European expeditions as a source of historic abundance data on marine organisms[1]

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Abstract

The abundance of marine organisms reported during the great European oceanographic expeditions can be a useful tool for assessing changes in marine biodiversity. Qualitative information from narratives of these early expeditions can be analyzed quantitatively and used to plot trends of observed abundances at a specific locality over time.

This paper focuses on 9 expeditions and 7 voyages to the Falkland Islands. Accounts of organisms occurring in the Falkland Islands were assembled from available expedition/voyage reports covering the period between the late 1500s to the early 1920s. Each observation or 'anecdote' in these reports (usually a sentence or paragraph) was ranked according to the perceived abundance of a group of species (e.g., marine mammals, seabirds, fishes, etc.) using a 5-level scale (i.e., extremely abundant; abundant; very common; common; rare; absent).

The results indicate that, in general, the most 'visible' or those deemed useful to humans (marine mammals, seabirds and large fishes), were the subject of half of all anecdotes assembled for marine organisms observed. For these groups, the relative number of 'extremely abundant' and 'abundant' observations decreased, while the relative number of 'rare' and 'absent' observations increased during the 300-year time period investigated. Inferences are drawn about the impact of European settlers (resource extraction) on other marine biota of the islands.

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Introduction

One of the components of biodiversity, 'taxonomic diversity', is often measured as the number of species. Human induced changes in the biosphere and its species composition are currently the major concerns in the evaluation of this component.

The task mandated by the Convention on Biological Diversity (CBD) to establish species inventories, among others, encouraged the development of electronic databases, especially those on names, and those on collections. FishBase, one such database, presents fish occurrence records in interactive biodiversity and/or species distribution maps as they may be used to determine areas of high biodiversity or endemism. Comparisons of these maps through time also help to identify trends in the fish biodiversity of the world's oceans and hence to the appropriate management actions needed for their conservation. Such distribution maps are available mainly for current commercially exploited fish species (Watson *et al*., 200@), with the lack of baseline biodiversity data being the main hindrance. The natural history collections accumulated in museums in Europe and North America over the last two centuries render possible analyses of temporal or chronological taxonomic diversity, i.e., location and date of sampling of a specimen) given that such collection data are computerised and updated to modern standards of quality.

Though not easily accessible, such data can be 'reacquired' from records of specimens from historical expeditions, e.g., the many French and English scientific expeditions from the late 1700s to the early 1900s. Records of specimens brought back by these expeditions are often available in digital format. However, the related geographic information, though extractable from the original expedition logs, is most often captured incompletely or even erroneously. Differences in the reference meridian used (e.g., Paris as opposed to that of Greenwich) and changes in the scientific name of the species and/or in the place names of the area in which the sample was caught need to be standardized before any useful analysis of the data can be done.

To meet this challenge, the *Sea Around Us* Project of the Fisheries Centre, University of British Columbia and the Ichthyology Laboratory of the Muséum National d'Histoire Naturelle collaborated to 'reacquire' records of specimens obtained by these early French expeditions.

In the course of reading the narratives of these expeditions, it occurred to us that descriptions and observations made by these early naturalists also provided data on relative abundance, size, and habitat, feeding behaviour, and uses and trade by the indigenous human population. Thus, a project to document the abundance of marine organisms observed by these great European oceanographic expeditions was launched. This project aims to gather qualitative information on the abundance of marine organisms from narratives of early expeditions, quantify them and finally use them to map trends of observed abundances in a specific locality over time. The final objective was to provide an older baseline of marine biodiversity and abundance.

We chose to focus on the Falkland Islands as an initial case study as these islands were apparently uninhabited when Europeans discovered them and have since been a port of call for many vessels. Following the evolution of the marine ecosystem in these islands and the impact of colonization by Europeans might thus provide valuable insights.

Materials and Methods

An initial bibliographic search identified more than 5,000 records responding to a combination of the keywords: Falkland, expedition, survey, voyage, and natural history. However, only 50 were pertinent to our study, of which, 16 (or 3,700 pages) were available at the University of British Columbia library (see Table 1).

