Conservation Management Plan for the sei whale (*Balaenoptera borealis*) in the Falkland Islands

September 2024

Sei whale surfacing amongst sooty shearwaters in Berkeley Sound (Caroline Weir / Falklands Conservation)

Acknowledgements

This Conservation Management Plan was developed in partnership with the Falkland Islands Government (FIG) during the Darwin Plus project DPLUS126. It was produced by Caroline Weir (Falklands Conservation) and reviewed by Andy Stanworth (FC), Mike Jervois (FIG) and Emma Harte (FIG).

Recommended citation

Sei Whale CMP (2024). Conservation Management Plan for the sei whale (*Balaenoptera borealis*) in the Falkland Islands. Falklands Conservation, Stanley, Falkland Islands. September 2024.

Table of Contents

1. Purpose

The sei whale (*Balaenoptera borealis*) is a species of large baleen whale, classified as Endangered by the International Union for Conservation of Nature (Cooke, 2018) due to heavy global exploitation by commercial whaling operations that occurred particularly between the 1950s and 1970s. The waters around the Falkland Islands host a globally significant seasonal feeding aggregation of the species (Weir, 2021), resulting in the area being recognised by the IUCN as both a Key Biodiversity Area and an Important Marine Mammal Area for sei whales.

In the absence of native terrestrial mammals, marine mammals represent a significant component of the Islands' total biodiversity. Sei whales are one of the most abundant and widely distributed cetacean species in the Falklands, and their important role within the Islands includes:

- They are a charismatic **flagship species** and a conspicuous indicator of the health of the marine environment. Their presence engages the local community, and increases human connection with, and awareness of, marine habitats;
- They are **ecosystem engineers** with high influence on the productivity of the marine ecosystem (Roman et al., 2014). They influence foodwebs through direct predation of crustaceans, and their defecations support nutrient cycling and boost phytoplankton growth which fuel the marine foodwebs on which commercial fisheries depend. They are also predated on themselves around the Islands by killer whales (*Orcinus orca*), and the substantial remains of successful kills provide an annual windfall of food to marine animals including scavenging seabirds;
- They play a significant role in **mitigating climate change** by removing atmospheric CO_2 (Pearson et al., 2023) This includes storing atmospheric carbon directly in their large biomass over many decades and stimulating carbon-capturing phytoplankton blooms by expelling nutrient-rich faeces at the surface. Furthermore, following death their carcasses often sink to the seafloor, trapping the carbon stored in their bodies at the bottom of the ocean and preventing it from returning to the atmosphere; and
- They have the potential to generate **economic revenue** through currently unrealised whale-watching ecotourism. For example, cetacean-related tourism in rural parts of West Scotland during 2000 was estimated to have generated a total gross income (direct and indirect) of £7.8 million (Parsons et al., 2003).

This Conservation Management Plan (CMP) summarises current knowledge of the sei whale in the Falkland Islands. It aims to ensure that the sei whale population using the Islands is maintained at a stable, or improved, level in forthcoming decades. Currently, no information exists on the island-wide population size of the sei whale or on population trend (i.e., decline, stable, increase) that usually underpin species status assessments. While acquiring this information would be possible, it needs significant funding and logistical resources, and would likely require the generation of multi-decadal datasets as has been the case for other large mobile marine predators which fluctuate in occurrence between years (Kaschner et al., 2012; Hammond et al., 2013). In the absence of those data, this CMP focuses on threat mitigation rather than on establishing and monitoring a favourable conservation status, with the underlying approach that establishing overall population trend, while certainly desirable, may not be needed if the threats that potentially cause individual mortality or population decline are appropriately mitigated such that they do not impact sei whales around the Islands.

The CMP is the result of eight years of field research carried out on sei whales in the Falkland Islands since 2017, comprising:

- An EU Best 2.0 project funded by the European Union in 2017 (Weir, 2017);

- A project funded by Falklands Conservation, The Royal Society for the Protection of Birds; and the Falkland Islands Government (FIG) Environmental Studies Budget in 2018 (Weir, 2018);
- A 3-year (2019–2021) Darwin Plus (DPLUS082) project funded primarily by the UK Government and with match funding from the project partners comprising the British Antarctic Survey, University of California Santa Cruz, Sea Mammal Research Unit, Shallow Marine Survey Group, New England Aquarium, Ketos Ecology, Happy Whale, and Fundación MERI (Weir, 2022); and
- A 3-year (2021–2024) Darwin Plus project (DPLUS126) funded primarily by the UK Government and with match funding from the project partners comprising the National Oceanic and Atmospheric Administration, Instituto Aqualie, British Antarctic Survey, Aarhus Institute of Advanced Studies, Sea Mammal Research Unit, Happy Whale, and Falkland Islands Government.

Recommendations within the CMP (Section 5) are provided in three core areas:

1. Policy and permitting;
2. Mitigation and management; and
3. Assessing species status.

2. Existing Policy and Conservation Designations

2.1. International legislation

The sei whale is listed as a globally Endangered species in the latest International Union for Conservation of Nature (IUCN) Red List assessment (Cooke, 2018), meaning that it *faces a very high risk of extinction in the wild*. It is listed under criterion A1 as a species for which the causes of population reduction [whaling exploitation] are reversible, understood and have ceased. As an Endangered species, sei whales are also included in several international agreements to which the Falkland Islands are signatories (Table 1).

Table 1. Multilateral environmental agreements with relevance to sei whales, to which the Falkland Islands are a signatory (see Falkland Islands Government, 2021).

Convention/Agreement	**Sei whale listing**	**Details**
International Convention for the Regulation of Whaling 1946 (as amended)	Included	Sei whales have been protected from commercial whaling since 1979 in the Southern Hemisphere. They are also protected by the global whaling moratorium implemented in 1986.
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).	Appendix I	Sei whales are listed as a species threatened with extinction for which international trade is prohibited. CITES is incorporated into the written law of the Falkland Islands through the **Endangered Species Protection Ordinance 2015**.
Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention 1979)	Appendix I	The sei whale is listed as a migratory species that is in danger of extinction throughout all or a significant portion of its range. Parties that are a Range State to a migratory species listed in Appendix I shall endeavour to strictly protect the species by: prohibiting the taking of such species; conserving and where appropriate restoring their habitats; preventing, removing or mitigating obstacles to their migration, and controlling other factors that might endanger them.

Convention/Agreement	Sei whale listing	Details
	Appendix II	The sei whale is listed as a migratory species that has an unfavourable conservation status and that requires international agreements for its conservation and management.
Convention on Biological Diversity (CBD)		Under the Convention, governments undertake to conserve and sustainably use biodiversity through Aichi Biodiversity Targets. They are required to update existing legislation to protect species and habitats, to develop national biodiversity strategies and action plans, and to integrate these into broader national plans for environment and development. The CBD Strategic Goals and Aichi Targets are implemented in the Falkland Islands through the **Falkland Islands Biodiversity Framework 2016-2030** which aims to conserve and enhance the natural diversity, ecological processes and heritage of the Falkland Islands, in harmony with sustainable economic development. It recognises that the Falkland Islands have a global responsibility for the protection and well-being of a number of species and habitats, for which the islands have stronghold populations. It states that by 2020, the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.

2.2. National legislation

Three current pieces of national legislation include provision for protecting sei whales in the Falklands:

1. **Conservation of Wildlife and Nature Ordinance 1999**
   Contains provisions for the protection of wildlife (Part II) and conservation areas (Part III). Under the Ordinance, all wild marine mammals are protected species (Part 4: 4b) for which it is an offence to deliberately capture or kill (Part 4: 1a), or to damage or destroy the breeding site or resting place (Part 4: 1c) without a licence. It is also an offence to knowingly keep, transport, sell or exchange, or offer for sale or exchange, any live or dead protected wild animal, or any part of, or anything derived from, such an animal (Part 4: 2) without a licence. **The Fisheries (Conservation and Management) Ordinance 2005** extends the Conservation of Wildlife and Nature Ordinance 1999 to include the Falkland Islands Conservation Zones (to the 200 nm limit).

2. **Marine Mammals Ordinance 1992**
   Makes it an offence to take, wound or kill any marine mammal in the Falkland Islands or in Falkland Islands waters (comprising the Falkland Islands Conservation Zones) with intent to do so (3.1a), to poison any marine mammal (3.1b), to use explosives in a way that may harm a marine mammal (3.1c), or to use any net, trawl line or hook of a type or length likely to take, kill, wound or harm any marine mammal (3.1d; 5). The ordinance also controls the import and export of any marine mammal (or part of), whether living or dead.

3. **Offshore Minerals Ordinance 1994 (amended 1997 and 2011)**
   In Schedule 1, damage to the environment (p69) is defined as “any impact on the living or non-living components of the environment of the controlled waters or of the Falkland Islands or the ecosystems of the controlled waters or the Falkland Islands and includes harm to atmospheric, marine or terrestrial life.” In Schedule 5, Important Bird Areas (IBAs) and Important Plant Areas (IPAs) are recognised as environmentally sensitive areas which should be accounted for when assessing environmental impact. The **Offshore Petroleum (Licensing) Regulations 1995/2000** were promulgated under Section 7 of the Offshore Minerals

Ordinance 1994. Section 7(3) of the Ordinance provides that a reference to '*the clauses of the licence*' is a reference to the model clauses incorporated in a licence pursuant to regulations made under this section together with any conditions imposed, in addition to any such model clauses, on the grant of the licence or otherwise in accordance with the Ordinance. Protection of cetaceans is governed as a licence term under Section B4 of Schedule 6 (1995 regs) or Schedule 7 (2000 regs) and detailed in the Petroleum Operations Notice (PON) 3 form issued to Licensees by the Falkland Islands Government (FIG) Department of Mineral Resources. Guidance is generally based on that of the UK's Joint Nature Conservation Committee (JNCC), and includes the use of visual and acoustic methods to detect cetaceans ahead of seismic operations, the use of a 'soft start' to gradually increase power level over time, and the requirement to delay the onset of operations if cetaceans are within 500 m of an airgun array.

Currently, no Species Action Plan (SAP) exists for cetaceans in the Falkland Islands; the previous SAP expired in 2018[1] and did not recognise the specific importance of the region for sei whales which had not yet been well studied in 2008 when the SAP was produced. The Falkland Islands State of the Environment Report 2008 (Otley et al., 2008) provided criteria for selecting those species and habitats that warrant an action plan. The sei whale qualifies for at least four of those criteria:

- A(i) Classified as Critically Endangered, Endangered, or Vulnerable;
- A(ii) Annex I or Annex II species under Bonn Convention (Convention on Migratory Species);
- A(iii) An Appendix I species under CITES (where other factors combine to enhance the level of threat); and
- B(ii) A substantial historical decline (>75%) even when species population size has stabilised.

Furthermore, a sei whale CMP is relevant to several of the strategic objectives of the Falkland Islands Environment Strategy 2021–-2040 (Falkland Islands Government, 2021), including:

- To protect and enhance our biodiversity (ecosystem integrity), reducing its loss through tackling threats;
- To increase knowledge of the marine, terrestrial and aquatic environments and biodiversity, through identifying and filling key knowledge gaps, to support effective governance and decision-making;
- To have healthy, functioning and robust marine and coastal ecosystems in the Falkland Islands through protections and management; and
- To consider, manage and minimise the impact of economic activities and development on the environment, taking a long-term strategic approach that considers future generations and incorporates environmental assessment.

2.3. Biologically important areas

Biologically important areas (BIAs) are important for the conservation of protected species and where aggregations of individuals display biologically important behaviour such as calving, foraging, resting or migration. Two spatial tools have been developed by the IUCN to identify BIAs for cetaceans on a regional or global level using available data and expert scientific knowledge about species' distribution, abundance, and behaviour, comprising:

1. *Important Marine Mammal Areas (IMMAs)* – Discrete portions of habitat, important to marine mammal species, that have the potential to be delineated and managed for conservation. IMMAs are a means of incorporating marine mammals into existing national and international conservation tools, including Ecologically or Biologically Significant Areas

[1] Otley, H. (2008). Falkland Islands Species Action Plan for Cetaceans 2008-2018. Falkland Islands Government.

(EBSAs) under the CBD, and Key Biodiversity Areas (KBAs) identified through the IUCN Standard.

2. *Key Biodiversity Areas (KBAs)* – Sites of global importance for the persistence of biodiversity. The Key Biodiversity Area Partnership supports nationally led efforts to identify the places on the planet that are critical for the survival of unique plants and animals, and the ecological communities they comprise, through a criterion-based approach.

In recent years both an IMMA and a KBA have been fully endorsed by the IUCN as spatial areas for which evidence supports recognition as globally important foraging habitats for the sei whale in the Falkland Islands:

- **Falkland Islands Inshore KBA** recognised in 2021 under both Criterion A1 (threatened biodiversity) and Criterion D1 (global persistence of demographic aggregations) (see Weir, 2021): https://www.keybiodiversityareas.org/site/factsheet/49174
- **Falkland Islands Inner Shelf Waters IMMA** recognised in 2023, with sei whales qualifying under both Criterion A (species or population vulnerability) and Criterion C2 (key life cycle activities: feeding areas): https://www.marinemammalhabitat.org/portfolio-item/falkland-islands-malvinas-inner-shelf-waters-imma/

Both the KBA and the IMMA comprise the inner shelf waters extending to 100 m depth around the Falklands (Figure 1).

