Recent changes in the status and distribution of moulting Common Eiders *Somateria mollissima* in Shetland

Martin Heubeck* and Mick Mellor

**Correspondence author. Email: martinheubeck@btinternet.com*
University of Aberdeen (SOTEAG), c/o Sumburgh Head Lighthouse, Virkie, Shetland ZE3 9JN, UK.

Abstract

Common Eiders *Somateria mollissima* in Shetland are believed to be essentially resident within the archipelago, and may be closer to *S. m. faeroensis* than to *S. m. mollissima*, the subspecies found in mainland Scotland. Surveys during the late summer moulting period indicated the population in Shetland declined from an estimated 15,500 birds in 1977 (subsequently revised to 17,000) to c. 6,000 by 1997. Further surveys in August 2009 and August 2012 located 5,782 and 4,627 birds, respectively. The 2009 count suggested little change in numbers since the late 1990s, whilst the 20% difference between 2009 and 2012 is believed to represent a genuine decrease rather than any artefact of survey coverage or accuracy. The distribution of moulting Eiders changed fundamentally during the 2000s, from traditional sites on the exposed, outer coastline to the vicinity of shellfish and finfish aquaculture sites on the sheltered, inner coastline; by 2009–12 approximately two-thirds of the moulting population was associating with aquaculture sites. The reason for the recent decrease in the population is unknown, but possible contributory factors discussed include mortality from oil pollution, deterrence measures taken at aquaculture sites, and predation by marine mammals, especially by Killer Whales *Orcinus orca*.

Introduction

The Common Eider *Somateria mollissima* is an abundant coastal-breeding seaduck with a holarctic distribution. In the Western Palearctic, its breeding range extends from Franz Josef Land and Spitzbergen south through Scandinavia and the Baltic to The Netherlands and Brittany, and through the northern parts of the British Isles northwest to the Faroes and Iceland. While some populations are migratory, those breeding in the British Isles, the Faroes and Iceland are essentially resident, making local, seasonal movements only (Cramp & Simmons 1977). There is considerable geographic variation in body size and plumage, and in the northeast Atlantic del Hoyo *et al*. (1992) recognised *S. m. mollissima* in the British Isles, mainland Europe and the Russian Arctic; *S. m. faeroensis* in the Faroes; and *S. m. borealis* in Iceland and northern Norway. Cramp & Simmons (1977), however, noted that those in Orkney and Shetland may be closer to *faeroensis* than *mollissima*. A recent comparison of biometrics, DNA and

plumage features suggested that Shetland birds would be better classified as *faeroensis* (Furness *et al*. 2010). Although differences between *faeroensis* and *mollissima* may be clinal, and while *faeroensis* has yet to be accepted onto the British List, Common Eiders in Shetland are now treated separately from those elsewhere in the UK in some status reports (e.g. Holt *et al*. 2012).

Large numbers of Common Eiders (hereafter 'Eiders') had been killed by oil pollution incidents in the North Sea and the Baltic Sea in the late 1960s and early 1970s (Greenwood & Keddie 1968; Swennen & Spaans 1970; Joensen 1972; Joensen & Joensen 1977). With this in mind, and with a decision having been taken in 1973 to site a major oil-exporting terminal in the north mainland of Shetland, the Nature Conservancy Council began counts of Eiders in Shetland in the mid 1970s. The surveys focussed on late summer when flocks of moulting, flightless birds were known to gather in particular areas, typically at headlands or small islands remote from human disturbance, where birds could feed, roost ashore, and quickly find shelter from varying wind directions. Adult males began to gather at these locations in early June, were joined by females by August, and numbers declined through September, presumably as birds regained flight and dispersed (Jones & Kinnear 1979). It was noted that the sex ratio varied between locations, and that females and juveniles were usually grouped together rather than being scattered among males. A total of 13,800 birds was counted at 24 sites in August 1977, with an estimated total of 15,500 birds being present in Shetland (Jones & Kinnear 1979; but see below). Moult flocks were found in the same general areas each summer, but the number of Eiders using any particular area could vary considerably from year to year. Thus, when the Shetland Oil Terminal Environmental Advisory Group (SOTEAG) began a programme of seabird monitoring in 1978, periodic surveys of all known moulting locations in a single year were used to derive population estimates.

These surveys recorded a decline through the 1980s and 1990s, from a revised estimate of 17,000 birds in 1977 (based on numbers recorded regularly in the 1980s at sites not covered in 1977) to 6,000 by 1997 (Heubeck 1987, 1993; Dunnet & Heubeck 1995; Pennington *et al*. 2004). Oil pollution in the winter of 1978/79 and abnormal but unexplained mortality the following winter probably accounted for the loss of c. 5,000 birds, but the cause(s) of a further 40% decrease in the population between 1984 and 1991 was largely unknown. From surveys carried out in 2001–02 and 2005–06 it became evident that a proportion of the moulting population had moved from traditional locations on Shetland's exposed, outer coastline and was spending the late summer close to aquaculture sites in the sheltered voes (sea inlets) of the inner coast. Here, Eiders were feeding and roosting at Salmon *Salmo salar* farms with increasingly large and automated cage installations, or feeding at farms cultivating Blue Mussels *Mytilus edulis* on long-line tethered ropes. This paper describes the results of further surveys in August 2009 and 2012, and compares the numbers and distribution of Eiders with previous years.

Methods

Counts were made from land or from chartered hard-hulled boats, the survey periods being 9–25 August 2009 and 31 July to 24 August in 2012. Counts from land were usually conducted by a single observer using binoculars and a 20–60x telescope, while those from boats were made by at least two observers, who reached a consensus when flock sizes had to be estimated. The number of adult and immature males ('black' birds) and females and juveniles ('brown' birds) were counted separately, or their proportions in flocks were estimated, but they were not always possible to distinguish in some flocks in certain light conditions. The location of birds was recorded to an Ordnance Survey grid reference accurate to ± 50 m, and any apparent association with aquaculture sites was noted. In both years, we checked all known traditional moulting areas on the exposed outer coast, all aquaculture sites (finfish and shellfish) and their adjacent waters and shorelines on the inner coast, and generally looked for and recorded Eiders during other fieldwork. In this way, we covered an estimated 80% of Shetland's 2,700 km long coastline in 2009 and nearer 90% in 2012, the sections not surveyed being high, exposed cliffs with no history of moulting Eiders. Weather and sea conditions were generally favourable in both years, and the 2012 survey began slightly earlier than usual to take advantage of flat calm sea conditions along Shetland's west coast. The numbers found are presented in 13 geographic 'Areas', which largely reflect historic usage by Eiders and coverage on surveys, but also variation in the extent and development of aquaculture (Figure 1).

