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ABSTRACT BOOK

What Adélie penguins can tell you about chlorophyll

David Ainley¹, Grant Ballard², Ben Saenz³, Glenn Ford⁴, Erin Conlisk¹, Kendra Daly³, Randy Jones⁵, Walker Smith⁵, Steve Pierce⁶, Dennis Jongsomjit², Stacy Kim⁷, Amélie Lescroël⁸, Viola Toniolo⁹, Sam Veloz²

¹H.T. Harvey & Associates, Los Gatos, California, USA, ²Point Blue Conservation Science, Petaluma, California, USA, ³Marine Sciences, University of South Florida, St Petersburg FL, USA, ⁴RG Ford Consulting, Portland, OR, USA, ⁵Virginia Institute of Marine Science, Gloucester Point, VA, USA, ⁶School of Marine Sciences, Oregon State University, Corvallis OR, USA, ⁷Moss Landing Marine Laboratories, Moss Landing CA, USA, ⁸Centre d'Ecologie Fonctionnelle et Evolutive, UMR 5175, CNRS - Université de Montpellier - Université Paul-Valéry Montpellier - EPHE, Montpellier, France, ⁹Earth System Science, Stanford University, Stanford CA, USA

We investigated the foraging habitat and preyscape experienced by Adélie Penguins (ADPE) breeding at colonies on Ross Island, using tags that allowed investigation of foraging trip extent and depth, coincident with an ocean glider and ROV equipped with acoustics, CTD, and fluorescence measurement capabilities. Remotely-sensed data were also used to quantify habitat. At the same time we recorded the composition of meals provided to ADPE chicks. Three different study designs were used at two different colonies, 2005-2014. In the first, we found that ADPE foraged most successfully in areas of elevated chlorophyll, which with other habitat characteristics, indicated the presence of sub-mesoscale eddies that facilitated prey retention. These eddies were associated with bathymetric features (troughs). Penguin behavior indicated their search for high quality prey patches. In the second, we found that ADPE, together with baleen whales, altered the measured preyscape, reducing prey availability, but in a way uncoupled from actual phytoplankton prevalence. In the third investigation, ADPE foraged to depths that avoided the low visibility present in intense blooms, again apparently uncoupled from any direct positive connection to phytoplankton prevalence and again altering the preyscape. While chlorophyll intensity is commonly used to explain seabird occurrence patterns, our results indicate that at the scale or level of foraging in real space/time, armed with actual knowledge of the preyscape, the penguin-bloom interaction has unexpected elements, i.e. association with high chlorophyll is not the end of the story.

Are Adélie Penguin Foraging Volumes Determined by Breeding Population Size?

Grant Ballard¹, Dennis Jongsomjit¹, Sam Veloz¹, Katie Dugger², Phil Lyver³, David Ainley⁴

¹Point Blue Conservation Science, Petaluma CA, USA, ²U.S. Geological Survey, Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Corvallis OR, USA, ³Landcare Research, Lincoln, NZ, ⁴H.T. Harvey, Los Gatos CA, USA

Our previous research showed that the foraging areas for three Adélie penguin colonies on Ross Island varied in size in correlation with their breeding population size, implying a prey-depletion effect with consequences to the geographic structuring of populations. In addition, the foraging areas of birds from the small to medium-sized colonies (Capes Royds and Bird) overlapped one another, while the vast numbers of birds at the largest of the three (Cape Crozier) apparently excluded foraging birds from the other colonies. As further evidence of the prey-depletion effect, we have repeatedly observed the within-season expansion of the Cape Crozier foraging area (but not that of the other colonies), to the point where we believe it has reached an energetically imposed limit, presumably due to inter and intra-specific competition for food. Since these initial studies, Cape Crozier's population size has grown dramatically, providing the opportunity to evaluate whether it was in fact at its energetic limit (i.e., whether the foraging area would continue to expand with population growth). It also remains unclear to what extent the relationships we found previously would hold true when considering the entire volume of the foraging space utilized by each colony, not just the area of the ocean surface. As such, we collected foraging position and dive data from 307 breeding Adélie penguins at Capes Royds, Bird, and Crozier, during seven breeding seasons (2005-2012). During the study, populations ranged from ~3,900 breeding pairs at Cape Royds, to ~69,000 pairs at Cape Bird, to ~282,000 pairs at Cape Crozier, with substantial annual variability within colonies as evidenced by counts derived from annual aerial photography. We evaluated (1) to what extent the variability in foraging areas and volumes could be explained by variability in population size (both within and across colonies), (2) to what extent the areas and volumes overlapped within colonies (across years) and across colonies (within years), and (3) whether foraging volume, like area, consistently expands within breeding seasons at Cape Crozier. Results help to further elucidate the patterns observed in Adélie penguin population size and location, with implications to the design of marine reserves intended in part to protect them.

Successes and Failures of de-oiling African penguins

Peter Barham^{1,2}, Richard Sherley³, Anton Wolfaardt², Res Altwegg⁴, Barbara Barham⁵, Rob Crawford⁶, Nola Parsons⁷, Phil Whittington^{8,9}

¹H H Wills Physics Laboratory, University of Bristol, Bristol, BS8 1TL, UK, ²Animal Demography Unit, Department of Biological Sciences, University of Cape Town, Rondebosch 7701, South Africa, ³Environment and Sustainability Institute, University of Exeter, UK, ⁴Statistics in Ecology, Environment and Conservation, Department of Statistical Sciences, University of Cape Town, Rondebosch 7701, South Africa, ⁵Department of Biological Sciences, University of Bristol, Bristol, BS8 1UG, UK, ⁶Oceans and Coasts, Department of Environmental Affairs, PO Box 52126, Cape Town 8000, South Africa, ⁷Southern African Foundation for the Conservation of Coastal Birds, PO Box 11116, Bloubaerg 7443, South Africa, ⁸East London Museum, PO Box 11021, Southernwood 5213, South Africa, ⁹Department of Zoology, Nelson Mandela Metropolitan University, PO Box 77000, Port Elizabeth, 6031, South Africa

Since 1968, over 35,000 African penguins *Spheniscus demersus* have been de-oiled in South Africa. The majority were oiled in two catastrophic spills: in 1994 and 2000, 10,000 and 19,000 penguins were oiled, respectively. Large percentages (91% in 2000) were de-oiled, banded, released and monitored for subsequent survival and breeding success. Survival rates of de-oiled and unoiled penguins were similar in non-breeding individuals for at least 10 years after oiling. De-oiled penguins from both spills that attempted breeding suffered costs associated with reproduction. After 1994, the incidence of breeding abstinence by penguins was elevated in de-oiled birds and intermittent breeders suffered higher mortality. An estimated 27% of de-oiled penguins did not breed after 1994, while after 2000 those that bred had survival rates 7 to 17% lower than unoiled birds in two years following the spill. Clutch sizes and hatching success were unaffected, but over 13 years the birds de-oiled in 2000 fledged 6% fewer chicks per pair than unoiled birds. After both spills fledging rates, fledging periods and chick growth rates were negatively impacted, but only apparently when prey availability was low.

In this paper we will discuss in detail the overall impact of de-oiling these birds on the conservation of the African penguin in light of the long-term detrimental effects of oiling on their ability to rear chicks.

Is age in the eyes and feet of a penguin?

P. Dee Boersma^{1,2,3}, John Samaras⁴, Ginger A. Rebstock¹, Kathryn P. Wellington¹, Katie A. Holt¹

¹University of Washington, Department of Biology, ²Global Penguin Society, ³Wildlife Conservation Society, ⁴Woodland Park Zoo

Knowing the age structure of a population improves demographic models, but birds lack structures, such as teeth and otoliths, used to age other animals. Marking and following large numbers of individuals is required to know the age structure of a penguin population beyond the distinction between juvenile and adult plumage. In a large population of Magellanic penguins (*Spheniscus magellanicus*) at Punta Tombo, Argentina we coded eye and foot color. The penguins ranged in age from less than one year to more than 28 years of age. We examined eye (iris) pattern and color defining “distinct” eyes as reddish-colored irises with concentric red and pink rings and “indistinct” eyes as plain, dark-brown irises. More than 75% of 2-3 year-old Magellanic penguins had distinct eyes, compared to 50-75% of 4-6 year-olds, 25-50% of 7-20 year olds, 10-25% of 21-24 year olds, and <10% of 25+ year olds (n = 3262). Foot color progressed from mostly white to mixed (mottled) to mostly black. The webbing stayed white longer than the skin on the tops of the toes and tarsometatarsus. We also examined foot color in a small known-age zoo population of Humboldt penguins (*S. humboldti*). In Humboldt penguins, feet became mostly black within a year of hatching, but continued to darken slowly with age (n = 44, maximum age = 25 years). In Magellanic penguins, feet took several years to become mostly black (n = 78). Nestlings had mostly white feet with small specks of black (n = 16). About half of adults 3-11 years old had mottled feet and half had mostly black feet. Eleven of 12 adults 23 years or older had black or almost all black feet. Individual variation in both eyes and feet prevents aging an individual with a high degree of certainty, but a population may be split into broad adult age classes based on eye and foot color.

Best practices and guidelines to document effects of fisheries competition on seabirds, with an emphasis on penguins

William J Sydeman¹, Sarah Ann Thompson¹, Andre Punt², Robert Furness³, Robert JM Crawford⁴, Richard Sherley⁵, Nicole C Bransome⁶

¹Farallon Institute, ²University of Washington, ³University of Glasgow, ⁴South African Department of Environmental Affairs, ⁵University of Exeter, ⁶The Pew Charitable Trust

The notion that marine top predators (seabirds and marine mammals) and commercial fisheries compete for the same resources (i.e., small pelagic fish) has been of interest to the marine conservation community for decades. Recently, however, this topic has received renewed attention with the implementation of the ecosystem-based approach to fisheries management (EBFM), particularly since fisheries are increasingly targeting forage nekton such as krill, anchovy, sardine, etc. Documenting seabird-fisheries competition is difficult as it requires spatially explicit information on 1) fisheries effects on local to regional forage nekton distribution, abundance, and spatial organization, and 2) forage nekton relationships to seabird foraging ecology, predator-prey interactions, numerical responses/demography, and population dynamics. In addition, documenting such interactions has been challenged by lack of controls in experiments, poor understanding of scale, confounding factors (climatic impacts) in correlative/observational studies, prey-switching, and lack of syntheses.

We convened an international group of fisheries and seabird scientists to review, discuss, and synthesize previous approaches and methods to study and document seabird-fisheries competition. We evaluated three approaches to gain insight into potential fisheries impacts on seabirds and other predators: 1) models including food web models that parameterize biomass (i.e., Ecopath with Ecosim, Atlantis) 2) Experimental manipulation of fisheries (e.g., time-area closures) in the vicinity of seabird colonies or marine mammal rookeries and 3) direct observational studies.

To date, there has been no synthesis of these modelling, experimental, or observational approaches to document fisheries impacts on seabirds. We analysed these approaches through several case studies including an observational study examining the impacts of fisheries on seabirds in the North Sea, experimental approaches to fisheries closures off South Africa to determine impacts on the endangered African penguin, and models of intermediate complexity for assessing fisheries competition with seabirds.

We share recommendations for best practices including data requirements, method variations, appropriate uses and other considerations when using each of the three approaches identified for documenting competition for forage resources between fisheries and marine predators including seabirds like penguins.

The colour of penguin colonies: Satellites and spectroscopy at Signy

Jennifer Brown^{1,2}

¹University of Cambridge, ²British Antarctic Survey

Five penguin species breed in Antarctica: emperors, Adélies, chinstraps, gentoos and macaronis. These are important Antarctic upper trophic level predators and under predicted climate change are believed threatened. Accurate monitoring of these populations is of growing importance owing to the changing environment in which these penguins live, particularly the Western Antarctic peninsula where rapid warming is occurring. The inaccessibility and size of many colonies makes ground based monitoring difficult with remote sensing providing an alternative, relatively low cost, monitoring method. Advancing current penguin monitoring methods will help improve estimates of population trajectories at a regional scale. Recent and future progress in remote sensing, with new satellite sensors and platforms, offers an increased potential for accurate, consistent large scale data collection. This will enable us to address previously untested hypotheses on penguin population change.

This research focuses on difficult to monitor brush-tailed penguins (Adélies, chinstraps and gentoos), aiming to develop new techniques and algorithms to improve their monitoring in Antarctica. Penguin detection in satellite imagery is based on the red/brown guano (poo) stains that colonies create as these stains are evident from space (Fretwell and Trathan 2009, Fretwell et al. 2013, Lynch and LaRue 2014, Schwaller et al. 2013). When adults arrive at the breeding site they produce a light pink guano stain. The guano stain changes to a more reddish hue when the chicks hatch, and continues to get darker with increased guano deposition. After the birds leave the site it weathers and degrades back to a more brownish colour. The varying phenologies of pygoscelid species indicates that a difference in guano colour at colonies may enable species differentiation in satellite imagery.

Fieldwork undertaken in Signy, Antarctica (November 2014 - January 2015) using a field spectroradiometer obtained significant reflectance spectra of Adélie and chinstrap guano. Satellite imagery coincident with the fieldwork was obtained from WorldView3 (~40cm spatial resolution) and Landsat 8 (~15m spatial resolution) to be used in combination with the collected spectra. Analysis of this data investigates guano colour change, addressing development over time and differences between species, aiming to improve penguin species detection from satellite imagery.

Foraging distribution of gentoo penguins, *Pygoscelis papua*, at Marion Island with a unique twist

Tegan Carpenter-Kling¹, Jonathan M. Handley¹, Pierre A. Pistorius¹

¹DST/NRF Centre of Excellence at the Percy FitzPatrick Institute for African Ornithology, Department of Zoology, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa

Knowledge of seabird distribution is critical toward understanding their foraging ecology. For the first time, this study investigated the foraging behaviour of gentoo penguins at sub-Antarctic Marion Island using global positioning system (GPS) loggers and temperature depth recorders (TDRs). During August 2014, loggers were deployed on penguins brooding recently hatched chicks. The loggers were only retrieved five days after deployment to facilitate capturing multiple tracks of each individual. This resulted in 32 GPS tracks with corresponding TDR tracks from nine penguins. Firstly, this study revealed that the shallow inter-island shelf between Marion and Prince Edward Island is an important foraging area. This area is likely to provide predictable prey to the gentoo penguin as it provides an ideal habitat for three main dietary components of these penguins: Nototheniid fish, and a benthic (*Nauticaris marionis*) and a pelagic (*Euphausia vallentini*) crustacean species. Additionally, visualization of tracks revealed two classes of trips. Short trips that we predict to be for self-maintenance as these trips were followed by a rest period on the beach overnight; as determined from GPS loggers. Tracks of greater distance and duration were always followed by adult birds returning to the colony, where we predict feeding of chicks to have occurred. A number of seabirds alternate between long and short trips during chick rearing. Chicks benefit from frequently being fed but this is to the expense of the adult's energy reserves. Therefore, to compensate for this energy loss, periodically adults perform longer foraging trips, to further, more predictable and profitable prey patches for self-maintenance to restore body stores. To our knowledge, this is the first study to associate short trips with self-maintenance. We suggest that due to the close proximity of a predictable foraging area for these penguins at Marion Island, there is minimal energetic cost to return to land after self-provisioning. Hence, unlike other seabirds, gentoo penguins at Marion Island are uniquely afforded the opportunity for short self-maintenance trips.

Metabarcoding analysis of DNA in scats reveals jellyvore diet amongst food consumed by little penguins

Catherine Cavallo¹, Bruce Deagle², Andre Chiaradia³, Sonia Sanchez Gomez¹, Simon Jarman², Graeme Hays⁴, Richard Reina¹

¹School of Biological Sciences, Monash University, Clayton, VIC 3800, Australia, ²Australian Antarctic Division, Kingston, Tasmania 7050, Australia, ³Research Department, Phillip Island Nature Parks, PO Box 97, Cowes, Victoria 3922, Australia, ⁴Centre for Integrative Ecology, School of Life and Environmental Sciences, Deakin University, Warrnambool, Victoria 3280, Australia

Diet composition of marine predators is used to investigate food web dynamics and ecosystem functioning, but conventional diet analysis techniques can be invasive, time-consuming and limited in sample size. New developments in DNA dietary analysis allow accurate interpretation of large quantities of predator scats quickly and cheaply. Metabarcoding, facilitated by Next Generation Sequencing, can identify most prey DNA at species level within a scat sample. This includes soft-bodied prey that is overlooked by conventional hard-parts and stable isotope analysis. Using metabarcoding within an integrated monitoring approach, we measured little penguin (*Eudyptula minor*) diet, foraging success, breeding success and chick mass at two breeding sites within 2 km of each other on Phillip Island, Australia. Penguins at these sites forage in different areas, and are monitored by Automated Penguin Monitoring System weighbridges that record the identity and weight of individuals entering and leaving the sites. Metabarcoding analysis of scats from both sites revealed the changing composition of prey species in diet over time. We also discovered that soft-bodied prey such as salps and cnidarians are more prevalent in Little Penguin diet than previously detected using conventional and isotopic methods. Our integrated approach revealed diet segregation at both sites, despite their close proximity, and demonstrated the direct influence of temporal changes in diet composition on breeding success and chick growth. The rapidity of sampling and analysis and the ability to collect large sample size continuously with little disturbance to breeding colonies provides valuable food web information suitable for long-term monitoring programs for predator conservation as well as ecosystem and fisheries management.

Telomeres shorten and then lengthen during growth in Magellanic penguins

Jack A. Cerchiara¹, Rosa Ana Risques², Donna Prunkard², Jeffrey R. Smith³, Olivia J. Kane¹, P. Dee Boersma¹

¹Department of Biology, University of Washington, Seattle, WA 98195-1800, USA, ²Department of Pathology, University of Washington, Seattle, WA 98195-1800, USA, ³School of Environmental and Forest Sciences, University of Washington, Seattle, WA 98195-1800, USA

For long-lived species, enhanced adult survival can increase the potential for future reproductive events. In some long lived species, longer telomeres are correlated with increased survival. If telomere length is important to survival, adults should enter breeding with long telomeres to maximize their lifespan. Chick growth, however, is energetically costly, and is characterized by high levels of cell proliferation, which is linked to shorter telomeres. Additionally, mitochondria are the source of both the energy production for growth, as well as damaging reactive oxygen species that can shorten telomeres. We characterized the dynamics of telomere length and mitochondria number for Magallenic penguins (*Spheniscus magellanicus*) from hatch day through the oldest adults, with a special focus on growth. We tested how growth impacted telomeres by taking blood from wild known-age Magellanic penguin chicks every 15 days from hatching to 60 days of age. We also sampled a set of 1-year-old juvenile penguins, and adults aged 4 to 27+ years. We used qPCR to measure telomeres and NADH-dehydrogenase, which reflects mitochondria number. Telomeres were significantly shorter on day 15 than on hatch day but returned to length at hatching when the chicks were 45 and 60 days old. The length of telomeres of newly hatched chicks, chicks aged 45 and 60 days, juveniles, and adults aged 45yrs were similar. Mitochondrial copy number increased significantly from hatch to age 15 days and remained similar at 30 days of age. Mitochondria number then dropped significantly to hatch-day levels by 45 days of age. The number of mitochondria decreased in adult penguins by age 7-8 years and remained similar throughout adulthood. Our results indicate that while telomeres shorten during growth, Magellanic penguins elongate telomeres and enter breeding with telomeres similar to their hatch day length, which may enhance adult survival.

Biodiversity hotspots of penguins around the world: adaptive framework for conservation

Francisco Ramírez¹, Isabel Afán², André Chiaradia³

¹Department of Conservation Biology, Estación Biológica de Doñana(CSIC), Sevilla, Spain, ²Laboratorio de SIG y Teledetección, Estación Biológica de Doñana (CSIC), Sevilla, Spain, ³Research Department, Phillip Island Nature Parks, Victoria, Australia

Climate change is fast affecting penguin ecosystems through changes in water temperature, current circulation and, ultimately, marine productivity. Penguins, as many other seabirds, are facing new environmental conditions that may prove suboptimal for most of them all over their range. Today, almost 70 % of the penguin populations are declining in numbers. The other 30% of penguin populations are stable or increasing. Most of these declines have been happening in the last 30 years.

The challenge for penguin biologists and marine environmental managers alike is to identify priority areas for penguin biodiversity conservation. Penguin responses to climate change may be species and site specific. Identifying these areas may only be feasible today through spatial analyses on environmental impacts. In this work, we combined information on most penguins' global distribution with environmental data on long-term oceanographic changes to identify hotspots of penguin biodiversity in the southern hemisphere that are more prone to environmental distress. We will present data on environmental impacts at an unprecedented fine spatial resolution that will let to evaluate the specific impacts on penguins from local to the regional scales.

First we will present a global snapshot with information on marine biodiversity globally with a novel assessment of the impacts of climate change and industrial fisheries, identifying areas of high marine biodiversity that are particularly affected by climate and human stressors. We compiled a species-level database recording the global distribution of over 2000 marine species, comprising of fish, marine mammals and seabirds in order to identify hotspots of marine biodiversity.

We then identified four main marine hotspots of penguin biodiversity: south of Australia and New Zealand; south of the Indian Ocean, around the Antarctic Peninsula and around the Argentinean Patagonia. The main environmental perturbations at these hotspots are changes in sea surface temperature (SST), with striking changes around the Antarctic Peninsula and the Argentinean Patagonia, where the SST temporal trend contrasts with the general ocean warming by experiencing local to regional decreases. Marine productivity (Chlorophyll-a concentration) has also increased dramatically around the Antarctic Peninsula, which coincides with an area where most penguin populations are stable or increasing. The variations in ocean circulation are mostly happening in South Australia/New Zealand hotspot, where populations are mainly decreasing. In this study, we provide a simple and adaptive framework to identify the marine hotspots of penguin biodiversity and assist the conservation of penguins around the world.

The Role of Vocalizations in Socially Facilitated Breeding Behavior for Two *Spheniscus* Penguins with Contrasting Breeding Cycles

J. Alan Clark¹, Jessica Kemper², P. Dee Boersma³

¹Fordham University, Bronx, NY USA, ²African Penguin Conservation Project, Lüderitz, Namibia, ³University of Washington, Seattle, WA USA

Coloniality is rare in the animal kingdom. An exception to this pattern is found in seabirds, where 95% of seabird species, including most penguin species, are colonial. Coloniality gives rise to unique and complex behavioural patterns, including breeding behaviour. Often behaviours in colonial species are socially facilitated, that is, the behaviour of nearby conspecifics impacts the behaviour of their neighbours. Vocalizations increase vocal and sexual behaviour in many species through social facilitation. Using playback experiments, we examined the role of vocalizations in facilitating social behaviour in two *Spheniscus* species: African and Magellanic penguins which are closely related yet have highly contrasting breeding cycles. While African penguins can begin the breeding cycle in any month of the year, Magellanic penguins have a highly synchronized annual breeding cycle. One common function of socially facilitated behaviour is to help synchronize breeding cycles at a colony. Given the major difference between African and Magellanic penguin breeding cycles, we predicted that we would find stronger evidence for the role of vocalizations in socially facilitated breeding behaviours for Magellanic penguins than for African penguins. Consistent with our prediction, we found that Magellanic penguins responded strongly to playback of ecstatic male display calls by increasing the rate of many breeding behaviours, including ecstatic male display calls, duets, flipper patting, fights, and copulations. In strong contrast, we found that African penguins did not respond to the playback stimuli. These results support our initial hypothesis and should inform conservation management actions for these species. With climate change, species' ranges are shifting, and conservation managers are increasingly interested in developing conservation actions that manipulate populations such as recruitment of individuals to new colonies, recolonization of abandoned colonies, and increasing the density of declining colonies. For seabirds, such programs have often involved the use of acoustic lures. However, the effectiveness of acoustic lures is contingent on the focal species' breeding ecology. What might be effective for Magellanic penguins may not be as effective for African penguins. A better understanding of socially facilitated breeding behaviours can play a key role in the success of management programs for colonial species of conservation concern.

