

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

XIAOTONG LV<sup>1,2,#</sup>, QINGSHAN ZHAO<sup>1,#,\*</sup>, MENG DAN FEI<sup>1</sup>,  
YUSUKE SAWA<sup>3</sup>, TOSHIO IKEUCHI<sup>4</sup>, GUOXU YU<sup>5</sup>, JIN ZHANG<sup>6</sup>,  
FANJUAN MENG<sup>1</sup>, JING ZHANG<sup>1,2</sup>, YONG ZHANG<sup>7</sup>, YANBO XIE<sup>8</sup>,  
LEI CAO<sup>1,2</sup> & ANTHONY D. FOX<sup>9</sup>

<sup>1</sup>State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China.

<sup>2</sup>University of Chinese Academy of Sciences, Beijing 100049, China.

<sup>3</sup>Yamashina Institute for Ornithology, 115 Konoyama Abiko, Chiba 270-1145, Japan.

<sup>4</sup>Head office of “Foster a Goose Program”, Miyagi 989-6315, Japan.

<sup>5</sup>Changdao National Marine Park Management Center, Shandong 265899, China.

<sup>6</sup>Changdao National Nature Reserve Management Center, Shandong 253399, China.

<sup>7</sup>Co-Innovation Center for Sustainable Forestry in Southern China,

College of Life Sciences, Nanjing Forestry University, Nanjing 210037, China.

<sup>8</sup>Department of Modern Physics, University of Science and Technology of China, Hefei 230026, China.

<sup>9</sup>Department of Ecoscience, Aarhus University, C.F. Møllers Allé 8, DK-8000 Aarhus, Denmark.

#Joint first authors. \*Correspondence author. E-mail: qszhao@rcees.ac.cn

## Abstract

The East Asian Brent Goose *Branta bernicla nigricans* population is currently estimated at 5,000–8,700 individuals (just *c.* 1% of all Brent Geese *B. bernicla* globally) and is designated by the Conservation of Arctic Flora and Fauna (CAFF) as a priority species for conservation on the East Asian-Australasian Flyway (EAAF). Wintering numbers are concentrated in Japan (where *c.* 2,500 individuals occur, with an increasing trend), but numbers currently in China (estimated at 5,000 two decades ago) are unknown, emphasising the need for an updated assessment of their abundance and distribution there. A Brent Goose caught in Japan was tracked for five months as it wintered on Sanggou Bay in Shandong Province, confirming this area as a wintering site occupied by the population. Coastal and offshore surveys of Sanggou Bay in January 2023 and 2024 found up to 319 Brent Geese in offshore waters (124 in 2023; 319 in 2024), foraging in aquaculture areas > 2 km from the coastline. As these numbers exceed 1% of the East Asian Brent Goose population (*i.e.* > 65 individuals), Sanggou Bay

qualifies as a site of international importance for the species. The Brent Geese were seen feeding on algal growth within Sweet Kelp *Saccharina japonica* and oyster (Ostreidae) aquaculture infrastructure and were rarely disturbed by kelp and oyster farmers (who are active mainly in summer), so were subject to almost zero human disturbance. A literature review of Brent Goose distribution and abundance during 1912–2024 suggested that the population historically wintered in the coastal waters of Shandong and Jiangsu Provinces, with up to 10,000 individuals recorded (before 2002), but reports were of < 10 birds present during 2002–2012. Despite our observations, and those documented since 2012, we suspect that fewer Brent Geese winter in China now than two decades ago. We recommend that the Sanggou Bay offshore area be protected and a national survey undertaken, both of the geese and their food resources (e.g. subtidal eelgrass *Zostera* sp. areas in the Yellow and Bohai Seas) to confirm their distribution, with long-term monitoring put in place for sites where they occur. Restoration of natural seagrass habitats around Changdao Island, Shandong Province (where the Bohai Sea and Yellow Sea meet), which supported the largest numbers historically, is also needed to attract Brent Geese to winter there again.