Table 1. The number of adult males, females and juveniles, and unsexed birds recorded on the 2009 and 2012 surveys of moulting Common Eiders *Somateria mollissima* in different areas of Shetland (see Figure 1), and the numerical difference between the two surveys.

	2009			2012		2009	2012	
Area	**Males**	**Fem./j.**	**unsexed**	**Males**	**Fem./j.**	**Total**	**Total**	**Diff.**
1. Fair Isle			282	91	87	282	178	-104
2. South Mainland	34	130		35	148	164	183	+19
3. Scalloway Islands / Vaila	1,754	753	147	1,135	485	2,654	1,620	-1,034
4. Foula & Papa Stour	256	183		188	166	439	354	-85
5. St Magnus Bay	15	291		185	345	306	530	+224
6. Northwest Mainland	41	69		1	56	110	57	-53
7. North Yell Sound		7		51	33	7	84	+77
8. South Yell Sound	184	409	73	280	219	666	499	-167
9. North Unst	1	29	12	2	57	42	59	+17
10. Bluemull Sound	2	149		1	184	151	185	+34
11. Out Skerries / Whalsay	9	101		217	145	110	362	+252
12. East Mainland Voes	333	221		153	121	554	274	-280
13. Bressay & Noss	181	116		118	124	297	242	-55
Total	**2,810**	**2,458**	**514**	**2,457**	**2,170**	**5,782**	**4,627**	**-1,155**
% difference				-13%	-12%		-20%	

Table 2. Details of Common Eider *Somateria mollissima* flocks of 100 or more birds whose size had to be estimated in blocks of five or ten birds. These accounted for 26% and 37% of the 2009 and 2012 survey totals, respectively.

Year; Area	From boat/land	Flock size	% males
2009; 3	Boat	900 ± 50	50 %
2009; 3	Boat	135	100 %
2009; 3	Boat	450	90 %
Total		**1,485**	
2012; 3	Boat	350	30 %
2012; 3	Boat	300	100 %
2012; 3	Boat	100	100 %
2012; 5	Land	460	40 %
2012; 8	Land	300	40 %
2012; 11	Boat	200 ± 10	80 %
Total		**1,710**	

Results

The total number of birds counted was 5,782 in 2009 and 4,627 in 2012, 20% fewer (Table 1, Figure 1). Most were in small, scattered groups which could be counted accurately, but in both years there were some dense flocks of 100 or more birds whose numbers could only be estimated by repeated 'counts' in blocks of five or ten; these comprised 26% of the survey total in 2009 and 37% in 2012 (Table 2).

The proportions of males and female/juveniles varied considerably by area, and within some areas differed between the two survey years (Table 1). In 2009, 9% of the survey total was not sexed. The count at Fair Isle was of 268 adults and 14 juveniles, and given the sex ratio in the 2012 count there, and in years prior to 2009, there was probably a slight preponderance of adult males in 2009. Elsewhere, a total of 232 birds were not sexed because of light conditions and we cannot guess at the ratios of 'black' and 'brown' birds. Despite this uncertainty, it would appear that the reduction in numbers between 2009 and 2012 affected both adult males and 'brown' birds (females and juveniles).

There has been no aquaculture at Fair Isle or in the South Mainland (Figure 1, Areas 1 & 2), and in the latter the main moult location in the late 1990s was around Sumburgh Head, where 1,322 birds (91% males) were counted in 1997; this had reduced to 349 (68% males) by 2006, and 97 (35% males) by 2012. Moulting Eiders have long used traditional locations around the Scalloway Islands (Figure 1, Area 3) but it was not until 2005–06 that aquaculture sites around Vaila Sound were checked. Area 3, which has extensive aquaculture, held 46% of the survey total by 2009, and was where the greatest reduction in numbers occurred between 2009 and 2012 (Table 1). There has been no aquaculture at Foula and Papa Stour (Figure 1, Area 4); in 2009 and 2012, and for the first time, no flocks were found on the coast of Papa Stour itself, but there were respective totals of 182 and 115 at the Ve Skerries, to the northwest of Papa Stour. The extensive aquaculture sites in

the southern voes of St Magnus Bay (Figure 1, Area 5) were first surveyed by boat in 2006, while the eastern and northern coasts of St Magnus Bay had previously been covered from land; in 2012 the main concentration was of 489 birds (38% males) at mussel farms. In Northwest Mainland (Figure 1, Area 6), although there are salmon cages and extensive mussel lines in the narrow Ronas Voe only a small number of moulting Eiders utilise them and by 2012 the formerly large flocks on the outer coast had gone.

No works licences are issued for aquaculture in North Yell Sound (which includes Sullom Voe) because of the presence of the Sullom Voe oil terminal and it associated tanker traffic (Figure 1, Area 7), and only in 2005 was it realised the extent to which moulting Eiders were using aquaculture sites in South Yell Sound (Figure 1, Area 8), with 12% of the survey total recorded there in 2009, and 11% in 2012. In North Unst (Figure 1, Area 9), only one voe hosts aquaculture, which presently attracts the small number of Eiders that have previously been recorded there. In the Bluemull Sound area, between the islands of Yell, Unst and Fetlar (Figure 1, Area 10), substantial numbers of Eiders had become attracted to salmon cages and mussel lines in one voe in east Yell by 2006, at least, the first year this location was checked thoroughly. The few aquaculture sites at Out Skerries (Figure 1, Area 11) are in too confined a situation to attract Eiders; in 2012, the count of 279 birds (92% males) to the west of Out Skerries, was the largest at any 'natural' site that year.

Quite when moulting Eiders began using the East Mainland Voes (Figure 1, Area 12) is unknown, but birds in winter were largely at offshore skerries in 2001/02, but in 2002/03 were mostly in the sheltered voes (pers. obs.). Those recorded in August 2006 (404, 62% males) were mainly associated with mussel lines whereas those in 2009 and 2012 were all at salmon cages, although as in other areas with mixed aquaculture they probably utilise both. Bressay / Noss (Figure 1, Area 13) has been largely free of aquaculture, and moulting numbers declined from 38% of the survey total in 1996 to 5% in 2009 and 2012.

In summary, while the proportion of the total moulting Eider population associating with aquaculture sites may have been recorded less rigorously before 2005, it is safe to say that it has risen from negligible in the late 1990s to around two-thirds in 2009 and 2012 (Table 3).

Discussion

Although small-scale mussel farming had been tried in Shetland in the early 1980s, its recent development began in the late 1990s, with table production (i.e. for human consumption) rising from 822 tonnes in 2001, to 2,605 tonnes in 2007, and 3,840 tonnes in 2010 (53% of the total Scottish production), by which time there were 108 active sites in the island, 33% of the total in Scotland (Shetland Islands Council 2011). As had occurred on the west coast of Scotland (Ross & Furness 2000), these sites inevitably attracted Eiders although at least initially, this mainly seemed to occur in spring (Pennington *et al*. 2004).