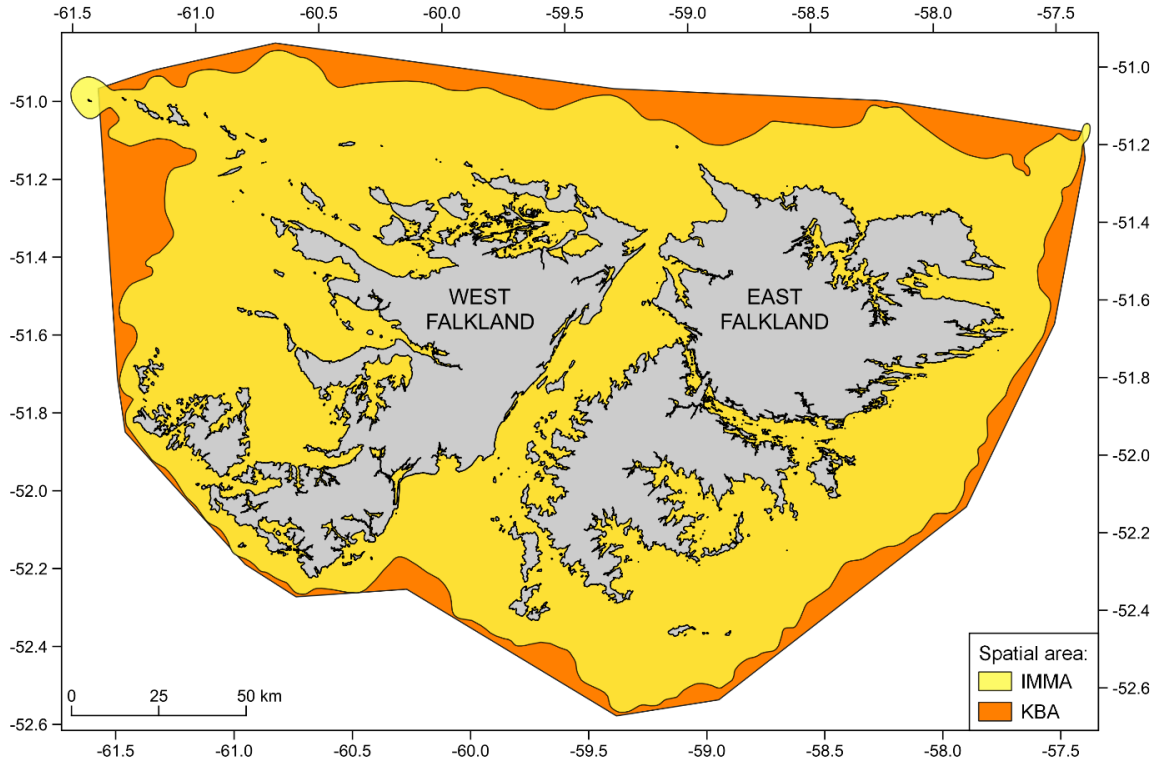


Figure 1. Spatial extent of the Falkland Islands Inshore KBA and the Falkland Islands Inner Shelf Waters IMMA, both recognised by the IUCN as globally important foraging habitat for sei whales.

3. Current Knowledge

A brief overview of current knowledge of sei whale occurrence around the Falkland Islands is provided below.

3.1. Description

The sei whale is a species of large baleen whale reaching average body lengths of around 15 m. It is characterised by a slender body, slightly arched jawline, a prominent erect dorsal fin positioned two-thirds of the way along its back, a light chevron marking extending over the back behind the blowholes, and a distinctive forward-angled and upsweeping “brush mark” located on the upper flank, approximately midway between the blowholes and the dorsal fin (Figure 2).

3.2. Distribution and habitat

Sei whales occur worldwide from polar to tropical waters, although their densities are highest at mid-latitudes (20 to 55°) in water temperatures of 8°C to 18°C (Horwood, 1987). In many geographic areas they primarily inhabit the continental slope or deep ocean basins (Horwood, 1987). However, around the southern part of South America including Chile, Argentina, and the Falkland Islands, sei whales also routinely occupy neritic, including nearshore, habitats (Acevedo et al., 2017; Häussermann et al., 2017; Weir, 2017).

Figure 2. Sei whales in Berkeley Sound, showing the characteristic tall and erect dorsal fin, long streamlined back, and paler flank markings of the species.

Most confirmed records of sei whales in the Falklands are from inner shelf waters to 100 m water depth and within ~45 km of the shore, reflecting the distribution of targeted boat surveys carried out in three areas (Berkeley Sound, Falkland Sound, and West Falkland: Figures 3 and 4). The scarcity of documented sightings in other inner shelf areas around the Falklands likely reflects the absence of systematic survey effort in those areas (Weir, 2021). This was also indicated by modelling to predict suitable habitat for sei whales (Baines and Weir, 2020; Figure 5), and more recently by satellite-tracking that showed animals using several previously undocumented areas (Figure 6).

While sei whales are relatively well-studied in nearshore waters, only very limited data are currently available to document their occurrence in open (>45 km from shore) neritic, slope and oceanic habitats around the Falklands. For example, remote acoustic monitoring carried out in 400 m water depth to the north of the Falklands between December 2012 and July 2013 recorded vocalisations identified as sei whale song between late January and May, including almost daily between February

and April (Hipsey et al., 2013; Cerchio and Weir, 2022), indicating that sei whales may be very regular in some offshore habitats within the Falkland Islands' Conservation Zones.

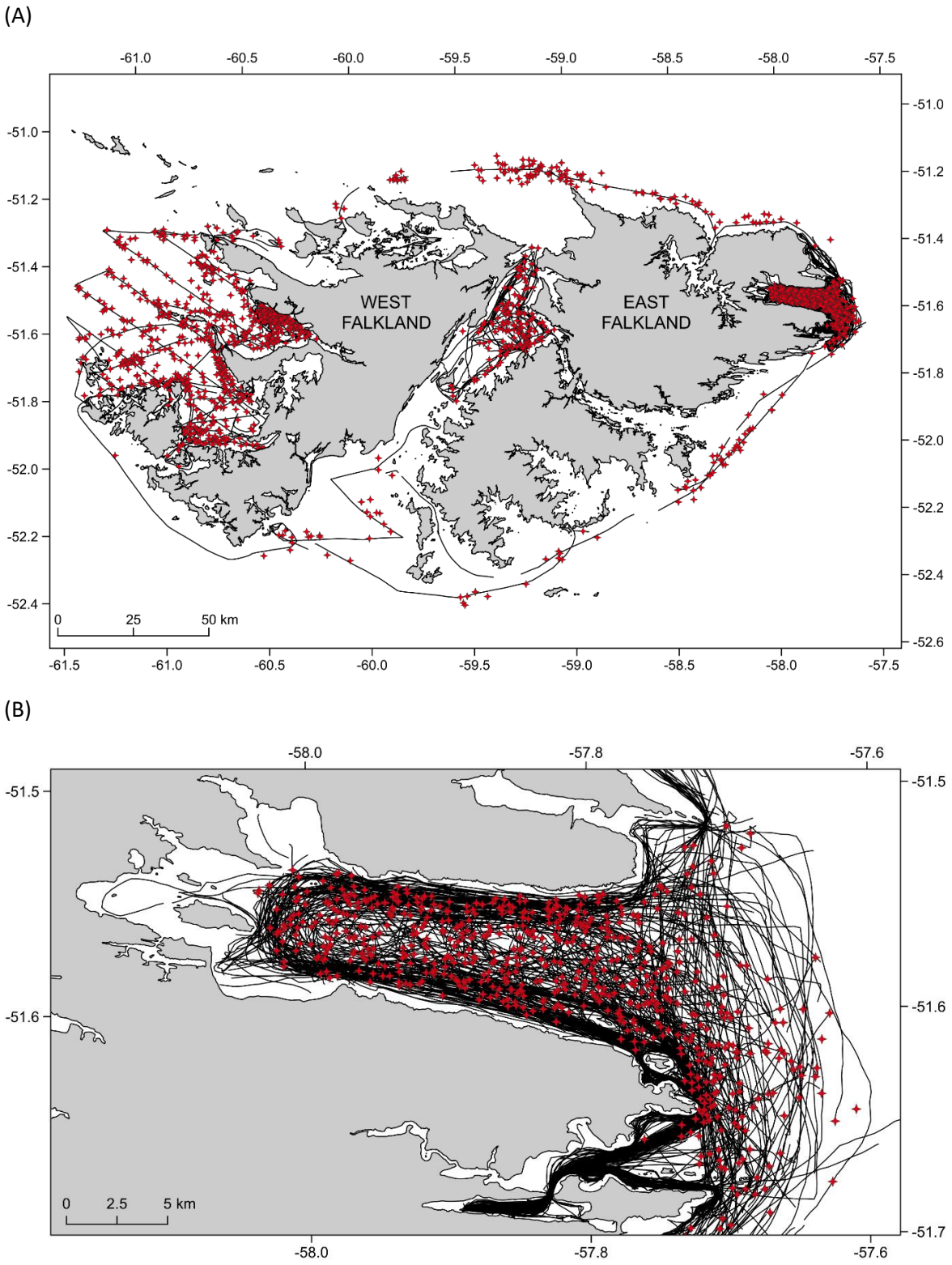
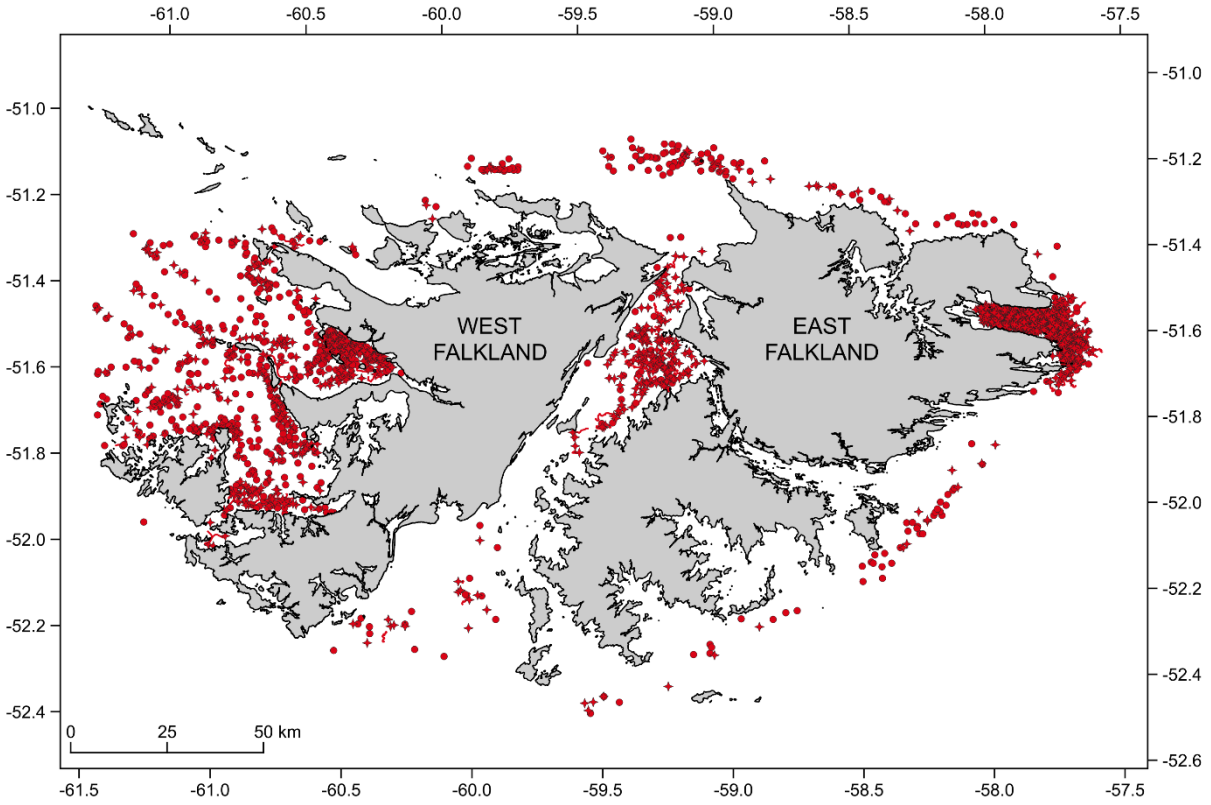


Figure 3. The spatial distribution of boat-based survey effort (12,966 km: black lines) and associated on-effort sei whale (and large baleen whales likely to be sei whales) sightings (n=1,779: red symbols) recorded during Falklands Conservation boat surveys carried out in favourable weather conditions (Beaufort sea state ≤4, swell of ≤2.5 m, and visibility of >5 km) between Feb 2017 and May 2024: (A) island wide; and (B) expanded view of Berkeley Sound. Data included are from January to June only to reflect known sei whale seasonality.