**Key words:** Brent Geese, habitat status, field survey, Sanggou Bay, wintering area.

The Brent Goose *Branta bernicla* has a global population of approximately 550,000–640,000 individuals, consisting of three subspecies: the Dark-bellied Brent Goose *Branta bernicla bernicla*, Light-bellied Brent Goose *B. b. brota* and Pacific Brent Goose (or Black Brant) *B. b. nigricans*. *B. b. bernicla*, which winters primarily in Western Europe was estimated at *c.* 200,000–280,000 individuals in 2000–2010, and is currently declining in numbers. *B. b. brota*, which winters in the eastern United States and Ireland, has a population of *c.* 200,000 (1999–2011) showing an increasing trend. *B. b. nigricans* winters along the Pacific coast of North America and East Asia and has a population of *c.* 161,000 (2000–2015), with a declining trend (Wetlands International 2012, 2023a; Sedinger *et al.* 2019; Lewis *et al.* 2020; BirdLife International 2024; Wilson

*et al.* 2024). The East Asian population of *B. b. nigricans* is relatively small at *c.* 5,000–8,700 individuals, and accounts for only 1% of Brent Geese globally. The Conservation of Arctic Flora and Fauna (CAFF) prioritises the Brent Goose as a species of concern in the East Asian-Australasian Flyway (EAAF), identifying an understanding of its distribution and population as an urgent need in East Asia (Wetlands International 2012; CAFF 2019).

In East Asia, wintering Brent Geese occur in four countries: North Korea, South Korea, Japan and China. The largest number recorded on the Korean Peninsula amounted to approximately 550 birds (*c.* 400 in South Korea, January 2001; *c.* 150 in North Korea, November 2018), with fewer individuals reported more recently. Since its highest counts of *c.* 400 individuals made about 20

years ago, numbers in South Korea have gradually declined, and in the last decade (2013–2023) the highest record was of 10 birds, mainly reported from coastal areas (Moore 2017; Wetlands International 2012; National Institute of Biological Resources 2004–2019; Sawa *et al.* 2020; Andreas 2023). Between 2019 and 2023, the highest count in coastal and offshore North Korean waters was 155 (in 2018), although continuous, systematic survey data are lacking (Moore 2018; Wetlands International 2023b). There are currently *c.* 2,500 Brent Geese in Japan, which compared with around 500 reported in the winter of 1998/99 and about 1,000 in 2018/19, shows a slow upward trend, mainly concentrated in coastal areas (1998/99–2018/19; Fujii 2017; Sawa *et al.* 2020). According to E.E. Syroechkovskiy Jr., China historically supported *c.* 2,500–5,700 Brent Geese, but their distribution was unknown and, because of the massive changes to intertidal areas of the China coastline, they faced a real risk of extinction (Syroechkovskiy 2006; Wetlands International 2012). In summary, wintering Brent Geese in East Asia were almost entirely confined to coastal areas, primarily concentrated in Japan and China. However, data on the number and distribution of Brent Geese within China are based on studies conducted 20 years ago, which urgently need updating.

From 2014 to 2017, surveys of Brent Geese conducted nationwide in Japan revealed that their numbers were highest in spring and autumn, reaching around 9,000 individuals, significantly more than were counted in winter (2,500–3,000 individuals, Fujii 2017). Fujii (2017) therefore speculated

that some of the Brent Geese stopping in Japan during the autumn might continue migration to winter in China and South Korea, although evidence for this was lacking. The latest Brent Goose satellite tracking data from Japan indicated that one individual wintered in the offshore area of Weihai, Shandong Province, China, staying there for up to five months from November 2021 to April 2022. This instigated a joint research project involving China and Japan, which conducted coastal and offshore surveys in Sanggou Bay and its surrounding areas in Shandong Province during January 2023 and January 2024, to obtain data on the numbers, distribution and habitat use of Brent Geese in the region. Additionally, we compiled historical data from the literature on the abundance and distribution of Brent Geese in China between 1912 and 2024 to provide a scientific basis for the effective protection of this species.

