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BRIEF REPORT

An ecologically important leopard seal aggregation site in South Bay, Livingston Island

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Abstract
Leopard seals (*Hydrurga leptonyx*) are apex predators that shape Southern Ocean food webs through consumption of a wide range of prey. Despite their ecological importance and broad circumpolar distribution, consistent aggregation sites are poorly documented. During the 2025–2026 austral summer, we identified and monitored a previously undocumented aggregation of leopard seals in South Bay, Livingston Island, Antarctica. Over two months (Nov–Jan), we conducted land- and ice-based observations, photo-identification, and biological sampling as part of the first systematic study of leopard seals at this site. We recorded 33 unique individuals in South Bay, which is a relatively high seasonal count compared to recent reports from other known aggregations over the past decade. Most individuals (91%) were adults in good to excellent body condition. We had repeated sightings of nine individuals, indicating potential seasonal residency to South Bay. Feeding activity, including predation on penguins, flying seabirds and krill, was observed and confirmed with scat analysis. Reproductive behaviors, including male–female co-occurrence on icebergs, mating calls, and the presence of a visibly pregnant female, were documented. Together, the repeated site use, local foraging, and reproductive activities suggest that South Bay is an ecologically significant, multi-use habitat for leopard seals. These findings provide a baseline for long-term leopard seal monitoring and may inform consideration of ecologically significant habitats in the design of Antarctic Specially Protected Areas (ASPAs).

Keywords Marine mammals · Antarctica · Population monitoring · Apex predator

Introduction

Leopard seals (*Hydrurga leptonyx*) are apex predators in Antarctic and subantarctic ecosystems that feed across a wide range of trophic levels (e.g., krill, fish, penguins, flying seabirds, and other seals) and are known to exert strong top-down effects on certain prey, including Antarctic fur seals (*Arctocephalus gazella*; Krause et al. 2020, 2022; Sperou et al. 2025b). Leopard seals have a circumpolar distribution around Antarctica, extending northward to southern South America, New Zealand, and sub-Antarctic islands (Hupman et al. 2020; Borras-Chavez et al. 2024). Despite

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this broad range, identifying consistent leopard seal aggregation sites has proven difficult due to their solitary behavior, low densities, unpredictable distribution, and challenges monitoring remote glacier-associated habitats (Southwell et al. 2008). Only a few sites across their range are recognized as true aggregation areas, and only a subset of these sites have repeated observations that allow assessments of residency patterns (e.g., Cape Shirreff [South Shetlands, Livingston Island; (Woodman et al. 2024)], Laguna San Rafael and Tierra del Fuego [southern Chile; (Borras-Chavez et al. 2024)], Danco Coast [Antarctic Peninsula; (Botta et al. 2018)], Bird Island [South Georgia; (Forcada and Robinson 2006)], and Marion Island [north of Antarctic Polar Front; (Ross et al. 2025)].

South Bay (62°27′–62°48′ S, 59°45′–61°15′ W) is a large inlet on the southern coast of Livingston Island, in the South Shetland Islands, bordered by outlet glaciers that contribute ice and meltwater to the bay. The surrounding habitat supports high biodiversity, including several pinniped species (e.g., Weddell seals, *Leptonychotes weddellii*; crabeater seals, *Lobodon carcinophaga*; southern elephant seals, *Mirounga leonina*), as well as cetaceans (e.g., humpback whales, *Megaptera novaeangliae*). This area also supports diverse seabird communities, with nine species of nesting birds reported in the region (Metcheva 2005).

Leopard seals have been observed in South Bay near the Bulgarian Antarctic Station "St. Kliment Ohridski" since at least 1966, when two leopard seals were reported during a census of marine mammals around Livingston Island (Aguayo and Torres 1967). Opportunistic photographs of individuals have been collected over subsequent decades. However, these records were obtained outside of formal research programs, and the area has never been systematically studied for leopard seals or other phocid (true seals) species. As a result, the prevalence, habitat use, and residency patterns of leopard seals in South Bay have remained unknown.

