Late nesting makes Barnacle Geese *Branta leucopsis* sensitive to anthropogenic disturbance in the Russian part of the Baltic Sea

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Abstract

Barnacle Geese *Branta leucopsis* have bred in the Russian part of the Gulf of Finland since 1995. The species starting to breed in this area later than in the western Baltic Sea and North Sea regions, which were first colonised in the 1970s and early 1980s respectively. Since then, the breeding distribution has continued to expand through Lake Ladoga to Lake Onega in northwest Russia, which currently forms the north-easternmost limit of the range for of this temperate-breeding population. Nowadays, Barnacle Geese in the Russian part of the Gulf of Finland breed later than in other Baltic countries, including neighbouring Finland. The egg-laying period, which starts between 1 May–25 June and peaks during 11–25 May, is longer than for Barnacle Geese nesting in western parts of the temperate zone and also in comparison with those breeding in the Russian Arctic. The mean clutch size of 4.95 (s.e. ± 0.07) eggs is however larger than in other parts of the Baltic and in Arctic areas. Nests were found only on islands occupied by Herring Gulls *Larus argentatus*, which is the most common predator of Barnacle Goose eggs in the region. The Herring Gulls' egg-laying period lasted from April to June; thus, incubation of Barnacle Goose eggs occurs during the gulls' nesting and brood rearing period. It is suggested that anthropogenic disturbance could adversely affect Barnacle Goose breeding success in the Russian part of the Gulf of Finland, through tourist activity displacing geese from their nests at a time when the gulls are also breeding nearby. Specific features of the environment (late spring, predation risk and tourist activity) and the characteristics of this particular goose population (recent colonisation of the area, small population size and late breeding period) should be taken into account in developing conservation management programmes for geese in the region.

Key words: breeding success, disturbance, Herring Gull *Larus argentatus*, predator pressure, range expansion.

Barnacle Geese *Branta leucopsis* bred exclusively at Arctic latitudes until the late 20th century, when they started to nest in the Baltic Sea region, initially on Gotland Island, Sweden, during the 1970s (Larsson *et al.* 1988; Black *et al.* 2014). The first breeding attempt in Finland was recorded in 1985 (Väisänen *et al.* 1998) and the first nest in the Helsinki metropolitan area was registered in 1989 (Väänänen *et al.* 2011). By 2010, the number of Barnacle Geese breeding in Finland was estimated at 3,500 pairs, including 1,440 pairs nesting in the Helsinki area (Väänänen *et al.* 2011; Yrjölä *et al.* 2017). Further south, a breeding pair was first encountered in the North Sea region (in the Netherlands) during 1981 (van der Jeugd *et al.* 2009). Numbers breeding both in the Baltic (Germany, Sweden, Belgium, Denmark, Finland, Estonia) and North Sea (Netherlands) countries have since increased steadily, to reach 21,000 and 25,000 birds respectively by 2005 (Voslamber *et al.* 2007; Feige *et al.* 2008). The population breeding in the Russian Arctic also increased over this period, to an estimated 1,200,000 individuals by 2015 (Fox & Leafloor 2018).

In the Russian part of the Gulf of Finland, Barnacle Geese were first seen nesting on Dolgy Reef Island, very close to the Russian–Finnish border, in 1995 (Gaginskaya *et al.* 1997). By 2015, numbers in the Russian part of the Gulf of Finland had reached 76 breeding pairs (Kouzov *et al.* 2018). The first Barnacle Goose nest at Lake Ladoga in northwest Russia was found in 2010 (Agafonova *et al.* 2016) and the breeding range then extended to Lake Onega where a pair was found nesting in 2015 (Hohlova & Artemiev 2015). The Russian part of the Gulf of Finland, along with Lakes Ladoga and Onega, thus forms the eastern and northernmost extent of the breeding range for temperate-breeding Barnacle Geese, with the geese populating these areas later than the North Sea and western Baltic Sea regions. Relatively few pairs currently breed in the area, at the edge of the temperate breeding range, and this part of the population is therefore sensitive to environmental change.

Previous studies have shown that the timing of egg-laying by Barnacle Geese in the Baltic Sea region advanced significantly (by about 6 days) over a 20-year period from 1984–2004 (van der Jeugd *et al.* 2009). Observations made of hatching dates indicate that the first clutches now appear at the beginning of April, with peak egg-laying at the end of April (van der Jeugd *et al.* 2009). Likewise in the Helsinki area, pairs started to nest a little later over the period 1989–2013, with nesting now commencing in late April (Väänänen *et al.* 2011; Yrjölä *et al.* 2017). Nesting success varies with predation pressure (Larsson & Forslund 1994; Kleefstra 2014), with mammals being the main predators of goose eggs and goslings (Kleefstra 2014). Predation by the invasive American Mink *Neovison vison* is relatively high in the Helsinki Archipelago in some years (Yrjölä *et al.* 2017).