(A)



(B)

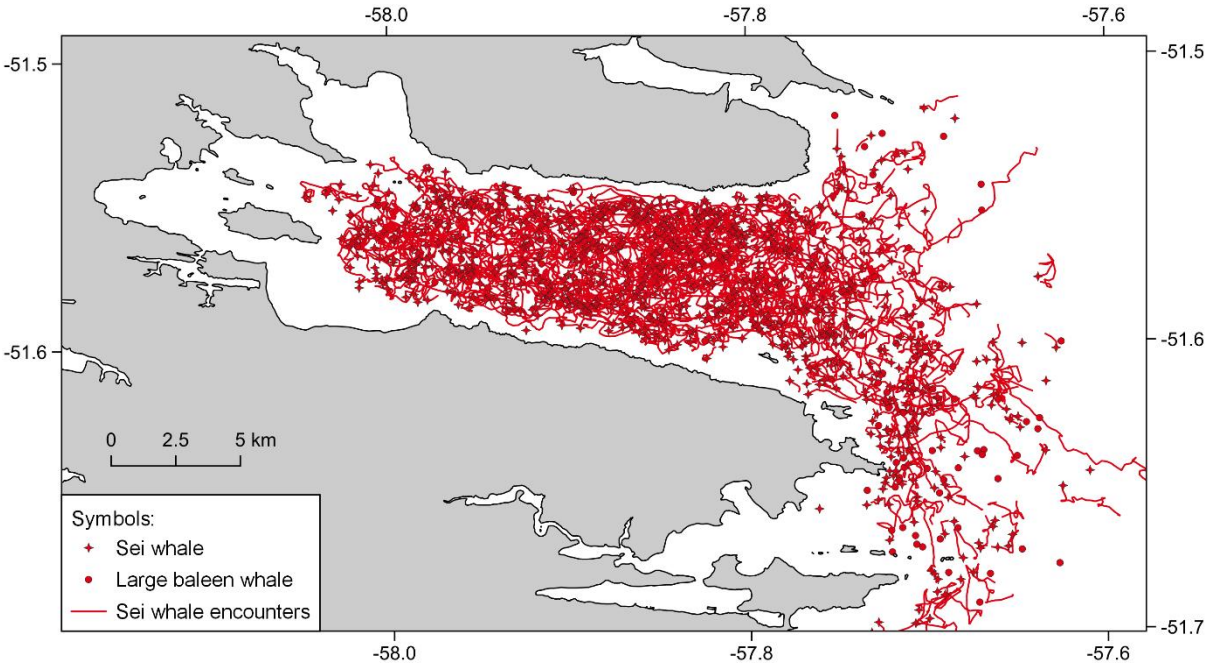


Figure 4. Locations of all (both effort-related and opportunistic) sei whale sightings (n=1,281) and sei whale encounter effort (red lines) recorded during boat work by Falklands Conservation between 2017 and 2024: (A) island wide; and (B) expanded view of Berkeley Sound. Data included are from January to June only to reflect known sei whale seasonality. Encounter effort refers to time spent in proximity to sei whales while collecting photo-identification data etc, and essentially shows the movements of whales over the course of a data collection encounter.

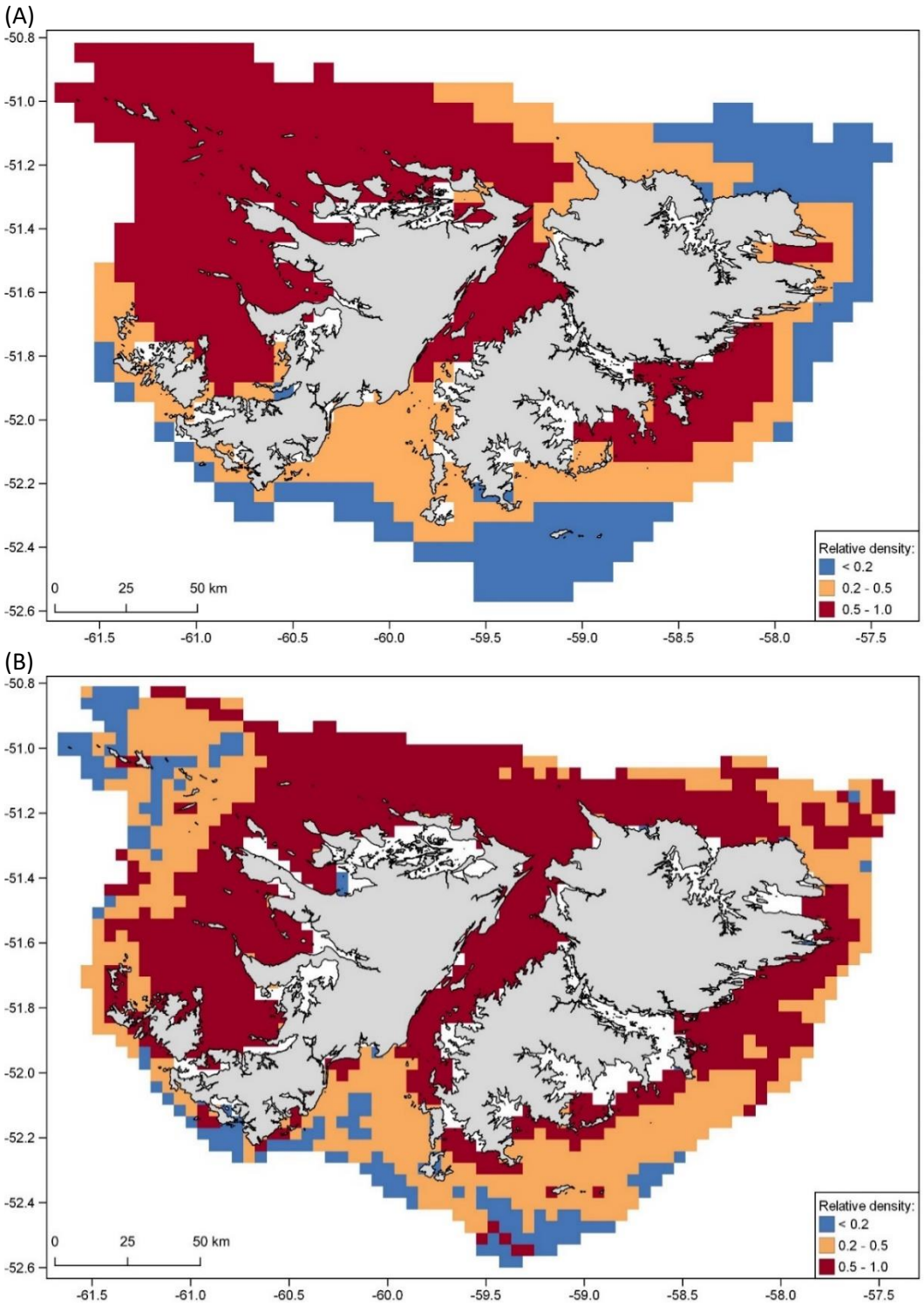


Figure 5. Predicted relative density of sei whales around the Falkland Islands (adapted from Baines and Weir, 2020) based on: (A) a generalized additive model at 7 km resolution explaining 34.7% of deviance; and (B) a MaxEnt model at 4 km resolution with a discriminatory value of 0.60. The grids extend to approximately 100 m water depth. The predicted relative densities shown within each map are relative to one another and scaled to 1; they do not represent absolute densities. Consequently, even the lowest 20% of predicted relative density values in the Falklands dataset could translate to a higher actual density of animals than reported elsewhere worldwide. In combination, the results indicate that suitable sei whale habitat is widespread.

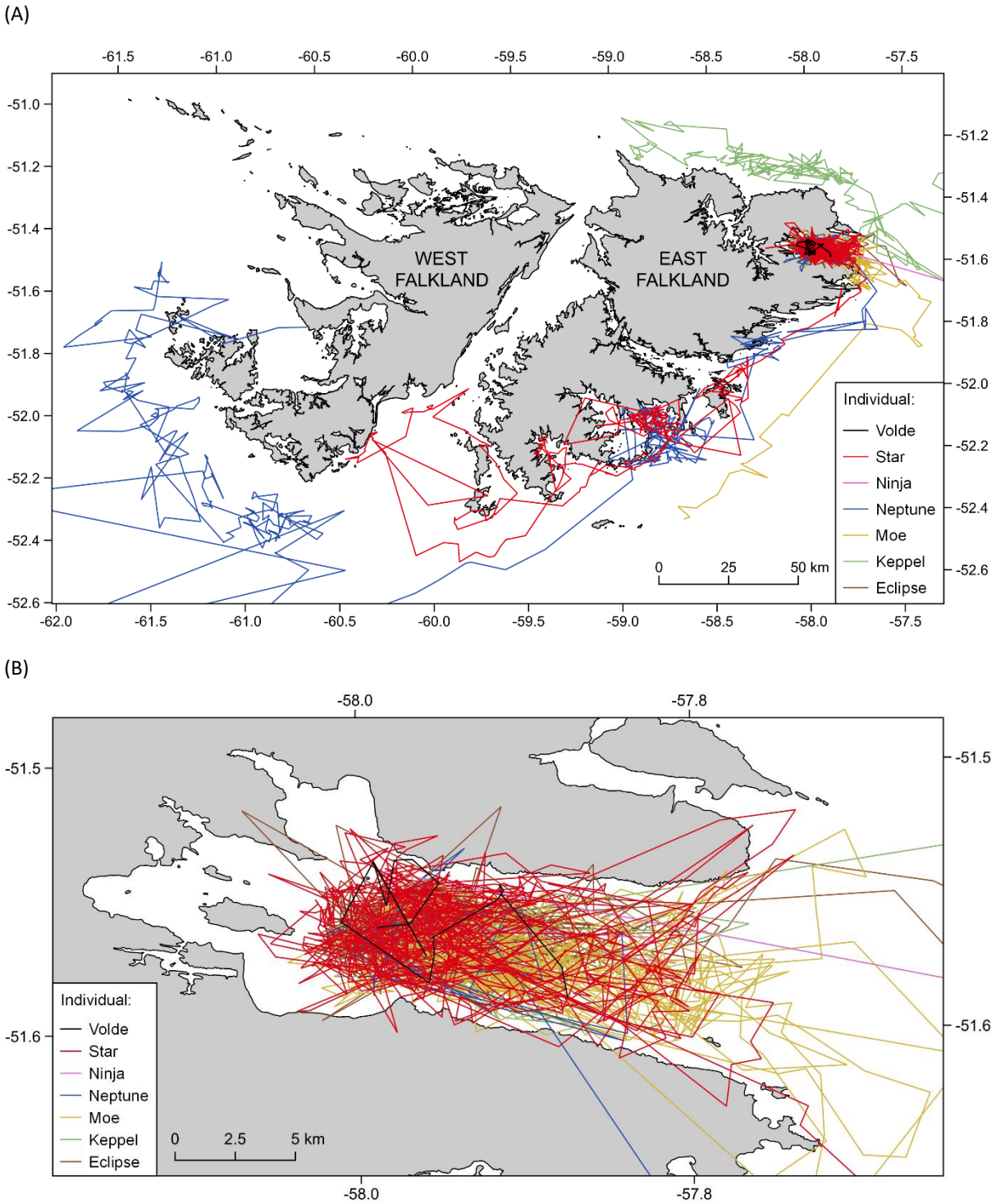


Figure 6. Data from seven sei whales satellite-tagged in Berkeley Sound: (A) All data showing movements in coastal waters of the Falklands; and (B) high-quality data only (Argos location quality 1+2 and Fastloc GPS) showing movements within Berkeley Sound following tagging. Individual tags transmitted for 10–56 days. Two animals (Volde and Eclipse) remained within the vicinity of Berkeley Sound for the entirety of their tag transmission durations (16 and 27 days respectively).

3.3. Seasonality

Boat surveys carried out in the Falkland Islands since 2017 recorded sei whales between January and June, with a strong seasonal peak between February and May (Figure 7). A two-year acoustic monitoring programme in Berkeley Sound recorded sei whales daily from mid/late January to early April in both years (Cerchio et al., 2022), while presence in the early (Nov–Jan) and late (May–Jun) parts of the season varied between years (Figure 8). Small numbers of intermittent sei whale acoustic detections occurred from July to October, with presence being lowest during August and September (Figure 8). Together, the data support strongly seasonality, with whales using Falklands' waters throughout summer and autumn (Nov–Jun), and occurrence much lower during winter and spring (Jul–Oct). It should be noted that the arrival to, timing of peak numbers in, and departure from, Falklands' waters, varies between years and between sites (Weir, 2022).

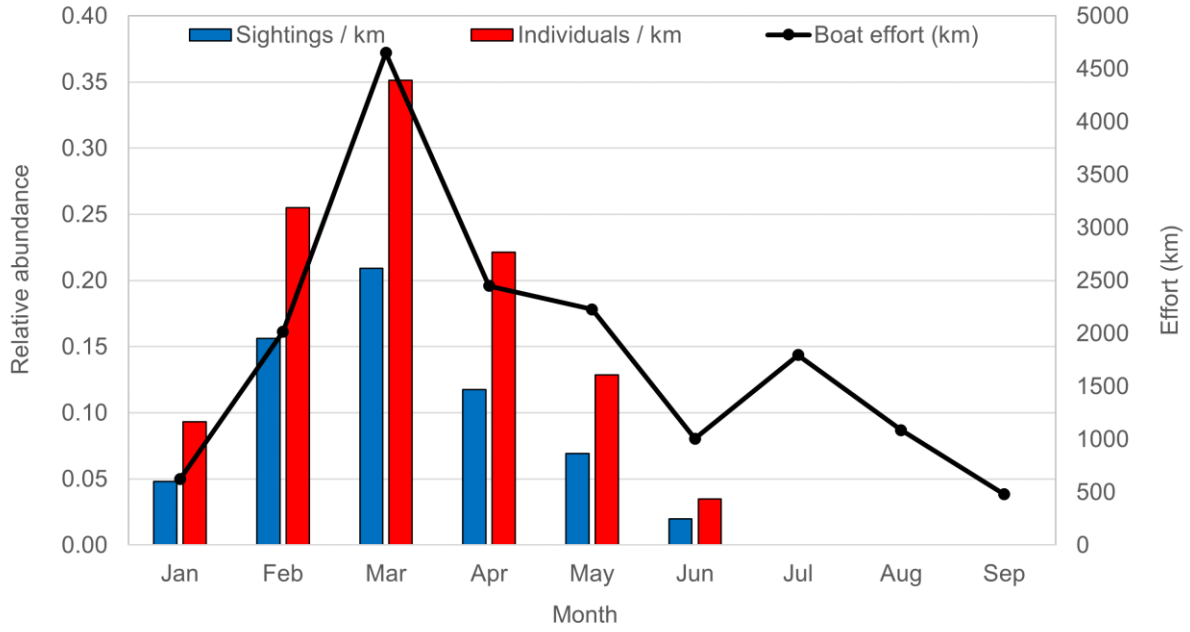


Figure 7. Monthly relative abundance of sei whales and large baleen whales (recorded between January and mid-May, and therefore assumed to be sei whales) recorded during Falklands Conservation boat surveys between January 2017 and May 2024. Relative abundance was calculated using 16,326 km of boat-based search effort and 1,779 associated sightings collected in favourable weather conditions (defined here as Beaufort sea state ≤4, swell of ≤2.5 m, and visibility of >5 km). Note that no targeted boat survey work for sei whales has occurred between October and December. Boat survey effort includes the Berkeley Sound region in all months, Falkland Sound between February and June, and West Falkland during February and March.