Here, we present the first systematic documentation of leopard seals in South Bay, Livingston Island. Our primary objectives were to (1) quantify seasonal prevalence and counts, (2) assess short-term residency patterns, and (3) document feeding and breeding-associated behaviors. In order to evaluate the significance of this site, we compared our findings to other known leopard seal aggregation areas. Through this work, we aim to evaluate the ecological importance of South Bay for leopard seals and provide a baseline for future monitoring efforts.

Methods

We surveyed and monitored leopard seals in South Bay from 18 November 2025 to 9 January 2026 while working from the Bulgarian Antarctic Station "St. Kliment Ohridski" with logistical support from the Bulgarian Antarctic Institute (Fig. 1). Station personnel reported opportunistic sightings and shared photographs from 10 January–3 March 2026, after which the station closed, and observations ceased for the season.

Observations were conducted around South Bay, weather permitting, using a small boat and on-foot surveys along the shoreline near the Bulgarian base on the northern shore of the inlet. During surveys, we recorded the total number of leopard seals, geographic coordinates, and the substrate animals were in/on (i.e., ice, land, or water). Individuals were visually assessed for age class based on body size and sex based on the presence or absence of a visible genital slit (Rogers 2009; Hupman et al. 2020). Individuals were photographed and identified using unique pelage spot and scar patterns, and images were subsequently compared across sampling periods to determine whether individuals had been previously observed within the season (Forcada and Robinson 2006; Borras-Chavez et al. 2024). Body condition was visually assessed using a qualitative 1–5 scoring system based on the presence of bony protrusions (Hupman et al. 2020). A 5 mm tissue sample (hair, skin, and blubber) was collected using a remote biopsy system (G.U.T. 50, Teleinject, Germany) for future analyses of diet, health status, and genetic relationships among individuals and other populations. Research was approved by the University of Rhode Island IACUC and conducted under NMFS permit #26767 and Antarctic Conservation Act permit #2024-018.

Result & discussion

We collected over 6,000 photographs and approximately 15 h of video footage of leopard seals in South Bay. Surveys were conducted on 34 days (with 15 additional days lost to weather), and leopard seals were documented on 19 of those survey days. In total, we recorded 68 sightings, identified 33 unique individuals, and successfully sampled 23 individuals.

Demographics

Leopard seal counts were highest from mid- to late November, and declined throughout December, and increased in early January. We had a maximum of eight seals recorded in a single day on both November 20, 2025, and January 4, 2026 (Fig. 2). Among the 33 individual leopard seals