## Methods

### Goose tracking data and home range analysis

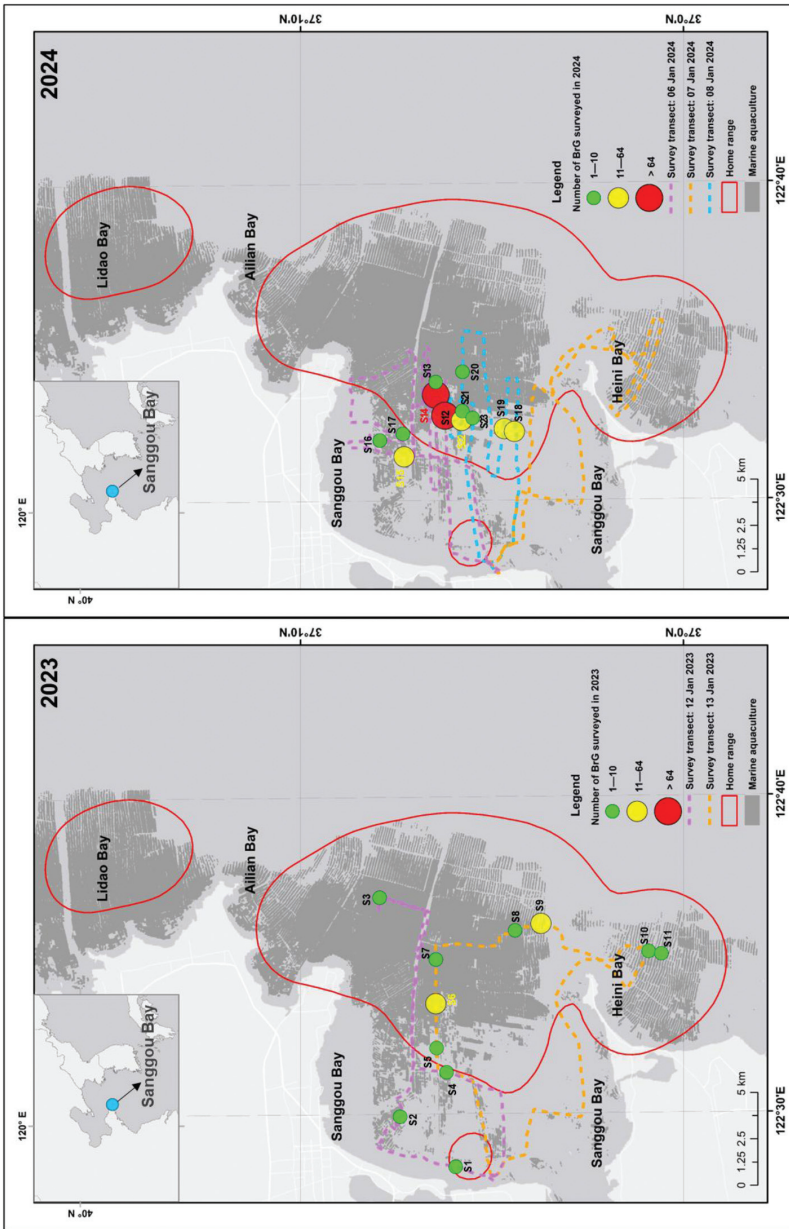
A total of 20 Brent Geese were captured in Japan and fitted with GPS tags: 12 in 2018 and 8 in 2021 (Sawa *et al.* 2020; Y. Sawa, pers. comm.). Detailed tracking data for a full winter was obtained for one tagged Brent Goose, captured at Notsuke Bay in eastern Hokkaido, Japan (43.58°N, 145.23°E) on 5 November 2021, that continued migration to China. The tagged bird was fitted with a neck band type transmitter, Flex II (21 g including the device and attachment materials, Druid Technology Co., Ltd.), which recorded one GPS location every 2 h and transmitted