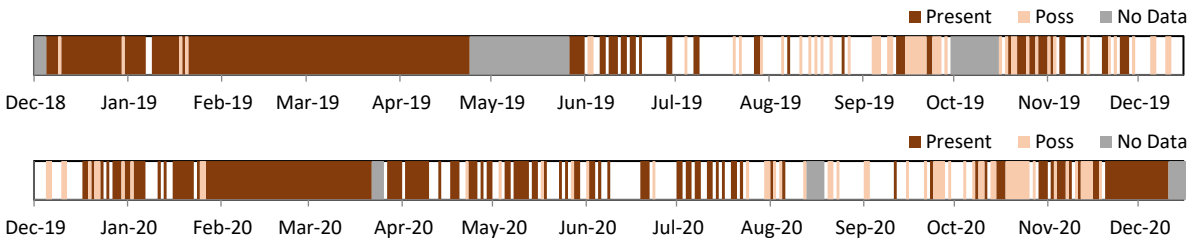


Figure 8. Daily presence of sei whale vocalisations in Berkeley Sound from 5 December 2018 to 10 December 2020 (see Cerchio et al. (2022) for more details). Confidence in presence for each day is indicated as positive confirmation by the acoustic detection of 3 confident calls ('Present'), or as possible occurrence by the acoustic detection of <3 confident calls, or ≥3 possible calls ('Poss'). White represents areas where data exist but no vocalising whales were detected. Grey represents periods of no data between the acoustic deployments.

3.4. Behavioural drivers of occurrence

Sixty-five percent of whales landed at the New Island coastal whaling station between 1905 and 1915 comprised sei whales (Weir, 2017), confirming the long-term use of Falklands' waters by the species. The primary driver for their occurrence in the Falklands is feeding, evidenced by observations of skim- and lunge-feeding at the surface on squat lobster krill (*Munida gregaria*) and amphipods (*Themisto gaudichaudii*), and of regular defecations (Weir, 2017, 2018, 2022; Weir et al., 2019). Faecal analysis recorded calanoid copepods and lobster krill in the highest number of samples, although 11 taxonomic orders were represented suggesting that sei whales in the Falklands predate a range of crustacean prey depending on what is seasonally available (Jackson et al., 2022a). The presence of mother-calf pairs in the Falklands (Weir, 2022) suggests that some lactating mothers forage around the Islands to meet their energetic demands while nursing their calves, and it is also likely that calves are weaned in the region and feed there during their first critical months of self-sufficiency.

It was recently discovered that sei whales produce mid-frequency song in the Falklands (Cerchio and Weir, 2022), with singing in Berkeley Sound commencing during the autumn prior to the animals migrating to their winter breeding areas. Singing in balaenopterids is a male breeding display and indicates that Falklands' waters are used for reproductive behaviour potentially including courtship and mating (Cerchio and Weir, 2022).

3.5. Migration and movements

Like most other baleen whale species, sei whales undertake region-wide seasonal migrations between the subtropics where mating and calving occur in winter, and summer feeding grounds located at higher latitudes (Horwood, 1987). Little information is available on the migration routes of sei whales globally; however, some individuals feeding in the Falklands use a wintering area off Brazil (20–25ºS: Weir et al., 2020). There is evidence for site fidelity of sei whales to the Falklands' feeding ground, with inter-annual photographic recaptures showing that individuals return in different years (Weir, 2022) and therefore that the region comprises a feeding destination rather than an area simply transited through.

In the Falklands, sei whales exhibit inter-individual variation in their movements. For example, several animals satellite-tagged in Berkeley Sound remained foraging within the Sound continuously for several weeks, while others moved away within days (see Figure 6). Similarly, around 40% of whales photographed each year are recaptured on one to seven dates spanning multiple months within the same season (Weir, 2017, 2018, 2022). This includes some inter-site movements within the same season, for example three movements between Falkland Sound and Berkeley Sound during 2019 and 2020 (Weir, 2022).

Sei whales are capable of rapid movements. A photographic recapture demonstrated a whale moving 27 km overnight (Weir, 2018), and a suction-cup tag deployment revealed a rapid movement comprising a straight-line distance of at least 40 km in 12 hr (Segre and Weir, 2022). Some individuals and groups can maintain average swim speeds of 7–8 km hr^{-1} (Weir et al., 2018), meaning that they could potentially travel from one side of the Falklands to the other in less than two days.

The combined evidence indicates that sei whales foraging in the Falklands are widely distributed and highly mobile, and their reliance on dynamic prey resources results in high inter-individual variation in their fidelity to particular sites within a season and the extent of their movements around the Islands (Weir, 2021).

3.6. Population structure

Due to the difference in timing of their use of low latitude wintering areas, sei whales are assumed to occur as largely separate populations within the Northern and Southern Hemispheres. Genetic work supports that assumption, with only one shared haplotype documented to date between Southern Hemisphere (Chile/Falklands) and North Atlantic sei whales (Huijser et al., 2018; Jackson et al., 2022b).

Sei whales in the Falkland Islands have high haplotype and nucleotide diversity, and show significant haplotype frequency differentiation from Chile and the North Atlantic (Jackson et al., 2022b). While the Chilean and Falklands populations are differentiated, genetic evidence suggests that there may be some movements of individuals between them (Jackson et al., 2022b).

Within the Falklands, intra- and inter-annual photographic recaptures of individuals has revealed connectivity between the different study sites (Weir, 2017, 2018, 2021, 2022). Those data suggest that individual sei whales move around the entirety of Falkland's inshore waters, and therefore marked population structure *within* the Islands may not be expected; however, that is yet to be determined.

3.7. Population status and trends

Sei whales have a global conservation status of Endangered (Cooke, 2018), which is a legacy of severe population reductions due to whaling exploitation. Sei whale catches worldwide during the 1900s exceeded 290,000 animals, of which 205,000 occurred in the Southern Hemisphere (Rocha et al, 2014). While the species is presumed to be recovering, the absence of robust population surveys in many parts of their range (especially in the Southern Hemisphere) hinders understanding of population size and trends. The IUCN Red List Assessment (Cooke, 2018) applied a conventional deterministic age-structured modelling approach to estimate the global population size in 2020 as ~40,000 mature animals and ~80,000 aged 1+ (i.e., all ages except calves of the year) animals (see Weir, 2021 for more information).

The total number of sei whales catalogued from photo-identification work in the Islands between 2017 and 2021 was 678 (FC, unpublished data), which is considered a significant under-representation of the true numbers considering the limited spatial extent of the study sites, substantial weather constraints, and low natural markings and challenging behaviour of sei whales. An abundance survey conducted on the west coast of West Falkland during February/March 2018 produced total design-based estimates of 716 (CV=0.22) sei whales and 916 (CV=0.19) combined sei whales and unidentified large baleen whales, and model-based estimates of 707 (CV=0.11) sei whales and 895 (CV=0.074) combined sei whales and unidentified large baleen whales (Weir et al., 2021). It is considered highly likely that most, if not all, of the unidentified baleen whales recorded during that survey also comprised sei whales. The density of sei whales recorded during the 2018 survey was at least two orders of magnitude higher than the densities recorded in any large-scale abundance surveys carried out worldwide (Weir et al., 2021), indicating that Falklands' waters support globally significant numbers of sei whales and rank among the largest 10 aggregation sites known for the species.

There has been no national assessment of the conservation status or population trend of the sei whale in the Falkland Islands. The total population size in the Islands remains unknown, and no data are available to indicate whether the population is stable, increasing or decreasing.

4. Threat Assessment

Although Falklands' waters are in relatively pristine condition, the routine use of neritic and nearshore habitats by sei whales around the Islands increases their potential overlap with human activities compared with other, more pelagic, parts of the species' global distribution range. The IUCN-CMP Unified Classification of Direct Threats[2] was used to identify threats and stressors (i.e., impacts that might result in stress, injury, or mortality) that have the potential (past, present, or future) to affect sei whales using the marine habitats around the Islands. Potential stressors can be categorised as (Wright and Kyhn, 2015):

1. Directed takes – e.g., mortality from hunting (whaling);
2. Incidental takes – e.g., mortality from ship strikes, bycatch, exposure to underwater detonations. Surviving these events can result in injury;
3. Injury – e.g., tissue damage from vessel strike, hearing loss from high-level noise exposure, or toxic loading and bioaccumulation; and
4. Disturbance – e.g., whales being displaced from key habitats, changing behaviour, or the masking of communication signals by manmade noise.

While the assessment of directed and incidental takes may be relatively straightforward, determining injury and disturbance is a more complex process but equally important. For example, disturbance can have important energetic consequences or cause behavioural responses with fitness implications for individuals or populations (Wright and Kyhn, 2015).

Threats relevant to sei whales in the Falkland Islands are described in Annex 1 and summarised in Table 2. Risk is defined as the interaction between the probability or likelihood of the occurrence of a given event, and the consequences (impact) should such an event occur (Copping et al., 2020). A broad likelihood of occurrence was identified in Annex 1 and Table 2. However, the consequences of occurrence for sei whales in the Falkland Islands remain unclear because of the lack of robust information on population size and trend, the lack of data on cumulative impacts, and the absence of quantitative management thresholds in the Falklands against which to measure effect.

Therefore, this CMP simply identifies potential threats for sei whales (Annex 1, Table 2), provides an indication of their likelihood (Annex 1, Table 2), and makes recommendations towards better understanding and mitigating those threats (Section 5). Eight main potential stressors were identified, all except one of which (whaling) occurred across multiple threats/activities (Table 2).

In practice, multiple stressors may affect a population simultaneously, resulting in interactive cumulative impacts that may be additive, synergistic or antagonistic[3] in nature (Tyack et al., 2022). A notable example are the combined *lethal stressors* of entanglement and vessel strike on the Critically Endangered North Atlantic right whale (*Eubalaena glacialis*: Sharp et al., 2019). Assessing each of those threats individually would clearly under-estimate the total impact of the combined threats on the mortality of that species. Assessing the cumulative impacts from multiple stressors is complex and often has inherently high uncertainty (Williams et al., 2016; Tyack et al., 2022). Quantifying the population-level impacts of multiple *sublethal stressors* on populations incorporates further complexity and requires in-depth knowledge of population dynamics and threats which is usually only available for very well-studied species.

[2] https://www.iucnredlist.org/resources/threat-classification-scheme

[3] Cumulative effects may be additive, where the combined effect is equal to the added effect of each stressor in isolation; synergistic, where the combined effect is greater; or antagonistic, where the combined effect is less than the added individual effects (Tyack et al., 2022).

Table 2. Potential threats (human activities) and stressors identified for sei whales in the Falkland Islands. Threats are colour coded by likelihood. Stressors are allocated to the threats for which they are most significant; for example, localised alterations in prey availability could potentially result from many of the activities but large-scale impacts are most associated with fishing and climate change.

Potential threat/Activity	**Potential stressor**							
	Pollution / habitat degradation	Habitat loss	Underwater noise[1]	Increased vessel activity[2]	Entanglement	Collision[3]	Hunting	Altered prey availability
1.2. Coastal development	X	X	X	X				
2.4. Marine & Freshwater Aquaculture	X	X	X	X	X			
3.1. Oil & Gas Drilling	X	X	X	X				
3.3. Renewable Energy (marine)	X	X	X	X	X	X		
4.3. Shipping Lanes	X	X		X		X		
5.4.1/5.4.2. Intentional Use (whaling)							X	
5.4.3/5.4.4. Unintentional Use (fishing)					X			X
6.1. Recreational Activities				X		X		
6.2. War, Civil Unrest & Military Exercises			X	X				
6.3. Work & Other Activities				X		X		
8. Invasive Species, Genes & Diseases	X							
9.1. Domestic & Urban Waste Water	X							
9.2. Industrial & Military Effluents	X							
9.3. Agricultural & Forestry Effluents	X							
9.4. Garbage and Solid Waste	X							
9.6. Excess Energy	X		X					
11. Climate Change & Severe Weather	X	X						X

[1] Specifically referring to non-vessel noise associated with human activities, for example piling, seismic airguns, explosives, naval sonars, the use of Acoustic Deterrent Devices, etc.

[2] Causing disturbance from underwater noise associated with vessel propellers/engines/generators/thrusters, along with the secondary associated increases in potential for vessel strike and entanglement in vessel mooring/anchor equipment.

[3] Includes both collision with the underwater structures used in marine renewables, and vessel strike.

Likelihood of threat occurrence in the Falkland Islands:

Threat code	**Description**
Past	Threat that occurred in the past but is not currently present.
Current	Threat already occurs in the Falkland Islands.
Near future	Threat with the potential to develop within the next decade.

Threat code	**Description**
Possible future	Threat with the potential to develop within the next century.
?	Threat of unknown likelihood status.