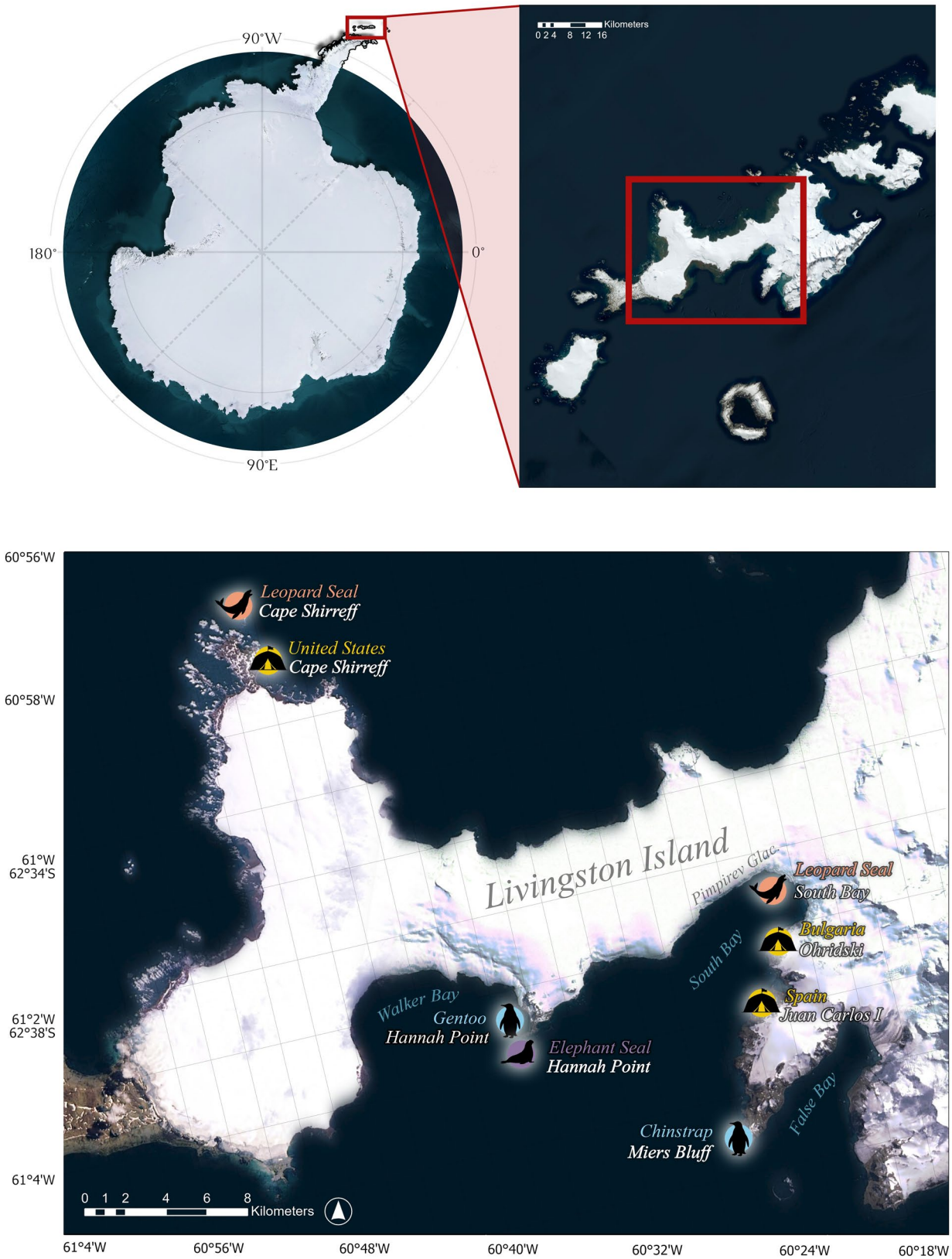

Fig. 1 Map of Livingston Island, South Shetland Islands, Antarctica, showing the location of the newly documented leopard seal aggregation in South Bay and the long-term monitoring site at Cape Shirreff. Research stations and nearby penguin and pinniped colonies are included. Insets show the location of Livingston Island within the South Shetland Islands and Antarctica

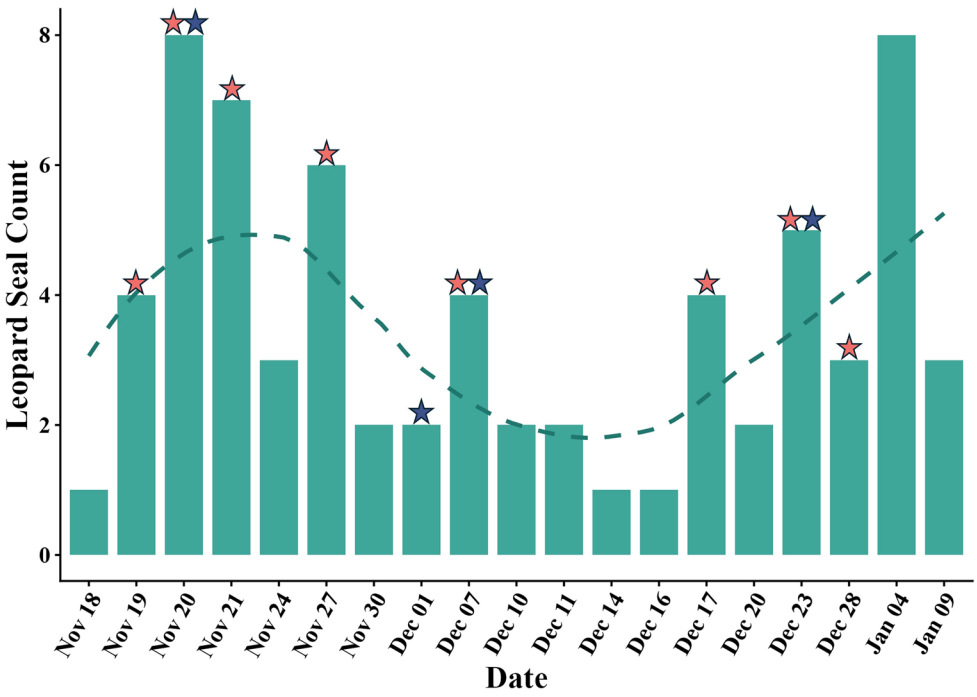

Fig. 2 Leopard seal counts in South Bay, Livingston Island, Antarctica. Green bars represent total counts per survey day, and the dashed line shows a LOESS-smoothed trend. Pink stars indicate days when breeding behaviors were observed, and blue stars indicate days when feeding events were documented