data via the GSM mobile networks once a day. The collared Brent goose stayed in Sanggou Bay from 28 November 2021 to 30 April 2022. At that time, we had no further information on the distribution of geese in the bay. To facilitate the development of day-time survey plans, we extracted only those day-time GPS positioning points in the tracking data which indicated that the goose was not flying on determining its home range, so that the survey could cover areas used by the tagged individual and other geese in the vicinity more effectively. Movements of this bird were determined from the GPS locations, with ground speeds between consecutive locations, and the distance travelled was calculated using the “distHaversine” function of the R package *geosphere*, which calculates the shortest distances between locations using the great circle-distance method to quantify horizontal distance (Hijmans 2023). Prior to analysis, GPS fixes that we assigned to flying status (defined as speeds > 1.11 m/s, this threshold being considered relatively precautionary, based on Gudmundsson *et al.* 1997) were excluded from the dataset. To obtain the local solar position (relative to horizon) for each GPS fix we used the latitude, longitude and time of each GPS fix in the “getSunlightPosition” function of the R package *suncalc* (Thieurmel & Elmarhraoui 2019). Nocturnal GPS fixes (local solar position < 15°) were excluded from the dataset, and we created 95% home range estimates based only on diurnal GPS fixes using the “hr\_kde” function (Kernel density estimation with the default bandwidth) of the R package *amt* (Signer *et al.* 2019; Signer & Fieberg 2021).

## Field survey

Based on tracking data of the one collared bird in 2021 and historical information of Brent Geese (see below), a survey was conducted in Sanggou Bay and its surrounding areas, near Rongcheng and Weihai in Shandong Province (Fig. 1). The survey included shoreline point counts (binocular observations extending 2 km from the shore) in the four bays (Lidao, Ailian, Sanggou and Heini) in 2023 and offshore boat counts (20 ton boat in both years, with binocular observations made from the boat following transects > 2 km from the shore) in Sanggou Bay and northern Heini Bay in 2023 and 2024. Sanggou Bay is a semi-closed bay with an area of 143 km<sup>2</sup>, approximately 70% of which is used for aquaculture, located at the eastern end of the Shandong Peninsula (37.02°–37.15°N, 122.35°–122.58°E; China State Oceanic Administration 1991; Yang 2018). Artificial marine aquaculture covers 27% of Sanggou Bay, with the Oyster *Ostreidae* and Sweet Kelp *Saccharina japonica* beds representing *c.* 40% and 30% of the total artificial marine aquaculture area, respectively (Wang 2010; see also Fig. 1).

The coastline of Sanggou Bay juts into the Yellow Sea and is surrounded by land on the north, west and south, with its mouth extending from Shuangdao (37.148°N 122.575°E) in the north to Chudao in the south (37.042°N 122.572°E, Fig. 1). The bay is situated in the East Asian monsoon region and experiences a typical maritime climate with abundant summer rainfall and mild winter temperatures. The average temperature is around 12°C (highest in August, average 24°C; lowest in January, average –2.8°C).



**Figure 1.** Numbers and distribution of wintering Brent Geese found at Sanggou Bay, near Rongcheng and Weihai in Shandong Province, China during the surveys in 2023 and 2024, together with the home range of the GPS-tracked individual. Red polygon = the 95% kernel density for the home range of the tagged during November 2021 to April 2022. Orange dashed lines = survey transects. Circles = location of the boat when Brent Geese were observed. Colours and numbers of Brent Goose counted from each location are as follows: green (small) = 1–10; yellow (medium) = 11–64; red (large) = > 64 birds. Codes correspond to the ID column in Supporting Materials Table S1. Distribution of marine aquaculture activity (grey shading) is derived from Fu *et al.* (2021).

There is generally minimal winter icing in the bay, with average annual sea surface temperature 13.9°C (lowest in February, 2°C; highest in August, 26°C; China State Oceanic Administration 1991). The mild winter climate provides favourable conditions for wintering Brent Geese.

