

Assessing tourism patterns in the South Shetland Islands for the conservation of 19th-century archaeological sites in Antarctica

Research Article

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Author for correspondence:

María Ximena Senatore,
Email: mxsenatore@conicet.gov.ar

María Ximena Senatore^{1,2} 

Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET-INAPL), Argentina and Universidad Nacional de la Patagonia Austral (UNPA), Argentina

Abstract

Although archaeological studies focusing on 19th-century sealing have been performed over the past 30 years, its history and sites have traditionally had low visibility in Antarctic narratives and the Antarctic Treaty System policymaking on heritage. Researchers face the challenge of increasing the visibility of sealers' history and public awareness of the importance of conserving the oldest sites of Antarctica. In this paper, we propose that identifying patterns of tourism activity in the South Shetland Islands, specifically in their temporal and spatial dimensions, could help protect these sites and engage visitors with the early history of Antarctica. Data collected by the International Association of Antarctica Tour Operators were used to calculate landing point usage trends over time and the frequency of passenger landings from 2003–2004 to 2015–2016. We defined six different visitation patterns with temporal tendencies of passenger landings that varied from increasing, constant, or decreasing trends over time, differing in the magnitude and intensity of visitation. This information was used to assess the situation of particular sites located in the vicinity of tourism landing points. We set priorities for their conservation and management decisions and highlighted their relative potential to engage visitors with the stories of 19th-century sealing in Antarctica.

Introduction

Archaeological research regarding the earliest occupation in Antarctica has been conducted for the last three decades in the South Shetland Islands (SSI) (e.g. Pearson, 2018; Pearson & Stehberg, 2006; Pearson, Stehberg, Zarankin, Senatore, & Gatica, 2008; Senatore, 2018a; Senatore & Zarankin, 1999; Stehberg, 1983, 2003; Stehberg & Cabeza, 1984; Zarankin & Senatore, 1996, 1999, 2000, 2005, 2007; Zarankin et al., 2011), and the conservation and management of these sites has become a matter of concern for scientific teams (e.g. Pearson, Stehberg, Zarankin, Senatore, & Gatica, 2010; Senatore 2018b; Senatore & Zarankin, 2011, 2012; Stehberg, 2004; Stehberg, Pearson, Zarankin, Senatore, & Gatica, 2008). The archaeologists stated that their conservation is essential for the research about the human past in Antarctica and their heritage values are essential components of the research process. Conserved sites and objects also offer an opportunity to narrate the past, and tourism activities related to these 19th-century sites could contribute to engage visitors with the stories of sealers in the Antarctica. However, no specific actions have been undertaken yet under the Antarctic Treaty System (ATS) in order to ensure effective conservation and management of these sites or to enhance their visibility and interpretation for visitors.

In Antarctica, conservation awareness at historic sites has focused mainly on well-known huts representative of the Heroic Era of Antarctic Exploration (Pearson, 2011). The initial projects emphasised hut restoration, making the structures accessible to visitors (Harrowfield, 2005, p. 10). Since the 1960s, most of the conservation actions and management plans have been successfully implemented at specific and unique historical buildings, from a site-focused perspective (e.g. Harrowfield, 1991; Ledingham, 1979) or a local perspective (e.g. Ashley & Mackay, 2004). Thus, many of them have been opened to visitors (e.g. Hughes, 1992, 1994; Hughes & Davis, 1995; Stonehouse & Snyder, 2010; Watson, 2011).

In this paper, we propose that identifying patterns of tourism activity in the SSI could help protect these sites and engage visitors with the early history of Antarctica. Focusing on tourism activities, this study contributes to the discussion on conservation challenges of historical sites, expanding the initial site-focused approaches and emphasising on the sealing sites along the SSI coast from a regional perspective. In this context, the studies of tourism visitation patterns that have expanded initial site-focused approaches in the Antarctic Peninsula (AP) are the most useful tools for understanding the current situation of the sites in relation to tourism practices in the SSI (e.g. Bender, Crosbie, & Lynch, 2016; Lynch, Crosbie, Fagan, & Naveen, 2010). Specifically, we are interested in identifying the locations wherein tourism occurs;

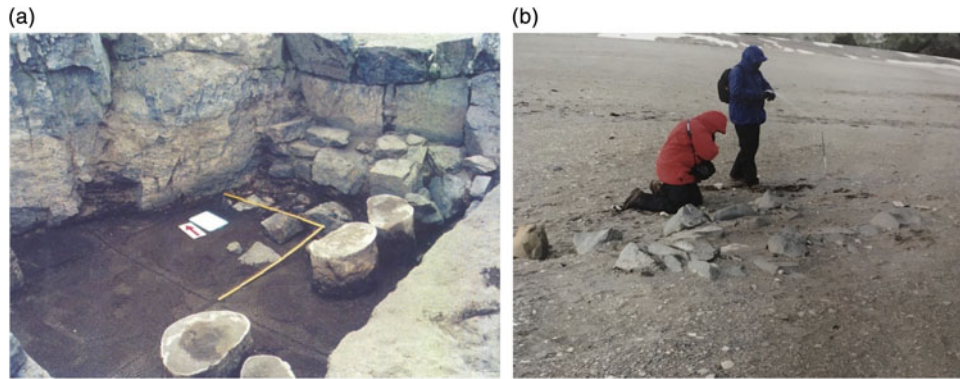


Fig. 1. Nineteenth-century sealing sites showing different degrees of visibility in Peninsula Byers, Livingston Island, SSI. (a) View of Playa Sur 1, excavated site with whale vertebrae and mineral charcoal fireplace inside the stonewall hut (Photo M. X. Senatore). (b) View of structure made of rocks placed in an open beach during archaeological fieldworks (Photo M. X. Senatore).

understanding long-term trends of visitation; and building spatially explicit models for tourism activities that would benefit future decision-making on protecting, managing, and enhancing the interpretation of sealing sites for visitors.

In the next section, we first offer a brief overview of the archaeological research on the earliest occupation in Antarctica conducted in the last three decades, showing why future management plans of the oldest occupations of Antarctica will have to consider crucial aspects of archaeological phenomenon such as the region-wide dispersion of archaeological sites along the SSI and their vulnerability to human activities based on fragility and low visibility. Second, we focused on the SSI to identify patterns of tourism activity, considering landing point usage trends over time and the frequency of passenger landings, in their temporal and spatial dimensions, for better informed protection measures for archaeological sites from a regional perspective. Finally, we used this information to assess the number and situation of 19th-century archaeological sites located in the vicinity of tourism landing points and set priorities for enhancing the visibility of the sites and the sealing history and defining future conservation plans.

Overview of the archaeological research in the SSI

Historical and archaeological studies about the oldest human occupations in Antarctica and the knowledge derived from these studies as well as sealers' expeditions to the SSI have had a relatively low impact on Antarctic narratives (Senatore & Zarankin, 2014). Initially, the literature on sealing focused mainly on the first sighting of the SSI and the early sealing seasons ca. 1825 (e.g. Balch, 1902; Campbell, 2000; Gould, 1941; Martin, 1940; Miers, 1920; Pyne, 2003; Stackpole, 1950). In addition, historical studies have helped link the 19th-century sealing industry in Antarctica to broader contexts from economic and social approaches (e.g. Basberg, 2017; Basberg & Headland, 2008; Berguño 1993a,b; Headland, 1999, 2017; Jones, 1981a,b; Maddison, 2014; Richards, 2003). Archaeological studies have contributed to widening the scope of the Antarctic history studies, showing the analytical power that material culture studies have in understanding sealers' everyday life experiences on a local scale and focusing on the relation between sealers' SSI expeditions and capitalist global expansion (Pearson & Stehberg, 2006; Zarankin & Senatore, 2000, 2005, 2007).

The results of the archaeological research projects developed in the SSI since the 1980s have shown the historical significance, location, chronology, and characteristics of the occupations.

Sealing activities were developed in the SSI as part of a comprehensive strategy that contributed to the rapid incorporation of uncharted and unknown places in the Antarctic (Senatore, 2018a). The sealers employed the regional strategy of exploration and occupation by landing gangs of men along the rocky outcrops to build camps to remain on shore during temporary stays. The experiences of those groups of sealers living and working onshore were the first of their kind in Antarctica. With regard to the impact on the environment, archaeological research has demonstrated that in the early 19th century, economic activities were linked to the exploitation of elephant seals, fur seals, and a combination of both, indicating an opportunistic strategy rather than a specialised strategy focused on a specific resource (Senatore, 2018a).

For protection and management purposes, 19th-century sealing sites are better understood as a regional phenomenon limited to the SSI. Archaeological research offers a significant corpus of information on sealing camps, huts, objects, and marine resources exploited during the 19th century in the SSI (e.g. Pearson, 2018; Pearson & Stehberg, 2006, 2011; Pearson et al., 2008; Senatore, 2018a; Senatore & Zarankin, 1999; Stehberg, 2003; Stehberg & Cabeza, 1987; Stehberg & Lucero, 1985, 1996; Stehberg et al., 2008; Zarankin & Senatore, 1996, 2000, 2005, 2007; Zarankin et al., 2011). To date, more than 30 sites have been discovered through fieldwork observations and archaeological surveys along the coasts of the islands, 19 of which have been studied in depth through excavations. An updated open database was built by Laboratório de Estudos Antárticos em Ciências Humanas (LEACH)-Universidade Federal de Minas Gerais that compiled all of the data collected throughout the SSI since the 1980s (<http://www.leach.ufmg.br/>). The archaeological structures are typically found either isolated or as groups with heterogeneous structures, dimensions, and functions. They were often built to take advantage of the local orography, such as caves, natural shelters, or on the rock face of a cliff or sea stack, only rarely appearing on an open beach. The structures shared some building techniques, such as the raw materials that were used, morphology, or size. Some of them were often simple huts enclosed within low walls made of stones without mortar (Fig. 1). They were roofed using sailcloths made of sealskins and other fabrics and held together by beams made of whale ribs or jaws, wood, or timber. The raw materials used were primarily those available on the beach.

In addition to low visibility of their remains, which makes them nearly imperceptible to visitors without adequate guidance, the sealing sites show the main characteristics of the polar sites,

specifically their fragility and simplicity (Barr, 2010). Many of the sites are areas in which objects and stones were distributed along accessible shores. Because these sites consist of local resources, they present low contrast with the SSI landscape. Visibility variations due to snow cover make the sites susceptible to human activities, specifically to the number of visitors, and the circulation path followed onshore.

In general, the ATS offers a repertory of protective mechanism and management tools that could contribute to the protection of sealers' historical remains (Barr, 2018). However, no specific actions focused on the conservation or management of these particular sites have been undertaken yet. Some conceptual and practical limitations to the protection of sealing sites under the ATS have been discussed (Barr, 2018; Senatore, 2018a,b, 2019; Senatore & Zarankin, 2011, 2012; Stehberg et al., 2008). The conservation status of the archaeological sites has been evaluated over time, and human and natural factors that influence their deterioration have been identified for specific areas of the SSI (Oliva, Ruiz-Fernández, Zarankin, Casanova-Katny, & Nofre, 2017; Pearson et al., 2010).

