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BIRDS AND MARINE MAMMALS

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ABSTRACTS SUBMITTED TO THE (CANCELLED) SCAR 2020 OSC IN HOBART

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In-situ observations of an intact natural whale fall in Palmer Deep, Western Antarctic Peninsula

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In early 2017, an intact whale fall was discovered by personned submersible in Palmer Deep, off Anvers Island along the Western Antarctic Peninsula. The skeleton of a ~ 9m Antarctic minke whale (Balaenoptera bonaerensis) lay on a steeply sloped, muddy substrate at 963m and was observed to be in the later enrichment-opportunist stage of decomposition. The skeleton remained largely articulated, with several caudal vertebrae scattered upslope and a disarticulated jaw and baleen plates downslope. The community of organisms present was filmed in HD for approximately two hours; observed fauna included representatives of at least ten phyla, and comprised at least ten OTUs directly associated with the bones (polychaetes Osedax and Vigtorniella, plus several amphipod species, being most abundant), and a further 15 OTUs considered incidental (the fish Notolepis coatesi and salp Salpa thompsoni most abundant). The observed faunal distribution suggests patterns consistent with planted whale falls and supports the oil gradient hypothesis. This discovery represents the highest-latitude natural whale fall reported to date.

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Using aerial survey data to understand Adélie penguin metapopulation dynamics in the Ross Sea

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The Adélie penguin (Pygoscelis adeliae) is an indicator species used to detect and monitor the effects of environmental change on Antarctic marine ecosystems. Since the early 1980s, New Zealand has conducted an annual aerial census of Adélie penguins along the western edge of the Ross Sea from Ross Island to Cape Adare. Data are submitted to the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) Ecosystem Monitoring Programme (CEMP). Population dynamics within a colony are the result of the demographic processes of survivorship, recruitment and dispersal among neighbouring colonies. We use the annual census data to develop a metapopulation model to assess how these processes are influenced by sea ice conditions. We hypothesise that sea ice conditions in their over-winter range influence survivorship and the overall number of breeding pairs in the Ross Sea. October-November ice cover in the vicinity of a colony should influence breeding-colony access, return rates and dispersal among neighbouring colonies. That is, if extensive ice prohibits access to a colony, individuals may immigrate to neighbouring colonies. Sea ice cover during the breeding season (December-January) should influence prey abundance and Adélie penguin recruitment rates. Understanding these spatiotemporal dynamics is critical to detecting and describing ecosystem changes, and predicting long-term effects of climate change on Adélie penguin populations in the Ross Sea.

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Fin whale (Balaenoptera physalus quoyi) distribution in Antarctic and Australian waters using passive acoustic monitoring

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The fin whale has a global distribution with all populations listed as vulnerable, yet little is known about the present-day distribution, movements and abundance of the Southern Hemisphere sub-species, B.physalus quoyi. This study uses passive acoustic monitoring as a tool to identify the seasonal distribution of fin whales as they disperse from Antarctic to Australian waters. Sampling was conducted from 8 sites in Antarctic and Australian waters from 2002-2018, providing a total of 35 annual records. Acoustic presence in Antarctic waters, indicates a yearly pattern of presence of fin whales at the southern Kerguelen plateau from February-June, with a mean of 61.3 calling days and 41,512.3 sounds detected per year. At the Dumont d'Urville site, acoustic presence was identified from February-May with a mean of 37 calling days and 8,798.5 sounds detected per year. In comparison, the Casey site had a seasonal pattern of presence from February-May with a mean of 5.6 calling days and 2,049.7 sounds detected per year; with no fin whale presence detected in 2018. Arrival of fin whales in Australian waters occurred first on the west coast, at the Cape Leeuwin site, which had a decadal pattern of presence from May-October, with the earliest detection on the 12th of April, 2008. On Australia's east coast, at the Tasmania site, fin whale presence was identified from May-October. The consistent seasonal trends in presence, number of calling days and detections provides valuable information on the distribution and migratory patterns of this Southern Hemisphere sub-species of fin whale.

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Chinstrap penguin increases foraging distance in response to tick parasitization

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The tick Ixodes uriae has been recently reported as present in the three species of pygoscelis penguins distributed along the Antarctic Peninsula. Their effects on the penguins have been described reducing survival, transmitting blood parasites and diseases and affecting their immune response. However, tick effects on the performance capability of the penguins have never been studied. The distribution and abundance of ticks in the chinstrap penguin rookery of Vapour Col in Deception island, South Shetlands, offers the opportunity to study their potential effect on the foraging performance of penguins. Foraging behaviour data were obtained by means of GPS and TDR (time-depth recorder) devices attached during five days on the penguins. We recorded data on mean duration of the foraging trip, mean foraging trip distance, maximum trip distance, mean number of dives, mean total time diving, mean dive duration and maximum depth. We also studied whether ticks could affect food intake or the foraging habitats used by the penguins at sea by means of stable isotopes of N and C analyses. Our results show that penguins inhabiting the area with high density of ticks travel more distance and use more pelagic habitats measured by carbon stable isotope than penguins living in the area with low density of ticks. No effects were detected in diving behaviour or duration of the foraging trip. No differences were found in the diet measured by N stable isotope.

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Genetic and toxicological status of southern elephant seals (Mirounga leonina) around Antarctic waters with emphasis on the colony at Isla 25 de Mayo (King George Island), South Shetland Islands, Antarctic Peninsula

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The southern elephant seal (SES) (Mirounga leonina) has a circumpolar distribution, breeding mainly on sub-Antarctic islands, and making long trips between breeding colonies, molting locations and foraging areas, exposing to pollutants such as mercury (Hg). Although individuals show fidelity to a set of established breeding colonies, their migratory habits may allow long-range gene flow. To assess the Hg concentrations and genetic status of SES on the colony at Isla 25 de Mayo (KGI; 62º15'S, 58º39'W), skin samples from free-ranging individuals (n=60) were collected using a remote biopsy dart during 2015-2016 austral summer. Toxicological results indicated that SES Hg concentrations ranged between 142-1,915 ng/g (mean=730 ng/g, SD=388), values higher than reported for humpback whales skin in western Antarctic Peninsula (mean=35 ng/g, SD=3.7, n=14), due likely to feeding ecology (whales prey on krill whereas SES consume fish and squid). Regarding genetics, the mitochondrial DNA Control-Region results showed a high haplotype diversity, and indicated that SES from KGI are closely related with individuals from Elephant Island, Livingston Island, and Islas Malvinas (Falkland Islands), but maintained restricted genetic flow with individuals from Macquarie Island and the now extinct colony from Victoria Land Coast. Microsatellite analyses confirmed high genetic diversity. Parentage analyses identified 2% of individuals in the sample as mother-offspring, 16% as full/half siblings and 82% as unrelated individuals. These results agree with previous findings of long-distance genetic dispersal mediated mainly by SES males. Due to large feeding range, SES can be a good sentinel to continue pollutant monitoring in Antarctic and sub-Antarctic waters.

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Occurrence of marine mammals along the Southeastern Pacific Ocean and the western Antarctic Peninsula, observed on board of the "ARC 20 de Julio" vessel during Colombian Scientific Expeditions to Antarctica

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The Marine Mammal Monitoring Program at the Colombian Antarctic Program has conducted marine mammal survey on board the "ARC 20 de Julio", a Colombian Navy vessel, with the goal of assessing occurrence patterns of marine mammal species along the Southeastern Pacific Ocean (SPO) and the Southern Ocean (SO), following a transect from Panama to the western Antarctic Peninsula. A total of 1,745h (38,785km) of visual observation effort were conducted along around 92,709km of distance traveled during four expeditions (2014-2015 to 2018-2019 austral summers). A total of 917 marine mammal sightings were recorded, 701 of which were identified to the species level, representing 29 species (SO=5; ESP=20; both=4). Encounter rates (ER), assessed separately for the SPO and SO, were calculated by groups observed per 100h and 1,000km, showing the highest ER to the South American fur seal and humpback whale for the SPO and SO, respectively. Univariate kernel analyses were conducted to explore the influence of Chlorophyll-a concentration and bathymetry over the most common marine mammal species distribution. These analyses suggested that species frequency is higher within productive areas. Regarding bathymetry, the South American fur seal, bottlenose dolphin, dusky dolphin, and killer whale seem to be more frequent in waters less than 1,000m in depth, in contrast to the common dolphin, blue and sperm whales. Further survey and monitoring are needed to effectively assess abundance and distributional pattern as well as the potential impacts of anthropogenic activities and climate change on marine mammals' distribution in the SPO and the Antarctic Peninsula.

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The Humpback Whale Sentinel Program Reveals 2017 as an Anomalous Year in the Eastern Antarctic Sea-ice Ecosystem

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In 2017, the world observed some of the most dramatic changes recorded in Antarctica in modern history. July 2017 saw 10% of the Larsen C ice-shelf cleave off as a massive iceberg. The year continued with the appearance of a 300,000 m2 polynya in the winter sea-ice off east Antarctica, and summer sea-ice coverage was the lowest ever recorded, 27% below the mean annual minimum. The Humpback Whale Sentinel Program (HWSP) is a long-term, circum-Antarctic biomonitoring program for surveillance of the Antarctic sea-ice ecosystem. It is designed to complement existing sentinel programs under the Convention for the Conservation of Antarctic Marine Living Resources
Ecosystem Monitoring Program, and produce open source data for Antarctic and cetacean research communities. HWSP conducts annual monitoring of five distinct southern hemisphere humpback whale populations, equating to 'eyes' on 80% of the circum-Antarctic region. The longest record of annual sentinel parameter measurements (12-years) is available for the eastern Australian migrating stock (E1). Temporal analysis of sentinel parameters of the E1 population revealed 2017 to be an outlier. Blubber tissues revealed new dietary signatures, not previously observed; animals were in poorer nutritional state, and the migratory cohort showed a greater than average skew towards males within precisely comparable time windows; potentially indicating missed, delayed or incomplete migration among reproductive females as an energy conserving strategy. Finally, the stranding incidence of juveniles and calves was significantly elevated. Results presented here lend strength to the use of migratory baleen whales for capturing present-day changes within the remote Antarctic ecosystem.

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Movements and diet of Weddell seals in the southern Weddell Sea

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Satellite tracking and stable carbon (δ13C) and nitrogen (δ15N) isotope data were used to assess seasonal movements and trophic position of five Weddell seals (Leptonychotes weddellii) in the southern Weddell Sea in 2018.

The seals travelled greatest overall distances in autumn and winter. Distances were shorter in spring and summer when seals spent a greater proportion of time hauled out on sea ice. Total distances travelled per day varied between sexes and over seasons. The seals' haul out behaviour switched between primarily nocturnal (autumn and winter) to diurnal patterns (summer and spring). Location data indicated that polynyas were frequented more often in winter and autumn, and less often in spring although the marginal ice edges of the polynyas were still used to haul out.

Average δ13C value where higher in seals sampled in the southern Weddell Sea (-21.43 ‰) compared to those in the Ross Sea (-24.3 ‰ – -22.5‰) and similar to seals sampled in the Western Antarctic Peninsula (-22.4‰ – -20.1‰). This highlights the seals' preference for foraging near productive coastal zones and over enriched benthic communities. Weddell seals in our study area consume similar prey types as revealed by average δ15N values of 13.85 ‰, which are similar to those of Weddell seals in other areas of Antarctica.

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Foraging behavior of lactating Antarctic fur seals at the extreme edge of their breeding distribution

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At its most southerly breeding range, the Antarctic fur seal operates at its highest field metabolic rate in an environment challenging the physiological limits for energy acquisition. Currently, we have little understanding on how edge colonies, already coping with high environmental variability, may deal with additional variation contributed by specific atmospheric events. By using a combination of diet estimates and biologging we evaluated how additional environmental variability (2014/15 El Niño year compared to non-El Niño years) may affect the behavior of colonies already operating near their metabolic limit. Foraging behavior was compared between all years using 18 variables that represent: trip duration, recovery time (time ashore and at the surface), diving effort, spatial distribution and diet. We found differences in proportion of each prey consumed, a reduction in recovery time after each trip (shorter time ashore) and more trips to oceanic waters and the shelf break. No differences were found in diving effort or diving variables indicating individuals may be operating at their physiological maximum. Although prey consumed changed during the breeding season in all years, the proportions of each prey consumed differed. Overall, females prioritize changes on where and what to eat over how they dive. Behavioral plasticity is an evolutionary advantage in the face of rapid environmental change, but it may have its limits. Those limits can be best understood in populations breeding constantly in the fast lane of life.