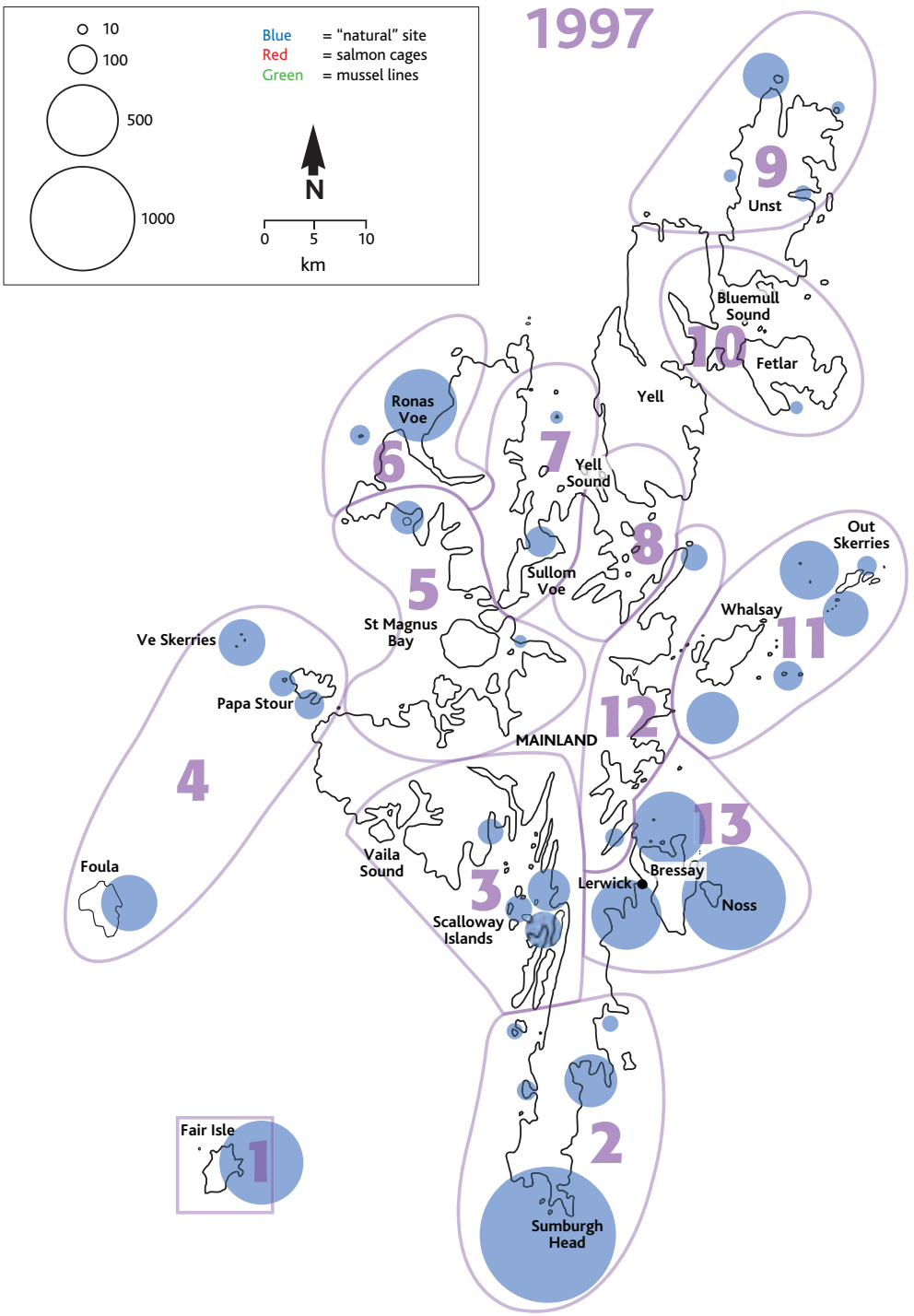

Figure 1a. The distribution of moulting Common Eiders *Somateria mollissima* in Shetland in 1997. Groups of 10 or more birds are indicated, whether at traditional locations away from aquaculture sites (blue), or apparently associating with finfish farms (red) or shellfish farms (green). Fair Isle lies 40 km SSE of the position indicated.