For the protection and management of the 19th-century sealing sites, the Antarctic Special Protected Areas (ASPAs) are of particular interest. In 2002, the Annex V on Area Protection and Management of the Madrid Protocol came into force and established mechanisms to designate and manage ASPAs based on "outstanding environmental, scientific, historic, aesthetic, or wilderness" values (Art. 3(1)). The largest proportion of known sealing archaeological sites on the SSI are within three ASPAs (ASPAs No. 125 Fildes Peninsula in 25 de Mayo/King George Island, ASPA No. 126 Peninsula Byers, and ASPA No. 146 Cape Shireff on Livingston Island). As visitor traffic is regulated in these areas, the sites will never be at risk from the tourism factor. However, the general protection afforded by the ASPA regulations is not enough to protect each site (Barr, 2018, p. 8), and researchers still face the challenge of increasing the visibility of the sealers' sites within the ASPAs. The Committee for Environmental Protection (CEP), which was created to provide advice and formulate recommendations to the parties related to the implementation of the Protocol, has produced guidance material for protecting and managing Antarctic areas visited by tourism. The Site Guidelines for Visitors could also contribute to the protection of the archaeological sites. This tool was not developed specifically with the objective of protecting historic remains. However, it could help enhance the visibility of the sealing archaeological sites. The aim of these guidelines is to provide specific instructions on the conduct of activities at the most frequently visited Antarctic sites. Currently, from the 12 available for the SSI, only one—Yankee Harbour (YH) on Greenwich Island—mentions 19th-century sealers' remains near the landing point used by tourist boats.

Assessing tourism visitation patterns in the SSI

Tourism studies and trends identified for the AP (Bender et al., 2016; Lee & Hughes, 2010; Lynch et al., 2010) are considered a broader context for understanding the SSI. We investigated the extent to which the patterns and scenarios defined for the AP were represented in the SSI. The islands are included in the itineraries of tourist cruises that visit the AP. Tourism is operated mainly by members of the International Association of Antarctica Tour Operators (IAATO) within the parameters of the ATS. However, there are other ships, specially yachts, that are not belonging to the IAATO that reaching the Antarctic region as well.

The SSI themselves are not a destination for commercial tourism, except for the one-day programme for tourists offered by the Chilean company Aerovias DAP, which includes walks along the coast of the Fildes Peninsula (Braun, Mustafa, Nordt, Pfeiffer, & Peter, 2012). Traditional expeditions are operated by cruise vessels that carry between 5 (sailing boats and yachts) and 200 passengers. They include the landing of small passenger groups by using a Zodiac rubber boat, but the number of passengers landing at one time is restricted to 100 by the ATS. For the sector of seaborne trips with landings, the IAATO member operators offer educational programs for visitors to experience and learn about Antarctica.

The analyses in this paper were based on publicly available specific data describing tourism landing activities of the IAATO members in the SSI. These analyses could be conducted on a regional scale based on data about tourism activities that have been collected by the IAATO during the past two decades and are available online. Conducting analyses of tourism visitation patterns on a regional scale, such as in the SSI, could not only enhance management and conservation plans but could also contribute to the identification of specific lines of inquiry and research on human impact and help define approaches to the uncertainties that remain regarding cumulative impact in different areas of the archipelago.

We performed three series of analyses focusing on different aspects of these data. The *temporal analyses* focused on the temporal trends of tourist activities within the SSI compared to the AP; the *spatial analyses* evaluated the distribution of landing points among the islands. The *spatiotemporal analyses* focused on the identification of common temporal patterns of passenger landings across different landing points.

Methods

The analyses were performed using tourism statistics available online, provided by the IAATO for 13 seasons from 2003–2004 to 2015–2016, which include records of site-specific landing by IAATO members. A database, which includes information regarding tourism statistics for these 13 seasons, was created. This database collected the number of tourists and ships that visited the SSI as well as the number of passenger landing points for each season. In addition, for each individual landing point (59 total landing points), the database included the number of passenger landings at each point during each season. The number of tourists who visited the SSI was determined by counting the visitors on board the ships that made at least one landing in the SSI. The information was collected from the IAATO general web page (<https://iaato.org/home>) and the IAATO statistics page (<http://iaato.org/antarctic-peninsula-sites>) during 2016. For each landing site within the SSI (59 points), the database also included its geolocation. This information was partly obtained from the limited list of landing sites and geolocations available on the IAATO general web page (for the 18 landing points within the SSI) and from the Scientific Committee on Antarctic Research Composite Gazetteer of Antarctica (<https://data.aad.gov.au/aadc/gaz/scar/>) (for the 41 remaining landing points).

The *temporal analyses* focused on the temporal trends of tourist activities within the SSI compared to the AP. In particular, the time series associated with the total number of landing points, passenger landings, ships, and tourists were analysed for the SSI and the AP. Each of these four time series consisted of 13 time points (2003–2004 to 2015–2016). These SSI time series were displayed and compared to the equivalent time series within the entire AP. To investigate the temporal trends, for each target time series,

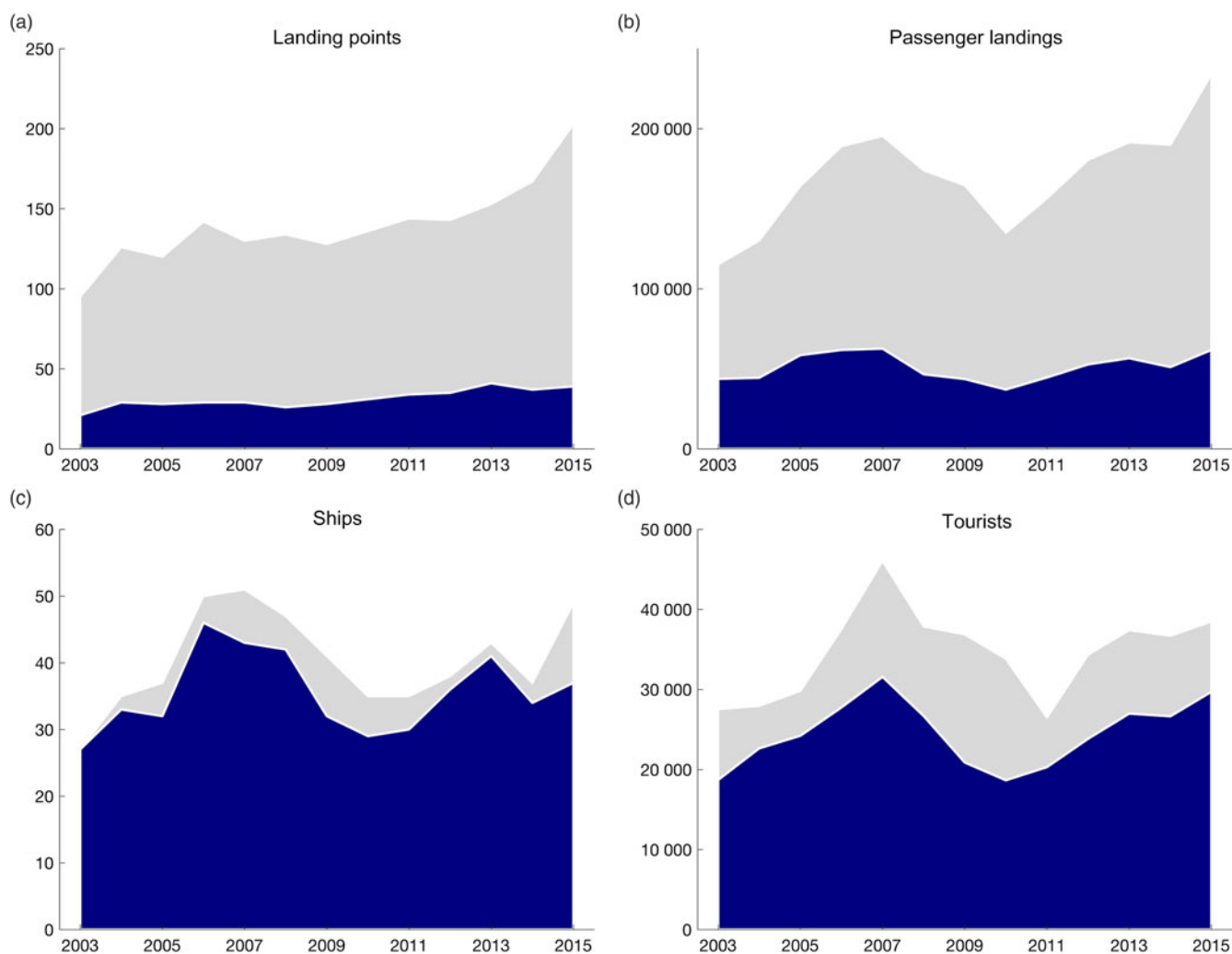


Fig. 2. Representation of the variation of (a) landing points, (b) passenger landings, (c) ships, and (d) tourists from 2003–2004 to 2015–2016. The Antarctic Peninsula (grey) and the South Shetland Islands (blue).

we computed the unique association with each of the other time series together with potential linear global growth factors using a multiple regression model. For example, the total number of landing points was modelled using a linear combination of five factors: a constant term, a linear temporal trend, and three additional factors modelling the association between the total number of landing points and that of landings, ships, and tourists, respectively.

The *spatial analyses* evaluated the distribution of landing points among the islands. The SSI maritime contours were obtained from the Trinity Peninsula area and the SSI map from “Coastal-change and glaciological map of the Trinity Peninsula area and the SSI, Antarctica: 1843–2000” (Ferrigno et al., 2006). Landing point geographical coordinates were obtained in detail in the data collection section. In addition, the geographical coordinates of archaeological sites within the SSI were obtained from published research. The geographical coordinates of the landing points and archaeological sites were projected on the map using a grid of 1° latitude by 3° longitude as a reference and using a stereographic polar projection transformation. Additional maps were constructed, displaying the total number of passenger landings within each landing point.

The *spatiotemporal analyses* focused on the identification of common temporal patterns of passenger landings across different landing points. For this purpose, we used hierarchical clustering

(Ward’s linkage, Ward, 1963) to identify potential patterns among the landing time series of the 59 SSI landing points. Clustering is a procedure that groups a set of objects in such a way that objects in the same group are more similar than those in other groups. In these analyses, we defined groups of landing points based on the similarity of their landing time series. A logarithmic transformation of the number of landings at each landing site and at each point of time was used to normalise the total number of landings across different sites partially. The optimal number of clusters was determined using a 2% decrease variance threshold (Ward’s criterion). For each cluster of landing points, we constructed a map displaying the location of these landing points, as well as a plot displaying the temporal evolution of the number of landings within members of this cluster. We also evaluated the degree of superposition for each cluster of landing points with the archaeological sites identified from scientific research.