The eastern part of the temperate breeding range used by Barnacle Geese – in the Gulf of Finland, Ladoga Lake and Onega Lake – is characterised by cold winters and solid ice cover. Onset of vegetation growth in spring is later here than in the other parts of the Baltic, and in these climatic

conditions the timing of the breeding season could differ from that for geese breeding further south and west. Predation pressure in the area is low (Kouzov *et al.* 2018), but Herring Gull *Larus argentatus* colonies are situated on most of the islands in the Gulf of Finland, and gulls are common predators of eggs and small goslings (Ebbinge & Spaans 2002; de Fouw *et al.* 2016). Predation risk should be considered as an important factor influencing the migration and breeding behaviour of geese (Jonker *et al.* 2010; de Fouw *et al.* 2016). However gulls can also provide protection to other birds nesting in their vicinity, and the costs and benefits of such associations have been discussed in several studies (Bourget 1973; Burger 1984; Young & Titman 1986; Götmark 1989; Väänänen 2000; Ebbinge & Spaans 2002).

This paper describes the timing of the breeding season for Barnacle Geese in the new more eastern part of their temperate breeding range, to determine whether breeding is later than in the North Sea and Baltic Sea areas initially colonised by the geese. We also compared the clutch size of the Barnacle Goose in the eastern part of the Gulf of Finland with the clutch sizes in the other breeding regions, and studied the presence and the breeding dates of Herring Gulls on islands populated by Barnacle Geese, to investigate whether the presence of the gulls appears to have a positive effect (through protection) or negative effect (through predation) on Barnacle Geese breeding in the area.

Methods

Annual surveys of Barnacle Geese breeding in the eastern part of the Gulf of Finland were conducted from 2010–2017 inclusive. Observations were made on the Soykinsky and Kurgalsky Peninsulas, Dolgy Reef, on the islands of Reymosar, Rodsher, Galochy, Malaya Otmel, Ryabinnik, Nerva, Vostochny Greben, Kamennaya Zemlya, Zapadny Greben, Tuman, Stoglaz, Gusiny, Virginy, Dolgy Kamen, Maly, Moshchny, Vigrund, Gogland, Bolshoy Tyuters, Maly Tyuters, Seskar, and Sommers, on the Maly Fiskar Archipelago, the Bolshoy Fiskar Archipelago, and on the islets of Hitomatala, Vigrund, Vestgrund, Vikkala, Kurgalsky and Tiskolovsky Reefs (main sites indicated in Fig. 1). Every island was visited once or twice during the incubation period, to count the number of nesting pairs and to estimate onset of laying dates. The timing of the visits varied depending on whether weather conditions permitted travel to the islands. However, most observations were carried out at the end of May and at the beginning of July, to ensure that early and late nesting pairs were included in the surveys. The clutch initiation period is very long and the incubation stage of the clutches differed between visits, but even during the first visit to the islands at the end of May clutches were found in both the earliest and the latest stages of incubation.

At the smaller islands (area = 1–12 ha), nests were counted across the entire area of the island. The large islands (Bolshoy Tyuters, Maly Tyuters, Moshchny, Maly) are covered by forest, and here nests were searched for only in biotopes suitable for Barnacle Geese, in a coastal strip no more than 200 m wide. Nests with clutches were mapped, and the number of eggs in each

