0.0%	**Negative**
Lapwing	2%	2%	67%	58%	0.8%	Uncertain
Knot	4%	8%	2%	3%	0.0%	Negative
Sanderling	35%	45%	0%	0%	0.0%	**Negative**
Dunlin	3%	3%	5%	9%	0.1%	Negative
Black-tailed Godwit	2%	2%	33%	47%	0.4%	Negative
Bar-tailed Godwit	49%	35%				**Negative**
Curlew	14%	3%	32%	8%	2.7%	Uncertain
Greenshank	21%	9%	43%	6%	5.4%	Positive
Redshank	9%	5%	30%	6%	1.6%	Positive
Turnstone	21%	6%	64%	3%	8.1%	**Positive**
Black-headed Gull	28%	5%	19%	8%	3.2%	Positive
Common Gull	9%	9%	21%	7%	1.1%	Positive
Lesser Black-backed Gull	25%	16%	0%	0%	0.0%	Positive
Herring Gull	11%	9%	27%	15%	1.8%	Positive
Great Black-backed Gull	8%	9%	38%	28%	1.8%	Positive

[1] For details of calculation method, see paragraphs 4.26-4.28.

[2] See paragraphs 4.6-4.11. Species where there is a high level of confidence about the response are indicated in bold.

Oyster licenses and license applications and intertidal mussel applications [Scenario 4]

4.40 The total extent of areas with oyster licenses, oyster license applications and/or mussel license applications is 173 ha amounting to around 25% of the total area of intertidal habitat within the Douglas Strand-Cromane area. These areas are mainly concentrated in sectors APP1-APP4 and OY1-OY4 and occupy 40% of the combined area of these sectors. There are 12 ha of oyster licenses, oyster license applications and mussel license applications outside these sectors occupying 4% of the total area of the remaining sectors.

4.41 The overall worst-case scenario level of impact varies from 0-4% for most species, but is less than 1% for species with a known negative response to the presence of intertidal mussel and/or cultivation (Table 3.9). Some species occurred in considerably higher numbers in the Douglas Strand-Cromane area in 2011 compared to 2009/10. Overall count data for Castlemaine Harbour is not available yet for the 2010/11 season. However, if we assume that overall numbers remained the same, then the overall level of impact would increase to 5.0% for Shelduck, 3.4% for Wigeon, 3.4% for Mallard, 74% for Shoveler, 2.8% for Dunlin and 9.8% for Black-tailed Godwit.

4.42 Bar-tailed Godwit did not occur in the Douglas Strand-Cromane area in the 2011 counts. If it was uniformly distributed throughout the Douglas Strand-Cromane area in 2009/10, then complete exclusion from areas occupied by oyster trestles and intertidal mussel culture would reduce the total Castlemaine Harbour population by 12.3%. However, the flock maps from 2009/10 indicate that it mainly occurs on the outer mud/sandflats across Castlemaine Harbour. Therefore, it is unlikely to have occurred in significant numbers within sectors APP2-APP4, OY1 and OY3.

Table 4.9 - Potential worst-case scenario of full occupation of the oyster licenses and the mussel and oyster license applications, assuming complete exclusion from areas with intertidal mussel cultivation.

	% of 2009/10 LT counts in the Douglas Strand-Cromane area		% of 2011 counts in sectors APP1-APP4 and OY2		Worst-case scenario impact[1]	Response to intertidal mussel and oyster cultivation[2]
	Mean	SD	Mean	SD		
Light-bellied Brent Goose	11%	12%	95%	8%	4.2%	Uncertain
Shelduck	17%	19%	32%	18%	2.2%	Uncertain
Wigeon	8%	8%	71%	19%	2.3%	Uncertain
Teal	12%	12%	73%	26%	3.5%	Uncertain
Mallard	6%	3%	57%	13%	1.4%	Uncertain
Shoveler	25%	50%	39%	18%	3.9%	Uncertain
Little Egret	27%	9%	57%	51%	6.2%	Uncertain
Grey Heron	19%	11%	50%	36%	3.8%	Uncertain
Oystercatcher	13%	4%	48%	18%	2.5%	**Positive**
Ringed Plover	3%	5%	100%	0%	1.2%	**Negative**
Grey Plover	0%	1%	49%	44%	0.0%	**Negative**
Lapwing	2%	2%	79%	36%	0.6%	Uncertain
Knot	4%	8%	17%	24%	0.3%	Negative
Sanderling	35%	45%	0%	0%	0.0%	**Negative**
Dunlin	3%	3%	51%	41%	0.6%	Negative
Black-tailed Godwit	2%	2%	65%	28%	0.5%	Negative
Bar-tailed Godwit	49%	35%				**Negative**
Curlew	14%	3%	56%	11%	3.1%	Uncertain
Greenshank	21%	9%	48%	15%	4.0%	Positive
Redshank	9%	5%	52%	16%	1.9%	Positive
Turnstone	21%	6%	86%	16%	7.2%	**Positive**
Black-headed Gull	28%	5%	34%	9%	3.8%	Positive
Common Gull	9%	9%	58%	26%	2.1%	Positive
Lesser Black-backed Gull	25%	16%	38%	53%	3.8%	Positive
Herring Gull	11%	9%	43%	22%	1.9%	Positive
Great Black-backed Gull	8%	9%	51%	29%	1.6%	Positive

[1] For details of calculation method, see paragraphs 4.26-4.28.

[2] See paragraphs 4.6-4.17. Species where there is a high level of confidence about the response are indicated in bold.

Potential disturbance impacts

4.43 Potential disturbance impacts from aquaculture activities to birds within the licenses and license applications are included in the above assessments.

4.44 There are also potential for disturbance impacts from boats accessing the licenses and license applications, and from activities within the licenses and license applications causing disturbance to adjoining areas.

Disturbance levels

4.45 During the 2009/10 counts, powered watercraft were recorded as causing disturbance within the Douglas Strand-Cromane area on two occasions (Table 4.10; source – NPWS counts). Aquaculture-related human activity within the intertidal zone was also recorded as causing disturbance on two occasions (two events on the same count day). Aquaculture machinery was recorded on two occasions and Aquaculture-related human activity within the intertidal zone on a further occasion without any disturbance impacts being noted.

4.46 During the 2011 counts, aquaculture-related activity was recorded on three of the count dates, but only coincided spatially with sector counts on one of these days (5 January); on the other dates the activity was only observed distantly and any impacts could not be recorded. On 5 January, boats were recorded visiting sectors OY4 and OY5. A dog associated with people working on trestles in OY4 spent 40 minutes chasing birds within a radius of around 200 m.

Table 4.10 – Disturbance events recorded in sectors OK468 and 469 during the 2009/10 counts.

Date	Disturbance type	Number of events	Duration	Impact	Species affected	Response
05-Oct	Human (on-foot, intertidal aquaculture)	2	short/discrete event	Y	MA, RK, T., WA	Moderate
21-Nov	Powered watercraft	2	short/discrete event	N		
04-Jan	Shooting	1	short/discrete event	N		
04-Jan	Powered watercraft	1	continued after count period ended	Y	CU, ET, HG, RK	Weak
04-Jan	Human (on-foot, shoreline)	1	short/discrete event	Y	PB	Weak
25-Jan	Powered watercraft	1	continued after count period ended	Y	RM	High
25-Jan	Aquaculture machinery	1	continued after count period ended	N		
01-Feb	Aquaculture machinery	1	50-100% of count period	N		
01-Feb	Human (on-foot, intertidal aquaculture)	2	continued after count period ended	N		
01-Feb	Winkle picking)	1	continued after count period ended	N		

Date	Disturbance type	Number of events	Duration	Impact	Species affected	Response
01-Feb	Human (on-foot, intertidal aquaculture)	1	continued after count period ended	N		

Weak response: waterbirds move slightly away from the source of the disturbance.

Moderate response: waterbirds move away from the source of the disturbance to another part of the count unit; they may return to their original position once disturbance ceases.

High response: waterbirds fly away to areas outside of the count unit and do not return during the current count session.

Assessment

4.47 These observations show that aquaculture activities can cause disturbance to waterbirds. The data is too limited and patchy to assess the average frequency and duration of these activities.

4.48 Intertidal oyster cultivation involves a relatively high level of husbandry activity, with the potential to cause disturbance to waterbirds using intertidal habitat at low tide. Observations at sites with intensive oyster cultivation indicate that many species of waterbirds habituate to the disturbance. Similarly, Kelly (1996) found that the presence of oyster workers did not cause large-scale movement of birds, or affect the distribution of birds. However, species that show avoidance of oyster trestles may be displaced by the disturbance as well as, or instead of, the habitat changes.

4.49 In general, disturbance to waterbirds outside the occupied plots would have a lower impact than habitat changes causing complete exclusion within the plots. The assessments above show that at current levels of oyster cultivation in this area, and with moderate expansion (e.g., full occupation of the licenses); the worst-case scenarios do not predict high levels of impact. The actual impacts of habitat changes and of disturbance impacts would both be substantially lower than these worst-case scenarios. Therefore, at current levels of oyster cultivation in this area, and with moderate expansion (e.g., full occupation of the licenses); it seems unlikely that disturbance is having, or would have, a significant impact on intertidal waterbird populations.

4.50 Intertidal mussel cultivation generally has lower potential for generation of disturbance impacts than intertidal oyster cultivation.

4.51 Boat access may also cause disturbance to waterbirds in subtidal habitat. The Douglas Strand-Cromane area appears to be important for Red-breasted Merganser and they were recorded as being by boats (and leaving the area) during one of the 2009/10 counts. However, such disturbance events would have to be of frequent occurrence, and/or exclude the birds from highly productive feeding grounds, to have a significant impact on the population. This seems unlikely given the data collected so far.

4.52 Boat access does not appear to cause any disturbance to the Cormorants roosting on the outer sandbanks.

Conclusions

4.53 The existing level of oyster cultivation within Castlemaine Harbour is very small. The percentage of intertidal habitat occupied by trestles is too small to detect avoidance of trestles. If any avoidance of trestles is occurring, it is highly unlikely that it is having a significant impact on the overall population levels within Castlemaine Harbour.

4.54 Under a worst case scenario, where waterbirds are completely excluded from areas occupied by oyster trestles, full occupation of the licensed plots would affect up to 1% of the total Castlemaine

Harbour populations of various species, and possibly up to 2% of the Shelduck and Black-tailed Godwit populations and 4% of the Bar-tailed Godwit population. Similarly, under this scenario, full occupations of plots with active applications, as well as the licensed plots would affect up to 3% of the total Castlemaine Harbour populations of various species, and possibly up to 4% of the Black-tailed Godwit population and 7% of the Bar-tailed Godwit population. Also under this scenario, full occupation of the mussel license applications would affect up to 3% of the total Castlemaine Harbour populations of various species, and possibly up to 5% of the Shelduck and Bar-tailed Godwit populations and 8% of the Black-tailed Godwit population. Finally, under this scenario, full occupation of the oyster license and of the mussel and oyster license applications would affect up to 4% of the total Castlemaine Harbour populations of various species, and possibly up to 5% of the Shelduck population, 10% of the Black-tailed Godwit population and 12% of the Bar-tailed Godwit population.

4.55 For most species where we have some evidence of negative responses to trestles, the level of impact predicted under these scenarios would be less than 0.5%. This reflects the fact that these species tend to occur on the outer sandflats, while the most of the affected areas are close to the shore.

4.56 The above worst-case scenarios, assume complete exclusion from areas occupied by oyster trestles and/or intertidal mussel cultivation. This is a highly unrealistic assumption as many species show a neutral or positive response and even those that show a negative response are often not completely excluded (see paragraphs 4.8 and 4.14-4.15).

4.57 Full occupation of the licenses and license applications is probably also an unrealistic assumption. In sites that we have surveyed or visited, full occupation of the oyster licenses rarely occurs, while in the mussel nursery area in Castlemaine Harbour the overall cover of mussels in 2009/10 was only 11% (Gittings and O'Donoghue, 2011).

4.58 As discussed above oyster cultivation rarely occupies the full extent of the licensed plots. However, it often extends outside the licensed plots. While the total area occupied is usually less than the licensed area, the predictions made above may be affected if the actual development of oyster cultivation does not follow the boundaries of the licenses and license applications.

4.59 Finally, the predictions made above are based on limited data and combine datasets from two winters, and there is no data on species distribution within the Douglas Strand-Cromane area during the autumn/early winter period. Also, conclusions about species response to oyster cultivation are based on preliminary data analyses and may be subject to change.

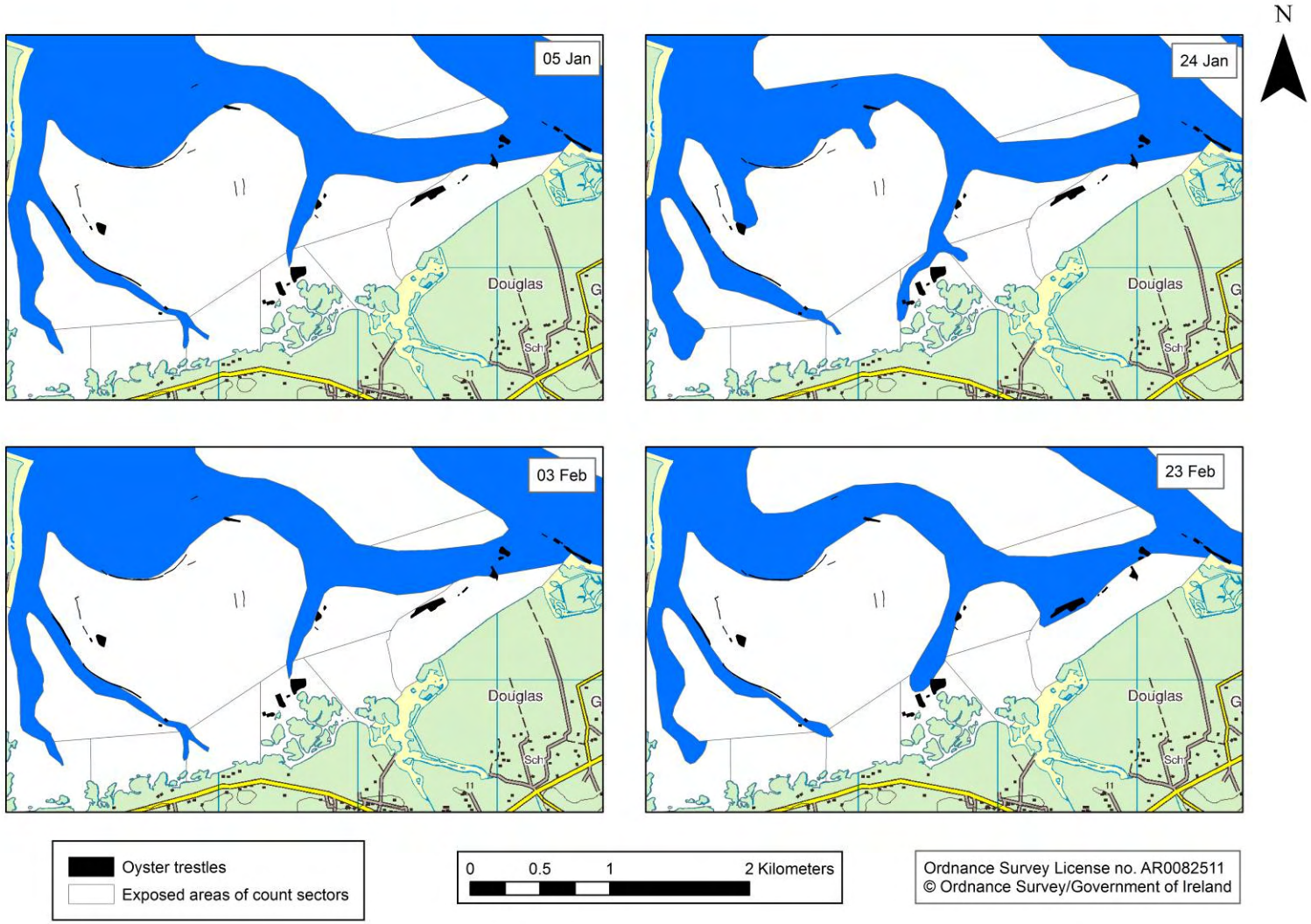

Figure 4.1 – Tidal exposure of count sectors and oyster trestles during the 2011 counts.