Accounts of marine organisms occurring in a specific locality were extracted and encoded into the historic expeditions and surveys database; a relational Access database hosted within the *Sea Around Us* Project website (see www.seaaroundus.org). Each observation or 'anecdote' (comprising of one or several sentences or paragraphs) was ranked according to the perceived abundance of a group of species, using a multi-level coding system suggested by Jeremy Jackson (Scripps Institution of Oceanography, University of California, San Diego, USA; pers. comm.), viz: extremely abundant; abundant; very common; common; rare; absent; and were listed as 'occurrence' when no inference on abundance was possible.

Coding was based on words used in the descriptions indicating relative amounts of observed marine organisms (see Table 2). For example, “fish abound along the coast” was coded as abundant, while “enormous quantities of” was coded extremely abundant. Anecdotes were taken at face value in an effort to remain objective, i.e., interpretation of the implicit meanings of these anecdotes was avoided as much as possible. Note that coding can be repeated independently by one or more researcher(s) in order to reduce subjectivity.

Each anecdote was assigned to the functional group being described (marine mammals, seabirds, turtles, fish, invertebrates, seaweed, algae, others). Scientific names of the species, when mentioned or footnoted, as well as other biological (e.g., size) and ecological parameters (e.g., feeding and spawning behavior) were recorded. If the anecdote described several groups of species in one sentence, separate records were entered to account for each functional group mentioned (including the name of species when specified). Each anecdote was linked to the following information:

- the “sampling station”, i.e., the coordinates, time of arrival and departure, the country and locality names of the 'station';
- the expedition details;
- the source and online links to the entire text, if available;
- the specimen accession number, if identified, and online links to the website of the museum that holds the specimen, if available.

The abundance anecdote records (see Table 1) were separated by functional groups and arranged chronologically. Observations for each functional group were further subdivided into chronological groups; each chronological group having equal numbers of observations to allow for within-group comparisons. The total number of observations per coding level (see Table 2 for examples) was obtained for each chronological group (represented by the mean year). Then, the ratio of each coding level over the total number of observations within a chronological year was obtained. This permitted the plotting of the ‘perceived’ abundance (in %; by coding level) of each functional group over time.

To test the plausibility of the resulting time series trends, estimates of extracted biomass or numbers of individuals killed were obtained from independent sources.

Table 1. Sources and number of abundance 'anecdotes' included in this study.

	Expedition name	Years	No.	References
1	Sebald de Weert's voyage to the South Sea and Magellan Strait	1598-1600	13	Kerr (1824)
2	Strong's voyage to the South Seas	1689	6	Boyson (1924)
3	de Gennes' voyage to the Straits of Magellan	1696	12	Callender (1967)
4	Dampier's voyage to the South Seas	1703	2	Boyson (1924)
5	L. A. de Bougainville's voyage to the Malouine (or Falkland) Islands	1763-1764	117	Pernetty (1773)
6	L.A. de Bougainville's voyage around the world	1766-1769	13	Bougainville (1982)
7	Observations of natural history by individual voyagers	1817-1829	1	Gough (1992)
8	Voyage of the *Beagle*	1831-1836	41	Armstrong (1992); Keynes (2000)
9	George Nares' voyage around the world.	1872-1876	2	Moseley (1892)
10	Rupert Vallentin's independent voyages to the Falkland Islands	1897-1911	133	Boyson (1924)
11	Observations of natural history by individual voyagers	1725-1924	80	Various authors*
	Total		390	

1725-1797 (Boyson, 1924); 1839 (Charton, 1848); 1856 (Malte-Brun, 1856); 1861 (Dechambre, 1871); 1801-1893 (Boyson, 1924) ; 1903-1924 (Boyson, 1924); 1909-1918 (Nippgen, 1921)

Table 2. Examples of anecdotes and the coding system applied to them.