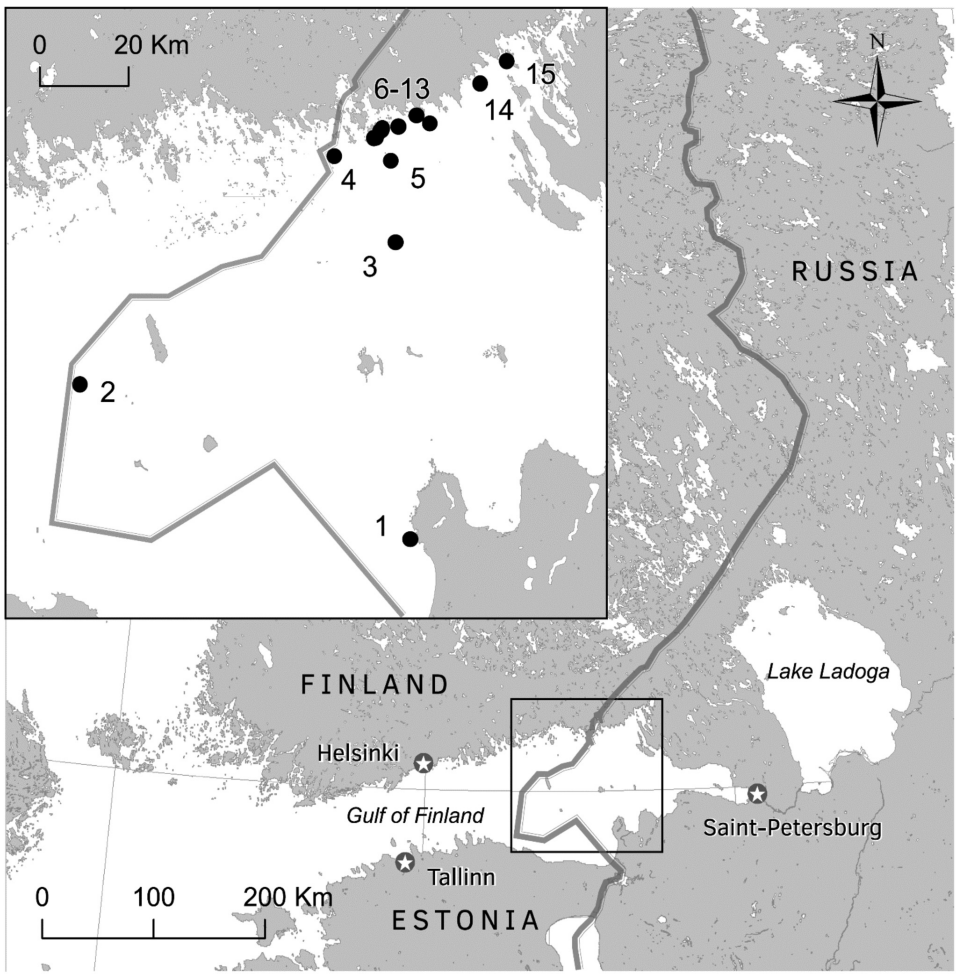

Figure 1. Distribution of Barnacle Goose nests in the eastern part of the Gulf of Finland in 1995–2017. 1 = Reymosar Island, 2 = Rodsher Island, 3 = Nerva Island, 4 = Dolgy Reef Island, 5 = Bolshoy Fiskar Archipelago, 6 = Zapadny Greben Island, 7 = Vostochny Greben Island, 8 = Galochy Island, 9 = Kamennaya Zemlya Island, 10 = Malaya Otmel Island, 11 = Ryabinnik Island, 12 = Tuman Island, 13 = Maly Fiskar Archipelago, 14 = Gusiny Island, 15 = Stoglaz Island.

clutch was recorded. Incubation stage was determined by the egg floating test (Westerkov 1950) and clutch initiation dates were then calculated by back-dating from the hatch date based on an average Barnacle Goose incubation period of 24 days (Tombre & Erikstad 1996) plus 1 day/egg and an assumed "skip-day" for clutches with more than four eggs (following Ely & Raveling 1984). In Canada Geese *Branta canadensis*, the egg flotation method tends to overestimate clutch age in early incubation

and underestimates it in late incubation (Walter & Rusch 1997), but it offers a suitable non-invasive method as long as this level of inaccuracy (± 4 days) is borne in mind when considering the data presented here. Incubation stage and clutch size was determined for some but not for all clutches, because some islands were visited for a very short period and there was insufficient time to make the tests. Clutch initiation dates estimated for the geese were grouped into 5-day periods for analysis.

In addition to the Barnacle Goose surveys, Herring Gull nests were counted on islands occupied by nesting Barnacle Geese. Incubation stages of the gull clutches were again determined by the egg floating test, using a 29-day incubation period to determine the onset of laying (Dementyev *et al.* 1951). Onset of egg-laying dates was also calculated from the age of the gulls' chicks, determined on the basis of their plumage development (Dementyev *et al.* 1951). Because we used the more subjective measure of chicks' age in addition to the egg floating test to determine onset of laying, clutch initiation dates were grouped into 10-day periods for Herring Gull analyses.

Whether the mean number of Barnacle Goose pairs recorded nesting each year increased significantly during the study was determined by linear regression analysis. Unpaired *t*-tests were used to determine whether clutch sizes recorded for geese that started egg-laying relatively early (in May) were significantly larger than those laid later in the season (June), as found in other studies (Perrins 1970; Prop & de Vries 1993; Dalhaug *et al.* 1996). Data published on mean clutch sizes recorded for Barnacle Geese breeding in the Russian Arctic each year were also compared, using unpaired *t*-tests, with the mean clutch sizes recorded for geese each year in the present study, although it should be noted that data from the Russian Arctic studies were in different years to those from the Gulf of Finland.

Results

Barnacle Geese were found breeding on 18 islands in the study area during 2010–2017. Four islands with the highest number of nesting pairs (Dolgy Reef, Maly Fiskar, Malaya Otmel and Ryabinnik), which each had a mean of at least 5 nests over the study period, were all colonised by the geese at the start of the study in 2010 or 2011 (Table 1). The mean number of nests recorded each year increased significantly from 0.5 nests/island in 2010 to 4.2 in 2015, before dropping slightly to 3.7 and 3.1 in 2016 and 2017 respectively (linear regression: $F_{1,6} = 15.09$, $P = 0.008$, Fig. 2). First clutches were laid between 11–15 May in the first two years (2010–2011) and from 1–10 May thereafter (Table 2), and the latest egg-laying dates were 21–25 June in 2011 and also in 2013–2016. Most of the clutches (73%, $n = 174$) appeared between 11–31 May, with a peak between 11–25 May (Table 2, Fig. 3), and peak egg-laying commenced *c.* 5–10 days after the appearance of the first clutches in most years of the study (Table 2).