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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
MS	Mute Swan	*Cygnus olor*
GJ	Greylag Goose	*Anser anser*
PB	Light-bellied Brent Goose	*Branta bernicla hrota*
SU	Shelduck	*Tadorna tadorna*
WN	Wigeon	*Anas penelope*
T.	Teal	*Anas crecca*
MA	Mallard	*Anas platyrhynchos*
PT	Pintail	*Anas acuta*
SV	Shoveler	*Anas clypeata*
SP	Scaup	*Athya marila*
RM	Red-breasted Merganser	*Mergus serrator*
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*
NB	Spoonbill	*Platalea leucorodia*
WA	Water Rail	*Rallus aquaticus*
MH	Moorhen	*Gallinula chloropus*
OC	Oystercatcher	*Haematopus ostralegus*
RP	Ringed Plover	*Charadrius hiaticula*
GV	Grey Plover	*Pluvialis squatarola*
L.	Lapwing	*Vanellus vanellus*
KN	Knot	*Calidris canutus*
SS	Sanderling	*Calidris alba*
ER	Western Sandpiper	*Calidris mauri*
EP	Least Sandpiper	*Calidris minutilla*
DN	Dunlin	*Calidris alpina*
SN	Snipe	*Gallinago gallinao*
BW	Black-tailed Godwit	*Limosa limosa*
BA	Bar-tailed Godwit	*Limosa lapponica*
	Marbed Godwit	*Limosa fedoa*
CU	Curlew	*Numenius arquata*
DR	Spotted Redshank	*Tringa erythropus*
GK	Greenshank	*Tringa nebularia*
RK	Redshank	*Tringa totanus*
	Willet	*Catoptrophorus semipalmatus*
TT	Turnstone	*Arenaria interpres*
BH	Black-headed Gull	*Larus ridibundus*

Code	Name	Scientific name
CM	Common Gull	*Larus canus*
LB	Lesser Black-backed Gull	*Larus fuscus*
HG	Herring Gull	*Larus argentatus*
GB	Great Black-backed Gull	*Larus marinus*

Appendix B – Species distribution maps

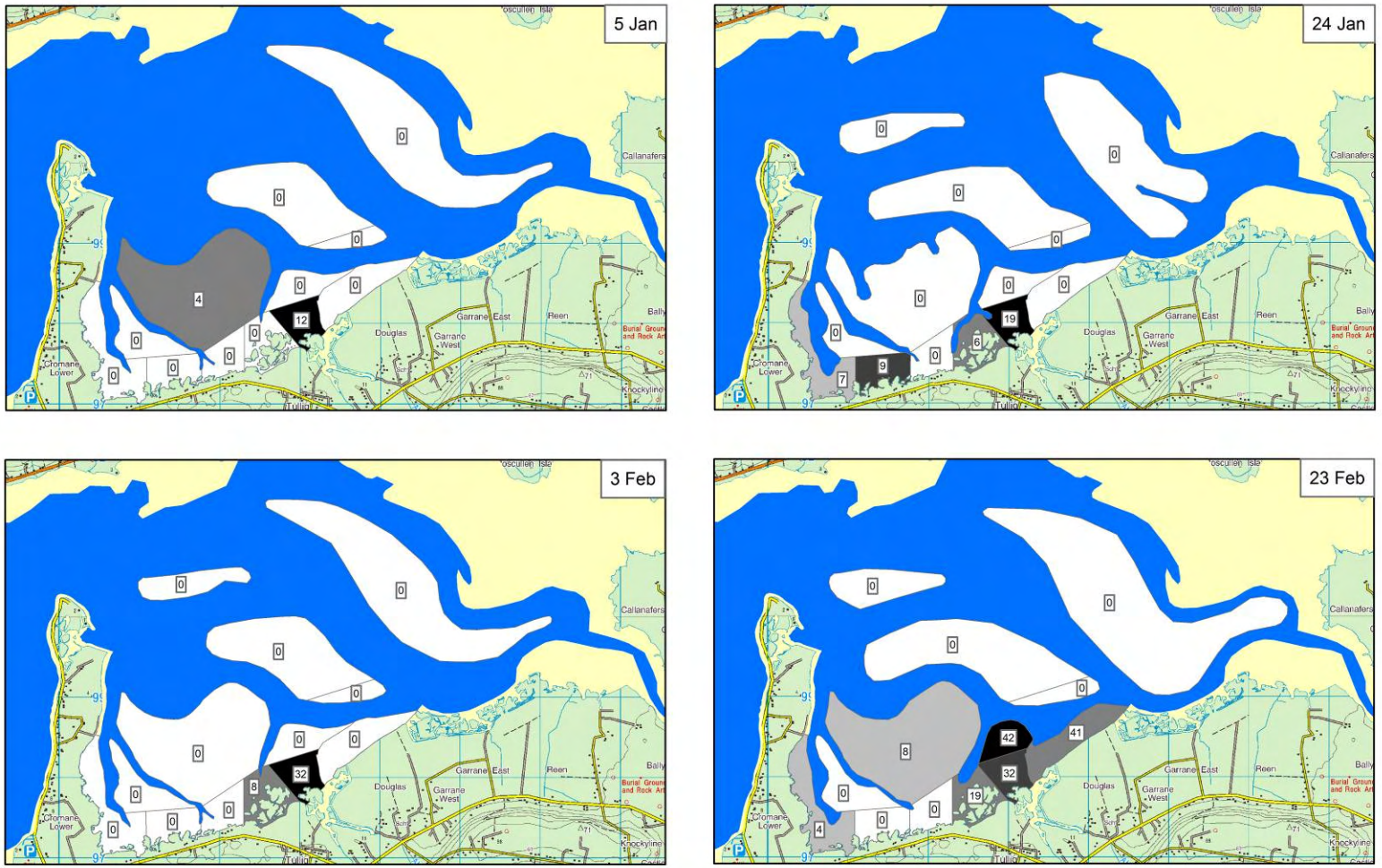
B.1.1 This appendix includes maps showing the distribution within the Douglas Strand-Cromane area of waterbird species recorded in the 2011 counts.

B.1.2 Four maps are included for each species showing the distribution on each count date.

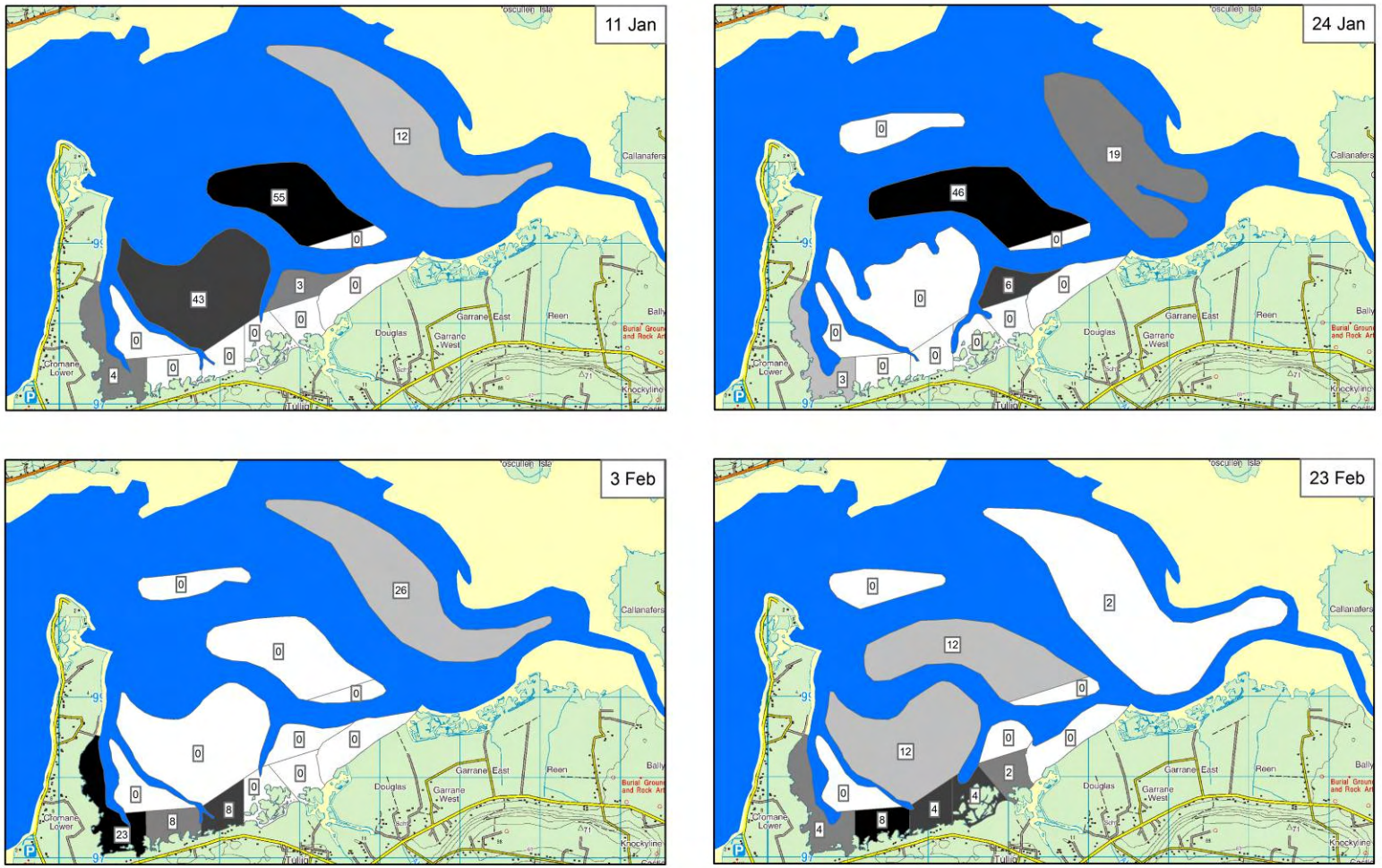
B.1.3 The maps show the tidal exposure of the count sectors on each count date. Note that sector C5 was not exposed on the 5 January count.

B.1.4 Each map illustrates the density in each count sector relative to the total numbers recorded on that count date. The density is indicated by the shading of the count sector, from white (no birds) to black (maximum density). The densities shown are relative and the absolute values are, therefore, not necessarily comparable between count dates.

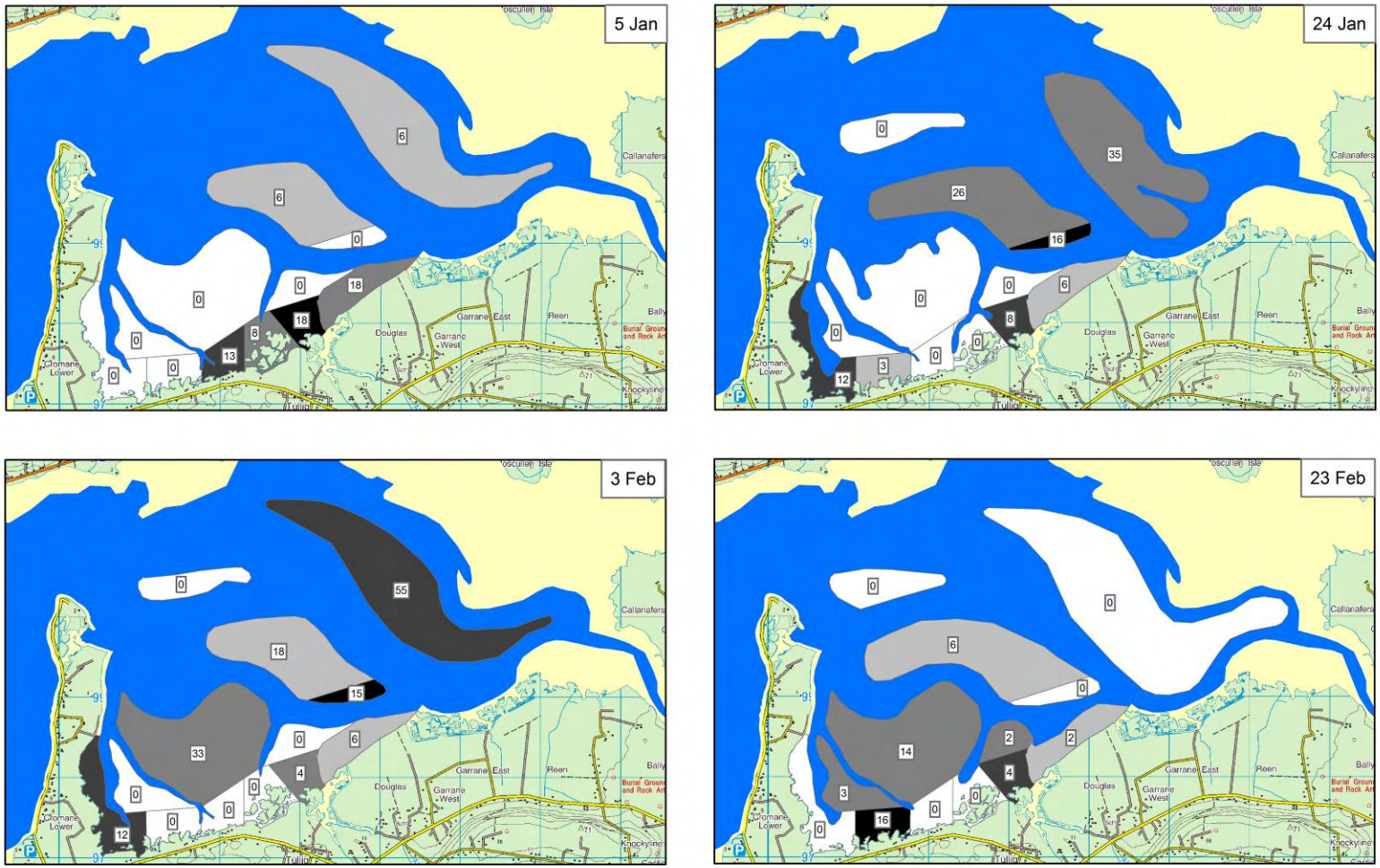
B.1.5 The actual count in each sector is shown as a label within each sector.



