The largest known wintering concentration of Brent Geese *Branta bernicla nigricans* in East Asia along the coast of the Shandong Peninsula, China

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Abstract

The number of Brent Geese *Branta bernicla nigricans* wintering in East Asia is small, and their winter distribution in China remains poorly known. Previous surveys have identified Sanggou Bay, Shandong Province, as an internationally important wintering site, with 124, 319 and 850 birds recorded in January 2023, 2024 and 2025, respectively. GPS tracking and field surveys were conducted along the coast of Shandong Peninsula in January 2026. One tagged Brent Goose migrated from Notsuke Bay, Japan, to coastal Shandong, where it utilised both Sanggou and Lidao Bays throughout the winter. Guided by real-time GPS data, a boat survey on 8 January recorded 1,496 Brent Geese in southern Sanggou Bay, followed by a shore-based survey on 9 January that identified 74 birds across Lidao and Ailian Bays. The minimum total count of 1,570 birds is equivalent to *c.* 18% of the estimated 8,700 Brent Geese wintering in East Asia, although considerable uncertainty remains regarding the actual numbers. This represents the largest known wintering concentration in the region. The discovery of this large offshore concentration also suggests that previous shore-based surveys may have underestimated the number of Brent Geese using offshore aquaculture areas. These results indicate that the aquaculture-dominated coastal waters from Lidao Bay to Sanggou Bay constitute a key wintering area for Brent Geese in East Asia; however, further systematic surveys are needed to assess annual variation and detectability.

Key words: aquaculture, GPS tracking, Lidao Bay, Sanggou Bay.

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Brent Geese *Branta bernicla nigricans* wintering in East Asia are distributed mainly along the coasts of Japan, the Korean Peninsula and China, and the published estimate of their wintering numbers is of *c.* 8,700 individuals (Cao *et al.* 2020; Wetlands International 2026). Whilst considerable uncertainty remains regarding the actual total, because survey coverage is incomplete, this number still comprises only a small fraction of the North American population of the same subspecies, which was estimated at *c.* 161,500 individuals during 2012–2015 (Sedinger *et al.* 2019). This subspecies has also shown evidence of a global population decline (Sedinger *et al.* 2019). Brent Geese wintering in East Asia therefore are of particular conservation concern, because of their relatively small numbers, incompletely known distribution and susceptibility to anthropogenic pressures such as illegal hunting and habitat loss and degradation (Syroechkovskiy 2006; MacKinnon *et al.* 2012). The Conservation of Arctic Flora and Fauna (CAFF) has identified the Brent Goose as a species of concern within the East Asian–Australasian Flyway (EAAF), emphasising the urgent need to clarify its distribution, abundance and ecology in East Asia (CAFF 2019).

Recent tracking studies have revealed a part of migration routes and internationally important staging and wintering sites for Brent Geese wintering in East Asia (Sawa *et al.* 2020a). The Lena and Yana River deltas in Arctic Russia have been suggested as potential breeding areas (Syroechkovskiy 2006; Shimada *et al.* 2017). However, movements between Alaska and Japan have also been documented (Derksen *et al.* 1996), and the breeding origins and overall summer distribution of Brent Geese wintering in East Asia remain poorly understood. During autumn migration, a substantial proportion of the East Asian wintering Brent Geese stages at Notsuke Bay in eastern Hokkaido, Japan, where a maximum count of 8,600 birds has been recorded (Sawa *et al.* 2020b). Subsequently, approximately 2,500–3,000 individuals remain to winter in Japan, while some birds migrate onwards to North Korea and China (Fujii 2017; Sawa *et al.* 2020a, b; Lv *et al.* 2024). In China, more than 10,000 Brent Geese were historically reported from the coasts of the Shandong and Jiangsu provinces before 2002, but very few records were available for 2002–2020 (Lv *et al.* 2024). Recent global positioning system (GPS) tracking and field surveys conducted through a joint China–Japan research project revealed that Sanggou Bay, Shandong Province, China, repeatedly supports more than 1% of the East Asian population, with 124 birds in 2023, 319 in 2024 and 850 in 2025, confirming that the bay is an internationally important wintering site for this species (Lv *et al.* 2024; Wetlands International 2026; Meng *et al.* in press). However, these counts remain below the historical estimates for the number of Brent Geese wintering in China, which ranged from *c.* 2,500 to 6,000 individuals (Wetlands International 2026). This discrepancy in counts may reflect either a shift in wintering distribution or an actual decline in the number of Brent Geese wintering in East Asia. However, the available data do not allow us to distinguish between these possibilities. Further surveys therefore are needed to determine whether additional

birds remain undetected within Sanggou Bay, adjacent offshore waters, or other coastal areas. Focusing on the former, further GPS tracking and systematic field surveys are required, particularly in the offshore areas of the Shandong and Jiangsu coastal regions, as emphasised by Lv *et al.* (2024).