Herring Gulls were present on every island occupied by Barnacle Geese. They always nested in colonies, with the largest colony reaching 852 nests in the Bolshoy Fiskar Archipelago (Table 3). The gulls started nesting one month earlier than the Barnacle Geese, with first clutches laid in

Table 1. Nests of Barnacle Geese found on the islands of the eastern part of the Gulf of Finland in 2010–2017 (– = no counts were made).

	2010	2011	2012	2013	2014	2015	2016	2017	Mean no. nests
Dolgy Reef	1	5	4	1	5	8	9	7	**5.0**
Maly Fiskar	2	6	2	3	4	12	10	10	**6.1**
Bolshoy Fiskar Archipelago:									
• Fiskar	0	0	1	1	1	1	0	0	**0.5**
• Kivimaa	0	0	1	1	1	1	2	4	**1.3**
• Mannonen	1	1	1	0	2	2	1	0	**1.0**
• Bolshoy Zapadny	0	0	1	1	1	2	1	1	**0.9**
Reymosar	0	0	0	0	0	0	0	0	**0.0**
Rodsher	1	0	0	0	0	0	0	–	**0.1**
Galochy	–	3	–	1	3	5	3	0	**2.5**
Malaya Otmel	–	6	–	3	10	14	8	1	**7.0**
Ryabinnik	–	4	1	2	6	10	11	8	**6.0**
Nerva	–	0	2	2	2	3	2	–	**1.8**
Vostochny Greben	–	0	0	0	5	6	4	2	**2.4**
Kamennaya Zemlya	–	0	0	0	2	3	2	–	**1.2**
Zapadny Greben	–	0	0	0	0	2	1	1	**0.6**
Tuman	0	0	0	0	0	4	3	2	**1.1**
Stoglaz	–	0	0	–	0	3	10	9	**3.7**
Gusiny	0	0	0	0	0	0	0	1	**0.1**
Total islands visited	**10**	**18**	**16**	**17**	**18**	**18**	**18**	**15**	
Total nests	**5**	**25**	**13**	**15**	**42**	**76**	**67**	**46**	
Nests/island	**0.5**	**1.4**	**0.8**	**0.9**	**2.3**	**4.2**	**3.7**	**3.1**	

the beginning of April. Their main egg-laying period extended between 11 April and 10 May and peaked during 21–30 April (Table 4, Fig. 4). Some single nests appeared as late as 11 June.

Barnacle Goose clutch sizes ranged from 2 to 6 eggs, with an overall mean of 4.95 eggs (s.e. ± 0.07; n = 184) recorded over the 2010–2017 study period. Annual average clutch sizes varied from 4.00 (± 0.33) eggs

Table 2. The number of Barnacle Goose clutches initiated at different stages of the breeding season (in 5-day periods) in the eastern part of the Gulf of Finland, for each year of the 2010–2017 study.

Year	May						June						Total
	1	2	3	4	5	6	1	2	3	4	5	6	
2010			2	1			1						4
2011			2	5	4	2	1				2		16
2012		1	2	3	1					1			8
2013		1	2	4	2		1				1		11
2014		3	6	5	3	4	1		1	2	3		28
2015		6	15	14	9	11	4	1	1	6	3		70
2016		4	14	11	10	12	2	2		4	4		63
2017	3	5	5	4	19	2	1						39
Total	**3**	**20**	**48**	**47**	**48**	**31**	**11**	**3**	**2**	**13**	**13**		**239**