Anecdote	Source	Functional group	Rank
The island which M. de Bougainville set on fire, was at first called Penguin Island because these birds were found there in such numbers, that upwards of two hundred perished in the flames. There remained however, a prodigious quantity; and we found some of them at every step.	p. 190 in Pernetty (1773)	Seabirds	Extremely abundant
Toutes les côtes abondent en poissons, la plupart peu connus.	p. 98 in Bougainville (1982)	Fish	Abundant
Notothenia sima, *Richards. Stanley Harbour. Very common.*	p. 53 in Boulenger (1900)	Fish	Very common
On the hulks at the extremities of both the dockyard jetty and also the Falkland Island Company's west store, numbers of Trophon geversianus *in the most perfect condition can be obtained.*	p. 336 in Boyson (1924)	Invertebrates	Common
… les boeufs, chevaux, porcs et lapins importés par les Français et les Espagnoles s'y sont depuis considérablement multipliés à l'état sauvage. Au contraire les amphibies, qui étaient extrêmement nombreux, y ont été à peu près détruits par les pêcheurs anglais et américains.	p. 266 in Charton (1848)	Marine mammals	Rare
Here are no sea-tortoises, but many land ones.	p. 63 in Callender (1967)	Sea turtles	Absent
Once when out on a whaler we had the good fortune to secure a fine whale and while making it fast to the side of the steamer some dozens of these birds suddenly appeared round the ship.	p. 297 in Boyson (1924)	Whales and seabirds	Occurs

Results

Descriptive natural history

The narratives included in this study provided us with a view of the natural history of the Falkland Islands (see Figure 1) from the time of their sightings by the Spanish and Portuguese sailors and subsequent inclusion as "*Insule 7 delle pulzelle*," on the first map to bear the name of *America* by Martin Waldseemüller in 1507 (Haeber, 2003).

Observations by '*privateering*' explorations, e.g., that of Captain John Davys of the *Desire*, of the second '*privateering*' expedition of Thomas Cavendish in 1591-1593 (Pepper, 2001) were more cartographic and described how these ships replenished supplies but had little mention of the natural resources they encountered in these islands. Most of the earlier narratives mention that the Falklands were 'barren,' providing little or no wood and no access to freshwater. However, seabirds and seals were observed as 'extremely abundant' – expectedly so since these animals are easily seen. Sebald de Weert, vice-admiral of a Dutch fleet on board the *Blijde Boodschap* wrote: "*They here saw vast numbers of those birds called 'plongeons' or divers, because they dive into the water to catch fish* [probably penguins, given that they were in Penguin Island at the time of observation, but could also refer to diving petrels]. *They killed there ten or fourteen of them with sticks, and might have killed as many as would have served the whole fleet* [5 ships at 100 men each would have amounted to 500 mouths to feed], *but would not lose the opportunity of a fair wind*" (p. 133 of Kerr's 1824 interpretation of Sebald de Weert's observations upon arriving at Penguin Isle on 6 April 1599; see other de Weert anecdotes at www.seaaroundus.org).

The Englishman William Dampier on board a buccaneer's ship in 1684, wrote the following: *January 28th we made the Isles of Sebald de Weert* […] *where we found foul rocky Ground, and the Islands barren, and destitute of trees, but some Dildo-bushes growing near the Sea-side. We saw the same day vast shoals of small red Lobsters, no bigger than one's Finger* […]." Boyson (1924) identifies this as a shrimp, *Munida surugosus*, "*much liked by whales and penguins.*" The genus *Munida* belongs to the decapod family of squat lobsters, Galatheidae, and the species occurring in the Falklands is *Munida subrugosa*, with benthic adults but planktonic larvae (Tapella *et al.*, 2002). However, the swarming description might refer to what is now termed as 'lobster krill' (usually *Munida gregaria*, but also other species of *Munida*) occurring in the diets of sea lions, *Otaria flavescens* (Thompson *et al.*, 1997) and penguins (Clausen and Pütz, 2003).

The first recorded landing was not until 28 January 1690 when the British captain, John Strong, anchored at Bold Cove, Port Howard where he wrote: "[…] *this land doth show like a great many Islands […] there is several keys that lye along shore. Wee sent our boat on Shoar to one of them and they brought on board abundance of Pengwins and* *other fowl and Seals* […].” Strong named the islands after the Viscount of Falkland, one of the owners of his ship, the *Welfare* (Boyson 1924; Pepper, 2001).

At the end of the 17th century, French seafarers, quietly establishing an extensive trade with South America, used the islands as their base, which they called *Îles Malouines*, after St. Malo, a city in northwestern France (Boyson, 1924). French activity in the southern seas led to the establishment of a French colony at Fort St. Louis (named after the ship *St. Louis* commanded by Jacques Gouin de Beauchêne which landed there in 1698) in the East Falkland by Louise-Antoine Comte de Bougainville (Pernetty, 1773; Taillemite, 1997). Bougainville’s stay (1763-1764) and successive voyages (1766) to the Falkland Islands provided not only detailed descriptions of aquatic and terrestrial life, but also of their abundance (Bougainville, 1771; Pernetty, 1773).