Results: patterns in tourism visitation in the SSI

Temporal patterns in tourism visitation in the SSI

Approximately 88% of the ships going to AP included landings in the SSI (Fig. 2c), and 71% of the AP tourists visited the islands (Fig. 2d). The proportion has remained constant with small

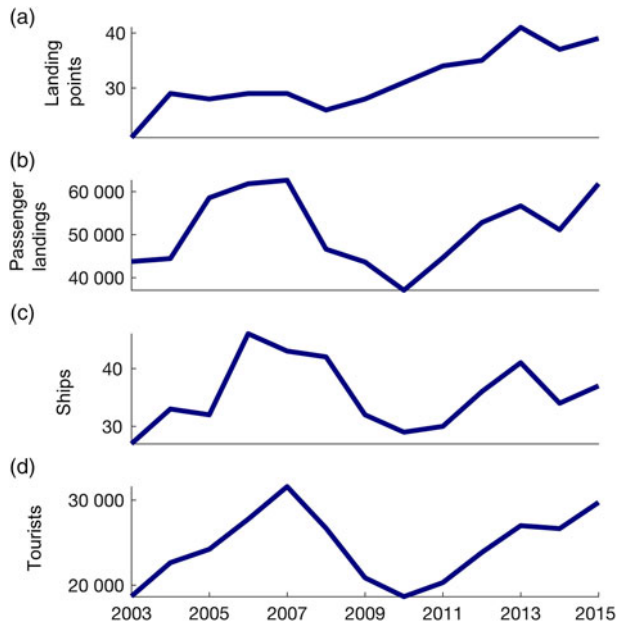


Fig. 3. Representation of the temporal sequences of (a) landing points, (b) passenger landings, (c) ships, and (d) tourists from 2003–2004 to 2015–2016 in the South Shetland Islands.

variations. Among the landing points in the AP, 22% were within the SSI (Fig. 2a) and 30% of the total passenger landings were on the islands (Fig. 2b). In the last three seasons, an increase in the number of landing points was observed for the AP ($T(11) = 5.44$, $p < 0.001$) as well as for the SSI ($T(11) = 6.31$, $p < 0.001$). The number of ships visiting the SSI and the number of tourists who landed were highly correlated ($r = 0.84$, $p < 0.001$) (Figs. 3c and 3d); however, the number of landing points was not influenced by these factors ($F(2.9) = 0.41$, $p = 0.67$). A linear trend was observed over time for the number of landing points, increasing, on average, one to two points a year with comparatively small additional temporal fluctuations ($T(8) = 5.64$, $p < 0.001$) (Fig. 3a). By contrast, the number of ships, tourists, and passenger landings did not show a significant linear increase within the relatively larger temporal fluctuations observed ($T(8) < 1.39$, $p > 0.20$) (Figs. 3b–d). From the differences observed in the number of landing points, ships, tourists, and passenger landings, we concluded that the number of tourists could not be considered a major pressure factor for the opening of new landing points in the SSI.

Spatial patterns in tourism visitation in the SSI

In the SSI, 59 landing points, including 13 scientific stations used by IAATO members, were identified from 2003–2004 to 2015–2016 (Fig. 4). The assessment of the distribution of tourist activities along the SSI showed that 90% of the passenger landings occurred at 13 (22%) landing points. The uneven distribution of tourism already identified for the AP also occurred in the SSI. Lynch et al. (2010) and Bender et al. (2016) proved that a significant proportion of land-based tour activities in the AP region are concentrated in a small number of places. In 2013–2014, almost 68% of all landings occurred at just 15 sites (Bender et al., 2016, p. 200).

Spatiotemporal patterns in tourism visitation in the SSI

The cluster analysis resulted in the definition of six groups that characterise different patterns of visitation over time (Fig. 5). The groups were characterised according to their number and temporal trends in passenger landings. Group 1 included 12 landing points and showed a recent increase in number of passenger landings, with a mean of 4 landings in the first six seasons (2003–2004 to 2008–2009) and a mean of 196 landings in the last season (2015–2016) (Fig. 6). Group 2 had 16 landing points and showed a constant limited number of passenger landings ranging between 0 and 30 passenger landings across the entire period (Fig. 7). Group 3 had 5 landing points and was characterised by a decreasing number of passenger landings, a mean of 216 landings in the first season (2003–2004) and 12 landings in the last season (2015–2016) (Fig. 8). In Group 4, there were 6 landing points and the temporal trend was constant medium, ranging between 130 and 1067 passenger landings across the entire period (Fig. 9). Group 5 included 4 landing points, and the number of passenger landings showed an early increase from 0 in the first season (2003–2004) to a mean of 258 in 2007–2008 and 1262 in 2015–2016 (Fig. 10). Group 6 presented 16 landing points and maintained a constant and high number of passenger landings over time, ranging between 3437 and 5838 passenger landings across the entire period (Fig. 11).

As presented in Table 1, the groups showed a wide-ranging number of landing points and differed in size, ranging from 4 to 16 landing points. Temporal tendencies varied from increasing, constant, or decreasing trends over time. Two groups showed an increasing trend (Groups 1 and 5) but differed in the magnitude and intensity of growth over time as well as in the timing of the increase. Group 5 showed a comparatively early increase in passenger landings starting around 2005–2006, while Group 1 started to increase later around 2010–2011. Three groups (2, 4, and 6) presented a constant trend differing in the magnitude and intensity of the visitation. Even though these groups exhibited a constant trend of passenger landings, the frequency of visitation presented differences (ranging 0–30 in Group 2; 130–1067 in Group 4, and 3500–6000 in Group 6).

Archaeological sites and tourism visitation patterns in the SSI

Identifying these six visitation patterns contributes to understanding the vulnerability of specific 19th-century sites located near tourist landing points and should form a basis for setting priorities in the development and implementation of specific site conservation and management strategies. The visitation patterns help identify the potential of specific sites to engage visitors with the stories of 19th-century sealing in Antarctica.

Localisation of the passenger landing points near the archaeological sites was observed in four cases (Fig. 12): (A) Elephant Point on Livingston Island, (B) YH on Greenwich Island, (C) Turret Point (TP) on 25 de Mayo/King George Island, and (D) Desolation Island.

- A. The first case is Elephant Point on Livingston Island (Fig. 13). This landing point belongs to Group 1, which is characterised by a recently increasing trend over time. The archaeologists identified a highly visible assemblage of stonewall structures (sites Punta Elefante (PE1), PE2, PE3, PE4, Punta Elefante X (PEX1)). The site PE2 is the most well preserved of the

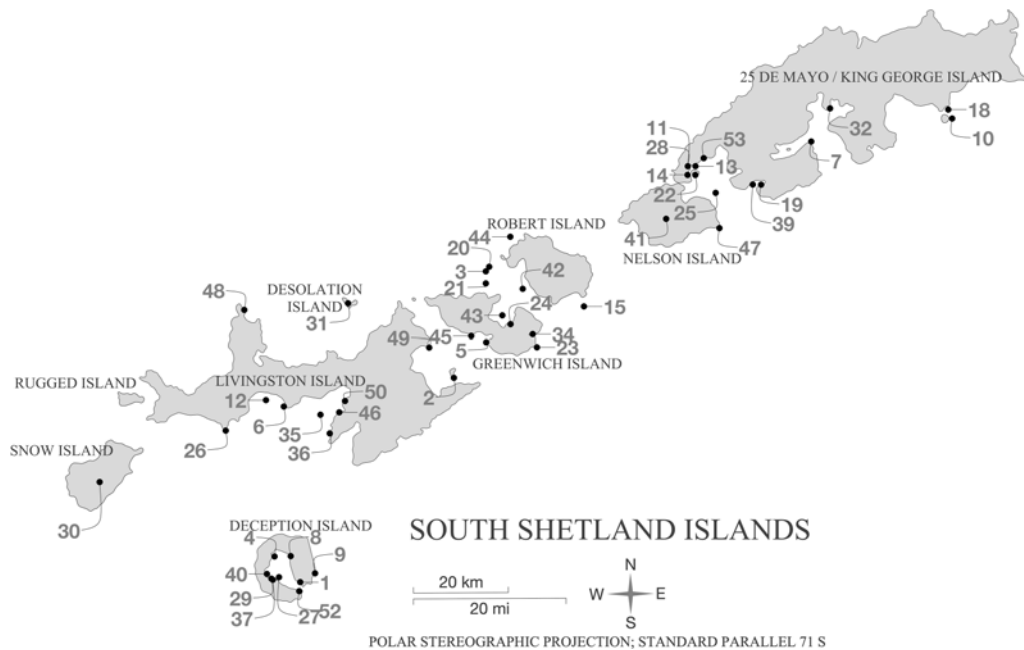


Fig. 4. Distribution and names of the landing points in the South Shetland Islands used by IAATO members from 2003–2004 to 2015–2016. 1 = Whalers Bay; 2 = Half Moon Island; 3 = Aitcho Islands – Barrientos Island; 4 = Telefon Bay; 5 = Yankee Harbour; 6 = Hannah Point; 7 = Arctowski Station; 8 = Pendulum Cove; 9 = Baily Head; 10 = Penguin Island; 11 = Frei Station; 12 = Walker Bay; 13 = Bellingshausen Station; 14 = Great Wall Station; 15 = Robert Point; 16 = Cape Lookout; 17 = Point Wild; 18 = Turret Point; 19 = Jubany; 20 = Aitcho Islands – Other; 21 = Dee Island; 22 = Ardley Island; 23 = Fort Point; 24 = Arturo Prat Station; 25 = Maxwell Bay; 26 = Elephant Point; 27 = Port Foster; 28 = Fildes Station; 29 = Deception Base Research Station; 30 = Snow Island; 31 = Desolation Island; 32 = Ferraz Station; 33 = Cape Valentine; 34 = Hardy Cove; 35 = South Bay; 36 = Sally Rocks; 37 = Gabriel de Castilla Station; 38 = Gibbs Island; 39 = Potter Cove; 40 = Fumarole Bay; 41 = Nelson Island; 42 = English Strait; 43 = Discovery Bay; 44 = Heywood Island; 45 = Triangle Point; 46 = Juan Carlos I Station; 47 = Duthoit Point; 48 = Cape Shirreff; 49 = Edinburgh Hill; 50 = Ohrdiski (Bulgarian Station); 51 = Walker Point; 52 = Neptunes Bellows; 53 = Artigas Station; 54 = Admiralty Bay; 55 = Deception Island; 56 = Elephant Island; 57 = Fildes Peninsula; 58 = Greenwich Island; 59 = Livingston Island.

- SSI (A. Zarankin personal communication, 1 March 2012). They were partially excavated, establishing their functionality and use by sealers in the 19th century (Oliva et al., 2017).
- B. The second case is YH on Greenwich Island. This landing point belongs to Group 6, which consistently presented the highest number of landings. Even though it is a highly visited place and the sealers' remains are mentioned in the Site Guidelines for Visitors, there is not a monitoring plan for assessing the impact on the archaeological site. The archaeological site was first identified in the 1960s (White 1966 in Lewis Smith & Simpson, 1987; Pearson & Stehberg, 2006) and surveyed in 2000 (Zarankin & Senatore, 2007). The archaeologist observed one structure formed by lines of stones (site YH) associated with a semi-buried large iron pot, and the remains of material culture and mineral charcoal dispersed on the surface (Fig. 14a). The low visibility of the structure and cultural remains make them imperceptible to visitors without experienced guidance (Senatore & Zarankin, 2012). Yet, it is crucial to consider the scientific relevance of this archaeological site. First, this type of structure has not been very frequently observed by archaeologists in the SSI. Because they have not been excavated, the functionality of these types of structures has not yet been determined. Second, the iron pot in YH (Fig. 14b) is the only one of this kind, identified in situ in the SSI.
- C. The third case is TP on 25 de Mayo/King George Island. The information about the archaeological site (site TP) is limited (M. Pearson personal communication, 1 March 2019). Although it was identified and recorded by archaeologists in the early 1980s, it has not been excavated (Stehberg, 2003).