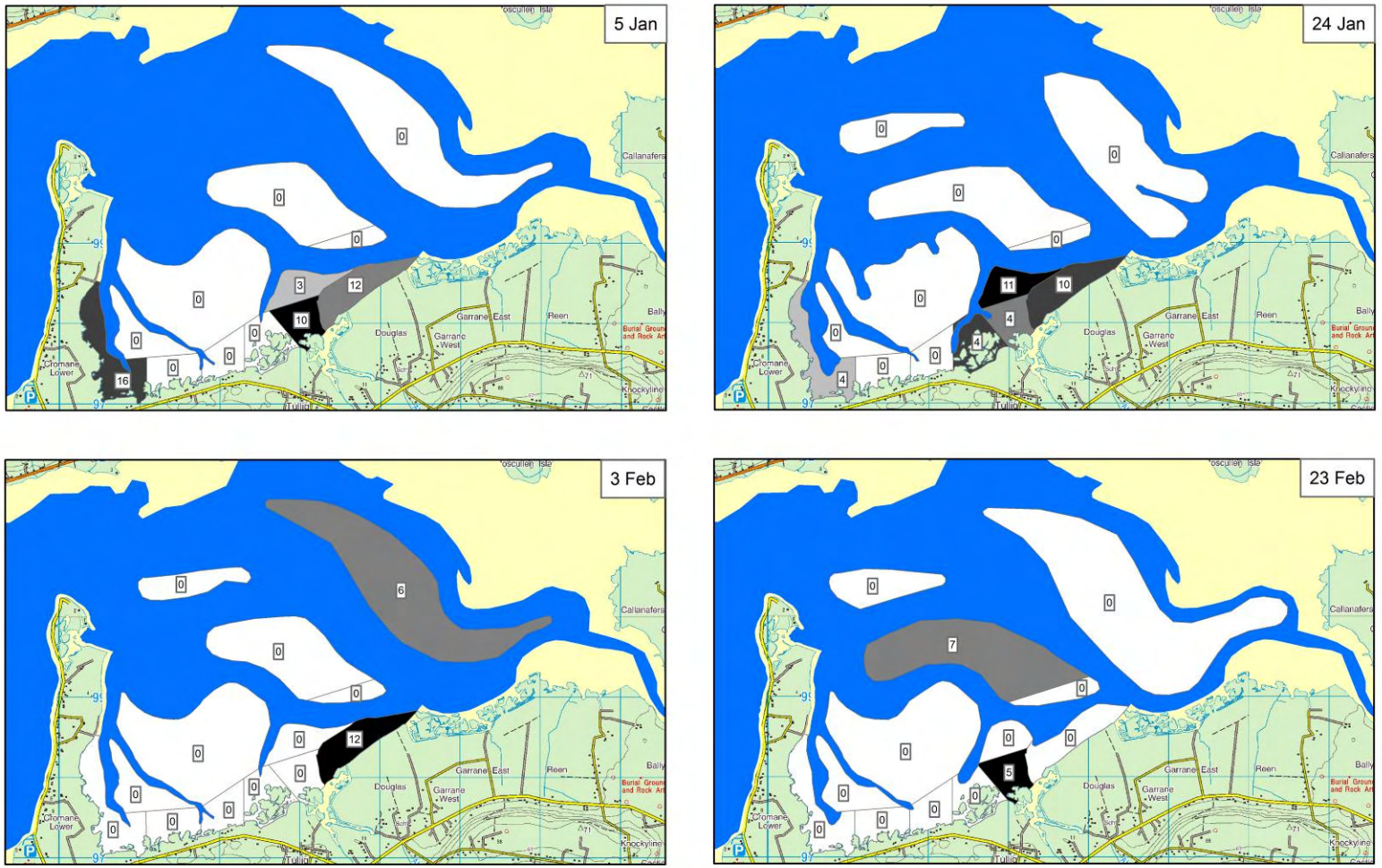
Light-bellied Brent Goose



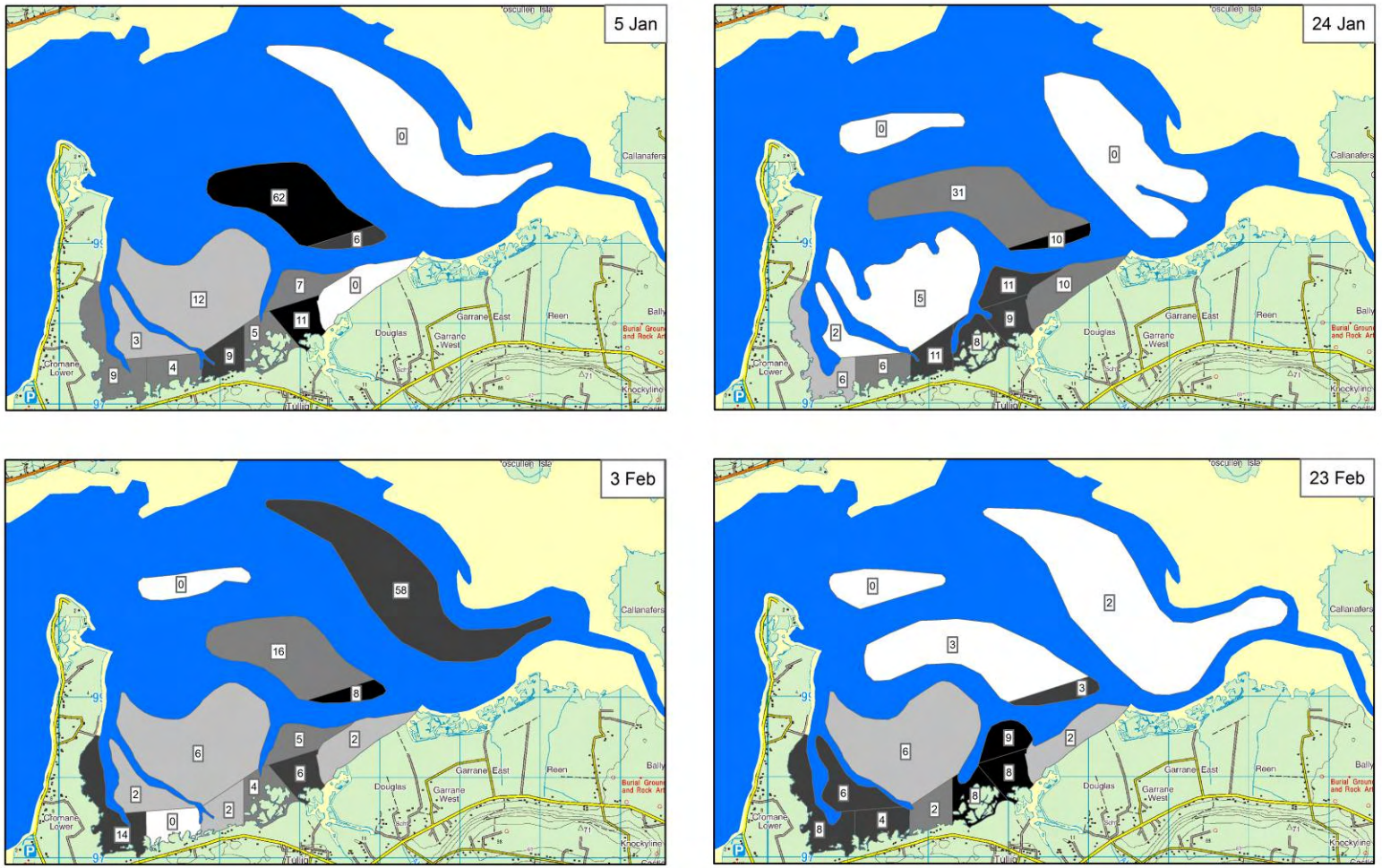
Shelduck



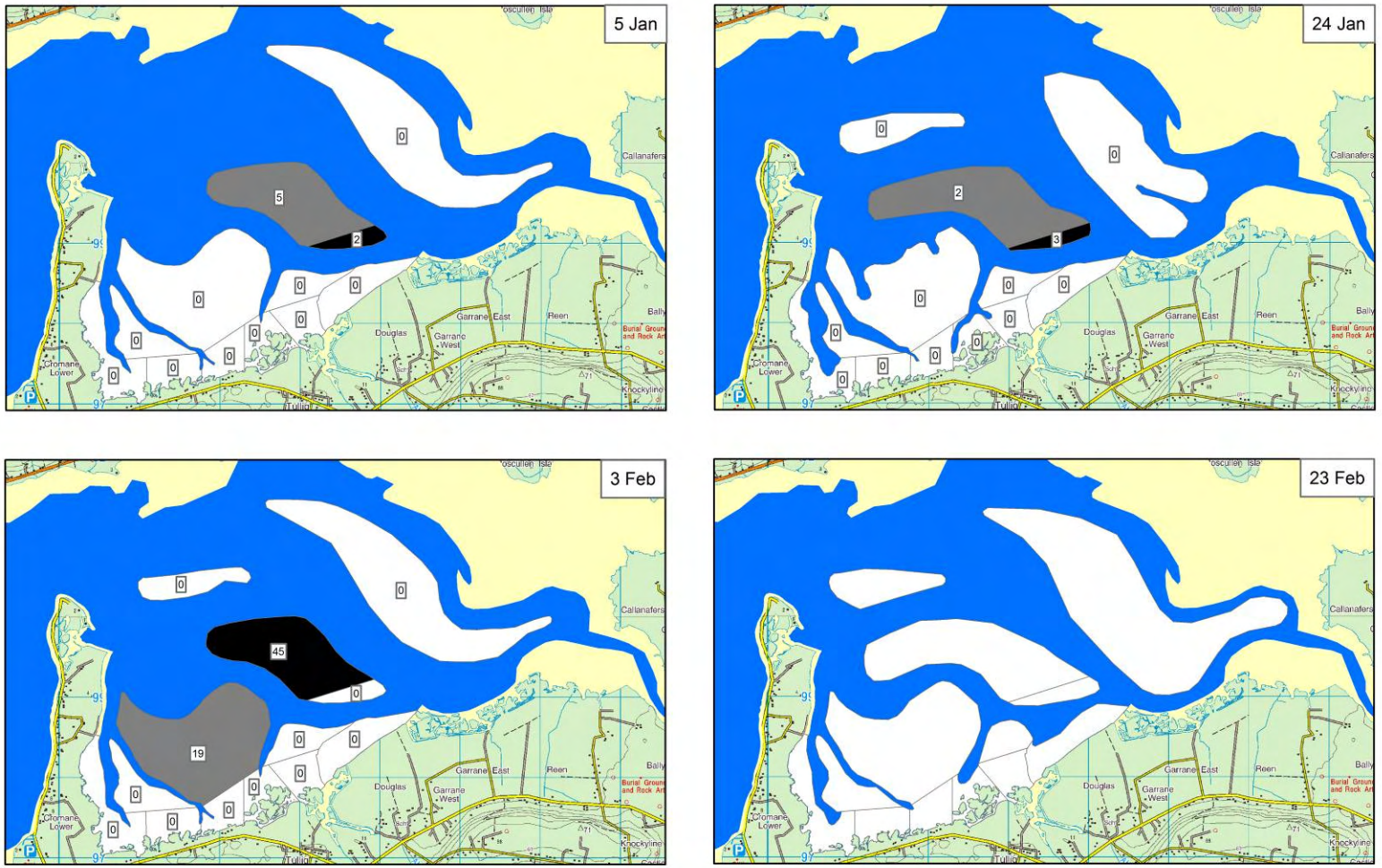
Wigeon



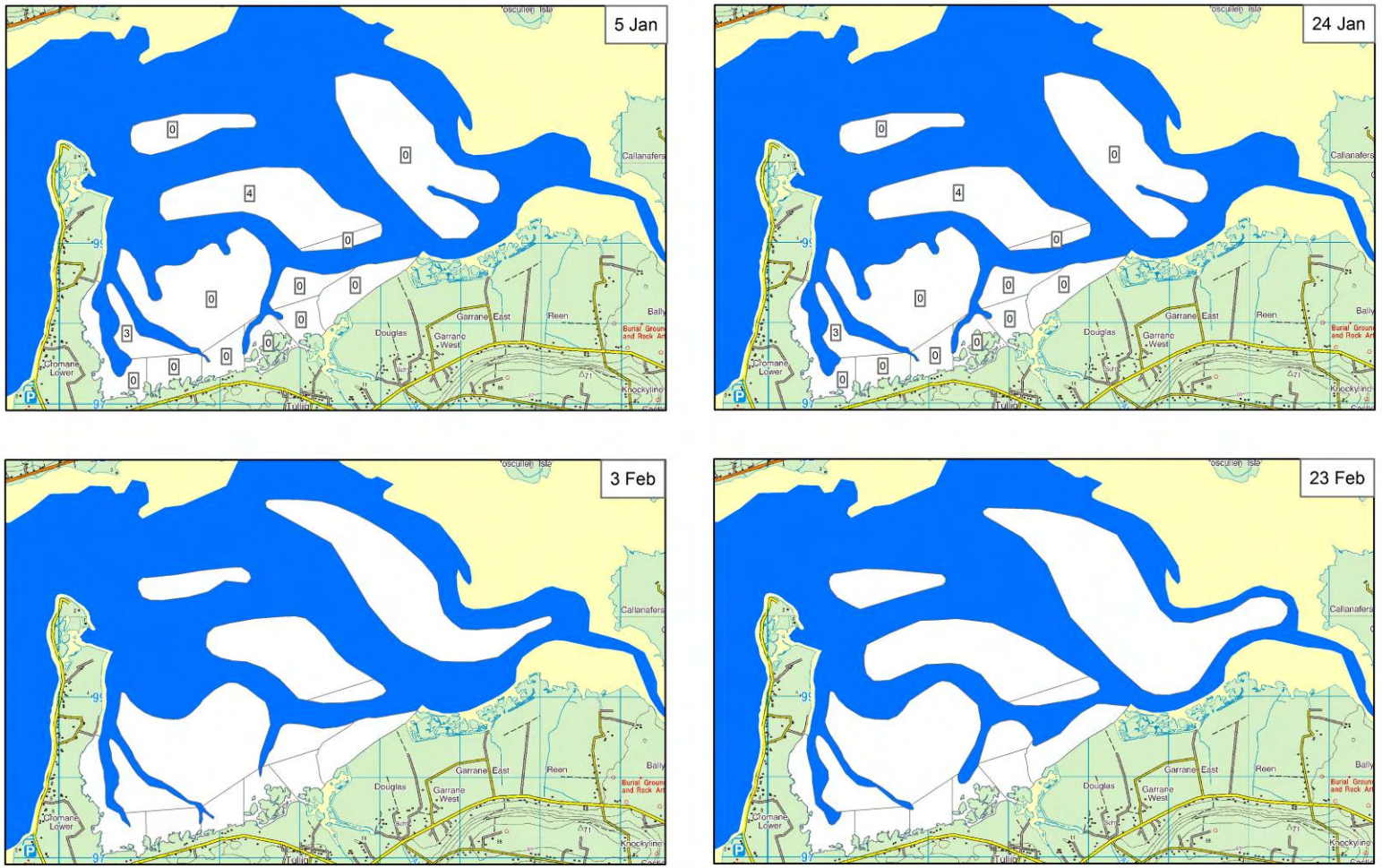