identified, there were 10 females, 12 males, and 11 of unknown sex. Most individuals were classified as adults ($n=30$), with only three individuals categorized as juveniles (two males, one female). We observed an additional 15 leopard seals but could not individually identify them, making it unclear whether they represented previously identified or new individuals. All identified individuals were in good or excellent body condition (scores of 4–5).

Seasonal residency

Leopard seals can exhibit localized residency, remaining within ~50 km of a given area for several months and returning annually to specific sites (Rogers et al. 2005). Some leopard seals in South Bay exhibited short-term seasonal residency. Nine individuals (adult males = 3; adult females = 3; juvenile males = 2; juvenile female = 1) were resighted multiple times in different days (2–4 sightings) throughout the study. One juvenile male was documented on 4 separate occasions between November 21 and January 28, a span of 68 days. In contrast, an adult female was observed on November 24 and not recorded again until January 28, a 66-day interval between sightings. However, because survey effort was weather-dependent and South Bay is extensive, individuals may have been present but not detected. These observations indicate both consistent use of the area, as well as return of individuals to the bay over extended periods. Future monitoring is needed to identify long-term patterns of residency and site fidelity of leopard seals in South Bay.

Feeding events

Other leopard seal aggregations sites are characterized by local large mesopredator breeding colonies (e.g., penguins, Antarctic fur seals) which leopard seals are known to prey on (Krause et al. 2020). Here, we observed two leopard seal predation events on seabirds close to Hannah Point and Hurd Peninsula, which have nearby seabird breeding colonies (Ceia et al. 2021). On November 20, 2025, an adult leopard seal caught and feed on a skua (*Stercorarius spp.*) in the water just offshore of Hurd Peninsula (Online Resource 1). Another predation event occurred on December 7, 2025, where two adult leopard seals were observed feeding on penguins (Online Resource 1). In addition to these observed predation events, we collected scat from leopard seals hauled out on ice/land. We found penguin feathers and remains in four scat samples, further confirming that leopard seals in South Bay likely feed on gentoo and chinstrap penguins from nearby colonies.

We also observed two feeding events where leopard seals were presumably feeding on Antarctic krill (*Euphausia superba*). On December 1, 2025, two adult seals remained near the surface while swimming close to an iceberg and repeatedly lifted their heads above water with mouths open before submerging; both exhibited visible throat movements suggesting ingestion of a prey bolus (Online Resource 1). Similar behavior was observed in a single adult on December 23. We suggest that these leopard seals were feeding on krill using suction filter feeding, similar to behaviors documented in captive leopard seals feeding on small prey

(Hocking et al. 2013). We note that these presumed krill foraging events occurred on sunny days when humpback whales and multiple gentoo and chinstrap penguins were also documented feeding nearby. Additionally, on these same days, we observed numerous krill washed up along the shoreline. Together, these coincident feeding aggregations and shoreline krill strandings suggest that krill may be locally abundant and represent a potential food source for leopard seals in South Bay.

While we did not observe leopard seals preying on other pinnipeds, we documented three adult crabeater seals with scars and fresh wounds potentially caused by leopard seal predation attempts (November 24, 2025; November 30, 2025; December 27, 2025; Online Resource 1). Crabeater seals are a known prey of leopard seals (Siniff and Bengtson 1977; Hall-Aspland and Rogers 2004; Khoyetskyy 2020). Signs of leopard seal predation on crabeater seals are often characterized by two parallel slashes along the trunk of the crabeater seal's body created by the leopard seal's canines which leave distinctive scars as crabeater seals are known to roll to escape this type of predation event (Siniff and Bengtson 1977). Most of the scars we documented on crabeater seals were healed. However, one crabeater seal had a small, fresh, open visible wound on the left lateral flank near the hind flippers that could have been made by a leopard seal. However, future dietary and stable isotope analyses will further resolve predator–prey interactions between crabeater and leopard seals in South Bay.