The first sighting of the site was recorded by geologists in the 1960s and published several years later with a picture and a brief description of the remains (White 1966 in Lewis Smith & Simpson, 1987, p. 68). Based on the snow cover, the visibility of the structure varies during the summer, making it imperceptible to visitors (M. Pearson personal communication, 1 March 2019) (Fig. 15). The site is located near the landing point that belongs to Group 4, which is characterised by a constant temporal trend with intermediate range of passenger landings across the entire period. Despite being frequently visited by tourists, the sealers' remains are not mentioned in the Site Guidelines for Visitors available for this area.

- D. The fourth case is Desolation Island, where several archaeological sites were identified and studied near Cora Bay and Blythe Bay (Stehberg, 2003; Stehberg & Lucero, 1985). Some of them were excavated and studied in depth in the 1990s (site Co2). The structures were characterised by their low visibility and presented different functions and chronology of use from the 19th to the 20th century (Stehberg, 2003, pp. 109–129). The landing point in the vicinities of the archaeological sites belongs to Group 3, characterised by a decreasing trend over time.

It is possible that similar situations also occurred in other places of the SSI, such as Admiralty Bay–Point Hennequin and Fildes Peninsula on 25 de Mayo/King George Island. However, that could not be confirmed, as the information currently available is not precise regarding the geographical coordinates of the landing points.

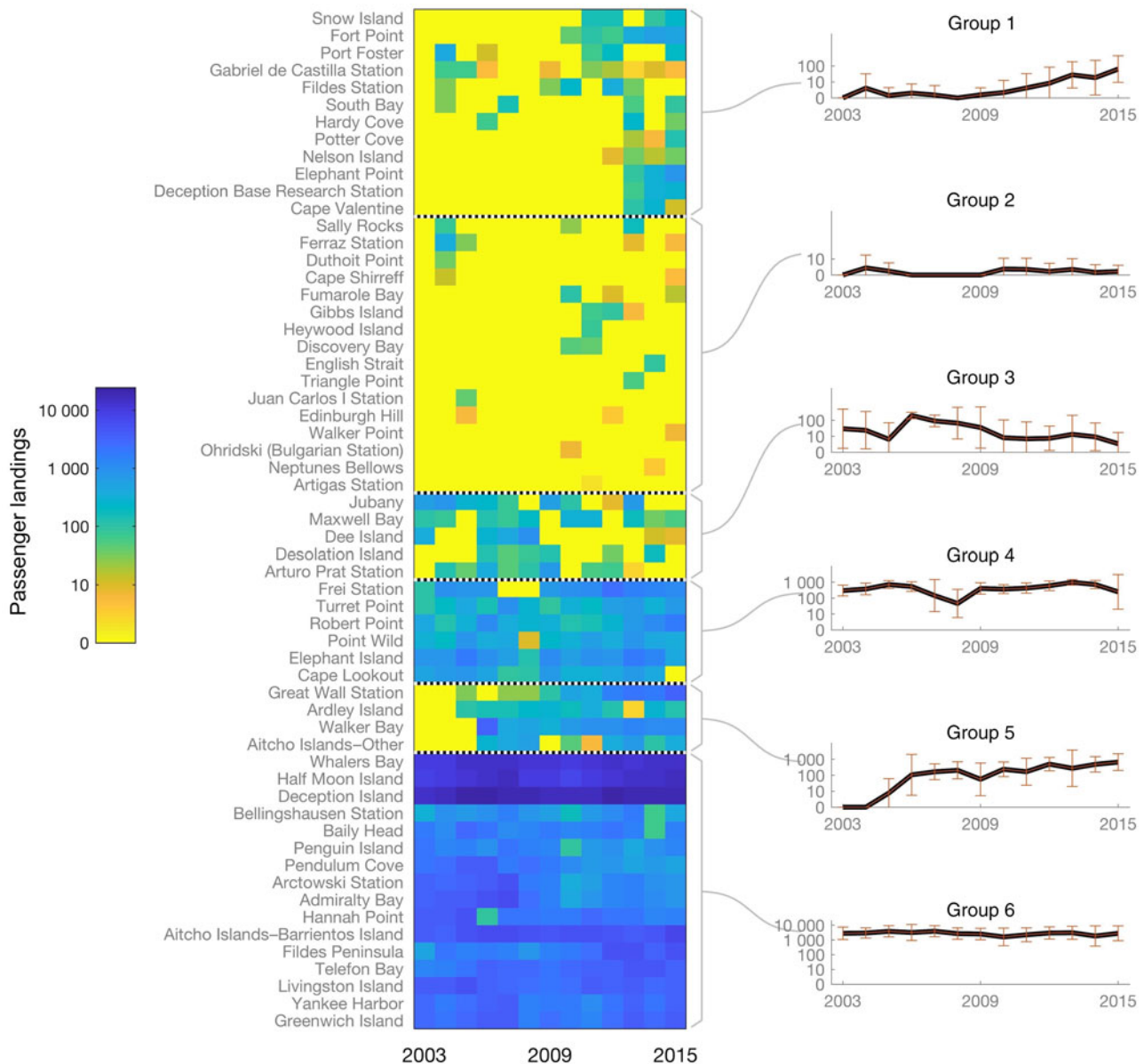


Fig. 5. Representation of the patterns of tourism visitation in the South Shetland Islands over time resulting from cluster analysis.

Discussion: using tourism visitation patterns for the conservation of the archaeological sites in the SSI

In this paper, we identified long-term trends and spatiotemporal patterns of tourism visitation for the SSI, considering trends of landing points used over time and the frequency of passenger landings; thus, we identified the archaeological sites located near the places used for tourism activities. Over time, there has been a significant increase in landing points used in the AP and in the SSI. On the islands, a linear trend over time was observed for the number of landing points, which constantly increases by one or two points a year on average. During that period, a total of 59 landing points were used.

In this context, we emphasise that even though the data available confirmed that the vicinities of four archaeological sites are being used as landing points by tourism so far, the trends show that the number of landing points in the SSI is increasing and it is inevitable that other sites will be reached through tourism. Therefore, any proposal for the protection and enhancement of the visibility

of the sites should be elaborated before other sites are included in cruise itineraries, rather than after they are visited. Information on the ways that unvisited places of the SSI have been incorporated in tourism could forecast the incorporation of new landing points and the potential impact on 19th-century archaeological sites.

In the SSI, we found that tourism during the last decade has been a highly concentrated activity, with 90% of all landings occurring at 13 sites that represent 22% of all the landing points. The spatiotemporal analysis showed that this uneven distribution was more heterogeneous than the concentrated–dispersed spatial visitation patterns could indicate. We defined six different visitation patterns that should contribute to setting priorities in the specific management strategies for the 19th-century archaeological sites. Temporal tendencies varied from increasing, constant, or decreasing trends over time, differing in the magnitude and intensity of the visitation. They could also be interpreted as the current regional scenarios for assessing tourism impact and conservation challenges in the SSI.

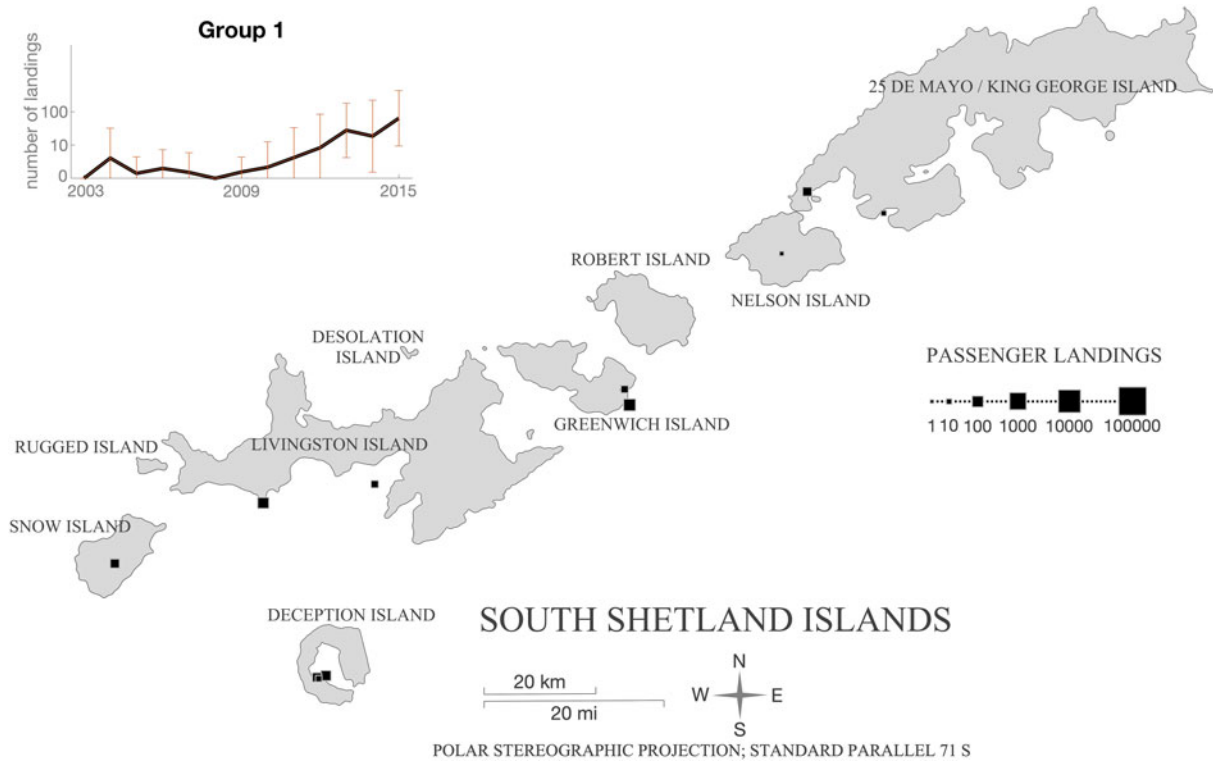


Fig. 6. Group 1 landing point distribution in the South Shetland Islands.