Teal



Mallard

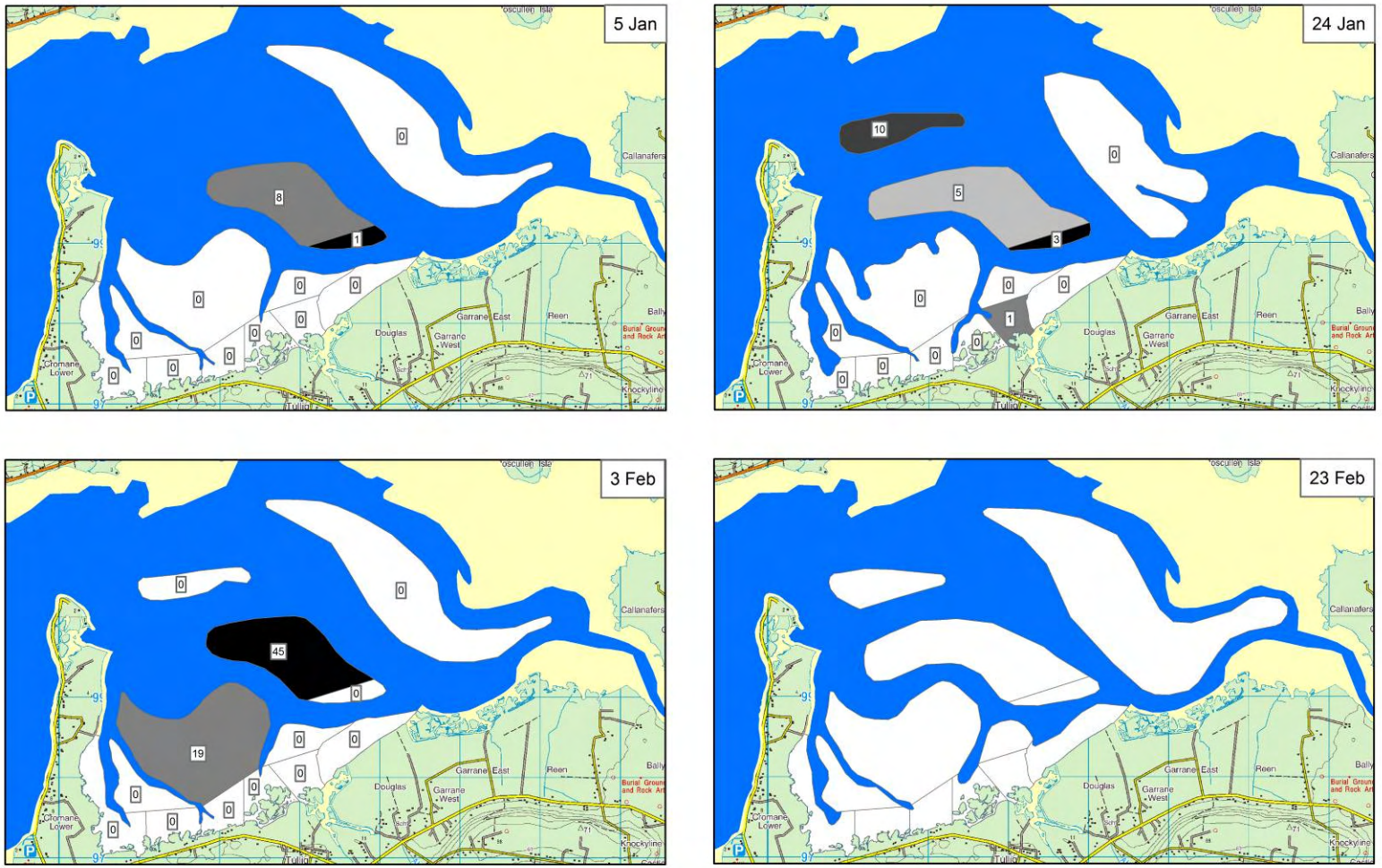


Shoveler



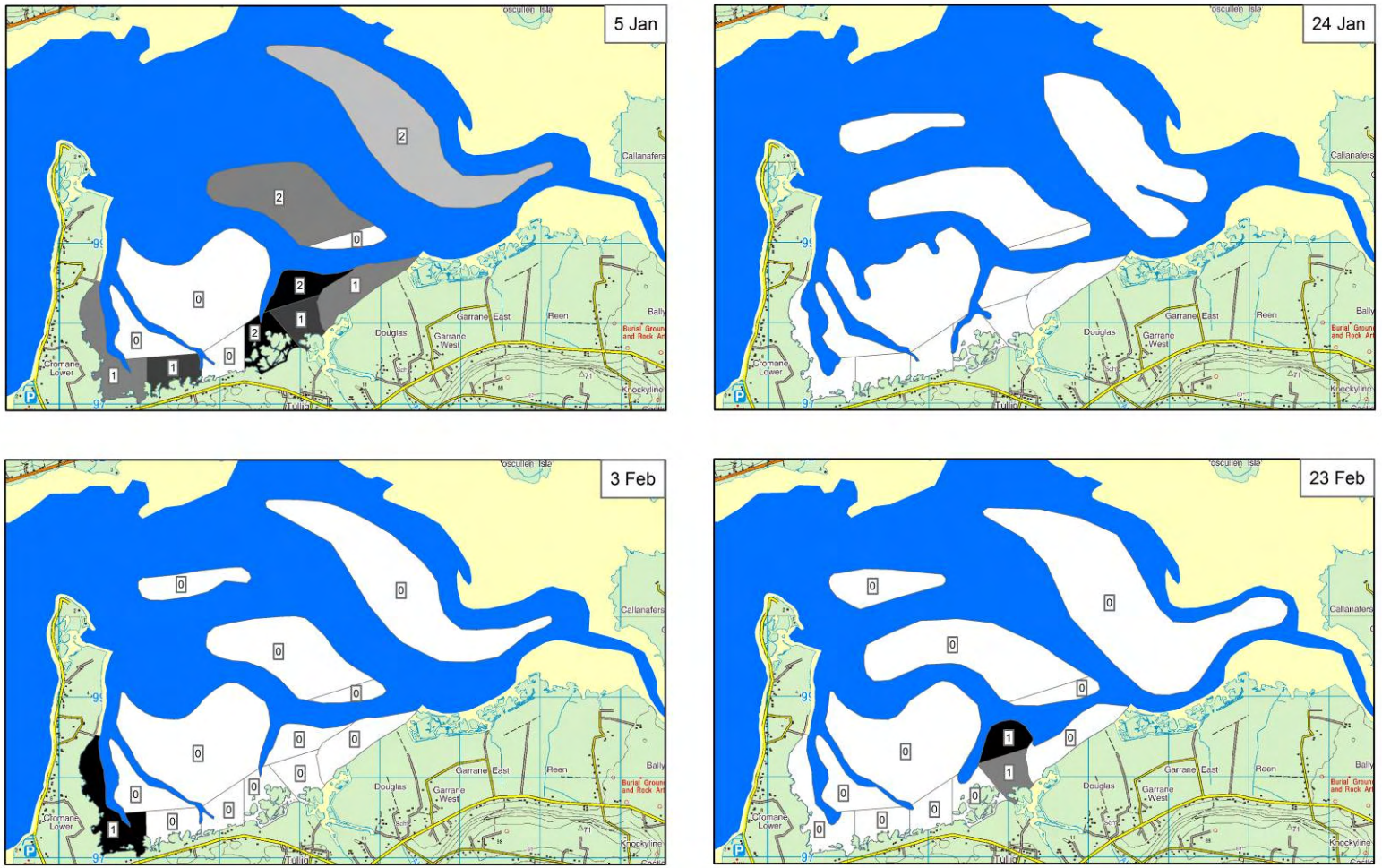
Note - birds mainly occurred in subtidal habitat, so densities not shown