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Foraging ecology of Antarctic Minke whales (Balaenoptera bonarensis) elucidated from fine-scale kinematic data and new methods of determining prey distribution from fisheries acoustic data

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Antarctic minkes are prevalent in the West Antarctic Peninsula, though they are not as frequently observed as other cetaceans since they usually forage near the ice edges deep in bays, and little is known of their specific foraging habits and habitat use. In 2018 and 2019 we deployed 33 suction cup accelerometer and video tags in concert with acoustic prey mapping in Andvord and Paradise Bays at ~ 64°S, 62°W. Feeding behavior ranged from feeding at the surface to deeper feeding around 200 m. Combined accelerometer and video data revealed that foraging and filtering was extremely rapid, with inter-lunge-intervals as low as 9 seconds and filtering of the entire 4-5 m3 buccal cavity in less than 5 seconds- a rate of approximately 1 ton of water per second. Video data also revealed sequential, simultaneous foraging of up to 5 animals in a group over the course of several dives. Simultaneous prey-mapping from boats trailing immediately behind tagged whales reveals that whales return to patches that they have previously foraged in, and analysis of the distribution of prey densities reveals that if minkes forage in the densest parts of patches the size of their foraging dives, they can improve their foraging efficiency by greater than a factor of 3. The unique prey conditions in the deep, icy parts of Antarctic bays were likely a niche unexploited by larger baleen whales prior to whaling, and the need to exploit these conditions likely helped drive the speciation of Antarctic minke whales.

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The Cytological, Microbiological Evaluation of Ocular Surface Samples Taken from Penguin Species of the Antarctic Peninsula II: Immunohistochemical and Phylogenetic analysis

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The study aims to assess the efficiency and usability of ocular surface cytology, in terms of cellular and microbiological diagnosis, in penguins belonging to the Pygoscelis genus. For examination of cytological samples, impression and brush cytology techniques were used. Cell specimens collected by brush cytology were used for the evaluation of cell morphology and the presence of bacteria, fungi after undergoing cytospin centrifugation. Cytological changes were evaluated under light microscopy according to Nelson's grading system. Impression cytology was used as a simple method for the sampling and counting of conjunctival goblet cells. Due to the adhesion capability of the sampling device, impression cytology were used to collection of the most superficially located cells on the ocular surface. Corneoconjunctival surface epithelial cells and sporadic inflammatory cell infiltrations were observed. High rates of goblet cells were noted in some of the preparations. Microscopic examination of preparations revealed superficial, intermediate and basal epithelial cells organized in layers. Degenerate epithelial cells, fibrine, neutrophil leukocyte, bacteria and fungi, cellular debris and mucus were detected on eyes. Psychrobacter Genusu Corynebacterium and Corynebacterium sphenisci were mostly isolated on the ocular surface.Genus Psychrobacter is found in different environments.Most of the Psychrobacter species studied were isolated from cold and saline environments. Global environmental change affecting pollution, increased connectivity and pathogens is likely to cause future diseases in this region.Oppurtunistic fungal infections can facilitate traumatic injuries to the ocular tissues.Strong IL-4 supports its reactivity.

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Temporal and ontogenetic variation in trophic ecology of crabeater seal (Lobodon carcinophaga) from the east Antarctic Peninsula

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We analysed stable isotopic composition in dentine Growth Layers Groups (GLGs) – in canines from mummified (~100 yr) seals from Marambio Island. GAMMs (General Aditive Mixed Models) were run to understand the ontogenetic variation in $\delta^{15}N$ and $\delta^{13}C$ values. Additionally, we analysed whisker segments of mummified and actual crabeater seals to estimate their isotopic niche area. Yearlings showed wider isotopic niche area, higher $\delta^{15}N$ and lower $\delta^{13}C$ than subadults and adults. The latter showed no differences in isotopic values. GAMMs showed significant effects of GLGs in the isotopic values, with an increase in $\delta^{13}C$ from GLG-1 to GLG-5/6 and a decrease in $\delta^{15}N$ from GLG-1 to GLG-3. Higher $\delta^{15}N$ in yearlings may be influenced by lactation as well as tissue catabolism during the post-weaning fast. After 5-6 years (sexual maturity) values tend to stabilize. These trends probably reflect differences in the foraging pattern of younger individuals or the effect of high growth rate on isotopic discrimination values between prey and predator tissues. Actual seals showed wider isotopic niche areas and higher $\delta^{15}N$ than mummified seals. No significant differences were found for $\delta^{13}C$. Changes in baseline could explain these $\delta^{15}N$ differences. We provide novel information on the trophic ecology of crabeaters from the eastern Antarctic Peninsula.

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Variability in tissue-specific isotopic discrimination factors (Δ13C and Δ15N) between Antarctic krill Euphausia superba and free-ranging Pygoscelis penguins

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For top consumers in marine environments, isotopic discrimination factors (Δ13C and Δ15N) between food and consumers' tissues are expected to be similar amongst related species. However, the few studies conducted in the laboratory indicate a large variability among species, which should be potentially higher in free-ranging animals. Here, we test for differences in tissue-specific Δ13C and Δ15N values of two wild penguin species (Chinstrap Pygoscelis antarctica and Gentoo P. papua) breeding in sympatry at Livingston Island (Antarctica). A total of 41 adults and 28 chicks, and food items comprised exclusively by Antarctic krill (Euphausia superba), were sampled for stable isotope analyses. Overall, Δ13C values varied between -1.8 and 4.0 ‰ and Δ15N values ranged from 1.2 to 6.1 ‰, and these differed between species, tissues and age-classes. While discriminant factors differ between adults of both species only for δ13C values (in feathers and blood), chicks of both related species showed highly distinct Δ13C and Δ15N values in nails and muscle (in feathers differed only in Δ13C). Our results show that discriminant factors can differ substantially between closely related species preying on similar prey, especially in δ13C value. Variation in Δ13C was driven by species, tissue and age-class, while variation in Δ15N was mostly driven by tissue type. Discriminant factors may be associated to physiological and/or stress factors which may fluctuate in the wild, and this was particularly evident on chicks. This study highlights the use of diet specialized species on the determination of discriminant factors in the wild.

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Use of the opportunistic method to study penguin diet: which tissue is best for stable isotope analysis?

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Tissues from penguin carcasses are increasingly used for isotopic analysis of diet. This method is known as "opportunistic sampling" since chick carcasses are commonly found around active colonies and can be easily sampled without disturbing nesting penguins. However, depending on the tissue sampled, there could be variable results and/or differences in fractionation. Here, we investigated isotopic signatures (δ13C and δ15N) and variability among four tissues (feather, skin, toenail, and bone) collected from fledgling-period chick carcasses of three pygoscelid penguin species at 25 de Mayo/King George Island, South Shetland Islands, Antarctic Peninsula, during austral summer 2017-2018. We accounted for annual and geographic variation in isotope values by limiting our collection to one region and one season. A total of 20-30 carcasses per species was sampled at active colonies of Adélie (Pygoscelis adeliae) and Gentoo (P. papua) penguins at Stranger Point, and from Chinstrap penguins (P. antarctica) at the nearby Barton Peninsula in February 2018. Isotopic signatures varied among tissues due to fractionation, but all tissues revealed dietary differences among the species. Skin had the highest variability and was the least reliable tissue for isotope analysis while toenails had the lowest variability. Comparison of isotopic values between two bones (tibiotarsus and coracoid) showed no significant differences suggesting that sampling of any major skeletal element will provide similar results when the same element is not available from all carcasses sampled. Our results allow more informed opportunistic sampling to accurately estimate and compare penguin diet among species and between ancient and active colonies.

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Using a dynamic energy balance IBM to assess drivers of change in the population of elephant seals at Macquarie Island

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Southern elephant seals are predatory, capital breeding, marine mammals with a circumpolar distribution. The population on Macquarie Island has been a part of longitudinal studies since 1949 and is in decline at an average rate of -1.46% per year. The exact drivers behind the population decline are unknown, and while migration has been discounted, competing hypotheses postulate increase in female mortality, decrease in recruitment, breeding success, environmental changes at foraging grounds and yearling survival.

We use a dynamic energy balance individual based model (DEB-IBM) to evaluate four hypotheses regarding the observed population decline on Macquarie Island through implementing scenarios of i) climate variability ii) reduction of yearling survival iii) reduction in the fecundity of mothers, and iv) density dependence in the model. The modelled population trajectory for all scenarios (except a reduction in fecundity of mothers) closely followed the observed trend in the decline of southern elephant seals at Macquarie Island.

The underlying emergent properties of the population and individuals were reasonably realistic. An overall weakness in the model was a poor representation of interannual variability, as compared to the observations. Thus, although the model produced interesting emergent behaviour of individuals and the overall population, none of the scenarios in isolation could explain the driver behind the observed population decline. We conclude that it is likely that a combination of drivers has resulted in population change at Macquarie Island.

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Foraging Behavior and Physiology of the Leopard Seal in the Antarctic Peninsula

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The Antarctic Peninsula is one of the most rapidly changing habitats in the world. To better understand the ability of the leopard seal, an apex predator in the Antarctic ecosystem, to cope with a changing environment, we examined the foraging behavior and habitat utilization of leopard seals using satellite telemetry over two years. We deployed a total of 21 satellite-linked tracking devices on 4 adult males, 17 adult females, and one juvenile female leopard seal on Cape Shirreff Livingston Island, Antarctica during April-May 2018 and 2019. Mean mass was 404 kg and ranged from 147 to 540 kg. Seals predominately remained in the South Shetland Islands moving between other penguin and fur seal colonies throughout the South Shetland Islands. In 2018 two female seals transited well to the northeast, with one stopping at South Georgia Island. Seals made short shallow dives with a mean depth of 29 ± 7 sd meters and a duration of 3.6 ± 0.5 sd min. The single deepest dive was 720 m and the longest was 10.1 minutes. Physiological parameters were taken on 9 individuals and were consistent with a shallow aerobic diver, with a blood volume of 134 ± 5.2 sd ml/kg. Hematocrit ranged from 44 – 56 with a mean of 51 ± 4 sd. Myoglobin concentrations in the locomotor muscles 6 animals ranged between 44.9 ± 1.4 se mg/gr for Longissimus dorsi and 32.9 ± 0.8 se for pectoralis muscle.

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An empirical investigation into self-awareness of Antarctican penguins: An application of Modified Mirror Test (MMT)

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Penguins are special type of flightless birds mostly available in the southern hemisphere, and one of the very few species living in the earth for over 60+ million years. Penguins are social birds-feed, swim and nest in discrete homogeneous groups in ice-sea zones of Antarctica. They exhibit a spectacular example for cooperative behaviour by having a well-organised social system with defined family ties. Well-orchestrated group behaviour enables them to meet the challenges of extreme environments of Antarctica, albeit with a primitive brain structure. All these characteristics have made them quite special in the evolutionary history. Self-awareness and Self-recognition qualities may be regarded as essential pre-requisites towards formation and maintenance of rookeries (=penguin groups). It generates a cooperative framework to withstand extremes of Antarctica. Self-awareness ability is one of the building blocks for the development of robust penguin societies. Their social and awareness network appears to be strong and vibrant.

The present study was undertaken to test self-recognition of Antarctican Adelie penguins (Pygoscelis adelia) as a building block of their society. The test was conducted during the 39th Indian expedition to Antarctica in the month of January-February 2020. The empirical investigation using a newly devised Modified Mirror Test (MMT) confirmed that penguins are self-aware about themselves in individual and group level. The uniqueness of the experiment which was improved over the pioneering work on self-recognition experiment on Chimpanzees and pigeons done by G.G.Gallup (1968 & 1970) and Skinner (1981) will be presented and discussed in the SCAR open science conference 2020.