The French relinquished the islands to the Spanish in 1767 and from then on, the islands were known by the Spanish name of *Malvinas*. In the early 1830s, a successful colony of ‘cowboys’, the ‘gauchos,’ was exporting dried beef (and salted fish) to Brazil and wool to London (see www.falklands.info). However, the British reclaimed the islands in the 1840s, renaming them the Falklands, and the population of ‘gauchos’ was replaced by settlers from England (Cawkell, 2001). This era marks the beginning of the exploitation of terrestrial and aquatic resources, though American sealers had already been harvesting the seal populations around the islands since the late 1700s.

Charles Darwin’s visits to the islands in 1833 aboard the *Beagle* and again in 1834 provided a rich collection of specimens along with notes, from Captain Robert Fitzroy, Syms Covington (Darwin’s servant) and Darwin himself, describing the islands’ natural resources. Upon arriving, Darwin found the islands ‘desolate’ being “*universally covered by a brown wiry grass, which grows on the peat* […] *& excepting snipes & rabbits, scarely any animals*” (Armstrong, 1992). Covington, on the other hand, found “[…] *low Bushes with red berrrys* [sic] *which are very good eating* […]” and “[…] *enormous numbers of Bullocks Horses & Pigs* […] *Rabbits, wild geese & Ducks* […] *& most excellent Snipe Shooting in the Marshy ground & Long grass, which the Island in general is very little else*.” Darwin later on found that the islands were not desolate after all. They had “[…] *an immense quantity & number of kinds of organic beings which are* *intimately connected with the Kelp* […] *the infinite number of small fish which live amongst the leaves* […] *Crustacea of every order swarm*, […] *Encrusting Corallines & Aztias are excessively numerous* […] *The number of compound & simple Ascidia is a very observable fact* […] *Heurobranchus is common: but Trochus & petalliform shells abound on all leaves* […].” Darwin believed that since these islands will “[…] *become a very important halting place* […]” with “[…] *fine harbors, plenty of fresh water & good beef* […]” (letter to Caroline Darwin, 6 April 1834; cited in Armstrong, 1992). Darwin also expressed concern that, as the islands became colonized, rare, endemic and exploited species of the islands, e.g., he was here referring to the Falkland fox (‘warrah’), “[…] *will be ranked among those species which have perished from the face of the earth*.” (Darwin, 1839-1843).

Time series trends of perceived abundance

Of the many references available on voyages to the Falkland Islands, we limited our data gathering on the narratives in English and French available to us through the University of British Columbia Library, i.e., we screened 7,000 pages to identify 194 pages which contained useful anecdotes for marine organisms.

For these, we extracted about 500 observations on terrestrial, aquatic and marine organisms for the Falkland Islands from the various publications we examined from the 1590s to the 1920s (see Table 1). However, only 390 records were of marine organisms and of those only 353 were usable: marine mammals (15.9%), seabirds (14.2%), fish (5.7%), invertebrates (30.0%), algae and sea grass (5.9%). Occurrence of marine organisms, where no indication of abundance was mentioned, was inferred from 28.3% of these usable observations. The rest were observations for which no date and/or years was mentioned and were thus not used.

Of the five functional groups considered here, only marine mammals, seabirds and invertebrates could be analyzed. The other groups were not as viable due to paucity of records.

The plots of relative abundance over time showed that, for marine mammals and seabirds, the number of observations that classified organisms as ‘extremely abundant’ and ‘abundant’ decreased over time. Conversely, the number of observations that classified them as ‘rare’ and ‘absent’ increased (Figures 2a and 2b). Note that, even with a limited number of observations, the same relative trends were observed for fishes and marine plants (Figures 2c and 2e). Figure 2d, however, shows the opposite trend for invertebrates.