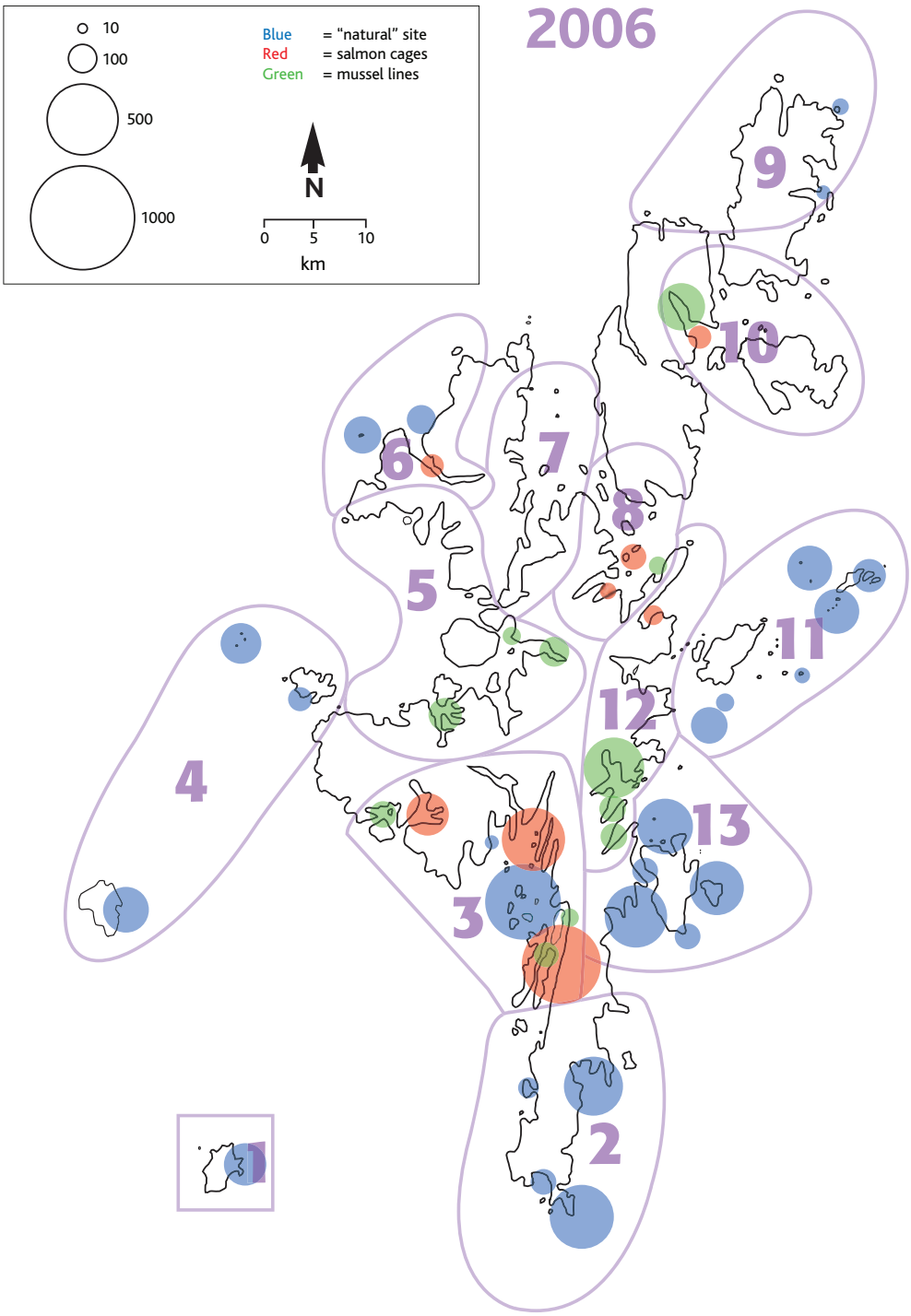

Figure 1b. The distribution of moulting Common Eiders *Somateria mollissima* in Shetland in 2006. Groups of 10 or more birds are indicated, whether at traditional locations away from aquaculture sites (blue), or apparently associating with finfish farms (red) or shellfish farms (green). Fair Isle lies 40 km SSE of the position indicated.

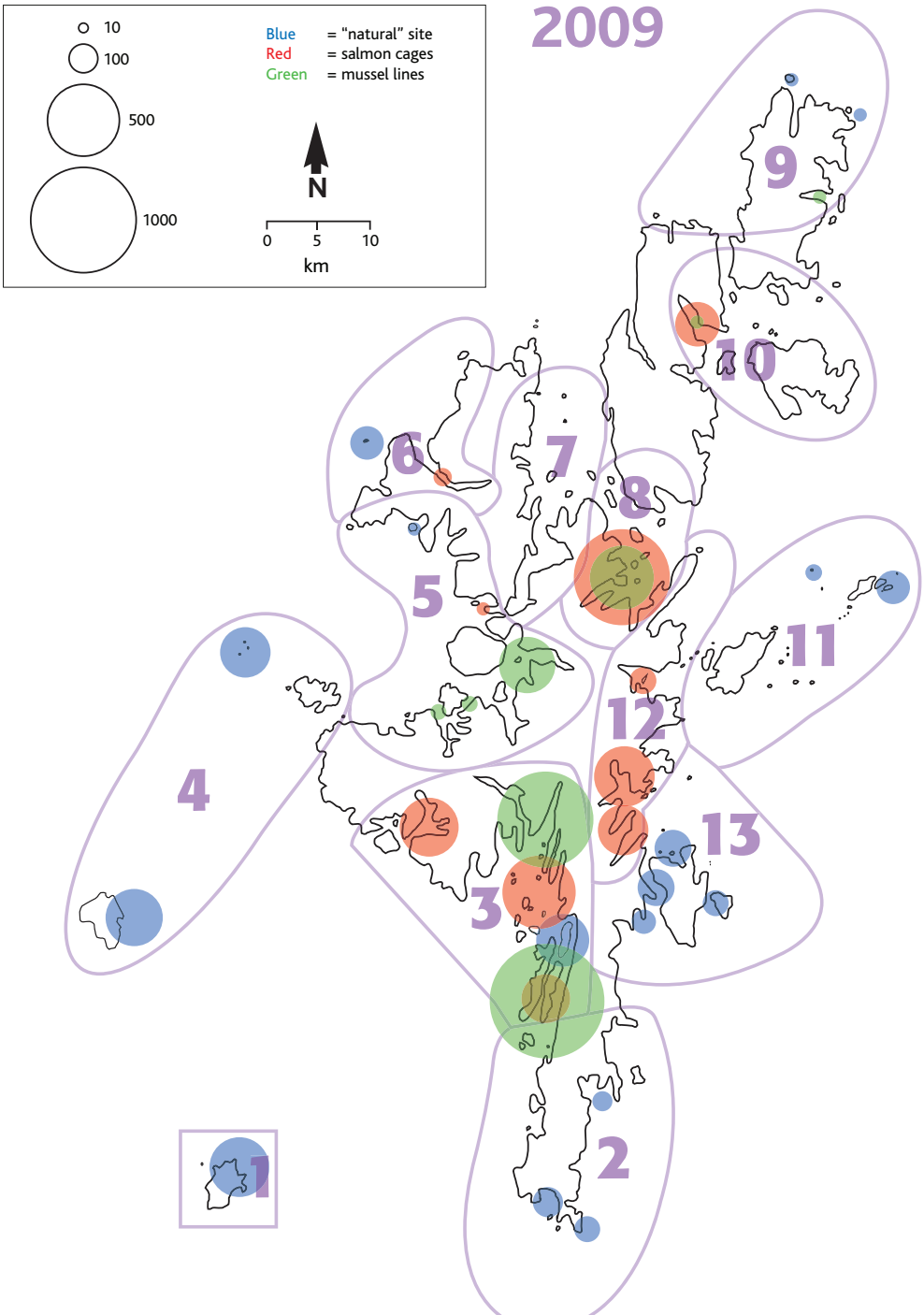

Figure 1c. The distribution of moulting Common Eiders *Somateria mollissima* in Shetland in 2009. Groups of 10 or more birds are indicated, whether at traditional locations away from aquaculture sites (blue), or apparently associating with finfish farms (red) or shellfish farms (green). Fair Isle lies 40 km SSE of the position indicated.