In the present study, we continued GPS tracking and field surveys along the coast of Shandong Peninsula, China. In January 2026, we recorded 1,570 Brent Geese, representing the largest known wintering concentration in East Asia. This finding substantially improves the current knowledge of the winter distribution of Brent Geese in China and highlights the importance of conserving offshore aquaculture areas in Sanggou Bay and surrounding coastal waters.

Methods

Tracking research

Seven Brent Geese were captured and fitted with neck-band transmitters (OMNI 4G, 14 g; Druid Technology Co., Ltd., Shenzhen, China) at Notsuke Bay, eastern Hokkaido, Japan (43°35'N, 145°18'E), on 19–23 November 2025. The transmitters recorded one GPS location every 2 h and transmitted the data once daily via GSM mobile networks. One of the tagged geese migrated to the coastal area of the Shandong Peninsula, China, where it remained from 4 December 2025 to 12 April 2026, whereas the other tagged individuals wintered in Japan.

The home range of the tagged goose wintering in China was estimated using the 95% utilisation distribution (UD) and its core area using the 50% UD, based on fixed kernel density estimation (KDE; Seaman & Powell 1996). The KDEs were calculated using the R package 'adehabitatHR' (Calenge 2023) in R version 4.5.1 (R Core Team 2025). We used the reference bandwidth method implemented in adehabitatHR to estimate 95% and 50% UD.

Field surveys

Field surveys were conducted along the coast of the Shandong Peninsula, China, including the northern coast of Weihai City, Rongcheng Bay, Lidao Bay, Ailian Bay and Sanggou Bay (37°01'–37°22'N, 122°13'–122°44'E), from 7 to 10 January 2026 (Fig. 1). The coastal area from Rongcheng Bay to Sanggou Bay is one of the most intensively developed aquacultural regions (Liu *et al.* 2024). Long-line cultivation of kelp and bivalves dominates aquaculture practices within Sanggou Bay, where Brent Geese predominantly feed on the opportunistic Sea Lettuce *Ulva* sp. growing on the ropes suspended between buoys (Meng *et al.* in press).

Shore-based surveys were conducted across 31 sampling points from 09:00–17:00 h on 7, 9 and 10 January 2026 (Fig. 1). At each point, the coastal waters were scanned up to a distance of 2 km using 8–15× binoculars and 20–60× spotting scopes. Concurrently, a boat survey was conducted from 09:00–15:30 h on 8 January 2026 to target the offshore location of the tagged Brent Goose, based on data derived from its transmitter signal received at 10:00 h on the same day. The total length of the boat survey track was 90.3 km. During the boat survey, Brent Geese were recorded within 500 m on either side of the boat using 8–