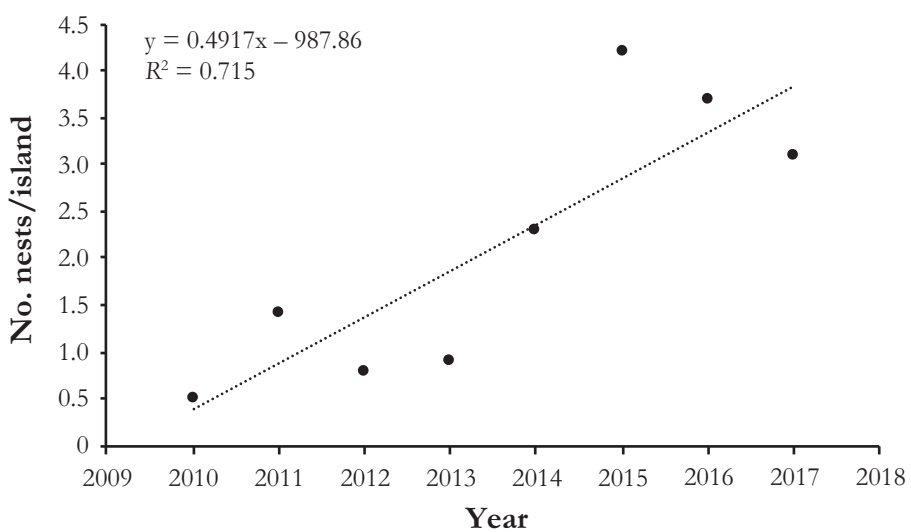

Figure 2. Number of Barnacle Goose nests per island in the Russian part of the Gulf of Finland during 2010–2017.

Table 3. The number of Herring Gull nests found on the islands of the eastern part of the Gulf of Finland in 2010–2017 (– = no counts were made).

	2010	2011	2012	2013	2014	2015	2016	2017	Mean no. nests
Dolgy Reef	213	40	224	173	307	321	211	132	202.6
Maly Fiskar	475	–	481	143	232	271	211	195	286.9
Bolshoy Fiskar Archipelago	573	300	852	585	431	512	442	461	519.5
Rodsher	48	–	–	–	–	–	–	–	48.0
Galochy	–	27	–	24	42	35	29	18	29.2
Malaya Otmel	–	4	–	5	12	9	4	1	5.8
Ryabinnik	242	225	250	201	170	186	154	133	195.1
Nerva	–	102	–	130	–	160	175	–	141.8
Vostochny Greben	–	12	34	43	80	93	18	4	40.6
Kamennaya Zemlya	–	15	17	11	21	26	28	24	20.3
Zapadny Greben	–	35	53	31	51	43	62	48	46.1
Tuman	48	28	43	32	38	46	49	36	40.0
Stoglaz	–	98	105	–	118	134	153	121	121.5
Gusiny	–	–	–	–	–	–	–	50	50.0

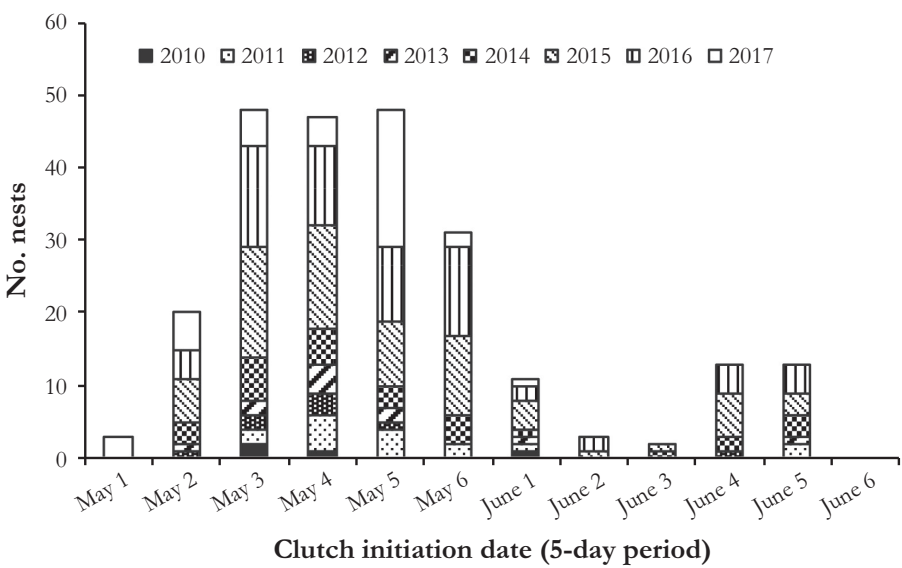

Figure 3. Onset of egg-laying (in 5-day periods) for Barnacle Geese nesting in the Russian part of the Gulf of Finland.

Table 4. The number of Herring Gull clutches initiated at different stages of the breeding season (in 10-day periods) in the eastern part of the Gulf of Finland, for each year of the 2010–2017 study.

Year	April			May			June			Total
	1	2	3	1	2	3	1	2	3	
2010		4	519	55	9					587
2011			157	88	12	2	3	2		257
2012		5	597	105	1					708
2013			292	108	4					404
2014		156	443	47	1	1	5			647
2015		301	492	52	2	2				847
2016		281	439	25	4		3	4		749
2017	3	4	427	38	3		4	11		475
Total	**3**	**751**	**3,366**	**518**	**36**	**5**	**15**	**17**	**0**	**4,674**