Do penguins play leap-frog? Niche partitioning in Adélie and Chinstrap penguins: the roles of allochrony and phase-dependent foraging ranges

Harriet Clewlow¹, Norman Ratcliffe¹, Mike Dunn¹, Stacey Adlard¹, Steve Votier², Rod Downie³, Akinori Takahashi⁴

¹British Antarctic Survey, ²University of Exeter, ³WWF, ⁴National Institute of Polar Research Japan

Ecological theory states that closely related species with similar ecological requirements, occupying the same fundamental niche will display niche partitioning in areas of overlap to reduce competition. Sympatrically breeding congeneric seabirds commonly display allochrony (differences in timing of breeding) and this, in combination with phase-dependant variability in foraging trip duration, can lead to spatio-temporal segregation of species by foraging areas. This causes birds to “leap-frog” one another in time and space to exploit distinct spatial niches as the season progresses. Seabird phenology is sensitive to temperature change but species do not always respond to the same degree. Therefore, if the timing of breeding of one species advances at a different rate to that of its competitor niche overlap may increase, leading to synchronous breeding, increased inter-specific competition and population declines in one or both species. Alternatively if both species advance their phenology at similar rates, thus preserving allochrony, then niche partitioning and the level of competition experienced will be unaffected. Adélie and Chinstrap penguins have similar foraging ecology in terms of diet, dive depths and phase-dependent foraging ranges. Allochrony is therefore likely to be important in reducing competition between these species. This leads us to formulate the following hypotheses:

- a. Adélie and Chinstrap penguins show phase-dependent foraging distributions
- b. Allochrony causes “leap-frogging” of foraging areas
- c. Breeding synchronisation would substantially increase niche overlap
- d. Phenology of the two species will advance in parallel due to climate change as competition will be an important selective force in preserving allochrony

Data was collected at Signy Island, South Orkneys during breeding seasons from 1999 to 2015. Penguins were fitted with rapid-acquisition GPS, (43 Adélie and 52 Chinstrap), or PTT tags, (50 Adélie and 75 Chinstrap; tag type year dependant). Phases were defined as incubation (~33days), guard (~22 days) and crèche (~25 days).

Foraging paths will be modelled in the ‘R’ package CRAWL, which accounts for ARGOS errors and uncertainty in the path the bird followed between fixes. Species- and phase-specific foraging areas will be determined and overlaps assessed, both on the basis of the observed level of allochrony and on the assumption of complete synchrony due to climate change, to quantify the degree of niche partitioning that allochrony induces. ANCOVA will be used to model species-specific relationships between hatching dates and temperature to determine whether their phenology advances in parallel or interactively and quantify the change in competition future warming scenarios may produce.

Changes in pelagic fish shoaling behaviour are likely to complicate interpretation of results from studies aimed at detecting effects of pelagic fishing on seabird foraging

Janet C. Coetzee¹, Dagmar Merkle¹, Johan Rademan¹

¹ Branch: Fisheries Management, Department of Agriculture, Forestry and Fisheries, Private Bag X2, Rogge Bay 8012, South Africa

A rapid decline in African penguin numbers gave rise to a programme of fishery closures around sensitive penguin breeding-colony islands off the West Coast of South Africa in 2008. This initiative included alternating closures to fishing around a pair of islands (Robben and Dassen Islands) in an attempt to determine whether or not an experiment would have a reasonable chance of detecting effects of closure to pelagic fishing for a number of key penguin demographic metrics.

Information on the availability of forage fish around the islands was collected during regular hydro-acoustic surveys. Apart from information on available fish biomass in close proximity to the islands, differences in fish shoaling behavior around these two islands and between periods when islands were open and closed to fishing have emerged. Our results suggest that pelagic fish shoals around Dassen Island are denser and have a greater vertical extent during open years, but are deeper in the water column, closer to the bottom and have a larger perimeter and an increased compactness index during closed years. This pattern switches around for schools found around Robben Island. The location of schools in the water column is likely to influence foraging success as penguins generally are limited by the maximum depth at which they can feed successfully. Foraging success rates are also likely to be influenced by school size, number of schools and level of organisation.

The facts that shoaling behaviour appears to differ between closed and open periods and that the direction of change in shoaling response to closure status changes between islands are important findings that are likely to complicate the interpretation of results from the island closure study and change our perceptions of the proportion of biomass available to penguins.

Investigating low breeding success as a possible cause for the decline of the little penguins

Diane Colombelli-Négrel¹

¹ Flinders University, School of Biological Sciences, Adelaide, Australia

Over the past decade, populations of little penguins (*Eudyptula minor*) have been seriously declining across South Australia. A number of factors have been suggested to explain this decline such as mortality at sea, emigration to other sites, low reproductive success and/or poor juvenile survival. But to date, the role of these variables is still not fully understood. In addition, to fully understand population decline, it is important to disentangle mortality of adults (which decrease population size) versus mortality of offspring (which suppress population dynamics). In this study, I investigated breeding performance and return rates of little penguins on Granite Island for 17 years in relation to patterns of population decline. I focused on the impacts of human disturbance, breeding site, abandon and predation on breeding success. Despite drastic population decline since 2001, breeding success on Granite Island has increased significantly from 0.54 fledglings per breeding pair in 1990 to 1.50 in 2013. Breeding site was the main factor affecting breeding success, but I also found a negative impact of predation. However, I found that both fledgling and adult return rates were extremely low, suggesting little survival between years – perhaps due to low survival from parasites, starvation, or marine predators.

Trophic ecology of African penguins: A review and contribution from stable isotopes

Maëlle Connan¹, G J Greg Hofmeyr^{2,3}, Lorien Pichegru¹, Alistair McInnes⁴, Pierre A Pistorius¹

¹DST/NRF Centre of Excellence at the Percy FitzPatrick Institute of African Ornithology, Department of Zoology, Nelson Mandela Metropolitan University, PO Box 77000, Port Elizabeth 6031, South Africa, ²Department of Zoology, Nelson Mandela Metropolitan University, PO Box 77000, Port Elizabeth 6031, South Africa, ³Port Elizabeth Museum at Bayworld, Humewood 6013, Port Elizabeth 6013, South Africa, ⁴DST/NRF Centre of Excellence at the Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa

The endangered African penguin *Spheniscus demersus* is endemic to southern Africa and the only penguin species breeding on the African continent. Its population has decreased dramatically over the last century from more than 1.5 million in the early 1900s to c.a. 17 000 pairs in 2013. From the inception of African penguin diet studies in the 1950s, all but one have identified prey or prey remains from stomach contents. Despite all the advantages of this method, it has well known biases such as being a snap-shot method and not accounting for the differential digestion of prey species. Furthermore, contents obtained from breeding adults at their colonies represent the chick's rather than adult's diet. Therefore we assessed diet using a combination of stomach contents and stable isotope samples. Fieldwork was conducted in 2013 at two of their largest breeding colonies: St Croix and Bird islands in Algoa Bay (south-east coast of South Africa). In addition to stomach contents, various samples (blood, feathers, egg membranes) were collected for carbon and nitrogen stable isotope analyses. This allowed us to study the influence of colony (St Croix/Bird), season (non-breeding/breeding/prior to moulting/prior to laying), stage (adult/chick), and adult's sex (male/female) on the diet. Results indicate that anchovy *Engraulis encrasicolus* represented >98 % of identified prey in the stomach contents. Colony, season and stage, but not adult sex, significantly influenced stable isotope values. Isotopic niches identified by standard Bayesian ellipse areas, and convex hulls, highlighted differences among groups and the variability among individual penguins. The Bayesian mixing model MixSIAR GUI revealed that adults favoured chokka squid *Loligo vulgaris* for themselves during particular stages of their annual cycle, but concurrently fed their chicks small pelagic fish. Our findings provide new insights in the feeding ecology of African penguins and this may help to understand how African penguins respond to changes in the marine environment.

The economic value of penguins and their tenuous conservation status: are we investing in penguin futures?

Peter Dann¹, Dee Boersma² et al.

¹Research Department, Phillip Island Nature Parks, PO Box 97, Cowes, 3922. Australia, ²Department of Biology, University of Washington, Seattle, WA 98195-1800, USA

Global tourism generates \$1.2 trillion annually and economically rivals many industries including mining and fishing in some areas. Wildlife tourism is estimated to contribute 20-40% to global tourism. Penguins appeal to a wide range of audiences for a variety of reasons. Whether it is their gait and general appearance, their being an integral part of a broader ecotourism experience or their remarkable specialisations to life at sea, penguins enjoy universal popularity and are a significant contributor to wildlife tourism in the Southern Hemisphere. Tourism experiences associated with penguins in the wild are generally visits to colonies or landing sites. Our preliminary estimates of the value of penguin-related tourism worldwide indicate that it is in the billions to regional economies (*we are currently preparing a full analysis for this presentation*). Penguin popularity and their capacity or potential to generate wealth would seem to ensure their protection in perpetuity. However this is far from the case. According to the IUCN (2013), 11/18 species of penguin (60%) are threatened. In an extensive review of threats facing penguins, Trathan et al (2014) listed pollution, habitat loss and impacts of fishing as primary threats to penguins worldwide; all factors humans can readily mitigate. Increased threats from climate change are also predicted and at their current rate of becoming threatened, penguins may disappear from much of their range. The disparity between the declining conservation status of penguins and our affection for them raises two obvious courses of action. Firstly we need to increase our efforts to ensure that everyone is aware of the threats facing penguins and what can be done to ameliorate these threats, and, secondly, we need to use every argument for appropriate responses to their deteriorating situations including the importance of their economic value. In this presentation we will examine the status, and management of the world's penguins in relation to the tourism benefits they provide with a view to determining what we have learnt and what we do next to afford better protection for the world's penguins.

Molecular evidence of extra-pair paternity and intraspecific brood parasitism in Magellanic Penguin (*Spheniscus magellanicus*)

Anna Carolina Milo Marasco¹, João Stenghel Morgante¹, Melina Barrionuevo², Esteban Frere², Gisele Pires de Mendonça Dantas³

¹Universidade de São Paulo, Instituto de Biologia, Brazil, ²Universidad Nacional de la Patagonia Austral, Puerto Deseado, Argentina, ³Pontifícia Universidade Católica de Minas Gerais, PPG Biologia de Vertebrados, Brazil

Recent studies have shown that, despite most of the avian species being socially monogamous, they present different reproductive strategies, such as extra-pair paternity (EPP) and intraspecific brood parasitism (IBP). We investigated the genetic mating system of Magellanic penguins (*Spheniscus magellanicus*), a seabird species that is supposed to be extremely monogamous, with low or no evidence of extra-pair paternity, due to philopatry, partners faithfulness among years and intense biparental care. During two breeding seasons (2010 and 2011) we sampled 170 individuals of 44 different nests from Isla Quiroga colony (88 offspring, 38 putative mothers and 44 putative fathers) and the parentage was determined based on the analysis of 9 microsatellites markers. Extra-pair paternity was detected in 31% of all offspring and 48% of the nests had at least one extra-pair young. In addition, 6% of chicks were not the offspring of the putative mother or either member of the social pair, indicating evidence of intraspecific brood parasitism. These results reveals a low rate of IBP, but a high rate of EPP, both previously undescribed for this species and shows that Magellanic Penguins successfully engage in extra-pair copulations.

Penguins Online

Lloyd S. Davis¹

¹Centre for Science Communication, University of Otago, Dunedin, New Zealand

The last 20 years has seen a revolution in the way people access information: today the most common – and still growing – means for gathering information about penguins is through the internet. As penguin researchers, then, it behoves us to have an online presence, but it is not enough to simply put information online and hope that it will reach its intended audience. The sheer volume of online resources is enormous and getting your “voice” heard is difficult. “Content is king” is an oft-repeated adage about the internet, but research suggests that good content by itself may not be enough to ensure high rankings by search engines or visitations to a website. Here I report on the findings of a unique study that aimed to determine the most important elements attracting visitors to webpages about penguins. I established 19 websites about individual species of penguins. To standardise the content and provide comparable information on each species, I used species’ descriptions taken from *Penguins* by Davis and Renner (2003, Poyser). To control for differences in popularity of each penguin species in online searches, I took the number of monthly searches for each penguin name (as provided by Google Adwords) in concert with the number of unique visitors to each site (determined from Google Analytics and Awstats) to calculate audience reach. All the websites were initially generated in Rapidweaver using Elixirgraphic’s Ruby theme to create sites with the same simple design. The sites were maintained in this fashion for over a year to provide a baseline level of activity. Thereafter, groups of sites were manipulated systematically either by adding header images, images embedded within the content, video, additional content, or content written in a more “accessible style.” Features that made a website more media-rich positively influenced the number of visitors to a site and improved rankings in online searches using Google and Bing, although the effect was not consistent for all sites. Similarly, both the volume of content and the accessibility of the writing had a positive effect too. One of the most dramatic findings of this ongoing research has been the evident effect of the domain name itself, with names that contain the actual search term and .com (versus .org or .net) names providing a significant advantage. In sum, presentation and packaging are as important for the efficacy of communicating science about penguins in the online arena as the information itself.

Breeding propensity, age-specific survival, and age-at-1st reproduction of Adélie penguins in relation to colony size and environmental variation

Katie M. Dugger¹, David G. Ainley², Grant Ballard³, Phil O'B. Lyver⁴, Kerry Barton⁵

¹U.S. Geological Survey, Oregon Cooperative Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon, USA, ²H.T. Harvey and Associates, Los Gatos, California, USA, ³Point Blue Conservation Science, Petaluma, California, USA, ⁴Landcare Research, Christchurch, New Zealand, ⁵BartonK Solutions, Nelson, New Zealand

Similar to other seabirds, the Adélie penguin (*Pygoscelis adeliae*) exhibits high survival, delayed maturation & high breeding philopatry, although we previously confirmed that survival & breeding philopatry can vary in response to environmental variation. However, age-related variation in key demographic parameters is still poorly understood for this species. Using data collected on individuals banded as chicks, and multi-state capture-recapture models, we estimated age-related variation in survival, age-at-1st reproduction and breeding propensity over 18 years from a 3-colony metapopulation in the Ross Sea, Antarctica. A preliminary analysis with 13 years of data suggested that survival varied in relation to breeding status (non-breeder>pre-breeder>breeder), age (lowest survival observed the first 2 years), colony size (lower survival at smallest colony), and by year. Recruitment rate into the breeding population increased through age 8, with no differences observed between colonies and penguins do not breed every year after recruitment into the breeding population. This initial analysis did not yet reach the upper limit of the breeding Adélie penguin lifespan, so the addition of 5 more years of data may help us disentangle the confounding effects of age class, reproductive state and environmental variation. Understanding the complex population dynamic components of this system may help us understand the mechanism responsible for maintaining the large degree of size discrepancy (orders of magnitude differences) amongst these 3 colonies & the role annual environmental variation plays in maintaining this system.

Plasticity of penguin foraging behaviour in the face of environmental change – implications for conservation

Ursula Ellenberg^{1,3}, Thomas Mattern^{1,2,3}, Pablo Garcia-Borboroglu³, Klemens Pütz⁴, Philip J. Seddon²

¹Department of Ecology, Environment and Evolution, La Trobe University, Melbourne, Australia, ²Department of Zoology, University of Otago, Dunedin, New Zealand, ³Global Penguin Society, University of Washington, Seattle, USA,

⁴Antarctic Research Trust, Am Oste-Hamme-Kanal 10, 27432 Bremervörde, Germany

Seabirds are often protected at their breeding colonies whereas conservation of their marine habitat is lagging behind. Even the definition of marine important bird areas (IBAs) proves difficult due to limited understanding of large scale dynamic marine processes that will affect seabird distribution and foraging success. A first step are national efforts to protect marine habitats adjacent to important breeding colonies. Using two New Zealand penguin species as an example, we illustrate current challenges and opportunities for effective and anticipatory protection of coastal marine habitats in the face of environmental change. Species with a restricted breeding distribution are considered particularly vulnerable to environmental change and perturbations in their marine habitat. Fiordland penguins (*Eudyptes pachyrhynchus*) breed discontinuously confined to a mere ~500km stretch along New Zealand's rugged southwest coast. Yet, despite their limited distributional range, the species appears remarkably adaptable using diverse oceanic habitats, ranging from shallow coastal and continental shelf, to pelagic and even fjord ecosystems with an agility we are just beginning to appreciate (see presentation by Mattern et al.). Yellow-eyed penguins (*Megadyptes antipodes*), in comparison, appear less flexible in their foraging strategies. As almost exclusive bottom foragers Yellow-eyed penguins are limited to the shallow continental shelf regions along the more accessible southeast coast of the South Island, Stewart Island and outliers. We know next to nothing about Yellow-eyed penguin populations on the sub-Antarctic Auckland and Campbell Islands other than they may be declining similar to their mainland counterpart. Both, Yellow-eyed and Fiordland penguins are endemic to southern New Zealand and classified as threatened, although there is a mismatch in threat categories considered by the IUCN and New Zealand's own classification system (Yellow-eyed penguins, IUCN endangered, NZ vulnerable; Fiordland penguins, IUCN vulnerable, NZ endangered). While threats on land are reasonably well understood and managed, the threats they are exposed to at sea require urgent attention. We will discuss how the differences in marine ecology and behavioural plasticity of Fiordland and Yellow-eyed penguins may affect their ability to cope with environmental change, and provide data to inform and refine current conservation efforts.

The paleohistory of Adélie Penguins in the Ross Sea since the Last Glacial Maximum: a review and update

Steven D. Emslie

Department of Biology and Marine Biology, Univ. of North Carolina, 601 S. College Rd., Wilmington, NC 28403 USA

The past record of Adélie penguins (*Pygoscelis adeliae*) in the Ross Sea region, Antarctica, now extends to over 45,000 years and is the longest record known for any living species of penguin. Because this species requires ice-free terrain for breeding and open-water access to beaches where colonies are located, it is an excellent indicator species for past marine and sea ice conditions. Previous research on abandoned colonies in the Ross Sea has indicated that this region was occupied by these penguins before the Ross Ice Shelf began advancing ~27,000 years ago at the beginning of the last glacial period. Penguins disappeared from the Ross Sea as this shelf advanced and blocked coastline, reaching its maximum extent by the Last Glacial Maximum at ~18,000 – 20,000 B.P. Adélie penguins presumably were occupying refugia on islands or portions of the continental shelf that were exposed above sea level at that time and did not begin reoccupying the Ross Sea until ~8000 B.P. when the Ross Ice Shelf was retreating to its current position during Holocene warming. New data from this region add to the known occupation history of Adélie penguins and how climate events in the Holocene over the past 8000 years have caused abandonment and occupation of colonies along the Scott and Victoria Land Coasts in relation to sea ice extent and other factors. One large-scale population shift is hypothesized from the southern to northern Ross Sea at ~2000 B.P. when the Scott Coast was abandoned and remains so today. This hypothesis is being tested with new radiocarbon and stable isotope ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) analyses on penguin tissues recovered from excavations of abandoned colonies from Cape Hallett and Cape Adare in the northern Ross Sea.

IUCN Penguin Specialist Group and penguins' conservation status

P. Garcia Borboroglu^{1,2}, P. D. Boersma^{1,2}, S. Ellis^{1,2}, A. Chiaradia^{1,3}, R. Moreno⁴, K. Pütz⁵, T. Schneider⁶, P. Seddon^{1,7}, A. Simeone^{1,8}, C. Small⁴, A. Steinfurth⁹, P. Trathan^{1,10}, L. Waller^{1,11}, B. Wienecke^{1,12}

¹IUCN SSC Penguin Specialist Group Steering Committee, ²Global Penguin Society, U.S.A./Argentina, ³Phillip Island Nature Parks, Australia, ⁴BirdLife International, ⁵Antarctic Research Trust, ⁶Association of Zoos & Aquariums,

⁷University of Otago, New Zealand, ⁸Universidad Andres Bello, Chile, ⁹DST-NRF, Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Scientific Director, ¹⁰British Antarctic Survey, U.K., ¹¹Cape-Nature, South Africa,

¹²Australian Antarctic Division, Australia

The International Union for the Conservation of Nature (IUCN) Species Survival Commission (SSC) approved the establishment of the Penguin Specialist Group (PSG) and asked Dr. Borboroglu and Dr. Boersma to be Co-Chairs. They appointed a Steering Committee that participated of the first workshop of the group held in March in Florida, U.S.A.. The Steering Committee defined the PSG's vision as "Wild penguins in perpetuity", with a mission to "provide scientific advice that informs policy and engages people in effective conservation action". The Global Penguin Society fostered the initiative and is acting as its partner funding organisation. Among several goals, the group seeks to: identify studies needed, critical areas, management actions, and threats to penguin species; provide scientific advice on conservation and management of penguins to interested parties; facilitate dissemination of scientific information concerning penguins, including supporting publications and regional and international meetings and to coordinate input from penguin experts worldwide to compile information for the IUCN Red List assessments. Just prior to the IPC9, a Penguin Specialist Group workshop was organised, material compiled and information provided for Birdlife to assess the conservation status for the 18 penguin species. A review of the process to establish the Penguin Specialist Group, the evolution of penguin conservation status, and the conservation priorities identified by the Group in the workshop will be presented.

The long and winding road to the Punta Tombo Marine Protected Area: Mickey Mouse vs. powerful fisheries

P. Garcia Borboroglu^{1,2,3}, L. M. Reyes^{3,4}, M. Giaccardi³, P. D. Boersma^{2,3}, G. A. Rebstock^{2,3}, M. E. Góngora⁴, N. Caloni⁵

¹National Research Council-CONICET, Argentina, ²University of Washington, U.S.A, ³Global Penguin Society, U.S.A./Argentina, ⁴Universidad Nacional de la Patagonia San Juan Bosco, Argentina, ⁵Universidad Nacional de General Sarmiento

At their largest colony, Punta Tombo, Chubut, Argentina, active nests of Magellanic penguins declined >30% over 30 years. Reproductive success is low, feeding trips increased 45 km over 10 years, and starvation, the major cause of chick death, kills nearly 40% of chicks annually. A 210-ha Provincial reserve protects part of the breeding colony on land but until now there was no marine protected area (MPA). An MPA protecting the foraging area of adults with small chicks (a critical stage of the breeding cycle) could reduce chick starvation and adult mortality, and increase reproductive success. Using available science the Global Penguin Society (GPS) and the Government of Chubut Province promoted, designed and financed this initiative. The MPA created, located on the central Patagonian coast of Argentina, includes 60 kilometers of coastline and will influence the management of 100,000 hectares extending 12 nautical miles offshore. Its main goal is to protect the feeding area of 500,000 Magellanic penguins that breed in nearby colonies. It also aims to protect the eco-tourism industry and improve the management of fishing activity. Nature-based tourism is one of the main sources of incomes and jobs for this region. The MPA is now one of the core areas of the recently designated Blue Patagonia UNESCO Biosphere Reserve. Political interest in this MPA was garnered thanks to the visit of the Walt Disney Company during a very limited window of political opportunity to secure this protection. Seven days before the change of governors, legislators and President in Argentina, the Legislative Body of Chubut Province approved the MPA (Law 103/15). Science was important but political and economic interests behind the scenes were crucial aspects of negotiation. At the very last minute, fisheries brought pressure and politicians managed to stop the treatment of the law at the congressional plenary session. By then, scientific evidence was not even a variable on the table. Intense interaction with the media, current and future government officials, and travel agents that operate in Punta Tombo helped to balance the discussion. Final negotiations that reduced the originally proposed area and some changes in the draft law were successful in protecting foraging areas for penguins and a rich assemblage of other marine species using these waters.

Investigating the effects of spatial management of South African fisheries on African penguins *Spheniscus demersus* in the Western Cape

Jennifer Grigg¹, Richard B. Sherley², Antje Steinfurth^{3,4}, Kate Campbell^{4,5}, Katrin Ludynia^{4,6}, Azwianewi B. Makhado⁷, Leisha Upfold⁷, Johan Visagie⁸, Robert J.M. Crawford^{4,5,7}, Marc Holderied¹, Grainne McCabe⁹

¹Department of Biological Sciences, University of Bristol, UK, ²Environment and Sustainability Institute, University of Exeter, UK, ³Percy FitzPatrick Institute of African Ornithology, DST-NRF Centre of Excellence, University of Cape Town, South Africa, ⁴Marine Research Institute, University of Cape Town, South Africa, ⁵Animal Demography Unit, University of Cape Town, South Africa, ⁶Department of Biological Sciences, University of Cape Town, South Africa, ⁷Department of Environmental Affairs, Cape Town, South Africa, ⁸CapeNature, South Africa, ⁹Bristol Zoological Society, Bristol, UK

The African penguin *Spheniscus demersus* population has decreased by over 90% since 1900 and, in South Africa, within the last decade has decreased by around 10% per year since 2004. Reduced access to food, has influenced breeding success and survival of African penguins and driven the current decline. Shifts in prey availability away from South Africa's west coast have resulted in a mismatch between the locations of the penguin breeding colonies and their prey. However, it remains unclear whether commercial fisheries affect the penguins by competing for food and over what spatial scale this occurs. Poor sardine availability, potentially exacerbated by a regional concentration of fishing effort, may also be affecting the population. As the population decline continues, it becomes increasingly important to understand the penguin-fishery competition and implement appropriate spatial management.