Consideration of cumulative effects is required for planners of major activities under Environmental Impact Assessment (EIA) and Environmental Impact Statement (EIS) processes of the European Union and United Kingdom, and is also important for regulators developing recovery plans for threatened or endangered species (Tyack et al., 2022). Nevertheless, due to their overwhelming complexity cumulative impacts still often receive only superficial consideration in EIS (Williams et al., 2016), despite increasing evidence of their management relevance (e.g., Murray et al., 2021; Tyack et al., 2022).

When considering cumulative impacts it should be acknowledged that sei whales travel hundreds of miles during their annual migrations and are likely to be exposed to human activities across the wider south-west Atlantic region and not solely during the months that they are using the Falkland Islands feeding ground.

5. Recommendations

Recommendations towards minimising the potential impacts from human activities on the sei whale and its critical foraging habitats around the Falklands are provided below in three core sections:

1. Policy and permitting;
2. Mitigation and management; and
3. Assessing species and BIA status.

5.1. Policy and permitting

Recommendations		**Potential Stressors (Table 2)**
1.	**Sei whales recognised as a Priority Species in Falklands' legislation**. The Falkland Islands Biodiversity Strategy (2008–2018) listed Priority Species for which Action Plans (APs) were required. The importance of Falklands' coastal waters as a globally important feeding ground for Endangered sei whales was not recognised at that time, and the species was lumped with 'pelagic cetaceans' requiring only a basic AP. The significance of Falklands' waters as a stronghold for sei whales in a national, south-west Atlantic, southern hemisphere and global context should be recognised by their inclusion as a Priority Species in future biodiversity legislative and regulatory frameworks.	All stressors
2.	**Amendments to legislation to improve sei whale protection.** Sei whales are included (along with all marine mammals) as protected species in the Conservation of Wildlife and Nature Ordinance 1999 (Part 4: 4b) and in the Marine Mammals Ordinance 1992. Both pieces of legislation prohibit the intentional capture, wounding or killing of marine mammals within the Falkland Islands Conservation Zones (FICZs; see Section 5.2). However, the existing legislation does not cover: • Disturbance. It is increasingly recognised that disturbance to whales can have energetic consequences and impacts on fitness (McHuron et al., 2021). Under the EU Habitats Directive, all cetaceans are European Protected Species for which legislative frameworks consider the intentional or reckless disturbance or harassment of cetaceans to be an	All stressors

Recommendations		Potential Stressors (Table 2)
	offence[4]. It is recommended that similar recognition and inclusion of disturbance impacts on cetaceans is incorporated into Falklands legislation, given that inshore waters host sensitive sei whale aggregations engaged in both feeding and reproductive behaviours; • Critical habitats other than breeding sites or resting places (Conservation of Wildlife and Nature Ordinance 1999: Part 4: 1c). It might be recognised that other habitats support critical and sensitive behaviours, including important sei whale foraging habitats; • Noise sources other than explosives (Marine Mammals Ordinance 1992: 3.1c). It should be recognised that a range of high amplitude noise sources have the potential to disturb, injure or kill cetaceans, including (but not limited to) pile-driving, airgun arrays and drilling, and it is recommended that this statement be revised accordingly; or • Harm, injury or mortality arising from the use of fishing gear other than 'net, trawl line or hook' (Marine Mammals Ordinance 1992: 3.1d; 5). It is recommended that this statement is broadened to include all fishing gear, or at least expanded to include ropes and fixed gear which provide a potential entanglement risk to baleen whales.	
3.	**Incorporation of sei whale KBA and IMMA into EIS and relevant legislation.** The KBA and IMMA delineate high-use foraging habitats for Endangered sei whales. Potentially adverse activities (Annex 1) being proposed within those areas should require an EIA/EIS that includes specific assessment of impacts on sei whales and their habitats using best available evidence. Recognition of KBAs was apparent in some expired policy documents in the Falklands (for example the Falkland Islands Biodiversity Framework 2016–2030) but is not recognised in others. It is recommended that the KBA and IMMA should be incorporated into relevant legislation in the same way that Important Bird Areas and Important Plant Areas are currently recognised (e.g., Offshore Minerals Ordinance (Amendment) Bill 2011, Schedule 5, Section 2).	All stressors
4.	**Permit requirements consider sei whale entanglement in fixed fishing gear.** Permits issued for the use of fixed fishing gear within sei whale foraging habitats in the Falkland Islands should include requirements to: • Utilise best practice gear modifications to reduce (weighted ground lines) or eliminate ('ropeless' fishing) the risk of sei whale entanglement; • Label gear so that it can be traced back to a fishery/operator/area; • Immediately report the location and type of any lost gear; and • Immediately report the location and nature of any observed whale entanglement and require expert advice on handling it.	Entanglement
5.	**Introduce permitting requirement for sei whale ecotourism.** One of the highest potential likelihoods of vessel collision and disturbance is from vessels that purposefully approach sei whales. A permitting scheme already exists for approaches associated with research and filming, but should also be introduced for operators wishing to approach whales for	Vessel disturbance Collision

[4] https://www.gov.scot/binaries/content/documents/govscot/publications/advice-and-guidance/2020/07/marine-european-protected-species-protection-from-injury-and-disturbance/documents/marine-european-protected-species-guidance-july-2020/marine-european-protected-species-guidance-july-2020/govscot%3Adocument/EPS%2Bguidance%2BJuly%2B2020.pdf

Recommendations		Potential Stressors (Table 2)
	ecotourism, requiring attendance of a brief training course on the species and the Cetacean Code of Conduct, and that annual summary data are provided to the regulator on the number of trips carried out in order to monitor future impacts. A requirement for an onboard naturalist is also recommended, both to increase the educational outreach to passengers and to help monitor compliance with the CCoC.	
6.	**Adopt the Cetacean Code of Conduct for the Falkland Islands into formal policy.** The CCoC is currently a voluntary guidance document but would be more effective with formal incorporation into policy and an associated requirement for vessels to report possible or definite vessel strikes to the Maritime Authority.	Collision Vessel disturbance
7.	**Continued legislation to limit pollutants.** The Falkland Islands has signed multilateral conventions such as the International Convention for the Prevention of Pollution from Ships (MARPOL) in 1995, the United Nations Convention on the Law of the Sea in 1997 and the International Convention on Oil Pollution Preparedness, Response and Co-operation in 2021, and has national legislation such as the Maritime (Amendment) Ordinance 2019 and the Maritime (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 2019, which make provision for reducing marine pollution. Continued (or improved) strict waste management both terrestrially and marine is recommended.	Pollution
8.	**Fishing licences for sei whale prey species.** Currently, the prey species targeted by sei whales in Falklands' coastal waters are not the focus of commercial fisheries. It is recommended that any future harvesting of sei whale prey species is subject to comprehensive assessment to determine its potential impacts on sei whale use of the foraging areas.	Altered prey

5.2. Mitigation and management

In the absence of robust information on species status, the emphasis of the recommendations within this CMP is on reducing the potential impacts of human activities on Endangered sei whales with the goals of: (1) achieving zero mortality; and (2) minimising disturbance to ensure that habitats used for critical behaviours (feeding, breeding, resting etc) remain suitable for occupation by the species.

Recommendations		Potential Stressors (Table 2)
1.	**Establish defined management goals and thresholds.** For threats to be effectively assessed and managed, there needs to be (Tyack et al., 2022): (1) well-defined management goals for individuals and populations defined by legislation, value judgement or biological significance; and (2) definition of the management goal status or threshold against which an effect can be measured and managed. For example, the US Marine Mammal Protection Act specifies Potential Biological Removal (PBR) which is defined as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. Without establishing a regulatory framework and quantitative thresholds for	All stressors

Recommendations		Potential Stressors (Table 2)
	what comprises acceptable levels of whale disturbance or mortality in Falklands' waters, it is difficult for stakeholders to robustly evaluate the impacts of sublethal or lethal stressors on sei whales from their activities (for example, in EIS). It is recognised that this is a long-term goal and requires robust information on population size/trend and on defining suitable criteria to establish population-level impacts. However, given their Endangered global status and the unique importance of the Falkland Islands for the species, it is recommended that achieving zero mortality from human impacts is a stated management goal for sei whales.	
2.	**Schedule activities to avoid whale sensitivities in time**. Sei whales have a well-defined temporal occurrence in Falklands' coastal waters (Section 3.3). Planning short-term intensive coastal human activities to occur from July to October would avoid most sei whale sensitivity (even within the KBA/IMMA).	Underwater noise Entanglement
3.	**Locate activities to avoid spatial overlap with whales**. The spatial limits of the KBA and IMMA encompass globally-important foraging habitats for sei whales. Locating potentially adverse activities outside of those high-use areas might reduce the likelihood of impacts on sei whales.	Habitat loss Entanglement Collision
4.	**Use best practice approaches for real-time noise mitigation.** The UK Joint Nature Conservation Committee has developed guidelines for minimising the potential impacts on marine mammals from high amplitude noise including geophysical surveys, impact piling and use of explosives[5]. Following these guidelines provides a baseline level of best practice mitigation for industry. The development and use of Falklands-specific guidance is recommended considering the specific sensitivities found around the Falklands including sei whales. Noise modelling results should be applied in a precautionary approach, given the lack of audiogram data for any baleen whale species and the specific importance of Falklands' waters for breeding and feeding whales.	Underwater noise
5.	**Reduce speed of large vessels in high-use sei whale habitats.** Reducing the speed of large vessels is understood to greatly decrease the likelihood of a vessel strike proving fatal to baleen whales (Annex 1). Implementing a 10 knot vessel speed restriction for large (>20 m or 65 feet) vessels[6] inside the KBA/IMMA during the peak sei whale season (Feb–Apr) would likely be an effective collision mitigation approach.	Collision
6.	**Use measures to reduce whale entanglement risk in fixed fishing gear.** Ropes and lines in the water column present risk for sei whale entanglement, especially in foraging areas. The ropes associated with fixed fishing gear (including gillnets and crab/lobster pots) and surface marker buoys are the leading sources of documented baleen whale entanglement globally (see Annex 1). Measures to reduce entanglement risk include minimising the number of vertical lines in the water column and weighting groundlines to lie flat on the seabed. Measures to eliminate the risk of	Entanglement

[5] https://jncc.gov.uk/our-work/marine-mammals-and-noise-mitigation/

[6] https://www.fisheries.noaa.gov/national/endangered-species-conservation/reducing-vessel-strikes-north-atlantic-right-whales

Recommendations		Potential Stressors (Table 2)
	entanglement additionally include using 'ropeless' fishing methods[7] (developed specifically to address whale entanglement in pot fisheries).	
7.	**Use measures to reduce whale entanglement risk in platform moorings.** Ropes, lines, chains and other mooring gear in the water column present entanglement risks. This includes the moorings (and surface marker buoys) used for vessels and for other platforms including offshore drilling rigs and aquaculture facilities. Measures to reduce (but not eliminate) entanglement risk include minimising the number of lines in the water column and selecting high tension mooring options that reduce slack.	Entanglement
8.	**Acquire baseline datasets for offshore areas to assess and mitigate risks.** Currently there is almost no contemporary information on the distribution, seasonality, or behaviour of sei whales in Falklands' waters >100 m water depth including the majority of the FICZs. This remains a major deficit for assessing threats and mitigating impacts on sei whales in many areas used by commercial fisheries and offshore industry. Baseline datasets could comprise targeted visual surveys, acoustic work, and/or telemetry.	Underwater noise Vessel disturbance Entanglement Collision
9.	**Continue (or advance) the sampling and necropsy of dead whales.** Samples from dead sei whales may provide information pertinent to several current knowledge gaps including the identification of specific threats (e.g., vessel strikes, plastic ingestion) and the potential impacts from a range of disease and pollutant categories (see Annex 1), that will facilitate improved future evaluation of risk and mitigation.	Pollution Entanglement Collision
10.	**Investigate noise impacts (disturbance) on sei whales in Berkeley Sound.** There is clear overlap between foraging sei whales and shipping in Berkeley Sound, which make it a unique global site in which to assess sublethal noise impacts on the distribution and behaviour of sei whales. This would provide useful insight into the potential for displacement and changes in acoustic behaviour, and consequently inform the mitigation of potential noise impacts.	Underwater noise Vessel disturbance
11.	**Use the Cetacean Code of Conduct for the Falkland Islands.** Reducing vessel speeds, avoiding sudden changes of heading and providing whales with a wide berth are well established methods of reducing collision risk and disturbance. This is especially important for watercraft intending to specifically approach whales, including commercial and recreational ecotourism, film-makers, and researchers.	Collision Vessel disturbance
12.	**Improve awareness of the Cetacean Code of Conduct.** Awareness could be improved by issuing the CCoC with the standard information that the Maritime Authority issues to vessels using Stanley Harbour and that the FITB send to visiting ecotourism vessels, and by installing information boards at the public jetties.	Collision Vessel disturbance
13.	**Develop local expertise for handling entangled whales.** Effective and safe disentanglement of large whales requires trained personnel, or animals can be left in a worse situation carrying gear for months before succumbing. International training schemes are available.	Entanglement
14.	**Require that the bottom of antipredator nets are closed.**	Entanglement

[7] https://sustainableseastechnology.org/

Recommendations		Potential Stressors (Table 2)
	Antipredator nets are often used around marine aquaculture facilities, and baleen whales have been recorded trapped between the fish containment net and the antipredator net. Should marine aquaculture progress in the Islands, permitting should stipulate that antipredator nets are well maintained and the bottoms kept closed to reduce this risk, and there should be a mandatory requirement for the immediate reporting of whale entanglements.	
15.	**Investigate prey availability and link with sei whale occurrence.** The major prey species of sei whales in the Falklands have been identified, but little is understood of their spatio-temporal abundance or ecology, or how those influence whale occurrence. These prey-predator dynamics are an important avenue of research which would improve understanding of how to maintain foraging habitats and how climate change or the future development of fisheries that harvest sei whale prey might affect the whales.	Altered prey
16.	**Determine movements of sei whales in the wider south-west Atlantic.** Sei whales use the Falklands for only half of the year, and knowledge of where they spend the remaining months is critical to understanding cumulative threats and population structure. This information is likely most readily acquired using telemetry, despite the proven challenges of tagging sei whales.	All stressors

5.3. Assessing species and BIA status

Recommendations	
1.	**Establish population size and trend.** Conservation status assessments require knowledge of population size and trends, and information on whether the sei whale population around the Falkland Islands is increasing, stable, or decreasing. Acquiring such information is costly and challenging, for example it might require island-wide aerial surveys every 5–10 years. However, establishing population trend over the longer-term would provide the basis for national and global Red List assessments, improve understanding of the scale of threats, and facilitate reporting against management targets.
2.	**KBA status assessment.** The IUCN KBA guidance requires that an assessment is undertaken to re-evaluate KBAs every 8–12 years, in recognition that a species status may change or new information may become available on the appropriateness of the KBA boundaries. Establishing a long-term monitoring programme for the sei whale population is therefore desirable to assess the ongoing relevance of the KBA status.