Exogenous impact on marine mammals

Sealing in the Falklands started with de Bougainville’s French colony in Port Louis in 1775 (Hofman and Bonner, 1985) and the first of seal fur cargo was exported from the South Atlantic to Canton, China in 1784 (Bonner, 1968). In the late 1700s, the fur seal population in the Falklands experienced withdrawals averaging 2,000 to 4,000 seals per ship per voyage (Jones, 1992). Given the estimate of 102 sealing vessels operating in the area (Mill, 1905), the number of fur seals, *Arctocephalus australis*, caught in the region would have amounted to over 300,000 per voyage. The extraction of fur seals increased by 71% from 1775 to 1793 and continued at an average of 10% per year to 1821 (see Table 3). Fur seal skins and whale oil having increased in value, Louis Vernet, then governor of the Falkland Islands and its dependencies, invited immigrants from the Americas to establish agricultural businesses and to engage in whaling in the islands (Bocage *et al*., 1831). Fourteen years later, Saint-Martin (1845) noted that the once prodigiously numerous seals were being ‘foolishly annihilated’ (see also Charton, 1848). By 1919, the fur seal population in Beauchêne Island was locally extirpated (Strange, 1976). Sea lions, *Otaria flavescens*, suffered a similar fate with a 7% rate of extraction per year from 1928 to 1952 (see Table 4 of Rodriguez and Bastida, 1998). Associated sealing activities led to the extirpation of elephant seals, *Mirounga leonina*, in the Falklands in 1871 (Armstrong, 1994).

Whaling, which surreptitiously began in the early 1700s (fur sealers switched to whaling when whales were found) and flourished in the mid 1800s with as much as 600 sailboats plying the southern seas. This was undoubtedly a result of the invitation extended by Louis Vernet to Americans (see above). Whaling diminished steadily with the decrease in the price of whale oil during the second half of the 19^{th} century (Stevenson, 1915). However, the introduction of the steam boat by Sven Foyn in 1866 led to more efficient whaling and in 1904, the first whaling company, Compañia Argentina de Pesca, was established in Buenos-Aires. This company exploited South Georgian waters and, by 1915, the Falkland Islands and its dependencies held the most important fishery of whales in the world (Salvesen, 1914), with 21 whaling companies, 6 coastal and 2 floating processing stations and a seasonal production of 430,000 barrels of whale oil (Stevenson, 1915). The species of whales harvested in and around the Falkland Islands were primarily Fin whale, *Balaenoptera physalus* and Sei whale, *B. borealis*. Given that a 20 metre Fin whale gave 50 barrels of oil and a 10 metre Sei whale gave about 25 barrels of oil (see Stevenson, 1915), we estimate a maximum of about 9,000 whales killed per year.

Table 3. Some records on the exploitation of South Atlantic and Falkland Islands marine mammals and penguins.

Year	Extracted	Abundance	Remarks	Source
1766	900		Falkland Islands; Elephant seals	Armstrong (1994)
1775	13,000		Falkland Islands; Fur seals (skins)	Bonner (1968)
1791		102	Southern Oceans; Sailboats	Mill (1905)
1793	361,900		South Seas; Fur seals (skins)	Armstrong (1994)
1821	202,500		South Seas; Fur seals (skins)	Armstrong (1994)
1850		600	South Seas; Sailboats	Stevenson (1915)
1865	2,250,000		Stanley, East Falklands; Rockhopper and Gentoo penguins	Armstrong (1994)
1871		0	Falkland Islands; Elephant seals	Armstrong (1994)
1881		40	Stanley, East Falklands; Sailboats	Anon (1881)
1904		1	Falkland Islands; Steamers	Stevenson (1915)
1912	430000		Balaenoptera musculus; Falkland Islands; Whale oil barrels	Stevenson (1915)
1915		21	Falkland Islands and dependencies; Steamers	Stevenson (1915)
1919		11	Beauchêne Island, Falklands; remaining Fur seals	Strange (1976)
1933	39,700		Albermarle Sation, West Falklands; Sea lions	Strange (1983)
1971		5,000	Falkland Islands; recovering Elephant seals	Armstrong (1994)
1994		20,000	Falkland Islands; recovering Fur seals	Armstrong (1994)

Validation of time series trends with exogenous impact on marine mammals

As most of the sources on extractive activities in the Falkland Islands dealt with marine mammals, we were only able to validate the time series of perceived abundance for this group. The data on seals (fur and elephant) and sea lions (Table 3) plotted in Figure 3 corroborate the decrease in relative abundance of marine mammals as suggested in Figure 2a. In view of these results, we can conclude that our methodology validates the usefulness of anecdotes as data source for marine mammal biodiversity trends analysis.