Since 2008 experimental small-scale closures to purse-seine fishing have been alternated around four main breeding colonies off the west and south coasts of South Africa. In addition, in 2014 an agreement with the sardine fishery was implemented, whereby sardine catches between the west and south coasts is to be split in proportion to the respective observed biomass distribution. Indicators of African penguin breeding output as measured by chick growth and chick condition, as well as foraging parameters have been collected at all four islands since 2008. Comparisons of these indicators from Robben Island and Dassen Island, penguin breeding colonies off the west coast of South Africa, provide an insight into the effectiveness of these fisheries management regimes as conservation measures for African penguins.

While fishing closures were in place, African penguins at Robben Island decreased their foraging effort, and chick condition increased significantly. However, there was no difference in chick growth. In contrast, at Dassen Island, the closures provided no benefit to foraging or penguin breeding output. In order to determine the impact of the spatial management of the sardine fishery, further years of monitoring are required. This will provide data over a sufficient number of years to identify trends and disentangle the effects of fisheries management from seasonal effects. Overall these results suggest that small scale fishing closures can benefit African penguins, but would not be sufficient to offset current population declines on their own. Further research is required to determine whether small-scale closures in conjunction with other spatial management systems would be effective in mitigating the effect of changing environmental conditions for African penguins.

Pre- and post-moult movements of African Penguins

Jennifer Roberts¹, Christina Hagen², Lorien Pichegru^{1,3}, Peter Ryan¹, Ross M. Wanless^{1,2}

¹Percy FitzPatrick Institute for African Ornithology, University of Cape Town, ²Seabird Conservation Programme, BirdLife South Africa, ³Coastal and Marine Research Institute at the Nelson Mandela Metropolitan University, South Africa

Moult in penguins is an energetically expensive process that entails an enforced fast of several weeks, so it is essential that birds store sufficient reserves to survive the moult itself and resume foraging immediately thereafter. The population of African Penguins *Spheniscus demersus* has undergone a rapid decrease in the last 60 years and it is thought that low adult survival rates are the cause. Little is known about the movements of African Penguins outside of the breeding season, a time when mortality may increase. We investigated the movements of penguins from two colonies, Dassen Island (west coast) and Bird Island (south coast), over three years during the pre- and post-moult foraging periods to determine the threats they might face during these times and what potential conservation measures could be put in place. Tracking devices (either Platform Terminal Transmitters or GPS loggers) were attached to adults with large chicks to determine pre-moult movements and adults that had finished moulting and met feather length and body condition criteria to track post-moult movements.

The non-breeding home range of adult African penguins from each colony was calculated using minimum convex polygons. Simple linear models were used to assess initial mass, body condition and track parameters in relation to island, period (pre- or post- moult), year and sex. Fine-scale fisheries catch data were obtained from the Department of Agriculture, Forestry and Fisheries and the overlap compared with penguin use areas.

During both pre- and post-moult periods penguins from Dassen Island travelled farther than those from Bird Island and spent more time at sea. There was little overlap between the pre- and post-moult distributions of penguins from Dassen Island, while at Bird Island there was substantial overlap between the two periods, especially in the vicinity of the island. Similar areas were used by penguins at both islands between years. The areas of highest overlap between penguin use areas and fish catch were concentrated in small specific areas on the west coast, with little overlap on the south coast. The findings support previous evidence that Bird Island is a more predictable feeding environment; penguins are in better condition and do not need to travel as far to find food before and after moulting. The large distances travelled by the penguins during the non-breeding period make conservation action difficult, however there are areas used consistently by penguins and fisheries that could be targeted for innovative fisheries management strategies.

Habitat influence on foraging characteristics of Gentoo penguins (*Pygoscelis papua*) at the Falkland Islands

Handley J¹, Ratcliffe N², Baylis A³, Crofts S³, Stanworth A³, Brickle P⁴, Pistorius P¹

¹DST/NRF Centre of Excellence at the Percy FitzPatrick Institute for African Ornithology, Department of Zoology, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa, ²British Antarctic Survey, Cambridge, UK, ³Falklands Conservation, Falkland Islands, ⁴South Atlantic Environmental Research Institute, Falkland Islands

The Falkland Islands now globally hold the largest population of Gentoo penguins, *Pygoscelis papua*. Understanding the mechanisms driving their foraging ecology at this archipelago is therefore largely relevant to the species as a whole, and is important for effective conservation management. We use the first combination of TDR, GPS and animal borne camera loggers for a penguin species, coupled with data from stomach content analysis, at multiple sites across the Falkland Islands, to gain insight into Gentoo penguin foraging ecology. The study was conducted during the breeding period, in the austral summer of 2012 and 2013. A total of 90 birds were fitted with both TDR and GPS units, of which 41 also carried cameras. Ninety seven diet samples were collected, with 26 of these from birds carrying all three instruments. Birds were sampled from three colonies across the archipelago, Steeple Jason in the Northwest, Cow Bay in the Northeast and Bull Roads in the South. During all sampling periods, the mean maximum distance from colony, total trip distance and trip duration were greatest at Cow Bay. Similarly, key dive characteristics showed birds to be diving deepest and for greatest duration at Cow Bay. Using filtered location data based on dive position we identified key foraging areas. Camera footage, coupled with stomach content analysis, revealed that at Bull Roads where crustaceans dominated the diet, there was a high prevalence of crustaceans in the footage. This was in contrast to Cow Bay, where fish dominated the diet, and minimal crustaceans were seen in the footage. These data increase our knowledge of Gentoo penguin foraging ecology. Notably too, we shed new light on the use of animal-borne camera loggers as potential indicators of prey availability and display the use of free software in order to quantify prey abundance.

Validating a Citizen Science reveals patterns in phenology and reproductive success around the Scotia Arc.

Tom Hart¹, Caitlin Black¹, Louise Emmerson², Casey Youngflesh³

¹Department of Zoology, University of Oxford, South Parks Road, Oxford, OX1 3PS, UK, ²Department of Environment, Australian Antarctic Division, Channel Hwy, Kingston, Tasmania, Australia, ³Department of Ecology and Evolution, Stony Brook University, Stony Brook, NY 11794 USA

Within the Antarctic Peninsula, the potential threats of climate change, fishing, tourism and science are all confounded. To disentangle these threats, we require increased replication and representation of colonies exposed to different levels of these threats. Remote, time-lapse cameras offer an insight into the lives of colonial seabirds through year-round constant-effort monitoring. Since 2010, we have placed a network of cameras throughout the Scotia Arc, which can now be used to extract data on the timing of breeding, reproductive success and predation rates of different colonies. These cameras have generated hundreds of thousands of photos over five years, presenting a new challenge in terms of data extraction, curation and processing.

Using a citizen science approach, we test whether accurate data can be extracted from images on a large scale, suitable for processing data from a network of over 100 cameras. In September 2014, we launched Penguin Watch (www.penguinwatch.org), which is a citizen science portal where volunteers interpret images via clicking on penguins. In the first year of launch, 2.5 million visitors annotated 80 million penguins from 300,000 images. Here we present the first results of this citizen science programme and we demonstrate the accuracy and scope of the data that can be extracted from such a network. We conclude by demonstrating the utility for nest-based survival tools across a range of colonial species.

Overlap of the foraging habitats of krill-dependent penguins with the Antarctic krill fishery in the southwest Atlantic

Jefferson T. Hinke, Anthony M. Cossio, Michael E. Goebel, Christian S. Reiss, Wayne Z. Trivelpiece, George M. Watters

Antarctic Ecosystem Research Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration 8901 La Jolla Shores Drive, La Jolla 92037, USA

In the Scotia Sea, krill-dependent penguins forage in waters that are actively fished for Antarctic krill. Potential competition for this shared resource is a motivating factor for ongoing work to understand fishery impacts on penguins. Despite a long-standing monitoring program to study penguins throughout the Scotia Sea, clear parameterization of the functional responses of krill-dependent predators to variation in krill biomass and/or krill catches remains elusive. In the absence of clear functional responses, alternative metrics of predator-fishery interactions may provide useful means to advance precautionary management of the krill fishery. Tracking data on penguins provide clear insight on habitats used by predators to sustain their populations. As such, the data represent a critical piece of information for informing spatial allocations of catch in fisheries management. Therefore, we analyzed six years of satellite telemetry data, collected from 2009 through 2014 at Cape Shirreff, Livingston Island and Admiralty Bay, King George Island, to identify the extent and location of areas with concurrent overlap of predators and krill fishing activity. Concurrent overlap was observed throughout the Scotia Sea across a range of spatiotemporal scales despite relatively small populations of instrumented animals and short deployments that occurred mainly during summer breeding seasons. Areas of high overlap generally occurred near tagging locations but also in more distant areas where fishing activity was concentrated. Overlap generally occurred where mean krill densities were relatively high, both in horizontal and vertical space. In particular, overlap was relatively high the Bransfield Strait, commensurate with recent intensification of fishing activity there and seasonal movements of predators into the Bransfield Strait during winter. Our results demonstrate that direct overlap of krill-dependent predators with the fishery on small spatiotemporal scales is relatively common in the Antarctic Peninsula region. A precautionary approach to the allocation of krill catches suggests that measures to avoid large increases in catch in areas of overlap are prudent. We also note that a new study, to be conducted in 2016/17, will track penguins from numerous breeding sites scattered throughout the Antarctic Peninsula with the aim increasing the spatial extent of data on habitat use by Pygoscelid penguins during winter.

Estimating annual and lifetime reproductive performance of known-age Adélie penguins: An exploration of life history theory

Peter J. Kappes¹, Katie M. Dugger², Grant Ballard³, David G. Ainley⁴, Phil O'B. Lyver⁵, Kerry J. Barton⁶, Alexander D. Fraser^{7,9}, Robert A. Massom^{8,9}

¹Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife Unit, Oregon State University, Corvallis, OR, USA, ²U.S. Geological Survey, Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife Unit, Oregon State University, Corvallis, OR, USA, ³Point Blue Conservation Science, Petaluma, CA, USA, ⁴H.T. Harvey and Associates, Los Gatos, CA, USA, ⁵Landcare Research, Lincoln, New Zealand, ⁶BartonK Solutions, Nelson, NZ, ⁷Institute for Low Temperature Science, Hokkaido, University, Japan, ⁸Australian Antarctic Division, Department of the Environment, Kingston, Tasmania, Australia, ⁹Antarctic Climate and Ecosystems Cooperative Research Centre, University of Tasmania, Hobart, Tasmania, Australia

Life history theory posits that natural selection results in individuals optimizing the allocation of resources to maximize lifetime reproductive output (fitness). Because an individual's residual reproductive value decreases with age, life history theory predicts that iteroparous breeders should maximize their fitness by allocating investment between current and future reproduction. Various hypotheses have been proposed to explain observed patterns of age-based reproductive performance. These explanations and mechanisms are not necessarily mutually exclusive and in combination can produce a variety of age-related patterns. Because both within-individual change (e.g. intrinsic: experience, senescence; extrinsic: habitat, environment) and between-individual change (e.g. selective appearance and disappearance of phenotypes) influence fecundity, disentangling these effects can help us understand the patterns they produce. Ultimately, studies of age-dependent reproductive performance should take into account individual heterogeneity in life histories and encompass the entire lifespan of the individual. Differences in individual quality, age, or experience are not always evident under "average" environmental conditions; thus, life history studies of age-dependent reproductive success should incorporate and account for responses associated with the full range of environmental conditions that characterize the system. We used a 20-year mark-resighting data set of known-age Adélie Penguins to investigate patterns in individual age-based fecundity and lifetime reproductive success. Our study encompassed a range of sea ice conditions, including extremes in sea ice conditions, in order to investigate hypotheses proposed to explain age-based fecundity patterns and lifetime reproductive performance. These are being used to parameterize an agent-(individual-) based population model of the Ross Island, Antarctica Adélie penguin metapopulation.

Emperor Penguin Colony Populations in the Ross Sea from 2000 to 2012; end of an era of aerial photographic censuses and colony assessments

Gerald L. Kooyman, Paul J. Ponganis

Center for Marine Biotechnology and Biomedicine, Scripps Institution of Oceanography

There are seven emperor penguin colonies distributed throughout the traditional boundaries of the Ross Sea, extending from Cape Roget to Cape Colbeck. The length of the coastline, including the Ross Ice Shelf, is about 10 percent of the coast of Antarctica. Yet, the greatest concentrations of emperor penguins are found along this coastline. This is on the order of about 60,000 breeding pairs. Over a 12-year period from 2000 to 2012, there has been a nearly continuous record of population size of most, and sometimes all seven, of the Ross Sea emperor penguin colonies. All data were obtained by analyzing aerial photographs. The key finding compared to Pointe Géologie, the emperor penguin colony most often used in population models, which has been stable for nearly 40 years, is the large annual variations in populations of individual colonies in the Ross Sea. In two sequential years, the smallest colony of Cape Crozier has ranged from 1200 to 0 chicks fledged. The adult count of zero in 2001 at Cape Crozier was unprecedented. The event was cataclysmic. With the exception of the Cape Crozier recovery there are no trends in any other colony. Since 2000, Cape Washington, the world's largest colony, has hovered around 15,000 for both chicks and adults. From 1983-2000, when only chicks were counted, the total for chicks was nearer to 20,000. Cape Colbeck, on the other hand, doubled the number of chicks from 1994 to 2012. The adult count doubled between 2008 to 2012. In summary, our earlier conclusion from a 2007 report, "Ultimately, we expect emperor penguin populations are most responsive to local sea-ice conditions in the molt area, and at the colony," remains valid. A single emperor penguin colony may not be a good environmental sentinel, because this species of penguin is not bound to a nesting site like other penguins, but move about within the colony, and even to other colonies. There are at least three possibilities for census count fluctuations: 1) Harsh times cause a die-off of chicks in the colony or of adults elsewhere; 2) the adults emigrate; 3) the adults skip a year of breeding if pre-breeding foraging has been unsuccessful. Such variability indicates that all Ross Sea colonies should be sampled annually if there is any possibility of understanding the population changes and the most important environmental factors regulating the colony sizes.

Interaction of acoustic and visual signals involved in the mate choice of king penguins

Hannah Joy Kriesell^{1,2,3}, Thierry Aubin⁴, Francesco Bonadonna⁵, Anna Nesterova^{2,3,5}, Doris Gomez⁵, Marine Benoiste^{2,3}, Fiona Le Taro^{2,3}, Yvon Le Maho^{2,3,1}, Céline Le Bohec^{2,3,1}

¹Centre Scientifique de Monaco (CSM), Laboratoire International Associé 'BioSensib' (LIA 647/CSM-CNRS), Monaco,

²Université de Strasbourg, Institut Pluridisciplinaire Hubert Curien (IPHC), LIA-647 BioSensib, Strasbourg, France,

³Centre National de la Recherche Scientifique (CNRS), UMR 7178, LIA-647 BioSensib, Strasbourg, France, ⁴Institut des NeuroSciences Paris-Saclay (Neuro-PSI), UMR 9197 (CNRS, Université Paris XI), Orsay, France, ⁵Centre d'Ecologie Fonctionnelle et Evolutive (CEFE), UMR 5175 (CNRS, Université de Montpellier), Montpellier, France

Previous studies showed that coloured ornaments of king penguins (*Aptenodytes patagonicus*) play a role in mate choice. King penguins also use vocalisations during courtship and for kin recognition, hence relying on acoustic communication during the entire breeding season.

Thus, to understand the process of mate choice, we need to acknowledge the multimodal character of intraspecific signals involved. We hypothesize that mate choice in king penguins is based on interactions between acoustic and visual signals, reflecting the sex, quality, and breeding status/experience of individuals. This study is the first to investigate both call and ornament parameters in parading and breeding birds.

We expect that acoustic (e.g. total call duration, energy below 1500 Hz) and ornamentation characteristics (hue, chroma, brightness) and their relative contribution, differ between successful and unsuccessful breeders, and depend on who the signals are directed to (potential partner, definite partner, chick).

Data were collected at Possession Island, Crozet Archipelago, in 2015/2016. We sampled both early (November-December) and late parading/breeding individuals (January-March), since the timing of reproduction within a season has been shown to reflect relative fitness and influence lifetime reproductive success.

We first recorded display calls of king penguins during courtship. We then captured them for weight measurement and blood sampling (testosterone/oestrogen, corticosterone levels), reflectance and size of ornaments, and morphological measurements (beak, flipper, tarsae length). Calls and breeding status of individuals were recorded throughout the breeding season to investigate differences in call parameters with the fasting status and context (parading adults, breeding couples, parent-chick communication).

We secondly focused on micro-tagged birds being long-term monitored by an automatic identification system, allowing us to have precise life-history information. We explored the relation between acoustic/ornamentation characteristics, age and individual quality traits (i.e. breeding experience, breeding performance, and foraging efficiency). Calls of couples were

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recorded during partner shifts in incubation and guarding phases. Both partners were captured to obtain measurements as described above. We studied differences of acoustic and visual signals between the sexes and examined pairing assortment.

Preliminary results show that calls differ depending on the context, i.e. calls of parading birds being shorter, containing fewer syllables than calls of individuals during shifts. First analyses showed a correlation between spectral parameters of the beak spot and age and body condition, suggesting that ornaments signal individual quality to conspecifics.

This study integrates multimodal signals and will allow for a better understanding of mate choice and individual quality information encoded in those signals.

Fossil Evidence for the Timing and Pattern of Penguin Evolution

Daniel T. Ksepka

Bruce Museum

Penguins have one of the deepest and most extensive fossil records within Aves. Fossils from stem lineage penguins (lineages that diverged prior to the last common ancestor of the 18 extant penguin species) reveal details of the early history of Sphenisciformes and have greatly expanded our understanding of the first 50 million years of penguin evolution.

Despite progress in resolving penguin phylogeny, the age of the penguin crown clade remains controversial. Analyses employing “molecular clocks” have yielded estimates for the last common ancestor of the 18 extant penguin species ranging from 20.4 to 40.5 million years. Novel methods for simultaneously analysing molecular and morphological data allow temporal and morphological character data from fossil penguins to inform both the shape of the phylogenetic tree and age estimates for divergence events. Analyses using these methods suggest that the last common ancestor of modern penguins evolved only ~12.5 million years ago. Within this framework, we can explore the timing of shifts in penguin anatomy. Data collected from new specimens has revealed that early stem penguins retained a transitional humerus bone microstructure that is similar to that of subadults of modern penguins, but had already acquired dense, osteosclerotic bone in the hindlimb elements. New endocasts from Antarctic fossil penguins reveal several transitional features including olfactory bulbs that are reduced compared to petrels but larger than those of modern penguins, and a lack of caudal expansion of the Wulst, a protrusion of the cerebral hemisphere.

Tracking Adélie penguins throughout their lives: how do inter-individual differences in foraging ecology translate into demographic differences?

Amélie Lescroët¹, Grant Ballard², Melanie Massaro³, Katie Dugger⁴, Scott Jennings⁵, Annie Pollard⁶, Elizabeth Porzig², Annie Schmidt², Phil Lyver⁷, David Grémillet¹, David Ainley⁸

¹Centre d'Ecologie Fonctionnelle et Evolutive, UMR 5175, CNRS - Université de Montpellier - Université Paul-Valéry Montpellier - EPHE, Montpellier, France, ²Point Blue Conservation Science, Petaluma, California, USA, ³School of Environmental Sciences, Charles Sturt University, Albury, Australia, ⁴U.S. Geological Survey, Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Department of Fisheries and Wildlife, Corvallis, Oregon, USA, ⁵Oregon State University, Department of Fisheries and Wildlife, Corvallis, Oregon, USA, ⁶Coos Bay, O Point Blue Conservation Science, Petaluma, California, USA, ⁷Landcare Research, Lincoln, NZ, ⁸H.T. Harvey & Associates, Los Gatos, California, USA

Age variation in reproductive performance and survival of iteroparous breeders is a well-documented, widespread phenomenon. In vertebrate populations, average performance generally increases with age in early adulthood as a result of (1) a population process (i.e., the selective appearance/disappearance of individuals of different phenotypes) and (2) individual processes of maturation or restraint. In older age classes, the average reproductive performance and survival can either (1) decrease (i.e., senescence), (2) stay stable if the disappearance of frail individuals from the population masks senescence or if high mortality levels remove individuals from the population before they start to senesce, (3) increase as a result of terminal investment. The mechanisms underlying such age variation remain unclear, and proximate causes, such as differences in physiology and behavior, are just beginning to be investigated in the wild. As the ability of individuals to extract energy from their environment directly determines the amount of energy that can be invested in fitness-related activities, foraging efficiency appears to be a key parameter to investigate. Using time-depth recorder and 3-axis accelerometer data collected over 4 consecutive field seasons (2010-2013) on 173 known-age and known-breeding history Adélie penguins (3-15 yr old), we tested for the linear and non-linear effects of age on the foraging effort, success and efficiency. As inter-individual differences can be more pronounced when prey availability is low, we also tested for interactions between age and environmental conditions. Finally, we examined how inter-individual differences in foraging performance within a same age-class translate into differences in reproductive performance. Our results explain how a minority of individuals consistently achieves higher breeding success than others and therefore contributes the most descendants to the next generation.

The energetic challenges of foraging at sea: explaining normothermia and energy waste when resting in cold waters in king penguins (*Aptenodytes patagonicus*)?

Agnes Lewden¹, Tessa Van Valssum², Batshéva Bonnet³, Caroline Bost³, Yves Handrich¹

¹IPHC, DEPE, CNRS-UDS, UMR 7178, 23 rue Becquerel, 67087 Strasbourg Cedex 2, France, ²University of Roehampton, and department of Life Sciences Holybourne avenue SW16 4JD roehampton london, UK, ³Centre d'Etudes Biologiques de Chizé - Centre National de la Recherche Scientifique, 79360 Villiers en Bois, France

Penguins foraging at sea may experience substantial energy costs linked (1) to the research of favorable foraging areas located at several hundreds of kilometers from their breeding colony, (2) to the realization of intensive bouts of deep foraging dives and (3) to the thermogenic demands of resting at night in cold waters. While resting, one might expect energy expenditure to be minimal.

Surprisingly however, in king penguins (*Aptenodytes patagonicus*), studies have shown that resting at sea during the night could actually represent a higher energy cost than diving activities during daylight. This apparent paradox is probably linked with contrasting thermoregulation processes while foraging and resting. During hunting activities at depth, birds are believed to use adaptive hypothermia to reduce their energy expenditure and increase apnea capacity.

However, after their foraging day global body re-warming to normothermia contributes to increasing heat-loss during the night. We hypothesise that an energetic conflict occurs between thermoregulatory adaptations minimizing heat loss and the energy expended for digestive processes. While diving, using adaptive hypothermia saves energy, but birds are unable to assimilate the end products of prey digestion (i.e. free fatty acids; FFA) in their peripheral subcutaneous adipose tissue (SAT) as blood perfusion to SAT is reduced. While resting at night, re-perfusion of peripheral tissues would allow assimilating FFAs but with the unavoidable cost of re-warming and losing heat to the cold surroundings (energy loss).

Using an experimental set-up in a water-tank continuously renewed with natural cold seawater, we investigated variations in the body temperature of resting king penguin, and the relationship between body temperature and digestive processes. To this end, two groups of birds (fed or fasted during the day) were monitored while resting at night. We measured their energy expenditure with respirometry, heart rate frequency, and accelerometers to determine the energy cost of reconnecting blood circulation to peripheral tissues and maintaining normothermia in cold sub-Antarctic waters.

Geographic variation in vocal behavior of gentoo penguins (*Pygoscelis papua*)

Maureen Lynch, Heather Lynch

Stony Brook University

Very little is known about the vocal repertoire of gentoo penguins (*Pygoscelis papua*), and even less is known about the importance of vocal behavior in geographically-isolated colonies. The gentoo penguin's geographic range includes isolated sub-Antarctic Islands as well as the Antarctic Peninsula, and individuals are highly site faithful to discrete breeding colonies in those localities. There is evidence that gentoo penguins display vocal dialects on a broad regional scale, but we do not yet know at what spatial scale these vocal differences become apparent, or whether fine-scale divergence among breeding colonies in the same region may influence movement patterns of individuals among established populations, or into newly colonized populations. Geographic vocal divergence is not uncommon among birds, especially in those species that display vocal learning, and inter-colony variations in vocalizations have been observed in some colonial seabirds. These patterns indicate that there are benefits to having similar vocal characteristics to one's neighbors which outweigh the benefits of producing an individualized call among a high level of background noise.

To further explore the spatial pattern of gentoo penguin dialects, gentoo penguin ecstatic calls were recorded at multiple breeding colonies along the Antarctic Peninsula, South Georgia, and the Falkland Islands. Multivariate analyses were applied to characteristics of the ecstatic call to examine how characters differ among colonies, and how the degree of variation within a colony compares to variation among different colonies. Data from captive penguins were also included to examine whether zoo and aquarium populations present the same vocal behavior divergence as seen in the wild colonies and if that vocal divergence changes over time in newly established captive populations. These data give us a view into the importance of vocal behavior in established colonies, as well as in new and emerging colonies in the wild where mate choice and Allee effects may have marked effects on colony growth and success.

