

First observations for 20 years of Brent Geese *Branta bernicla* wintering on the Shandong coast, China

Table S1. Details of Brent Goose surveys undertaken in the (a) offshore areas (> 2 km from shore) and (b) coastal areas (< 2 km from shore) areas of Lido Bay, Ailian Bay, Sanggou Bay, and Heini Bay (10–13 January 2023; 6–8 January 2024). Transect survey lines covered in offshore boat surveys are prefixed with S, and survey sections surveyed from shore are prefixed with L. Habitat types were classified into two categories: “Aquaculture”, which is characterised by obvious aquacultural features, such as floating buoys, and “Natural”, which consists of open water areas without fishing vessel activity. The survey recorded the number of Brent Geese and other waterbird species at each site, with other species mainly consisting of ducks, gulls, and swans. No other goose species were observed.

(a) Offshore

Region	Habitat type	Number of birds		Number of species	ID	Survey length (km)	Survey areas (km ²)	Date
		Brent Goose	Other birds					
Sanggou Bay	Aquaculture	1	0	1	S01	49	39	12 Jan 2023
		8	0	1	S02			
		5	2	2	S03			
		3	0	1	S04	53	54	13 Jan 2023
		1	0	1	S05			
		60	0	1	S06			
		2	0	1	S07			
		2	0	1	S08			
		35	0	1	S09			

Table S1 (continued).

Region	Habitat type	Number of birds		Number of species	ID	Survey length (km)	Survey areas (km ²)	Date	
		Brent Goose	Other birds						
Heini Bay		4	0	1	S10	53	54	13 Jan 2023	
		3	0	1	S11				
		83	0	1	S12	68	49	06 Jan 2024	
		2	0	1	S13				
		107	0	1	S14				
		34	0	1	S15				
		2	0	1	S16				
		8	0	1	S17				
		Aquaculture							
		Sanggou Bay		0	0	0	—	56	46
11	0			1	S18				
20	0			1	S19	47	44	08 Jan 2024	
4	0			1	S20				
5	0			1	S21				
42	0			1	S22				
1	0			1	S23				
Total in 2023				124	2		102	93	
Total in 2024				319			171	139	
Overall total				443	2		273	232	

Table S1 (continued).

(b) Coastal

Region	Habitat type	Number of birds		Number of species	ID	Survey length (km)	Survey areas (km ²)	Date
		Brent Goose	Other birds					
Lidao Bay	Natural	0	40	2	L01			
	Aquaculture	0	5	1	L02			
	Aquaculture	0	43	4	L03			
Ailian Bay	Natural	0	94	9	L04	24	15	10 Jan 2023
	Aquaculture	0	47	8	L05			
	Natural	0	129	7	L06			
Sanggou Bay	Natural	0	46	5	L07			
	Natural	0	137	5	L08			
	Natural	0	384	10	L09	40	12.5	11 Jan 2023
	Natural	0	51	9	L10			
Heini Bay	Aquaculture	0	59	6	L11			
Heini Bay	Aquaculture	0	33	9	L12			
	Natural	0	17	3	L13	6	5	12 Jan 2023
Heini Bay	Natural	0	26	2	L14			
	Natural	0	1	1	L15			
	Natural	0	21	4	L16	13	12.5	13 Jan 2023
Sanggou Bay	Natural	0	21	3	L17			
	Natural	0	252	8	L18			
Total (2023)		0	1,406			84	45	

Table S2. Historical records of Brent Geese from 17 provinces in China (from 1912 to January 2024). Data sources are based primarily on literature searches, conference reports, and birdwatching records. The data are separated into before 2002, 2002–2012 and 2013–2024 based on China’s Ecological Civilization Policy in 2012. Seasonal divisions are as follows (Sawa *et al.* 2020): winter (December–February of the following year); summer (June–August) and migration (spring: March–May; autumn: September–November). The data are arranged according to location (ID), season, duration, type (offshore: >2 km from shore; coastal ≤ 2 km from shore; or inland) and provinces from north to south. Locations for each ID code are illustrated in Fig. S2. The “**Delete or not**” column indicates whether **duplicate** records from the same area in the same season were deleted, or others **excluded** (*i.e.* uncertain reports where the date/time were not documented, records away from wetlands, or summer records).