Breeding activities

The Antarctic breeding season for leopard seals is thought to occur from early November through early January, although pupping is asynchronous, not all females reproduce annually and females may become receptive to mating as early as October (Southwell et al. 2003). Here, we documented multiple reproductive behaviors, including male underwater vocalizations, male spyhopping around females, visible indicators of mating attempts (e.g., exposed genitalia), and signs of pregnancy (e.g., females with enlarged abdominal regions and/or enlarged mammary glands consistent with reproductive condition [e.g., late pregnancy or early lactation]; (Stirling and Siniff 1979; Rogers 2009; Kienle et al. 2024; Sperou and Borras-Chavez et al. 2025a; Fig. 3). Overall, reproductive behaviors occurred throughout the season but increased in frequency later, often with multiple events recorded on the same day. Evidence of sexual or reproductive activity were recorded during 40% of the survey days (Fig. 2).

Specifically, we documented exposed genitalia (two males) and enlarged mammary glands (two females) on four occasions (Fig. 3A-B). Additionally, we detected in air and underwater mating calls on seven occasions. Male leopard seal vocalizations are strongly associated with the breeding season and are thought to function in sexual advertisement, potentially facilitating mate attraction and/or competition among males (Rogers 2009; Kienle et al. 2024). Kienle et al. (2024) similarly documented vocalizations in association with paired male–female sexual behavior, supporting a reproductive context for the vocalizations observed in South Bay.

Furthermore, we observed males spyhopping near females hauled out on icebergs on seven occasions (Fig. 3C-D) and documented seven instances of males and females on the same iceberg (Fig. 3D-E), including one case involving one female and two males (Fig. 3D). Spyhopping has been associated with mating behavior (Kienle et al. 2024), but it is not exclusively reproductive and may also facilitate visual assessment of the surrounding environment. Nevertheless, its occurrence near hauled-out females, together with other reproductive behaviors observed during the same period, suggests that these observations may have occurred within a reproductive context. These male–female associations, together with exposed male genitalia and reproductive vocalizations, are consistent with the paired sexual behaviors described by Kienle et al. (2024) and provide additional evidence of reproductive activity in this region. Lastly, we documented one pregnant female on December 28, 2025 (Fig. 3F) with a pronounced bulge around her ventral abdominal region near the umbilical area, just rostral of her teats (Sperou and Borras-Chavez et al. 2025a). Given the timing of this observation within the reported pupping season and the pronounced abdominal distension consistent with late-stage pregnancy, this observation raises the possibility that South Bay may also provide habitat used by females during late gestation and potentially parturition. Together, the occurrence of reproductive vocalizations, male–female associations, apparent mating attempts, and a late-stage pregnant female suggests that South Bay may represent an important area for leopard seals during the reproductive period but further monitoring is needed to confirm.

Comparison to other aggregations

Recent observations from known leopard seal aggregation sites provide important context for comparison. At Marion Island, located north of the Antarctic Polar Front, a total of 35 presumed individual leopard seals have been recorded over a 19-year period (2006–2024), with most sightings occurring in September (Ross et al. 2025). In southern Chile, two aggregation sites have been identified, Tierra del Fuego and Laguna San Rafael. Expedition-based documented counts of leopard seals totaled 15 in Tierra del Fuego in 2023 and 20 at Laguna San Rafael, with 19 total individuals