Note, however, that the decreasing trends demonstrated in Figures 2a-2c, were not replicated for invertebrates (Figure 2d). One logical explanation comes to mind: marine mammals, seabirds and large pelagic fishes were far more 'visible' to explorers and voyagers than the usually smaller and sessile invertebrates. The increase in perceived abundance towards the mid-1800s may be an artifact resulting from the more thorough scientific expeditions, which sampled all marine organisms throughout the taxonomic hierarchy. However, we could argue that by this period, the populations of larger more profitable resources had declined (see Charton, 1848 and Armstrong, 1994) and the colony's need to identify other sources of profit generated further explorations of their coastlines, leading to the higher visibility of populations of mollusks and crustaceans which before were only utilized for local subsistence.

Discussion

In his contribution on the 'shifting baseline syndrome of fisheries,' Pauly (1995) defined anecdotes as earlier knowledge, extracted from the historical and anthropological literature. He defends the importance of such observations in shifting the baseline of knowledge in marine fisheries, beyond the start of industrialized fisheries, and proposes that fisheries managers and policy makers develop frameworks to incorporate knowledge from, e.g., 200 years ago into contemporary attempts at ecosystem-based fisheries management. Moreover, the use of historical information in establishing the major impact of overfishing on the disturbance (inflicted by humans) on marine ecosystems was convincingly demonstrated by Jackson *et al*. (2001) using data spanning 125,000 years of ecological records.

This study suggests that qualitative data can be standardized and transformed to a semi-quantitative format for time series trends analyses and may have the potential to be used in validating trends obtained from ecosystem models, e.g., Ecosim and Ecospace (see Pitcher, 2001), analyses of trophic levels (e.g., Morales and Roselló, 2004 and Steneck *et al*., 2004) or archeo- and paleoecological studies (e.g., Pandolfi *et al*., 2003; Jackson and Johnson, 2001). The challenge to re-acquire such data remains to be met, however, and we believe that continuing to populate the database used in this study, extending its coverage to more geographical areas, will facilitate future analyses of this genre (see Zeller *et al.*, 2005): thus, giving a new purpose to the often forgotten stacks of precious documents hidden in the various rare book collections in museums, libraries and private collections around the world.

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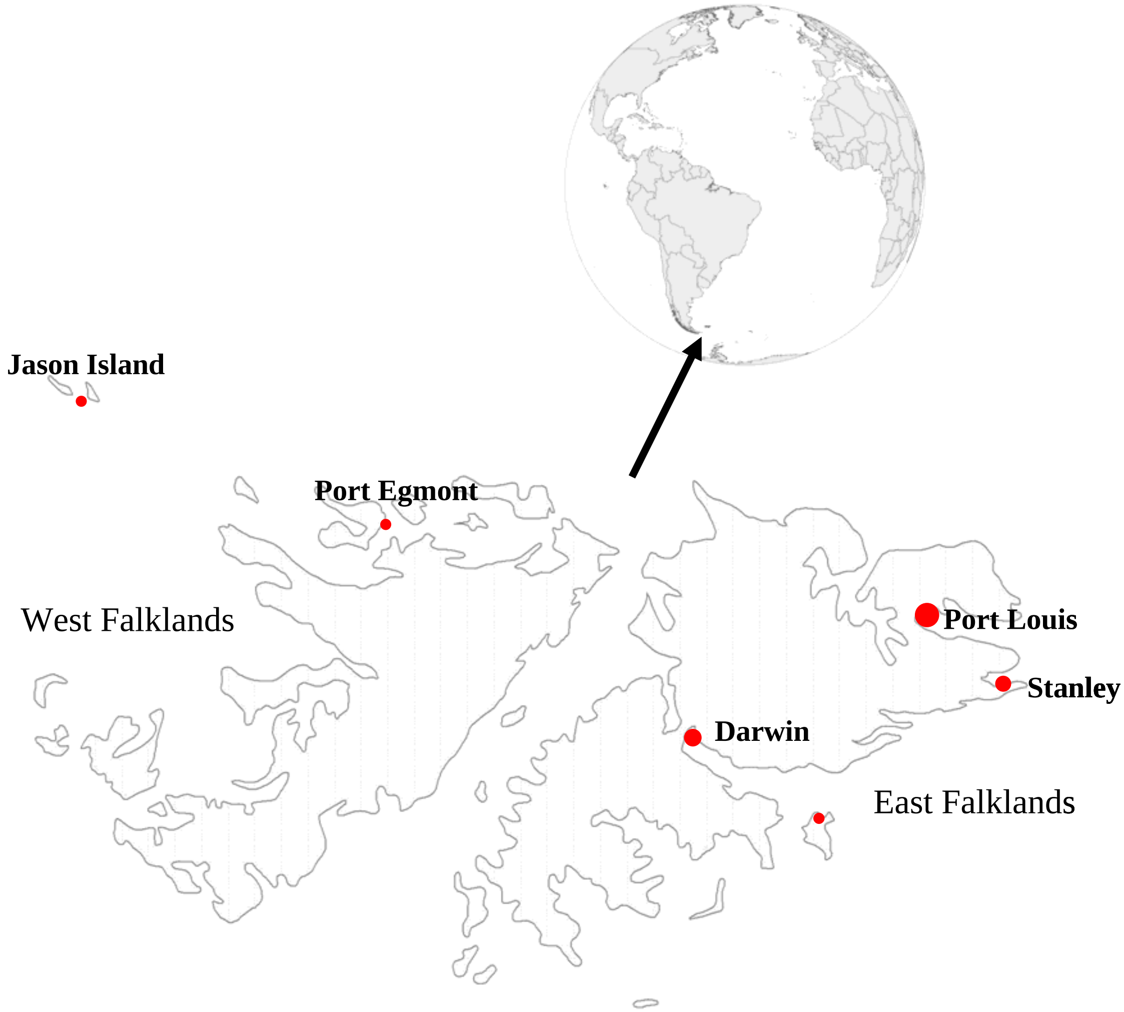
Figure 3. Perceived abundance of marine mammals (%) in the Falkland Islands (see Figure 2a) overlaid with total number of extracted seals (fur and elephant seals and sea lions; see Table 3) and number of recovering seal populations (fur and elephant seals only; see also Table 3).