ID	Season	Duration	Type	Province	Time	No. Brent Goose counted	Site name	Reference	Delete or not
1	Winter	Before 2002	Coastal	Shandong	1992	10,000	Changdao Island	*1	
2				Shandong	Feb 1993	1,200	Changdao Island	*2	
3				Shandong	1998	203	Swan Lake, Rongcheng	*3	
4				Shandong	Dec 2001	1	Rongcheng Whooper Swan Nature Reserve	*4	
5				Jiangsu	Jan 1990	46	Sheyang Salt Works	*2	
6				Fujian	Feb 1912	1	Fuzhou Area	*5	
7			Inland	Hunan	Jan 1986	1	Waterbird Island, Hengyang	*6	
8		2002–2012	Coastal	Hebei	Feb 2003	1	Beidaihe, Qinhuangdao	*4	
9				Taiwan	Dec 2012	1	Yilan County, Su’ao Township	*	
10			Inland	Hebei	Jan 2006	1	Bayi Reservoir, Xingrai	*7	
11				Hubei	Jan 2010	1	Danjiangkou Reservoir	*4	
12		2013–2024	Offshore	Shandong	Jan 2023	124	Sanggouw Bay, Weihai	This survey	
13					Jan 2024	319	Sanggouw Bay, Weihai	This survey	

Table S2 (continued).

ID	Season	Duration	Type	Province	Time	No. Brent Goose counted	Site name	Reference	Delete or not
14	Winter	2013–2024	Coastal	Liaoning	Feb 2022	1	Dawangjia Island, Zhuanghe	*4	
15				Liaoning	Feb 2023	1	Dawangjia Island, Zhuanghe	*4	
16				Shandong	Feb 2013	1	Weihai	*4	
17				Shandong	Feb 2021	1	Liangcheng Estuary Wetlands, Rizhao	*4	
18				Shandong	Feb 2021	1	Liangcheng Street, Rizhao	*4	Duplicate
19				Zhejiang	Jan 2015	1	Yongqiang Coast, Wenzhou Bay	*4	
20				Fujian	Jan 2024	1	Zhuoqi NeiHu, Longhai District, Zhangzhou	*4	
21				Fujian	Feb 2024	1	Zhuoqi NeiHu, Longhai District, Zhangzhou	*4	Duplicate
22				Guangdong	Feb 2019	1	Santouzui Beach, Xitou Village, Yangxi County	*4	
23				Guangdong	Feb 2019	1	Santouzui Beach, Xitou Village, Yangxi County	*4	Duplicate
24			Inland	Henan	Dec 2018	1	Henan Yellow River Wetland National Nature Reserve	*8	
25				Anhui	Dec 2023	1	Shijiu Lake, Ma'anshan	*4	
26				Anhui	Jan 2017	1	Caizi Lake, Anqing	*9	
27				Jiangxi	Jan 2023	30	Poyang Lake, Jiujiang	*4	
28				Jiangxi	Dec 2022	1	Yongxiu, Jiujiang	*4	Duplicate

Table S2 (continued).