6. References

Acevedo, J., Aguayo-Lobo, A., González, A., Haro, D., Olave, C., Quezada, F., Martínez, F., Garthe, S. and Cáceres, B. (2017). Occurrence of sei whales (*Balaenoptera borealis*) in the Magellan Strait from 2004-2015, Chile. Aquatic Mammals, 43: 63–72.

Baines, M. and Weir, C.R. (2020). Predicting suitable coastal habitat for sei whales, southern right whales and dolphins around the Falkland Islands. PLOS ONE 15(12): e0244068

Cerchio, S. and Weir, C.R. (2022). Mid-frequency song and low-frequency calls of sei whales in the Falkland Islands. Royal Society Open Science, 9(11): 220738

Cerchio, S., Stanworth, A. and Weir, C.R. (2022). Passive acoustic monitoring. In: Weir CR (ed) Conserving Falklands' whale populations: addressing data deficiencies for informed management. Falklands Conservation, Stanley, Falkland Islands, pp 175–218

Cooke, J.G. (2018). *Balaenoptera borealis*. The IUCN Red List of Threatened Species 2018: e.T2475A130482064. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T2475A130482064.en.

Copping, A.E., Hemery, L.G., Overhus, D.M. et al. (2020). Potential Environmental Effects of Marine Renewable Energy Development—The State of the Science. Journal of Marine Science and Engineering, 8: 879.

Falkland Islands Government. (2021). Falkland Islands Environment Strategy 2021–2040. Stanley, Falkland Islands. 52 pages. Available from: website: https://www.fig.gov.fk/policy/environment/environment-strategy

Hammond, P.S., Macleod, K., Berggren, P. et al. (2013). Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. Biological Conservation, 164: 107–122. https://doi.org/10.1016/j.biocon.2013.04.010.

Häussermann, V., Gutstein, C.S., Bedington, M., Cassis, D., Olavarria, C., Dale, A.C., Valenzuela-Toro, A.M., Perez-Alvarez, M.J., Sepúlveda, H.H., McConnell, K.M., Horwitz, F.E. and Försterra, G. (2017). Largest baleen whale mass mortality during strong El Niño event is likely related to harmful toxic algal bloom. PeerJ, 5: e3123. DOI 10.7717/peerj.3123

Hipsey, S.J., Delarue, J., Martin, B., Burns, R.D.J., Lumsden, E. (2013). Static Acoustic Monitoring Programme for the Sea Lion Development Area. JASCO Document 00591, Version 1.0. Technical report by JASCO Applied Sciences for Premier Oil plc Falkland Islands Business Unit.

Horwood, J. (1987). The sei whale: population biology, ecology and management. London: Croom Helm. 375 pp.

Huijser, L.A.E., Bérubé, M., Cabrera, A.A., Prieto, R., Silva, M.A., Robbins, J., Kanda, N., Pastene, L.A., Goto, M., Yoshida, H., Víkingsson, G.A. and Palsbøll, P.J. (2018). Population structure of North Atlantic and North Pacific sei whales (*Balaenoptera borealis*) inferred from mitochondrial control region DNA sequences and microsatellite genotypes. Conservation Genetics, 19: 1007–1024.

Jackson, J.A., Stowasser, G. and Weir, C.R. (2022a). Diet of sei and southern right whales. In: Weir CR (ed) Conserving Falklands' whale populations: addressing data deficiencies for informed management. Falklands Conservation, Stanley, Falkland Islands, pp 123–151.

Jackson, J.A., Buss, D.L., Carroll, E.L. and Weir, C.R. (2022b). Genetics. In: Weir CR (ed) Conserving Falklands' whale populations: addressing data deficiencies for informed management. Falklands Conservation, Stanley, Falkland Islands, pp 152–164.

McHuron, E.A., Aerts, L., Gailey, G., Sychenko, O., Costa, D.P., Mangel, M. and Schwarz, L.K. (2021). Predicting the population consequences of acoustic disturbance, with application to an endangered gray whale population. Ecological Applications, 31: e02440.

Murray, C.C., Hannah, L.C., Doniol-Valcroze, T., Wright, B.M., Stredulinsky, E.H., Nelson, J.C., Locke, A. and Lacy, R.C. (2021). A cumulative effects model for population trajectories of resident killer whales in the Northeast Pacific. Biological Conservation, 257: 109124.

Otley H, Munro G, Clausen A and Ingham B. (2008). Falkland Islands State of the Environment Report 2008. Falkland Islands Government and Falklands Conservation, Stanley.

Parsons, E.C.M., Warburton, C.A., Woods-Ballard, A., and Johnston, A.H.P. (2003). The value of conserving whales: the impacts of cetacean-related tourism on the economy of rural West Scotland. Aquatic Conservation: Marine and Freshwater Ecosystems, 13: 397–415.

Pearson, H.C., Savoca, M.S., Costa, D.P., Lomas, M.W., Molina, R., Pershing, A.J., Smith, C.R., Villaseñor-Derbez, J.C>, Wing, S.R. and Roman, J. (2023). Whales in the carbon cycle: can recovery remove carbon dioxide? Trends in Ecology and Evolution, 38: 238–249.

Rocha, R.C. Jr., Clapham, P.J. and Ivashchenko, Y.V. (2014). Emptying the oceans: a summary of industrial whaling catches in the 20th century. Marine Fisheries Review, 76: 37–48.

Roman, J., Estes, J.A., Morisette, L. et al. (2014). Whales as marine ecosystem engineers. Frontiers in Ecology and the Environment, 12: 377–385.

Segre, P.S. and Weir, C.R. (2022). Suction cup tagging. In: Weir CR (ed) Conserving Falklands' whale populations: addressing data deficiencies for informed management. Falklands Conservation, Stanley, Falkland Islands, pp 165–174.

Sharp, S.M., McLellan, W.A., Rotstein, D.S. et al. (2019). Gross and histopathologic diagnoses from North Atlantic right whale *Eubalaena glacialis* mortalities between 2003 and 2018. Diseases of Aquatic Organisms, 135: 1–31.

Tyack, P.L., Thomas, L., Costa, D.P. et al. (2022). Managing the effects of multiple stressors on wildlife populations in their ecosystems: developing a cumulative risk approach. Proc. R. Soc. B 289: 20222058. https://doi.org/10.1098/rspb.2022.2058

Weir C.R. (2017). Developing a site-based conservation approach for sei whales *Balaenoptera borealis* at Berkeley Sound, Falkland Islands. Falklands Conservation report. Version 1.0, September 2017. 115 pp.

Weir C.R. (2018). A preliminary assessment of endangered sei whales (*Balaenoptera borealis*) in two candidate Key Biodiversity Areas in West Falkland. Falklands Conservation report. Version 1.2. 128 pp.

Weir, C.R. (2021). Supporting evidence for the proposal of Falkland Islands Inner Shelf Waters as a KBA for endangered sei whales (*Balaenoptera borealis*). Falklands Conservation, Stanley, Falkland Islands. 36pp.

Weir, C.R. (ed.). (2022). Conserving Falklands' whale populations: addressing data deficiencies for informed management. Technical Report for DPLUS082. Falklands Conservation, Stanley, Falkland Islands. Version 2, 30 Oct 2022. 231 pp.

Weir, C.R., Taylor, M., Jelbes, P.A.Q. and Stanworth, A. (2018). Cue rates and surfacing characteristics of sei whales (*Balaenoptera borealis*) in the Falkland Islands. Journal of Cetacean Research and Management, 19: 43–55.

Weir, C.R., Stanworth, A., Cartwright, S., Jelbes, P.A.Q., Taylor, M. and Pompert, J. (2019). Distribution and movements of sei whales (*Balaenoptera borealis*) on coastal feeding grounds in the Falkland Islands (Malvinas). World Marine Mammal Conference, Barcelona, Spain, December 2019.

Weir, C.R., Oms, G., Baracho-Neto, C.G., Wedekin, L.L. and Daura-Jorge, F.G. (2020). Migratory movement of a sei whale (*Balaenoptera borealis*) between Brazil and the Falkland Islands (Malvinas). Marine Mammal Science, 36: 1050–1057. DOI: 10.1111/mms.12687

Weir, C.R., Taylor, M., Jelbes, P.A.Q., Stanworth, A. and Hammond, P.S. (2021). Distribution and abundance of sei whales off the west coast of the Falkland Islands. Marine Mammal Science, 37: 919–933.

Williams, R., Thomas, L., Ashe, E., Clark, C. and Hammond, P.S. (2016). Gauging allowable harm limits to cumulative, sub-lethal effects of human activities on wildlife: A case-study approach using two whale populations. Marine Policy, 70: 58–64.

Wright, A.J. and Kyhn, L.A. (2015). Practical management of cumulative anthropogenic impacts with working marine examples. Conservation Biology, 29: 333–340.

Annex 1. Assessment of IUCN-CMP Threats[8] that have the potential (past, present, or future) to affect sei whales in the Falkland Islands

The colour coding definitions of Likelihood are provided with Table 2.

1. Residential & Commercial Development 1.2. Commercial & Industrial Areas		Likelihood

Coastal development in the Falkland Islands is currently small-scale and focussed predominantly on Stanley Harbour/Port William and Mare Harbour. Both areas have port operations with fixed and floating structures extending into the marine environment for vessels to berth. Falkland Islands Government (FIG) intends to replace the existing Falklands Interim Port and Storage System (FIPASS) with an updated and expanded port development, and there are also plans underway to modify yacht mooring facilities and public jetties. Stanley Harbour is additionally the main area of human habitation in the Islands, with a range of associated impacts on coastal waters (e.g., sewage outflow, waste management, recreational watercraft etc).

In addition to direct loss, or degradation, of habitats associated with coastal development, the construction of marine facilities often incorporates activities such as dredging, pile-driving, use of explosives, bathymetric surveys, and other activities that result in changes to habitats or the introduction of high amplitude noise into the habitats used by cetaceans. Additionally, the expansion of port facilities is likely to result in higher vessel traffic in coastal waters with associated increased noise and risks of vessel strike and mooring entanglements.

2. Agriculture & Aquaculture 2.4. Marine & Freshwater Aquaculture		Likelihood

Marine finish aquaculture farms consist or a rigid structure, net pens, and a mooring system. The cage nets and antipredator nets are usually made of synthetic materials, commonly nylon, with antipredator mesh sizes in the 3.8 to 20 cm range depending on target species (Bath et al., 2023). Ropes are used for both the mooring lines and grid system lines, and are most commonly made of polysteel with a tensile strength more than 25% higher than polypropylene (Bath et al., 2023). Cage locations are also marked with navigational surface buoys that pose a further risk for animal entanglements if the vertical lines are slack (Bath et al., 2023).

The main potential impacts on whales from marine aquaculture facilities are habitat exclusion (especially when placed in key foraging or transit areas), underwater noise (associated with installation/removal, vessel operations, and the use of acoustic deterrents such as Acoustic Deterrent or Harassment Devices (ADDs and AHDs)), increased vessel activity, habitat degradation (e.g. eutrophication or disease affecting prey availability, and increased marine debris), and entanglement in mooring lines and antipredator nets. At least five species of baleen whale have been reported entangled in marine finfish farm net pens or cages (Bath et al., 2023). There is one documented mortality of a sei whale from entanglement in ropes and metal chain at a salmon net pen in Chile during 2020. Additionally, fatal entanglements in mussel farm spat lines have been recorded for Bryde's whales (*B. edeni)* in New Zealand (Bath et al., 2023), a species very similar in morphology and habits to sei whales.

[8] https://www.iucnredlist.org/resources/threat-classification-scheme

3. Energy Production & Mining 3.1. Oil & Gas Drilling		Likelihood

This threat comprises exploring for, developing, and producing petroleum and other liquid hydrocarbons. Around the Falklands, 26 hydrocarbon seismic surveys were carried out between 1977 and 2013 in attempts to locate commercially viable oil reserves, with the most recent occurring in 2013 (Sean Hayes pers. comm., FIG Department of Mineral Resources). Test drilling of several oil wells has occurred since 1998 (Otley et al., 2008). A 30-year commercial oil extraction operation was recently proposed for the Sea Lion Field in Licence Blocks PL004 and PL032 (approximately 220 km north of the Falklands in 450 m water depth).