From 10–14 January 2023, we surveyed coastal waters of Sanggou Bay on the Shandong Peninsula by car and offshore waters by boat. From 6–8 January 2024, a boat survey was conducted in the same offshore waters of this bay. The latitude of the surveys ranged between 36.896°–37.268°N. The total linear length of the coastal and offshore surveys was approximately 356 km, including 83 km from shore (L01–L18 in Supporting Materials Fig. S1) and 273 km offshore (2023: S01–S11, 102 km; 2024: S12–S23, 171 km, in Fig. 1; Supporting Materials Table S1 and Fig. S1). For the coastal survey, we followed the approach of Cao *et al.* (2008) and used satellite images, local knowledge and tracking data to identify key survey areas for counting Brent Geese at distances up to 2 km from shore. For the offshore survey, we planned to use strip-transect techniques following Komdeur *et al.* (1992), but due to the size of the aquaculture area and the size of the vessels used, we were restricted by the areas we could access by boat. We recorded all birds out to 500 m on each side of the boat. In ArcGIS 10.7, we created a buffer zone of 500 m on both side of the offshore survey tracks to ensure that any overlapping areas were only counted once. The total coverage area of the two surveys was  $\approx 195 \text{ km}^2$ : 45 km<sup>2</sup> on coastal waters within 2 km of the shore; 150 km<sup>2</sup> at sea (with some overlap of areas covered in 2023 and 2024),

of which 75% (108/143 km<sup>2</sup>) of the survey area was within Sanggou Bay (see Supporting Materials Table S1). The survey focused on Brent Geese, but included all observed waterbird species, their GPS locations, and any disturbances encountered. Photographs of Brent Geese and their habitats were also taken. We identified birds within two habitat types: aquaculture areas (Aquaculture) with distinct features, such as floating buoys, and natural (Natural) without any signs of aquaculture.

According to the Ramsar Convention, the 1% criterion for the East Asian Brent Goose population is 65 individuals (Wetlands International 2012). If the survey found > 65 individuals, Sanggou Bay could be considered as internationally important wintering habitat for the subspecies on its East-Asian Australasian Flyway (Mundkur & Langendoen 2022).

### Review of historically documented numbers and distributions

For this literature review we collected and examined observation records, published papers (mainly in Chinese), report documents and unpublished reports, to compile a historical account of the abundance and distribution of the Brent Goose in China from 1912 to January 2024 (data sources are listed in Supporting Materials Table S2). In cases where there were multiple records from the same locations during the same season of the same year, the maximum value was extracted. If the reported numbers were the same, on nearby dates, only one record was recorded in the database. A total of 56 records were obtained, and after removing six duplicate records from the same area in



the same season, and also excluding 10 uncertain records (reports where the date/time were not documented, records away from wetlands, and summer records), 40 records remained, involving 35 locations in 17 provinces (Supporting Materials Table S2 and Fig. S2).

The data were divided into two periods: before and after 2002. In 2012, China implemented its “Ecological Civilisation Policy”, which has implications for nature conservation, so the records from 2002 to 2024 were further divided into 2002–2012 and 2013–2023 (Huan 2023). The annual cycle was split into four periods: winter (December–February of the following year), spring migration (March–May), autumn migration (September–November), and summer (June–August) (Sawa *et al.* 2020). Excel 2019 and ArcGIS 10.7 software (ESRI 2019) were used for data processing and mapping, respectively.

## Results

### Goose tracking data and home range analysis

Of 20 Brent Geese captured during autumn in Japan, one wintered in China, another in North Korea, and 18 in Japan. The individual in China wintered in Sanggou Bay and the surrounding area for 153 days and exploited a home range area (estimated from the non-flight diurnal GPS fixes) of 222 km<sup>2</sup> (Fig. 1).

### Field survey

In January 2023, no Brent Geese were observed from the 18 coastal survey points (L01–L18; see Fig. S1). During the offshore boat survey, 124 Brent Geese individuals

were recorded distributed between 11 points, with counts ranging from 1–60 individuals (Supporting Materials Table S1, Fig. S1). Two points had counts of > 10 individuals (35 at S06, 60 at S09; Supporting Materials Table S1). The closest Brent Geese to the coastline were at point S01, *c.* 0.8 km from the shore, while the rest were > 2 km from the coast, and the furthest were 12 km from land (Fig. 1).