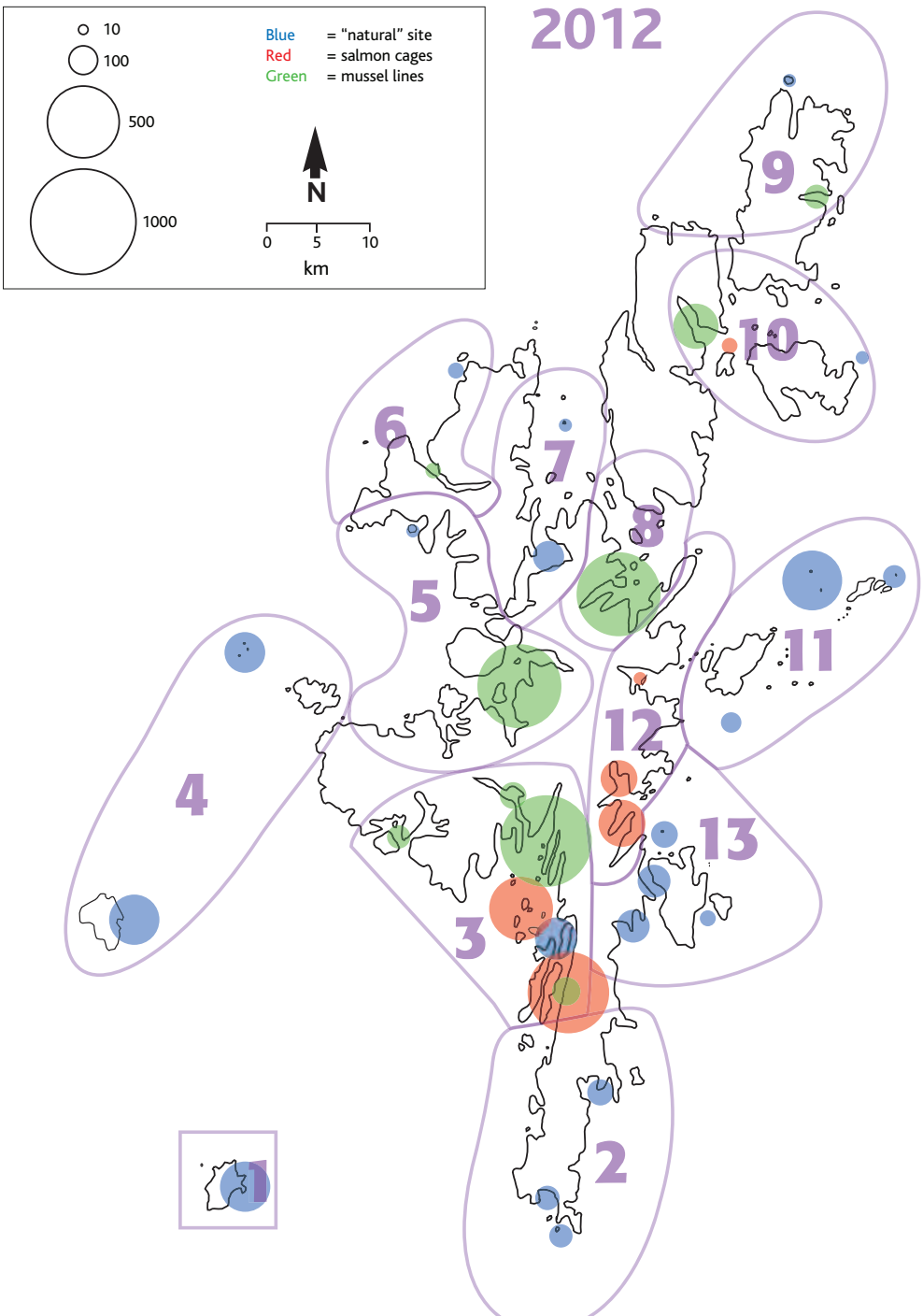

Figure 1d. The distribution of moulting Common Eiders *Somateria mollissima* in Shetland in 2012. Groups of 10 or more birds are indicated, whether at traditional locations away from aquaculture sites (blue), or apparently associating with finfish farms (red) or shellfish farms (green). Fair Isle lies 40 km SSE of the position indicated.

Table 3. Counts of moulting Common Eiders *Somateria mollissima* in different areas of Shetland, 1996–2012 (see Figure 1). * = no coverage. Counts in brackets indicate incomplete coverage compared to other years.

Area	1996	1997	2001	2002	2005	2006	2009	2012
1. Fair Isle	293	477	239	376	211	126	282	178
2. South Mainland	1,249	1,581	1,274	1,200	582	652	164	183
3. Scalloway Islands / Vaila	[354]	[369]	[945]	[1,130]	1,469	1,692	2,654	1,620
4. Foula & Papa Stour	412	511	571	737	526	316	439	354
5. St Magnus Bay	[154]	[95]	[95]	[173]	[110]	200	306	530
6. Northwest Mainland	458	405	390	240	206	206	110	57
7. North Yell Sound	76	83	6	22	11	0	7	84
8. South Yell Sound	*	*	[7]	[5]	190	109	666	499
9. North Unst	187	207	116	68	[18]	41	42	59
10. Bluemull Sound	[29]	[12]	[0]	[0]	[0]	188	151	185
11. Out Skerries / Whalsay	452	697	419	636	360	523	110	362
12. East Mainland Voes	[4]	[69]	*	*	[38]	404	554	274
13. Bressay & Noss	2,201	1,451	1,317	1,039	1,117	812	297	242
Survey total	**5,869**	**5,957**	**5,379**	**5,626**	**4,838**	**5,269**	**5,782**	**4,627**
% change since previous		+1%	-10%	+5%	-14%	+9%	+10%	-20%
% near aquaculture sites	>1%	0	6%	4%	15%	33%	70%	64%

The increased attraction of salmon cages to Eiders might seem less obvious. Salmon farming in Shetland began in 1983 and floating cages and their mooring ropes have always attracted marine growth, including mussels, which may have thinner shells and be preferred by Eiders to those growing on the seabed (Kirk *et al*. 2007). However, as the industry developed and expanded through the late 1980s and 1990s, salmon farms gradually changed from small, isolated groups of relatively flimsy cages where fish were fed manually by a workforce using small boats, to large reinforced structures covering thousands of square metres of the sea surface, with automated feeding barges moored alongside. These modern installations present a much greater surface area for marine growth, provide greater shelter in windy conditions, and are large enough that any workforce present only causes disturbance at one section of the farm at a time. Since they pose no economic threat, Eiders have generally been tolerated at salmon farms (G. Williamson pers. comm; pers. obs.) but may have only learned this gradually. A similar tolerance is shown towards Eiders attracted to the many salmon farms in the Faroes, where there are no mussel farms (J.-K. Jensen & B. Olsen pers. comm.)