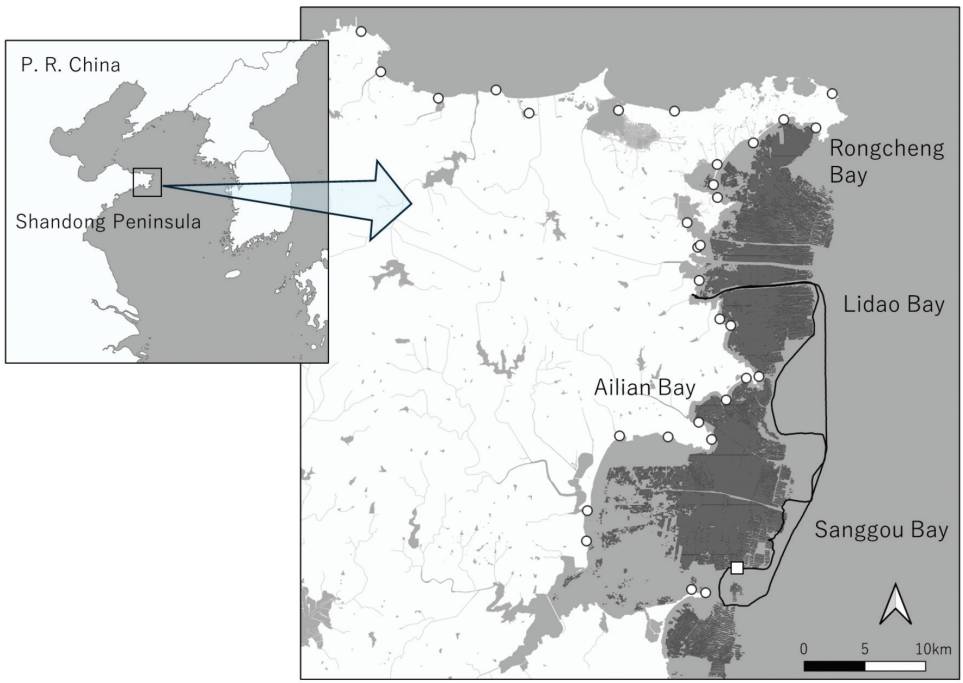


Figure 1. Study area on the Shandong Peninsula, China. White circles indicate shore-based survey points; the bold line and white square denote the boat survey track and boat survey observation point, respectively, in the 2026 survey. The shaded sea area represents long-line aquaculture areas (Fu *et al.* 2021).

15× binoculars. Large flocks were counted independently by multiple observers using binoculars and the counts were cross-checked. The survey team comprised six observers.

Results

Tracking results of tagged Brent Goose

One Brent Goose fitted with a transmitter on 19 November 2025 started migrating from Notsuke Bay on 26 November and reached the coastal area of the Shandong Peninsula on 4 December after staging on the west coast of North Korea. A total of 1,549 GPS locations were obtained before the signal was lost on 12 April 2026. In December 2025, the tagged bird primarily used Lidao Bay, whereas it used both Lidao and Sanggou Bays from January to April 2026 (Supporting Materials Fig. S1). The 95% home range and 50% core area throughout the wintering season were 430.7 km^2 and 95.6 km^2, respectively (Fig. 2).

Count surveys

Of the 31 shore-based survey points, Brent Geese were recorded at four locations on 9 January 2026, including three in Lidao Bay

and one in Ailian Bay, with a total of 74 individuals observed (Fig. 2). On 8 January 2026, a boat survey was conducted from Lidao Bay to the southern part of Sanggou Bay, targeting the location of a tagged Brent Goose recorded by GPS at 10:00 h on the same day (Fig. 1). No Brent Geese were recorded along outbound or return routes between Lidao Bay and the target location, although the sea conditions were calm and visibility was good throughout the boat survey. However, after reaching the GPS location of the tagged bird, we recorded a flock of 1,496 Brent Geese in the surrounding waters (Fig. 2). Most birds floated on the water surface or rested on buoys, whereas others flew around the flock. Among the birds of known age, juveniles accounted for 4.2% (250 adults, 11 juveniles).

Given that the tagged bird remained in the southern Sanggou Bay on both 8 and 9 January, the flocks observed in Lidao Bay and Ailian Bay on 9 January were treated as distinct from the 1,496 birds recorded during the boat survey on 8 January when calculating the minimum total count. Therefore, the total survey count was 1,570 Brent Geese (Table 1). No Brent Geese were observed along the northern coast of the Shandong Peninsula or in Rongcheng Bay.

Discussion

In this study, 1,570 Brent Geese were recorded in Sanggou, Lidao and Ailian Bays. The present count is equivalent to approximately 18% of the current winter count estimate of *c.* 8,700 Brent Geese in East Asia, although both the regional abundance estimate and our survey count are subject to uncertainty in detectability. To our knowledge, this represents the largest wintering concentration reported to date in East Asia; the previous highest known concentration was 713 birds recorded in Shizugawa Bay, Japan in December 2025 (Minami Sanriku Nature Center Friendship Association, unpubl. data). However, the substantially higher count in 2026 should not be interpreted as evidence of a population increase. Rather, it suggests that conventional shore-based and non-targeted offshore surveys tend to underestimate Brent Goose numbers in this complex aquaculture landscape, whereas real-time GPS tracking can significantly improve the detection of offshore flocks.