1578

Humpback whales in the Southern Hemisphere – need for transdisciplinary research to understand species response to changing climate

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Humpback whales are an iconic cetacean species present in all major oceans. Nearly hunt to extinction, the species' Southern Hemisphere populations have recovered in recent decades. Its annual migration between feeding and breeding grounds represents one of the largest animal migrations on earth, but also exposes them to a wide variety of environmental conditions. The majority of published studies on this subject list sea surface temperature (SST) and bathymetry as the most important environmental parameters followed by chlorophyll a, salinity, currents, and distance offshore.
Very limited research has been done to implement the effects of climate change into humpback whale life histories but is essential for estimating the future distribution and movements of this species.
To try and understand how environmental parameters vary in time and space under climate change scenarios (1.5, 2- and 4-degree Celsius of global warming), here we defined five key system modules: ocean biogeochemistry and physics; ocean and atmosphere interactions; whale biology; and anthropogenic impact. We use coupled mechanistic models at appropriate length- and timescales that integrate, based on the importance of environmental drivers, key physical, biogeochemical, biological, and ecological system parameters. Outputs of these models consequently feed into behavioral (agent-based) models that simulate humpback whale movements through time and space under current and future climate scenarios. Given the high ecosystem and economic value of this species, we believe our approach advances international whaling conservation efforts and may be advanced to other marine species. To follow up on the project visit www.whalesandclimate.org

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Long term foraging areas of top predators: how much tracking data do we need?

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Home ranges of terrestrial mammals are often delimited by physical barriers, while those of marine mammals are generally limited by biological processes including feeding, migration and breeding. This theoretically provides opportunity to use long-term marine mammal tracking data in detecting consequences of climate change in the absence of physical barriers. Identifying stability in important areas of habitat use may allow investigation of change in relation to variables indicative of climate change. Southern elephant seals (SES) from Marion Island have seemingly unlimited choice of pelagic space to exploit. We ask how many years of constant tracking data are needed to identify a core area of habitat use for the population? From a comprehensive database of 20 410 locations collected from 1999 through 2012; 6 309 at sea foraging locations were identified using a switching state-space model. Areas of high use were identified using kernel density estimators. We calculated overlap in annual foraging areas with Bhattacharyya's Affinity (BA) index. A kernel with all locations was used as a baseline to measure the variance in overlap with annual kernels. The mean difference in overlap was 0.25 (±0.14), with greatest difference in overlap being 63% in 2000 and smallest difference in overlap being 0.06% in 2008. Our final habitat kernel was more representative of female SES habitat use (BA=0.93, 57% of locations, n=75) than of male SES habitat use (BA=0.84, 42% of locations, n=48). We suggest that our current database of tracking locations of SES from Marion Island encompasses 75% of SES habitat use.

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Penguin Microbes

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Within all higher organisms, lives a thriving ecosystem of microorganisms including, bacteria, viruses and fungi. These microorganisms are crucial for an animal's health, nutrition and physiology, playing an important role in digestion, protection against harmful pathogens, secretion and synthesis of essential vitamins, minerals and amino acids. So what microbes colonise the penguin gut and what functional pathways are involved? Previous studies using amplicon sequencing have assisted in the profiling of the microbial community within different penguin species. However, amplicon sequencing is restricted to a specific target region (bacteria, virus, and parasite) and due to the short read length is often unable to identify organisms to the species and genus level. This study used shotgun metagenomics to sequence the microbial community (including viruses) and the associated functional pathways of king, gentoo and macaroni penguins. Similar to previous studies species specific differences were observed between the three species. In addition a number of known pathogenic organisms were identified. Over 2,600 functional pathways were identified in the study with significant differences observed between species in approximately 2,000 pathways, with many of these pathways being present in macaroni penguins and absent in king and gentoo penguins

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So_Predbase – An unprecedented database of archival and tracking data from a key Southern Ocean migrator

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Understanding the effects of climate change on Southern Ocean ecosystems, including changes in marine resources, biodiversity and ecosystem plasticity, requires data on trophodynamics. Yet, basic biological information, paramount for quantifying and predicting whole ecosystem changes is not available for species across all trophic levels in vast regions of the Southern Ocean. Marine predators provide an integrated summary of the status of the rarely sampled organisms down the food chain and are effective tools to monitor changes in bioaccumulated contaminants in remote oceanic environments. Here, we present the framework for a new database housing an unprecedented ten-year+ tracking and archival tissue dataset for a key Southern Ocean marine predator, the Antarctic fur seal (Arctocephalus gazella) across large spatial scales to meet the critical datagaps described above. Breeding adult female Antarctic fur seals at Marion Island were geo-tagged between February and April 2008-2019, in each year which is toward the end of lactation and before dispersal from breeding sites prior to commencing their winter migration. Sampling of archival tissue collection (whiskers and blood samples) also occurred at this time and upon the return of the females. SO_PREDBASE will be comprised of stable isotope (δ13C and δ15N) data on whiskers and blood, trace metals on whiskers and tracking data collected from GLS loggers on a decadal time scale. As an archival tissue, the whiskers will help us to encode longitudinal records of those biochemical features to infer temporal changes in foraging plasticity and physiological status which can potentially be attributed to climate change.

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Underwater Homing Tactics of Weddell Seals in the Antarctic Shore-Fast Sea Ice Environment

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Most activities of Weddell seals occur during dives that extend hundreds to thousands of meters and require the seals to hold their breath for 20 minutes or more. In the fast-ice environment, breathing holes are scarce. Consequently, seals must return to a previous breathing hole or locate a new one to avoid drowning; how they navigate underwater with such precision is not known. This study used field experiments to test multiple hypotheses concerning the sensory cues and tactics Weddell seals employ to navigate underwater in this challenging environment, with special attention to their possible use of geomagnetic cues. An archival data logger was fitted to 10 adult seals, which were released at three locations that differed in the orientation of the geomagnetic field, and allowed to perform voluntary dives. Analysis of three dimensional dive tracks demonstrated that outbound paths of dives progressively increased in distance from the breathing hole. Seals returned home on remarkably straight paths, or they traveled directly to a frequented route then turned straight toward home. These findings are consistent with piloting by landmarks. Seventy-five percent of the frequented routes were directly below known linear disturbances in the snow on the top of the ice, indicating that the landmarks were overhead visual cues. They were able to do so during both daylight and surface twilight, presumably due to exceptional visual sensitivity in low light environments. We did not find evidence that seals navigated by geomagnetic or hydrodynamic cues under these conditions.

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Long-Term Passive Acoustics Monitoring of the Ross Sea Marine Protected Area

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The Ross Sea region of the Southern Ocean is one of the most isolated and pristine environment on the planet and it is protected by the world's largest marine protected area (MPA). Commercial fishery for Atlantic toothfish also takes place in the Ross Sea, and uncertainties exist on its effects on the overall ecosystem, especially its interaction with top predators.

NIWA is leading a New Zealand programme to study the conservation value of the Ross Sea region MPA. Under this programme, we deployed three passive acoustics recorders in the Ross Sea to: 1) study the seasonal occurrence of sperm whales; and 2) understand ecological connectivity between this top predator and toothfish. We aim at understanding the potential effects of commercial toothfish fisheries on sperm whales in the Ross Sea region. Our passive acoustic research in the Ross Sea also provides an opportunity to study its soundscape and its modifications under future climate variability/change.

Data were collected recording for 342 seconds at a sampling rate of 48 kHz, then 64 seconds at a sampling rate of 125 kHz, and then to turn off for 12 minutes. This duty cycle permitted to record for an entire year, from summer 2018 to summer 2019. The recorders were refurbished and redeployed in summer 2019, and we are planning another instrument swap in 2021.

Data revealed the presence of baleen whales, the foraging of sperm whales and other odontocetes, as wells as temporal presence of leopard and Weddell seals under the ice.

1098

Modelled mid-trophic pelagic prey fields improve understanding of marine predator foraging behaviour

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For oceanic predators, foraging behaviour is influenced by processes that shape the distribution of prey over multiple scales. We use a spatiotemporally resolved simulation model to describe difficult-to-observe mid-trophic prey distribution within the Southern Ocean, and demonstrate insights that this modelled prey field provides into the foraging behaviour of a widely distributed marine predator, the southern elephant seal.

From a five-year simulation of prey biomass, we computed climatologies of mean prey biomass (average prey conditions) and prey biomass variability (meso-scale variability). We also compiled spatially gridded metrics of seal density and diving behaviour from 13 years of tracking data. We statistically modelled these metrics as non-linear functions of prey biomass (both mean and variability) and used these to predict seal distribution and behaviour. Our predictions were consistent with observations, indicating that seals aggregate in regions of high mesoscale activity where eddies concentrate prey. Here, seals dived deeper and spent less time hunting, likely targeting deep but profitable prey patches. Seals generally avoided areas of low eddy activity where prey was likely dispersed. Most seals foraged south of the Subantarctic Front, despite north of the front exhibiting consistently high simulated prey biomasses. This emphasises the importance of mesoscale prey biomass variability relative to regionally high mean biomass. Our work demonstrates the value of coupling mechanistic representations of prey biomass with predator observations to provide insight into how biophysical processes combine to shape species distributions. This will be important for robust prediction of species' responses to future system change.

1203

Unravelling Isoscapes at the Base of the Antarctic Ecosystem for Robust Dietary Evaluation of Humpback Whales

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Isoscapes of Southern Ocean marine ecosystems are not uniform, varying spatially and temporally. Euphausiids in the Ross and Amundsen seas have significantly higher $\delta^{15}N$ values but lower $\delta^{13}C$ values than zooplankton from the Western Antarctic Peninsula even though phytoplankton $\delta^{15}N$ and $\delta^{13}C$ values do not differ significantly among these regions. Phytoplankton $\delta^{15}N$ values only vary temporally. Understanding and accounting for such spatial and temporal variations in isoscapes at the base of the Antarctic ecosystem, is particularly important when assessing the diet of high-fidelity Antarctic krill (Euphausia superba) consumers like southern hemisphere humpback whales (Megaptera novaeangliae), to avoid interpretation bias of results. Here, we analysed Antarctic krill sampled in different Southern Ocean regions, plus skin biopsy samples of five distinct southern hemisphere humpback whale breeding stocks to assesses if spatial differences in Antarctic krill $\delta^{13}C$ and $\delta^{15}N$ isoscapes match spatial differences in humpback whale $\delta^{13}C$ and $\delta^{15}N$ isoscapes. Krill samples were collected in the austral summer preceding winter biopsy sampling, ensuring a temporal within-year match. As each southern hemisphere humpback whale breeding stock is thought to utilise distinct Antarctic feeding grounds, we hypothesised that the diet of the breeding stocks would reflect krill isotopic profiles from their feeding ground. Evaluating inter-population variability in isotopic profiles, with prey isoscapes in the Antarctic feeding grounds allows us to refine conclusions about the diet of humpback whales and provide supporting evidence for feeding ground locations for the individual breeding stocks.

1201

The effects of lipids in stable isotope analysis (13C and 15N) of Southern hemisphere humpback whale blubber and skin

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$\delta^{13}C$ and $\delta^{15}N$ stable isotope values in blubber and skin are widely used to study the diet of free-ranging cetaceans. Blubber has a higher lipid content than skin, which can introduce bias in $\delta^{13}C$ values as lipids are enriched in ^{12}C causing a decrease in bulk tissue $^{13}C/^{12}C$. Therefore, it is imperative to assess which tissue provides more reliable results for stable isotope analyses. Thus far, isotopic differences between both tissues have only been investigated for northern hemisphere humpback whales. They are known to have a broader diet than their southern hemisphere counterparts, which feed mostly on Antarctic krill. $\delta^{13}C$ and $\delta^{15}N$ values were determined for lipid-extracted blubber, and duplicate bulk and lipid-extracted skin biopsy samples of southern hemisphere humpback whales using a SERCON EA-Hydra 20-20 isotope ratio mass-spectrometer system. C:N ratios of lipid-extracted were within the same range of 3.0 – 3.3 as C:N ratios of northern hemisphere humpback whales, while bulk skin and lipid-extracted blubber showed higher C:N ratios. Both $\delta^{13}C$ and $\delta^{15}N$ values of lipid-extracted skin increased significantly compared to bulk skin. While the increase of $\delta^{13}C$ in lipid-extracted blubber and skin was expected, $\delta^{15}N$ values of skin also increased significantly and unpredictably after lipid extraction. Considering this, for diet inferences, we recommend that lipid-extracted skin is used for $\delta^{13}C$ values and that bulk skin tissue is used for $\delta^{15}N$ values. Any application of these values should further take into account the faster turnover of skin compared to lipid stores, and hence the temporal reference to diet.