The relative lack of mobility of Eiders during the late-summer moult makes this the most practical time of year in which to census the whole population, but the need now to check aquaculture sites and potential nearby shoreline roosts, as well as traditional moulting areas, including those not used for many years, makes the task more complex and more expensive (in terms of boat hire). The similarity of the survey totals in 1996 and 1997 (Table 3), when mussel farming was in its infancy, would suggest that few Eiders were overlooked in those years and that the Shetland population probably stood at about 6,000 birds. A proportion of the population was undoubtedly overlooked in 2001–02 and 2005 (and possibly 2006) before it was fully

appreciated just how attractive aquaculture sites had become. The numbers recorded on the thorough 2009 survey (5,800 birds) would suggest little change, or at most a slight decline since the late 1990s, but the 20% decrease recorded by the even more thorough 2012 survey was unexpected, and cannot be explained by any difference in coverage of the coastline.

The difference in the 2009 and 2012 survey totals is also unlikely to be due to counting error, even though estimating numbers of moulting Eiders in dense flocks can be difficult. Comparison of visual estimates with counts of the same flocks from aerial photographs shows a tendency for observers to underestimate flock sizes, generally by 10–15% (Follestad *et al*. 1988; pers. obs.). If we had underestimated numbers by 15% in the three flocks in 2009 and the six flocks in 2012 where birds could not be counted individually (Table 2), this would have added only 223 and 257 to the respective survey totals, which would then still have differed by 19%.

It is possible that a change in timing of breeding could affect the phenology of the moult cycle. The onset of laying at an Eider colony in Iceland advanced over a 30-year period (1977–2006), but only by a week and with much annual variation (D'Alba *et al*. 2010), and no such trend was found over a similar period at the Isle of May, southeast Scotland and the Farne Islands, northeast England (Wanless *et al*. 2009). The only long-term evidence on timing of breeding in Shetland is the date of the first sighting of Eider ducklings, which although not recorded systematically is given in Shetland Bird Reports for 30 years in the period 1974–2012, with no suggestion of any trend to earlier laying (Figure 2). There is no other evidence to suggest any change in the timing of moult, which is asynchronous according to sex and probably also breeding status, and nothing to suggest that August is no longer the most appropriate time for a census, i.e. when the greatest proportion of the population is flightless.

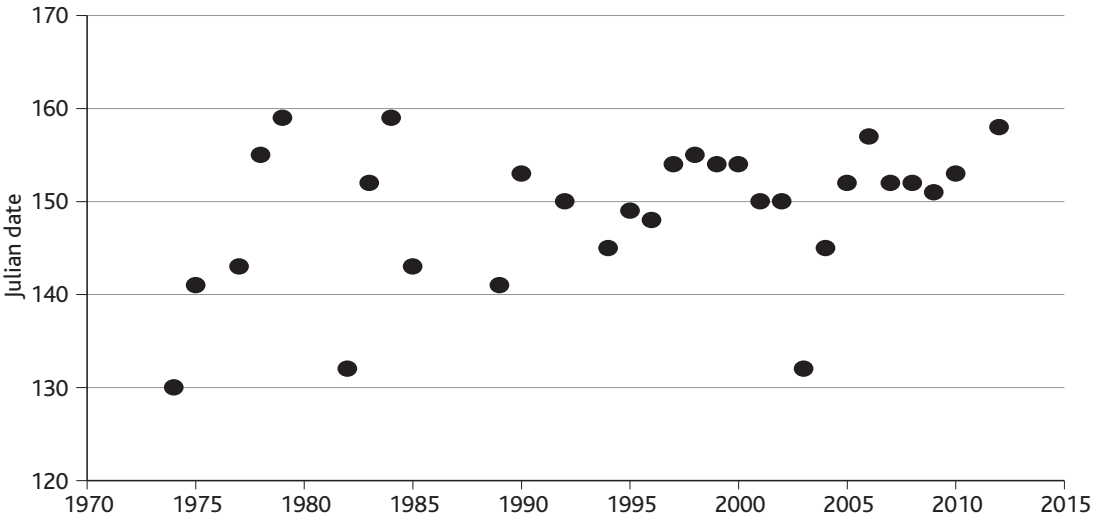

Figure 2. Julian date (1 January = 1) of the first sighting of Common Eider *Somateria mollissima* ducklings, as reported in Shetland Bird Reports 1974–2012.

The slight difference in the timing of the 2009 and 2012 surveys, with 2,580 birds counted between 31 July and 8 August 2012 (56% of the total), before the 2009 survey began, could have meant that a proportion still capable of flight in early August 2012 went undetected. However, this is unlikely to have contributed much to the difference in the survey totals of 1,150 birds, given that virtually all adult males would have been flightless in early August, and that the ~10% of the coast not surveyed in 2012 was largely exposed and with no history of use by moult flocks. A very few birds have been recorded flying on previous surveys, usually females in early August and males in late August, but none were seen to do so in 2009, even when approached by boat. In 2012 the only birds seen to fly were a group of 17 females sitting ashore on 31 July, which flew away from our boat but immediately settled on rocks nearby, while on 7 August about 60 females out of a flock of 137 (all 'brown' birds) feeding at mussel lines flew away from our boat, although weakly and all landed on the sea within c. 300 m. Females with broods never flew when approached by boat, and whether they can actually do so is unknown.

While 9% of birds in 2009 were unsexed, the survey totals suggest a slight preponderance of males in the Shetland population, with 'black' birds comprising 53% of the sexed total in 2009 and 53% of the survey total in 2012 (Table 1), while a small proportion of 'brown' birds in both years will have been juvenile males. A bias towards males has been found among adults in spring in a number of Eider populations, e.g. in northeast Scotland (Milne 1974), northeast England (Coulson 2010), and southwest Finland (Kilpi *et al*. 2003). Whether this is actually the case in Shetland is difficult to determine, as there have been no such systematic counts of adults in spring. Standard counts in winter distinguish between adult males, immature males and females and in 2012/13 recorded respective totals of 1,284 (48.7%), 183 (6.9%) and 1,170 (44.4%) in five different survey areas, but these proportions varied markedly between areas and in comparison with previous winters (SOTEAG unpubl. data).

Predation of Eider ducklings by gulls and skuas has long been suggested locally as a contributory factor in the long-term decline of Eiders in Shetland, but this has occurred for decades. Unfledged chicks and fully-grown juveniles were included in both the 2009 and 2012 survey totals, and while we have no direct evidence of their relative survival to the time of being counted (i.e. that mortality may have been exceptionally high in 2012), broods of juveniles were still identifiable in the third week of August 2012, and the ratio of immature to adult males in winter, while varying between areas, was no lower in winter 2012/13 (0.14:1, n = 1,467) than in 2009/10 (0.12:1, n = 1,372; SOTEAG unpubl. data).