Attempted rescue of Africa's Penguins – South Africa's first marine biodiversity management plan

Makhado AB¹, Barham PJ², Crawford RJM¹, Hagen C³, Makoala M¹, Mann J⁴, Morris T³, Nupen L⁵, Parsons N⁶, Pichegru L⁷, Shannon LJ⁵, Sherley R⁸, van der Spuy S⁶, Waller LJ⁹, Weller F⁵, Oosthuizen WH¹

¹Department of environmental Affairs, ²University of Bristol, ³Birdlife South Africa, ⁴The South African Association for Marine Biological Research (SAAMBR), ⁵University of Cape Town, ⁶SANCCOB, ⁷Nelson Mandela Metropolitan University, ⁸CapeNature

The African Penguin *Spheniscus demersus*, Africa's only extant penguin, is confined to southern Africa, where it breeds between central Namibia and southern South Africa. It is one of a suite of seabirds endemic to the Benguela upwelling ecosystem off southwest Africa, where it feeds on small forage fish, including anchovy *Engraulis enchrasicolus* and sardine *Sardinops sagax*.

The African Penguin population has decreased dramatically. In South Africa numbers fell from an estimated 1.45 million birds in adult plumage at Dassen Island alone in 1910 to about 0.2 million at all breeding localities in 2000. A further collapse of penguins off South Africa occurred in the early 21st century, including a 90% decrease at colonies north of Cape Town following a shift of prey to the southeast. In Namibia, numbers fell by > 90% after the mid-1950s. The species now has an IUCN Red List status of Endangered.

In response, the South African government developed a Biodiversity Management Plan for the African Penguin (BMP-AP) that was published in 2013 under the National Environmental Management Biodiversity Act of 2004. The plan aim is to halt the decline of the African Penguin population in South Africa within two years of its implementation and thereafter to achieve a population growth that will result in a down-listing of the species in terms of its IUCN Red List status.

Here we discuss the development and initial implementation of the BMP-AP and consider the potential of some of the proposed actions (e.g. establishment of a new colony closer to the present distribution of prey, improved breeding habitat, reduction of seal predation and closures of fishing around colonies) to attain the plan's objectives.

Penguin Promises – Encouraging effective conservation action

Judy Mann-Lang^{1,2}, Gabby Harris¹, Roy Ballantine², Jan Packer²

¹South African Association for Marine Biological Research, ²School of Business (Tourism), University of Queensland, Australia

The Penguin Promises campaign encourages people to make a promise to the penguins, a promise to become more environmentally responsible. This presentation will answer the question 'What are the ingredients of a successful conservation action - behaviour change campaign?'

African Penguins are iconic birds, charismatic and appealing, and endangered. uShaka Sea World, a large aquarium complex in Durban, South Africa, has exhibited African Penguins for over 30 years. In 2011 a behaviour change campaign entitled 'Penguin Promises' was initiated. Unlike most campaigns that rely on donations, the tag line for this campaign was 'We don't want your money honey, we want your love'. Visitors to uShaka Sea World were invited to make a hand-written promise to the penguins on a post card and post their card in specially designed post boxes situated at the penguin exhibit and at the EcoHouse – a special climate change exhibit. The data on the postcards, including each promise, an email address and simple demographic data were captured. Four to 18 months later the participants were requested to complete a detailed on-line questionnaire. This questionnaire aimed to determine if participants had kept their promise and included comprehensive environmental orientation questions and demographic details. Data from 4 490 promise cards and 370 questionnaires have been analysed. The results showed that, 4-18 months after making a promise, about half of the visitors who responded to the post-visit questionnaire could mention at least one environmental behaviour that they had undertaken subsequent to their visit. The data revealed interesting relationships between demographics and environmental orientation, and highlighted a number of important components to be included in future behaviour change campaigns. It is clear that the pressing environmental challenges facing our planet will not be solved without a wide scale change in the behaviour of people. The results of this work will provide valuable information for the design of future behaviour change campaigns. The presentation will also discuss some of the other components of this interesting campaign.

The advantages of breeding in diverse habitats: Site-dependent effects of El Niño on foraging behaviour in Fiordland penguins/tawaki

Thomas Mattern^{1,2,3}, Ursula Ellenberg², Pablo Garcia-Borboroglu³, Klemens Pütz⁴, Dave Houston⁵, Philip J. Seddon¹

¹Department of Zoology, University of Otago, Dunedin, New Zealand, ²Department of Ecology, Environment and Evolution, La Trobe University, Melbourne, Australia, ³Global Penguin Society, University of Washington, Seattle, USA, ⁴Am Oste-Hamme-Kanal 10, 27432 Bremervörde, Germany, ⁵Department of Conservation, Auckland Regional Office, New Zealand

During the breeding season, penguins, like all central place foragers, have to balance the need for breeding habitat with the requirement to find food to sustain themselves and their offspring. Some penguin species are confined to narrow distributional ranges for which they have adapted highly specialized foraging strategies. This, however, might render these species vulnerable to environmental perturbations that cause a spatial and temporal mismatch between food availability and penguin foraging requirements. Fiordland penguins/tawaki (*Eudyptes pachyrhynchus*) breed discontinuously along a stretch of only ~500 km of coast on New Zealand's South Island. Yet, despite their limited distributional range, the species utilises remarkably diverse oceanic habitats, ranging from shallow coastal and continental shelf, to pelagic and even fjord ecosystems. Consequently global environmental disruptions might differentially affect parts of the population depending on which habitats are used. As part of the 5-year 'Tawaki project' investigating for the first time the marine ecology of Fiordland penguins across their entire distributional range, we simultaneously studied foraging ranges and diving behaviour at two sites, Jackson Head/West Coast and Milford Sound/Fiordland, when globally the 2015 El Niño started to unfold. At Jackson Head, the penguins feeding situation at sea appeared dramatic as indicated by a high rate of starvation-related chick mortality. GPS logger data revealed that in September female penguins, which are sole provider of food in the first four weeks after chick hatching, travelled up to 100 km from their breeding site, staying at sea for two or more days. Satellite data suggest lower than usual ocean productivity that occurred further offshore, probably as a result of El Niño related wind patterns. At the same time, Fiordland penguins in Milford Sound experienced a successful breeding season, seldom travelling further than a few kilometres from their breeding colony; no bird was found to forage outside the fiord. Diving data further showed substantial differences in foraging effort between both sites, with penguins from Jackson Head consistently diving to depths of 100 m or more, while their Fiordland counterparts made mainly shallower dives. Overall the feeding situation seemed to be near perfect for Milford Sound penguins. If and how this was related to weather patterns is unclear. Nevertheless, our data indicates that environmental variations can have markedly different effects on marine habitats utilized by Fiordland penguins, and highlights that habitat diversity needs to be taken into account when assessing effects of climate related environmental change and perturbations.

MAPPPD: Mapping Application for Penguin Populations and Projected Dynamics

Grant R. W. Humphries¹, Philip McDowall¹, Christian Che-Castaldo¹, Matthew Schwaller², Heather Lynch¹

¹Department of Ecology and Evolution. Stony Brook University. Stony Brook, New York, ²NASA Goddard Space Flight Center, Greenbelt, MD

The Mapping Application for Penguin Populations and Projected Dynamics (MAPPPD) is a web application designed to deliver Antarctic penguin population data in an open access framework for use in conservation management. The database contains over 3000 count records for the entire Antarctic for four penguin species: Emperor (*Aptenodytes forsteri*), Chinstrap (*Pygoscelis antarctica*), Gentoo (*Pygoscelis papua*), and Adélie (*Pygoscelis adeliae*). This database integrates everything that is known about the distribution and abundance of Antarctic penguins south of 60 S, completely documented and made available for use by Antarctic scientists, policymakers, NGOs, and other stakeholders. Data on penguin populations have been collected via individual counts, published articles, aerial imagery, and newer populations estimates obtained from both high-resolution commercial satellite imagery and medium resolution Landsat imagery. On the back-end of the database, a Bayesian model framework constructs population estimates using these various data sources, and projects population dynamics into the future. Furthermore, these data are also used in an occupancy model to determine the likelihood of species occurring at the various sites in our database. A simple map interface is provided to allow users to query the database visually with polygons, by species, or site name. Upon data selection, modelled population estimates with associated confidence intervals will be provided and graphed and available to be downloaded in a variety of formats. Users will be given the option to download a PDF report which will contain the most recent estimate of penguin populations at all selected sites, as well as any polygon land masks or Landsat images used to identify those colonies. Tables of the raw counts will also be available for download. To ensure individuals receive credit for their contributions and to maintain transparency, all data sources will be provided in the PDF reports. During this presentation, we will demonstrate how to use MAPPPD and the types of data that can be accessed. Further to this, we will be giving other scientists the opportunity to submit their own data to this project in order to enhance our ability to effectively manage this important ecosystem.

Conserving African Penguins. Are fish really the key?

Alistair M McInnes¹, Peter G Ryan¹, Miguel Lacerda², Lorien Pichegru³

¹Percy FitzPatrick Institute, DST/NRF Centre of Excellence, University of Cape Town, Cape Town, South Africa,

²Department of Statistical Sciences, University of Cape Town, Cape Town, South Africa, ³Coastal and Marine Research Institute, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa

Understanding threats to marine top predators is often compromised by limited knowledge on the availability of their prey, especially in upwelling regions where a few species of so-called forage fish dominate mid-level trophic interactions. The recent collapse of African Penguin numbers off South Africa is believed to be strongly linked to the abundance of their pelagic fish prey, anchovy and sardine, which are vulnerable to exploitation by commercial purse-seine fishing and changes in oceanographic conditions. This study investigates the characteristics of prey aggregations targeted by African Penguins to determine how penguins respond to their variability. The study was conducted in Algoa Bay, South Africa, where half of the global population of this endangered species now breeds. The distributions of penguins were modelled against 47 acoustic surveys of fish distribution and abundance (n=47) conducted within the foraging ranges of breeding penguins, between October 2011 and April 2014. Penguin distribution at sea was estimated both from direct counts during surveys as well as from the locations of dive bouts inferred from breeding birds tracked using GPS loggers deployed concurrently on 14 survey days.

The horizontal distribution of fish had little influence on the location of penguins but they were significantly associated with the vertical distribution of their prey at fine scales (0.5 km) using both at-sea count and tracking data. Model results showed avoidance of fish schools located near the seabed by penguins at these fine scales potentially related to African Penguin hunting mode and/or the reduced ability to locate these aggregations. Activity budgets of breeding penguins, i.e. trip duration, path length and maximum distance travelled from colony, were negatively correlated with fish abundance and these relationships were strengthened when using only targeted fish aggregations, i.e. fish located in the mid- to upper water column. Our results highlight the need to monitor and, where necessary, manage external drivers of targeted aggregations of pelagic fish, notably those that influence the vertical distribution and abundance of penguin prey. Our findings provide evidence for the negative influence of reduced prey availability on the performance of African Penguins at sea which is likely to have a direct bearing on the current conservation status of this species.

Late Holocene occupation history, population movements, and diet in Adélie penguins as inferred from ornithogenic soils from the northern Ross Sea region, Antarctica

Ashley McKenzie, Steven D. Emslie

University of North Carolina Wilmington, Department of Biology and Marine Biology, 601 South College Rd., Wilmington, North Carolina 28403

The Adélie penguin (*Pygoscelis adeliae*) is an important bio-indicator of marine environmental conditions in Antarctica. This species is well adapted to sea ice and many facets of their life history are strongly associated with sea ice fluctuations that occur on an annual basis. Colony formation of the Adélie penguin during the breeding season depends upon the presence of ice-free terrain, access to open water and a proximate reliable food source. Continuous use of a breeding site over time leads to the deposition and development of ornithogenic soils that can range in age from hundreds to thousands of years. The cold and often dry environmental conditions in Antarctica also facilitate the preservation of organic remains in these soils, including penguin bones, feathers, eggshells and other tissues, as well as hard parts of their prey in guano (squid beaks, fish bones and otoliths). Thus, these soils form a natural archive of biological tissues that can be analyzed for information on past ecosystems. Here, we present results of excavations and sample collection from modern and abandoned Adélie penguin colonies located at Cape Hallett and other sites in the northern Ross Sea during the 2015/2016 austral summer. These sites are particularly rich in well preserved organic remains and provide new information on the occupation history and population movements of Adélie penguins in the late Holocene. In particular, we use bulk and compound specific stable isotope analyses ($\delta^{15}\text{N}$ and $\delta^{13}\text{C}$), and radiocarbon dating on preserved tissues and guano in ornithogenic soils to test the hypothesis that Adélie penguins underwent a major population shift, and perhaps a dietary change, at 2000 BP when the southern Ross Sea was abandoned. This abandonment also corresponds with the first occupation of major breeding localities in the northern Ross Sea, implying that changing environmental conditions were responsible for a large-scale population movement. Our analyses also provide a broader knowledge of the marine environment over the past 2000 - 7000 years in the Ross Sea.

Down the rabbit hole: lessons learnt from 7 years of the African Penguin island closures experiment

Taryn Morris, Ross Wanless, Christina Hagen

BirdLife South Africa

The population of the African Penguin *Spheniscus demersus*, endemic to Southern Africa, is at its lowest recorded level, with estimated population declines of *ca.* 99% in the last 100 years. While historical declines were largely as a result of direct human exploitation and habitat alteration, dramatic declines in recent years have been linked in part to decreased availability of the penguin's primary food source of sardine *Sardinops sagax* and anchovy *Engraulis encrasicolus*. Partly attributable to environmental induced shifts in anchovy and sardine biomass, decreased availability of fish stocks has largely been compounded by continued extraction by purse-seine fisheries with little spatial or temporal management. In 2008, the South African government initiated a large-scale experiment aimed at testing possible effects of prohibiting purse-seine fishing around penguin colonies. The closures to fishing have since been alternated between four main penguin colonies on islands on the west (Dassen and Robben Islands) and south (Bird and St. Croix Islands) coasts of South Africa. Here, we aim to assess the broad benefits and disadvantages that have arisen from this long-term experiment and draw on lessons that can be learnt. While preliminary results indicate potential benefits of island closure to some indirect penguin population indices, broad level population effects are more difficult to prove due to both feasibility and to positive effects possibly being masked by broader ecosystem dynamics. Efforts to prove that fishing has direct negative impacts on penguins have thus resulted in a divisive process that is yet to yield consensus whilst resulting in significant socio-economic impacts to the small pelagic fisheries. We emphasize that in pitting penguins against fisheries, we have failed to highlight the significance of the decline of the African Penguin as an indicator of lower trophic fish stock health and consequently broader ecosystem health. We reiterate that reversing the decline of this endangered top-predator is integral not only for conservation aims but also for the potential importance of this sensitive species as a key indicator useful for ecosystem approaches to fisheries management.

Zoological research for understanding penguin reproductive biology and maximizing population genetic diversity

Justine K. O'Brien, Gisele A. Montano, Karen J. Steinman, Todd R. Robeck

SeaWorld & Busch Gardens Reproductive Research Center, SeaWorld Parks & Entertainment, San Diego, CA 92109

In addition to their roles in educating and inspiring the general public, zoological animals can facilitate an extensive understanding of a species' biology, the knowledge of which can be integrated into *in situ* conservation efforts. Our research on zoo-based penguin species has revealed new information on sperm biology and physiological changes necessary for egg formation, fertilization and successful production of offspring. Although the current genetic diversity and demographics of many zoological penguin species in North America are sufficient to classify such populations as sustainable into the foreseeable future (www.aza.org), it is imperative that careful management continues to ensure equal founder representation and that genetically underrepresented individuals reproduce. Both goals can be challenging owing to the perennial monogamy exhibited by the majority of penguin species. The integration of reproductive technologies such as artificial insemination and semen cryobanks into captive breeding programs could significantly improve the management of zoological penguin populations in several ways. It would reduce both the need to transport animals for breeding loans and the incidence of associated disease introduction risk, and it would permit the introduction/reintroduction of valuable genetics into the population well after the cessation of a male's reproductive lifespan. To this end, techniques for the production of offspring using artificial insemination and chilled or frozen sperm have recently been developed, and 12 *Spheniscus magellanicus* chicks have hatched to date, with four of those derived from frozen semen. This presentation will review principal findings of our reproductive research and the current status of assisted reproductive technology in four penguin species (*S. magellanicus*, *S. humboldti*, *Aptenodytes patagonicus*, *A. forsteri*), with discussion on potential contributions of this knowledge to *in situ* conservation efforts.

At-sea distribution and diving activity of juveniles *Aptenodytes* penguins in the South Indian Ocean

Florian Orgeret, Charles-André Bost

CNRS CEBC FRANCE

During the first year of their life, fledged penguins at-sea disperse during several months to one year without any return at their colony. Information on their at-sea activity and survival during this period of their life cycle is essential because their mortality controls recruitment to reproductive stages and thus the future of populations. In addition, it is young individuals that disperse most and have the potential to emigrate and colonize new environments. During the last years we instrumented with data archiving tags transmitting to the Argos system a total of 17 and 15 juveniles of the 2 *Aptenodytes* penguins, the king penguin *Aptenodytes patagonicus* (from Crozet islands) and the emperor penguin *Aptenodytes forsteri* (from Adélie Land). First analysis indicate juveniles emperors disperse away from Antarctica toward the north of the pack-ice edge, in the polar frontal zone. The number of daily dives they performed strongly increased as well as dive depth and duration. Their diving efficiency was lower than those of adults. During austral fall and winter the individuals generally moved south-westward, precisely close to the extending pack-ice. Preliminary analysis confirm that the northward exodus exclude them of potential area of overlap with the adults. Juveniles king penguins performed very distant trips, up to 4000 km far off their colony. In autumn they gradually travelled toward the south, off the polar frontal zone. Some juveniles travelled as south as -62°8, i.e. right across dense sea ice. Juveniles behave in a very distinct way of the breeding adults, exhibiting much more exploratory looping trips. The juvenile behaviour of the 2 species is discussed in relation to the life history strategies of the *Aptenodytes* genus according to the marine habitat used (Antarctic vs Sub-Antarctic).

Analysing indicators for the success of rehabilitation for the African penguin in South Africa

Nola J Parsons^{1,2}, Adam M Schaefer³, Ralph ET Vanstreels⁴

¹Southern African Foundation for the Conservation of Coastal Birds, 22 Pentz Drive, Tableview, Cape Town, 7443, South Africa, ²Bayworld centre for Research and Education, Port Elizabeth, 6013, South Africa, ³Harbor Branch Oceanographic Institute, Florida Atlantic University, Ft. Pierce, Florida, USA, ⁴Pathology Department, College of Veterinary Medicine and Animal Sciences, University of São Paulo, São Paulo State, Brazil, CEP 05508-270

The population of African penguins (*Spheniscus demersus*) has collapsed by 95% since the 1950s, and the species is currently classified as Endangered with a total population of approximately 26,000 breeding pairs. The Southern African Foundation for the Conservation of Coastal Birds (SANCCOB) facility at Cape Town (Western Cape, South Africa) receives approximately 900 African penguins for rehabilitation every year. From 2002 to 2013, more than 10,000 African penguins were received at this facility, with a release rate of approximately 75%. Post-release studies have demonstrated that oiled adults and hand-reared chicks have relatively good survival and breeding productivity after being rehabilitated. In this presentation we provide descriptive analysis of the overall patterns of admission, health and mortality of approximately 3,700 adult African penguins admitted for rehabilitation over a 12 year period. The following variables were analysed: reason for admission, time of year, location of rescue, body mass, haematocrit, plasma protein, infection by blood parasite, duration of stay, rehabilitation outcome and cause of death. We will discuss how the history and clinical parameters of an individual upon admission can be used to understand human impacts and conservation threats to penguin populations in the wild, and how they can be used as prognostic indicators to enable better decision making during rehabilitation. Additionally, besides giving feedback for the rehabilitation process, necropsy and clinical admission data can be used as passive disease surveillance, allowing for the early identification of conservation-significant pathogens and in-depth investigations of their epidemiology and pathology. This is arguably the largest dataset on the rehabilitation of penguins, and the lessons learned from it will not only contribute to the conservation of African penguins but also to other threatened penguin species that may benefit from rehabilitation.

Assortative mating in a monomorphic seabird

D. Smith¹, C.D. McQuaid¹, L. Pichegru²

¹Department of Zoology and Entomology, Rhodes University, Grahamstown 6140, South Africa, ²Coastal and Marine Research Centre, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa

Sexual dimorphism is widespread among birds and mammals, with males typically being larger than females, and thought to derive from sexual selection. In some instances, it may decrease competition between sexes of the same species. One of the mechanisms that may contribute to the maintenance of sexual dimorphism is assortative mating, or more specifically, disassortative mating. African Penguins (*Spheniscus demersus*) are long-lived monogamous birds that display bi-parental care making mate selection of utmost importance.

Here we assessed whether African penguins display assortative mating behaviour, using of a large biometric database from penguins breeding on Bird Island, Algoa Bay, between 2011-2013. In addition, with nest attendance video footage in 2013, we explored the influence of intrinsic (assortative mating, brood size and chick age) and extrinsic (environmental conditions, anthropic disturbance) factors on penguins' breeding behaviour and performance.

A total of 262 pairs of African penguins breeding on Bird Island were measured between 2011 and 2013, of which chick growth was measured for 154 pairs. A strong positive relationship was observed within pairs of African penguin for every morphometric measurement, and the strongest correlation was for body condition. However, pairs most assorted by bill length showed higher chick growth rates than pairs less assorted.

In 2013, peak nest arrival and departure times of parents did not change over the breeding season (March-June), nor with levels of disturbance or the size of the brood. Provisioning rates were unrelated to parental morphology or assortative index, but increased as chicks grew larger, but also with at-sea chlorophyll *a* concentration, and when maximum air temperature was lower. Parental absenteeism commenced earlier and was greater in nests frequently handled by researchers than in undisturbed nests, although fledging success was similar. A third of manually-monitored nests shared chick-guarding duties unequally, although this phenomenon was independent of parental sex or morphology.

As the African Penguin edges closer to the brink of extinction it is essential to gain a complete understanding of factors that influence breeding success. These findings augment past foraging ecology studies and demonstrate that parental quality, anthropic disturbance and environmental conditions can affect the nesting behaviour of this highly threatened seabird.

King Penguins in the Magellan Strait, Chile: Inshore foraging throughout the year indicates substantial behavioural plasticity

Klemens Pütz¹, Julieta Pedrana², Camila Campos-Fuentes³, Alejandro Simeone³, Claudia Godoy^{4,5}, Pablo García-Borboroglu⁶, Benno Lüthi⁷

¹Antarctic Research Trust, Am Oste-Hamme-Kanal 10, 27432 Bremervörde, Germany, ²Recursos Naturales y Gestión Ambiental, CONICET - INTA, Ruta 226 km 73.5, CC 276, 7620 Balcarce, Argentina, ³Universidad Andrés Bello, Departamento de Ecología y Biodiversidad, Republica 470, Santiago, Chile, ⁴Global Penguin Society, La Marina 1405, 8920007 Comuna San Miguel, Santiago, Chile, ⁵Parque Pingüino Rey, Estancia San Clemente, Isla Grande de Tierra del Fuego, Chile, ⁶Global Penguin Society, Marcos Zar 2716, 9120 Puerto Madryn, Chubut, Argentina, ⁷Antarctic Research Trust (Switzerland), General-Guisanstr. 5, 8127 Forch, Switzerland

King Penguins (*Aptenodytes patagonicus*) are considered as oceanic mesopredators, foraging predominantly in frontal systems. However, since 2010 increasing numbers of King Penguins frequent the Magellan Strait, Chile, and a prospective breeding ground has been established at Bahía Inútil (53°27.7'S; 69°18.5'W), a bay to the east of the Magellan Strait. This location is more than 300 km away from the open sea in the Atlantic and Pacific Oceans, respectively, and thus provides an inshore habitat that differs largely from the usual high-sea foraging sites of conspecifics from other breeding sites. The aim of this study was to gain first insights into the foraging behaviour of King Penguins settling in the Magellan Strait and to elucidate potential behavioural adaptations to this inshore environment.

In December 2014, 5 GPS- and 7 Time-Depth-Recorders were attached to individuals engaged in courtship or just after egg-laying. Furthermore, 10 satellite transmitters were attached to birds of unknown breeding status in March 2015 to monitor their winter movements. By chance, one parent of the first and only successfully fledged chick was selected.