Red-breasted Merganser

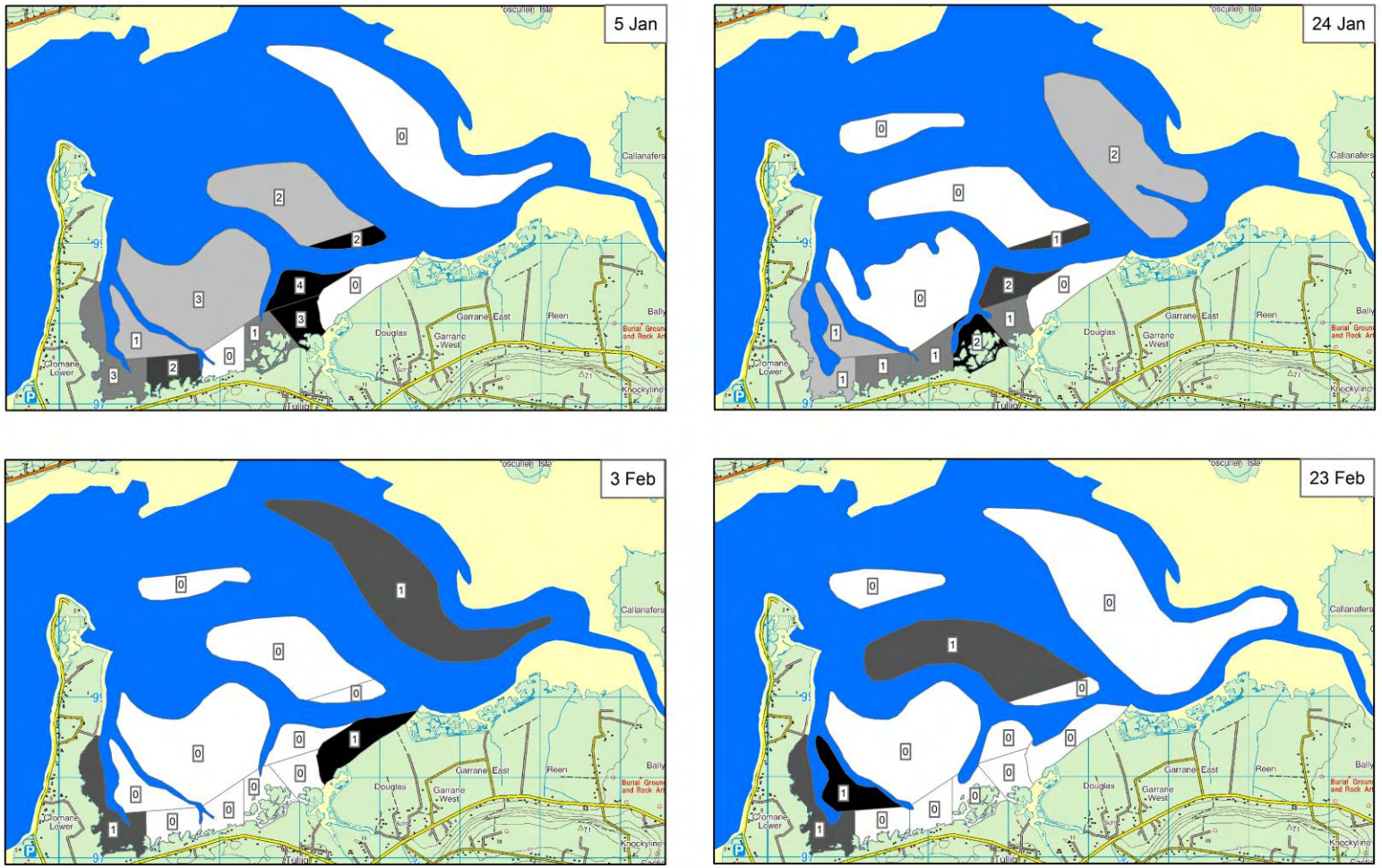


Note - some birds occurred in subtidal habitat

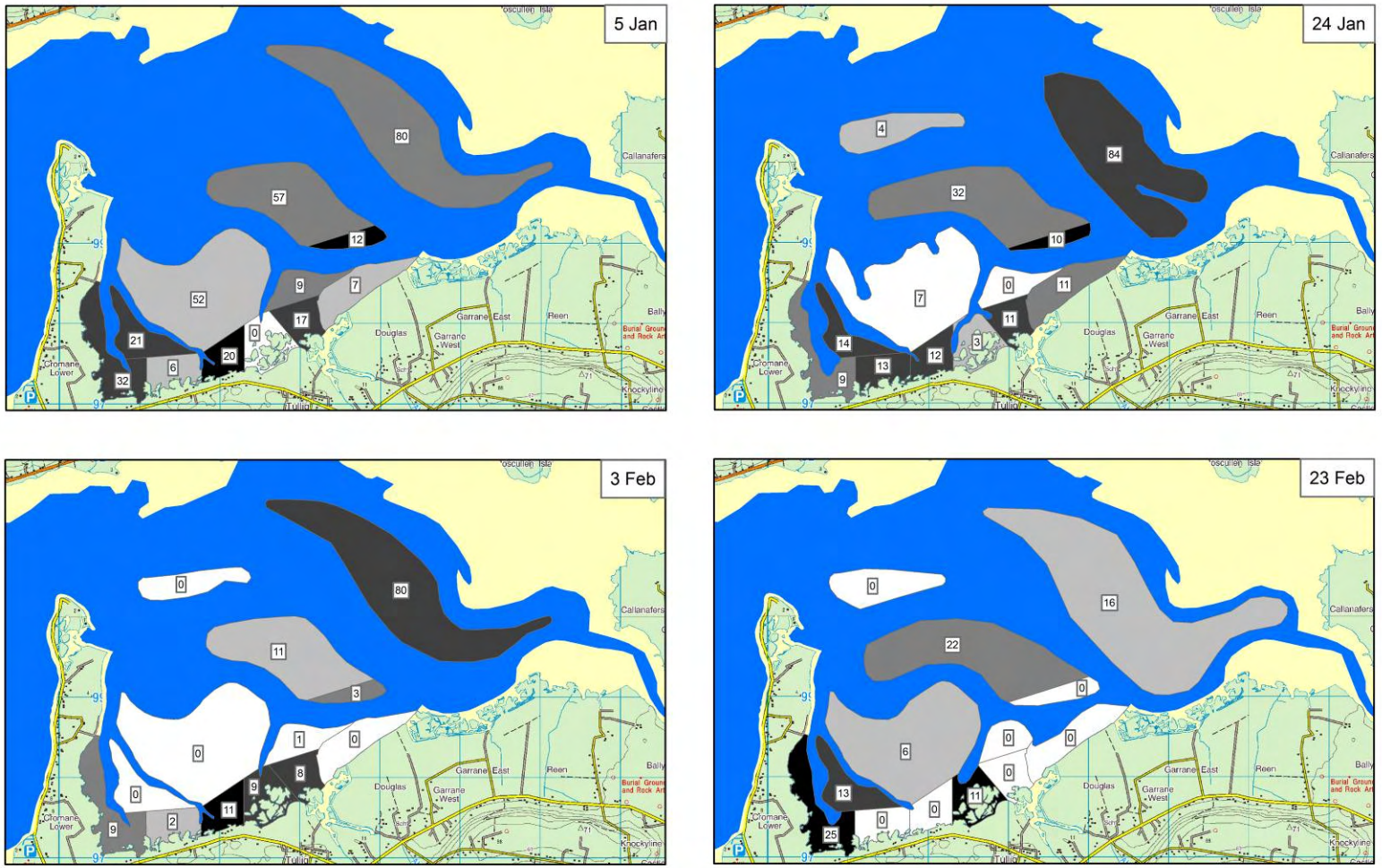
Cormorant



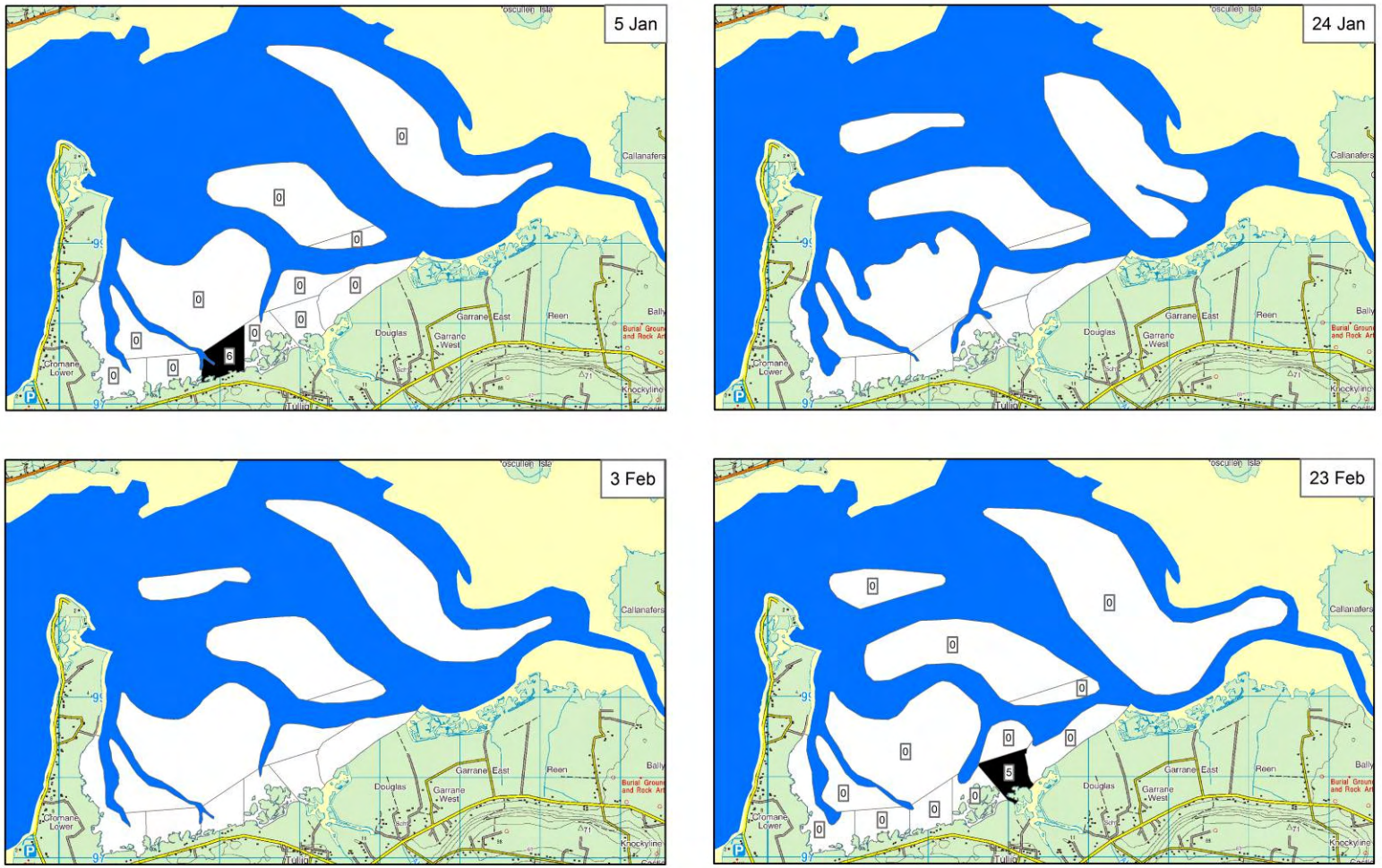
Little Egret



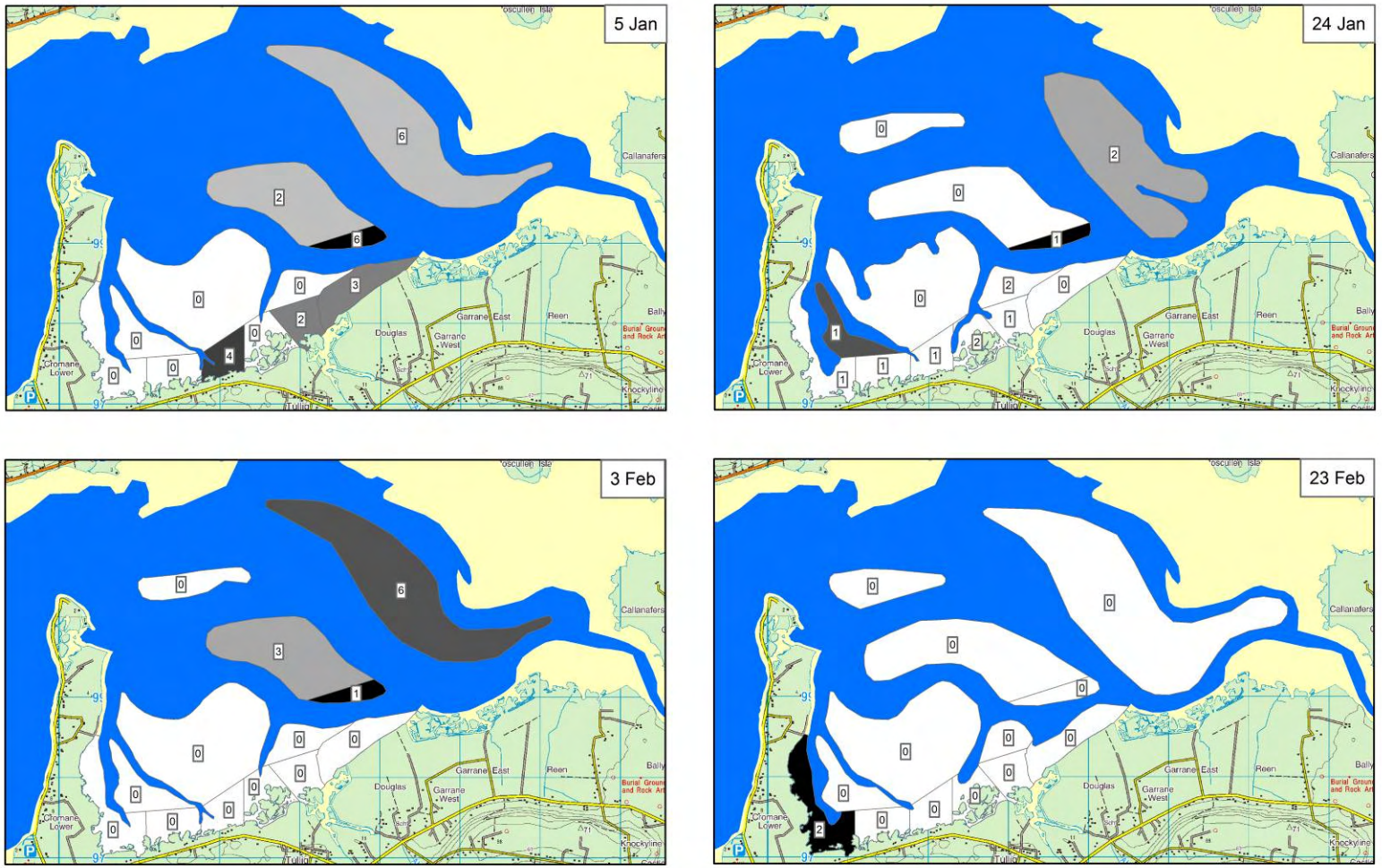
Grey Heron