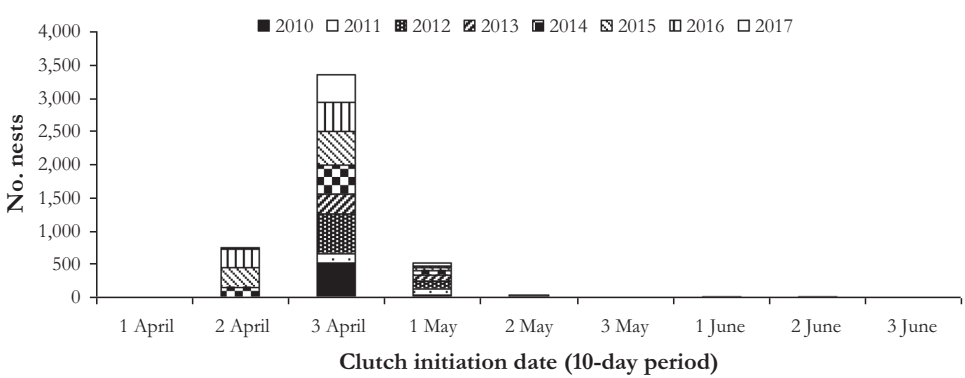

Figure 4. Onset of egg-laying (in 10-day periods) for Herring Gulls nesting on islands colonised by Barnacle Geese in the Russian part of the Gulf of Finland.

in 2011 to 5.31 (± 0.13) eggs in 2015, with only one clutch (of 3 eggs) measured in 2010 (Table 5). The average clutch size of clutches initiated in May was 5.20 ± 0.07 (n = 147). For the clutches initiated in June, it was 3.92 ± 0.13 (n = 37). Clutch sizes were significantly higher for clutches found in May than in June (t_{182} = 8.77, P < 0.001). Average clutch sizes recorded in the eastern part of the Gulf of Finland were

Table 5. Average clutch sizes for Barnacle Geese in the eastern part of the Gulf of Finland during 2010–2017.

Year	May		June		All clutches	
	Average clutch size (± s.e.)	No. of clutches	Average clutch size (± s.e.)	No. of clutches	Average clutch size (± s.e.)	No. of clutches
2010		0	3.00	1	3.00	1
2011	4.43 ± 0.30	7	3.00 ± 0.58	3	4.00 ± 0.33	10
2012	5.00 ± 0.45	5	4.00	1	4.83 ± 0.40	6
2013	4.83 ± 0.31	6	3.50 ± 0.50	2	4.50 ± 0.33	8
2014	5.35 ± 0.21	17	4.00 ± 0.31	7	4.96 ± 0.21	24
2015	5.61 ± 0.09	44	4.00 ± 0.30	10	5.31 ± 0.13	54
2016	5.20 ± 0.12	40	4.17 ± 0.17	12	4.96 ± 0.11	52
2017	4.79 ± 0.15	28	4.00	1	4.76 ± 0.15	29
Total	5.20 ± 0.07	147	3.92 ± 0.13	37	4.95 ± 0.07	184

significantly larger than for Barnacle Goose clutches in many Russian Arctic regions (Table 6).

Discussion

Observations made of Barnacle Geese in the Russian part of the Gulf of Finland, where the species was first recorded breeding in 1995 (Gaginskaya *et al.* 1997), found that new nests appeared between 1 May and 25 June. This 56-day onset of laying period (41 days for 90% of nests) is much longer than in Arctic and western areas of the temperate zone. In the Barents Sea, 90% of all nests were initiated within a period of 12 days, compared with 15 days in the Baltic and 36 days in the North Sea (van der Jeugd *et al.* 2009). The duration of this period may be associated not only with the latitude of nesting (van der Jeugd *et al.* 2009) but also with the duration of the settlement of each region by geese.

The start of the breeding season was also later in the Russian part of the Baltic, with pairs in the neighbouring Helsinki area starting to nest in late April (Väänänen *et al.* 2011; Yrjölä *et al.* 2017), and peak onset of laying in the study area (from 10–25 May) was 1–3 weeks later than on Gotland in the central Baltic Sea (van der Jeugd *et al.* 2009). This may be attributable to the later timing of snow and ice melt, and later onset of vegetation growth locally. Recent colonisation of the Russian part of the Gulf of Finland (Kouzov *et al.* 2018) could be another reason. In the western Baltic,

Table 6. Average clutch sizes in different regions of the Russian Arctic, and the results of *t*-tests on comparing these with average clutch sizes recorded in the eastern part of the Gulf of Finland (4.95 ± 0.07, $n = 184$).