ID	Season	Duration	Type	Province	Time	No. Brent Goose counted	Site name	Reference	Delete or not
29	Spring	Before 2002	Coastal	Hebei	May 1992	6	Beidaihe Natural Ecological Park	*5	
30				Hebei	May 1995	20	Happy Island	*5	
31				Hebei	May 1995	2	Happy Island	*5	Duplicate
32			Inland	Heilongjiang	May 1997	1	Zhalong Nature Preserve	*5	
33		2002–2012	Coastal	Liaoning	May 2010	17	Yalujiang Estuary	*10	
34				Liaoning	Apr 2008	5	Shicheng Islands, Zhuanghe	*4	
35				Shandong	May 2002	1	Yellow River Delta National Nature Reserve	*11	
36				Shandong	May 2010	1	Liugong Island, Weihai	*4	
37		2013–2024	Coastal	Liaoning	Apr 2018	1	Dawa District, Panjin	*5	
38				Liaoning	Apr 2020	1	Dongfang Wetland Park, Linghai, Jinzhou	*4	
39				Liaoning	May 2013	4	Jinshitan Sea-farming Pond	*5	
40				Zhejiang	Mar 2016	3	Xixi National Wetland Park, Hangzhou	*4	
41				Guangdong	Apr 2023	1	Bangdong Park, Panyu District, Guangzhou	*4	
42			Inland	Inner Mongolia	Apr 2020	1	Haolibao Wetland, Hulun buir	*4	
43				Jilin	Apr 2018	1	Moon Island, Erdao District, Changchun	*4	
44				Beijing	May 2018	2	Central Island, Beijing Sun Park	*5	
45				Beijing	Apr 2014	1	Huairou Reservoir	*5	
46				Beijing	Apr 2014	1	Huairou Reservoir	*5	Duplicate

Table S2 (continued).

ID	Season	Duration	Type	Province	Time	No. Brent Goose counted	Site name	Reference	Delete or not
47	Autumn	2013–2024	Coastal	Liaoning	Nov 2021	1	Sea Melody, Zhongshan District, Dalian	*4	
48				Shandong	2014	50	Yellow River Delta National Nature Reserve	*12	
49	Winter	2013–2024	Inland	Shaanxi	Dec 2021	12	Tian Gu Seven Road, Xi'an	*5	Excluded
50	Spring	2002–2012	Inland	Guangdong	May 2006	1	Guangdong	*4	Excluded
51		2013–2024	Inland	Beijing	May 2017	2	Temple of the Sun Park	*5	Excluded
52				Hebei	Mar 2022	5	Baoding	*5	Excluded
53	Summer	2002–2012	Coastal	Liaoning	Jun 2007	1	Pikou Port, Pulandian District	*4	Excluded
54				Shandong	Aug 2005	1	Qingdao	*4	Excluded
55		2013–2024	Coastal	Hebei	Jun 2014	1	Happy Island	*5	Excluded
56			Inland	Hebei	Jun 2014	2	Wuling Mountain NNR	*5	Excluded
57				Jiangxi	Jun 2016	1	Jiangxi Agricultural University, Nanchang	*4	Excluded
58	–		Inland	Henan	2007	16	Eastern Section of the Yellow River Wetland	*13	Excluded

References: *1 = Fan 2001, *2 = Waterbird Specialist Group of the Chinese Ornithological 1994, *3 = Yan 1999, *4 = Bird Report website in China (<http://www.birdreport.cn>), *5 = ebird website (<https://ebird.org/home>), *6 = Zhong & Chen 1989, *7 = Wu & Zhao 2006, *8 = Guo *et al.* 2020, *9 = Wu & Gu 2017, *10 = China Coastal Waterbird Census Group 2015, *11 = Zhang 2012, *12 = Sun *et al.* 2015, *13 = Zhai 2009.