1179

Long-term monitoring reveals divergent population trends for six seabird species in the Maritime Antarctic

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Fildes Peninsula and Ardley Island, King George Island, South Shetland Islands, represent one of the largest ice-free areas in the Maritime Antarctic. The region is characterized by a high biodiversity and is a reproduction site for fourteen bird species. Based on seabird monitoring data collected between 1979/80 and 2019/20 divergent population trends could be detected. While Adélie and chinstrap penguin populations in the area have declined considerably and have now stabilized at a low level, the breeding pair number of gentoo penguins showed a substantial growth and turned the colony on Ardley Island into the biggest colony of this species in the Antarctic. The local population of southern giant petrels was negatively affected by human activities, particularly by the establishment of several new Antarctic stations in the 1980s. After observed nest site shifts towards areas with less anthropogenic disturbance several formerly abandoned colonies were reoccupied and the overall trend for this species is now positive. The breeding pair number of kelp gulls showed considerable variation and declined slightly during the study period. In contrast, the population of cape petrels declined dramatically and almost completely disappeared in the area. The contrary seabird population trends can is be attributed to a divergent reaction to a variety of environmental factors. Our long-term monitoring data set represents an exceptional high value as it contributes to the knowledge of the seabird population development in the WAP area.

1533

Environmental DNA as a tool for monitoring Antarctic vertebrates

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Environmental DNA (eDNA) is any DNA shed into the environment by an organism. eDNA surveys are a useful tool for detecting species that are scarce, elusive or cryptic as they don't rely on sightings and can detect multiple species in a single sample. Though eDNA surveys have been successful in other environments, the method has not been broadly used to study Antarctic vertebrates. I will discuss the potential of eDNA as a tool for detecting Antarctic vertebrates and touch on the advantages and challenges of using eDNA to identify and monitor species in remote locations. I will introduce our pilot study on detecting Weddell seal (Leptonychotes weddellii) DNA in snow samples, collected from the Turtle Rock breeding colony in Erebus Bay, and discuss the optimisation of methods at each step in the eDNA sequencing procedure, from snow collection to DNA extraction to downstream lab analyses. The aim of our research is to take this work from our lab, to the ice.
With rapidly advancing technology, eDNA surveys in Antarctica are becoming increasingly feasible. They are non-invasive, cost-efficient and can lead to larger sample sizes. This is important in Antarctica where challenging environments can make even large vertebrates difficult to find, an example being crabeater seals (Lobodon carcinophagus) which live on the Pack Ice. Thus, eDNA surveys have great potential as monitoring and conservation tool in Antarctica.

1717

Whales return to the epicentre of whaling? Preliminary results from the 2020 cetacean survey at South Georgia/Islas Georgias del Sur

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Over 170,000 whales were killed in the sub-Antarctic waters of South Georgia/Islas Georgias del Sur (SG, South Atlantic) from 1904 to 1965. In recent decades, whales are regular summer visitors, with the southern right whale (Eubalaena australis) and humpback whale (Megaptera novaeangliea) most commonly reported. A 23-day cetacean survey was conducted in SG waters during January/February 2020, using directional acoustics and visual surveys to localise whales, and collecting skin biopsies, photo-identifications, and blow samples for microbiome analysis. The survey focussed on southern right whales (SRW), and also collected sightings, photo-identifications and skin biopsies from other species. A total of 1,147.1 nautical miles of visual survey effort was conducted. In total, cetaceans were encountered 540 times, including SRW (10 encounters of 11 individuals), humpback whales (409 encounters, ~790 individuals) and blue whales (Balaenoptera musculus, 38 encounters, ~58 individuals). Two SRW were satellite tagged and their movements subsequently tracked. Photo-identifications and biopsies were collected from SRW (11 and 7 respectively), humpbacks (48 and 17 respectively) and blue whales (25 and 9 respectively). Aerial imagery was collected via Unmanned Aerial Vehicle during four SRW encounters, with three blow samples also collected. Additionally, one faecal sample was collected from one SRW. This was the first expedition to conduct whale surveys along the remote south coast of SG since whaling ended, and overall yielded an unprecedented number of sightings of both blue and humpback whales, suggesting that the waters of SG are again becoming an important summer feeding ground for both species.

7

The influence of environmental and social factors on the demography of killer whales (Orcinus orca) at sub-Antarctic Marion Island

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Predator populations have been found to be responsive to bottom-up processes. However, a thorough understanding of the response of marine predators to temporal variations in environmentally driven conditions is lacking. Killer whales, Orcinus orca, are apex marine predators occupying every ocean on the planet but much still remains to be investigated, particularly regarding the population at Marion Island in the southern Ocean. We used single- and multistrata analyses in RMARK on mark-recapture data to investigate the demography and effect of environmental, social and prey covariates on survival of killer whales at Marion Island over a 12 year period (2006-2018). Survival ($\Phi = 0.98$) and population growth ($\lambda = 1.01$) rate were found to be constant with no differences in survival between sex or age classes. Sea surface temperature, the southern oscillation index, fur seal pup numbers and several measures of sociality at time lags (t0 to t-4) did not significantly explain temporal changes in survival. Survival was however significantly explained by southern elephant seal pup numbers at a one year time lag (t-1), Patagonian toothfish fishing effort at a one and two year time lag (t-1 and t-2) and the mean strength of association at a one year time lag (t-1). These results suggest that the survival of killer whales at Marion Island is partly influenced by prey availability and social structure. Social structure may therefore play an important role in killer whale survival during future anthropogenic changes to the environment as a result of climate change.

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Use of space places Southern Giant Petrels as useful monitors of Antarctic Peninsula

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While Antarctic Peninsula (AP) experiences fast environmental change, it is challenging for researchers to cover simultaneously a substantial amount of sensible areas in order to properly monitor those changes. In this study, we show that, by continuously tracking throughout the breeding season individuals from a single population of Southern Giant Petrels SGP (Macronectes giganteus), it is possible to have access to environmental conditions in a large array of habitats along the whole AP. Breeding SGPs engaged on 5 to 15 days long foraging trips across a 5000 kilometers wide area between the Weddell and Bellingshausen seas. SGPs more likely reduced speed below 10 km/h, denoting foraging behavior, in low to intermediary ice cover conditions at land habitat, and in pelagic habitats when ice cover was >75%. SGPs also were more likely to reduce speed nearby penguin colonies in lower ice conditions. We also found evidence of association with glacier edges where Weddell seals (Leptonychotes weddellii) gather to rest. Therefore, tracking SGPs can give researchers access to conditions on a large variety of habitats and regions of the Antarctic Peninsula. A long-term study joining GPS tracking, animal-borne cameras and demography parameters on a small number of colonies should provide us with a large amount of data on distribution and condition of sea ice, glaciers, penguin and seal populations on different spatial and temporal scales.

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Identifying gaps and vulnerabilities for conservation of Southern Oceans' top-predators using zonation spatially explicit models

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The importance of marine protected areas MPAs have become unanimous among scientists. However, global coverage of MPAs is still deficient, particularly in Antarctica, only 0.4% of marine areas is under protection. In this study, I congregated ecological niche models and metrics with spatially explicit models to identify priority areas for conservation of marine top-predators in the southern oceans and identify gaps in the current MPA network. I found a generalized niche overlap of top-predators with fisheries that substantially reduced the ability of spatially explicit models to identify highly important areas and substantially increased extinction risk. Areas of high diversity of top predators were more likely to occur on areas of high vulnerability to fisheries than within current MPAs, indicating that the network fails to cover most of the highly important ecosystems. That is particularly concerning on the northern tip of the Antarctic Peninsula and East Antarctica. The results I found suggest that fishing pressures have been more important in decisions about placing of MPAs than the real needs of protection. Results support the use of reactive protection by prioritizing managing areas under high risk from fishing activities.

688

Antarctic icy waters hide some oases for emperor penguins: circumpolar habitat suitability analysis

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Predicting species persistence in the face of climate change requires an understanding of the drivers of species distribution. The emperor penguin's reliance on landfast sea ice is complex: low fast ice extent reduces the availability of breeding sites and may have consequences on food resources, but extensive fast ice causes longer foraging trips for parents and decreases the frequency of food delivered to the chicks. Until the past decade, addressing emperor penguin distribution and habitat has been limited, because continent-wide observations have eluded researchers until recently. Technological developments have enabled the use of satellite imagery to observe emperor penguin colonies and a better characterization of the sea ice habitat at finer spatial scale. Novel algorithms to characterize polynya and the icescape have also been recently developed. Our research aims to determine the habitat suitability of emperor penguin colonies across Antarctica using novel fast ice (fast ice persistence, volatility, month of maximum extent/stability), geomorphology (coastal complexity) and polynya (time-series of polynya openings based on sea ice production at a daily scale) metrics. The analysis was performed using sea icescape data from 2000 to 2018. This research will aid in understanding the mechanisms by which climate change may impact penguins in the realistic ice landscape, by studying the role of fast ice, polynyas and geomorphology on the distribution and persistence of penguin colonies. This has both short to long-term impacts for the conservation of this species by understanding its past and present distribution to better predict their distribution in the future.

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Trends in emperor penguin populations around the entirety of Antarctica

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Recent modelling research has suggested that emperor penguin populations are likely to decline substantially by the end of the 21st century due primarily to sea ice losses caused by climate change, even accounting for their ability to disperse among existing populations. As a fast-ice obligate, there are likely only two refugia for the species in the long-term in the Ross and Weddell Seas. However, because of their inaccessible habitats across the Antarctic coastline, it is impossible to visit colonies concurrently to assess their populations. Here, we used high-resolution satellite imagery (VHR) combined with aerial survey estimates as ground validation, and Bayesian analysis to estimate populations of emperor penguins at colonies around the continent during 2009-2018. Our models included accounting for the effects of satellite platform and intra-seasonal variation at colonies to estimate the breeding population. We found the majority of populations of emperor penguins were either stable or declining over the ten year period, with substantial annual fluctuations in population size at a few locations. Our results further the hypothesis that emperor penguins operate in a metapopulation framework and that changes at larger, regional scales are most biologically relevant. This work is the first empirical evidence of emperor penguin population change at the continent scale over 10 years.

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First census of Weddell seals from space: many fewer than expected

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Weddell seals are fast-ice-obligate, marine predators exhibiting an Antarctic circumpolar distribution that is associated with coastal habitats. Traditional methods of understanding population abundance, which have included shipboard or aerial transects and have been done sporadically beginning in the 1960s, are cost-prohibitive and dangerous. With the advent of high-resolution satellite imagery (VHR), the possibility of detecting seals from space became possible. We combined VHR with citizen science via the web platform Tomnod to do 1) a search-area reduction campaign to determine presence vs. absence along the fast ice, and 2) a tagging campaign to estimate abundance where present. Using new statistical methods and comparing to ground counts within Erebus Bay, Ross Sea to validate our work, we determined, for the first time, a full population census for the Weddell seal during 2010-2011. After correcting for the proportion of seals diving when images are taken, we find that the the 95% confidence interval for the estimated mean indicates that the actual number is <50% of the previously estimated population size of ~800,000 animals. Seals are distributed patchily around the continent with highest regional abundance in the Ross Sea (about 50% of the global population) and lowest abundance in the Amundsen Sea. Given the surprisingly low estimates combined with previous data suggesting seals in the Ross Sea may be declining, we suggest that dramatic action may be required to protect the species from the negative effects of fishing and climate change.

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Fronting up – How important are frontal regions to Southern Ocean migratory predators?