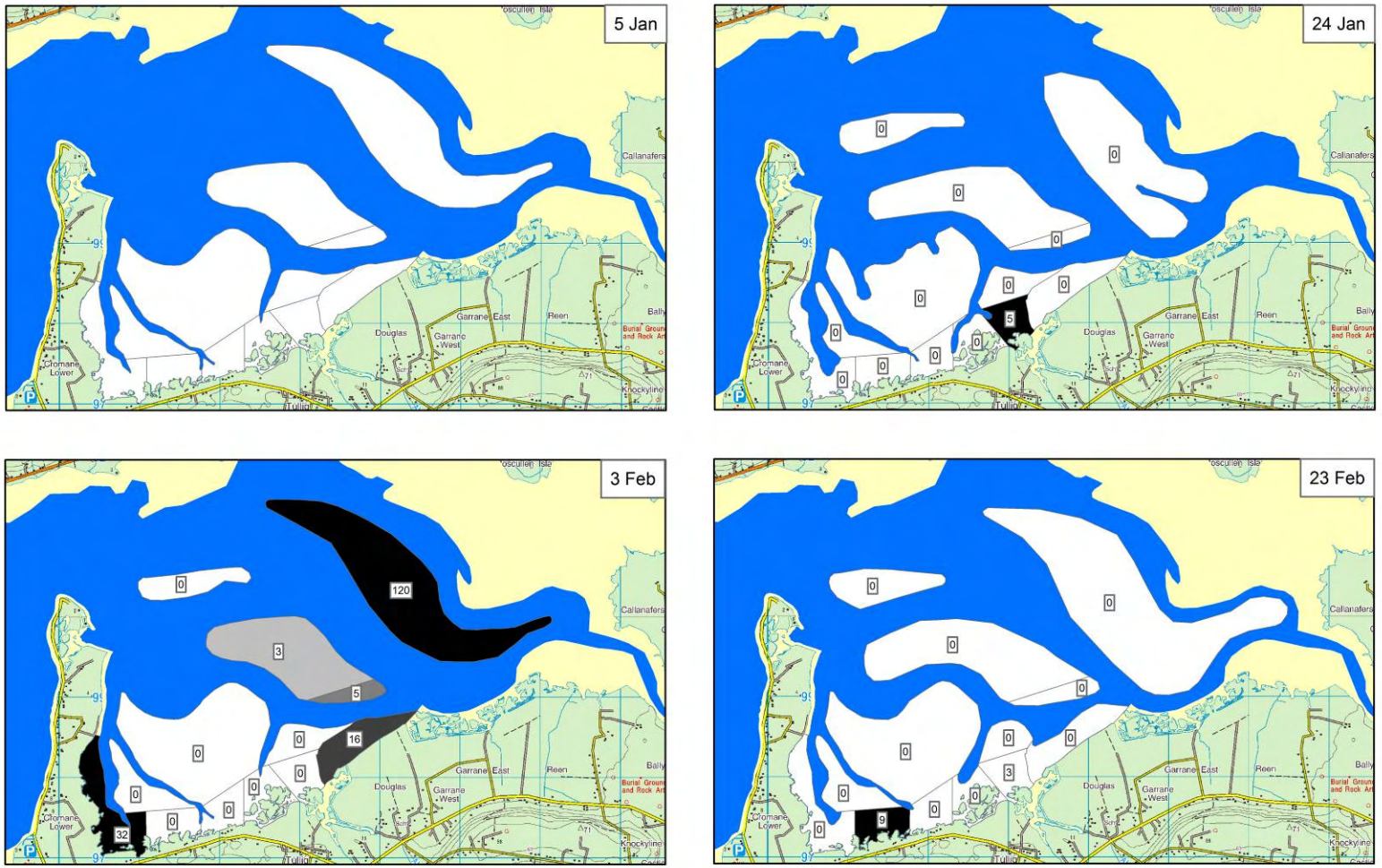
Oystercatcher



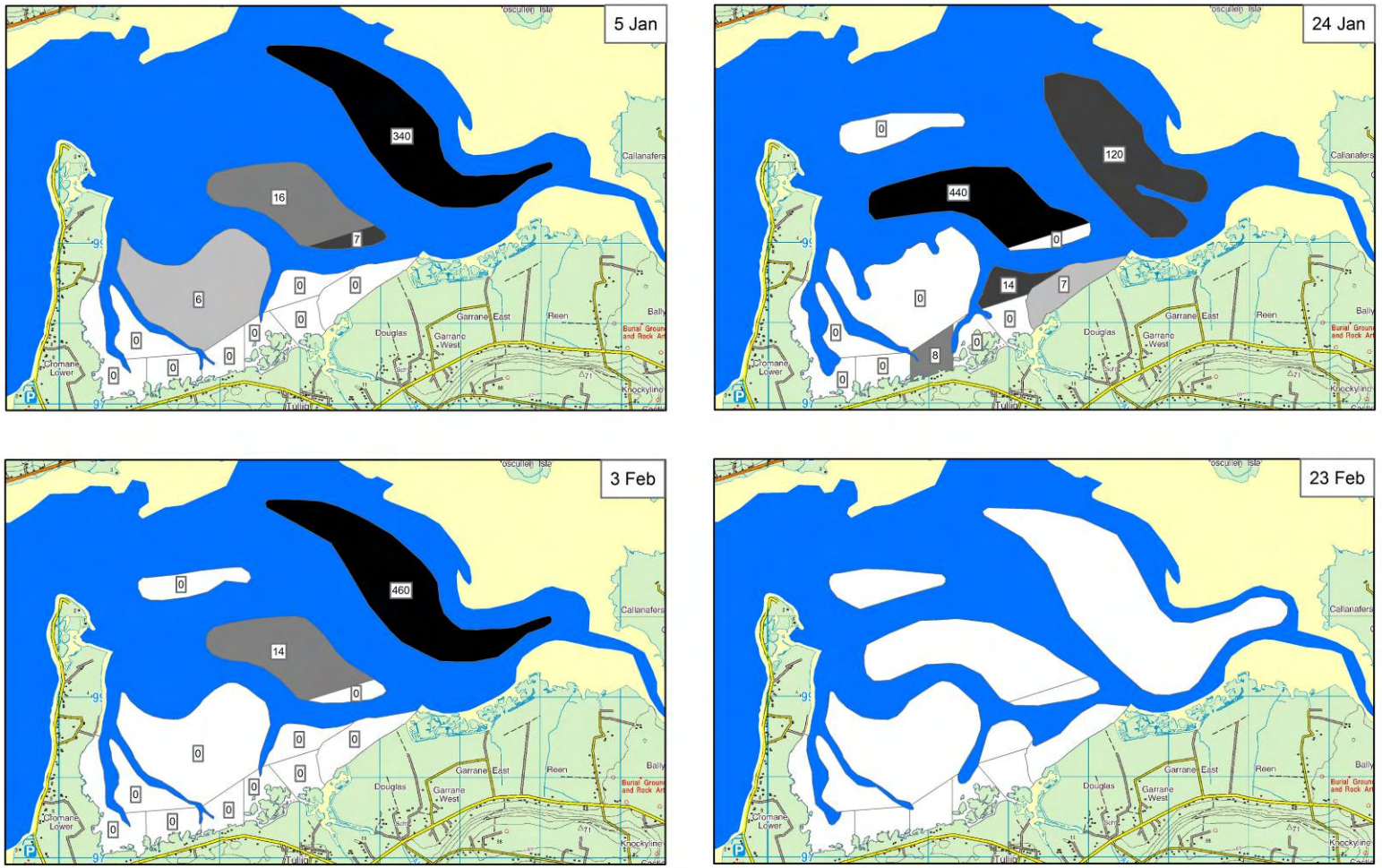
Ringed Plover



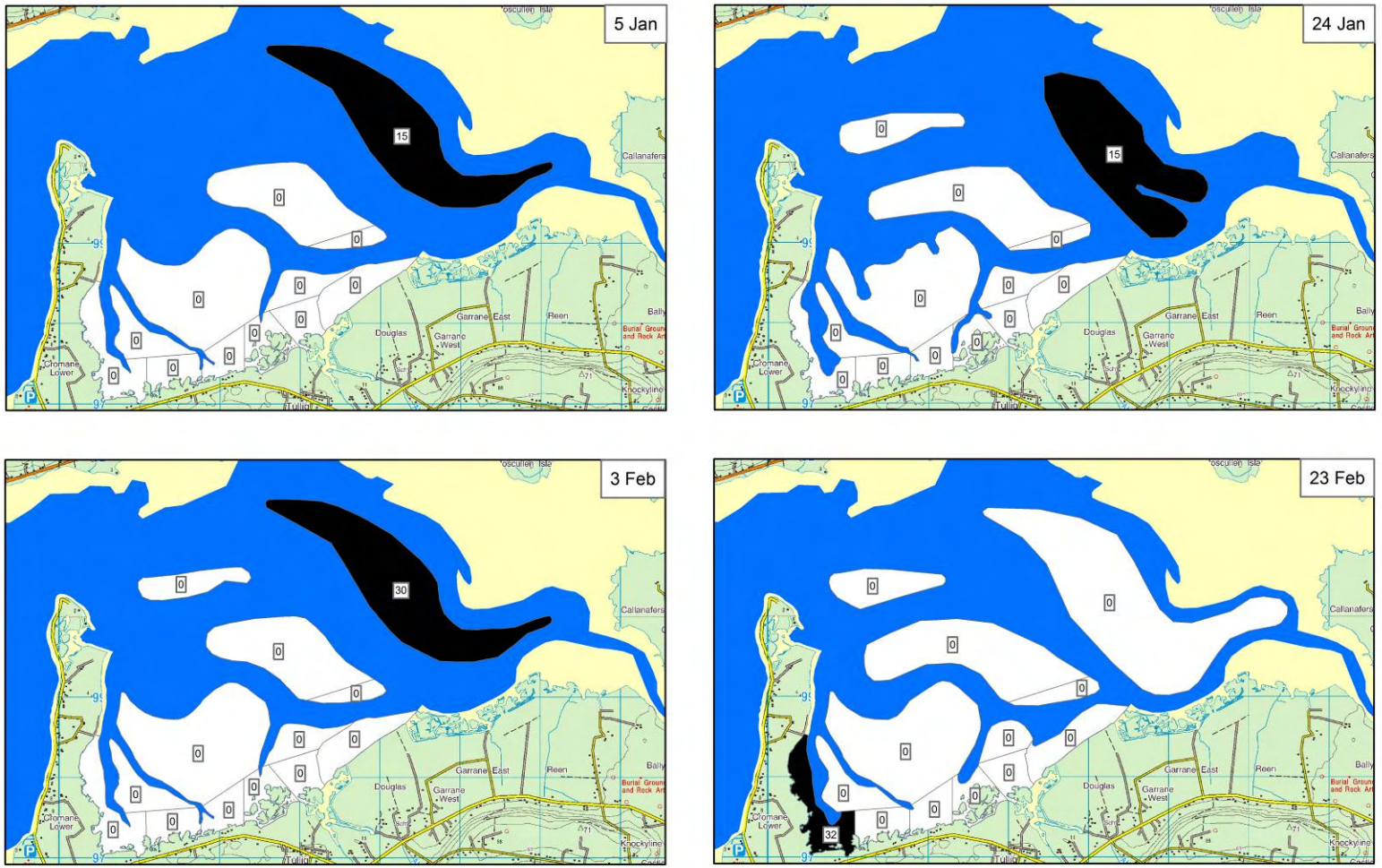
Grey Plover



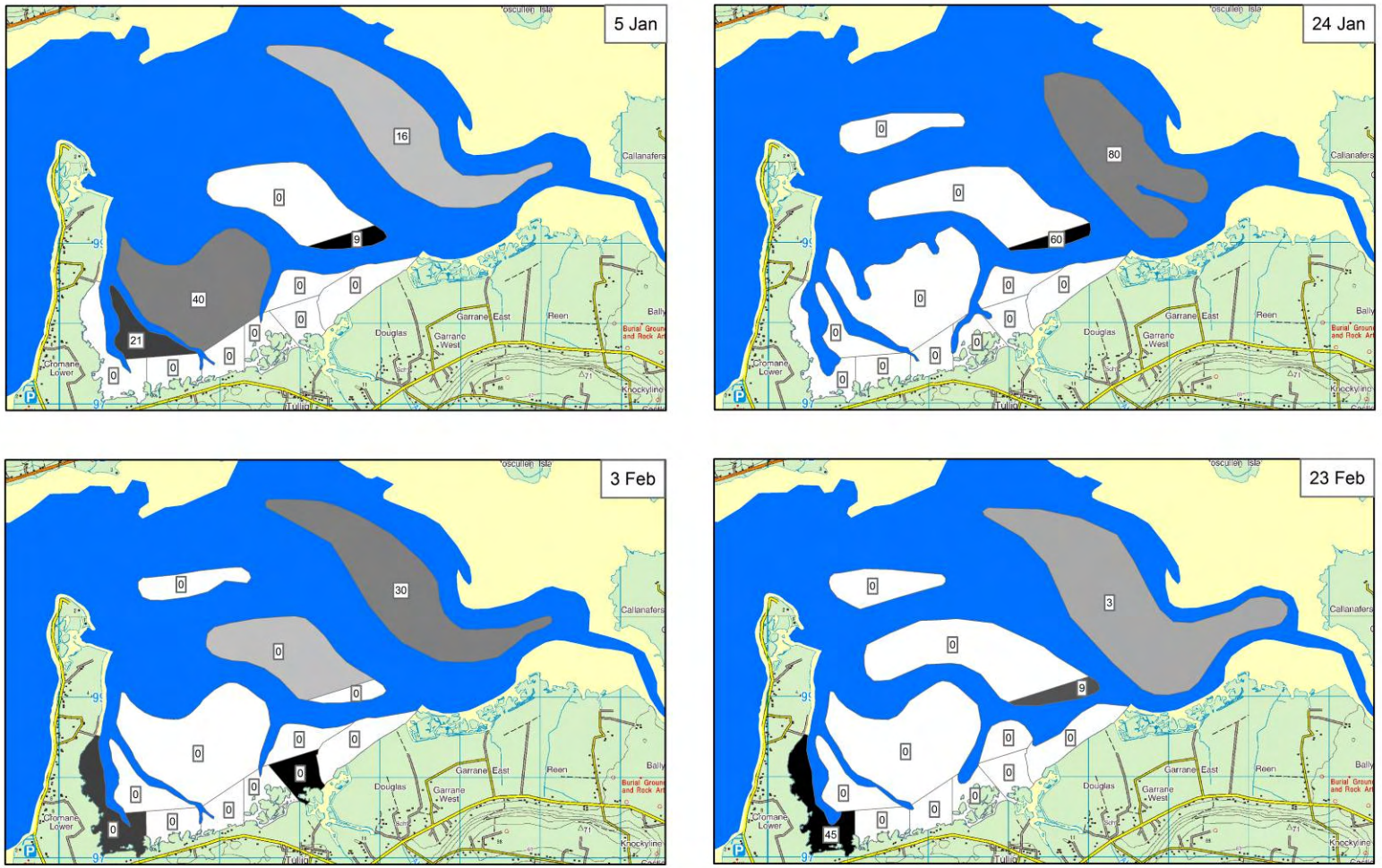
Lapwing



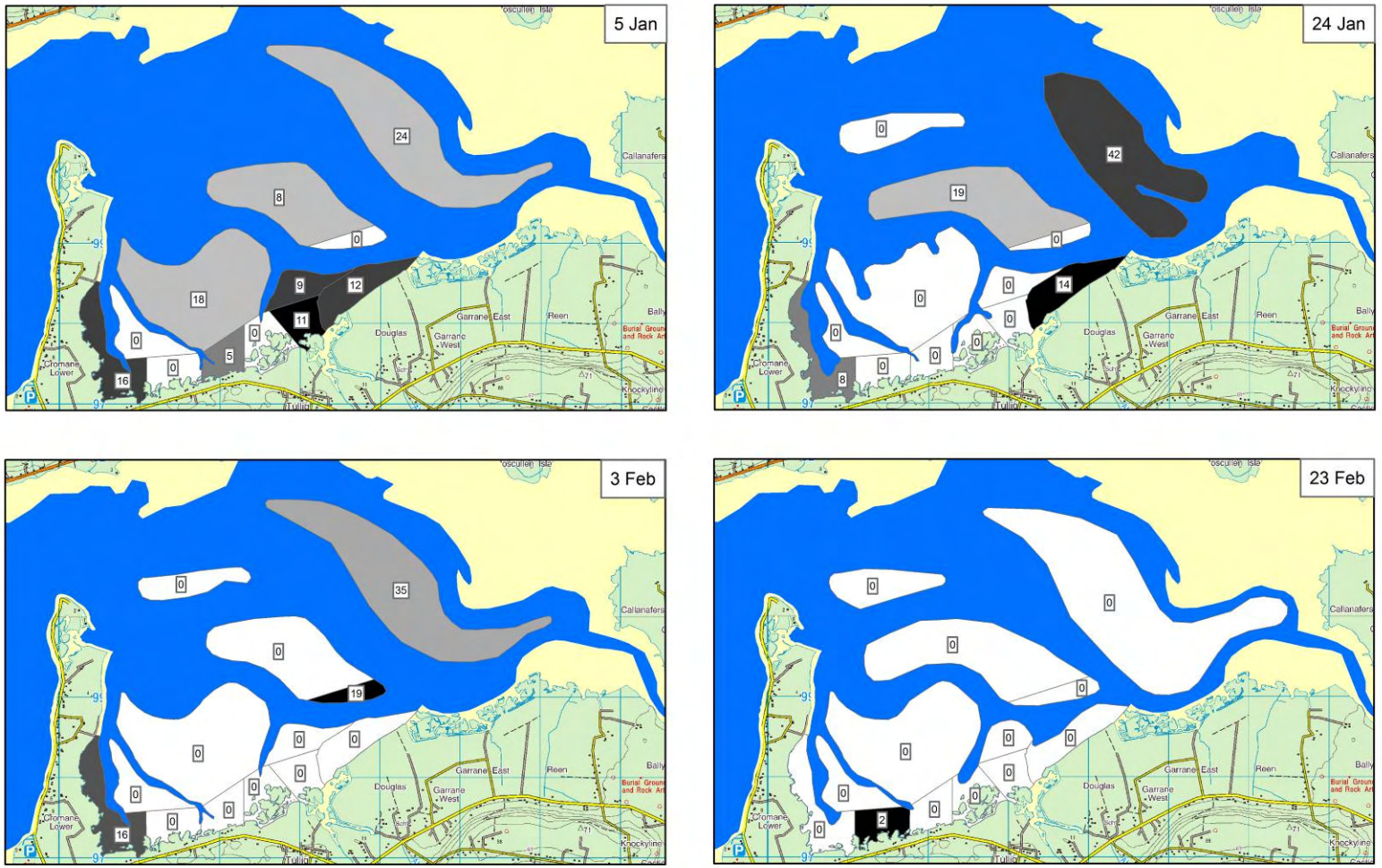
Knot