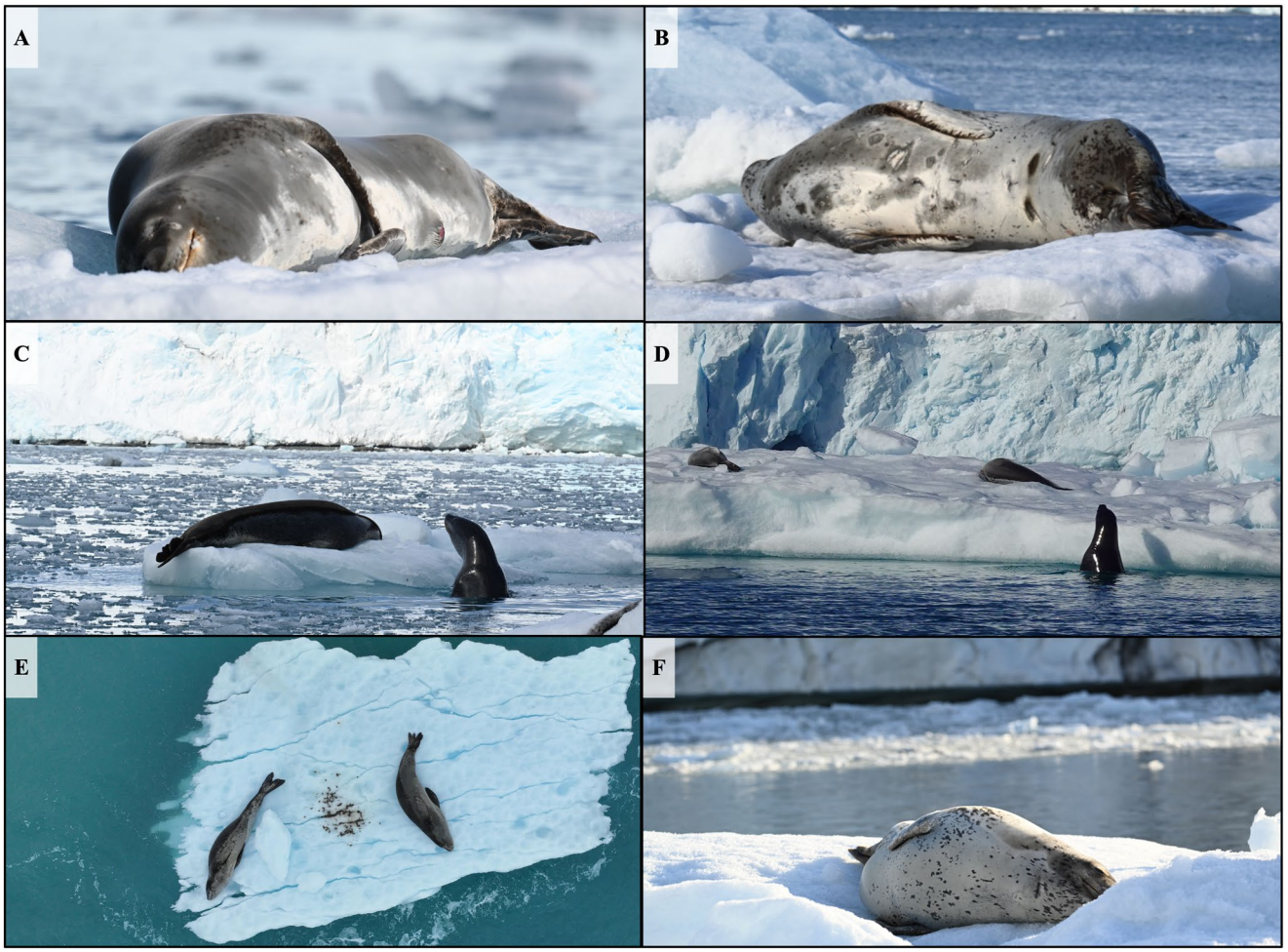

Fig. 3 Leopard seal breeding-associated behaviors observed in South Bay. (**A**) Adult male with exposed genitalia; (**B**) adult female with enlarged mammary glands; (**C**) adult male spyhopping toward a female; (**D**) adult female and male hauled out on an iceberg with an adult male spyhopping; (**E**) adult male and female co-occupying an iceberg; (**F**) adult female with a ventral abdominal bulge consistent with pregnancy. Photo credits: Oleg Vassilev; Ariel Leahy; José Seco; José Xavier; Emily Sperou

considered residents in the locations (10 in San Rafael and 9 in Tierra del Fuego; Borras-Chavez et al. 2024).