Predation of Eiders by Grey Seal *Halichoerus grypus* and Harbour Seal *Phoca vitulina* has been reported from elsewhere in the UK (Moore 2001; Kirkham 2008) and could occur in Shetland, but we are unaware of any instances of this. European Otters *Lutra lutra* predate a wide variety of seabirds in Shetland, and were known to have predated adult Eiders in Sullom Voe in the late 1990s (pers. obs.), but there is no evidence that such behaviour has suddenly become more prevalent.

More recently, there has been speculation about the impact on the Eider population of occasional predation events by Killer Whales *Orcinus orca*. Sightings of Killer Whales in Shetland's inshore waters are thought to have increased since the 1980s (Fisher *et al*. 1999), and peak in summer, coinciding with the Harbour Seal pupping season (Bolt *et al*. 2009). Cruising close inshore while hunting seals, groups of Killer Whales inevitably come across flocks of moulting Eiders. Although there had previously been some anecdotal reports of such encounters, the first attack to be described and reported was in Lerwick harbour in August 2005 (Figure 1, Area 13), when 30–40 Eiders were killed (Smith 2006); other attacks in which a similar number of Eiders were killed occurred nearby in July and again in August 2007 (Figure 3). Although these are the only incidents on record in Shetland, the Lerwick area is the most densely populated part of Shetland and Killer Whale sightings often attract large crowds of observers who can watch a pod's behaviour for several hours; it would seem likely that similar attacks have occurred but gone undetected in remoter parts of Shetland. Photo-identification has shown that some of the Killer Whales involved in the August 2007 incident were again present in Shetland in the summers of 2008, 2009 and 2011 at least, and were seen hunting Common Guillemots *Uria aalge* in Faroes in April 2009, where attacks on Eiders have been well documented and still occur (Bloch & Lockyer 1988; Foote *et al*. 2010; D. Bloch pers. comm.).

Among possible anthropogenic causes of a recent decline in Eider numbers, mortality from oil pollution can be ruled out. No oil pollution incident between the two moult surveys was known to have affected Eiders, and none were found oiled on monthly beached bird surveys throughout the islands between August 2009 and August 2012 (Figure 4; two adult male Eiders found at widely separated beaches in southwest Mainland in January 2009 had been contaminated by fuel oil

Figure 3. Killer Whales *Orcinus orca* attacked moulting Common Eiders *Somateria mollissima* near Lerwick (Figure 1, Area 3), killing about 50 birds. 15 August 2007. © *Hugh Harrop*.

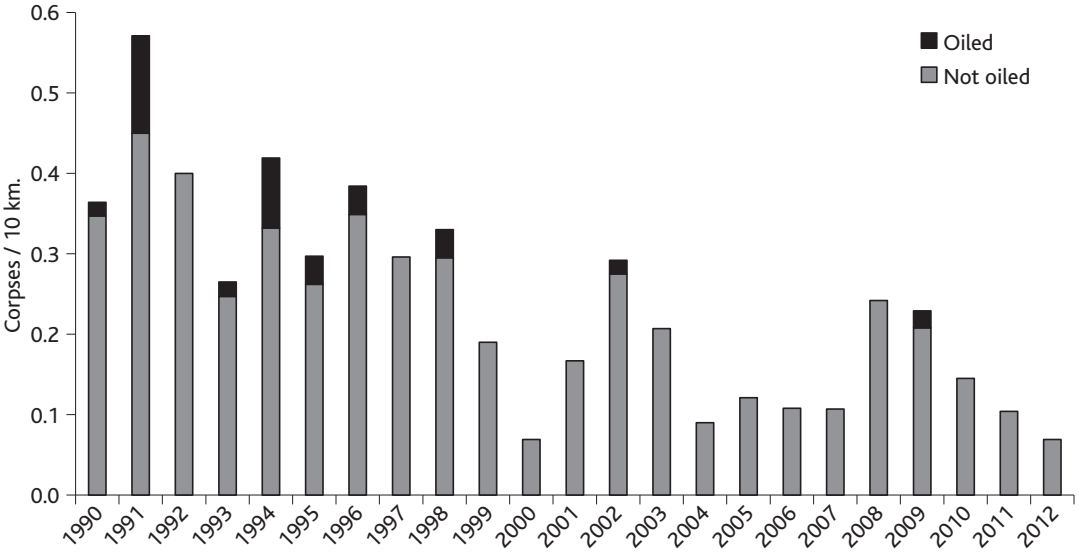

Figure 4. The annual total of Common Eiders *Somateria mollissima* found dead on monthly beached bird surveys in Shetland, 1990–2012. Coverage totals c. 48 km per month.

residues from a common source). Neither was there any obvious geographic, temporal cluster among the 21 Eiders (7 adult males, 1 immature male, 9 females, 4 juveniles) found dead in the 35 months between the two moult surveys, which might have suggested a single, abnormal mortality event.

Finally, consideration should be given to any conflict between mussel farming and Eiders. There is a long history of studies into minimising the impact of Eiders at mussel farms in Scotland (Dunthorn 1971; Galbraith 1992; Ross & Furness 2000) and elsewhere (Varennes *et al*. 2013), and techniques discussed or recommended range from lethal shooting, chasing ducks by boat, underwater and above-water scaring devices, to anti-predator netting. Many such deterrence methods have been tried at one stage or another in Shetland, the most common having been chasing flocks away by fast boat, but we are not aware of any scientific study into their efficacy, nor their potential impact on (for example) female body condition in the pre-laying period. A licence for lethal shooting was issued to one Shetland company by the Scottish Executive in November 2001 but was revoked following protests, and while there have been anecdotal reports of lethal shooting (as opposed to shooting to scare), they remain unsubstantiated. One mussel farmer who had deployed anti-predator netting at one site (in the west of Area 3; Figure 1) reported to Scottish Natural Heritage in November 2010 that it had drowned eight Eiders in 2008, 21 in 2009 and eight in 2010. How widespread this practice has been is uncertain, but at the time, the Shetland Islands Council Marine Planning Service commented that this farmer was "one of the few who deploy predator nets due to the cost and effort, which outweigh the losses" (M. Holmes pers. comm.), while the industry body Seafood Shetland noted that only one other mussel company reported deploying such nets, at two other sites (R. Henderson pers. comm.), but for how long and with what consequences is unknown.

The potential for lethal conflict is not confined to mussel farming, for in May 2013 a salmon farm manager was convicted of illegally setting fine monofilament nets (to 'deter' predatory seals) around cages (also in the west of Area 3) during spring and summer 2011, and although no evidence was presented of birds having been drowned, the potential for such mortality clearly existed given the attraction of Eiders to many salmon farms.

Locally, relations between conservation bodies and shellfish industry representatives are good, and continued open dialogue will be necessary to ensure that mussel farming and Shetland's Eiders can co-exist. The next moult flock survey is scheduled for August 2015, and it is to be hoped that a further decrease is not recorded then.