The tracked individual exhibited a 50% core area of 95.6 km^2 throughout the wintering season including Sanggou and Lidao Bays. Although neck bands have been reported to reduce breeding frequency in Brent Goose (Lensink 1968), telemetry from this individual was effective in locating a large offshore concentration that would have been difficult to detect using conventional shore-based surveys. Therefore, while the estimated core area should not be regarded as representative of the spatial distribution of other Brent Geese wintering in this region, it provides a useful basis for identifying priority areas for further systematic surveys. Field surveys in both the present and previous studies have only covered a limited proportion of the offshore areas used by the tracked individual (Lv *et al.* 2024; Meng *et al.* in press). In particular, Lidao Bay has not been sufficiently surveyed. Together with the detection of a large offshore flock in Sanggou Bay, this limited spatial survey coverage suggests that

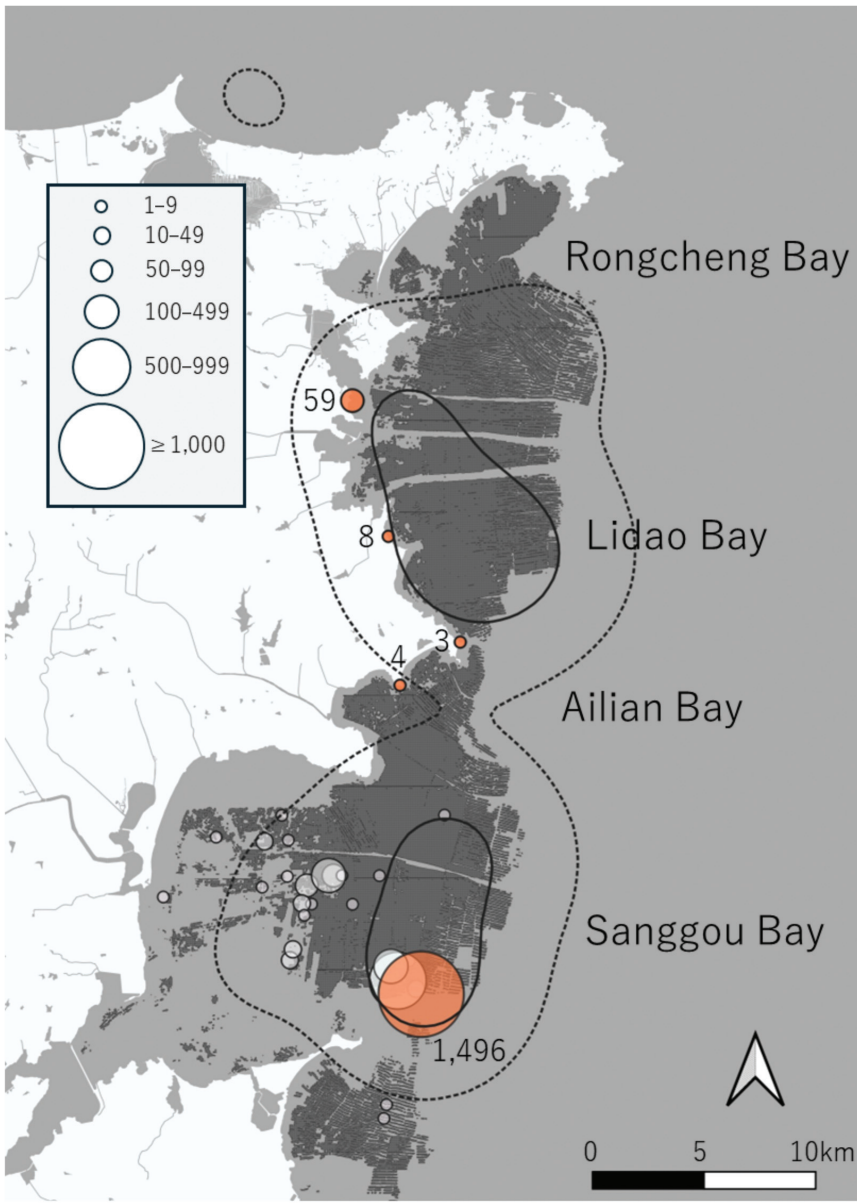


Figure 2. Distribution of Brent Goose flocks and the home range of the tagged bird. Circles show the locations where Brent Geese were observed, with circle size indicating flock size. Red circles = results from 2026; white circles = earlier records, from 2023–2025 (Lv *et al.* 2024; Meng *et al.* in press). Numbers = the number of individuals counted during this study. Bold and dashed lines represent the 50% core area and 95% home range of the tagged bird, respectively.

Table 1. Number of Brent Geese counted along the coast of the Shandong Peninsula, China, 2023–2026.