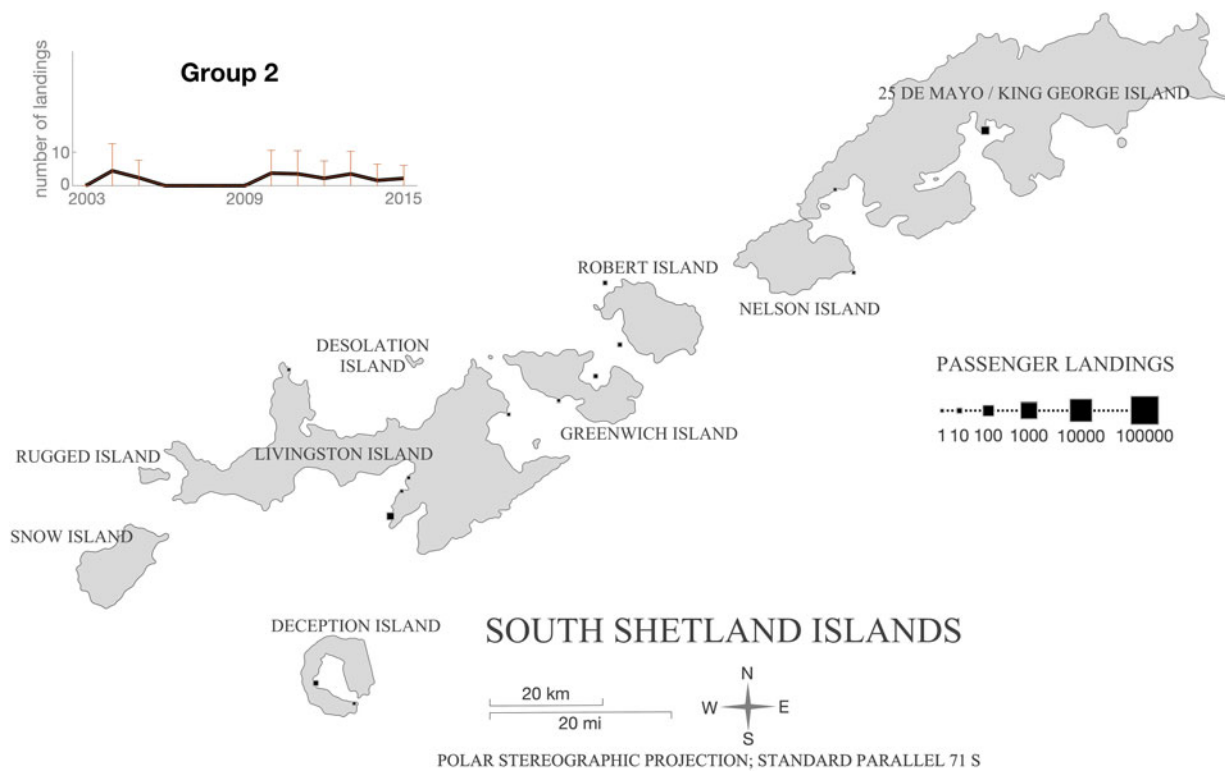


Fig. 7. Group 2 landing point distribution in the South Shetland Islands.

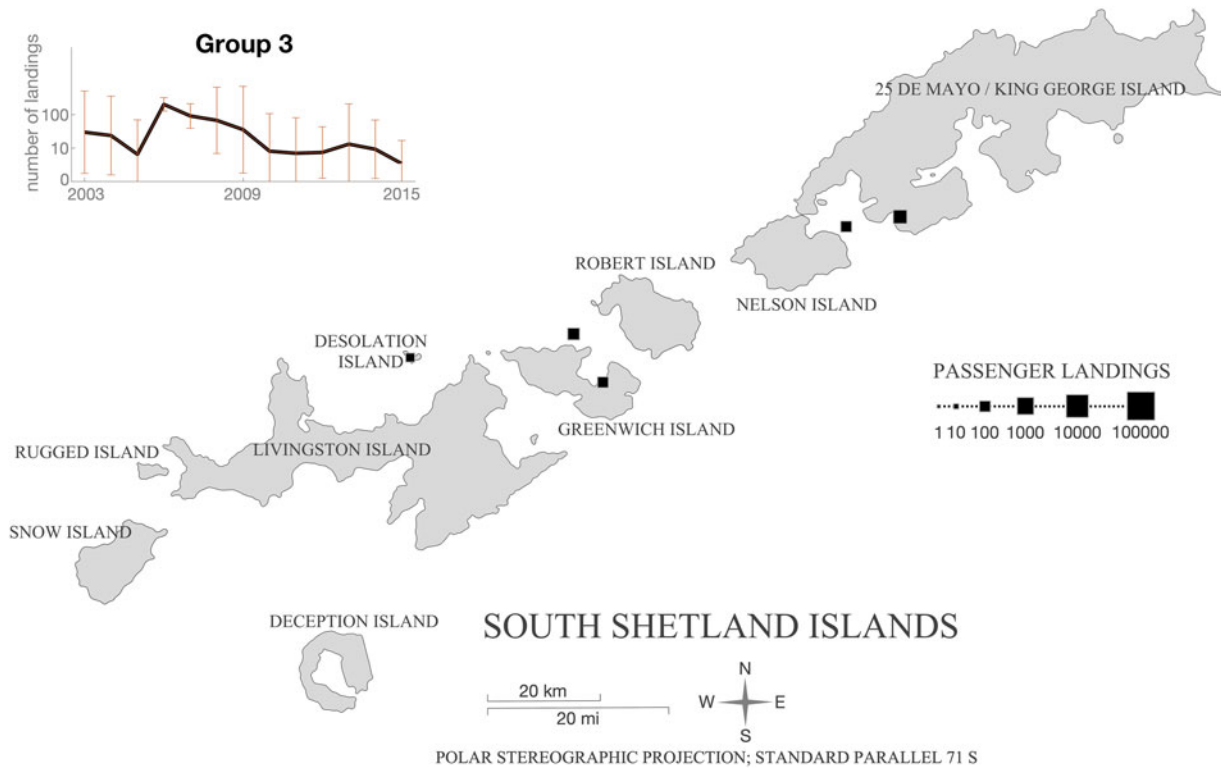


Fig. 8. Group 3 landing point distribution in the South Shetland Islands.

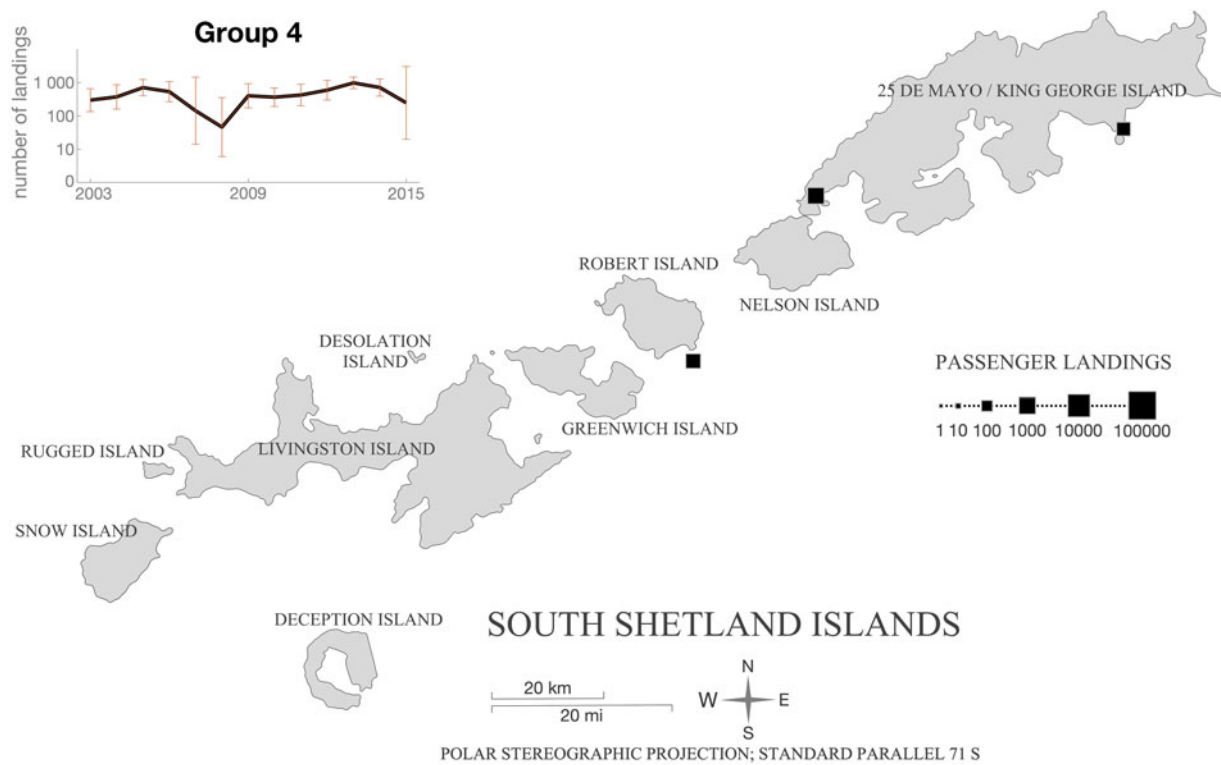


Fig. 9. Group 4 landing point distribution in the South Shetland Islands.

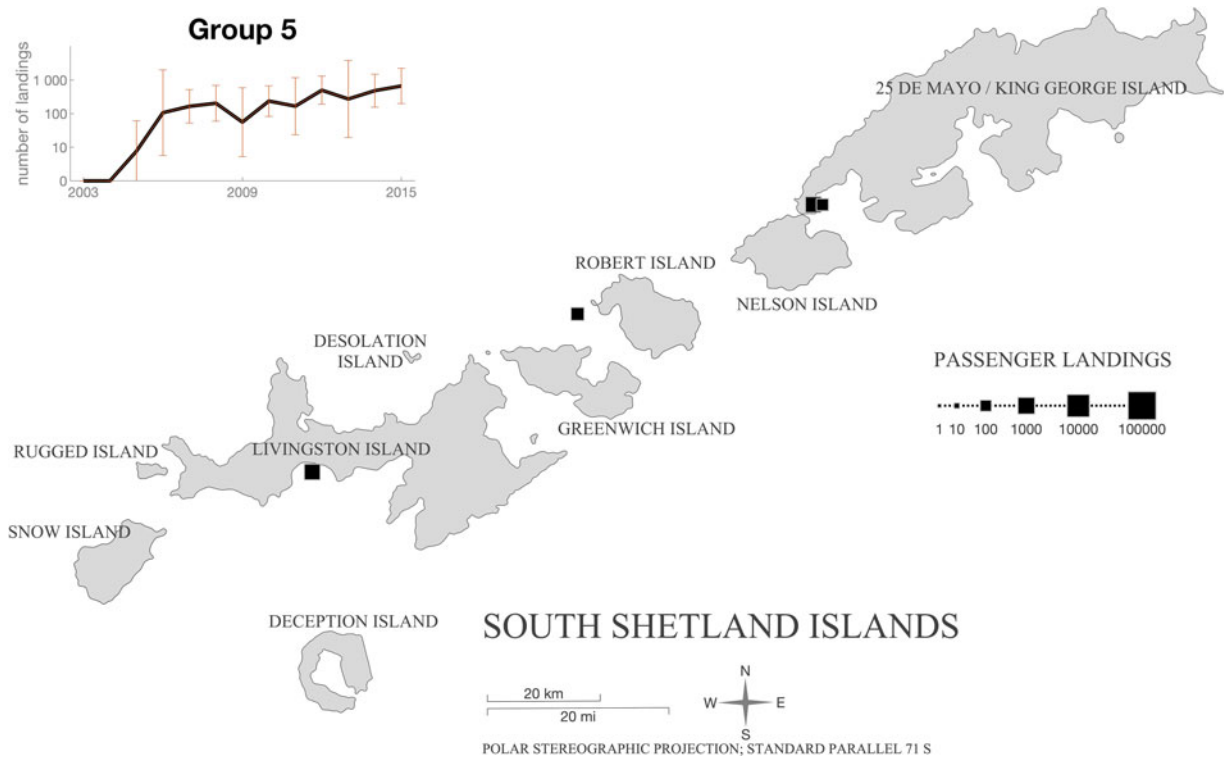


Fig. 10. Group 5 landing point distribution in the South Shetland Islands.