During the incubation period and during winter, all but one birds remained in the vicinity of the breeding site. Courtshipping birds remained in the Bahía Inútil and foraged not further than 30 km away from the colony for periods of up to 5 days, while incubating birds foraged up to 125 km away in the Magellan Strait for periods of up to 12 days. These differences were mirrored in the diving behaviour of the birds, with those foraging in the Strait diving deeper and longer. During the winter period, the foraging range was expanded and fjords and channels adjacent to the Strait were also occasionally used. However, one bird left the Magellan Strait eastwards, then turned south into the Drake Passage before heading ca. 2000 km west into the Pacific, where it remained for 71 days. Afterwards, the bird headed eastwards again, passed Cape Horn and continued travelling east until it reached South Georgia.

The results on the foraging behaviour of King Penguins are compared to the behaviour of conspecifics from traditional, highly oceanic breeding and foraging areas, and discussed with regard to behavioural plasticity required to forage successfully in the Magellan Strait. Finally, the results may provide some insights into the adaptations necessary to cope with global warming, which is predicted to negatively impact King Penguins at least at the Crozet Islands.

Contrasting foraging strategies in Gentoo and Magellanic Penguins breeding in sympatry in the Beagle Channel: niche segregation beyond competition

Andrea Raya Rey¹, Sabrina Harris¹, Gabriela Scioscia¹, Ricardo Sáenz Samaniego¹, Klemens Pütz²

¹Ecología y Conservación de Vida Silvestre, Centro Austral de Investigaciones Científicas, Consejo Nacional de Investigaciones Científicas y Técnicas, Bernardo A. Houssay 200 (V9410CAB), Ushuaia, Tierra del Fuego, Argentina,

²Antarctic Research Trust, Am Oste-Hamme-Kanal 10, D-27432 Bremervörde, Germany

Ecological niche theory predicts niche segregation to avoid potential competition between two closely related organisms. But what to expect when one species population is low in numbers? We investigated if segregation mechanisms exist in two closely related species, the Gentoo *Pygoscelis papua* and the Magellanic *Spheniscus magellanicus* penguin. Both species breed in sympatry on Martillo Island, Beagle Channel, Argentina, but while there are more than 6000 Magellanic penguin breeding pairs, the Gentoo colony holds only 31 active nests. We quantified and compared their ecological niche in space (horizontally and vertically) during the early chick rearing period using GPS-TDlogs to determine foraging parameters and stable isotope analysis techniques to investigate their diet. The foraging area, estimated as the 95% kernel density of dives >10m for Gentoo penguins, overlapped completely with the area for dives >5m for Magellanic penguins, while the 50% kernel density did not overlap. Magellanic penguins travelled further away from the colony compared with Gentoo penguins (45 km vs. 23 km), thus on average the trajectory was larger for Magellanic than for Gentoos (117 km vs. 77 km). Nevertheless, the trajectory sinuosity for both species was similar (0.67 for Magellanic and 0.62 for Gentoos). Accordingly, trip duration was longer for Magellanics (25 hs) in comparison to Gentoos (12 hs). Dive profiles revealed that Gentoos performed mainly benthic dives (63% of dives were U-shaped) while Magellanics presented pelagic dive profiles (49% were U-shaped, with W-dives twice as often as in Gentoos). This was also reflected in the bottom time per hour underwater being much higher in Gentoos (17 min/hs) compared with Magellanics (7 min/hs), while the number of wiggles per hour was much higher in Magellanics (33 wiggles/hs vs. 3 wiggles/hs). Mean dive duration also differed, with longer dives performed by Gentoos (80 s vs. 60 s). The differences in diving behaviour were also mirrored in their diet according to the stable isotope analysis. Magellanics consumed more Fuegian sprat (*Sprattus fuegensis*) while Gentoos preferred benthic prey (lobster *Munida* spp. krill among others). Our results indicate that segregation mechanisms in two related species persist even when one species is largely outnumbered by the other. This suggests that life history traits and physiological characteristics are strong forces that determine the foraging behaviour of penguins.

Estimating reproductive success using two surveys per season: a cautionary tale

Ginger A. Rebstock, P. Dee Boersma

University of Washington, Department of Biology; Global Penguin Society; Wildlife Conservation Society

Fecundity is an important demographic variable in wildlife populations, but it is difficult, time-consuming, and expensive to measure. For penguins and other seabirds reproductive success is commonly estimated from two surveys of a colony, one during incubation or egg laying and one during late chick rearing. However, we know of no studies validating this method. We used Magellanic Penguins (*Spheniscus magellanicus*) at a large colony (~200,000 nests) at Punta Tombo, Argentina, to compare the method with nest checks from before egg laying until after chicks fledged. We calculated reproductive success from nests checked daily to every 10 days and from two surveys, one in October and one in January, each season from 1994 to 2013. Reproductive success from surveys was nonlinearly related to reproductive success from nest checks ($R^2 = 0.90$). Long-term mean reproductive success was similar between the two methods: 0.584 ± 0.30 from nest checks and 0.588 ± 0.25 from surveys ($t_{17} = 0.11$, $p = 0.91$). Neither method showed a long-term trend; reproductive success did not increase or decrease significantly over time (nest checks: $p = 0.99$; surveys: $p = 0.57$) but was highly variable among years. In spite of the agreement between nest checks and surveys in long-term means and trends, the methods often disagreed for individual years. Reproductive success from surveys minus reproductive success from nest checks ranged from -0.36 in 1996 to 0.24 in 2009, with 12 of 18 years differing by > 15%. Surveys were thus a poor proxy for reproductive success in any given year. However, reproductive success (from nest checks) varied among years from 0.07 to 1.0 (out of a maximum of 2.0 chicks per nest), meaning that reproductive success in any one year using any method may be very misleading in demographic models. Reproductive success estimated from two surveys per season is reliable for long-term means and trends. It should be viewed with caution for any individual year, whether for use in demographic models or for comparison with other colonies, other years, or other methods.

Age-related changes in breeding performance of Little Penguins - restraint, constraint or selection?

C. Saraux¹, K. Edwards², A. Chiaradia³

¹Ifremer, UMR MARBEC, Avenue Jean Monnet, BP 171, 34203 Sète, France, ²Ocean and Earth Science, National Oceanography Centre, University of Southampton Waterfront Campus, European Way, Southampton, Hampshire, SO14 3ZH, ³Research Department Phillips Island Nature Parks, PO Box 97, Cowes, VIC 3922, Australia

In long-lived species, reproductive performances typically improve with age, reaching a plateau at middle age and subsequently declining in older age classes (senescing individuals). Three potential non-exclusive mechanisms have been proposed to explain the improvement of reproductive performance with age: (1) selection (poor quality individuals are removed from the population with increasing age), (2) constraint (individual efficiency increases through experience) and (3) restraint (reproductive investment increases with age as the residual reproductive value decreases). However few studies have aimed at teasing apart those hypotheses and quantifying their associated variance. In little penguins (*Eudyptes minor*), we used a 12-year dataset on individual and population monitoring to investigate the effect of age on breeding success. Breeding success followed a bell-shaped curve with performance increasing in the first few years, reaching a plateau at age 7 and subsequently declining at age 16, indicating senescence. Surprisingly however, breeding success increased again afterwards between the ages 18 and 20.

Separating within from between individual variance in reproductive success using mixed models enabled us to distinguish between individual change in breeding success and population selection. Regarding within individual changes, the patterns observed on breeding success were mediated by the combination of age-dependent foraging success as well as age-dependent breeding allocation. In order to better quantify these 2 processes (i.e. constraint vs. restraint), we constructed (1) a performance index using total body mass gain while foraging and (2) a breeding allocation index using the residuals of the relationship between mass allocated to the chicks through meal size and total body mass gain. We found that middle-aged penguins were more efficient foragers than younger penguins, spending less time foraging while increasing body mass gain. Our findings also revealed an interesting modulation of breeding allocation. In particular, the improved reproductive success at very old ages (when reproduction is probably equal to or more important than survival) appeared to result from terminal investment, with a 41% increase in the number of foraging trips being performed by females and a higher energy allocated to reproduction. Our study thus highlights the possibility of all three mechanisms co-occurring to affect the breeding success / age relationship and offers a novel approach to quantify the importance of each of them.

The relationship between nesting habitat, breeding success, and individual quality in Adélie penguins (*Pygoscelis adeliae*)

Annie E. Schmidt¹, Grant Ballard¹, Katie Dugger², Amélie Lescroël³, Phil Lyver⁴, David Ainley⁵

¹Point Blue Conservation Science, Petaluma CA, USA, ²U.S. Geological Survey, Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Corvallis OR, USA, ³CNRS, Montpellier, France, ⁴Landcare Research, Lincoln, NZ, ⁵H.T. Harvey, Los Gatos CA, USA

Nesting habitat quality may be a critical factor influencing large-scale patterns in penguin colony growth and decline. As climate warms, extreme weather may disproportionately affect some areas of a colony more than others, turning some locations into localized population sinks. For example, melting glaciers and snowfields may expose new nesting habitat that is attractive to penguins but may be more susceptible to flooding by meltwater. Whether or not this habitat is colonized may depend on the quality of the new habitat relative to existing habitat. In addition, at the scale of subcolonies (discrete groups within the larger colony) and individual breeding pairs, territories in smaller subcolonies or on the periphery of subcolonies may be more at risk from exposure, disturbance, and predation from South Polar Skua, and these factors might impact reproductive success and ultimately result in population change. At the finest scale, habitat selection theory predicts that individuals should attempt to settle in the highest quality habitat available to maximize their fitness. However, individuals may differ in their ability to compete for the highest quality nest sites and younger or poorer quality individuals may end up settling in the poorest quality nest sites. Here we use data collected from 1996-2015 at two Adélie penguin (*Pygoscelis adeliae*) colonies on Ross Island (Ross Sea, Antarctica) of different size and population growth rates to establish whether habitat characteristics affect breeding success and recruitment at the scale of colonies, subcolonies, and individual territories. We compare the breeding success of subcolonies of different size, shape, aspect, slope, isolation, and position (relative to edge of colony, snowfields and, glaciers) within and between colonies. We also use over 10 years of data on nest locations for more than 1000 known-age, known-history individuals to analyse the spatial distribution of individuals of varying age and quality. Understanding how individuals of different age and intrinsic quality interact with changing habitat provides valuable insight into the mechanisms of Adélie penguin population growth in the Ross Sea.

Sustainable Management of AZA Penguin Populations

Tom Schneider¹, Colleen Lynch²

¹Detroit Zoological Society, Chair AZA Penguin Taxon Advisory Group, ²Riverbanks Zoo and Garden, Consulting Biologist for AZA's Population Management Center

Penguins have been kept in zoos and aquariums for more than 100 years, enthralling visitors and helping zoos and aquariums engage people in learning about penguins and issues affecting them in nature. This engagement has the potential for significant impact given that more than 180 million people visit the 230 facilities accredited by the Association of Zoos and Aquariums (AZA) each year.

AZA institutions recognize the importance of long-term scientifically managed zoo populations and are committed to sustainable population management programs that ensure genetically and demographically viable animal populations in zoos and aquariums. Sustainable populations require collaboration and cooperation among all AZA institutions as well as analysis and decision-making with respect to species selection. AZA programs begin with identification of specialists in Taxon Advisory Groups who are charged with development of regional plans for species maintained in zoos and aquariums. The Penguin Taxon Advisory Group carefully assesses penguin populations in zoos and aquariums and develops the AZA Penguin Regional Collection Plan (RCP). The RCP process requires analysis of criteria including population size and viability, status of the species in the wild and the carrying capacity of zoos, as well as other factors, and recommends Species Survival Plan® programs to develop and implement scientific management of each population. Scientific management begins with development of a studbook database starting with the animals or eggs that founded the population and includes all individuals in the population. A team of population biologists employed by the AZA's Population Management Center utilize specially designed software to perform demographic, genetic, and viability analyses for each population. This information is used to make management recommendations for each individual in the population and each institution. Program goals are typically to maintain 90% of the founding population gene diversity in a demographically stable population for a minimum of 100 years.

This presentation will describe AZA's Regional Collection Plan and the processes used to determine penguin species selection for zoos and aquariums, describe the tools that are used for analyses, and how Species Survival Plans® are developed and implemented. The history and current status of the ten species that are sustainably managed in AZA institutions will be described including demographic data such as age-specific mortality, fecundity, and survivorship. The survival analysis of each population will be presented.

Parent ornamental colors predict offspring's early life growth and parental care in king penguin

Quentin Schull^{1,2}, Vincent A. Viblanc^{1,2}, Laureline Durand^{1,2}, Emilie Lefol^{1,2}, Pierre Bize³, Jean-Patrice Robin^{1,2}

¹Université de Strasbourg, IPHC, 23 rue Becquerel 67087 Strasbourg, France, ²CNRS, UMR 7178, 67087 Strasbourg, France. ³Institute of Biological and Environmental Sciences, University of Aberdeen, Scotland, UK

In king penguins (*Aptenodytes patagonicus*), raising the chick is a tricky business. Neither parent can raise the chick alone and parental cooperation is critical to success. Thus, mutual mate choice should occur for high quality partners that not only pass high quality genes to their offspring, but also provide high quality parental care. In this study, we tested the hypothesis that sexual ornaments used in mate choice provide a means for king penguins to assess the quality of parental care provided by tentative partners. Colour ornaments in king penguin (yellow-orange ear patches and a yellow-orange beak spot that also reflects ultraviolet) are known to convey information on individual physiological quality (body condition, stress levels, oxidative status, immunity). However, how those ornaments relate to chick care and reproductive success is unknown. To dissociate genetic from environmental effects, we cross-fostered eggs between 109 penguin pairs, and tested whether chick growth and health (immunity, oxidative stress) was best explained by the ornaments of genetic or foster parents. Positive links between chick phenotype and genetic parent ornamentation would suggest that genetic parents transfer “good genes” promoting high growth to the offspring or alter offspring phenotype via maternal effects (e.g. hormone or antibody transmission via the egg yolk). In contrast, positive links between chick phenotype and adoptive parent ornamentation would signal the ability of parents to care for their offspring during development. Both mechanisms are not mutually exclusive, and we might expect parental care to become more important as the chick ages. Indeed, our results show that offspring growth and health is best explained by the ornaments of genetic parents early in their development (up to day 35 post-hatching), but by the ornaments of foster parents later on (from day 105 post-hatching onwards). This suggests that maternal and genetic effects are likely fundamental in conferring a good start in life, but growth trajectories are driven by rearing conditions through parental rearing quality. Altogether, our results suggest that king penguin sexual ornaments are indicators of both genetic quality and parental care, and underline the importance of color ornaments in assessing partner quality through the entire breeding season.

Right place, wrong time: a broad-scale ecological trap revealed through metapopulation level tracking of juvenile African penguins

Richard B. Sherley¹, Katrin Ludynia², Bruce M. Dyer³, Tarron Lamont³, Azwianewi B. Makhado³, Jean-Paul Roux⁴, Kylie L. Scales⁵, Les G. Underhill⁶ and Stephen C. Votier¹

¹Environment and Sustainability Institute, University of Exeter, Penryn, Cornwall, TR10 9FE, UK, ²Department of Biological Sciences, University of Cape Town, Rondebosch 7701, South Africa, ³Branch: Oceans and Coasts, Department of Environmental Affairs, Cape Town 8000, South Africa, ⁴Ministry of Fisheries and Marine Resources, PO Box 394, Lüderitz, Namibia, ⁵Institute of Marine Sciences, University of California Santa Cruz, Santa Cruz, CA 95064, USA and National Oceanic and Atmospheric Administration (NOAA) Southwest Fisheries Science Center, Environmental Research Division, 99 Pacific Street, Suite 255A, Monterey, CA 93940, USA, ⁶Animal Demography Unit and Marine Research Institute, University of Cape Town, Rondebosch 7701, South Africa

Human-mediated pressures are rapidly degrading marine habitats worldwide. Where habitat worsens but animals continue to use historical relationships between environmental cues and habitat quality, they may fall into ecological traps. Many long-lived marine vertebrates refine their navigation and foraging skills over many years; thus inexperienced juveniles may be particularly vulnerable to selecting habitat that lowers fitness. Dispersal influences the population dynamics of many marine vertebrates, so effective conservation requires understanding of how immature animals use their environment. However, few studies have tracked juvenile animals in the ocean at a metapopulation scale. We used satellite transmitters (PTTs) to track the postnatal dispersal of 54 fledgling African penguins *Spheniscus demersus* from eight colonies spanning the species' breeding range. We assessed whether their behaviour enabled them to access high quality foraging habitat in light of widespread changes in the marine ecosystems of South Africa and Namibia. Our results suggest dispersal targeted productive areas (high chlorophyll-*a* concentration) within a particular thermal range (SST 14.5–17.5 °C), normally associated with high forage fish availability. However, environmental change and localised overfishing have driven ecological regime shifts in the Benguela Upwelling ecosystem, inducing mismatches between productivity and forage fish availability in some areas. As a consequence, fledglings from Namibia and western South Africa now forage in degraded habitats with a poor prognosis for their survival. Management that reduces pressure on scarce forage fish resources, such as spatially-explicit fisheries management, may be required to ensure the sustainability of this marine ecosystem. More broadly, our results have identified an ecological trap operating at an ecosystem-wide scale and highlight the importance of considering the initial dispersal of marine vertebrates in conservation planning.

Aggression and fitness in Magellanic penguins

Jeffrey R. Smith^{1,2}, Olivia J. Kane¹, Jack A. Cerchiara¹, P. Dee Boersma^{1,3,4}

¹University of Washington, Department of Biology, ²University of Washington, School of Environmental and Forest Sciences, ³Global Penguin Society, ⁴Wildlife Conservation Society

Variation in traits linked to fitness is the fuel for natural selection. Currently, relatively little is known, particularly in long-lived species, about the fitness consequences of individual behavioral variability, termed personality or temperament. What mechanisms maintain individual behavioral patterns is also largely unknown. Understanding the link between behavior and fitness in long-lived species is difficult resulting from the need for both an assessment of long-term behavioral consistency, something rarely tested, and long-term reproductive data on marked individuals. We measured aggression multiple times in Magellanic penguins (*Spheniscus magellanicus*) in 2007 to establish within-season consistency and retested individuals in 2015 to assess long-term consistency. We found significant differences in aggression among individuals and significant, positive correlations in aggression for individuals between settlement and egg laying in males ($p=0.50$) and egg laying and chick rearing in females ($p=0.66$) suggesting within-season consistency. Aggression scores were highly repeatable in males ($r=0.50$) and females ($r=0.67$). We also found that males are significantly more aggressive than females. Aggression of individuals retested in 2015 was similar to their aggression in 2007 suggesting long-term consistency. We then paired the aggression data with our 30+ year data set on known-age individuals to determine whether aggression is correlated with reproductive success and longevity, key components of fitness. In females, more aggressive individuals had significantly lower reproductive effort but aggression did not predict reproductive success. Age was negatively correlated with aggression in females although Magellanic penguins show long-term behavioral consistency suggesting higher mortality in more aggressive individuals. However, aggression did not predict whether or not an individual was re-sighted (a proxy for survival) at any point during a 3-year period (2012, 2013, 2014). For males, aggression did not predict reproductive effort, but did predict reproductive success. Moderately aggressive males fledged more chicks than either more aggressive or more docile individuals. Moderately aggressive males are the most common in our population suggesting high chick fledging by this group may partially account for behavioral maintenance, if aggression is heritable, and that both high and low aggression have reproductive costs. For males, aggression also did not predict re-sighting. Our analyses suggest Magellanic penguins are consistent in aggression over a significant portion of their lifetime and that aggression has fitness consequences.

Sex allocation and sex-specific parental investment in African penguins *Spheniscus demersus*

Anouk Spelt, Lorien Pichegru

Coastal and Marine Research Institute at the Nelson Mandela Metropolitan University, South Africa

Seabirds, living in unpredictable marine environments, have developed a distinct set of life-history traits to cope with this unpredictability – the “seabird syndrome”. For example, they are K-selected species, with a long-life span and small clutch size. In long-lived species, adults should favour their own survival to that of their brood, when resources are limited. Seabirds can also exhibit high behavioural flexibility which can depend on specific factors such as adult body condition, the need of the offspring and/or food availability. Recently, there has been an increasing interest in parental investment according to the sex of the parent and that of the chick (i.e. sex allocation), thanks to the development of molecular techniques which facilitated the sexing of monomorphic species. African penguins *Spheniscus demersus* are endemic to South Africa and Namibia, but currently endangered despite several conservation strategies being widely applied. Recent evidences showed a higher foraging effort by females during the breeding season, despite their bi-parental care, and a higher mortality of that sex. Here, we investigated parental investment in African penguins in relation to the sex of the parent and of the offspring and consequences on chick growth rates.

During the 2015 breeding season, a total of 93 African penguin nests were monitored on Bird Island, South Africa. Nest attendance of both parents was observed 2-hourly during a 6-day period, adult biometrics was measured to assess sex, and growth of chicks measured every 5-6 days for 3 weeks. Chicks were sexed from DNA extracted from their feathers. Female/male-ratio in African penguin chick production was significantly skewed towards males (1:1.52). Moreover, male chicks had higher growth rates and ended heavier than females at the end of the rearing season, suggesting a potentially higher survival of that sex post-fledging. Female parents generally performed more foraging trips and spent more time off the nest than male parents. Both adults increased their foraging trip duration with brood size, but females were more sensitive to the sex-ratio: their increase in foraging effort was higher when the brood was constituted of two males. The higher investment of female parents in their current brood compared to males could be the explanation for their lower survival. Added to the higher production of male chicks compared to females, this could eventually lead to a strong male-biased sex-ratio in the population. Conservation strategies might need to shift their attention towards the female African penguin.

Emergence of intense corvid predation on little penguin nests

Duncan R. Sutherland¹, Kasun B. Ekanayake², Peter Dann¹, Michael A. Weston²

¹Research Department, Phillip Island Nature Parks, Cowes, Victoria 3922, Australia, ²Centre for Integrative Ecology, School of Life and Environmental Sciences, Deakin University, 221 Burwood Highway, Burwood, Victoria 3125, Australia

Nest predation is a major cause of reproductive failure among birds, and can drive prey population declines. Here, we describe novel predatory behaviour of a corvid (little raven *Corvus mellori*) that has recently emerged, leading to widespread and intense predation of eggs of little penguins (*Eudyptula minor*).

The presence of penguin eggs in burrows correlated strongly with little raven activity, and this implies that little ravens may have learnt to exploit the plentiful food resource of little penguin eggs hidden within burrows. Little ravens congregate to coincide with the timing of penguin egg laying in the areas where penguins breed, but not when and where alternative seabird species nests were available.

Through the use of cameras and direct observation, we identified that 61% of monitored burrows (n = 203) were depredated by ravens, the only predator detected by camera traps. Analysis of burrow characteristics revealed two distinct types of burrows, only one of which was associated with egg depredation by ravens. Clutches destroyed by ravens were in burrows with wider and higher entrances, thinner soil or vegetation layer above the egg chamber, shorter and curved tunnels and greater areas of bare ground and whitewash near entrances. In addition, 86% were covered by vegetation through which ravens could excavate. Ravens used two modes to access the eggs: they attacked through the entrance (25% of burrow attacks, n = 124); or dug a hole through the burrow roof (75% of attacks, n = 124). On some occasions, ravens were observed to work in pairs, where one would dig through the burrow roof and one would distract the penguin at the entrance. Burrows that were subject to attack through the entrance had significantly shorter tunnels than burrows accessed through the roof.

The high rates of clutch loss recorded here highlight the need for population viability analysis of the penguin population to assess the effect of egg predation on population growth rates. The foraging niche of a corvid described here may have implications for burrow-nesting species worldwide where corvid populations are increasing, as they exhibit great capacity to adopt new foraging strategies to exploit novel prey.

Effect of prey type and patch density on foraging effort in little penguins (*Eudyptula minor*)

Grace J. Sutton, John P.Y. Arnould

Deakin University Australia

Understanding predator-prey interactions is vital for the management of their populations in response to environmental variability. Predator foraging decisions, such as where and when to search and how much energy to expend doing so, are greatly influenced by the abundance and distribution of prey in their proximate environment. Traditionally, for cryptic predators and prey, information on prey distribution has been inferred from behavioural responses of predators (e.g. GPS tracking and/or behaviour data loggers) or indirect indices of prey abundance (e.g. primary productivity). However, such methods rarely provide the temporal and spatial resolution required to accurately measure the prey field changes necessary for detecting predator responses. Recent technological advances in the miniaturisation of animal-borne video cameras now provide the ability to track predator behaviour in relation to their prey field in otherwise cryptic environments. The aims of the present study were to determine foraging effort in the world's smallest species of penguin in relation to prey availability. A total of 20 little penguins (*Eudyptula minor*) from two breeding colonies experiencing divergent oceanographic regimes in south-eastern Australia were sampled to determine hunting effort in response to prey type and patch density. Individuals were equipped with animal-borne video data loggers (to measure prey field), tri-axial accelerometers (to measure overall dynamic body acceleration, an index of energy expenditure) and time-depth recorders (to measure diving behaviour). For small schooling prey such as clupeoid fish, individuals expended more energy at higher density patches. In addition, little penguins increased their foraging effort in the presence of conspecifics suggesting individuals were competing rather than cooperatively foraging. Less effort was expended on low nutritional prey such as jelly fish and krill. This information provides new insights into how little penguins may respond to future prey dynamics, crucial information for predicting how its population may respond to changing climate.