In January 2024, a total of 319 Brent Geese were recorded at 12 points in flocks ranging from 1–107 individuals on the boat survey in the offshore areas of Sanggou Bay. Counts at two points exceeded 64 individuals (83 at S12, 107 at S14; Supporting Materials Table S1). All observation sites were > 2 km from the coast and the birds were too distant to be observed from shore (Fig. 1).

All observations of Brent Geese were made within the aquaculture area (Supporting Materials Table S1, Fig. S3), and primarily concentrated in the central region of Sanggou Bay in both years. Local residents confirmed that the central part of Sanggou is mainly used for cultivating oysters and that the northern area was mainly used for kelp cultivation in 2024 (Supporting Materials Fig. S4), though aquaculture conditions in the area may vary from year to year.

No boats or fishermen were recorded in the 2023 coastal and offshore survey (site points survey duration = 9 h; transect survey duration = 7 h). In 2024, however, Brent Geese were observed floating near 12 boats with 14 fishermen which caused no disturbance to the geese (survey duration = 16.5 h). The average distance from the fishing boats to the geese was 120 m (s.d. = 61, range = 20–200 m, *n* = 12).

In 2023, the Brent Geese ( $n = 124$ ) were observed swimming (12%) and flying (88%), with the geese at locations S06 and S09 all seen to be in flight, perhaps passing through. In 2024, of the Brent Geese ( $n = 319$ ) observed, 90% were seen swimming and 10% flying, with the geese seen at S12, S14 and S22 all swimming on the water.

### Historical numbers and distributions

Non-systematic records of Brent Geese were primarily concentrated during the wintering period. Over the past 30 years, Brent Geese have been reported in 17 provinces, including eight coastal provinces (from Liaoning to Guangdong, stretching north to south along the Chinese coastline) and nine inland provinces. Hebei includes coastal and inland records (Supporting Materials Table S2). Before 1986, there was only one record documented from Fujian in 1912.

During the wintering period from 1986 to 2002, records of Brent Geese were mainly distributed in Shandong, where numbers observed decreased from 10,000 individuals (at Changdao) in 1992 to just one in 2001. Brent Geese were recorded once in other coastal provinces (Jiangsu, 46 individuals in 1990) and one inland province (Hunan, one individual in 1986). Thus, before 2002, the distribution was limited to three provinces, with numbers peaking at 10,000 individuals. From 2002 to 2012, only one individual was recorded in two coastal provinces (Hebei and Taiwan) and inland in two provinces (Hebei and Hubei). Consequently, during this period, the distribution was limited to three provinces, where numbers were less than ten. From 2013 to January 2024, there were 13 records from five coastal provinces

(Zhejiang, Fujian and Guangdong, each with single individuals; in Liaoning, single individuals were recorded twice, with the maximum records in two areas of Shandong, Rizhao with one and Weihai with 319) and three inland provinces (Henan, one individual; in Anhui, single individuals were recorded twice and a maximum of 30 individuals in Jiangxi). Therefore, during this period, the distribution expanded to eight provinces, numbering fewer than 500 individuals. In summary, Brent Geese seemed to winter primarily in coastal areas of Shandong and Jiangsu but have occurred sporadically in the inland province of Jiangxi and elsewhere. Given the decline in wintering numbers in Shandong, it would appear that the numbers wintering in China decreased from 10,000 individuals (before 2002) to < 10 individuals (from 2002–2012), but with a slight increase in the last decade, although our observations at Shandong suggest that there are still < 500 individuals at the present time.

During migration periods, compared to just two autumn records, there were 16 records of Brent Geese in China in spring. The maximum number recorded during the spring migration period was 20 individuals (Cornell Lab of Ornithology 2022), and the maximum recorded during the autumn migration was 50 individuals (Sun *et al.* 2015), but the number of sites used during the spring exceeded those used in autumn.