Acknowledgements

For assisting with counts in 2009 and 2012, we are grateful to: Penny and Sheila Gear (Foula); Newton Harper and Helen Moncrieff (RSPB); Alistair Nayar; David Parnaby and Deryk Shaw (Fair Isle Bird Observatory); Rory Tallack and Howard Towll (Shetland Amenity Trust). We also thank boatmen Jim Dickson, Brian Edwardson, Victor Gray, the late Ronnie Johnson, Alan Longmuir, Edmund Nicolson, Jerry Ramsay, George Lamont Williamson, and Jonathan Wills. Harry Scott of Pica Design kindly produced the maps. Andy Foote (Uppsala University), Karen Hall (Scottish Natural Heritage, Lerwick), Paul Harvey (Shetland Biological Records Centre), and George Williamson provided helpful comments on a first draft, and Ib Krag Petersen and an anonymous referee improved the submitted manuscript. The SOTEAG seabird monitoring programme is funded by The Sullom Voe Association Ltd.

References

Bloch, D. & Lockyer, C. 1988. Killer Whales *Orcinus orca* in Faroese waters. *Rit Fiskideilder* 11: 55–64.

Bolt, H. E., Harvey, P. V., Mandleberg, L. & Foote, A. D. 2009. Occurrence of killer whales in Scottish inshore waters: temporal and spatial patterns relative to the distribution of declining harbour seal populations. *Aquatic Conservation: Marine and Freshwater Ecosystems* 19: 671–675.

Coulson, J. C. 2010. A long-term study of the population dynamics of Common Eiders *Somateria mollissima*: why do several parameters fluctuate markedly? *Bird Study* 57: 1–18.

D'Alba, L., Monaghan, P. & Nager, R. G. 2010. Advances in laying date and increasing population size suggest positive responses to climate change in Common Eiders *Somateria mollissima* in Iceland. *Ibis* 152: 19–28.

Dunnet, G. M. & Heubeck, M. 1995. The monitoring of breeding seabirds and eiders. *Proceedings of the Royal Society of Edinburgh* 103B: 137–164.

Dunthorn, A. A. 1971. The Predation of Cultivated Mussels by Eiders. *Bird Study* 18: 107–112.

Fisher, P. R., Adam, M. & Brown, E. G. 1999. Killer Whales (*Orcinus orca*) in Shetland waters. *Shetland Sea Mammal Report, 1998*: 12–16.

Follestad, A., Larsen, B. H., Nygård, T. & Røv, N. 1988. Estimating numbers of moulting Eiders *Somateria mollissima* with different flock size and flock structure. *Fauna norvegica Series C, Cinclus* 11: 97–99.

Foote, A. D., Similä, T., Víkingsson, G. A. & Stevick, P. T. 2010. Movement, site fidelity and connectivity in a top marine predator, the killer whale. *Evolutionary Ecology* 24: 803–814.

Furness, R. W., Mable, B., Savory, F., Griffiths, K., Baillie, S. R. & Heubeck, M. 2010. Subspecies status of Common Eiders *Somateria mollissima* in Shetland based on morphology and DNA. *Bird Study* 57: 330–335.

Galbraith, C. 1992. *Mussel Farms: Their Management Alongside Eider Ducks*. Nature Conservancy Council for Scotland, Edinburgh.

Greenwood, J. J. D. & Keddie, J. P. F. 1968. Birds killed by oil in the Tay Estuary, March and April 1968. *Scottish Birds* 5: 189–196.

Heubeck, M. 1987. Changes in the status of the Common Eider in Shetland, 1977–1984. *Scottish Birds* 14: 146–152.

Heubeck, M. 1993. Moult flock surveys indicate a continued decline in the Shetland Eider population, 1984–92. *Scottish Birds* 17: 77–84.

Holt, C. A., Austin, G. E., Calbrade, N. A., Mellan, H. J., Hearn, R. D., Stroud, D. A., Wotton, S. R. & Musgrove, A. J. 2012. *Waterbirds in the UK 2010/11: The Wetland Bird Survey*. BTO/RSPB/JNCC, Thetford.

Joensen, A. H. 1972. Studies on Oil Pollution and Seabirds in Denmark 1968–1971. *Danish Review of Game Biology* 6 (9).

Joensen, A. H. & Joensen, E. B. 1977. Oil Pollution and Seabirds in Denmark 1971–76. *Danish Review of Game Biology* 10 (5).

Jones, P. H. & Kinnear, P. K. 1979. Moulting Eiders in Orkney and Shetland. *Wildfowl* 30: 109–113.

Kilpi, M., Öst, M., Lehikoinen, A. & Vattulainen, A. 2003. Male sex bias in Eiders *Somateria mollissima* during spring migration into the Gulf of Finland. *Ornis Fennica* 80: 137–142.

Kirk, M., Esler, D. & Boyd, W. S. 2007. Morphology and density of mussels on natural and aquaculture structure habitats: implications for sea duck predators. *Marine Ecology Progress Series* 346: 179–187.

Kirkham, P. 2008. Common Eiders attacked and killed by Harbour Seal. *British Birds* 101: 442–447.

Milne, H. 1974. Breeding numbers and reproductive rate of Eiders at the Sands of Forvie National Nature Reserve, Scotland. *Ibis* 116: 135–152.

Moore, P. G. 2001. Concerning grey seals killing eider ducks in the Clyde Sea area. *Journal of the Marine Biological Association of the United Kingdom* 81: 1067–1068.

Pennington, M., Osborn, K., Harvey, P., Riddington, R., Okill, D., Ellis, P. & Heubeck, M. 2004. *The Birds of Shetland*. Christopher Helm, London.

Ross, B. P. & Furness, R. W. 2000. *Minimising the impact of eider ducks on mussel farming*. University of Glasgow.

Shetland Islands Council 2011. Shetland in Statistics. www.shetland.gov.uk/economic_development/documents/29523statisticpages_001 (accessed 23 July 2013).

Smith, W. E. 2006. Moulting Common Eiders devoured by Killer Whales. *British Birds* 99: 264.

Swennen, C. & Spaans, A. L. 1970. De sterfte van zeevogels door olie in februari 1969 in het Waddenbebeid. *Vogeljaar* 18: 233–245.

Varennes, É., Hanssen, S. A., Bonardelli, J. & Guillemette, M. 2013. Seaduck predation in mussel farms: the best nets for excluding common eiders safely and efficiently. *Aquaculture Environment Interactions* 4: 31–39.

Wanless, S., Frederiksen, M., Walton, J. & Harris, M. P. 2009. Long-term changes in breeding phenology at two seabird colonies in the western North Sea. *Ibis* 151: 274–285.