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Multiple definitions of Southern Ocean fronts have emerged over previous decades. This has led to confusion in the biological community on how best to quantify the importance of frontal regions for marine species. One of the definitions incorporates the dynamic features of frontal regions which are critical in establishing correlations with the movements and habitat use of highly mobile and migratory species. In this study we aimed to assess the importance of frontal regions to two highly migratory Southern Ocean marine vertebrates: the surface diving Antarctic fur seal (5-200m) and the deep diving Southern Elephant seal (400-2000m). To do this we sourced tracking data from a long-term time series of Antarctic fur seals tracks during the non-breeding period (SO_PREDBASE) and the MEOP data base of Southern elephant seal tracks. By undertaking this analysis we provide greater understanding on the importance of fronts to the two key Southern Ocean consumers at different vertical, temporal and spatial scales.

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Comparing isotopic niche metrics of Antarctic seals between sites under distinct climate warming conditions

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The Southern Ocean has been particularly vulnerable to global climate change. While the western Antarctic Peninsula (WAP) has suffered significant temperature fluctuations, the eastern AP (EAP) has not yet showed evident signs of disturbance. Yet, little is known about the influence of warming on the ecology of mammals such as crabeater (Lobodon carcinophaga) (CS) and Weddell seals (Leptonychotes weddellii) (WS). We compared species sampled on EAP (Weddell Sea, 6 CS, 4 WS) and WAP (Danco Coast, 13 CS, 14 WS) between 2014-2016 using stable isotopes of whiskers to assess how environmental differences may be shaping habitat use and diet. Mean values were -21.7‰ ($\delta^{13}C$) and 7.0‰ ($\delta^{15}N$) for EAP CS; -23.0‰ ($\delta^{13}C$) and 6.7‰ ($\delta^{15}N$) for WAP CS; -16.4‰ ($\delta^{13}C$) and 14.5‰ ($\delta^{15}N$) for EAP WS, -21.6‰ ($\delta^{13}C$) and 12.7 ‰ ($\delta^{15}N$) for WAP WS. Niche metrics were estimated through Stable Isotope Bayesian Ellipses in R. EAP showed wider isotopic niches for both species (CS: 2.0 vs. 1.1‰^{2}, WS: 7.8 vs. 1.4‰^{2}), which showed complete segregation within the isotopic space in both areas. $\delta^{13}C$ and $\delta^{15}N$ range were both larger for the EAP community (7.8-5.3‰ vs. 5.6-1.3‰, respectively), as well as mean distance to centroid (4.7 vs. 2.9‰) and mean nearest neighbor distance (9.5 vs. 5.8‰). All results point to a higher trophic length and diversity of basal resources in the EAP, which can be attributed to a higher environmental stability. Isotopic niche differences between species and sites may be due to the influence of climate on baseline values.

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Development of Diving Capability in Weddell Seal Pups

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Weddell seals (Leptonychotes weddellii) are among the deepest diving seals, and adult Weddell seal dive physiology is relatively well understood. However, little is known about the physiology and development of pups during early nursing and the transition to independence. The aim of this study was to investigate the development of diving capabilities in Weddell seal pups throughout early ontogeny. We calculated total body oxygen stores (TBO2) from blood and muscle sampled longitudinally at 1, 3, 5 and 7 weeks of age. These data were correlated with diving behavior measured with time-depth recorders. We found that Weddell seal pups started (at 1w) with mass-specific TBO2 values of 50.01±4.84 mL O2·kg-1; these mass-specific values declined slightly at 3w and then plateaued for the remainder of the nursing period, similar to what has been reported for other polar species. Muscle contribution to TBO2 increased from 18% for 1-week-olds to 21% in 7-week-old pups. We hypothesized that TBO2 would increase with dive experience rather than simply calendar age, but instead found that mass ($r^2=0.96$) and age ($r^2=0.89$) were more significantly correlated with total TBO2 ($P<0.0001$) than time spent in water ($P=0.006$, $r^2=0.59$) or dive duration ($P=0.007$, $r^2=0.38$). Pups spent the majority of their time in the water near the surface and thus did not likely experience hypoxia. Later exposure to hypoxia combined with diving experience may be the key to the subsequent increases in total TBO2 observed in yearlings and juveniles of this species.

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Antarctic fur seal males: tourists, trouble makers or an appropriate sentinel of the Antarctic marine ecosystem?

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In the Antarctic, predators are often used as marine ecosystem sentinels. The remote and harsh climate of Antarctica has resulted in species being monitored that are accessible during the austral summer and breed on land. This is particularly true along the West Antarctic Peninsula where the fishery for Antarctic krill operates and which is experiencing rapid warming, where breeding Antarctic fur seals and penguins have been used to infer changes in krill availability. However, breeding adults must return periodically to land in order to feed dependent offspring, restricting how much time can be spent at sea. Consequently, breeding and foraging indices derived from care-giving adults of a species will only integrate information over a subset of the marine environment, and therefore inferring changes in prey variability from predator indices may be a flawed conclusion. To highlight this we use data from an unmonitored, unconstrained life history stage of a monitored species; adult male Antarctic fur seals. We present tracking data collected from 18 individuals instrumented at the South Orkney Islands shortly after breeding. Using telemetry data, we demonstrate that the pattern of foraging by adult male Antarctic fur seals overlaps perfectly in time and three-dimensional space with breeding of a species currently monitored (Chinstrap penguins) and the areas used by the fishery. Indices collected from unconstrained predators may be more informative of ecosystem change than those currently used, which do not integrate information across the region of interest and may be subjected to interference competition from other, unmonitored species.

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Temporal patterns of abundance and distribution of marine predators across the Scotia Sea and western Antarctic Peninsula using platforms-of-opportunity

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Estimating the at-sea abundance and distribution of cetaceans and pinnipeds is typically conducted using a line-transect surveying strategy that is often logistically and financially difficult to enact on a frequent and regular basis. Such constraints are likely to limit the opportunity for information-gathering at management-relevant scales in space and time. New spatial modelling techniques that overcome some of the assumptions of old methods, such as random placement of transects, are now well grounded in the scientific literature (e.g., Williams et al. 2006). 'Platforms of opportunity', such as International Association of Antarctic Tour Operators (IAATO) vessels, thus offers a unique opportunity to collect fine-scale (within season) and coarse-scale (between seasons) resolution observational data on the distribution of marine mammals and seabirds, particularly in the Antarctic Peninsula region where the great majority of vessels operate regularly. Here we report on the first season of a new program designed to provide cross-seasonal, interannual estimates of cetacean and seabird abundances throughout the Drake Passage, Scotia Sea and the Straits of the West Antarctic Peninsula. We provide spatiotemporally evolving abundance and distribution estimates of 21 marine mammal and 30 seabird species across five cruises on two ships of opportunity during the 2019/2020 austral summer. We demonstrate that it is feasible to develop a high quality science-based time series of data useful for management and conservation purposes, and outline the roadmap for expanding this time series over the forthcoming years and across a greater number of vessels of opportunity.

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Bathymetry drives foraging location in late chick-rearing Emperor Penguins from Cape Crozier, Ross Sea

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The survival and success of marine predators depends on their ability to locate prey in a heterogeneous environment. To find prey that are patchily distributed, predators need to be able to adjust their foraging behavior depending on the conditions they encounter. Ice conditions and bathymetry have been associated with foraging locations of emperor penguins from Adélie Land and the Mawson coast during chick rearing. We investigated the movement and dive behavior of nine emperor penguins from Cape Crozier in November 2019, the most southern colony in the Ross Sea. Foraging trip duration ranged from 1 – 18 days (mean 11.2 days). Two birds traveled west of Ross Island (~130 km), spending time within 25 km of the continent (~400 m depth). Three birds traveled north between 75-130 km from the colony, and four birds traveled northeast to the Ross Bank (Between 130-300 km maximum distance from colony). All penguins swam over deep waters performing pelagic dives between 100-250 m depths. Seven penguins performed a mix of pelagic dives (usually < 200 m) over depths >500m and benthic dives to depths >350m when near the continent and over Ross Bank. Emperor penguins displayed flexible foraging behavior influenced by bathymetry, potentially targeting different prey during foraging trips depending on location.

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Comparative three-dimensional home ranges of adult male southern elephant seals

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Resource selection studies in ecology are commonly undertaken at a population-level, yet long-term individual-level studies are undoubtedly important. We compared the travelling- and dive behaviour characteristics of 22 adult male southern elephant seals (Mirounga leonina) tracked from King George Island / Isla 25 de Mayo (KGI) at the Antarctic Peninsula, with data obtained from 28 migrations performed by 17 adult males tracked from sub-Antarctic Marion Island (MI). The population-level home ranges of seals were similar in size for their two-dimensional home ranges (95% kernel density estimate: MI = 2.19 million km²; KGI = 2.1 million km²). However, Marion Island elephant seals typically performed deeper dives (MI = 605 ± 427 m; KGI = 444 ± 282 m), resulting in substantial differences between the total water volumes used when incorporating dive depths into population-level home range estimates (three-dimensional 95% kernel density estimate: MI = 1.4 million km³; KGI = 0.67 million km³). We further investigated the relative influences of population of origin, individual-level behavioural variability, estimated seafloor depths and migration type (i.e. post-moulting vs post-breeding migrations) on the three-dimensional home ranges of study animals. We found no statistically significant support for consistent individual-level differences in three-dimensional home range sizes between populations, but rather that individual-level variability explained most of the data variance, followed by other drivers (e.g. migration time and seafloor depth). These results highlight the need for continued broad-scale long-term individual-level monitoring in this species to inform population-level resource use and habitat requirements.

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Gentoo penguin population dynamics and the CEMP time-lapse camera validation experiment at Galindez Island, Antarctic Peninsula

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Gentoo (Pygoscelis papua) penguin colony population behavior/dynamics have been studied during 2018/19 and 2019/20 seasons. The detailed observation of bird arrival, nesting, hatch, and crèche has been provided in two colonies at the GAI CEMP site at Galindez Island nearby the Vernadsky station. We inform on the results of the visual survey of the penguin population and penguin count. During two seasons the winterers-biologists at Vernadsky station provided continuous observations every day/every five days of Gentoo's GBV and GPP sites. The results of visual observations of penguin population changes are discussed. The three seasons of the data validation experiment have been provided for pictures from time-lapse cameras of the CEMP camera monitoring project of CCAMLR are discussed. During 2017/18–2019/20 seasons, biologists-winterers at GAI CEMP site, provided daily observations of 15 Gentoo nests chosen in the three monitoring sites GBW, GPP1, and GPP2, simultaneously with automatic time-lapse cameras picturing. The results of visual observations have been compared with data from camera pictures. The comparison of lay, hatch, and crèche dates was undertaken. The preliminary results exhibit a reasonable correspondence within 0-3 days between visual observations and time-lapse camera data for three seasons. The standard deviation for each event varies from ±1 to ±3 days for control nests. However, the time delay in 1 to 3 days between the registered dates by the camera and visual observations was recorded. This delay should be taken into account when the event dates from camera data analyzed without correspondent visual observations.

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Results of the Pygoscelis penguin colonies survey in the Argentine Islands (Antarctic Peninsula) area

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The Gentoo (Pygoscelis papua) colonies survey in the area nearby the Vernadsky Antarctic station has been provided during the 2019/20 breeding season. The Gentoo penguins are the most populated species in the area from Booth Island in the north to Berthelot Islands in the south. The nesting of Gentoo penguins at Galindez Island was noted first in 1998 when in that time the southernmost colony of this penguin specie was attempted to form. The first successful Gentoo colony at Galindez Island was registered in 2007 with 26 nesting pairs. Since 2007 this colony exhibits a fast-growing penguin population. According to the 2019/20 count, the number of Gentoo nests at Galindez Island increased to about 1200 nests. The expansion of the Gentoo population to the south has also been confirmed by the appearance of the Gentoo colony at the shore near Demaria Mountain, where the 2019/20 count confirms about 590 pairs. The Gentoo colony at the Green Island (Berthelot Islands), which is possibly the southernmost studied site of the nesting habitat of this specie, is double in two years to about 40 nesting pairs according to 2019/20 count. Therefore, the Green Island colony exhibit an increase in numbers and an expansion of the Gentoo penguin population to the south. These results are also considered for modeling the distribution of the Gentoo penguin population in the area.