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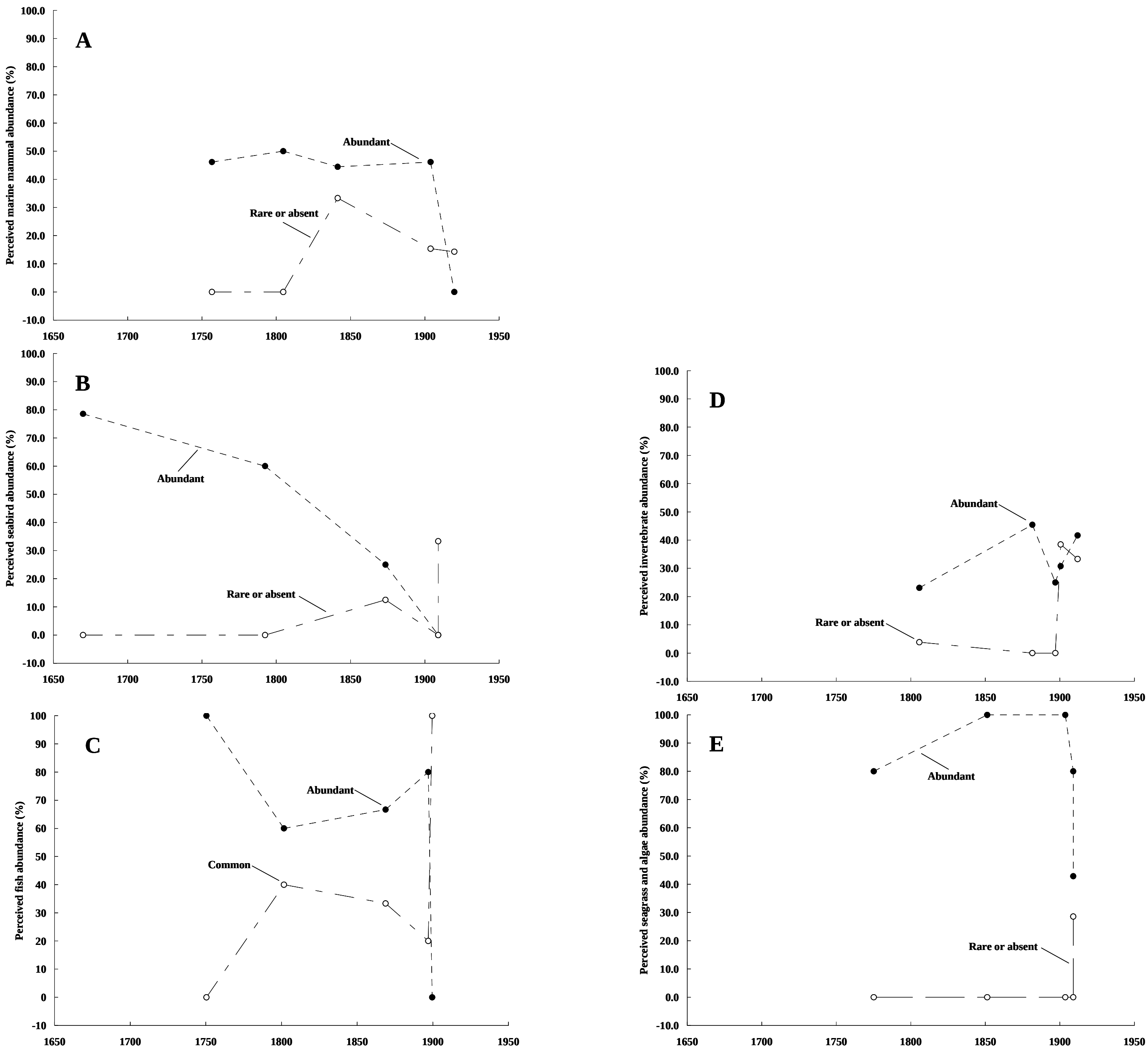