## Discussion

### Distribution of Brent Geese in Shandong and relationships with eelgrass *Zostera* sp.

In 2023, our surveys located a record flock of 124 overwintering Brent Geese in the



offshore waters of Sanggou Bay and Heini Bay, Shandong Province, China, with 319 counted in the same area in 2024. According to the criteria for describing sites of international importance for the East Asian Brent Goose population (*e.g.* holding 1% of the total populations, for which  $n = 65$  individuals), the offshore areas of Sanggou Bay qualify as an internationally important wetland for the geese. All Brent Geese were located  $> 2$  km from the coastline and were evenly distributed within the aquaculture area (except for one bird at point S01, Fig. 1). Typically, oyster and kelp farmers are active in the aquaculture area, for instance at infrequent intervals harvesting seaweed and clipping seedlings, when the wintering geese are not present. During our observations, some Brent Geese were observed near working boats (at *c.* 20 m from them), and the farmers showed no animosity towards the geese. We speculate that the Brent Geese experience very little human disturbance and have become habituated to their benign presence, leading them to maintain a relatively close distance to boats and farmers on the water.

These observations represent China's largest recorded aggregation of Brent Geese witnessed in the past 20 years. Overwintering Brent Geese are often associated with dense eelgrass beds, particularly Common Eelgrass *Zostera marina* in North America (Daniels *et al.* 2019; Elkinton *et al.* 2013), feeding on *Z. marina* in both natural and aquaculture areas in Japan (Shimada *et al.* 2020), whereas in Europe they primarily feed on *Z. marina* and Dwarf Eelgrass *Z. noltii* (Nacken & Reise 2000). Interestingly, Sanggou Bay is the site of

one of China's major eelgrass meadows, dominated by *Z. marina* (Zheng *et al.* 2013), but recent studies suggest a decline due to nitrogen eutrophication of coastal regions (Yang *et al.* 2018). Several studies have employed remote sensing techniques to map seagrass bed distribution, revealing an estimated 8.1 km<sup>2</sup> of seagrass meadows along the Shandong Province coastline (encompassing the Bohai and Yellow Seas), while seagrass beds are also present in the more northerly regions of Liaoning (6.2 km<sup>2</sup>) and Hebei (24.9 km<sup>2</sup>; Li *et al.* 2022). Utilisation in these areas is however restricted throughout the winter season due to sea ice cover (Yan *et al.* 2024). We propose to learn more about this, and the overwintering foraging dynamics of Brent Geese, in future studies.

In 2023, most Brent Geese were seen in flight, whereas the majority of birds observed in 2024 were swimming whilst foraging on the water. In both years, their distribution was associated with the oyster and kelp aquaculture areas of Sanggou Bay, where they also fed. This may suggest that they primarily feed on seaweed associated with the kelp, most likely preferring naturally occurring seaweed species with lower fibre content, such as Sea Lettuce *Ulva lactuca* growing in association with floating buoys and rope infrastructure (Supporting Materials Fig. S3), although we cannot exclude the possibility they are feeding on floating vegetation (potentially also including seagrasses) trapped in the aquaculture infrastructure.

There is a diversity of seaweed species including *Sargassum* which also grow in the oyster and kelp aquaculture areas of Sanggou Bay, besides the kelp. Whatever the

precise diet of the Brent Geese, according to the tracked individual who stayed here for 5 months, the area can provide a certain number of Brent Geese with overwintering food. For this reason, despite the artificial nature of the wintering food supply, we suspect that the aquaculture areas of Sanggou Bay provides a stable and predictable wintering habitat for Brent Geese at present, although evidently not in the numbers which the area sustained in the recent past. Considering that the numbers wintering in China have been < 500 individuals for the past decade, we recommend investigating the diet of these birds in these areas and establishing some degree of winter site protection to cover this important offshore area in Sanggou Bay.

During the coastal survey in Sanggou Bay, no Brent Geese were found close along the coast, and the shortest distance birds were recorded offshore was 0.8 km. This underscores the importance of conducting more extensive offshore surveys for Brent Geese in other potentially suitable coastal areas. The total area of Sanggou Bay is 143 km<sup>2</sup>, of which our survey covered *c.* 108 km<sup>2</sup> of the bay, about 76% of the water area. The area covered by the two winter surveys extended over 42% of the home range of the tracked individual. Our surveyed areas were concentrated in the central and southern parts of the 95% home range, but excluded the northern part, which based on the tracking data merit coverage in future investigations.