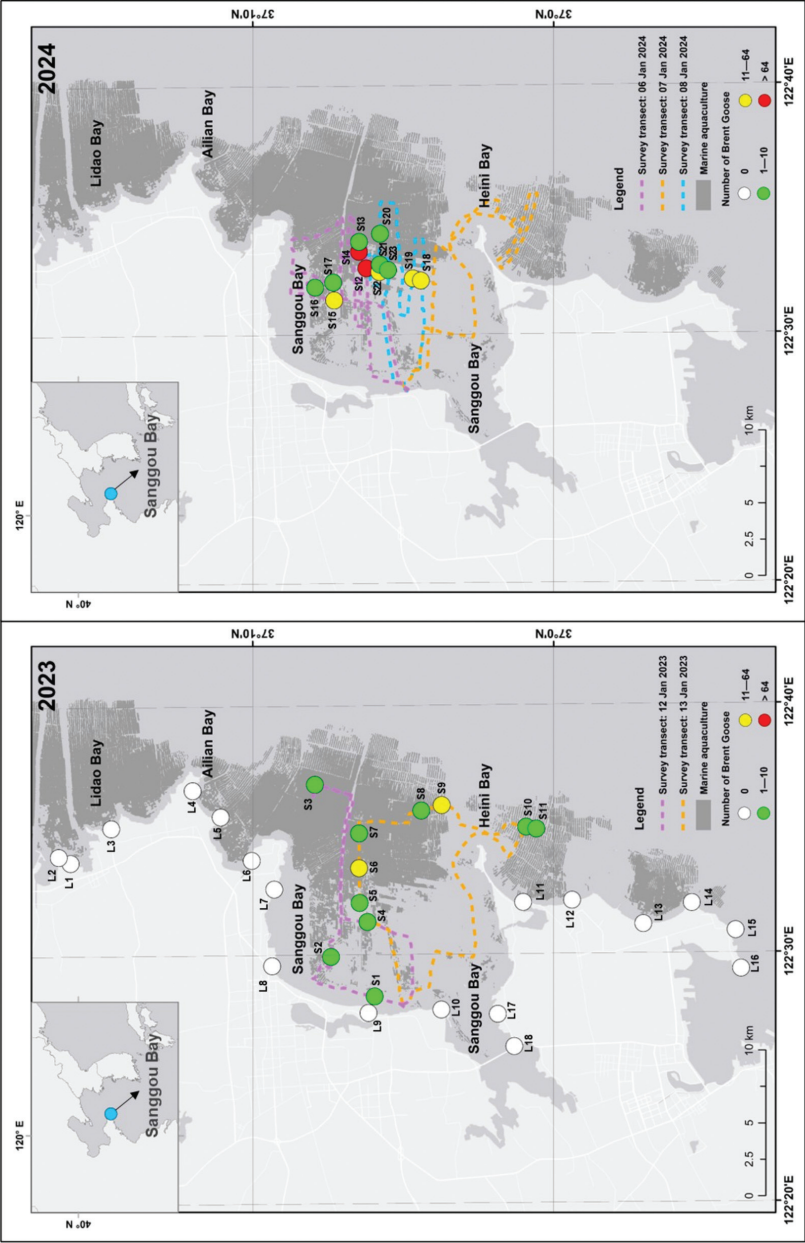


Figure S1. Counts and distribution of wintering Brent Geese surveyed in the coastal waters (10–13 January 2023, L01–L18) of Lidaao Bay, Ailian Bay, Sanggou Bay and Heini Bay of Rongcheng, Shandong Province, and offshore waters of Sanggou Bay and part of Heini Bay (10–13 January, 2023; 6–8 January, 2024), China. Numbers near the markers correspond to the ID column in Supporting Materials Table S01. Left: 2023 offshore boat transects on 12 January (purple line; 49 km long) and 13 January (orange line; 53 km long) in the northern and southern portions of Sanggou Bay, respectively (Sites: S01–S11). Right: offshore boat transects on 6 January (purple line; 68 km long), 7 January 2024 (orange line; 56 km long), and 8 January 2024 (blue line; 47 km long) in the northern, southern, and middle portions of Sanggou Bay, respectively (Sites: S12–S23).