Identifying Ecologically or Biologically Significant Areas for chinstrap penguins in the South Orkney Islands, especially where they may be in competition with the fishery for Antarctic krill

Phil Trathan, Claire Waluda, Norman Ratcliffe

British Antarctic Survey

Penguins have been described as sentinels, providing indications of ecosystem status and health. The Southern Ocean is changing and, not surprisingly, some penguin populations are also. In the Antarctic and maritime-Antarctic the pygoscelids exemplify current winners and losers. For example, at many locations gentoo populations are increasing and expanding their range, whilst chinstraps and Adélie populations are thought to be more vulnerable, at least in the Antarctic Peninsula and Scotia Sea regions.

That penguin numbers are changing is not in doubt, but the reasons for these changes are less well understood. Here, we review some of the threats to these species and potential conservation initiatives that may help secure their future. We describe details of the potential pressures that may arise from climate change, recovering marine mammal populations and from fishing, threats variously of global, regional and local concern.

In order to protect these sentinels, various international groups have advocated the need to set aside parts of the ocean as Marine Protected Areas. However, the international authority responsible for managing fisheries in the Antarctic, CCAMLR (the Commission for the Conservation of Antarctic Marine Living Resources), has been unable to agree any protected areas since 2009, despite considerable scientific evidence submitted in support of the designation of area protection.

Vital information needed to help protect penguins includes increased understanding about their use of key habitats in space and time. Here we report on habitat preference models developed to identify areas of importance for penguins foraging around the South Orkney Islands. Our models are based on GPS telemetry data, environmental correlates and the known distribution of penguin rookeries in the archipelago.

We also identify where and when penguins are most likely to be in competition with the fishery for Antarctic krill. We suggest how CCAMLR might proceed, using an experimental approach to managing the fishery, so that it gains further understanding whilst also protecting krill dependent predators such as penguins.

Do research activities have an impact on yellow-eyed penguins?

Y. van Heezik, A. Stein, B. Goldsworthy, P.J. Seddon, M. Young

Department of Zoology, University of Otago

Well-studied, long-lived species such as seabirds can be exposed to decades of investigator interventions, and if the species is of conservation concern, there is likely to be intensive monitoring and management as well. We determined whether investigator disturbance in the form of double banding, band maintenance, capture and handling, blood and stomach sampling, and device deployment, were additional factors influencing breeding success and lifetime reproductive success in the yellow-eyed penguin/hōiho (*Megadyptes antipodes*). The yellow-eyed penguin is a long-lived seabird that has been intensively studied on the Otago Peninsula of South Island, New Zealand for more than three decades, and is known to be vulnerable to human intrusion. In addition we specifically examined the effects of stomach flushing on adult re-sighting probability, productivity, and chick mass. The “water-offloading” technique has been used in diet studies of 17 of 18 species of penguins. We found no negative effects associated with any investigator disturbance type on breeding success and LRS. There was also no evidence for negative effects of stomach flushing, except when carried out in years of particularly poor food availability, or when flushing events exceeded four per nest per season.

Penguin mass mortality events: solving puzzles in the field

Ralph Eric Thijl Vanstreels¹, Renata Hurtado², Nola J. Parsons³, Patricia P. Serafini⁴, Marcela M. Uhart⁵, Pierre A. Pistorius⁶, Ursula Ellenberg⁷, José Luiz Catão-Dias⁸

¹Laboratory of Wildlife Comparative Pathology (LAPCOM), School of Veterinary Medicine, University of São Paulo, São Paulo, Brazil, ²Institute of Research and Rehabilitation of Marine Animals (IPRAM), Cariacica, Brazil, ³Southern African Foundation for the Conservation of Coastal Birds (SANCCOB), Cape Town, South Africa, ⁴National Center for Research and Conservation of Wild Birds (CEMAVE), Chico Mendes Institute for Biodiversity Conservation (ICMBio), Florianópolis, Brazil, ⁵Wildlife Health Center, School of Veterinary Medicine, University of California, Davis, United States, ⁶Department of Zoology, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa, ⁷Department of Ecology, Environment and Evolution, La Trobe University, Melbourne, Australia, ⁸Laboratory of Wildlife Comparative Pathology (LAPCOM), School of Veterinary Medicine, University of São Paulo, São Paulo, Brazil

Mass mortality events affecting hundreds to thousands of penguins have been reported. Carcasses are typically found at breeding colonies or washed ashore. Because these events are sporadic and often witnessed by researchers/personnel unprepared to collect data and samples for diagnostic analysis, the cause/s of penguin mass mortality events often remains unknown. Mass mortality events can result from a number of infectious and non-infectious causes, including: avian pox (*Avipoxvirus*), Newcastle Disease (*Newcastle disease virus*), infectious laryngotracheitis (*Penguin herpesvirus 1*), avian cholera (*Pasteurella multocida*), blood parasites (*Leucocytozoon*, *Plasmodium*), diseases of unknown aetiology (puffinosis-like disease, diphtheric stomatitis, penguin chick feather-loss disorder), starvation, drowning (entanglement in fishing gear), trauma (humans, domestic animals, predators, etc.), intoxication (toxic algal blooms, poisoning), oil spills, extreme weather events (storms, avalanches, mudflows, etc.), among others. In this presentation we will provide an overview of known penguin mass mortality events. We will demonstrate how detailed and systematic recording of the characteristics of a mass mortality event can contribute to the identification of its underlying causes. Recommendations will be provided on how researchers and conservationists can prepare to collect data and biological samples crucial for identifying the causes of a mass mortality event should they witness one in the field. Finally, we will discuss the precautions necessary to protect field teams from zoonoses (animal transmitted diseases) and to prevent investigation activities from inadvertently spreading pathogens.

Growing up under the spotlight: Effects of tourist visitation on the stress response and sex ratio in Magellanic penguin chicks at San Lorenzo, Argentina

Brian G. Walker¹, Frank A. Spizzoucco¹, C. Villanueva²

¹Fairfield University, Fairfield CT, USA. ²University of Tasmania, Hobart, Australia

Numerous studies have examined how tourism affects the behavior and physiology of penguins. The majority of these studies focus on adult penguins, with less attention having been focused on chicks – although disturbances and stress to chicks may be particularly problematic during their sensitive developmental period. Here we examine the effects of tourist disturbance on Magellanic penguin (*Spheniscus magellanicus*) chicks at a colony with an intermediate level of tourist disturbance (San Lorenzo, Argentina with ~10,000 people/year) and compare these results to our previous findings for a much more intensely disturbed colony (Punta Tombo, Argentina with >120,000 people/year). We examined the development of the hypothalamo-pituitary-adrenal (HPA) axis stress response by measuring the stress hormone corticosterone in chicks in both tourist-visited and undisturbed areas of the San Lorenzo colony. We additionally determined sex ratio of chicks hatched in both areas of the colony. Although our previous work at Punta Tombo showed tourist disturbance causes early expression of the HPA stress response, chicks at San Lorenzo did not show this early expression in either area of the colony. Additionally, there was no difference in sex ratio of chicks between the two areas, and for the colony as a whole, male:female hatch ratio was only slightly skewed towards males. These results suggest that care in examination of tourist disturbance effects on penguin colonies is warranted, and different levels of disturbance may differentially affect penguins' responses. Additionally, that sex ratio at hatch is nearly equal for male and female Magellanic penguins further suggests that survival post-fledge in these penguins is variable for the sexes, as adult sex ratio is typically highly skewed towards males at colonies in Argentina.

Developing a sustainable collaborative Education and Outreach program, inspiring students beyond the basic questions of life in a tent

Gary Wesche¹, Maureen Lynch², Heather Lynch²

¹Kansas City Zoo & Polar Educators International (PEI), ²Stony Brook University

Education and outreach is a vital component of science in the research world today. Researchers can be found visiting school classes worldwide, in person or virtually. How do educators and researchers move interactions to a higher level of engagement without placing unrealistic pressure on limited resources of time, money and equipment?

The Penguin 'CALLS' project has been a three year collaboration between Dr. Heather J. Lynch and Maureen Lynch of the research project "Acoustic evolution and its role in gentoo penguin colony formations" and Gary Wesche, Penguin Education Coordinator of the Kansas City Zoo. Integrated together are the conservation mission goals of the Association of Zoos & Aquariums and Kansas City Zoo, Common Core State Standards for literacy in science and technical subjects, Next Generation Science Standards for life sciences and engineering design, and education and outreach goals of Stony Brook University.

Through this partnership high school students have opportunities to interact with field researchers utilizing multiple distance learning platforms. Students participate in team discussions, become versed on current research, and learn to collect, analyze, and draw conclusions from real data. To facilitate science literacy, students are exposed to a variety of written and multimedia resources with pedagogical reading strategies integrated into the project's curriculum.

Multiple concepts are a part of scientific research studies. Concepts in fields of biological science, physical science, Earth science and mathematics are interwoven. Gathered for educators are resources related to these concepts and issues.

All research projects are dependent on the collection of data. This research study is dependent on some very new and unique methods of data collection. Engineering of collection devices is evolving, and new approaches to obtaining detailed and reliable data are emerging. Understanding data needs better informs individuals who will potentially design new forms of data collection. Additionally, analysis of collected data allows students to envision future steps in the research process. To this end students have access to multiple data sets provided by the university.

The final component is education and outreach. Dissemination of science knowledge, research, and discoveries enables the general public to improve their science literacy. The Kansas City Zoo hosts yearly science conferences designed in the format of the International Penguin Congresses. Student researchers submit abstracts and are selected to present work in poster sessions, oral sessions, or as featured keynote speakers. High school students have been recognized locally, nationally and internationally for their research.

Penguins in the voids

Eric J. Woehler

Birdlife Tasmania

Little Penguins (*Eudyptula minor*) nest and moult in natural and artificial voids in seawalls and breakwaters throughout coastal Australia and New Zealand. The size and characteristics of these voids are critical if breeding is to be successful. If the voids or the entrances are too small they do not provide viable habitat for the penguins, and if too large predators can access the nesting penguins.

The proposed upgrade of an arterial road adjacent to a Little Penguin colony in Tasmania will require some form of a seawall to be constructed to support the road upgrade. This provides an opportunity for the seawall construction to incorporate breeding habitat for penguins through the judicious placement of suitably sized rocks and fill materials commonly used for such constructions.

The St Kilda breakwater in Melbourne (Victoria, Australia) was built for the 1956 Olympic Games, and Little Penguins were first recorded nesting there in 1974. The St Kilda breakwater currently supports approximately 1200 breeding Little Penguins, was seen as a model for the proposed seawall construction in Tasmania. Data from seawalls and breakwaters used by penguins elsewhere around Australia and New Zealand were collated to provide additional information to identify key construction parameters.

The specific provision of artificial penguin breeding habitat in coastal constructions offers a conservation strategy and management option not currently implemented in Australia or New Zealand. In light of the ever-increasing spectrum of threats to Little Penguins, the construction of artificial habitats can substantially mitigate past and potential future impacts for Little Penguins (and other burrow-nesting penguin species). Construction of artificial breeding habitat could supplement or complement the provision of nest boxes for penguins.

The role of tourism in driving little penguin research at Oamaru, New Zealand

Philippa Agnew¹, Jason Gaskill²

¹Oamaru Blue Penguin Colony, Waterfront Road, Oamaru 9400, New Zealand, ²Tourism Waitaki, 8 Itchen Street, Oamaru, 9400, New Zealand

Nature-based tourism can provide benefits for both the local economy and the environment at the central focus of operations. Benefits to the environment arise from educational opportunities, encouraging an awareness of the nature environment, and the conservation of ecosystems. However, seldom does the revenue gathered from nature-based tourism directly fund research on focal species. At the Oamaru Blue Penguin Colony, monitoring and protection of little penguins (*Eudyptula minor*) began after the establishment of the colony in 1992. The penguins are protected from introduced mammalian predators and disturbance from people, and subsequently monitoring has found no impact on reproductive performance or survival. Breeding habitat for the penguins has been provided at the site. These measures also occur at other penguin breeding colonies, however, in addition (and in contrast to many sites), the Oamaru Blue Penguin Colony has provided all necessary funding towards a scientific research programme that began in 2009. The programme first provided funding for research towards a doctoral degree which examined the foraging behaviour of the penguins. The research also investigated variation in demographic parameters and determined environmental influences on those parameters. The outcome of the project is a greater understanding of how the penguins use the marine environment and how they are affected by changes within it. The research programme will continue to increase at the colony, incorporating the penguins outside of the colony and potentially other species, all as a direct result of funding from tourism.

An overview of wound management in African penguins admitted for rehabilitation at SANCCOB

Natasha Ayres¹, Nola Parsons¹, Stephen van der Spuy¹, Morag Sharratt¹, Nicky Stander¹, Juanita Raath²

¹SANCCOB, 22 Pentz Drive, Table view, Cape Town 7441, South Africa, ²SANCCOB, Seal Point Lighthouse, Cape St Francis, Eastern Cape 6312

Every year numerous wounded and injured African penguins are admitted to both the Western and Eastern Cape branches of SANCCOB. Despite the severity of many of the wounds seen, most individuals handle the rehabilitation process well. The prognosis is dependent on the anatomy around the wound in question, whether the wound penetrates into the body cavity and whether bone is exposed. A wounded penguin is often otherwise fit and healthy, and therefore difficult to catch in the wild. As such wound cases seen at SANCCOB are generally older injuries, once the bird has become weaker and easier to catch. Older injuries may be harder to resolve. The timeline of the birds' wound care depends on a number of factors such as initial habitus, freshness of the injury, cleanliness of the wound, bone involvement, extent of feather damage. The approach to wound care must be tailored to allow for the solid nature of penguin pus, calling for a more open healing approach than in mammals. The aim is to get the bird swimming as quickly as possible as it is of high importance for enrichment, feather quality and wellbeing of the penguin. A large proportion of the wounded penguins are released, although the length of rehabilitation varies between cases.

It is a priority of the African penguin Biodiversity Management Plan to limit adult mortality and rehabilitation of individuals, including those with wounds and injuries, works towards this goal. Collating data from 2013 to 2015 has allowed us to observe trends relating to type of wound/injury, location found, seasonality and age of birds that are admitted in order to provide colony feedback and possible management recommendations.

Color Trait Signals Health Condition in a Antarctic Penguin, the Gentoo Penguin (*Pygoscelis papua*)

Andrés Barbosa¹, Raul Cordero¹, Javier J. Cuervo¹, Maria Jose Palacios², Nestor R. Coria³

¹Dpt. Ecología Evolutiva. Museo Nacional de Ciencias Naturales, CSIC, Madrid, Spain, ²Dpt. Ecología Funcional y Evolutiva. Estación Experimental de Zonas Áridas, CSIC, Almeria, Spain, ³Instituto Antártico Argentino, Buenos Aires, Argentina

The relationships between secondary sexual characters such as color traits and health condition have been showed in several bird species. In general, findings point out that individuals with stronger colors show a better health than paler individuals. Such relationships should be stronger during the period of mate selection according to the sexual selection theory. Among penguins, Gentoo penguin has a red spot on the beak that has been shown that could be a trait under sexual selection showing relationships with body condition and being dependent of environmental factors such as diet, specifically krill which is a rich source of the carotenoid astaxanthin. However, until now no studies have been carried out in this species to determine which traits could be related with color variation and therefore could be signalized by color traits. Ecological studies about relationships between health parameters and secondary sexual characters has not been carried out in Antarctic penguins and Gentoo penguin show a good opportunity to test whether such relationships are present in the Antarctic fauna. Moreover, it has been found that krill stocks are affected by the climate change in the Antarctic Peninsula which could affect beak coloration of Gentoo penguin and then to sexual selection processes. In this study we test if there are any relationships between the beak color and cellular immunity in this penguin species during the pre-breeding and the breeding period. We expect that relationships should be stronger during the pre-breeding period as predicted by the sexual selection theory. Our results support the expectations as we found significant relationships only during the pre-breeding period. Individuals with redder beaks show better health than individuals with paler beaks as expected. Moreover, individuals with lower reflectance in the ultraviolet showed less stress than individuals with higher UV reflectance. In summary, our results show for the first time that color traits in the Gentoo penguin can be considered as a signaling character in this case of good health and that this signalization is only functional during the mating period as is expected under the sexual selection theory.

Location Relocation Relocation : Nest site fidelity of the African penguin *Spheniscus demersus* on Robben Island

Barbara J. Barham¹, Innes C. Cuthill¹, Richard B. Sherley²

¹School of Biological Sciences, University of Bristol, Bristol, UK, ²Environment and Sustainability Institute, University of Exeter, Penryn, Cornwall, UK.

The African penguin *Spheniscus demersus* is an endangered species which inhabits the southwest coasts of South Africa and Namibia. The species is in decline throughout its range, particularly on the western coasts; the decline is believed to be caused largely by shortage of food. A major aim of the Biodiversity Management Plan for the species is to attempt to establish new colonies in localities where there is adequate food supply. On Robben Island, there is an additional threat caused by removal of alien vegetation as part of the plan to restore the island to its natural environment and also for creation of fire breaks, thus causing loss of habitat for the penguins. Artificial nest boxes have been installed to provide alternative nesting habitat. There is therefore a pressing need to gain a better understanding of nest site fidelity and the factors that influence it, in a shrinking population where nest density is reducing, as well as the degree to which nesting birds will use artificial habitat.

A sample of easily identifiable penguins was selected using banded, transpondered and distinctively patterned birds. Extensive searches were carried out to attempt to locate a representative sub-sample of those birds. After applying mortality rates, 59% of the birds which would have been expected to survive were observed to return to the same general vicinity to breed; a further 8% were observed as non-breeders. 19% of breeders returned to the exact same nest site; the remainder (40%) took up nest sites within a range of 1 to 4 potential nest sites distance from the original nest. Simple modelling suggested that the number of nest sites moved followed a negative binomial distribution. Significantly lower rates of fidelity are shown in this study compared with previous studies, this may be due to older studies having been carried out when the nest density was greater and the population was increasing.

Communal Breeding: An Alternative and Successful Lifestyle for Some African Penguins on Robben Island?

Barbara J. Barham¹, Peter Barham²

¹School of Biological Sciences, University of Bristol, Bristol, UK, ²School of Physics, University of Bristol, UK

We have previously shown that the breeding success of African penguins (*Spheniscus demersus*) on Robben Island is negatively correlated with the overall density of nests in the colony (RB Sherley, PJ Barham, BJ Barham, RJM Crawford, BM Dyer, Population Ecology 56 (1), 119-128). We found that as the number of birds in the colony increased so the area it occupied grew in stages, with the birds expanding into new areas when the nest density exceeded about 40% of the available nest sites. We also found that as the nest density decreased from around 40% to around 10% so the breeding success increased significantly.

However in the past few years we have noticed an increasing tendency for some birds to choose to nest at a locally high density. These birds nest together under single large Rooikrans (*Myoporum tenuifolium*) bushes or in small contiguous groups of Tetragonia (*Tetragonia decumbens*) bushes or under large Manitoka (*Myoporum montanum*) trees. These groups of nests form small relatively dense 'communes' of between 3 to 8 nests. Within these 'communes' between 30 and 80% of the available nest sites are occupied at any one time during the breeding season.

The overall breeding success of birds choosing this communal breeding lifestyle is at least as good as that of the remaining birds that choose to breed in well separated nests at much lower density, typically less than 10% of the nest sites outside the communes have been occupied since 2009.

We have noticed two novel, co-operative nesting behaviours in these communes. We have found 12 cases where 3 different birds incubated the eggs at a single nest (corresponding to 0.6% of all nesting attempts) – of these 11 were within communes (corresponding to 5% of nesting attempts within communes) and 1 at a 'solitary' nest (corresponding to 0.04% of solitary nesting attempts). There are also two cases where we have observed the same bird incubating two separate clutches at the same time – both were within 'communes'.

All this behaviour has been found from observations made for different purposes as part of regular nest checks in the colony. We will, in the 2016 season, try to make a proper study into this communal nesting behaviour and will report on our preliminary findings.

Individual foraging behaviour may result in longer term changes in Little Penguin nest site density on Penguin Island and has implications for management strategies on land and at sea

B L. Cannell^{1,2}

¹Murdoch University, Perth, Australia, ²The University of Western Australia, Perth, Australia

The largest colony of Little Penguins in Western Australia is located on Penguin Island, 50 km south of Perth. Foraging habitat of the penguins has been studied during incubation (2008, 2009, 2013-2015) and chick rearing (2007-2009, 2013-2015). Whilst the majority of the penguins headed south from the colony, some headed northwards. Penguins whose nests were sited on the northeast of the island were more likely to forage north of the colony. During the marine heatwave in 2011, the arrival beach on the northeast of the island was the only one of 4 beaches studied that did not have a reduced number of penguins arriving at night- it is therefore likely that penguins who nested elsewhere on the island, and probably fed south of the colony, were less likely to attempt to breed during very warm SST events. Breeding success over several years, both before and after the marine heatwave, was also generally higher at nest sites on the northwest area. Little Penguins not only return to nesting areas close to where they were raised as chicks, but in fact arrive at the same beach that they used when they first left the colony. Therefore, as the incidence of La Nina events is predicted to increase, and SST are also predicted to rise in the SW of WA, the colony density may change in favour of sites where the individual foraging strategies of those penguins favour a northward heading. Such potential differences in foraging habitat should be considered when developing both marine and terrestrial management strategies.

How good are morphological and behavioral indicators in sex determination of Galápagos and Magellanic penguins?

Caroline D. Cappello¹, P. Dee Boersma^{1,2,3}

¹University of Washington, Department of Biology, ²Global Penguin Society, ³Wildlife Conservation Society

Sex determination is essential to many studies of ecology and behavior and can influence conservation actions. Several techniques have been used to determine the sex of birds with low sexual dimorphism, but reliable methods are often time consuming or invasive. Numerous studies have evaluated the usefulness of morphological measurements as quick and minimally invasive means of sexing penguins in the field. Studies of Magellanic, Humboldt, and African penguins have shown bill depth to be a useful indicator of sex, but few have included behavioral variables or within-pair comparisons of morphology in their analyses. Combining morphometric and behavioral indicators may increase accuracy and flexibility in sexing penguins. Using Galápagos and Magellanic penguins, we aimed to identify sexing methods that were accurate, reduced intrusiveness and researcher effort, and increased methodological flexibility. We used a classification tree (CART) analysis to determine the accuracy of sexing Galápagos and Magellanic penguins using four morphological measurements: bill depth, bill length, flipper length, and foot length. For Magellanic penguins, we included a within-pair comparison of bill depth and observations of two breeding behaviors: 1) which member of a pair settled the nest at the beginning of the season and 2) which member of a pair took the first long incubation stint. We used birds sexed through genetic analysis, cloacal examination, and dissection as our known-sex sample. Bill depth was the best splitting variable in Galápagos penguins, correctly classifying the sex of 95% of study penguins. For Magellanic penguins, within-pair bill-depth comparison, nest settlement, bill depth, and first incubation were the strongest indicators, correctly classifying the sex of 100%, 99%, 98%, and 98% of study penguins, respectively. These results suggest that penguins may be effectively sexed with minimally invasive procedures and that researchers have flexibility in their methodology. Though the discriminating threshold of morphological measurements may differ between colonies, behavioral indicators, within-pair comparisons of morphology, and the relative importance of each variable should be useful species wide.