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The characteristics of krill swarms in relation to the distribution of blue, fin, and humpback whales off east Antarctica

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The 2019 ENRICH Voyage (Euphausiids and Nutrient Recycling in Cetacean Hotspots) was a marine biological research voyage conducted in the Dumont D'Urville Sea from 19 January – 5 March 2019. One of the key aims of the multidisciplinary science programme was to better understand the relationship between baleen whales and their main prey, Antarctic krill (Euphausia superba). During the voyage visual and passive acoustic observations were used to detect and locate whales, while active acoustics were used to detect krill swarms. Blue whales (Balaenoptera musculus intermedia) were detected and located predominantly via passive acoustic monitoring (acoustic detections at 238/295 listening stations; 26 sightings). Fin whales (B. physalus) were detected more-or-less evenly via acoustic and visual methods (150/295 listening stations; 124 sightings), and humpback whales (Megaptera novaeangliae) were detected and located predominantly via visual observations (105 listening stations; 201 sightings). 1,679 swarms of Antarctic krill were detected along the ship's track using active acoustics, and their characteristics measured. Characteristics of krill swarms were then used to model the presence and density of Antarctic blue, fin and humpback whales. We address the challenges of using whale and krill observations that span vastly different spatial and temporal scales, and we discuss preliminary results from our models in the context of recovery of whale populations, and management of krill fisheries.

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Advances in long-term underwater passive acoustic monitoring around Antarctica

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Since 2004 the Australian Antarctic Division has collected over 100,000 hours of underwater sound recordings in Southern Ocean off East Antarctica. Recordings were made by mooring autonomous acoustic recorders at deep water sites along annual resupply routes to Australia's three stations in East Antarctica, and many sites have now yielded several consecutive and/or non-consecutive years of data. While early data were collected to listen for critically endangered Antarctic blue and endangered fin whales, over the years the number of species recorded has increased in step with improvements in hardware and digital storage. Since 2013, acoustic recorders have been able to provide information on the presence and behaviour of many Antarctic top predators including: crabeater, leopard, Ross, and weddell seals, sperm whales, killer whales, and all species of high-latitude, Southern Ocean baleen whales (blue, fin, humpback, Antarctic minke, sei, and southern right). Here we present a brief overview of this rich, long-term acoustic dataset including samples of the many weird and wonderful sounds that we typically detect. Additionally, we present high-level analysis of the seasonality of the loudest, most prominent sounds. Blue and fin whales were prominent late-summer through autumn; Antarctic minke whales from winter into early spring; crabeater and leopard seals were prominent in spring; and wind, wave, and ice noise was prominent late spring to mid-summer. This long-term biological and environmental monitoring programme is part of the Southern Ocean Hydrophone Network (SOHN), an international project of both the IWC-Southern Ocean Research Partnership and the Southern Ocean Observing System (SOOS).

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Observing penguin breeding phenology by time-lapse cameras at Ardley Island (South Shetland Islands)

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The breeding phenology and breeding success of seabirds are important indicators to describe the state of the marine ecosystem, as is reflected in CCAMLR Standard Methods A2 and A9. However, the collection of such data is time-consuming and, in many remote locations, logistically limited and always depends on weather conditions. Stationary cameras offer the opportunity to observe wildlife continuously and require much less effort in the field. Since 2016, we operate remote cameras in the penguin colony on Ardley Island (South Shetland Islands, Antarctica). These cameras are used to observe groups of Adélie and gentoo penguins. Our motivation for the installation was to determine the ratio between the number of individuals within the groups and the number of nests. This parameter has proven to be very reliable for the analysis of drone aerial photographs.
In the 2014/15 season, CCAMLR initiated the project "Establishing a CEMP Camera Network in Subarea 48.1". The network members successfully developed methods to extract breeding phenology from the camera data. We applied these methods to extract the parameters peak of egg laying and peak of hatching from the time-lapse cameras on Ardley Island.
For the breeding seasons 2016/17 and 2017/18 we compared the breeding phenology results with those data collected by classical methods in the same colony. We observed that the data obtained with both methods did not differ from each other in case of the local gentoo penguin population and only slightly in case of the Adélie penguin population.

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PenguinERA: Ecology, Reproduction and Adaptation for a climate change sentinel. Italian PNRA project for monitoring mid Victoria Land, Ross Sea, Adélie penguin population.

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The Adélie penguin is highly sensitive to ecosystem changes and it is considered an important bio-indicator of ongoing changes in the Southern Ocean. As habitat quality is likely to induce effects on physiology and behavior, PenguinERA project (PNRA 2016 AZ1.11) aimed to integrate the existing long-term monitoring program on this species with the measurement of a series of genetic and physiological parameters. Main activities are carried out by: (i) continuing the long-term monitoring series of data on Adélie penguin in the study area; (ii) identifying a series of proxies of penguin's health status by using non-invasive sampling techniques for measuring blood immune and genetic parameters; iii) integrating proxies with the bio-ecological responses and the genetic parameters, to establish a baseline against which ecosystem changes can be detected. The study area, which involves three Adélie penguin colonies nearby Terra Nova Bay and the Wood Bay (Ross Sea, Antarctica), it is known for its extraordinary biodiversity. PenguinERA would contribute to the understanding of the ecological role of a marine mesopredator such as the Adélie penguin, through the study of its distribution and behavior in relation to the quality of habitat, colony size, evolution and adaptation at the scales of the ecological and climatic processes. Monitoring and conservation studies will allow assessing the additional role of this species as a sentinel of climate changes.

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Climate-mediated environmental variability as a driver of chinstrap penguin foraging behaviour in the Bransfield Strait, West Antarctic Peninsula

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Rapid changes in the climate along the West Antarctic Peninsula (WAP) is having profound effects on associated marine ecosystems. In the northern WAP, warmer temperatures, sharp declines in sea-ice extent and increased wind have been reported. Concerns exist about concomitant changes in the abundance and distribution of Antarctic krill Euphausia superba, a keystone prey resource for upper trophic predators across the region. Chinstrap penguins Pygoscelis antarctica are one of the most abundant krill-dependent predators breeding along the WAP, and population declines in excess of 50 % have suggested changes in the availability of their prey. Yet two synoptic surveys for krill separated by 20 years have shown no change in krill abundance or gross distribution. Given these concerns, understanding how chinstrap penguins forage in different hydrographic regions is an important first step to understand how bottom-up processes may regulate ecosystem dynamics in this region. To determine the foraging behaviour in different hydrographic regimes, we studied the at-sea behaviour of chinstrap penguins on Nelson, Deception and Kopaitic islands in the Bransfield Strait throughout the 2018-19 breeding period. The contrasting hydrographic conditions in the vicinity of each island generated physical gradients across the Bransfield Strait, which resulted in spatial variability in the foraging behaviour of chinstrap penguins between colonies. Our results highlight (1) that mesoscale climate-driven hydrographic variability may modify krill availability to predators foraging in the Bransfield Strait (2) that accounting for mesoscale environmental variability is important if penguins are to be reliable bio-indicators of krill abundance in Ecosystem-Based Fisheries Management.

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Optimisation of Dietary DNA Extraction from Scat samples from Antarctic Top Predators for Metabarcoding

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Food web structure and function of polar ecosystems are dramatically changing due to climate change. Food web regulate mass and energy flow inside and among ecosystems and thus understanding their dynamics has crucial importance. High precision, high coverage dietary analysis tools focused on DNA extracted from scat samples provide a great insight into food web interactions. A non-invasive dietary analysis tool for vertebrates is possible by DNA food metabarcoding in animal scats. Many molecular methods can be employed to retrieve dietary DNA from scats, but many will also recover non-food DNA, which will complicate further PCR and library generation before high throughput sequencing. In order to better understand the role of top predators in Antarctic food webs and elucidate the effects of recent environmental changes, DNA remains in the faecal samples of several top predators (Gentoo Penguin, Chinstrap Penguin, Adelie Penguin, Brown Skua, Weddell Seal, Elephant Seal) of Antarctic Peninsula, sampled during the 2nd and 3rd Turkish Antarctic Expeditions (2018-2019). DNA remains from the samples (>40 per bird species and >15 per seal species) were extracted to be used in metabarcoding to understand the preyed species by the predators. Results gathered from different DNA extraction approaches will be presented to demonstrate how DNA metabarcoding enhances our awareness of the role of the top predators of the Antarctic Peninsula food webs.

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From progesterone in blubber to estimates of pregnancy rates: multi-year analysis of reproductive patterns in Western Antarctic Peninsula humpback whales reveals high recovery potential

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Antarctic humpback whale populations are recovering after intense commercial whaling in the 20th century. Along the Western Antarctic Peninsula (WAP) this recovery is occurring in a rapidly warming environment. To fully assess the recovery of these whales, understanding their current demography and reproductive dynamics is critical. As part of the National Science Foundation's Long Term Ecological Research program, our research group has collected skin and blubber biopsy samples from humpback whales within the nearshore waters of the WAP since 2010. We have assigned a pregnancy state, via blubber progesterone concentrations, to 412 female humpbacks during the austral feeding season between 2010-2018. Blubber progesterone concentrations indicated 62.9% of females sampled across the study were pregnant, with significant variation across all years (low: 36.36% 2010, high: 86.27% 204; $\chi 2 = 32.87$, df = 6, P=0.001). Additionally, we have also found evidence of annual reproduction among females, 57.35% of females accompanied by a calf were pregnant (10.6% of all females sampled). These high pregnancy rates corroborate with the similarly high reproductive rates observed across other Southern Hemisphere humpback populations. To our knowledge, this is one of the first long-term, non-lethal, demographic studies of Antarctic baleen whales and reflects on the demography of whales killed 100 years ago, placing their current population dynamics into the scope of current and future climatic trends. However, the potential response to climate change by humpbacks along the WAP is still unclear and further investigation is needed to better understand long-term population trends to facilitate successful conservation and management.

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Phylogeography and population genetic structure of Snow Petrel populations in east Antarctica

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Seabirds have an extraordinary ability to travel long distances, disperse freely between populations and maintain high levels of gene flow. Ironically, they also exhibit strong philopatry which may lead to pronounced genetic differentiation within and between populations. In this study, we investigated the phylogeography (using mitochondrial cytochrome b sequences) and population genetic structure (using cross-species nuclear microsatellite markers) of the most southerly breeding bird, the snow petrel Pagodroma nivea in Antarctica. The genetic sampling was conducted during three austral summers (2013-14, 2014-15 & 2015-16) under the Indian Antarctic Program at Larsemann hills, Schirmacher oasis and Svarthamaren hills in east Antarctica.

A total of 93 samples were sequenced at mitochondrial cytochrome b region for phylogeographic analysis whereas 142 samples were genotyped for microsatellites. A 792-bp long cytochrome b sequence was obtained from these samples and aligned using MEGAv.6.06. We identified 30 variable sites resulting in 33 haplotypes with three haplotypes were shared between the colonies furthest from each other, Larsemann hills and Svarthamaren hills. Haplotype diversity was higher at all three sites (>0.85). We identified two populations (K =2) from the bayesian individual clustering model in STRUCTURE 2.3. The FST values were found to be low (<0.04) indicating high gene flow between all three colonies. High dispersal ability and long-time spent foraging at sea might be attributed for lower genetic differentiation found between populations. This work lays the foundation for undertaking pan-Antarctic sampling for understanding connectivity amongst spatially disjunct populations of snow petrels.