The nearest known leopard seal aggregation to South Bay is Cape Shirreff (~25 km NE of South Bay; Fig. 1). Cape Shirreff, on northern Livingston Island, is an important seasonal feeding area where leopard seals are monitored annually from November to March by the U.S. Antarctic Marine Living Resources Program (U.S. AMLR), with peak densities occurring in January–February (Woodman et al. 2024). U.S. AMLR identified 27 unique leopard seals (seven known residents) in 2024/25 and 14 (five known residents) in 2025/26, with counts peaking in late January (Woodman et al. 2024; U.S. AMLR, *unpublished observations*). In comparison, we have 68 sightings of leopard seals, documented 33 unique individual leopard seals in South Bay during the 2025–2026 field season, over a much shorter time period (November–January), with nine showing patterns of short-term residency (Online Resource 2). Notably, we observed many of these individual leopard seals in early to mid-November, when leopard seal counts at Cape Shirreff are historically quite low (1–2 individuals at most; (Woodman et al. 2024). Together, these observations highlight the relatively high density of leopard seals in South Bay and suggest that, similar to Cape Shirreff, this area warrants continued and structured monitoring.

Conservation & management

The consistent presence of leopard seals in South Bay, combined with evidence of returning individuals, foraging, and breeding-related behavior, suggests the local ecological importance of this area for a Southern Ocean apex predator. South Bay is characterized by persistent small icebergs calved from tidewater glaciers, proximity to dense penguin colonies, and limited human activity, features that collectively resemble the few known leopard seal aggregation

sites. In addition, the high biodiversity of South Bay, including presumed abundant krill, high fish density, nesting seabird colonies, multiple pinniped species, and actively foraging cetaceans, further underscores its ecological significance. Notably, similar ecological characteristics have contributed to the designation of Cape Shirreff as an Antarctic Specially Protected Area (ASPA) under Annex V of the Protocol on Environmental Protection to the Antarctic Treaty, in part because of its importance as a breeding and resting site for Southern Ocean phocids and other krill predators (Shirreff).

Leopard seals were recently classified as Least Concern by the IUCN (Borras-Chavez and Hückstädt 2026), but the 2026 Antarctic Treaty Consultative meeting flagged the species for immediate reassessment as data become available (SCAR 2026). This need for reassessment reflects longstanding knowledge gaps, as leopard seals have not historically been a focal species in ASPA designations within Antarctic Treaty waters due to their wide-ranging and solitary behavior, limited long-term datasets, and the logistical challenges associated with monitoring them. Our findings emphasize the need for continued monitoring of South Bay and other specific environmentally relevant sites, to support their inclusion and the protection of key habitats for pinnipeds and other marine mammals within future site-based protection frameworks of the Antarctic Treaty. Furthermore, leopard seals can drive substantial declines in local prey populations, as documented at Cape Shirreff where predation has contributed to reductions in the local Antarctic fur seal population (Krause et al. 2024). This highlights that areas supporting high densities of leopard seals warrant close monitoring, as even a small number of apex predators can exert disproportionate top-down control and lead to marked declines in prey populations (Sperou et al. 2025b). Although our findings suggest that South Bay may represent an ecologically important area for leopard seals, our study was limited to a single field season and therefore cannot determine whether the patterns of abundance, residency, and habitat use documented here are consistent across years. Additional multi-year monitoring is needed to assess interannual variability, confirm the long-term importance of South Bay to leopard seals, and determine whether the area warrants consideration within future conservation or site-based protection frameworks.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00300-026-03553-3.

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Author contributions ESS: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing—original draft, and Writing—review & editing; JS: Conceptualization, Data curation, Investigation, Visualization, Resources, Writing—review & editing; AL: Conceptualization, Data curation, Investigation, Visualization, Resources, Writing—review & editing; JX: Conceptualization, Data curation, Investigation, Visualization, Resources, Writing—review & editing; SMW: Conceptualization, Data curation, Investigation, Visualization, Writing—review & editing; TDB: Conceptualization, Visualization, Writing—review & editing; EV: Data curation, Investigation, Resources, Writing—review & editing; KN: Data curation, Investigation, Resources, Writing—review & editing; DM: Data curation, Investigation, Resources, Project administration, Writing—review & editing; CB: Conceptualization, Investigation, Visualization, Funding acquisition, Resources, Writing—review & editing; SSK: Conceptualization, Investigation, Visualization, Funding acquisition, Project administration, and Writing—review & editing.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Ethical approval Not applicable.

Competing interests The authors declare no competing interests.

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