Effects of 2015 El Niño on Humboldt penguin chick production and breeding population

Cárdenas-Alayza, Susana^{1,2}, Bussalleu, Alonso J.¹, Cardeña, Marco A.¹

¹Punta San Juan Program, Universidad Peruana Cayetano Heredia, ²Chicago Zoological Society

Punta San Juan (PSJ) is the most important breeding colony for Humboldt penguins in Peru. The devastating effects of the strong 1997-98 El Niño caused a severe decline in this species, reducing colony size at this site from >4,000 to <800 individuals. Fortunately, since year 2000, population recovery at PSJ has taken place. However in 2015, another strong El Niño event developed. At PSJ between 2000-2015 population abundance and breeding success of Humboldt penguins has been systematically surveyed. The goal of this study is to understand the effect of the 2015 El Niño on the adult breeding population and on the number of chicks produced. Weekly surveys were conducted at main breeding colony S7/S8 where (i) number of nests occupied by roosting adults, (ii) nests with chicks and (iii) relative abundance of chicks and adult Humboldt penguins were estimated. Linear models show strong positive linear trends in the increase of number of nests occupied by roosting adults ($r^2=0.92$, $p<0.01$, Pearson correlation=0.96), number of nests with chicks ($r^2=0.86$, $p<0.01$, Pearson correlation=0.93) and the relative abundance of chicks ($r^2=0.82$, $p<0.01$, Pearson correlation=0.91) for years 2000-2014. When year 2015 is included, correlation coefficients are reduced for categories with only chicks, from 0.91 to 0.69 for relative chick abundance and from 0.93 to 0.66 for the number of nests with chicks. However, including year 2015 in number of nests occupied by roosting adults increases model performance ($r^2=0.93$, $p<0.01$, Pearson correlation=0.96) evidencing that the effects of the 2015 El Niño are on chick exclusive categories. From 2014 to 2015 there was a reduction in 71.02% (from 628 to 182) in the number of nests with chicks and of 68.87% in relative chick abundance (from 1028 to 320). Although no strong correlations were found with variables and monthly sea surface temperature anomalies (SSTA) for Coastal Peru El Niño Index, a four-fold increase in SSTA during 2015 compared to previous 15 years was detected. Thus, changes in environmental conditions during 2015 affected chick production at PSJ, but has not shown a negative effect on survival of adult breeding population. In conclusion, development of El Niño events at local level varies and will affect Humboldt penguin survival differently according to energetic reserves/demands of age classes. We recommend studies on local prey availability and environmental conditions at PSJ penguin feeding areas to better understand effects on survival and breeding success of Humboldt penguins.

Meaningful Impact in Penguin Conservation from Field and Zoo Collaboration

Bill Fraser¹, Ron Kagan²

¹Polar Oceans Research Group, ²Detroit Zoological Society

The Polk Penguin Conservation Center will open at the Detroit Zoo in April 2016 after more than four years of design and planning; it will be home to more than 80 penguins of four species – Gentoo, macaroni, rockhopper and king. The penguin center represents a revisioning of the role of zoos in penguin conservation in how it advances the state-of-the-art for how penguins live in captivity, in how zoo visitors learn about Antarctica's environment and ecological changes affecting penguins there, and how it represents the power and impact of collaboration between penguin biologists in the field and zoos. Collaboration included extensive research into the development of the facility's unique and authentic design utilizing the experience and knowledge of Dr. Bill Fraser of Polar Oceans Research Group, integration of penguin field science around the world in the visitor engagement program, and financial support of and staff collaboration in field studies on behavior, foraging ecology and breeding biology with the field operations of Polar Oceans Research Group in Antarctica.

The animal habitat provides an optimal environment for penguins with air temperature set to a near-freezing 37 degrees Fahrenheit, varied natural surfaces, snow and a 25-ft deep pool. The penguin center's program includes a one-of-a-kind 4D opportunity for zoo visitors to experience some of the extreme conditions of Antarctica as well as a way for people to travel through the penguins' underwater habitat. The facility's chilled, 326,000-gallon aquatic environment offers views of penguins "flying" above and beneath guests watching from within two acrylic tunnels along the bottom of the penguins' pool.

The Polk Penguin Conservation Center engages the nearly 1.5 million people who visit the Detroit Zoo each year in issues facing penguin populations and what people can do to help reduce human impact on penguins and penguin habitat. The work of penguin researchers and conservationists around the world are central to the guest engagement and education programs. Penguin conservationists rarely have opportunities to reach people at a scale possible in the Detroit Zoo's penguin center. The opportunity to share their knowledge of penguins and the fragile Antarctic landscape in ways that are broader and potentially more influential with respect to policy and action is one that few have available. The Polk Penguin Conservation Center is a unique and significant opportunity to directly connect field biologists with millions of people, beginning with the work of Dr. Fraser and the Polar Oceans Research Group.

The Polk Penguin Conservation Center – Advancing State of the Art for How Penguins Live in Zoos and How Zoo Visitors Learn About Them

Ron Kagan, Scott Carter

Detroit Zoological Society

The Polk Penguin Conservation Center will open at the Detroit Zoo in April 2016 after more than four years of design and planning. Home to 80 gentoo, macaroni, rockhopper and king penguins, it represents a giant leap forward in the state-of-the-art for how penguins live in captivity and how zoos educate the public about penguins, penguin conservation, climate change and polar ecology.

In 1968 the Detroit Zoo invented the first Penguinarium. It is a leader in captive penguin care and conservation, and it leads the AZA Penguin Advisory Group. In addition to knowledge and experience, extensive research in Antarctica went into the design of the Polk Penguin Conservation Center to ensure everything necessary to ensure great penguin welfare. Staff studied environmental features and observed thousands of wild penguins to design a habitat in which penguins can thrive, not just survive. The air temperature is a near-freezing 37 degrees Fahrenheit, and walking surfaces and nesting areas are varied, including snow and ice. A dramatic feature of the 33,000-square-foot facility is the chilled, 326,000-gallon, 25-ft deep pool. To ensure understanding of the penguins' wellbeing in the new facility, the DZS Center for Zoo Animal Welfare is conducting pre- and post evaluation of the penguins' behaviour and use of space.

The visitor engagement program helps zoo visitors learn about the extreme, rapidly changing Antarctic environment. The building's dramatic exterior evokes a tabular iceberg, and inside guests are engaged through technology including 4D effects, "heads-up" displays, projection mapping, extensive use of film and exploration history, focusing on the expeditions of Ernest Shackleton. Penguins are observed living in a chilled, indoor environment and "flying" above and beneath guests watching from within acrylic tunnels along the bottom of the penguins' pool.

Penguin field science is central to the visitor engagement strategy, connecting individual researchers with the nearly 1.5 million people who visit the Detroit Zoo each year. We are currently working with Dr. Bill Fraser of the Polar Oceans Research Group, including participating in field work at Palmer Station, Antarctica.

Consistent with its messages about reducing human impacts on ecosystems, the Polk Penguin Conservation Center was designed with many water- and energy-saving features. The building has net-zero water usage through the design of all aquatic features. The facility was designed with a super-insulated exterior building envelope and equipped with state-of-the-art heating and cooling systems to minimize energy consumption. It is completely powered by off-site wind energy.

The truth about "False Breeding": An opportunistic autumn breeding attempt in little penguins (*Eudyptula minor*)

Danielle Hedger¹, Richard D. Reina¹, André Chiaradia²

¹School of Biological Sciences, Monash University, Clayton, Vic 3800, Australia, ²Research Department, Phillip Island Nature Parks, PO Box 97, Cowes, Vic 3922, Australia

Long-lived animals experience energetic trade-offs associated with current reproduction and future survival. Penguins in particular need to adopt flexible breeding strategies due to fluctuations in limited resources within the marine system. Variables such as sea surface temperature (SST) and marine productivity, measured in chlorophyll-a concentration (chl-a), can influence seabird energy intake and thus species tend to synchronise breeding with the spring peak in prey availability. While variation in penguin reproductive timing and success has been well documented in the spring breeding season, few studies have examined breeding attempts outside this time. Little penguins (*Eudyptula minor*) are resident seabirds that can attempt multiple breeding events throughout a year. While larger colonies tend to be restricted to breeding in spring, at Phillip Island, Australia, a peak in penguin colony attendance during autumn has been linked to reproductive behaviours and interpreted as "False Breeding". Due to the costs associated with reproductive behaviours, this interpretation is at odds with seabird life histories. Here, we have combined colony attendance, nest occupancy and body mass data from field data and an automated penguin monitoring system over 11 years, to determine the pattern of the autumn peak in attendance and examine potential triggers such as SST and chl-a. The two peaks in penguin colony attendance and body mass trends during the autumn resembled the courtship and pre-laying phases of the spring breeding season. We concluded that the autumn peak is not a 'false breeding' behaviour but instead an "Autumn Breeding Attempt" (ABA). About 76% of spring breeding penguins attended ABA and were 2.5 years older than penguins that bred in the spring alone. It seems older birds are trying to increase their breeding effort due to a reduced residual reproductive value or alternatively, may be more experienced at responding to subtle external cues. Similarly to the spring breeding season, changes in lagged SST and chl-a around Phillip Island had a significant relationship with penguin attendance during autumn. However, ABA hardly resulted in eggs laid, as favourable environmental conditions may not persist over winter. All evidences indicate that ABA is a strategy little penguins and perhaps other temperate seabirds adopt to try and increase their breeding output when favourable environment conditions arise.

The effects of improved foraging conditions and decreased divorce rate on reproductive success of little penguins *Eudyptula minor*

Matthew D. Simpson¹, André Chiaradia², Lloyd Davis³, Richard D. Reina¹

¹School of Biological Sciences, Monash University, Clayton, Vic 3800, Australia, ²Research Department, Phillip Island Nature Parks, PO Box 97, Cowes, Vic 3922, Australia, ³Centre for Science Communication, University of Otago, New Zealand

The restricted foraging range of penguins means that parental foraging ability is crucial for chick survival. Poor foraging conditions would cause reproductive failure; leading to unsuccessful breeding pairs that are likely to divorce in the next season. Divorce disadvantages birds as they may start breeding later given that an increased in mate search time could result in later laying date. It is important that they time their breeding to coincide with peaks in productivity otherwise they must increase their foraging effort to compensate for the lower prey availability. Thus penguin breeding success can be affected by a combination of foraging performance, pair bonding and environmental changes but few studies have examined these parameters together. In this study, we investigated the variation of environmental and biological factors associated with foraging conditions and the consequences for reproduction in little penguins (*Eudyptula minor*) over a 12-year period. The rate of divorce was correlated with the reproductive success of little penguins. Years of lower divorce rate coincided with less variable foraging trip durations and higher reproductive success. Environmental factors at local (as index of the thermocline), regional (sea surface temperature) and global (Southern Oscillation Index).were present in some of the best fit models but with low relative importance compared to biological factors. This investigation has showed that an improved breeding success over a 12 year period was followed by more stable foraging conditions, slightly earlier breeding onset and decrease divorce rate under less variable environmental conditions in the little penguin marine environment. The interaction between foraging conditions and breeding ecology under global, regional and local environmental changes is crucial for understanding future implications for seabird species affected by commercial fishing and climate change.

Waddling on the Dark Side: Ambient Light Affects Attendance Behaviour of Little Penguins

Airam Rodríguez^{1,2}, André Chiaradia¹, Paula Wasiak¹, Leanne Renwick¹, Peter Dann¹

¹Research Department, Phillip Island Nature Parks, Australia, ²Department of Evolutionary Ecology, Estación Biológica de Doñana, Spain

Visible light on Earth largely comes from the sun, including light reflected from the moon. Predation risk is strongly determined by light conditions, and some animals are nocturnal to reduce predation. Artificial lights and its consequent light pollution may disrupt this natural behaviour. Here, we used 13 years of attendance data to study the effects of sun, moon, and artificial light on the attendance pattern of a nocturnal seabird, the little penguin *Eudyptula minor* at Phillip Island, Australia. The little penguin is the smallest and the only penguin species whose activity on land is strictly nocturnal. Automated monitoring systems recorded individually marked penguins every time they arrived (after sunset) at or departed (before sunrise) from 2 colonies under different lighting conditions: natural night skylight and artificial lights (around 3 lux) used to enhance penguin viewing for ecotourism around sunset. Sunlight had a strong effect on attendance as penguins arrived on average around 81 min after sunset and departed around 92 min before sunrise. The effect of moonlight was also strong, varying according to moon phase. Fewer penguins came ashore during full moon nights. Moon phase effect was stronger on departure than arrival times. Thus, during nights between full moon and last quarter, arrival times (after sunset) were delayed, even though moonlight levels were low, while departure times (before sunrise) were earlier, coinciding with high moonlight levels. Cyclic patterns of moon effect were slightly out of phase but significantly between 2 colonies, which could be due to site-specific differences or presence/absence of artificial lights. Moonlight could be overridden by artificial light at our artificially lit colony, but the similar amplitude of attendance patterns between colonies suggests that artificial light did not mask the moonlight effect. Further research is indeed necessary to understand how seabirds respond to the increasing artificial night light levels.

The marine ecosystem of Little Penguins in the Bass Strait, Australia: an integrate snapshot using ecosystem modelling - Ecopath

André Chiaradia¹, Catherine Bulman², Marta Coll^{3,4}, Joan Navarro^{5,6}, Peter Dann¹

¹Research Department, Phillip Island Nature Parks, Australia, ²CSIRO Oceans and Atmosphere, Hobart, Australia

³Ecopath International Initiative Research Association, Barcelona, Spain, ⁴Institut de Recherche pour le Développement. UMR MARBEC & LMI ICEMASA. Cape Town, South Africa, ⁵Estación Biológica de Doñana CSIC, Sevilla, Spain, ⁶Centre d'Ecologie Fonctionnelle et Evolutive CNRS, Montpellier, France

Food web models are powerful tools for describing ecosystem structure, for quantifying direct and indirect effects of environmental factors and human activities on trophic relationships and for examining the ecological role of the species.

Climatic variability adds difficulty by further altering further the structure and functioning of marine systems. A challenge for marine conservation is a quantitative understanding of how these multiple stressors (environment and human activities) will combine and interact to affect the food web change at a community and ecosystem level. Ecosystem modelling can compartmentalise and quantify these interactions in response to environmental variability.

We examined the food web of little penguins (*Eudyptula minor*) and associated species (prey and competitors) in the marine ecosystem of the north-west Bass Strait, Australia, by developing an ecological model using the freely available Ecopath with Ecosim modelling approach (<http://www.ecopath.org>). In this area, little penguins are top predators with a mean trophic level of 4.4 and have very low biomass in contrast with other top consumers.

Our results show the diet of little penguins strong overlap diets of key coexisting predator species. Australian anchovy (*Engraulis australis*), a key prey for little penguins in the last 10 years is also a major prey for short-tailed shearwaters (*Ardenna tenuirostris*) and crested terns (*Thalasseus bergii*). Barracouta (*Thyrsites atun*) is a common prey for penguins and also for Australian fur-seals (*Arctocephalus pusillus doriferus*) breeding and feeding in the western Bass Strait. Using qualitative simulations, it was revealed that an impact on Australian anchovy, barracouta or sardines (*Sardinops sagax*) is likely to have a negative effect on little penguin biomass.

The commercial annual fishery catch in this area has a moderate impact in the ecosystem. However, even such small fishery activity has a potential interaction with penguins as the landing from commercial gillnet fishery, a potential risk for penguin bycatch, represents 35% of the total landing in north-west Bass Strait.

The Ecopath food web model is our first step to understand the interactions of penguins with their marine environment so we can use it as a tool to evaluate stressors on the little penguin population by developing spatial-temporal simulations.

Weigh better: a new generation of weighbridge

Ross Holmberg¹, Kean Maizels², Richard Reina¹, André Chiaradia³

¹School of Biological Sciences, Monash University, Australia, ²Kean Electronics, Australia, ³Research Department, Phillip Island Nature Parks, Australia

Weighbridges are valuable tools in penguin research. Not only can individually marked penguins be monitored over time; population-wide ecological factors can also be analysed in great detail. These systems can collect massive amounts of data on colony attendance and body mass continuously and without manual handling. There are large amounts of research in the literature where these systems have been successfully used to conduct studies previously either impossible or impractical to attempt.

At Phillip Island, Australia weighbridges have been used for over 20 years with great success in little penguin (*Eudyptula minor*) research. The system is a modified version of the automated penguin monitoring system developed by the Australian Antarctic Division. It has revolutionised research of foraging habits of penguins by providing continuous fine scale information on their trips and their attendance behaviour at an individual level. However, the current system is over 20 years old, and computer power has increased many-fold over this period. These new technologies can allow for dramatic improvements to the efficacy and accuracy of these weighbridges.

Here, we compare a new generation system with the previous system. The system now stores every single record for post analysis, in a way that was not possible with the old system (over 20 million points per year in comparison with 500,000/year previously). By modelling the dynamics of each penguin as a continuous series of simple movements, each characterised by simple physical laws, we were able to mathematically verify the best way to calculate a penguin's mass, given the typically erratic measurements recorded from a weighing platform with relatively high sample frequency. We also addressed the disadvantages that come with automated weighing in the form of errors due to unpredictability in the penguins' behaviour. A penguin's movement during weighing, as well as where more than one penguin walks on the weighing platform at the same time, pose big challenges in the way data are collected and analysed. With storage of complete data logs making post-analysis possible, we are now able to determine ID and weights of all birds crossing the platform, even those crossings with multiple birds on the weighing platform.

Using lessons learnt from the old model, the updated weighbridge is providing a new generation of detailed biological information, hopefully continuing to make discoveries at the frontiers of little penguin foraging ecology in the next 20 years!

Landslide impacts on endangered Antipodes Island penguins

J. Hiscock¹, B.L. Chilvers²

¹Southern Islands, Department of Conservation, PO Box 743, Invercargill, New Zealand, ²Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Palmerston North, New Zealand

Climate change is increasingly being recognised as significantly altering the world's marine environment and affecting all aspects of marine species aquatic lives. Climate change is also altering weather patterns including frequency and strength of storm events causing significantly increased precipitation in some areas of the world bringing with it flooding and landslides potentially additionally impacting on where terrestrial marine species breed. Despite this little research has been undertaken to investigate these impacts on marine species. Worldwide, most crested penguin species (*Eudyptes* spp.) are in decline. New Zealand's subantarctic Antipodes Islands are of international significance for breeding seabirds including eastern rockhopper penguins (*E. filholi*) and erect-crested penguins (*E. sclateri*) penguins. Between 1995 and 2011 there was a 23% decline observed in the two penguin species on the Antipodes Islands. In January 2014, a significant storm ripped through the Antipodes Island area causing massive landslides, effecting approximately 20 percent of the islands land area. Here, we investigate nest abundance and distribution of the two penguin species to investigate the effects of these landslides on these already declining populations. Overall, there was a 10% decline in penguin's abundance between 2011 and 2014, however this decline was more significant for the erect-crest penguins (11.2% decline) than the rockhopper penguins (0.1% decline). Colonies affected by landslides showed less of a decline than those not affected. Given the timing of the landslides, the effects on each species differed, however the continued decline of erect-crested penguins at the Antipodes is an ongoing concern which needs further investigation before the population potentially goes extinct.

Diving behaviour of little blue penguins impacted by an oil spill: A clean-up and rehabilitation success?

B.L. Chilvers¹, K.M. Morgan¹, G. Finlayson¹, K.A. Sievwright¹

¹Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Palmerston North, New Zealand

The value of rehabilitating oiled wildlife is an on-going global debate. On October 5, 2011, the cargo vessel C/V Rena grounded on Astrolabe Reef, New Zealand (NZ), spilling over 300 tonnes of heavy fuel oil. As part of the Rena oil spill response, 383 little blue penguins (LBP, *Eudyptula minor*) were captured, cleaned, rehabilitated and released back into a cleaned environment. This research investigates foraging behaviour changes due either to the oil spill or by the rehabilitation process by comparing the diving behaviour of rehabilitated (n = 8) and non-rehabilitated (n = 6) LBPs and with LBP populations throughout NZ. Stable isotope analysis of feathers was also used to investigate diet. There were no foraging behaviour differences between rehabilitated and non-rehabilitated LBPs and the overall diving behaviour of these LBPs have similar, if not less energetic, foraging behaviour than other LBPs in NZ. This suggests the rehabilitation process and clean-up undertaken after the Rena appears effective and helps justify the rehabilitation of oiled wildlife across the world.

Diet, carotenoids and oxidative balance in four penguin species: an interspecific comparison

Colominas-Ciuró, R.¹, Carabajal, E.², D'Amico, V. L.², Bertellotti, M.², Benzal, J.³, Vidal, V.¹, Motas, M.⁴, Santos, M.⁵, Coria, N.⁵, Barbosa, A.¹

¹Dpto. Ecología Evolutiva, Museo Nacional de Ciencias Naturales (CSIC), Spain, ²Centro Nacional Patagónico (CONICET), Puerto Madryn, Argentina, ³Depto. Ecología Funcional y Evolutiva, Estación Experimental de Zonas Áridas (CSIC), Spain, ⁴Área de Toxicología, Facultad de Veterinaria, Universidad de Murcia, Spain, ⁵Instituto Antártico Argentino – División Biología, Cerrito 1248 (1010), Buenos Aires, Argentina

Nutrition influences the physiology of the organisms in several ways. The diet is a source of antioxidants that mitigate reactive oxygen species (ROS) damage. ROS are produced by normal metabolic activities (e.g. aerobic cell respiration) and, according to the free radical theory, damage biomolecules (e.g. lipids, proteins and DNA) unless quashed by antioxidants. Therefore, the disturbance in the pro-oxidant-antioxidant balance in favour of the former leads oxidative stress. Dietary antioxidants (e.g. vitamins and carotenoids) perform a main role in the whole antioxidant network and, for example, because of the impossibility to synthesis carotenoids by the birds, its efficiency may thus be affected by its diet. Krill is a main prey item for Antarctic Pygoscelis penguins: 70% (*P. papua*), 86% (*P. antarcticus*), 99.9% (*P. adeliae*) of the whole diet. It is rich in astaxanthin which has antioxidative properties being more active than other carotenoids. In contrast, Magellanic penguin (*S. magellanicus*) currently studied at Valdés Peninsula, account for 90 or more percent of anchovies (*E. anchoita*) in its diet. Quantification of ROS, oxidative damage and antioxidant capacity has attracted the attention to understand inter and intraspecific life-history variations. Hence, comparisons between species, sexes, populations, etc. are necessary. Our goal is to study the relationships between the diet, carotenoid concentration and oxidative stress. Diet was determined by means of stable isotope analyses, carotenoid concentration was determined by HPLC analyses and oxidative stress was accounted by analysing the oxidative damage (ROM) and the antioxidant capacity (OXY). Our results pointed out interspecific differences and that diet as showed by the trophic level could influence oxidative stress and the antioxidant defences.

Changes in the distributions of penguins and other seabirds around the southern hemisphere

Crawford RJM^{1,2}, Boersma PD³, Cannell BL^{4,5}, Garcia Borboroglu P^{3,6,7}, Lamont T¹, Lynch HJ⁸, Makhado AB¹, Simeone A⁹

¹Branch Oceans and Coasts, Department of Environmental Affairs, South Africa, ²Animal Demography Unit, University of Cape Town, South Africa, ³University of Washington, Seattle, USA, ⁴Murdoch University, Perth, Australia, ⁵Oceans Institute and School of Animal Biology, University of Western Australia, Australia, ⁶Global Penguin Society, Puerto Madryn, Argentina, ⁷Centro Nacional Patagonico, Puerto Madryn, Argentina, ⁸Stony Brook University, New York, USA, ⁹Departamento de Ecología y Biodiversidad, Universidad Andrés Bello, Santiago, Chile

There have been recent altered distributions of penguins and other seabirds around the southern hemisphere. In South Africa, eastward extensions into the Indian Ocean of the breeding ranges of at least two seabirds that formerly bred only in the Atlantic Ocean, increases in Indian Ocean populations of five other species that previously bred mainly in the Atlantic Ocean, and an increased proportion of African penguins in the Indian Ocean followed a southeast displacement of prey. In Western Australia, there were southward shifts in breeding distributions, or rapid growth of southern colonies, for eight tropical seabirds. By contrast, increasing SSTs were associated with decreased participation in breeding and a reduced breeding success of temperate little penguins. The Humboldt penguin has decreased in Peru; in northern Chile populations increased while populations from central Chile were stable or slightly decreasing. The overall southward trend of this species may be a response to strong El Niño events. In Argentina, new colonies of Magellanic penguins formed, expanding their breeding range to the north. The northernmost colonies increased and large colonies decreased. SST anomalies reported during the Magellanic penguin wintering stage resulted in large-scale mortality and penguins migrating farther north. In the western Antarctic Peninsula, Gentoo penguins expanded their range south in step with a southward retraction of heavy sea ice.

The widespread distributional changes, especially when coupled with pervasive recent changes in population numbers of some seabirds (including penguins) at sub-Antarctic islands and Antarctica, highlight the possibility of basin- to global-scale forcing and some such mechanisms have been formulated. We summarise information and look forward to gleaning further insights from chats around the poster.