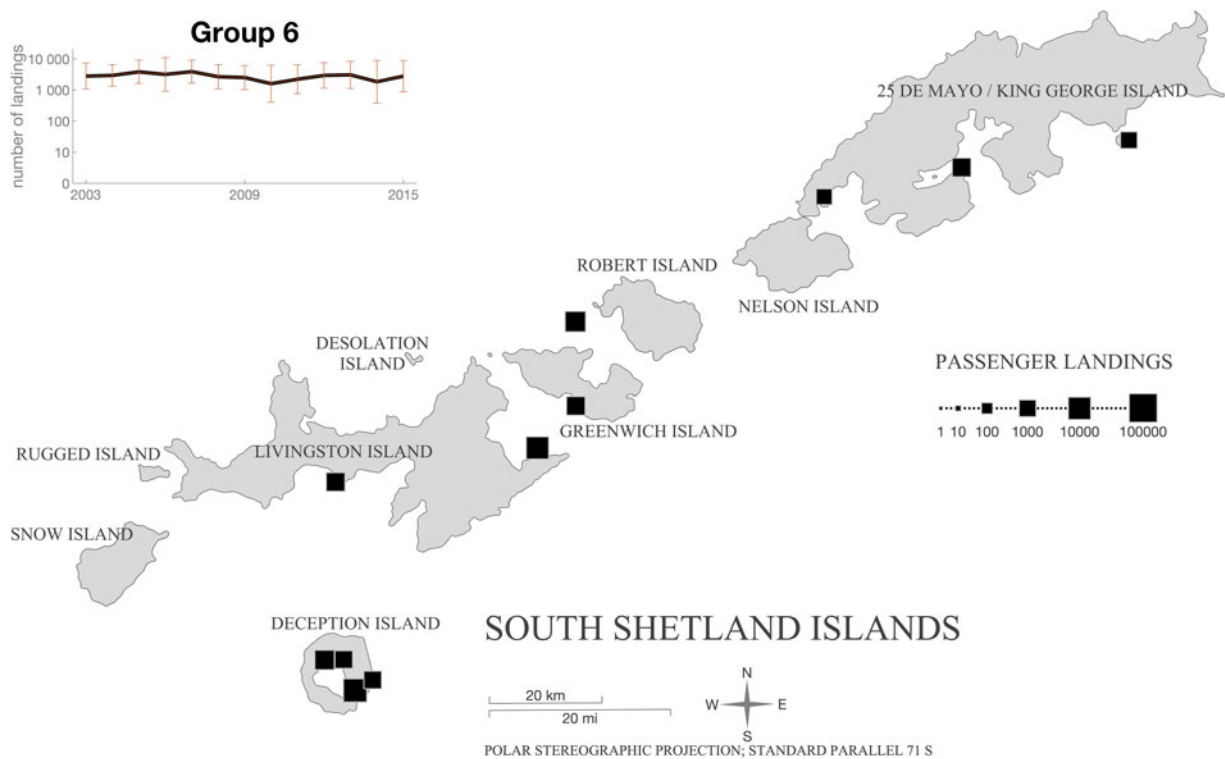


Fig. 11. Group 6 landing point distribution in the South Shetland Islands.

Table 1. Information of the patterns of tourism visitation in the SSI. Landing point areas near archaeological sites are showed in bold

| Group | Description of passenger landings temporal trend | Number of landing points | Tourist landings (range) | Name of landing points in the SSI |
|-------|--|--------------------------|--|---|
| 1 | Recent increase | 12 | A mean of 4 landings in the first six seasons (2003–2004 to 2008–2009) and mean of 196 passenger landings in the last season (2015–2016) | Snow Island, Fort Point, Port Foster, Gabriel de Castilla Station, Fildes Station, South Bay, Hardy Cove, Potter Cove, Nelson Island, Elephant Point , Deception Base Research Station, and Cape Valentine (Fig. 6) |
| 2 | Constant low | 16 | A range between 0 and 30 passenger landings across the entire period | Sally Rocks, Ferraz Station, Duthoit Station, Cape Shirreff, Fumarole Bay, Gibbs Island, Heywood Island, Discovery Bay, English Strait, Triangle Point, Juan Carlos I Station, Edinburgh Hill, Walker Point, Ohridski Station, Neptune Bellows, and Artigas Station (Fig. 7) |
| 3 | Decrease | 5 | A mean of 216 passenger landings in the first season (2003–2004) and 12 landings in the last season (2015–2016) | Carlini Station (former Jubany Station), Maxwell Bay, Dee Island, Desolation Island , and Arturo Prat Station (Fig. 8) |
| 4 | Constant medium | 6 | A range between 130 and 1067 passenger landings across the entire period | Frei Station, Turret Point , Robert Point, Point Wild, Elephant Island, and Cape Lookout (Fig. 9) |
| 5 | Early increase | 4 | No passenger landings in the first season (2003–2004), and a mean of 258 in 2007–2008 and 1262 in 2015–2016 | Great Wall Station, Ardley Island, Walker Bay, and “Aithcho Island–other” (Fig. 10) |
| 6 | Constant high | 16 | A range between 3437 and 5838 passenger landings across the entire period | Whalers Bay, Half Moon Island, Deception Island, Bellingshausen Station, Baily Head, Penguin Island, Pendulum Cove, Arcowski Station, Admiralty Bay Hannah Point, Aitcho Island–Barrientos Island, Fildes Peninsula, Telefon Bay, Livingston Island, Yankee Harbour , and Greenwich Island (Fig. 11) |

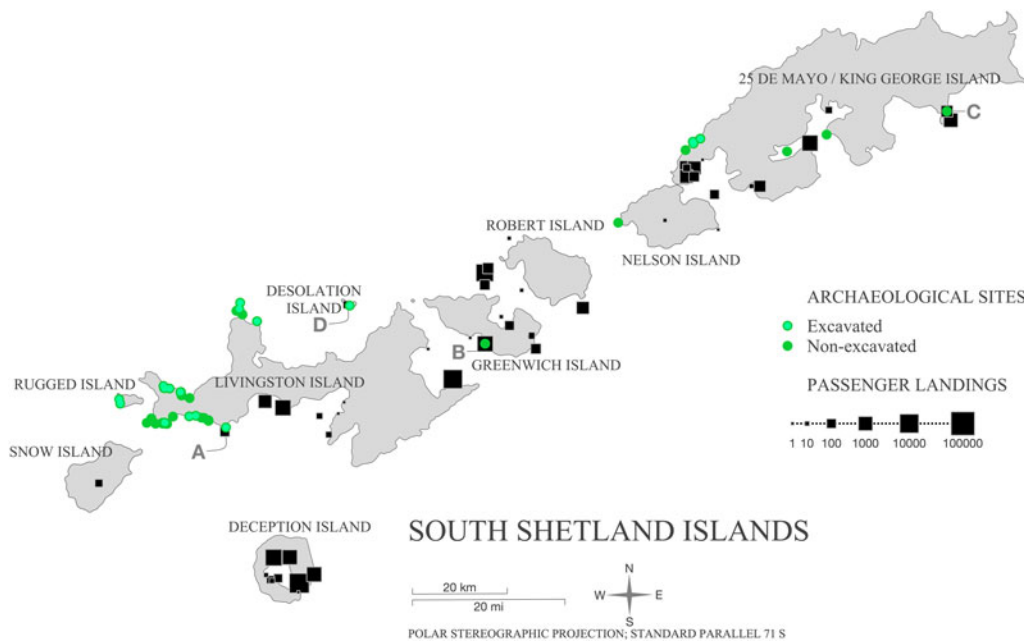


Fig. 12. Distribution of landing points showing the cumulative number of passenger landings and the location of 19th-century sealing archaeological sites in the South Shetland Islands.

Considering specific cases

We identified four cases of archaeological sites located in the vicinities of landing points. First, we identified an increasing visitation trend (Group 1) in an area that is still being researched, as the Elephant Point case showed the archaeological richness and

well-preserved sites. Second, we identified constant and highly focalised activity in the YH (Group 6) in an area of potential research interest having Site Guidelines for Visitors. Third, we observed an area that has been continuously and frequently visited (Group 4) in the vicinity of an archaeological site that has not yet



Fig. 13. Nineteenth-century sealers' remains in the vicinities of Elephant Point tourism landing points. View of the PEX1 site during archaeological fieldworks in Elephant Point, Livingston Island (Photo A. Zarankin LEACH).

been studied and is not mentioned in the Site Guidelines for Visitors. Fourth, we identified an area with a decreasing trend of low-frequency visitation (Group 3) that shows the diversity and richness of archaeological remains studied several years ago.

Considering the visitation patterns, the archaeological sites at higher risk of impact by human activities are located at Elephant Point on Livingston Island, due to their increasing visitation rates, and also at YH on Greenwich Island and TP on 25 de Mayo/King George Island, due to their relatively high and persistent tourist visitation rates. These sites must be prioritised for specific short-term conservation measures, and we recommend immediate action. Even though the sites located on Desolation Island should also be protected, their exposure to risk seems lower than in the other three cases, considering their comparatively lower and declining visitation rates.

In those specific cases, the protection and management proposals could be approached with a local view or site-specific scale considering the best options for each case. Available ATS tools such as the Visitors Site Guidelines could be considered the most useful ones to address the urgency of risk in the short term for those places already visited by tourism. The YH and TP areas have potential to engage visitors with the stories of sealers in Antarctica. Currently, there are guidelines available for all highly concentrated passenger landing points in the SSI, but the information offered about the location and characteristics of sealing sites is neither

sufficient nor detailed. We recommend the addition of specific and detailed information referring to the archaeological sites to the existing guidelines for the YH and TP areas. In all cases, the development and implementation of long-term associated managing and monitoring plans are crucial and strongly recommended in order to assess the effectiveness of the guidelines for the protection of the sites.

Elephant Point area represents a different situation, in which the protection of the archaeological sites entails the conservation and management of the entire area. According to our results, Elephant Point showed an increasing trend of tourism visitation during the studied period (2003–2004 to 2015–2016) without having a specific Visitor Site Guidelines or information specially produced for the protection of the archaeological sites. That scenario could represent a threat for the conservation of sites in which urgent measures should be taken in the short term. Currently, in the XL Antarctic Treaty Consultative Meeting (Beijing, 2017), a group of parties (Portugal, Brazil, Spain, and UK) jointly intended to inform the CEP's considerations on the protection and management of the Elephant Point area, possibly by designating it as an ASPA or by incorporating it within the nearby ASPA (ASPA 126 Byers Peninsula) (ATCM, 2017, pp. 159–160). They provided information on the high ecological value and historical significance of the ice-free area of Elephant Point and highlighted the importance of all five values outlined in Annex V to the Madrid Protocol (i.e. environmental, scientific, historic, aesthetic, and wilderness). At the same Antarctic Treaty Consultative Meeting, the IAATO informed the CEP that the Elephant Point area was used by tour operators, receiving about 1900 visitors in the last seasons (2016–2017) and “in the absence of specific site guidelines, landings were managed using the General Guidelines for Visitors to the Antarctic (annexed to Resolution 3 (2011)), and IAATO Mechanisms” (ATCM, 2017, pp. 174). IAATO offered to contribute expert knowledge of the site to future discussions, and the CEP expressed its interest in receiving further updates to continue developing protection and management options for the area (ATCM, 2017, pp. 175).