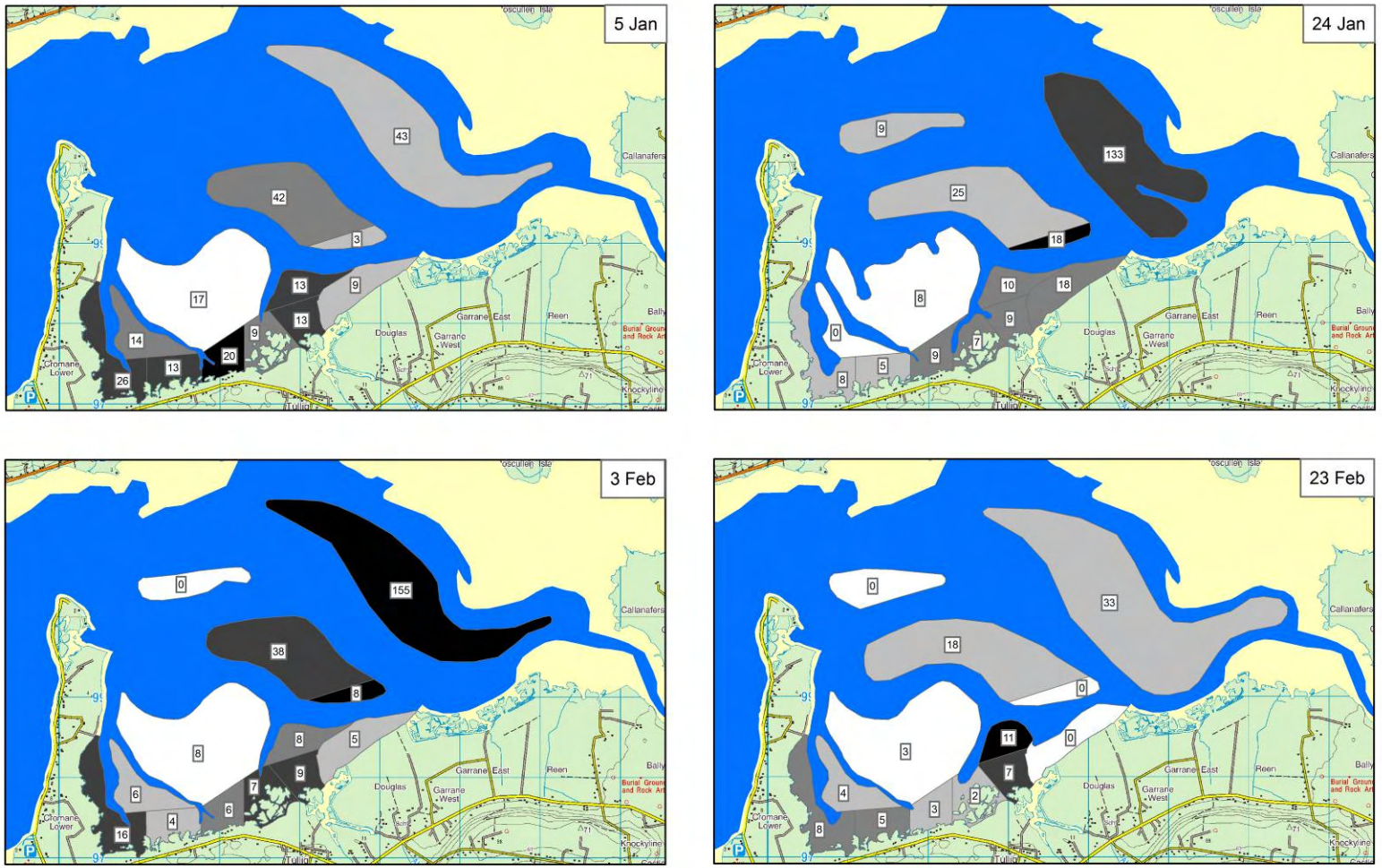
Sanderling



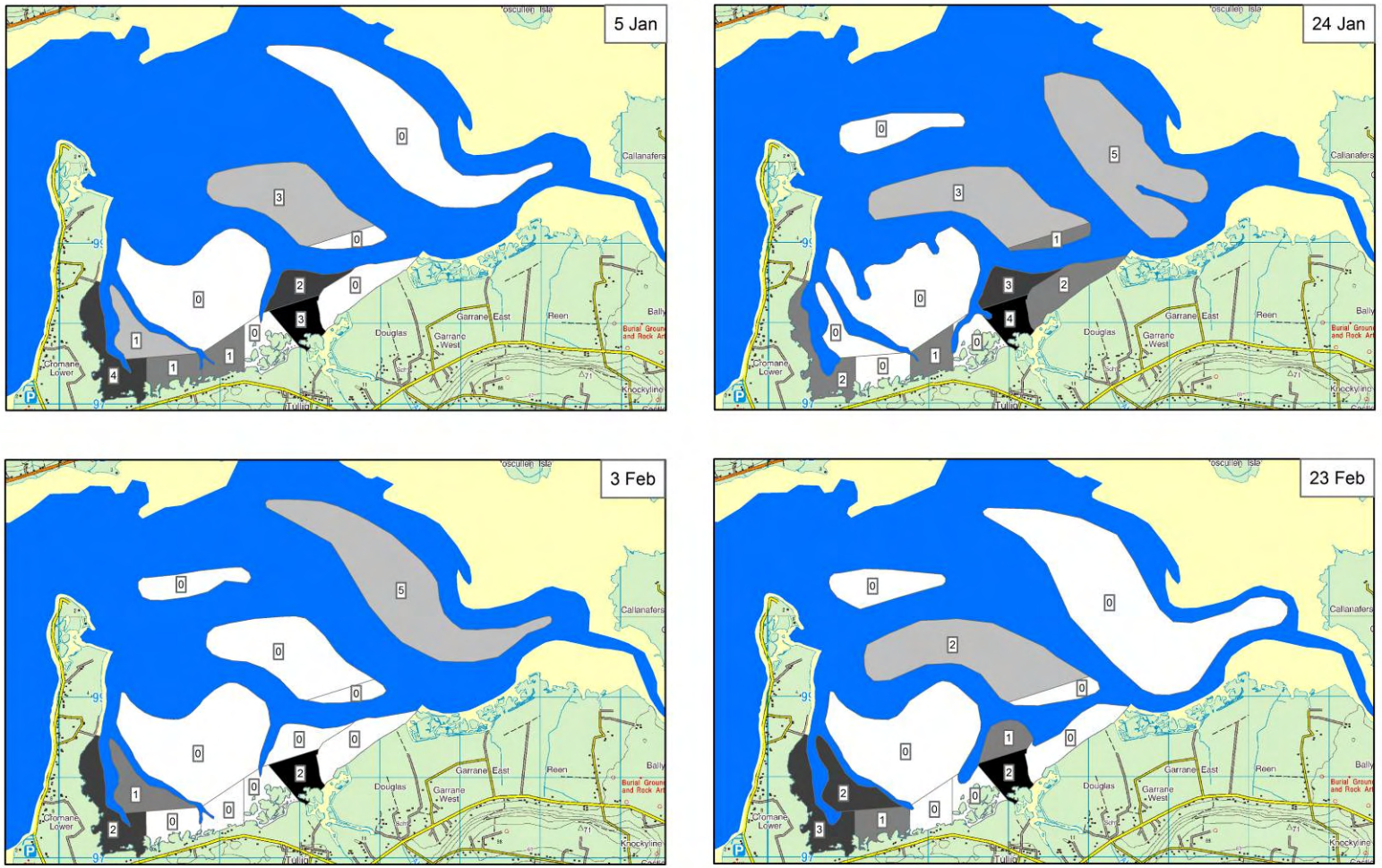
Dunlin



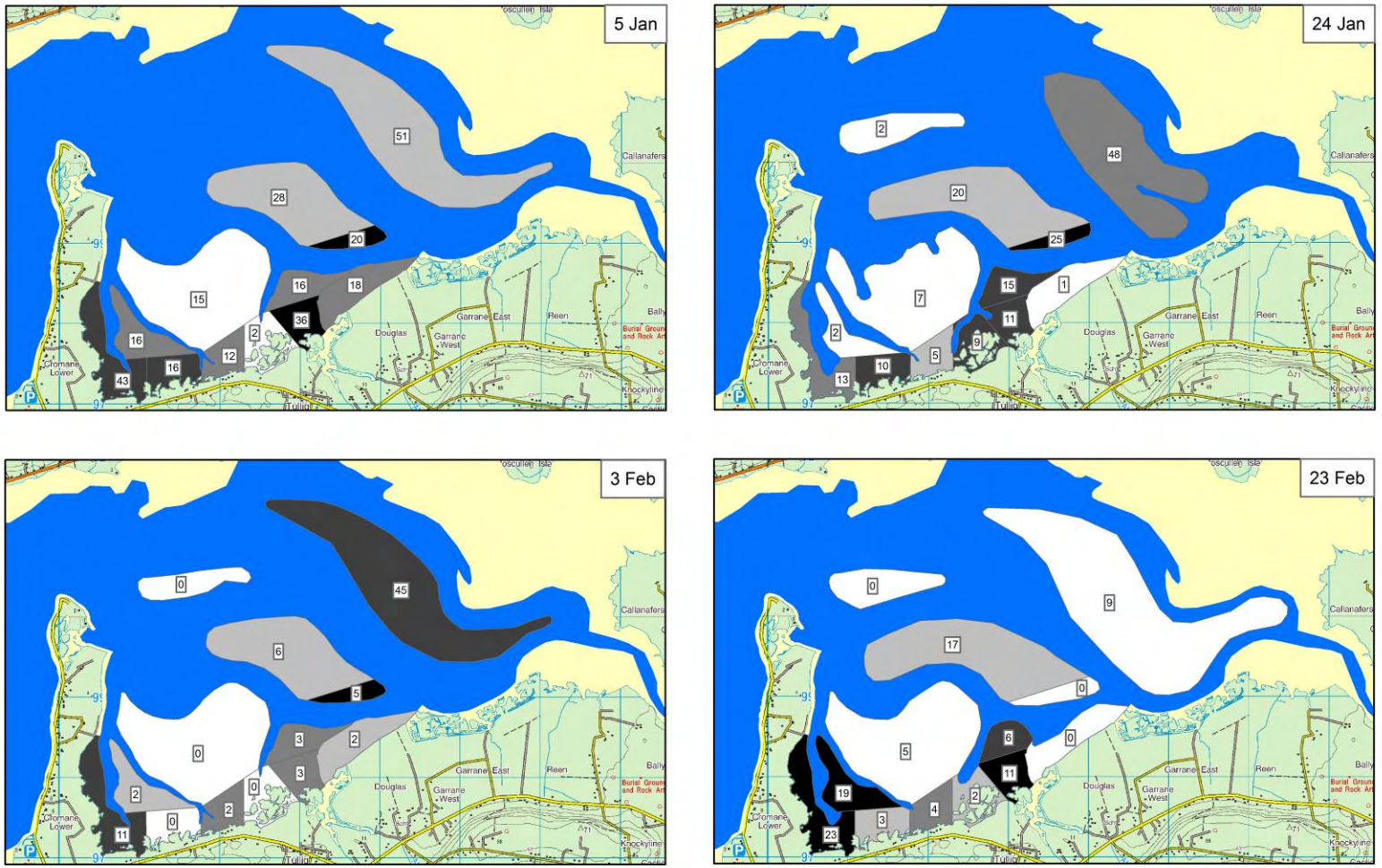
Black-tailed Godwit



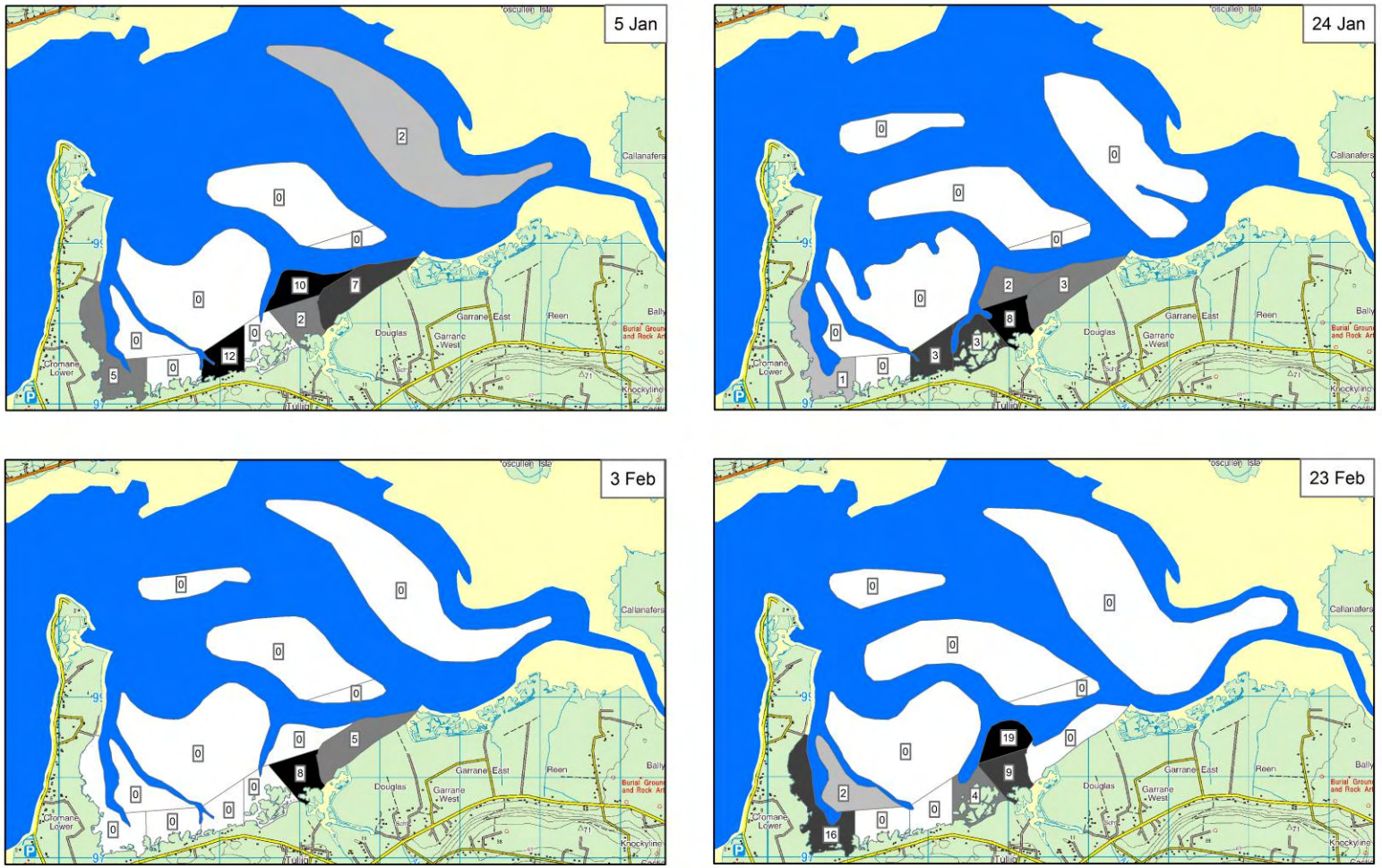
Curlew



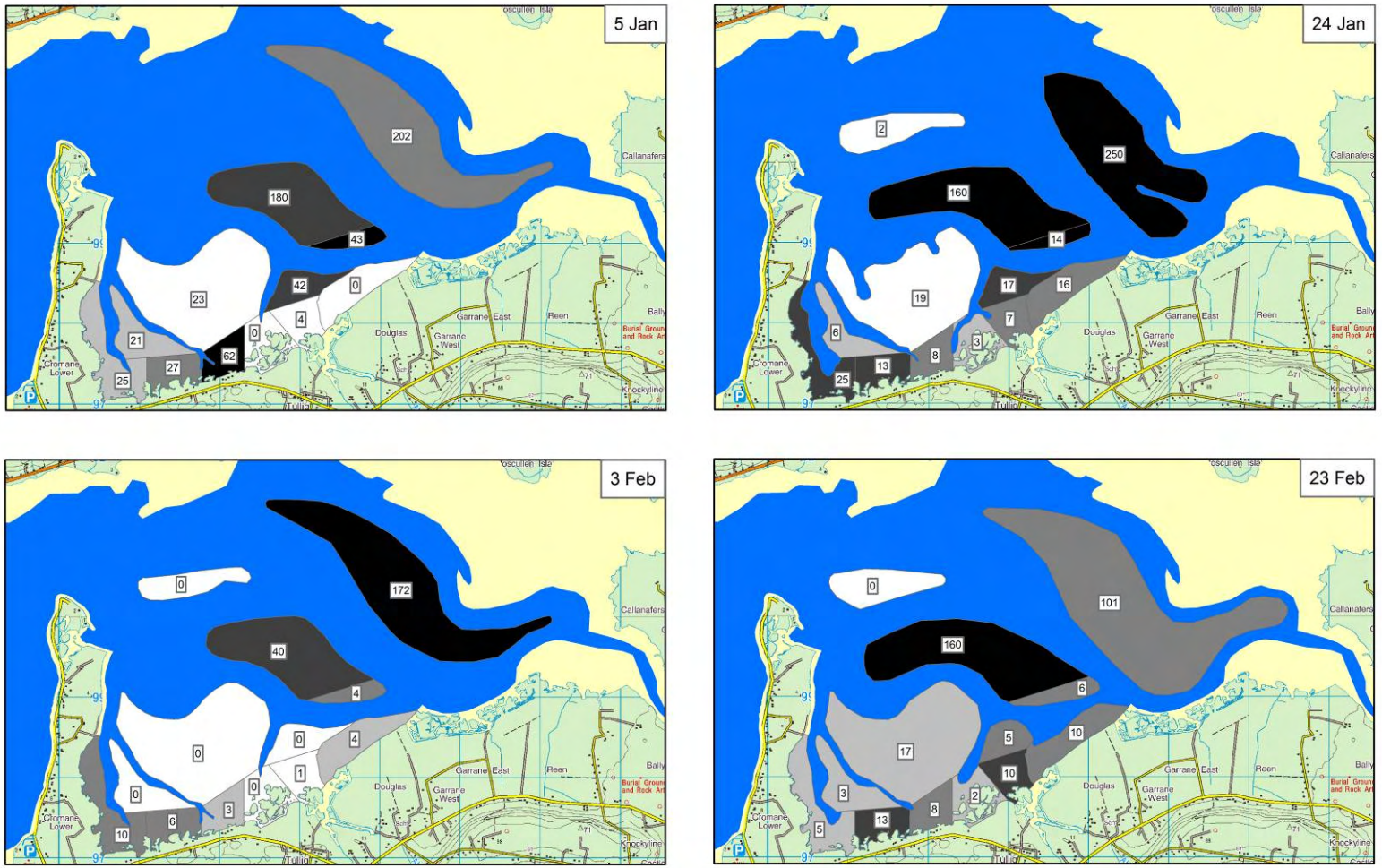
Greenshank