Area	Reference	Years	Average clutch size (± s.e.)	No. of clutches	d.f.	*t*-test
Kanin Peninsula	Filchagov & Leonovich 1992	1990–1991	4.67 ± 0.25	30	212	1.08 n.s.
Kolguev Island	Ponomareva 1992	1989–1990	3.99 ± 0.09	195	377	8.42 $P < 0.05$
Kolguev Island	Kondratyev *et al.* 2012	2006	3.61 ± 0.10	893	1,075	10.98 $P < 0.05$
Kolguev Island	Kondratyev *et al.* 2012	2007	3.36 ± 0.21	87	269	7.18 $P < 0.05$
Kolguev Island	Kondratyev *et al.* 2012	2008	3.42 ± 0.22	55	237	6.63 $P < 0.05$
Yugorsky Peninsula	Filchagov & Leonovich 1992	1990	4.08 ± 0.26	38	220	3.23 $P < 0.05$
Vaigach Island	Filchagov & Leonovich 1992	1991	4.32 ± 0.12	109	291	4.53 $P < 0.05$
Vaigach Island	Filchagov & Leonovich 1992	1988	4.02 ± 0.20	20	202	4.39 $P < 0.05$
Vaigach Island	Gurtovaya 1997	1995–1996	3.93 ± 0.19	59	241	5.04 $P < 0.05$
Kolokolkova Bay	van der Jeugd *et al.* 2003	2002	2.77 ± 0.10	252	434	17.86 $P < 0.05$

absolute timing of egg laying advanced considerably over the 20-year study period (van der Jeugd *et al.* 2009).

That geese in the northeastern parts of the temperate zone breed later than those to the south and west is supported by observations made of Barnacle Geese on the Valaam Archipelago of Ladoga Lake. Here, the geese lay their first eggs in the second half of May (Agafonova *et al.* 2016), and the one nest found in the northern part of Onega Lake in 2015 was started on 10 June (Hohlova & Artemiev 2015). Thus, onset of egg laying at Lakes Ladoga and Onega occurs even later than in the east of the Gulf of Finland, and the timing of the

nesting period at these lakes is similar to the schedule for geese breeding in the Russian Arctic (Gurtovaya 1997; van der Jeugd *et al.* 2003, 2009; Kondratyev *et al.* 2012).

Herring Gulls, the main egg predators of Barnacle Geese in the region, have established breeding colonies on many islands in the Gulf of Finland. Gulls take eggs when the parents temporarily leave their nests, but they also protect the area around their colony from other predators. As for some other colonial-breeding goose species which nest close to egg predators (de Fouw *et al.* 2016), all of the islands with nesting Barnacle Geese had Herring Gull colonies, and it is suggested that Barnacle Geese preferred to nest among gulls because the gulls provide warning of danger and deter predators from their nest sites (Ebbinge & Spaans 2002). The presence of gull colonies can also be beneficial to geese by the fertilising effects of their faeces on grassland utilised by geese for grazing, which can enhance the quality and quantity of goose feeding areas relative to surrounding areas not subject to such effects (Ebbinge & Spaans 2002; de Fouw *et al.* 2016). All Barnacle Goose nests at Lake Ladoga and Lake Onega also occurred on islands with Herring Gull colonies (Hohlova & Artemiev 2015; Agafonova *et al.* 2016). The association between Barnacle Goose nests and Herring Gull nests could be explained by the size of the islands. The only exceptions are the Bolshoy Fiskar archipelago and Malaya Otmel Island. The Bolshoy Fiskar archipelago is the most distant from the mainland group of islands, where geese are faced with a shortage of food. As a result, the number of geese in this area is low. The number of gulls is small on the island of Malaya Otmel because a substantial part of the island is covered with forest which is unsuitable for nesting by gulls.

Egg-laying by Herring Gulls lasted from mid-April until mid-May. Thus, Barnacle Goose incubation coincided with the gulls' nesting and brood-rearing period. Gulls stay on the islands until their juveniles fledge, and could predate goose nests throughout this period. However, the average clutch size of 4.95 ± 0.07 eggs for Barnacle Geese in the east of the Gulf of Finland was high and stable when compared with other Baltic areas, where nesting success varies depending on predation pressure from 2.67 ± 0.33 to 5.57 ± 0.10 eggs (Larsson & Forslund 1994; Kleefstra 2014).

Pressure from other types of predator is relatively low on the islands of the Gulf of Finland, although in exceptional cases Red Foxes *Vulpes vulpes*, Racoon Dogs *Nyctereutes procyonoides* or American Mink *Neovison vison* can reach the islands by walking over the ice in spring and stay for the summer. In some years, mink predation has been relatively high in the Helsinki Archipelago (Yrjölä *et al.* 2017). We never encountered mammalian predators, or signs of their presence, during our visits to the Barnacle Goose breeding islands in the Russian Baltic. White-tailed Eagles *Haliaeetus albicilla* and Hooded Crows *Corvus corone cornix* were also rare on the islands, whereas in other parts of the Baltic White-tailed Eagle numbers have recovered and become a common predator (Jonker *et al.* 2010; Yrjölä *et al.* 2017).