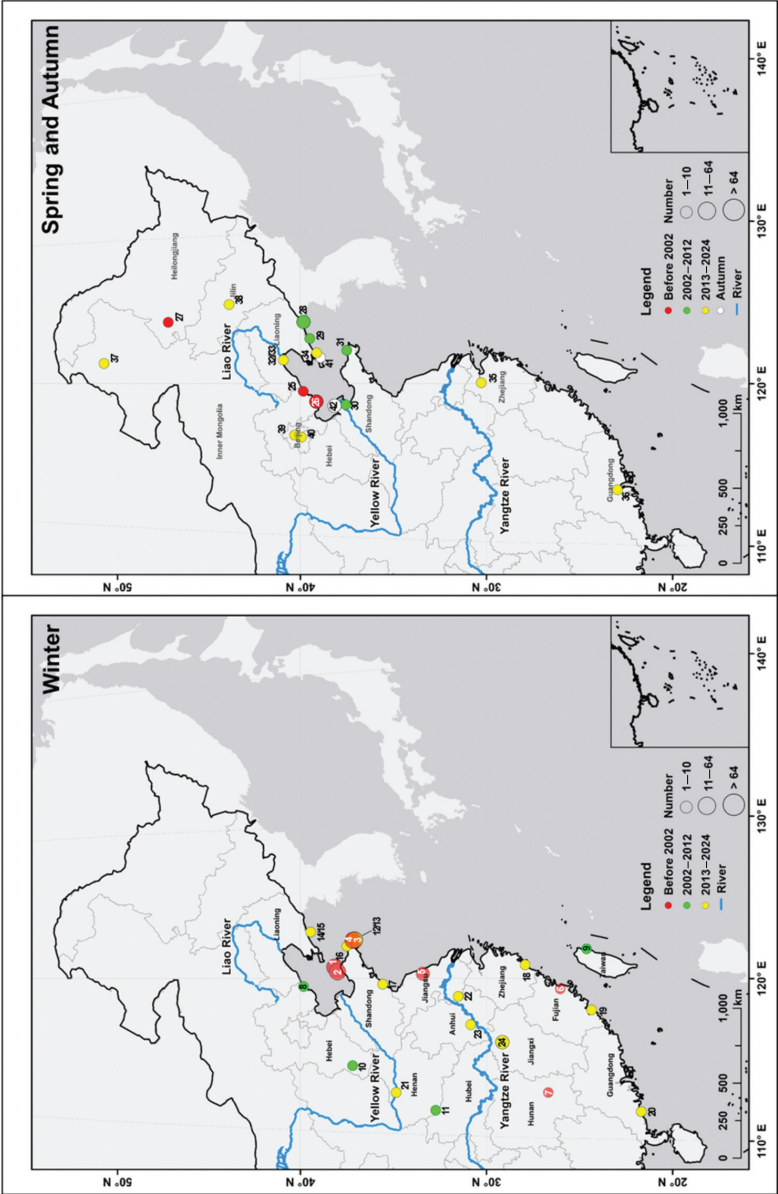


Figure S2. Distribution of Brent Goose observations in winter, spring and autumn in China from 1912 to January 2024 ($n = 42$). The winter distribution sites are shown on the left ($n = 24$). Latitude range: 21.675°–39.843°N. Red solid dots: Distribution records before 2002 ($n = 7$). Green solid dots: distribution records from 2002–2012 ($n = 4$). Yellow solid dots: distribution records from 2013–2024 ($n = 13$). The spring and autumn distribution sites are shown on the right ($n = 18$). Latitude range: 22.974–50.751°N. Spring data: red solid dots = distribution records before 2002 ($n = 3$); green solid dots = distribution records from 2002–2012 ($n = 4$); yellow solid dots = distribution records from 2013–2024 ($n = 11$). Autumn data: white circles ($n = 2$, 2013–2024). Small: 1–10 individuals; medium: 11–64 individuals; large: > 64 individuals. Number near the markers corresponds to the ID column in Supporting Materials Table S2. Data details are also available in Supporting Materials Table S2.



Figure S3. Brent Goose habitat in Sanggou Bay ($n = 2$), at Site S12 on 6 Jan 2024. The Brent Geese were all observed in the aquacultural areas of Sanggou Bay, where they were seen both swimming and flying. Photograph by Jing Zhang.



Figure S4. Sweet Kelp *Saccharina japonica* aquaculture in Shandong Province. The kelp is characterised by its large thalli, thick leaves and high nutritional content. It grows in shallow marine waters within the 20 m isobath. The kelp seedling period begins in August every year and ends in early November, with sowing taking place in late November. Harvesting is carried out from April to October. The raft cultivation method involves suspending kelp on seed ropes on both sides of the floating rafts from which it grows downward (Yan 2021). Photograph by Jing Zhang.



Figure S5. Brent Goose at Poyang Lake in Jiangxi Province, China, on 5 January 2023. Photograph by Binshao Lv.

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