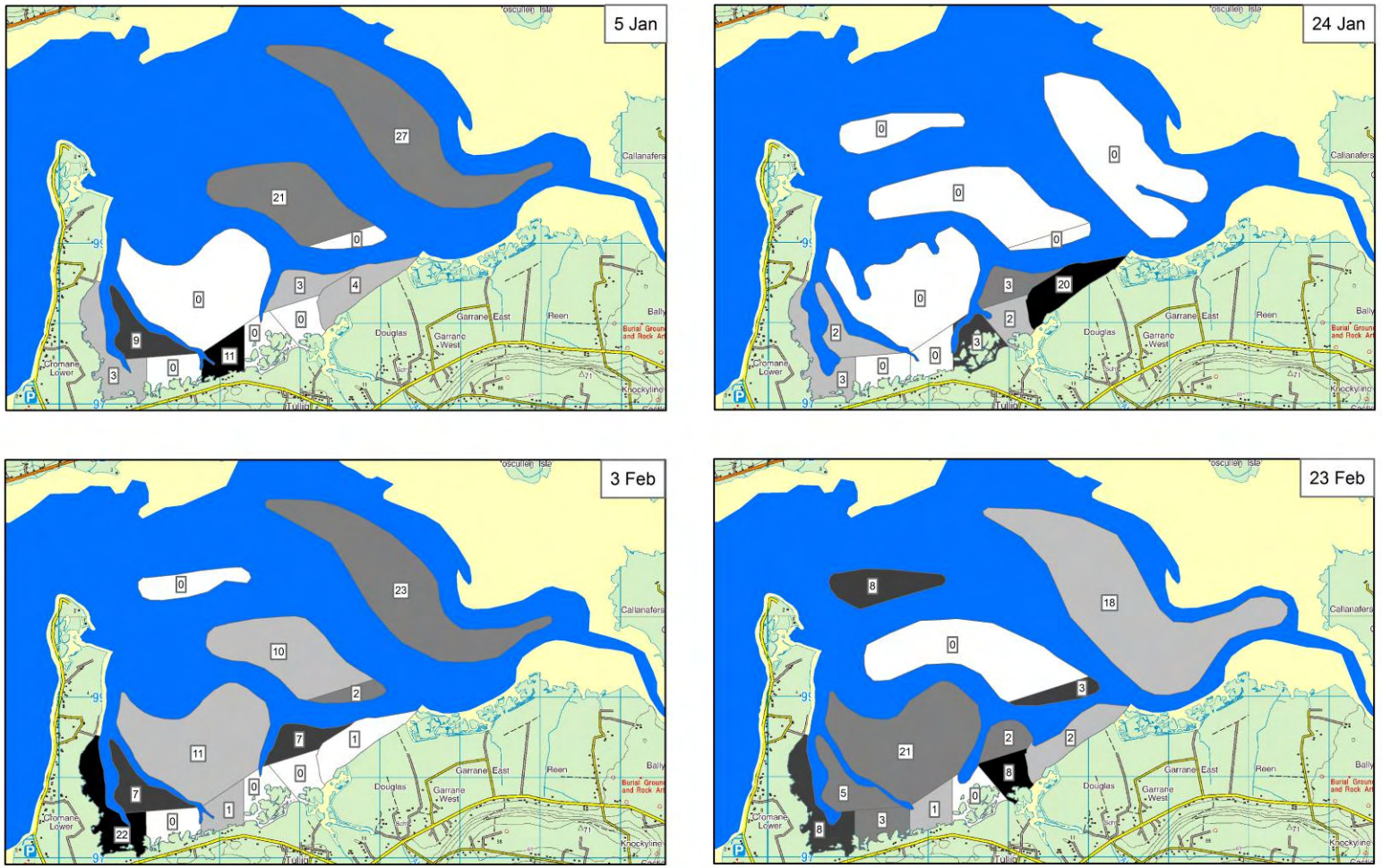
Redshank



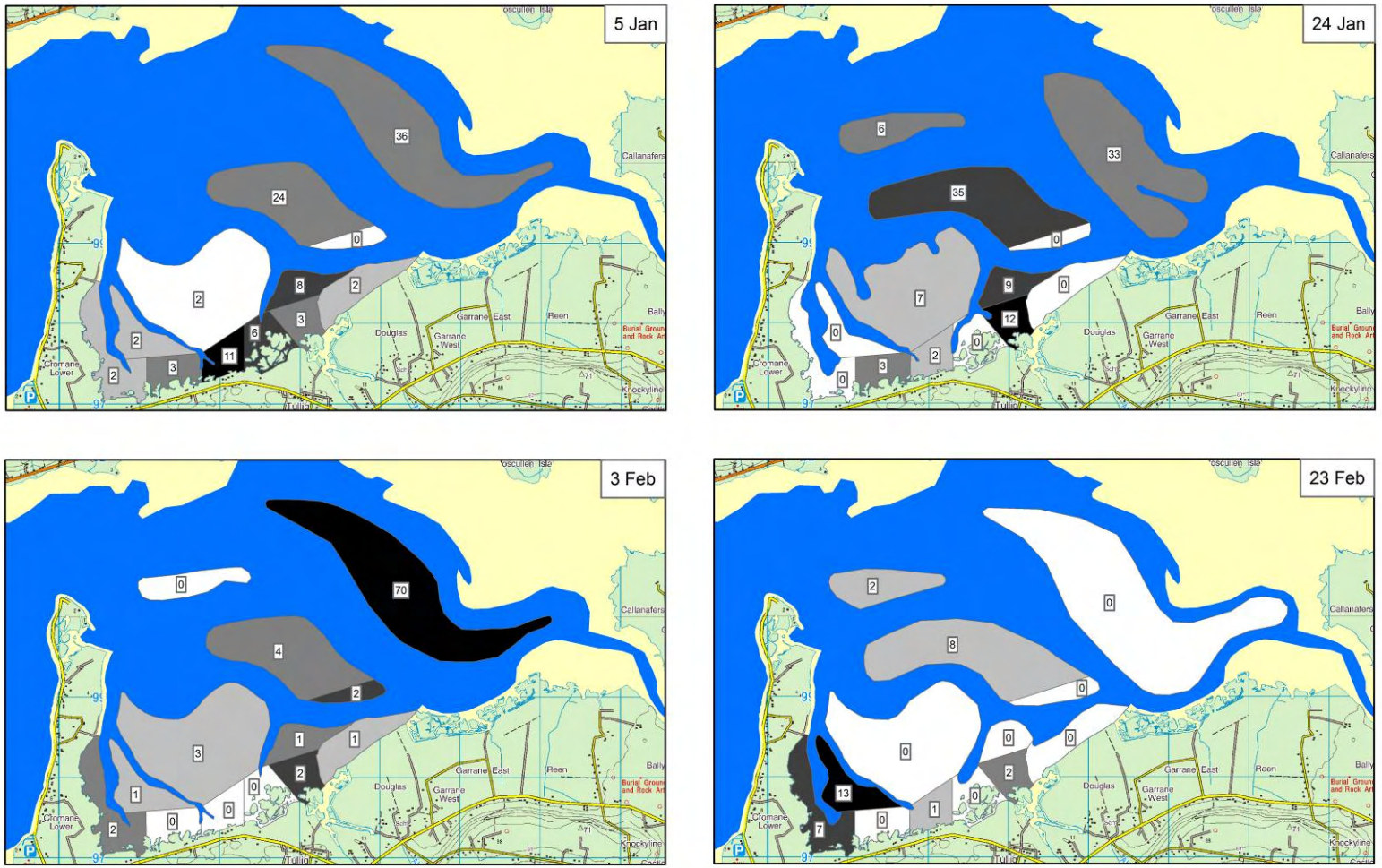
Turnstone



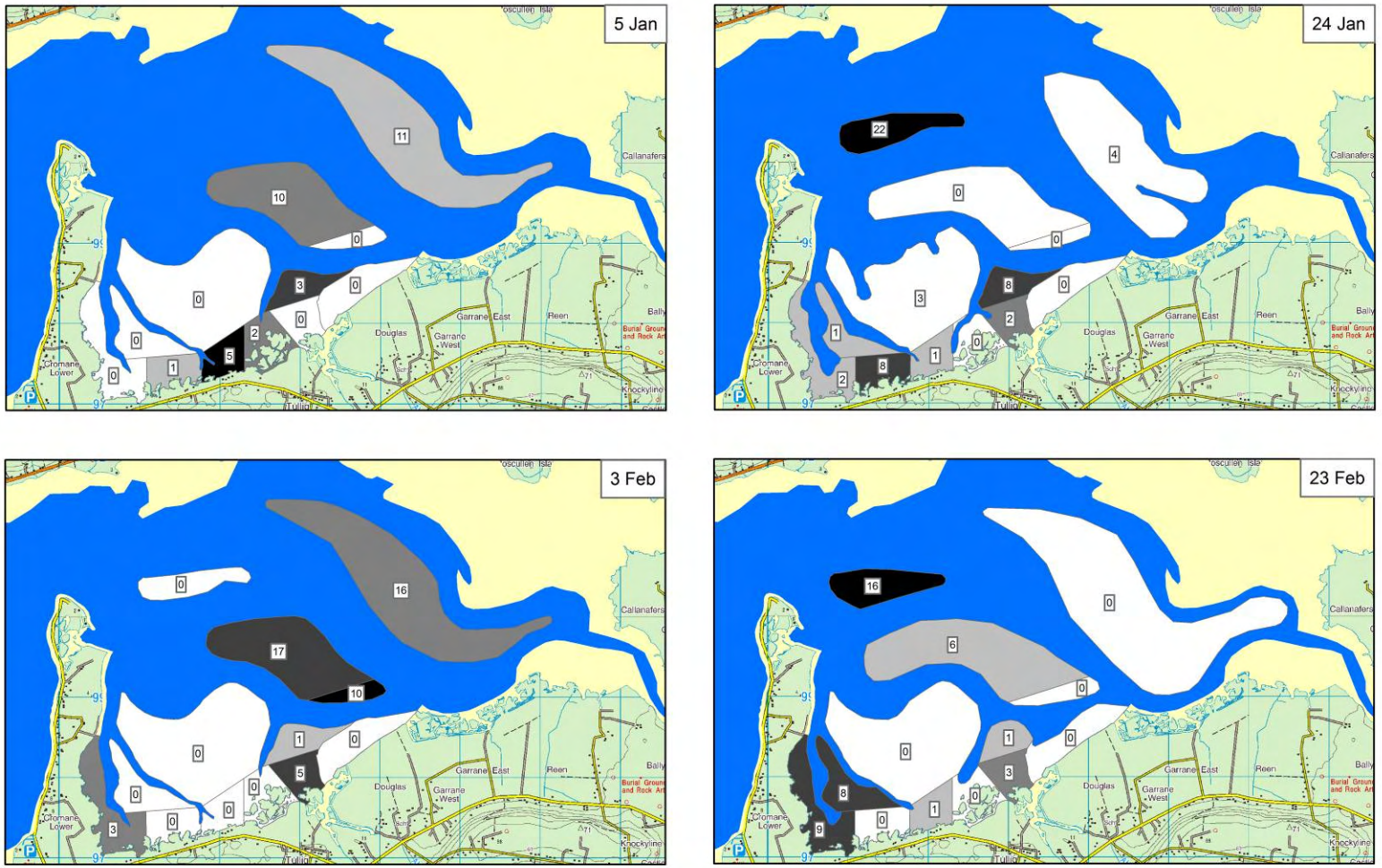
Black-headed Gull



Common Gull



Herring Gull



Great Black-backed Gull

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