Average clutch size in the eastern Gulf of Finland was significantly larger than that in

many Russian Arctic regions as well. While this is probably due to reduced predation pressure, it could also be related to the shortening of the spring migration route, and hence reduced energy costs, which affect the reproductive output of Arctic geese (Drent *et al.* 2007; Hahn *et al.* 2011). Higher levels of nesting parasitism by conspecifics could be another reason for the high clutch size, since this has been observed for Baltic Sea island-nesting Barnacle Geese, where it is associated with a shortage of nesting and feeding sites (Larsson *et al.* 1995; Kleefstra 2014).

The seasonal decline in clutch size observed in our study is typical of many avian species. Parents may reduce clutch size late in the breeding season in response to declining food supplies available for rearing young (Perrins 1970; Murphy 1986). Reproduction is costly, so because offspring survival decreases over the season, birds reproducing later reduce their clutch size (Hussell 1972; Murphy 1986; Hochachka 1990). If offspring value declines seasonally, then parents should be less willing to pay the cost of producing an egg late in the season (Rowe *et al.* 1994). Variation among individual condition, combined with seasonal decline in offspring value, can potentially explain both the delay in onset of reproduction in some individuals and their subsequent small clutches (Rowe *et al.* 1994), patterns evident in other Barnacle Geese studies (Prop & de Vries 1993; Dalhaug *et al.* 1996).

Thus, Barnacle Geese in the eastern part of the Gulf of Finland breed later than in other Baltic areas, even compared with those in the neighbouring Helsinki area. Their clutch size is relatively high, probably because predator pressure and human disturbance are low and birds have reduced migration costs. In spite of the low predator pressure and high clutch size, the population remains small and population growth rate is slow due to the limited area of suitable local feeding areas (Kouzov *et al.* 2018).

In the Helsinki archipelago, Barnacle Geese start to breed in late April, but tourist activity starts later in the season. As a result, goose breeding densities do not differ between islands protected from tourist activity and unprotected islands (Yrjölä *et al.* 2017). In the Russian part of the Gulf of Finland, Barnacle Geese nest in May–July; the nesting period is long and coincides with the breeding period of gulls. Boat navigation in the area usually opens following the ice melt in May, and tourist activity thus coincides with the timing of breeding by geese and gulls, increasing the possibility of anthropogenic disturbance having an adverse effect on the breeding success of the geese. Gulls only predate Barnacle Goose eggs in nests without attendant parents, but when people disturb geese the birds may leave their nests for short periods, during which time the gulls can take one or more eggs. Breeding in gulls' colonies therefore could be especially dangerous for Barnacle Goose nesting success if people persistently disturb incubating geese during the gulls' breeding period.

St. Petersburg is the biggest city on the Baltic Sea and the Gulf of Finland is a popular place for recreation. Fishing, camping, boating, yachting and kayaking are the most common tourist activities on the

islands of the gulf. Until 2018, almost all the islands where the Barnacle Geese nest were in the border zone with Finland with very strict restrictions on public access. All people wishing to land on the islands had to justify their actions and obtain special permission to visit them, with the result that tourist activity was kept to very low levels. In 2018, the regulations were changed and now anyone can visit almost all the islands without permission. Because the unique natural landscapes are appealing to tourists, the gulf is attracting increasing tourist activity, which could have an adverse effect on Barnacle Geese nesting in the area.

In response, in late 2017, the "East Gulf of Finland Reserve" was established to protect eight out of the 18 islands where Barnacle Geese breed. However, conservation activities of this reserve have yet to have any effect, because the funding has not been allocated and staff not yet recruited. Moreover, the important breeding islands of Maly Fiskar, Tuman, Stoglaz, Gusiny and Nerva still have no protective status at the time of writing. The establishment of regional protected areas on these islands would compensate for the growth in recreation disturbance and infrastructure development that is currently occurring in the eastern Gulf of Finland, such as the Nordstream 2 gas pipeline and the development of a liquefied natural gas plant in Dalnaya Bay (Chusov *et al.* 2019). Special measures will be required to maintain the conservation regime of these reserves and protect breeding birds in the area (Cherenkov *et al.* 2016). We hope that management of the islands of the eastern Gulf of Finland will take into account the specific bird populations and environmental conditions to maintain biodiversity in the region.

Acknowledgements

We would like to thank ornithologists of the St. Petersburg State University and the Zoological Institute of Russian Academy of Science: Alexander Kondratyev, Vadim Vysotsky, Vladimir Fedorov, Valery Buzun, Sergey Rezvyi, Anna Gaginskaya, Anna Rychkova, Natalia Iovchenko and Georgy Noskov, who took part in the monitoring of the islands. We thank Nord Stream AG for the financial support and the Baltic Fund for Nature for organising the expeditions in 2010–2014. Special thanks go to the teams of the Centaurus-II, Mirabel, Manyana and St. Nicholas yachts, and of the SMN boat for the pleasant trips and to Konstantin Andreev for improving the style of the manuscript. Two anonymous referees made helpful comments on an earlier draft of the paper.

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