Hydrocarbon exploration and extraction can have several potential impacts on sei whales (including indirectly via impacts on their prey), including: (1) oil spills at drill sites (see 9.2.1); (2) noise impacts from seismic surveys, drilling and other marine construction activities (see 9.6.3); (3) habitat loss/degradation; and (4) increased vessel traffic causing additional noise and collision risk (see 4.3).

3.3. Renewable Energy		Likelihood

This threat comprises exploring, developing, and producing renewable energy, which in the marine environment relates to offshore wind (OSW) and marine renewable energy (MRE). Once constructed, operational OSW farms produce relatively low noise, although it still has the potential to disrupt marine mammal behaviours (and affect their prey) within several hundred metres of each foundation (Thomsen et al., 2006). However, the construction process uses high amplitude pile-driving to install turbine foundations in the seabed, producing large amounts of acoustic energy that are audible to marine mammals over 80 km from the source (Thomsen et al., 2006) with the potential to kill or injure animals in proximity, or to disturb them over relatively wide areas (e.g., 25 km radius: Tougaard et al., 2009). MRE is generated from the power of tide and waves, most commonly the installation of tidal turbines and wave energy converters (Copping et al., 2020). The potential impacts of MRE on whales depend on factors including the attributes of the MRE device (e.g., its structure and whether it is submerged or floating), the type of resource (wave or tidal), and the spatial scale of the installation (single device or arrays), but potentially include changes in oceanographic processes, underwater noise, mooring entanglement (lines and cables), collision risk (underwater turbines), and changes in habitat (Copping et al., 2020).

Additionally, both OSW and MRE result in increased vessel traffic and related noise in the marine environment, increasing the risks of vessel strike and noise disturbance. Conversely, it is also recognised that OSW and MRE may offer potential benefits to cetaceans through the creation of artificial reef habitat and the exclusion of fisheries which might support higher densities of some prey, and the positive potential impacts of addressing global climate change (Bergström et al., 2014).

Neither OSW nor MRE are currently used in the Falkland Islands.

4. Transportation & Service Corridors 4.3. Shipping Lanes		Likelihood

This threat comprises transportation in the marine environment and the activities that maintain shipping lanes such as dredging. In the Falkland Islands, sei whales routinely forage in nearshore habitats including some of the highest areas of vessel activity in the Islands (Berkeley Sound and Choiseul Sound).

Sei whale foraging amongst vessel traffic including reefers, jiggers and a tanker in Berkeley Sound.

Low frequency (LF; <1,000 Hz) noise in the oceans is primarily generated by commercial shipping, including from propeller cavitation, propeller singing, and propulsion or other reciprocating machinery (Richardson et al., 1995). A North Pacific study found that over 99 and 94% of a modelled study area contained predicted noise levels above the approximation of pre-industrial conditions of 50 and 100 Hz respectively, including in areas occupied by endangered baleen whale species (Redfern et al., 2017). Larger vessels generally generate more LF noise because of their relatively high power, deep draft, and slower-turning (< 250 rpm) engines and propellers (Richardson et al., 1995). Exposure to vessel noise may result in auditory masking, behavioural changes from disturbance, and chronic stress. See also Threat 9.6 below.

Dredging is a worldwide excavation activity that involves removing sediment from a sea, river, or lakebed and depositing it elsewhere. It is usually associated with construction of ports and other marine infrastructure, extraction of marine aggregates, and the maintenance of waterways including shipping lanes. Physical injury or mortality from collisions, noise production, and increased turbidity are the main ways dredging affects marine mammals directly (Todd et al., 2015). Indirect impacts are less well understood but may result from changes to their physical environment, or to their prey (Todd et al., 2015). Evidence suggests that if management procedures are implemented, effects from dredging on whales are most likely to be auditory masking and short-term behavioural alterations and changes to prey availability (Todd et al., 2015).

Vessel strikes are a well-documented threat to large whales worldwide (Laist et al., 2001; Van Waerebeek et al., 2007), despite being under-reported due to carcasses sinking or drifting out at sea, or crews not noticing or failing to report them. They include whales being hit by the bow or hull causing blunt trauma (or whales becoming stuck across the front of a bulbous bow), or propeller strike causing tissue damage. The likelihood of vessel strikes increases as marine traffic expands and whale populations grow in size, and the risk is both higher, and more likely to result in serious injury or mortality, for faster vessels travelling above 10 knots (Laist et al., 2001). While sei whales generally occupy pelagic offshore habitats (with comparatively low shipping) in many areas globally, vessel strikes have still been documented for the species (Van Waerebeek et al., 2007; Glass et al., 2010). In the Falkland Islands, sei whales occur in high densities within nearshore habitats where interactions with vessels may be more prevalent. Minor collisions between sei whales and vessels have been documented several times in the Falklands (Weir, 2017, 2018), so far without damage to boats and with unknown outcomes for the animals.

5. Biological Resource Use 5.4.1/5.4.2. Fishing & Harvesting Aquatic Resources: Intentional Use		Likelihood

The major threat to sei whales over the last century and the driver of their current globally Endangered status was depletion originating from large-scale commercial whaling. The largest catches globally were in the southern hemisphere (~205,000 animals: Rocha Jr et al., 2014), and included catches within the Falkland Islands at New Island (Weir, 2017). Currently, sei whales are protected from commercial whaling by the International Convention for the Regulation of Whaling and the moratorium on commercial whaling implemented in 1986, although catches of 25 sei whales per annum are ongoing in Japan[9]. As whale populations continue to recover and grow globally, pressure to resume commercial whaling may increase.

5.4.3/5.4.4. Fishing & Harvesting Aquatic Resources: Unintentional Effects		Likelihood

The unintentional effects of fishing on sei whales potentially include:(1) changes in the availability of prey species resulting from human fisheries; and (2) entanglement in fishing gear.

Changes in prey abundance due to harvesting by krill and forage fish fisheries are recognised as possible threats to recovering large baleen whale populations (Surma and Pitcher 2015). In the Falkland Islands, commercial fisheries primarily target finfish and squid (*Illex argentinus* and *Doryteuthis gahi*), using bottom and demersal trawling, jigging, and demersal longlining. A no fishing zone extends to 3 nm offshore around the coast, and commercial fisheries operate from that zone to the 200 nm limit of the Falkland Islands Conservation Zones. The Fisheries (Conservation and Management) Ordinance 2005 aims to ensure the long-term sustainability of exploited stocks and their habitats through the licensing and regulation of fishing, and to reduce impacts on non-target species. Current information suggests that there is little overlap between the commercial fisheries described above, and the prey species consumed by sei whales in the Falklands (Jackson et al., 2022).

Entanglements occur when whales come into physical contact with materials in the water column, including ropes, nets, and lines. They most often happen in fixed fishing gear including gillnets and pot gear for crabs and lobsters (Johnson et al., 2005). However, entanglements of baleen whales have also been documented in yacht, catamaran and large vessel mooring ropes/chains (Bellazzi et al., 2012) and in aquaculture facilities (Bath et al., 2023). Entanglement is a significant contemporary threat to some baleen whale species and populations. For example, the unsustainable rate of entanglement in pot gear is directly responsible for limiting population recovery of the Critically Endangered North Atlantic right whale in the USA and Canada (Kenney, 2018) and the humpback whale (*Megaptera novaeangliae*) in Scotland (Rya et al., 2016). From an individual welfare perspective, whale entanglements are also considered one of the worst forms of human-caused mortality in wild animals, causing slow and painful deaths over many months (Casoff et al., 2011). Entanglements can injure and kill whales by restricting mobility, impairing their breathing, swimming or feeding abilities, and cutting into their tissue leading to amputation (e.g., of a flipper or fluke) or infection (Casoff et al., 2011). Sei whales are sometimes considered less vulnerable to entanglements than some other whale species, due to their pelagic distribution in many parts of the world. However, this is not the case in the Falklands where both their high inshore densities and feeding behaviour (both surface and subsurface lunging: Segre et al., 2021) render them more vulnerable to entanglement than elsewhere. There are documented examples of sei whale entanglements in the north-west Atlantic (Glass et al., 2010) and a sei whale entangled in rope was photographed in Berkeley Sound in the Falklands (Weir, 2017). Additionally, there is a documented mortality of a sei whale from entanglement in ropes and metal chain from a salmon net pen in Chile during 2020.

[9] https://www.mofa.go.jp/policy/economy/fishery/whales/japan.html

6. Human Intrusions & Disturbance 6.1. Recreational Activities		Likelihood

This threat comprises non-consumptive use of biological resources, and in the marine environment includes potential impacts on whales from recreational motorboats, watersports (e.g., jet-skis and divers), and whale-watching. The Falklands marine environment experiences vessel traffic related to a summer tourist industry (cruise and expedition vessels), infrequent launch-based whale-watching in the Stanley–Berkeley Sound area, occasional natural history film-making, and various privately owned watercraft including both motor and sail boats, jet-skis and kayaks. All of these may attempt to approach whales for viewing purposes. Considerable evidence (Parsons, 2012) exists to show that whales exhibit behavioural changes in response to the noise and repeated approaches of whale-watching traffic, along with acquiring injuries from vessel strike. Repeated exposure of individuals with long residency periods, as in the case of individual sei whales in Berkeley Sound, may also be problematic.

6.2. War, Civil Unrest & Military Exercises		Likelihood

This threat includes military activities that impact habitats and species. In the marine environment, this includes the use of powerful low- and mid-frequency naval sonars, and the noise and vessel strike risks associated with naval ships. The link between the use of powerful naval sonars and mass odontocete strandings has been well proven (Nowacek et al., 2007), while documented effects on baleen whales include disruption of feeding behaviour and displacement (Goldbogen et al., 2013; Sivle et al., 2016). The current level of use of naval sonars in the waters around the Falkland Islands is unclear.

6.3. Work & Other Activities		Likelihood

This threat includes species research. The only boat-based field research currently carried out on baleen whales in the Falkland Islands, is led by Falklands Conservation and focussed on the Port William–MacBrides Head area. Approaching whales for any purpose has the potential to cause disturbance and injury from vessel strike, as outlined for Threat 6.1. The use of invasive research techniques (e.g., biopsy sampling and satellite tracking) increases the potential for infection or injury, but even non-invasive techniques (e.g., photo-identification) require repeated approaches and can cause disturbance. Field research in the Falkland Islands requires a Research Licence from Falkland Islands Government, the application for which includes consideration of potential impacts on the target species.

8. Invasive & Other Problematic Species, Genes & Diseases		Likelihood

This threat includes harmful plants, animals, pathogens and other microbes that have been introduced/spread by human activities, genetically-modified species, virus/prion-induced diseases, and diseases of unknown cause. Evidence to date for this threat impacting sei whales globally is scant, but includes (Prieto and Weir, 2022): (1) viruses from the Families Caliciviridae and Adenoviridae (Van Bressem et al. 1999) and an unknown viral pathogen found in the lungs of 14% of sei whales examined in Iceland (Lambertsen 1990); (2) an unknown disease affecting 7% of sei whales in California that caused shedding of baleen plates and replacement by a papilloma type growth, affecting their ability to feed (Rice, 1977); and (3) a mass mortality of ~400 sei whales in Chile attributed to paralytic shellfish toxins produced during a harmful algal bloom (Häussermann et al. 2017). The importance of this threat for sei whales in the Falkland Islands is unclear.

9. POLLUTION 9.1. Domestic & Urban Waste Water		Likelihood

This threat includes water-borne sewage and non-point runoff from housing and urban areas that include nutrients, toxic chemicals and/or sediments. Since sei whales in the Falkland Islands occupy nearshore habitats in the vicinity of the main areas of human habitation (Stanley and Mount Pleasant Complex) there is potential for them to be impacted by sewage. Currently no information exists on either the state of this threat in the Islands (although assumed to be mitigated by existing waste management measures) or the susceptibility of sei whales to it.

9.2. Industrial & Military Effluents		Likelihood

This threat comprises water-borne pollutants from industrial and military sources such as mining, energy production, and other resource extraction industries that include nutrients, toxic chemicals and/or sediments. It includes oil spills from vessels and pipelines. Existing legislation to limit the discharge of effluents in the Falkland Islands is assumed to manage this threat. However, accidental oil spills from bunkering at sea, ship waste discharge, transshipments, and hydrocarbon extraction may occur. Oil pollution potentially affects whales through contaminated prey ingestion, skin and eye irritation, inhalation of fumes, and abandonment of polluted foraging areas (Clapham et al. 1999). The long-term accumulation of oils within copepods, means that baleen whale species for which copepods comprise a major part of the diet (including sei whales) may be at increased risk of ingesting petroleum oil during an oil spill (Werth et al. 2019). Additionally, although oil does not adhere to baleen, that characteristic may mean that while fouling of baleen is reduced then ingestion is increased (Werth et al., 2019).

9.3. Agricultural & Forestry Effluents		Likelihood

This threat comprises water-borne pollutants from agricultural, silivicultural, and aquaculture systems that include nutrients, toxic chemicals and/or sediments. In the marine environment, it includes nutrients from aquaculture (see Threat 2.4 above) and herbicides and pesticides.

Little information is available on the population-level impacts of contaminants on sei whales, although marine mammals are long-lived and can accumulate toxins in their blubber. However, persistent contaminants like polychlorinated biphenyls (PCBs) and pesticides generally occur at far lower levels in baleen whales than in odontocetes (Borrell and Aguilar 1987; O'Shea and Brownell 1994), due to their foraging at lower trophic levels. Currently no information exists on the status of this threat in the Falkland Islands.