Towards a regional perspective

A broader discussion on the management of all the 19th-century archaeological sites must consider not only the potential effectiveness of the tools currently available but also the spatial scale of the proposed plans (i.e. site-focused, local, regional). In this sense, the results of this paper could also inform a future long-term regional conservation and management strategy that considers the different visitation patterns and the increasing trend in the number of landing points for the SSI. These results offer information for assessing the potential usefulness of management plans either as different unconnected local plans or as one strategic regional management plan SSI-wide.

From a regional perspective, the discussion might consider tourist visiting patterns in setting priorities and in creating explicit criteria for selecting sites that could be accessible or restricted to visitors, that is, considering the location of archaeological sites for proposing ASPAs based on a balance between environmental and heritage values (e.g. Elephant Point area). Previous experience on human impacts on sites inside the ASPAs has to be critically and seriously considered (e.g. Braun, Hertel, & Peter, 2017; Pearson et al., 2010) in order to improve the conservation and management of the archaeological sites as well as to elaborate specific monitoring plans for them.

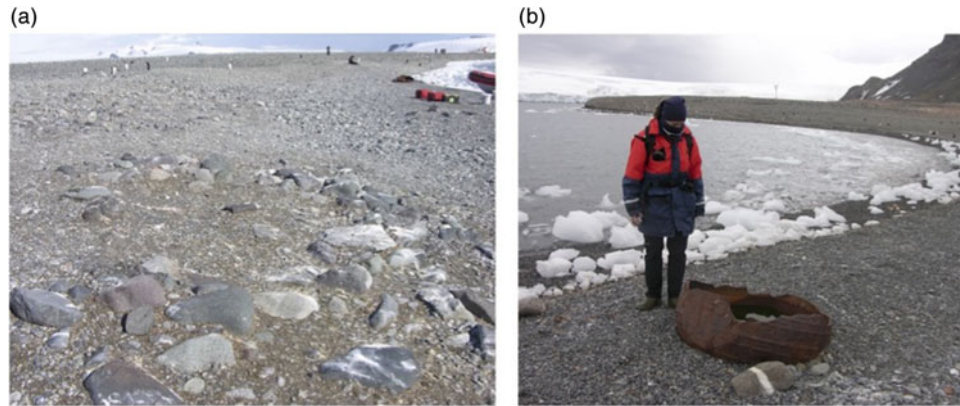


Fig. 14. Nineteenth-century sealers' remains in the vicinities of YH tourism landing point. (a) View of the YH site, structure of rocks placed in open beach (Photo M. X. Senatore). (b) View of the semi-buried iron trypot in YH, Greenwich Island (Photo M. X. Senatore).



Fig. 15. Nineteenth-century sealers' remains in the vicinities of TP tourism landing point. View of TP site in Turret Point, 25 de Mayo/King George Island (Photo M. Pearson).

The elaboration of a regional point of view for the protection of the sites could articulate specific factors as their scientific significance and conservation state. The significance of the sites for ongoing and future research projects depends on diverse criteria, such as the uniqueness of the sites and their representativeness among a group of similar sites (considering their chronology and functionality among other criteria). Their significance also

depends on whether they were objects of past research or subject of ongoing or future research plans, the degree of knowledge about the sites (e.g. excavated sites, recorded or seen), and the potential they have for future research.

Effective management plans should contribute to increase the sites' visibility as a way of protecting them and communicating their associated history. In this sense, much remains to be done. All IAATO member operators provide education programs as part of their trips. That could be considered as an opportunity to develop specific outreach programs to be used for visitors to experience the visitation of the sites as a way to learn about the oldest human occupations in Antarctica. In this sense, YH and TP areas could be highlighted for their potential to engage visitors with the stories of sealers in Antarctica. Plans for promoting meaningful engaging with sealing stories and enhancing the interpretation of the sites could be developed through collaborative projects between IAATO and bodies such as the International Council on Monuments and Sites-International Polar Heritage Committee and university research teams working on these sites. These projects could consider offering general narratives about the sealing history in the SSI, specific information about the archaeological sites that are already visited by tourism, and developing archaeological surveys, and protection or management proposals before new landing sites are selected. Some explorations on the use of sealing sites and objects in narrating the past and in creating social and individual memories have been initiated by research groups working in Antarctica (Senatore, Lüdecke, Nuviala, Arrebola, & Roldan, 2019; Soares & Mota, 2017; Soares, Nolasco, & Mota, 2018).

Until now, tourism has hardly paid any attention to historical sealing sites (Basberg, 2008). In fact, sealers' remains were often encountered unexpectedly by visitors without any reference or exhibition context (Lüdecke, 2010; Senatore & Zarankin, 2012). However, trends in tourism development are showing that traditional cruises and maritime tourism are being complemented by other modalities that offer a broad range of facilities and products (e.g. Bastmeijer & Lamers, 2013; Lamers, Liggett, & Amelung, 2012). In this context, visits to the oldest archaeological sites could be considered attractive for landings in the near future. Moreover, the scope of the projects for enhancing the visibility of the sealing history and sites should include not only tourism but also operators of the national programs developing activities in the SSI. Braun et al. (2017, p. 359) have observed that as a variety of human activities pose risks to the historic sites, "knowledge of the cultural value

of historic remains needs to be improved” and should be available to the authorities, tourist guides, and particularly, to members of national Antarctic Programs. Pearson et al. (2010, p. 62) have already suggested pre-trip training for national parties going to Antarctica that should include information and awareness training about the presence, significance, and protection of historical sites.

Conclusions

Despite the fact that archaeological studies have been performed in the SSI over the past 30 years, much remains to be done for the conservation of the sites. Early 19th-century sealers’ history and sites have traditionally had low visibility in Antarctic narratives as well as in ATS policymaking linked to Antarctic heritage. Researchers should accept the challenge of increasing the visibility of sealing history and sites and help draft future proposals for the conservation of the oldest Antarctic sites. The archaeological sites also offer an opportunity to narrate the past, and tourism activities related to these 19th-century sites could contribute to engage visitors with the stories of sealing in the Antarctica. The possibilities for achieving the conservation of the sealing sites depend on understanding how the complex process of cultural heritage occurs in Antarctica and the role that science, policymaking, and tourism could play in it.

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References

- Ashley, G., & Mackay, R. (2004). Mawson’s Huts Historic Site, Antarctica: the conservation management plan as a decision-making tool. In S. Barr & P. Chaplin (Eds.), *Cultural heritage in the Arctic and Antarctic regions* (pp. 44–52). Lorenskog: International Council on Monuments and Sites ICOMOS.
- Balch, E. (1902). *Antarctica*. Philadelphia: Press of Allen, Lane and Scott.
- Barr, S. (2010). Arctic and Antarctic – different, but similar: challenges of heritage conservation in the high Arctic. In S. Barr & P. Chaplin (Eds.), *Polar settlements – location, techniques and conservation* (pp. 14–23). Fjellhamar: International Council on Monuments and Sites ICOMOS.
- Barr, S. (2018). Twenty years of protection of historic values in Antarctica under the Madrid Protocol. *The Polar Journal*, 8(2), 241–264, <https://doi.org/10.1080/2154896X.2018.1541547>
- Basberg, B. L. (2008). *Antarctic Tourism and the Maritime Heritage*. Discussion Paper SAM, 20, (pp. 1–24). Berben: NHH.
- Basberg, B. L. (2017). Commercial and economic aspects of Antarctic exploration – from the earliest discoveries into the “Heroic Age”. *The Polar Journal*, 7(1), 205–226, <https://doi.org/10.1080/2154896X.2017.1324690>
- Basberg, B. L., & Headland, R. K. (2008). *The Nineteenth Century Antarctic Sealing Industry: Source, Data and Economic Significance*. Bergen: Institutt for Samfunnøkonomi.
- Bastmeijer, K., & Lamers, M. (2013). Reaching consensus on Antarctic tourism regulation calibrating the human-nature relationship? In D. K. Müller et al. (Eds.), *New issues in polar tourism: communities environmental, politics* (pp. 67–82). Dordrecht: Springer Science+ Business Media.
- Bender, N. A., Crosbie, K., & Lynch, H. (2016). Patterns of tourism in the Antarctic Peninsula region: a 20-year analysis. *Antarctic Science*, 28(3), 194–203.
- Berguño, J. (1993a). Las Shetland del Sur: el ciclo lobero. Primera parte. *Boletín Antártico Chileno*, 12(1), 5–13.
- Berguño, J. (1993b). Las Shetland del Sur: el ciclo lobero. Segunda parte. *Boletín Antártico Chileno*, 12(2), 2–9.
- Braun, C., Hertel, F., & Peter, H.-U. (2017). Environmental management – The Fildes Peninsula paradigm. In K. Doods, A. D. Hemmings, & P. Roberts (Eds.), *Handbook of the politics of Antarctica* (pp. 351–367). Cheltenham: Edward Elgar Publishing.
- Braun, C., Mustafa, O., Nordt, A., Pfeiffer, S., & Peter, H.-U. (2012). Environmental monitoring and management proposals for the Fildes Region, King George Island, Antarctica. *Polar Research*, 31(1), <https://doi.org/10.3402/polar.v31i0.18206>
- Campbell, R. J. (2000). *The Discovery of the South Shetlands Islands 1819–1820 as Recorded in Contemporary Documents and the Journal of Midshipman C.W. Poynter*. London: The Hakluyt Society Series III, Volume 4.
- Ferrigno, J. G., Cook, A. J., Foley, K. M., Williams, R. S.Jr., Swithinbank, C. H., Fox, A. J., ... Sievers, J. (2006). Coastal-change and glaciological map of the Trinity Peninsula area and South Shetland Islands, Antarctica: 1843–2001. U.S. Geological Survey Geologic Investigations Series Map I-2600-A, 1 sheet, scale 1:1,000,000, with 32-p. pamphlet. Available online at <http://pubs.usgs.gov/imap/2600/A>
- Gould, R. (1941). The charting of the South Shetland Islands. *Mariner’s Mirror*, 27(3), 206–242.
- Harrowfield, D. L. (1991). Archaeology of Borchgrevink’s stores hut, Cape Adare, Antarctica. *New Zealand Journal Archaeology*, 13, 177–197.
- Harrowfield, D. L. (2005). Archaeology in Antarctica. *New Zealand Journal of Archaeology*, 26, 5–28.
- Headland, R. (2017). Antarctic sealing voyages 1786 to 1922. In R. Headland (Ed.), *Historical Antarctic sealing industry*. Scott Polar Research Institute, Occasional Publication (pp. 171–223). Cambridge: Cambridge University.
- Headland, R. K. (1999). *A Chronology of Antarctic Exploration. A Synopsis of Events and Activities from the Earliest Times until the International Polar Years, 2007–09*. London: Bernard Quaritch.
- Hughes, J. (1992). Mawson’s Antarctic huts and tourism: a case for on-site preservation. *Polar Record*, 28(164), 37–42.
- Hughes, J. (1994). Antarctic historic sites: the tourism implications. *Annals of Tourism Research*, 21(2), 281–294.
- Hughes, J., & Davis, B. (1995). The management of tourism at historic sites and monuments. In C. M. Jones & M. E. Johnston (Eds.), *Polar tourism: tourism in the Arctic and Antarctic regions* (pp. 235–255). London and New York: John Wiley and Sons.
- Jones, A. G. (1981a). The British southern whale and seal fisheries part I. *The Great Circle*, 3(1), 20–29.
- Jones, A. G. (1981b). The British southern whale and seal fisheries part I. *The Great Circle*, 3(2), 90–102.
- Lamers, M., Liggett, D., & Amelung, B. (2012). Strategic challenges of tourism development and governance in Antarctica: taking stock and moving forward. *Polar Research*, 31(1), <https://doi.org/10.3402/polar.v31i0.17219>
- Ledingham, R. B. (1979). Expedition to renovate the 1912–13 Australian Antarctic Expedition Base Hut. *Polar Record*, 19(122), 485–492.
- Lee, J. E., & Hughes, K. A. (2010). Focused tourism needs focused monitoring. *Antarctic Science*, 22(1), 1, <https://doi.org/10.1017/S0954102009990782>
- Lewis Smith, R. I., & Simpson, H. W. (1987). Early nineteenth century sealers’ refuges on Livingston Island, South Shetland Islands. *British Antarctic Survey Bulletin*, 74, 49–72.
- Lüdecke, C. (2010). Gorgeous landscapes and wildlife: the importance and danger of Antarctic tourism. *Hemispheric and Polar Studies Journal*, 1(4), 213–231.
- Lynch, H. J., Crosbie, K., Fagan, W. F., & Naveen R. (2010). Spatial patterns of tour ship traffic in the Antarctic Peninsula region. *Antarctic Science*, 22(2), 123–130, <https://doi.org/10.1017/S0954102009990654>
- Maddison, B. (2014). *Class and Colonialism in Antarctic Exploration, 1750–1920*. United Kingdom: Pickering and Chatto Publishers.
- Martin, L. (1940). Antarctica discovered by a Connecticut Yankee, Captain Nathaniel Brown Palmer. *The Geographical Review*, XXX(4), 529–562.
- Miers, J. (1920). Account of the discovery of New South Shetland, with observations on its importance in geographical, commercial and