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Using empirically derived metabolic rates to calculate the aerobic dive limit in developing Weddell seals

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In air-breathing vertebrates, the aerobic dive limit (ADL) is defined by increases in plasma lactate following dives and represents a threshold of aerobic metabolism while diving. Directly measuring ADL involves instrumenting animals with dive recorders and taking post-dive blood samples to measure lactate. However, this is time-consuming and requires access to animals immediately post-dive; thus, ADL is frequently calculated (cADL) using total body oxygen stores (TBO_2) and metabolic rate (MR). While TBO_2 are often directly measured, MR is more difficult to measure and is estimated from data on similar size/age animals or using the allometric relationship between mass and MR described by Kleiber. However, there is a high degree of individual variability in MR and it varies with activity (resting on land vs in water and diving). We measured MR for Weddell seal pups (Leptonychotes weddellii) in air (MRA) and in water (MRW) at 1, 3, 5, and 7 weeks of age. We also estimated MR using 2xKleiber, the typical estimate for pups. We measured TBO_2 in separate individuals, and used these data to estimate cADL. cADL increased with age, whether MRA, MRW, or 2xKleiber was used for the calculation. Using MRW resulted in 18–26% shorter dive durations for each age class (3.8–6.3min) compared with using MRA (5.3–7.8min). Using 2xKleiber overestimated cADL for 1–5-week-old pups by ~10% for MRA, but by 32–39% for MRW. Thus, accounting for conditions when using estimated values is key to arrive at meaningful calculations when empirical measurements are not feasible.

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Development of Thermoregulation in Weddell Seal (Leptonychotes weddellii) Pups

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One of the greatest metabolic costs for endotherms is the energy allocated to thermoregulation. Weddell seal (Leptonychotes weddellii) pups must survive both on ice and in water, two very different thermal environments. This study examined thermal and energetic costs associated with development and thermoregulation in Weddell seal pups. We measured mass-specific metabolic rate in air (MRA) for 8 pups every 2 weeks, from 1–7 weeks old; mass-specific MR in water (MRW) was also measured, beginning at 3 weeks. Additionally, we assessed molt status and estimated body composition. There was a high degree of individual variability in MRA for 1-week-old pups (5.96–13.69 ml O2/min/kg), and with development it generally remained stable or decreased. MRW declined from 3–7 weeks. The difference between MRA and MRW (metabolic equivalence; MRE) also decreased from 3–7 weeks. Molt timing and duration were also variable but 7 of 8 pups were fully molted by 7 weeks. Pups gained mass from 1–5 weeks at a rate of 1.92±0.55 kg/day. The proportion of blubber increased from 1–3 weeks (25% to 38% of body mass), and remained steady from 3–5 weeks (38% to 40% of body mass). By 7 weeks, 6 of 8 pups had weaned and were losing mass. Timing of MRE did not vary with molt status or estimated body composition. Overall, these results indicate Weddell seal pups have developed their thermal capabilities in water by ~5 weeks of age, independent of the amount of lanugo fur or body composition.

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Tracking winter movement of Weddell seals from the western Ross Sea: is overwintering location related to breeding history and success?

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Weddell seals in the Ross Sea are known to feed on Antarctic toothfish, but the details of this predator-prey relationship remain elusive. A commercial fishery for Antarctic toothfish has been operating in the Ross Sea region since 1997, and stock models suggest that fishing has reduced the size of the spawning population of toothfish by about 30% to date. The toothfish spawning population is expected to reduce further to 50% of the unfished level (the CCAMLR fisheries management target) in the next few decades. There is the potential for this change in toothfish abundance to affect Ross Sea Weddell seal populations if, for example, seal breeding success or recovery of seal body mass between seasons depends on consuming toothfish. We present information on research in the south-western Ross Sea over the last 2 seasons to understand the overwintering movement of Weddell seals. We use information on seal movements to investigate locations of feeding and potentially infer feeding on Antarctic toothfish relative to other prey. Seals were satellite tagged in February/March and followed for about 9 months between the end of their moult and their return to breeding sites in McMurdo Sound. We compared over-winter movements by females who had pupped that season and so incurred the large energy cost involved in reproduction, with those who had skipped breeding that year. Overall movements were local but with some females making longer excursions up to 1200 km but still within the Ross Sea region Marine Protected Area.

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Winter diet of gentoo penguins from South Georgia determined using DNA metabarcoding and their overlap with the krill fishery

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The gentoo penguin Pygoscelis papua has a circumpolar distribution, with 26% of the world population residing at South Georgia. Unlike most seabirds breeding at South Georgia these penguins are present year-round and they forage inshore and roost on land at night even during the non-breeding season. The krill fishery around South Georgia operates during winter and this creates potential for the fishery to compete with gentoo penguins for food. This DNA-based diet study is part of a broader project that aims to examine overlaps in the distribution of penguin foraging and krill catches, and the dependence of penguins on krill for food during winter. For diet analysis 600 faecal samples were collected from Cumberland Bay and the Barff Peninsula in South Georgia over the 2018 winter. A universal marker (nuclear 18S) was amplified from samples to obtain broad diet information. Penguin was prevalent in these samples (>85% of the sequence recovered); however, prey DNA sequences were also recovered and were dominated by krill and bony fish. Samples that were positive for these two main prey groups (n=222) were subsequently analysed with group specific mitochondrial DNA primers for higher taxonomic resolution. The DNA results are in broad agreement with previous gentoo penguin diet studies during summer and winter. Satellite tracking data collected in parallel concludes that the overlap of gentoo penguins with the fishery is greater than previously thought, but the amount of spatial overlap and potential for competition is relatively low.

1236

Equilibrium through chaos: Application of game theory in the survival strategy of Antarctican penguins

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Penguins are one of the very few species living in the earth for more than 60 million years, around the time when dinosaurs ruled the earth. They are special type of flightless brids found exclusively in the southern hemisphere. Penguins are social birds – feed, swim and nest in groups and live in extreme cold climate. They also move in groups, which makes them an ideal species to study social biology of animals. Penguins exhibit a well-organized social system having defined family ties. Well-orchestrated group behaviour enables them to meet the challenges of extreme environments of Antarctica, albeit with a primitive brain structure. Penguins huddle together in a group when the temperature plummet. By sticking together they keep themselves warm. This huddling behaviour has been an interesting topic for researchers. Huddling behaviour is highest level of cooperation among the Penguins. Huddling is not motionless. Penguins continuously move from periphery to the centre and vice versa during the huddling. This continuous motion helps them to conserve energy. This conservation of energy is necessary for the Penguins as they fast for long durations.
We are interested in understanding this behaviour. Does game theory help in understanding this huddling phenomenon? We are interested to see if this cooperation among the penguins be achieved as a Nash equilibrium? In our contribution, we develop game theoretic models to study this behaviour and establish the rational foundations behind the cooperative (huddling) behaviour.

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Circumpolar analysis of the foraging areas and habitat use of southern hemisphere humpback whales

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Humpback whales (Megaptera novaeangliae) are globally-distributed baleen whales that show great flexibility in their foraging behaviour and habitat use. Southern Hemisphere populations typically migrate from low latitude overwintering areas to Antarctic foraging areas where they feed on Antarctic krill (Euphausia superba). Following the cessation of commercial whaling, most populations appear to be increasing and humpback whales are now numerous and widespread krill predators that can act as additional sentinels of the vast Southern Ocean system. We compiled existing tracking data from all seven migratory Southern Hemisphere humpback whale populations to identify key circum-Antarctic foraging areas and to better understand the habitat use of these populations in light of the heterogeneous conditions that each population encounters around the Antarctic. We fitted state-space models to satellite tracking data to identity the putative behavioural states of humpback whales. We then related these behavioural states to several oceanographic covariates using generalised additive models, allowing us to characterise the habitat-use of different populations. Our analyses of more than 380 tracks, 2003-2019, totalling some 246,000 location estimates, revealed important foraging areas that reflected areas of high biological productivity. Individuals from different populations encountered very different oceanographic environments and used these environments in distinct ways. This demonstrates the flexible foraging capabilities of this species. The results may have implications for the population trajectories of different populations, given the spatially heterogeneous environmental changes that have been observed and projected in the Southern Ocean.

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Tracking predators to protect Southern Ocean Ecosystems

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In a rapidly changing world, we need to know which areas warrant protection from current and forthcoming threats. This is hard to do objectively in the vast Southern Ocean. However, identifying where predators go also tells us where their prey can be found. If multiple predator species and their diverse prey are found in the same place, then this indicates an area of high ecological significance. We assembled Southern Ocean predator tracking data to produce a database of over 4000 individual animal tracks from 17 species. Statistical spatial models used these data to project the at-sea movements for all known colonies of each predator species across the entire Southern Ocean. These projections were combined across all species to provide an integrated map of those areas important to many different predators. These areas of ecological significance were scattered around the Antarctic continental shelf and in two oceanic regions, one extending from the Antarctic Peninsula into the Scotia Arc, and another surrounding the sub-Antarctic islands in the Southern Indian Ocean. Existing and proposed marine protected areas (MPAs) are mostly within these important habitats, suggesting they are currently in the right places. Yet, when using IPCC climate model projections to account for how areas of important habitat are likely to move by 2100, the same MPAs may not remain perfectly aligned with important predator habitats. Dynamic MPAs are therefore needed to ensure continued protection of Southern Ocean ecosystems and their resources in the face of growing demand by the current and future generations.

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Exploring relationship between foraging trips of chinstrap penguins and krill swarms structures off Nelson Island, South Shetland Islands

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Studying synchronously both the predator and prey spatial distribution is highly difficult, especially in isolated environments such as Antarctica. Usually, tracking is applied separately, on the one hand tracking the predator, identifying their primary foraging areas and timing; and on the other hand tracking the prey, its distribution and abundance. One of the largest chinstrap penguin (Pygoscelis antarcticus) colonies is located at Harmony Point (62.305°S; 59.195°W), Nelson Island. Tracking of chinstrap penguins in the 2019/20 austral summer allowed to identify foraging areas within a 30km from the coast. Penguins concentrated their foraging activities at a mean depth of 226.2 ± 197.0 and median depth of 129.0 meters. Concomitantly to the tracking of chinstrap penguins, we conducted an acoustic survey to study the spatial distribution, vertical structure and density of the Antarctic krill (Euphausia superba) swarms in the foraging area. Dense krill swarms were located mainly between 5 and 150 meters deep in areas closer to the coast, matching the habitat explored by the penguins. These synchronized monitoring provided a better understand of the chinstrap-krill relationship. We proposed that regular acoustic surveys would provide signals of how local krill variability influence the population dynamics of one of the most numerous chinstrap penguin population in the South Shetlands islands.

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Winter encounters of humpback whales (Megaptera novaeangliae) near the western coast of the Antarctic Peninsula

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Humpback whales (HW) use waters around the Antarctic Peninsula to feed in summer, before migrating to tropical breeding grounds in winter. However, little is known about winter presence in the region. To study HW distribution patterns during late autumn and winter, we conducted year-round cetacean monitoring at the Ukrainian Antarctic Akademik Vernadsky Station (Argentine Islands). We conducted 17 boat surveys from May 14 to July 24, 2019: 7 cruises in May, 4 in June, and 6 in July. We performed trips when the ice conditions allowed, until access to the open water was blocked by the ice. Most trips occurred in the waters of Penola Strait, French Passage, Petermann, Vedel, and Hovgaard Islands. HW presence during the winter was also logged by daily coastal observations. During the boat cruises we encountered 87 HWs in 41 groups: 18 sightings in May, 17 in June, and 6 in July. The group sizes ranged from 1-6 (Med=2). The primary behavior observed was feeding. HW were predominantly using the area between Petermann, Hovgaard, and Vedel Islands. The last HW encounter happened on July 8, confirmed by coastal observations. Our results indicate the late presence of feeding HW in the region in winter of 2019. It is known that krill move inshore during winter and it is very likely that the whales were taking advantage of ice-free areas during the first part of the winter. We show the ability to monitor winter whale presence in the Antarctic to better understand the impacts of changing conditions.