Year	No. of geese	Survey area	Survey method	Reference
2023	124	Sanggou Bay, Ailian Bay, Heini Bay	Shore-based survey, boat survey	Lv *et al.* 2024
2024	319	Sanggou Bay	Boat survey	Lv *et al.* 2024
2025	850	Sanggou Bay	Boat survey	Meng *et al.* in press
2026	1,570	North coast of Shandong Peninsula, Rongcheng Bay, Ailian Bay, Sanggou Bay	Shore-based survey, boat survey (GPS-guided)	This study

additional birds may remain undetected in offshore aquaculture areas. Future studies should consider the coastal and offshore aquaculture complex from Lidao Bay to Sanggou Bay as a priority survey area and assess whether additional concentrations occur within this region. Such systematic surveys are also needed to determine whether the historical estimate of *c.* 2,500–6,000 Brent Geese wintering in China (Wetlands International 2026) remains plausible. Beyond the Lidao–Sanggou Bay area, potential wintering areas along the Chinese and Korean coasts should also be assessed using information on historical distribution, eelgrass beds and aquaculture areas, followed by targeted field surveys.

Juveniles accounted for only 4.2% of the 261 birds for which age could be determined. This value was lower than the lowest juvenile ratio reported for the five geese species that overwintered in the Yangtze River in China from 2016 to 2019 inclusive (6%, Wang *et al.* 2021). This value should however be interpreted cautiously, because age was determined for only a subset of the flock, and spatial segregation of family groups can bias age-ratio estimates in Brent Geese (Ward *et al.* 2018). Furthermore, the breeding origins of Brent Geese wintering in East Asia remain poorly understood. Therefore, the observed ratio should not be interpreted as an unbiased estimate of population-wide reproductive success. Nevertheless, age-ratio surveys can provide useful indices of productivity when conducted using consistent methods over time. Use of sites by Brent Geese can also vary among years in relation to reproductive status and winter oceanographic conditions (Sedinger *et al.* 2006, 2011), potentially affecting age ratios observed at individual sites. Coordinated long-term monitoring of age ratios, conducted synchronously across major staging and wintering sites in East Asia, therefore would be valuable for distinguishing temporal variation in productivity from spatial variation in winter

distribution, and for improving our understanding of the demographic dynamics of Brent Geese wintering in East Asia.

Because the coastal area from Rongcheng Bay to Sanggou Bay contains extensive aquaculture facilities, detecting Brent Geese on the water surface can be difficult because numerous aquaculture buoys can obscure birds. Therefore, to conduct efficient surveys in this complex offshore environment, it is important to identify high-use areas through additional GPS tracking and to focus on future field surveys in these areas. Aerial surveys may also help to cover extensive offshore aquaculture areas, although their detectability and potential disturbance effects should be evaluated.

Sanggou Bay contains one of the major eelgrass beds in China, dominated by Common Eelgrass *Zostera marina*, but the spatial distribution and biomass of eelgrass in the bay declined by 42.8% between 2016 and 2020 (Li *et al*. 2020, 2022). Consequently, whereas eelgrass likely served as the primary food source for wintering Brent Geese in Sanggou Bay historically, these birds now appear to feed almost exclusively on epiphytic green algae growing on long-line aquaculture areas (Meng *et al*. in press). These findings indicate that extensive aquaculture in this area currently supports the largest known wintering flocks of Brent Geese in East Asia. However, the reliance on food resources associated with such an industrialised marine landscape may make geese highly vulnerable to future changes in aquaculture practices or habitat conditions (Meng *et al*. in press). It is therefore essential that systematic monitoring methods be developed and long-term monitoring of Brent Geese be continued in this area, which is now recognised as one of the most important wintering areas for the species in East Asia.

Acknowledgements

We are grateful for the contributions of the field expedition teams, including Yuhan Li and Qi Wu. We also thank the Qingdao Birding Association for their assistance with the field surveys in Shandong Province. We are grateful to Chieko Tamura, Kaoru Fujii, Noriyoshi Sasaki, Takaya Suzuki, Yoshihiro Fukuda, Mayumi Minari, Noriko Wada, Megumi Kobayashi, Aira Kobayashi and other members of the Notsuke Eco-Network for their help capturing Brent Geese in Japan. This study was supported by the Japan Fund for Global Environment, the Keidanren Nature Conservation Fund and the Bird Diversity Observation Network of the China Biodiversity Observation Networks.

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Photograph: Brent Geese at Sanggou Bay, China, by Karen Tanaka.