9.4. Garbage and Solid Waste		Likelihood

Marine debris, including plastics, discarded fishing gear, and other solid materials, can be blown or washed into the ocean from land or lost overboard from marine platforms. Such materials may affect baleen whales through ingestion or entanglement, with potential impacts including toxicity (e.g., microplastic ingestion), gastrointestinal blockage (ingestion of solids), compromised foraging ability (i.e., clogging of baleen plates), or impacts resulting from external entanglement (see Threat 5.4.3). Sei whales use nonselective feeding methods (skimming and gulping: Segre et al., 2021) to capture their prey, making them vulnerable to ingesting solid waste. Additionally, microplastic particles adhere within baleen and may constitute both a fouling risk and an ingestion threat (Werth et al. 2019, 2024).

Existing waste management legislation and facilities in the Falkland Islands are assumed to manage the safe disposal of garbage and solid wastes. However, marine microplastics are problematic to manage and their status in the Falklands is not well documented.

9.6. Excess Energy		Likelihood

This threat comprises inputs of heat, sound, or light that disturb wildlife or ecosystems, and specifically includes noise pollution. Sei whales communicate using a range of low frequency sounds and, in the Falklands, also produce mid frequency songs (Cerchio and Weir, 2022). Their sounds overlap with a variety of chronic (e.g., vessel noise, drilling) and acute (e.g., pile driving, some forms of dredging, underwater detonations, some types of military sonar, and seismic airguns) anthropogenic sound sources. Exposure to noise may result in physical injury as temporary threshold shifts (TTS) or permanent threshold shifts (PTS) in hearing, avoidance (including displacement from critical feeding or breeding habitats), disturbance (i.e., changes in behaviour), chronic stress, and the masking of important sounds used for communication (e.g., Southall et al., 2007). Noise may also impact whales indirectly, by affecting the distribution and abundance of their prey species. The degree of impact likely depends on numerous factors including those related to the sound source (e.g., amplitude, exposure duration), the environment (i.e., parameters affecting attenuation) and the receptor (e.g., distance away, age, sex, species). It is widely acknowledged that animals engaged in critical behaviours (feeding, breeding) may be more sensitive to noise yet in some cases also more motivated to tolerate it (e.g., Richardson et al., 1995; Ellison et al., 2011; Todd et al. 2015). The potential impacts of noise on sei whales in the Falkland Islands has received little research attention to date. However, Cerchio & Weir (2022) noted that noise from large ships was a major component of the Berkeley Sound acoustic soundscape and that the potential for acoustic masking and disturbance in Berkeley Sound is possibly of high conservation importance.

11. Climate Change & Severe Weather		Likelihood

This category comprises threats from long-term climatic changes which may be linked to global warming and other severe climatic/weather events that are outside of the natural range of variation. The potential impacts of climate change on cetaceans include changes in abundance, distribution, timing and range of migration, community structure, the presence and species composition of competitors and/or predators, prey availability and distribution, timing of breeding, reproductive success and, ultimately, survival (Learmonth et al., 2006). Sei whales are an ecologically flexible (Segre et al., 2021) and widely-distributed species, which may make them relatively resilient to some climate change impacts (MacLeod, 2009). However, there is a high degree of uncertainty regarding the oceanographic changes that will occur and both the direct and indirect (via prey) impacts that may result for sei whales.

REFERENCES

Bath, G.E., Price, C.A., Riley, K.L. and Morris Jr, J.A. (2023). A global review of protected species interactions with marine aquaculture. Reviews in Aquaculture, 15: 1686–1719.

Bellazzi, G., Orri, R. and Montanelli, S. (2012). Entanglement of Southern Right Whales (*Eubalaena australis*) in Gulf Nuevo, Chubut, Argentina. Paper SC/64/BC1 to the International Whaling Commission Scientific Committee.

Bergström, L., Kautsky, L., Malm, T., Rosenberg, R., Wahlberg, M., Capetillo, N.A., and Wilhelmsson, D. (2014). Effects of offshore wind farms on marine wildlife—a generalized impact assessment. Environmental Research Letters, 9: 034012.

Borrell, A. and Aguilar, A. (1987). Variations in DDE percentage correlated with total DDT burden in the blubber of Fin (Balaenoptera physalus) and Sei (*Balaenoptera borealis*) whales. Marine Pollution Bulletin, 18(2): 70–74.

Casoff, R.M., Moore, K.M., McLellan, W.A., Barco, S.G., Rotsteins, D.S. and Moore, M.J. (2011). Lethal entanglement in baleen whales. Diseases of Aquatic Organisms, 96: 175–185.

Cerchio, S. and Weir, C.R. (2022). Mid-frequency song and low-frequency calls of sei whales in the Falkland Islands. Royal Society Open Science, 9(11): 220738

Clapham, P.J., Young, S.B. and Brownell, R.L., Jr. (1999). Baleen whales: conservation issues and the status of the most endangered populations. Mammal Review, 29(1): 35–60.

Copping, A.E., Hemery, L.G., Overhus, D.M. et al. (2020). Potential Environmental Effects of Marine Renewable Energy Development—The State of the Science. Journal of Marine Science and Engineering, 8: 879.

Ellison, W.T., Southall, B.L., Clark, C.W. and Frankel, A.S. (2011). A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. Conservation Biology, 26: 21–28.

Glass, A.H., Cole, T.V.N. and Garron, M. (2010). Mortality and serious injury determinations for baleen whale stocks along the United States eastern seaboard and adjacent Canadian Maritimes, 2004-2008.Woods Hole, USA.

Goldbogen JA, Southall BL, DeRuiter SL, Calambokidis J, Friedlaender AS, Hazen EL, Falcone EA, Schorr GS, Douglas A, Moretti DJ, Kyburg C, McKenna MF, Tyack PL. 2013 Blue whales respond to simulated mid-frequency military sonar. Proc R Soc B 280: 20130657. http://dx.doi.org/10.1098/rspb.2013.0657

Häussermann, V., Gutstein, C.S., Bedington, M., Cassis, D., Olavarria, C., Dale, A.C., Valenzuela-Toro, A.M., Perez-Alvarez, M.J., Sepúlveda, H.H., McConnell, K.M., Horwitz, F.E. and Försterra, G. (2017). Largest baleen whale mass mortality during strong El Niño event is likely related to harmful toxic algal bloom. PeerJ, 5: e3123. DOI 10.7717/peerj.3123

Jackson, J.A., Stowasser, G. and Weir, C.R. (2022). Diet of sei and southern right whales. In: Weir CR (ed) Conserving Falklands' whale populations: addressing data deficiencies for informed management. Falklands Conservation, Stanley, Falkland Islands, pp 123–151.

Johnson, A., Salvador, G., Kenney, J., Robbins, J., Kraus, S., Landry, S. and Clapham, P. (2005). Fishing gear involved in entanglements of right and humpback whales. Marine Mammal Science, 21: 635–645.

Kaschner, K., Quick, N.J., Jewell, R., Williams, R. and Harris, C.M. (2012). Global Coverage of Cetacean Line-Transect Surveys: Status Quo, Data Gaps and Future Challenges. PLoS ONE 7(9): e44075. https://doi.org/10.1371/journal.pone.0044075

Kenney, R.D. (2018). What if there were no fishing? North Atlantic right whale population trajectories without entanglement mortality. Endangered Species Research, 37: 233–237.

Laist, D.W., Knowlton, A.R., Mead, J.G., Collet, A.S. and Podesta, M. (2001). Collisions between ships and whales. Marine Mammal Science, 17: 35–75.

Lambertsen, R.H. (1990). Disease biomarkers in large whale populations of the North Atlantic and other oceans, in McCarthy, J. E. & Shugart, L. R. (eds), Biomarkers of environmental contamination. Boca Raton, FL, USA: Lewis Publishers, 395–417.

Learmonth, J.A., MacLeod, C.D., Santos, M.B., Pierce, G.J., Crick, H.Q.P. and Robinson, R.A. (2006). Potential effects of climate change on marine mammals. Oceanography and Marine Biology: an Annual Review, 44: 431–464.

MacLeod, C.D. (2009). Global climate change, range changes and potential implications for the conservation of marine cetaceans: a review and synthesis. Endangered Species Research, 7(2): 125–136.

Nowacek, D.P., Thorne, L.H., Johnston, D.W. and Tyack, P.L. (2007). Responses of cetaceans to anthropogenic noise. Mammal Review, 37: 81–115.

O'Shea, T.J. and Brownell, R.L. Jr (1994). Organochlorine and metal contaminants in baleen whales: A review and evaluation of conservation implications. Sci Total Environ 154(2/3):179–200.

Otley, H., Munro, G., Clausen, A. and Ingham, B. (2008). Falkland Islands State of the Environment Report 2008. Falkland Islands Government and Falklands Conservation, Stanley.

Parsons, E.C.M. (2012). The negative impacts of whale-watching. Journal of Marine Biology, 2012: 807294.

Prieto R, Weir CR (2022) Sei whale *Balaenoptera borealis* Lesson, 1828. In: Hackländer K, Zachos FE (eds) Handbook of the Mammals of Europe. Springer, Cham. https://doi.org/10.1007/978-3-319-65038-8_86-1

Redfern, J.V., Hatch, L.T., Caldow, C. et al. (2017). Assessing the risk of chronic shipping noise to baleen whales off southern California, USA. Endangered Species Research, 32: 153–167.

Rice, D.W. (1977). Synopsis of biological data on the sei whale and Bryde's whale in the eastern North Pacific. Reports of the International Whaling Commission, Special Issue 1: 92–97.

Richardson, W.J., Greene, C.R., Malme, C.I. & Thomson, D.H. (1995). Marine Mammals and Noise. Academic Press, San Diego, CA.

Rocha, R.C. Jr., Clapham, P.J. and Ivashchenko, Y.V. (2014). Emptying the oceans: a summary of industrial whaling catches in the 20th century. Marine Fisheries Review, 76: 37–48.

Rya, C., Leaper, R., Evans, P. G. H., Dyke, K., Robinson, K. P., Haskins, G. N., Calderan, S., van Geel, C. F., Harries, O., Froud, K., Brownlow, A., & Jack, A. (2016). Entanglement: an emerging threat to humpback whales in Scottish waters. International Whaling Commission. https://pureadmin.uhi.ac.uk/ws/portalfiles/portal/3756894/SC_66b_HIM_01.pdf

Segre, P.S., Weir, C.R., Stanworth, A., Cartwright, S., Friedlaender, A.S. and Goldbogen, J.A. (2021). Biomechanically distinct filter-feeding behaviors distinguish sei whales as a functional intermediate and ecologically flexible species. Journal of Experimental Biology, 224 (9): jeb238873

Sivle, L.D., Wensveen, P.J., Kvadsheim, P.H., Lam, F-P.A., Visser, F., Curé, C., Harris, C.M., Tyack, P.L. and Miller, P.J.O. (2016). Naval sonar disrupts foraging in humpback whales. Marine Ecology progress Series, 562: 211–220.

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene, C.R., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A. and Tyack, P.L. (2007). Marine mammal noise exposure criteria. Aquatic Mammals, 33(4), 411-522. https://doi.org/10.1578/AM.33.4.2007.411

Surma, S. and Pitcher, T.J. (2015). Predicting the effects of whale population recovery on Northeast Pacific food webs and fisheries: an ecosystem modelling approach. Fisheries Oceanography, 24(3): 291–305.

Thomsen, F., Lüdemann, K., Kafemann, R. and Piper, W. (2006). Effects of offshore wind farm noise on marine mammals and fish, biola, Hamburg, Germany on behalf of COWRIE Ltd.
Todd, V.L.G., Todd, I.B., Gardiner, J.C., Morrin, E.C.N., MacPherson, N.A., DiMarzio, N.A. and Thomsen, F. (2015). A review of impacts of marine dredging activities on marine mammals, ICES Journal of Marine Science, 72: 328–340.

Tougaard J, Carstensen J, Teilmann J, Skov H, Rasmussen P. (2009). Pile driving zone of responsiveness extends beyond 20 km for harbor porpoises (*Phocoena phocoena* (L.)). Journal of the Acoustical Society of America 126: 11–14.

Van Bressem, M.F., Van Waerebeek, K. and Raga, J.A. (1999). A review of virus infections of cetaceans and the potential impact of morbiliviruses, poxviruses and papillomaviruses on host population dynamics. Diseases of Aquatic Organisms, 38: 53–65.

Van Waerebeek, K., Baker, A.N., Felix, F., Gedamke, J., Iniguez, M., Sanino, G.P., Secchi, E., Sutaria, D., Van Helden, A. & Wang, Y. (2007) Vessel collisions with small cetaceans worldwide and with large whales in the Southern Hemisphere, an initial assessment. Latin American Journal of Aquatic Mammals, 6(1): 43–69.Weir, 2017,

Weir C.R. (2017). Developing a site-based conservation approach for sei whales *Balaenoptera borealis* at Berkeley Sound, Falkland Islands. Falklands Conservation report. Version 1.0, September 2017. 115 pp.

Weir C.R. (2018). A preliminary assessment of endangered sei whales (*Balaenoptera borealis*) in two candidate Key Biodiversity Areas in West Falkland. Falklands Conservation report. Version 1.2. 128 pp.

Werth, A.J., Blakeney, S.M. and Cothren, A.I. (2019). Oil adsorption does not structurally or functionally alter whale baleen. Royal Society of Open Science, 6: 182194.
Werth, A.J., Kahane-Rapport, S.R., Potvin, J., Goldbogen, J.A. and Savoca, M.S. (2024). Baleen–plastic interactions reveal high risk to all filter-feeding whales from clogging, ingestion, and entanglement. Oceans 2024, 5, 48–70. https://doi.org/10.3390/oceans5010004