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Stable isotope values of baleen whales bone samples from Antarctic and Subantarctic whaling stations

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Baleen whales bone samples were collected from two former whaling stations in the Southern Ocean, one at the King George Island (62°04’47’’S, 58°20’47’’W), western Antarctic Peninsula, and another at the subantarctic South Georgia Islands (54°16’54’’S, 36°30’30’’W). We taxonomically identified the samples using bone collagen peptide mass fingerprinting (also known as ZooMS - Zooarchaeology by Mass Spectrometry). Among a total of 120 samples, we matched species identification and stable isotope (δ13C and δ15N) analyses of 44 specimens from Antarctic and 38 from Subantarctic. Three whale species were identified: humpback (Megaptera novaeangliae, n=18), fin (Balaenoptera physalus, n=21) and blue (Balaenoptera musculus, n=43). Fin whales had 13C-enriched values relative to blue whales from the Antarctic ($F=9.3$, $P<0.01$) and Subantarctic ($F=8.5$, $P<0.01$). Fin whales also had 13C-enriched values relative to humpback whales sampled in Subantarctic ($F=8$, $P<0.01$). Regarding δ15N values, fin whales had 15N-enriched values in comparison with blue whales both in Antarctica ($F=11.2$, $P<0.01$) and in Subantarctic ($F=7.5$, $P<0.05$). Fin whales δ15N values significantly differed spatially, with 15N-enriched samples in Antarctica in comparison with Subantarctic ($F=5.5$, $P<0.01$). SIBER (Stable Isotope Bayesian Ellipses in R) did not reveal any significant difference in isotopic niche widths between species ($P=0.75$) and areas ($P=0.30$) investigated, what can be related to the fact that the species are using a broad feeding area. Future comparisons with samples from contemporary (e.g. stranded) specimens can provide novel insights into temporal and spatial changes in baleen whales diet, as a result, for example, of climate variability and concurrent changes in marine ecosystem.

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Bird's-eye View: Adélie penguin populations on Ross Island

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Adélie penguin (Pygoscelis adeliae) abundance is a commonly-used indicator of Antarctic marine ecosystem health. Since the early 1980s, New Zealand has conducted an annual census of Adélie penguins in the Ross Sea region, with data submitted to the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) Ecosystem Monitoring Programme (CEMP). The number of breeding pairs is determined through aerial photography of colonies, and subsequent image processing and penguin counting using semi-autonomous software. Annual changes in the number of breeding pairs can be considered in relation to environmental variables, enabling hypotheses about drivers of population response to change to be tested.

The long-term record of Adélie penguin abundance and distribution in the Ross Sea provides an important baseline for research and monitoring associated with the Ross Sea region Marine Protected Area. It is valuable for assessing ecosystem resilience under changing environmental conditions, investigating the impacts of fishing and invasive species, and analysis of site-specific environmental relationships and species interactions. This poster presents the latest Ross Island Adélie penguin census data, and highlights the value of long-term records of an important Antarctic marine predator.

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Detection of specific immunoglobulins G (IgG) against canine distemper virus in Antarctic seals

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The first tests to detect the presence of canine distemper virus(CDV) and phocine distemper virus(PDV) antibodies in different species of Antarctic seals were done in the 80s. Current information about diseases in Antarctic wildlife including seals is scarce and fragmented. We analyzed 33 blood serum samples from three Antarctic seals species: Lobodon carcinophaga(CS), Hydrurga leptonyx(LS) and Leptonychotes weddelli(WS), collected at Cierva Cove, Western Antarctic Peninsula. Indirect immunoenzymatic assays (ELISA tests) were performed for the detection of specific IgG against CDV, with a commercial kit INGEZIM MOQUILLO IgG. We found positive serology for 100%LS, 90%WS and negative serology for CS. Since IgG are characteristics of the secondary immune response, the presence of IgG antibodies in LS and WS suggests that they have been probably infected in the past. This infection could be caused by the presence of sled dogs years ago although infections due to seal migratory movements cannot be ruled out as previously suggested. Negative serology for CS could be due to they were not infected or because antibodies were not detected using IgG. Further studies e.g. IgM, against CDV are necessary to strengthen our knowledge and be able to identify recent contact with the virus. Although mass mortality events in Antarctica are highly unusual, considering environmental changes observed in the region due to global change and that alien species and pathogens can be resilient to them, the study of viral infections and associated biosecurity measures become fundamental for conservation prospective and more research on this topic is needed.

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Chinstrap penguin abundance on Elephant Island, South Shetland Islands, Antarctica: Results of the 2020 census

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Over the past decade, considerable effort has been expended to document the population dynamics of the main Pygoscelis spp. penguins on the Antarctic Peninsula, yet critical questions remain. Adélie and gentoo penguin populations have been closely monitored, but the status of chinstrap penguins is not well understood. Chinstrap penguins are difficult to assess because their colonies occur in remote areas, and most have not been directly surveyed for decades. Few populations have sufficient historic or current data to assess whether numbers are increasing, decreasing, or remaining stable. This presents a key gap in our understanding of the Antarctic Peninsula region. Our simplest theories suggest chinstrap penguin populations should be increasing, but limited evidence suggests that they are decreasing sharply in some places while remaining stable in others. Elephant Island is a particularly important site for mapping the front lines of chinstrap penguin decline because colonies occur adjacent to marine areas known to have been negatively impacted by climate change and krill fishing. A thorough census of colonies on Elephant Island has not been conducted for at least 40 years. This paper presents the results of a comprehensive 2020 census of Elephant Island chinstrap penguins, based on ground counts and unmanned aerial vehicles. The findings provide an updated population assessment for the island and surrounding areas, and contribute more broadly to the debate regarding the relative roles of climate change and fishing as drivers of penguin population change in Antarctica.

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Adélie penguin diet at Signy Island, South Orkneys: comparing data from stomach flushing with faecal DNA analysis

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Monitoring variability in predator diets can provide key parameters for understanding and managing the Antarctic Ecosystem. At present, the diets of a number of penguin species are studied as part of the CCAMLR Ecosystem Monitoring Programme (CEMP) using stomach lavage to identify prey composition and mass. Recently, there has been increasing interest in less invasive methods for the analysis of predator diets, and analysing prey DNA in faeces may be a useful approach to complement existing diet monitoring. In order to directly compare these two methods we examined the diet of Adélie penguins Pygoscelis adeliae at Signy Island, South Orkney Islands (60°43'0"S, 45°36'0"W) during crèche (December/January) in 2014/15 and 2015/16. Each method produced a similar pattern of penguin diet, with a shift from almost exclusively krill in 2014/15 to a mixture of fish and krill in 2015/16. Stomach flushing allows some additional information (such as prey size) to be collected, however, faecal prey DNA sampling allowed more comprehensive sampling and DNA markers identified higher taxonomic diversity of fish prey. We discuss the results of this two-year pilot study in the context of the long-term diet dataset (1997-2020) derived using stomach lavage sampling. Faecal DNA analysis provides an opportunity to establish an alternative method for the long-term monitoring of predator diets and could significantly expand the information obtained for ecosystem monitoring.

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Novel insights into habitat use, diving and diet of the elusive Ross seal

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Ross seals (Ommatophoca rossii) are the least studied and scarcest of the Antarctic pinnipeds. Only two studies exist on its at-sea movements: four and eight individuals tracked in the Amundsen and Weddell seas respectively. Diving behaviour has only been recorded for seven individuals and no longitudinal stable isotope data exist. Between 2016 and 2019, we deployed 15 satellite trackers of which seven measured diving behaviour and collected whiskers for bulk-stable isotope analyses from 25 individuals, making this the single largest study on Ross seals to date. Tracking data was combined with the eight animals previously tracked in the Weddell Sea to build the first habitat model for the species. Ross seals travelled away from the Antarctic pack-ice to forage pelagically on myctophid fish and cephalopods. This is reflected in the sequentially sampled bulk stable-isotope data from collected whiskers, with oscillations in δ13C and δ15N values reflecting their south-north movements. During winter, they spend most of their time tracking the marginal sea ice while summer is spent in open water. Ross seals dive deeper, but not longer, during the day presumably following the diel vertical migrations of their preferred prey and haul-out behaviour is influenced by lunar phases. The habitat model shows that sea-surface temperature is the most important indicator of foraging behaviour and they prefer to forage in a very narrow temperature band. This contrasts with suggestions that Ross seals might benefit from climate change due to the receding ice and reduced travel distances required to reach the open water.

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Cephalopod component of the diet of Snares Penguins, Eudyptes robustus, at the Snares Islands, New Zealand, based on historical data from 1986-87

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In the Southern Ocean and adjacent waters, cephalopods are prey to numerous predators, including penguins. The Snares Penguin, Eudyptes robustus, an endemic species from Snares Islands, was used as a local biological sampler to evaluate the cephalopod component of its diet. As historical data on diet are rare for this species, a detailed analysis of the cephalopod component of the diet in the breeding season 1986-87 was carried out and the habitat and trophic level of cephalopods was assessed through stable isotope analyses. The results show that penguins fed on three species: two squids (i.e. Nototodarus sloanii and Onykia ingens) and one octopod species (i.e. Octopus campbelli). Nototodarus sloanii was the most important species in frequency of occurrence and mass, although O. ingens was the most important species by number. The squid species showed similar δ13C values, suggesting an occurrence in similar habitats on the continental shelf of Snares Islands. O. campbelli, showed lower δ13C values, potentially from more offshore waters, and fed on significantly higher trophic level (δ15N) prey when compared to squid species, leading to a completely segregated isotopic niche of this species. Lower diversity and higher sizes of prey were found when compared with more recent data (from the 2000's), suggesting shifts in the distribution and abundance of cephalopods around Snares Islands, probably due to changes in ocean currents and increasing water temperature throughout the years. This study provide essential biogeographic information of cephalopods species and relevant historical information for the conservation of this endemic penguin species.

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Evidence of environmental change in Antarctic marine ecosystems: Penguins, seals and their prey as bio-indicators of change

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Under the context of climate change, the Antarctic region is expected to exhibit considerable changes. We provide scientific evidence of changes in the ecology of top predators, and their prey, in the Antarctic and adjacent regions. Our studies show that Gentoo penguins from South Georgia exhibited different habitat preferences and trophic level according to different oceanographic conditions, similar to Humboldt penguins distributed further north (Xavier et al. 2018a, Chiu-Werner et al. 2019). Moreover, prey switching occurred in the diet of gentoo penguins at South Georgia during Winter, under warmer local conditions switching to their preferred prey Antarctic krill Euphausia superba when sea surface temperatures became colder (late September – early October). This change contributed to the observed demise of penguins and to the consequent later commencement of breeding (2-3 weeks later). Similarly, the foraging ecology of Antarctic fur seals from South Georgia was linked to squid availability, Antarctic krill abundance and regional oceanographic conditions (Abreu et al. 2019). In years of unusually warm oceanographic conditions around South Georgia and low Antarctic krill density, the numbers of the squid Slosarczykovia circumantarctica increased in the diet of Antarctic fur seals when Antarctic fur seals foraged offshore. These research results have been put forward to inform the Antarctic Treaty Parties and develop policies (Hughes et al. 2018) but they are also important for education and outreach initiatives to a wider audience (Xavier et al. 2018b, Xavier et al. 2018c, Roop et al. 2019).

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“Stone” can tell us what predators eat and where the diets from: Understanding the role of fish otolith in foraging ecology of predator

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The knowledge of the diets and foraging strategy of land-based and flying predators, particularly in relation to the distribution and abundance of their main prey, is crucial to understanding their role within highly variable marine food webs. On the other hand, by monitoring the diets of such predators a fishery-independent view of stock variability can be obtained. In the Southern Ocean to the south of the Antarctic Convergence 35 species of myctophids are found in the mesopelagic and bathypelagic waters. Of these 35 species, 11 have circumpolar distributions and are mainly widespread from the Antarctic Polar Front zone (APF) to the edge of the Antarctic continental slope. Four species of myctophids (Electrona antarctica, Electrona carlsbergi, Krefftichthys anderssoni, and Gymnoscopelus nicholsi) are distributed circumpolarly and are the important diets of top predators, particularly penguins, seals and flying birds. Otoliths (stone-like calcium carbonate structures) are found beneath the brain of most fish, and can be used to determine more than just age, growth and stock discrimination. The chemical composition of otoliths can also reveal information about the life history of the fish. So otoliths in the stomach of penguins can provide a good proxy to examine the diets and foraging strategy of penguins on myctophid fishes. In this talk, we will use the otoliths of myctophids as examples to investigate the foraging ecology of penguins, seals and flying birds.

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