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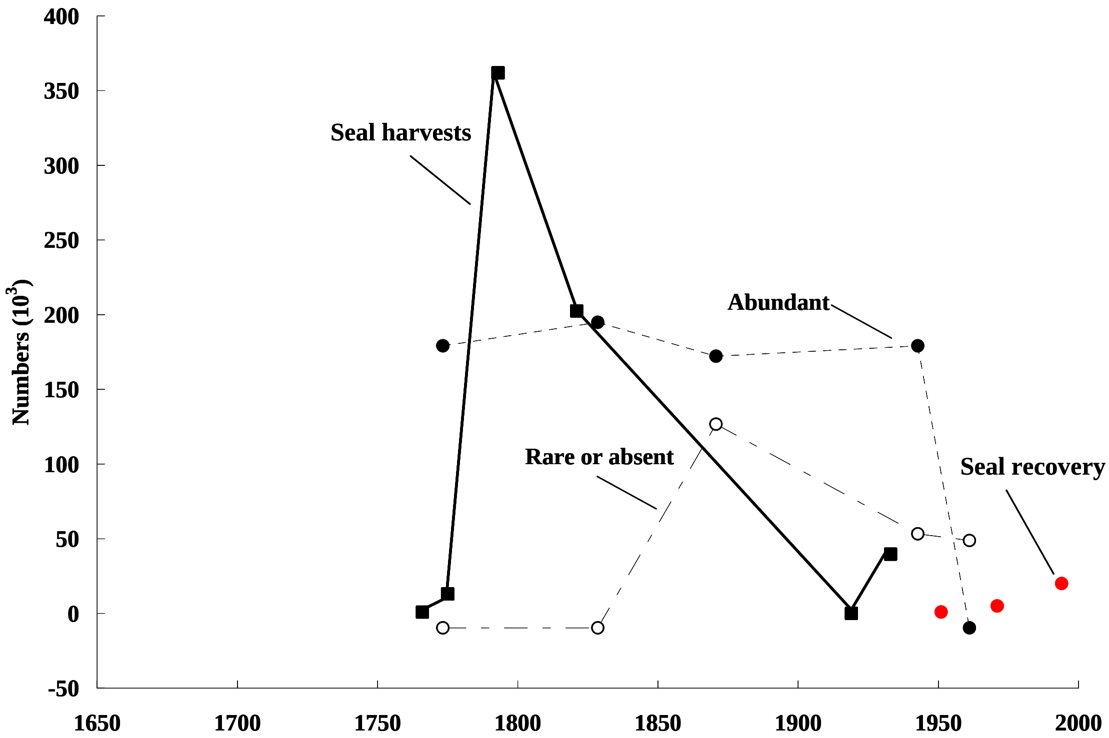

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