Birds are excellent indicators of environmental conditions, as they can quickly select areas of high forage quality and low predation/disturbance risk (Cao

*et al.* 2021). Historical records of large flocks on Changdao in Shandong Province (220 km northwest of Sanggou Bay) suggest that Brent Geese have until recently occupied other coastal areas. However, there have been no records of significant congregations in Changdao in the past 20 years, ascribed to heavy metal pollution in the surface marine sediments, poor environmental conditions, habitat degradation and increased human disturbance (Wang & Chi 2001; Wang *et al.* 2023). With the establishment of a national park on Changdao, it is recommended that natural seagrass habitats be restored in this area, with the hope of attracting Brent Geese back to winter there.

### **The number and distribution of Brent Geese in China**

Non-systematic surveys indicate a decline in the wintering population of Brent Geese in China from 10,000 individuals (in winter 1991/92; Fan 2001) over the past 30 years to < 500, but the likelihood remains that some other aggregations remain undetected and uncounted offshore, which we need to find either through further tracking or/and extended surveys. In the Red List of Biodiversity in China 2020, compiled by the Chinese Academy of Sciences and the Ministry of Ecology and Environment (Ministry of Ecology and Environment of the People's Republic of China & Chinese Academy of Sciences 2023), the status of the Brent Goose has not been determined due to a lack of data. Considering its relatively low overall abundance and declining trend, we recommend that it should be designated as a nationally protected species.

Migration season records were concentrated in Shandong province and its northern regions, including numerous records in Bohai Bay. There have, however, been three records from Inner Mongolia, Heilongjiang and Jilin, which suggests that some of the Brent Geese wintering in China might migrate north along the coast before following an inland route through the Lena and Yana River valleys to reach their nesting areas (Shimada *et al.* 2017; Sawa *et al.* 2020). Although the total distance from these provinces in northeastern China to the nearest breeding areas on the delta of the Lena River in the Russian Arctic is much shorter than following maritime migration routes along the coast, the absence of inland staging grounds may result in longer non-stop flight distances, so further investigation is warranted to determine whether Brent Geese use inland migration routes to and from the breeding grounds. Brent Geese are the most maritime of world's goose species, and inland winter observations are considered an unusual event for some populations, indicative of food shortages in their usual nearshore habitats and thus habitat switching (Vickery *et al.* 1995; Shimada *et al.* 2018). The extent to which the East Asian Brent Geese penetrate inland (at least 500 km from the nearest coastline) far exceeds such observations recorded for their European and Japanese counterparts, however, so inland migration routes may exist.

Brent Geese were observed in the offshore areas of Sanggou Bay, Shandong Province, in both years of the two-year survey, and the count of 319 individuals in 2024 was the largest number recorded for the species in

China in the past 20 years. This underscores the importance of conducting investigations in offshore areas, especially in the Shandong and Jiangsu coastal regions. Priority survey areas include the offshore areas of the Bohai and Yellow Seas (*e.g.* Sanggou Bay, the Yellow River Delta National Nature Reserve and offshore regions of major islands such as Changdao in Shandong Province; also Zhangzi Island at 39.194°N, 122.575°E in Liaoning Province; Fig. S2). *Zostera* is also an important source of food for the Mute Swan *Cygnus olor* during winter, so it is recommended that Brent Goose surveys be conducted in Mute Swan wintering areas on the Korean Peninsula (*e.g.* at Ptich'ye Lake-Tongbon-p'o Lake on the Russian-North Korean border, and at Yongyeon Lake in North Korea; Nilsson 2005; Meng *et al.* 2020).

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**Photograph:** Brent Geese flying over an artificial marine aquaculture area in Sanggou Bay, China by Jing Zhang.



**Photograph:** Brent Geese resting on artificial marine aquaculture infrastructure at Sanggou Bay, China, by Jing Zhang.