- political point of view: with two plates. *Edinburgh Philosophical Review*, III, 367–380.
- Oliva, M., Ruiz-Fernández, J., Zarankin, A., Casanova-Katny A., & Nofre, J.** (2017). Geocology and historical heritage in the ice-free area of Elephant point (Antarctica). Proposal for future environmental protection. *Geoheritage*, 9(1), 97–109, <https://doi.org/10.1007/s12371-016-0184-1>
- Pearson, M.** (2011). Polar heritage conservation and archaeology. In S. Barr & P. Chaplin (Eds.), *Polar settlements – Location, techniques and conservation* (pp. 24–34). Fjellhamar: International Council on Monuments and Sites ICOMOS.
- Pearson, M.** (2018). Living under their boats: a strategy for southern sealing in the nineteenth century – its history and archaeological potential. *The Polar Journal*, 8(1), 68–83, <https://doi.org/10.1080/2154896X.2018.1468606>
- Pearson, M., & Stehberg, R.** (2006). Nineteenth century sealing sites on Rugged Island, South Shetland Islands. *Polar Record*, 42, 1–13.
- Pearson, M., & Stehberg, R.** (2011). Geographic and technological influences on the location, nature and conservation of nineteenth century sealing sites in the South Shetland Islands. In S. Barr & P. Chaplin (Eds.), *Polar settlements – Location, techniques and conservation* (pp. 86–93). Fjellhamar: International Council on Monuments and Sites ICOMOS.
- Pearson, M., Stehberg, R., Zarankin, A., Senatore, M. X., & Gatica, C.** (2008). Sealer's sledge excavated on Livingston Island, South Shetland Islands. *Polar Record*, 44, 362–364.
- Pearson, M., Stehberg, R., Zarankin, A., Senatore, M. X., & Gatica, C.** (2010). Conserving the oldest historic sites in the Antarctic: the challenges in managing the sealing sites in the South Shetland Islands. *Polar Record*, 46, 57–64.
- Pyne, S.** (2003). *The Ice: A Journey to Antarctica*. London: Weidenfeld & Nicolson.
- Richards, R.** (2003). New market evidence on the depletion of southern fur seals: 1788–1833. *New Zealand Journal of Zoology*, 30, 1–9.
- SAT (Secretariat of the Antarctic Treaty)**. (2017). Final report of the fortieth Antarctic Treaty Consultative Meeting. Beijing, China, 2 May–1 June 2017. Retrieved from http://www.ats.aq/devAS/info_finalrep.aspx?lang=e&menu=2.
- Senatore, M. X.** (2018a). Antarctic historical sealing industry and material things. In R. Headland (Ed.), *Historical Antarctic sealing industry*. Scott Polar Research Institute, Occasional Publication (pp. 61–71). Cambridge: Cambridge University.
- Senatore, M. X.** (2018b). Arqueología y Turismo en las Islas Shetland del Sur, Antártida. *Pasos Revista de Turismo y Patrimonio Cultural*, 16(1), 99–116.
- Senatore, M. X.** (2019). Archaeologies in Antarctica from Nostalgia to capitalism: a Review. *International Journal of Historical Archaeology*, <https://doi.org/10.1007/s10761-019-00499-7>
- Senatore, M. X., Lüdecke, C., Nuviala, M. V., Arrebola, S., & Roldan, G.** (2019). Antarctic heritage as individual experiences. *Paper presented at SCAR SG-HASS Biannual Meeting*, Ushuaia.
- Senatore, M. X., & Zarankin, A.** (1999). Arqueología histórica y expansión capitalista. Prácticas cotidianas y grupos operarios en Península Byers, Isla Livingston de Islas Shetland del Sur. In A. Zarankin, & F. Acuto (Eds.), *Sed Non Satiata. Teoría Social en la Arqueología Latinoamericana Contemporánea* (pp. 171–188). Buenos Aires: Ediciones del Tridente.
- Senatore, M. X., & Zarankin, A.** (2011). Widening the scope of the Antarctic heritage archaeology and the ugly, the dirty and the evil in Antarctic history. In S. Barr & P. Chaplin (Eds.), *Polar settlements – Location, techniques and conservation* (pp. 51–59). Fjellhamar: International Council on Monuments and Sites ICOMOS.
- Senatore, M. X., & Zarankin, A.** (2012). Tourism and the invisible historic sites in Antarctica. In: *Heritage as a driver to development Part III Development as tourism* (pp. 592–601). Paris: ICOMOS.
- Senatore, M. X., & Zarankin, A.** (2014). Against the domain of master narratives: Archaeology and history in Antarctica. In C. Gnecco & C. Langebaek (Eds.), *Against the typological tyranny in archaeology: A view from South America* (pp. 121–132). New York: Springer.
- Soares, F., & Mota, M.** (2017). Arqueología digital abaixo de zero: uma proposta de mediação para a arqueología antártica. *Vestigios*, 11(1), 21–39
- Soares, F., Nolasco, R., & Mota, M.** (2018). Antarctic digital public archaeology. In R. Headland (Ed.), *Historical Antarctic sealing industry*. Scott Polar Research Institute, Occasional Publication (pp. 139–145). Cambridge: Cambridge University.
- Stackpole, E.** (1950). *The Voyage of the Huron and the Huntress: The American Sealers and the Discovery of the Continent of Antarctica*. Connecticut: Mystic Seaport Museum.
- Stehberg, R.** (1983). Terra Australis Incógnita: una ruta de investigación arqueológica. *Serie Científica del Instituto Antártico Chileno*, 30, 77–86.
- Stehberg, R.** (2003). *Arqueología Histórica Antártica: Aborígenes sudamericanos en los mares subantárticos en el siglo XIX*. Chile: Centro de Investigaciones Diego Barros Arana.
- Stehberg, R.** (2004). Archaeologists document historical heritage in the South Shetlands. In S. Barr & P. Chaplin (Eds.), *Cultural heritage in the Arctic and Antarctic regions. Monuments and Sites VIII Special Issue* (pp. 69–72). Lorenskog: IPHC-ICOMOS.
- Stehberg, R., & Cabeza, A.** (1984). Primera excavación de arqueología histórica Antártica. *Boletín Antártico Chileno*, 4, 15–17.
- Stehberg, R., & Cabeza, A.** (1987). Comienzos de la Arqueología Histórica Antártica en el Sitio Cuatro Pircas. *Revista Chilena de Antropología*, 6, 83–111.
- Stehberg, R., & Lucero, V.** (1985). Arqueología Histórica en la Isla Desolación. Evidencias de coexistencia entre cazadores de lobo de origen europeo y aborígenes del extremo sur americano, en la segunda década del siglo pasado. *Serie Científica del Instituto Antártico Chileno*, 46, 59–81.
- Stehberg, R., & Lucero, V.** (1996). Excavaciones arqueológicas en Playa Yámana, Cabo Shirreff, Isla Livingston, Antártica. *Serie Científica Instituto Antártico Chileno*, 46, 59–81.
- Stehberg, R., Pearson, M., Zarankin, A., Senatore, M. X., & Gatica, C.** (2008). Protection and preservation of the oldest sites of the Antarctic: the case of Fildes Peninsula and Byers Peninsula in the South Shetlands Islands. In S. Barr & P. Chaplin (Eds.), *Historical polar bases preservation and management, Monuments and Sites XIV Special Issue* (pp. 85–93). Lorenskog: International Council on Monuments and Sites ICOMOS.
- Stonehouse, B., & Snyder, J. M.** (2010). *Polar Tourism, an environmental perspective*. Bristol: Channel View Publications.
- Ward, J. H.** (1963). Hierarchical grouping to optimize an objective function. *Journal of the American Statistical Association*, 58(301), 236–244.
- Watson, N.** (2011). The Ross Sea Heritage Restoration Project: Technology, innovation & public engagement. In S. Barr & P. Chaplin (Eds.), *Polar settlements – Location, techniques and conservation* (pp. 81–96). Fjellhamar: International Council on Monuments and Sites ICOMOS.
- Zarankin, A., Hissa, S., Salerno, M., Froner, Y., Radicchi, G., Resende de Assis L. G., & Batista, A.** (2011). Paisagens em branco: Arqueología e Antropología Antárticas Avances e desafíos. *Vestigios*, 5(2), 11–51.
- Zarankin, A., & Senatore, M. X.** (1996). Ocupación humana en tierras antárticas: una aproximación arqueológica. In *Soplando el Viento. Actas III Jornadas de Arqueología de la Patagonia* (pp. 629–644). Neuquén and Buenos Aires: Universidad del Comahue e Instituto Nacional de Antropología Y Pensamiento Latinoamericano.
- Zarankin, A., & Senatore, M. X.** (1999). Arqueología en Antártida, estrategias, tácticas y los paisajes del capitalismo. In *Desde el País de los Gigantes: perspectivas arqueológicas en Patagonia* (pp. 315–327). Río Gallegos: Universidad Nacional de la Patagonia Austral.
- Zarankin, A., & Senatore, M. X.** (2000). Hasta el fin del Mundo. Arqueología en las Islas Shetland del Sur. El caso de Península Byers, Isla Livingston. *Praehistoria*, 3, 219–236.
- Zarankin, A., & Senatore, M. X.** (2005). Archaeology in Antarctica: nineteenth-century capitalism expansion strategies. *International Journal of Historical Archaeology*, 9, 43–56.
- Zarankin, A., & Senatore, M. X.** (2007). *Historias de un Pasado en Blanco: Arqueología Histórica Antártica*. Belo Horizonte: Argumentum.