Magnetic cleansing of oiled penguins: optimisation of technology and field trials

Peter Dann¹, John Orbell², Stephen Bigger², Lawrence Ngeh², Bernard Agana²

¹Research Department, Phillip Island Nature Parks, Phillip Island, Victoria 3922, Australia, ²College of Engineering & Science, Victoria University, PO Box 14428, Victoria 8001, Australia

For more than a decade, we have been working on advancing the rescue and rehabilitation of oiled wildlife using oil-sequestering particles and magnetic removal of contaminants from plumage and fur. This treatment has advantages over conventional detergent-based methods, including not requiring water, requiring significantly less recovery time post-treatment, being potentially useful on site, due to its portability, as well as being faster and cheaper. We know it removes oil from feathers, mammalian fur and rock and are confident that it will work on turtles and reptiles - but we need to evaluate the method on oiled wildlife under field conditions. Over the next three years we hope to achieve this in a three stage process: optimisation of the technology for use in the field, develop partnerships with key stakeholders around the world and evaluate the technology using oiled wildlife - if and when the opportunity arises. We are currently developing several elements of this technology further including the use of heated particles/pre-conditioning agents, the optimization of the magnetic field strength, the evaluation of new particle types and the further development of pre-conditioners to be used in conjunction with this technology. Concurrently, we hope to develop a global network of partners that we can work with to test the efficacy and potential of this technology for cleansing oiled wildlife. Protocols have been also developed that take into account health and safety aspects for both the practitioner and the wildlife. Testing has been carried out on the short-term navigation and annual breeding productivity of breeding Little Penguins, *Eudyptula minor*, exposed to levels of magnetism that are equivalent to those for a moderate cleansing process. Daily foraging tracks and number of chicks fledged per female were found to be the same for the experimental group as for the control group. Ideally, this three-year plan will provide an optimised magnetic particle technique for cleansing oiled wildlife in any location and that can also be used in conjunction with conventional cleaning techniques. A particularly useful potential application is the provision of a quick clean upon first encounter at while wildlife await transport to wildlife clinics.

Population structure of the Magellanic penguin are panmitic population or metapopulation?

Gisele P M Dantas^{1,2}, Gabriella C Maria³, Anna Carolina M Marasco³, Larissa Tormena de Castro³, Vanessa S Almeida³, Fabricio R Santos², Larissa R Oliveira⁴, Enrique Crespo⁵, Esteban Frere⁶, Ana Milliones⁶, Daniel González-Acuña⁷, João S Morgante³, Juliana A. Vianna⁸

¹Pos-Graduação em Biologia de Vertebrados, Pontifícia Universidade Católica de Minas Gerais, Brazil, ²Instituto de Ciências Biológicas, Universidade Federal de Minas Gerais, Brazil, ³Instituto de Biologia- Universidade de São Paulo, Brazil, ⁴Universidade do Vale do Rio dos Sinos, Brazil, ⁵Centro Nacional Patagónico (CONICET), Argentina, ⁶Centro de Investigaciones de Puerto Deseado, Universidad Nacional de la Patagonia Austral, Argentina, ⁷Universidad de Concepción, Facultad de Ciencias Veterinarias, Chile, ⁸Pontificia Universidad Católica de Chile, Chile, ⁹Universidad Andrés Bello, Facultad de Ecología y Recursos Naturales, Chile

Spatial subdivision, local extinction and recolonization influence the genetic variation in natural populations. Different levels of population structure can be identified in nature, from panmitic population, where high gene flow homogenizes diversity across localities, to metapopulation, where is expected to find combinations of moderate to high population differentiation. Gene flow, dispersal and recolonization can change according with ecological circumstances, due to climate changes and resources available. Therefore, evaluate the past and present demographic histories are extremely important to understand current population dynamics. We assessed mtDNA and microsatellite data for 210 Magellanic penguins from 13 breeding colonies in Chile and Argentina coastlines. High genetic diversity and reduced population structure was observed for Magellanic penguins. Bayesian analysis detected three genetic groups with low differentiation: Malvinas/Falklands, Atlantic coast (Argentina), and Pacific coast ($F_{STmic} = 0.085$, $p=0.001$, $F_{STmtDNA} = 0.085$, $p=0.001$). Population expansion was detected around 15,000 years ago, in agreement with the decrease of the sea level and the exposure of a continental shelf in front of the coast of Argentina and Malvinas/Falklands Islands. Low genetic differentiation among populations and consequence high migration fit with metapopulation scenario.

Out-of-season laying and molt behavior using artificial lighting in captive Magellanic Penguins

Jéssica Domato Ribeiro¹, Cristiane Schilbach Pizzutto¹, Valéria Ruoppolo^{2,3}, Ricardo José Garcia Pereira¹

¹Department of Animal Reproduction, School of Veterinary Medicine and Animal Science, University of São Paulo, Brazil, ²Emergency Relief Team, International Fund for Animal Welfare, Yarmouth Port, Massachusetts, USA,

³Department of Pathology, School of Veterinary Medicine and Animal Science, University of São Paulo, Brazil

Magellanic penguins (*Spheniscus magellanicus*) are often observed in Brazilian's zoological institutions, mostly in the southeast region. Although it is an endemic species, they only occur in Brazilian coast during winter time, and thereafter return to their colonies for breeding. They are seasonal breeders and, as other temperate birds, are guided mostly by photoperiod. However, many institutions at low latitudes do not provide a lighting systems in their enclosures in order to stimulate life history stages such as reproduction, molting and migration in captive individuals. "SABINA – School Park of Knowledge" at Santo André city (São Paulo – Brazil) is an educational park that sheltered 20 Magellanic penguins (11 males and 9 females) without previous reproductive history. In February 2012, we introduced a lighting protocol resembling photoperiod oscillations in Patagonia (45°S latitude) and started monitoring at a weekly basis social and reproductive behaviours in twelve of the individuals pertaining to this colony. Nevertheless, despite our efforts and quality equipments, a malfunction related to the clock timer caused an accidental increase in daylength during the winter (total of 3 months) which induced courtship, copula, nest and agonistic behaviors in three of the monitored pairs, at the same time it stimulated laying of two eggs by one of the females. Moreover, such incident provoked a second molt in all animals of the colony (August 2012) five months after the first molt (March 2012). This study demonstrated the applicability of lighting programs in Magellanic penguins, and raises the possibility of applying this tool in the induction of a "second breeding season" in the reproductive management of endangered species of penguins.

Evaluation of a rearing method to mitigate sibling competition in captive Magellanic penguins

Jéssica Domato Ribeiro¹, Catherina Bartalini Monteiro², Valéria Ruoppolo^{3,4}, Ricardo José Garcia Pereira¹

¹Department of Animal Reproduction, School of Veterinary Medicine and Animal Science, University of São Paulo, Brazil, ²Sabina – Park School of Knowledge, Santo André, Brazil, ³Emergency Relief Team, International Fund for Animal Welfare, Yarmouth Port, Massachusetts, USA, ⁴Department of Pathology, School of Veterinary Medicine and Animal Science, University of São Paulo, Brazil

As in most Spheniscidae, clutches in Magellanic penguins typically comprise two eggs, a situation that often leads to different survival rates according to birth order. Although captivity may favor survival of siblings, the first chick is most likely larger and stronger than the second one, a clear disadvantage during sibling competition for food resources. In order to address this problem, we tested a rearing technique with two siblings born in 2014, which consisted in removing the first chick (after 10 days of age) from the nest for 1:30 hour, every morning and evening, soon after it was fed by its parents. Such management intended to allow the second chick to eat better increasing its chances of survival. Eggs hatched two days apart from each other, and the first (male) and the second (female) chicks weighted 85 and 75 grams, respectively. By the time the second chick hatched, the first sibling was already 103 grams. Records of their weights were taken during a month, and manipulations stopped as soon as both siblings were capable of competing for the food provided by their parents. Despite the difference in their absolute weights, our management permitted siblings to exhibit a similar growth curve throughout the entire monitoring. This report demonstrates that a simple measure may lessen sibling competition for food leading to a more uniform growth of the young penguins.

Trends in the diet of two *Eudyptes* penguins at South Africa's Prince Edward islands from 1994-2015

Dyer BM¹, Crawford RJM^{1,2}, Makhado AB¹, Upfold L¹

¹Branch Oceans and Coasts, Department of Environmental Affairs, South Africa, ²Animal Demography Unit, University of Cape Town, South Africa

Two species of crested (*Eudyptes*) penguins breed at South Africa's Prince Edward Islands (Marion Island and Prince Edward Island) in the south-west Indian Ocean: Macaroni *Eudyptes chrysolophus* and Southern Rockhopper *E. chrysocome* Penguins. Since 1994, their populations have been decreasing and their diet during the chick-rearing stage of breeding has been monitored using methods recommended by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). The paper reports the different prey items eaten by the two penguins at Marion Island based on information collected from 1994 to 2015, a period of almost 22 years. For both penguins, euphausiids, notably *Euphausia vallentini* and *Thysanoessa vicina*, contributed most of the mass of the diet during chick rearing. Fish, especially myctophids, were important on occasions and their capture may have contributed to increased breeding success. Cephalopods were less important prey. The paper will document trends in the relative contributions of different prey species to the diets of the two species. It additionally will document trends in the mass of chicks of the two species at fledging and discuss the possible influence of diet on that mass.

Prey, Parasite and Plastic: Evaluation of gastric contents of Magellanic Penguins (*Spheniscus magellanicus*) during a mass stranding episode in Brazil

Mariana B. Ebert^{1,2}, Daiana P. Bezerra², Teodoro Vaske-Júnior³, João F. D. Pereira¹, Renato S. Martins¹, Ana Carolina Ewbank⁴, Reinaldo J. Silva¹

¹Wildlife Parasitology Laboratory, Parasitology Department, Biosciences Institute, São Paulo State University (UNESP), Botucatu, SP, Brazil, CEP 18618-970, ²Cananéia Research Institute (IPeC), Cananéia, SP, Brazil, CEP 11990-000, ³São Paulo State University (UNESP), Bioscience Institute, Littoral Campus, São Vicente, SP, Brazil. CEP 11380-972, ⁴Pathology Department, College of Veterinary Medicine and Animal Sciences, University of São Paulo (USP), São Paulo State, Brazil, CEP 05508-270

Magellanic penguins (*Spheniscus magellanicus*) are non-breeding visitors of the Brazilian continental shelf during their winter migration in search of abundant feeding grounds. From July-October 2010, 2.276 Magellanic penguins were beach-washed along the southeastern coast of São Paulo State, Brazil. We report the gastrointestinal contents of 51 juvenile carcasses in early decomposition stage from this mass stranding event. During necropsy, the gastrointestinal tracts were removed and washed over a sieve. Recovered fish otoliths and cephalopod beaks were used for species identification. The pelagic octopus *Argonauta nodosa* was the most abundant prey species (n=6012; P=84%), followed by pelagic squids of the Ommastrephidae family (n=328; P=60%), *Doryteuthis plei* (n=158; P=41%), *Lolliguncula brevis* (n=23; P=9%) and the octopus species *Tremoctopus violaceus* (n=4; P=3%). The 54 recovered otoliths were identified as *Isopisthus parvipinnis* (n=19; P=3%), *Stellifer rastrifer* (n=14; P=1%), *Micropogonias furnieri* (n=13; P=3%), *Paralonchurus brasiliensis* (n=5; P=1%) and *Trichiurus lepturus* (n=3; P=1%). Parasites were processed in laboratory for specific identification. Most birds (P=78%) were infected with at least one helminth species. The nematode *Contracaecum pelagicum* (P=74%; MA=41,8±7,6; MII=56,1±9,2) was identified in the stomach while the trematode *Cardiocephaloides physalis* (P=19%; MA=16,3±6,8; MII=83,3±26,9) and the cestode *Tetrabothrius lutzi* (P=29%; MA=29,9±12,4; MII=108,9±38,7) were identified in the small intestines. A total of 133 debris items were recovered from the stomach of 19 penguins and classified into four categories: soft plastic (80%), fishing-related (14%), hard plastic (4%) and latex (2%). The variety of identified prey species indicates an opportunistic foraging behavior during their winter migration, probably dependent on food availability. The described parasite species are commonly reported on Magellanic penguins; however, our results revealed lower prevalence, mean intensity and abundance values. This may be due to the age span of analyzed birds and/or small quantity of ingested items during migration. It is not clear if debris ingestion is a reflex of scarcity, inability in distinguishing prey items or low food selectivity due to hunger. Nevertheless, the risk of obstruction of the gastrointestinal tract and sub-lethal effects of debris ingestion and parasite loads contribute to penguin mortality. Data on ecology and biology of Magellanic penguins while on the Brazilian continental shelf are very limited and remain unclear. Further studies are needed to understand the impacts over the species survival during a period of high physical demand such as migration. Analyses of gastric contents are important to identify food items on which the Magellanic penguin rely on during migration, indirectly providing information on migratory patterns and food availability on our coast, while working as marine pollution indicators.

Do microplastics occur in the guano of the African Penguin?

I. Engelbrecht¹, K. Minnaar¹, H. Bouwman¹

¹Unit for Environmental Sciences and Management, North-West University, Potchefstroom, South Africa

Marine plastic pollution is considered an increasing risk to marine wildlife, possibly posing a threat to endangered species. Plastic debris is found in South African marine environments that may directly impair species that ingest them or get entangled in it, often leading to death or serious health consequences. This study focussed on the African Penguin *Spheniscus demersus* found in the marine section of Addo Elephant National Park on Bird Island near Port Elizabeth. Small fragments of plastic debris may be directly ingested when confused as prey, and can also be ingested indirectly via their prey such as small pelagic fish including anchovies and sardines. When the penguin ingests the plastic from whatever source, it passes through the oesophagus directly to the stomach where it can be stored either for regurgitation as food for the chicks or digested. When these plastics are regurgitated to the chicks, it may cause mortality as the chicks are unable to digest these substances. We extracted the plastics from guano samples collected on Bird Island using density separation by mixing the guano with sodium chloride and removing the supernatant from the solid residue. The supernatant was examined under a dissection microscope to separate the organic material from the micro plastic in the solution. The micro plastic particles were further characterised to polymer using Fourier transform - infrared spectroscopy (FTIR). We will discuss the findings and possible implications.

Establishing the effect of parasites on the health status, nesting behaviour and colony dynamics of African penguins (*Spheniscus demersus*)

Marcela Espinaze¹, Cang Hui², Lauren Waller³, Cuan McGeorge⁴ and Sonja Matthee¹

¹Department of Conservation Ecology and Entomology, Stellenbosch University, South Africa, ²Department of Mathematical Sciences, Stellenbosch University, and African Institute for Mathematical Sciences, ³CapeNature and Department of Biological Sciences & Animal Demography Unit, University of Cape Town, South Africa, ⁴CapeNature

The endangered African penguin (*Spheniscus demersus*) occurs naturally along the coast of southern Africa. The colony at Stony Point (SP) in Betty's Bay (Western Cape) is one of two mainland colonies. Although the colony at SP has experienced a gradual increase in penguin numbers (current population 2,626 breeding pairs in 2015), conservationists are concerned about an observed increase in nest and chick abandonment. It is suspected that parasites, and in particular soft ticks, might be one of the driving factors behind this behaviour. However, the impact of parasites on African penguins is poorly investigated, and it is uncertain what the extent of the problem is within the SP colony. This study aims to: 1) collect comprehensive data on the ecto- and endoparasite diversity and abundance of penguins (adults and chicks) and soft tick abundances within different nest types (natural open, natural covered and artificial), 2) compare soft tick abundances within the nest to several parameters associated with the nest: microclimatic conditions, spatial position of nests, nest density and nest occupancy, 3) record the general health status and body condition of penguins and 4) calculate the spatial covariance between regional colonies and regional population variability based on reported population counts from the DEA. Parasite abundances and general health status of the SP colony will be compared to surrounding island and land-based colonies (Robben-, Dassen- and Dyer Islands and Boulders Beach). The study will be conducted during the main breeding season (March-August) in 2016 and 2017. Through this study we hope to better understand the importance of parasites in nest and chick abandonment, and the implications that this might have for African penguin conservation.

A post mortem investigation on the 2015 mass stranding of juvenile Magellanic penguins (*Spheniscus magellanicus*) on the coast of São Paulo state, Southeastern Brazil

Ana Carolina Ewbank¹, Valeria Ruoppolo^{1,2,3}, Carlos Sacristán¹, Mariana Bertholdi Ebert⁴, Carolina Pacheco Bertozzi⁵, Ralph Eric Thuil Vanstreels¹, José Luiz Catão-Dias¹

¹Laboratory of Wildlife Comparative Pathology (LAPCOM), Department of Pathology, School of Veterinary Medicine and Animal Science, University of São Paulo (FMVZ-USP), São Paulo, São Paulo, Brazil, 05508-270, ²Aiuká Consultoria em Soluções Ambientais, Av. do Trabalhador 1799, Praia Grande, São Paulo, Brazil, 11725-000, ³International Fund for Animal Welfare, 290 Summer Street, Yarmouth Port, USA, MA 02675, ⁴Wildlife Parasitology Laboratory, Parasitology Department, Biosciences Institute, São Paulo State University (UNESP), Botucatu, São Paulo, Brazil, CEP 18618-970, Caixa Postal 510, ⁵Biopesca, Biosciences Institute, São Paulo State University (UNESP), São Vicente, Brazil, 11380-972.

The Magellanic penguin (*Spheniscus magellanicus*), an inhabitant of the coast of Chile, Argentina and Falkland/Malvinas Islands, reaches the South-Southeastern Brazilian continental shelf during their annual winter migration (March-September). Most of the beach-cast penguins are inexperienced and debilitated juveniles that while foraging in Brazilian waters may be impacted by anthropogenic activities, e.g., fishing interaction, pollution, ingestion of synthetic materials and oil spills. We discuss the anatomopathological findings in Magellanic penguins stranded along the Southeastern Brazilian coast on May-July, 2015. Beach-cast carcasses (n=20), live birds deceased while in rehabilitation (n=24), and birds drowned after becoming entangled in fishing nets (n=6) were analyzed. Due to freezing and advanced autolysis, only eight carcasses (16%) were considered appropriate for histological evaluation. Upon necropsy, all by-caught casualties were in excellent body condition, while all beach-cast and rehabilitation casualties were severely emaciated. Fragments of selected organs were fixed in 10% buffered formalin and processed according to routine histopathology protocols. Sexing identified 41 females and nine males. Histopathological findings were observed in the following systems: cardiac (100%), respiratory (100%), hepatic (62.5%), lymphoid (50%), gastrointestinal (25%), neurologic (25%) and others (25%). Fragments of inorganic (plastic, rubber, and ropes) and organic materials (wood and algae) were present in the gastric contents of 24% of the animals. The anisakid nematode *Contracaecum pelagicum*, previously reported in Magellanic penguins was the only endoparasite morphologically identified in the upper gastrointestinal tract of 10% of the animals. The advanced stage of autolysis precluded further gastrointestinal evaluation. Our results confirm previous studies indicating a higher mortality of juvenile females on our coast. The high number of foreign materials, poor body condition and pathological findings in beach-stranded and rehabilitation casualties indicate their difficulty in meeting their required daily nutritional needs, probably due to a combination of factors, e.g., pollution, anthropogenic activities (e.g. fishing, littering), low prey availability and the 2015 “El Niño” (one of the strongest on record). However, the excellent body condition of the by-caught birds suggests that some of these birds are finding successful feeding strategies, and while doing so, interacting with human fishing activities, thus increasing their chances of being injured and/or drowned. Further monitoring studies including *post mortem* examination are needed to clarify the number of annual casualties, their physical condition upon stranding and the threats faced by Magellanic penguins while on the Brazilian continental shelf, contributing to their conservation and our knowledge regarding their ecology and population dynamics. Acknowledgements: FAPESP 2010/51801-5, CAPES.

Morphometric sex determination and female-biased mortality in juvenile Magellanic penguins (*Spheniscus magellanicus*) on the coast of São Paulo state, Southeastern Brazil

Ana Carolina Ewbank¹, Valeria Ruoppolo^{1,2,3}, Carlos Sacristán¹, Ricardo de Francisco Strefezzi⁴, José Luiz Catão-Dias¹, Ralph Eric Thuil Vanstreels¹

¹Laboratory of Wildlife Comparative Pathology (LAPCOM), Department of Pathology, School of Veterinary Medicine and Animal Science, University of São Paulo (FMVZ-USP), São Paulo, São Paulo, Brazil, 05508-270, ²Aiuká Consultoria em Soluções Ambientais, Av. do Trabalhador 1799, Praia Grande, São Paulo, Brazil, 11725-000, ³International Fund for Animal Welfare, 290 Summer Street, Yarmouth Port, USA, MA 02675, ⁴Laboratory of Comparative and Translational Oncology, Department of Veterinary Medicine, Faculty of Animal Science and Food Engineering, University of São Paulo, Pirassununga, São Paulo, Brazil, 13635- 900

Magellanic penguins (*Spheniscus magellanicus*) breed in colonies on the coast of South America (Chile and Argentina) and Falkland/Malvinas Islands. They migrate northwards after the breeding season over the continental shelf to Uruguay and Southern and Southeastern Brazil, between March and September. This species presents discrete sexual dimorphism in body size; males are slightly larger than females. Sexing penguins by discriminant analysis of morphometric parameters is a relatively reliable, simple, fast, low cost and non-invasive technique. We studied the carcasses of 70 juvenile Magellanic penguins found on the coast of São Paulo state (Southeast Brazil) between May and July 2015. Studied individuals were classified in three groups: beach-cast carcasses (n=50), live birds admitted for rehabilitation but deceased while under care (n=13), birds drowned after becoming entangled in fishing nets (n=7). The following body measurements were evaluated: bill depth (BD), length (BL) and width (BW); oral commissure width (CW); total flipper (TFL) and elbow-flipper length (EFL); middle toe (MTL), tarsus and pelvic limb length (PLL); head (HC) and axillary circumference (AC); head-body (HBL) and total body length (TBL); and body mass. Upon necropsy, 58 females and 12 males were identified. All body measurements were higher in males than in females (Mann-Whitney test, $P<0.05$), with the exception of AC, HBL and body mass, which did not differ significantly between sexes. Discriminant functions previously described for sex determination of Magellanic penguins presented mediocre accuracy (80-83%), without a systematic bias for any of the genders. The discriminant function JUV-A [$D=(0.984 \times BD)-18.644$] had the best performance (83% accuracy for both sexes). The sex ratio was significantly female-biased for beach-cast carcasses (82% females; One-proportion test, $P=0.001$) and for penguins deceased during rehabilitation (92% females; One-proportion test, $P=0.003$); a similarly biased sex ratio was also noted for by-caught penguins (71% females) however the sample size precluded the demonstration of a significant difference ($P=0.453$). These findings confirm JUV-A as the currently most appropriate discriminant function for sex determination of Magellanic penguins, and are in agreement with previous studies documenting female-biased mortality of this species along the Brazilian coast. Despite being the most commonly stranded seabird species along the Brazilian Southern and Southeastern coasts, the factors leading to this sexual disproportion are still unclear. Therefore, it is imperative to develop more comprehensive studies to clarify the dynamics and ecology of Magellanic penguins and determinant factors regarding their winter movements, survival and conservation. Acknowledgements: FAPESP 2010/51801-5; Projeto Biopesca.

Morphometric Evaluation of Hemosiderosis and Necrosis in the liver of Magellanic Penguins (*Spheniscus magellanicus*) naturally infected by *Plasmodium* spp.

Ana Carolina Ewbank¹, Ralph Eric Thuil Vanstreels¹, Ricardo de Francisco Strefezzi², José Luiz Catão-Dias¹

¹Laboratory of Wildlife Comparative Pathology (LAPCOM), Department of Pathology, School of Veterinary Medicine and Animal Science, University of São Paulo (FMVZ-USP), São Paulo, São Paulo, Brazil, 05508-270, ²Laboratory of Comparative and Translational Oncology, Department of Veterinary Medicine, Faculty of Animal Science and Food Engineering, University of São Paulo, Pirassununga, São Paulo, Brazil, 13635- 900,

While foraging on the Brazilian continental shelf during winter migration, sick and/or debilitated Magellanic Penguins (*Spheniscus magellanicus*) found ashore are directed to rehabilitation centers along the coast. While under care, these birds may develop avian malaria, a mosquito-transmitted disease caused by protozoans of the genus *Plasmodium*. Hepatic hemosiderosis and necrosis have been previously described in avian malaria. We used morphometric techniques to evaluate hemosiderosis and necrosis in Perls- and reticulin-stained liver samples from 24 Magellanic penguins naturally infected by *Plasmodium* spp. and nine *Plasmodium*-negative Magellanic penguins (control group). All birds were kept under similar housing and husbandry regimens. *Plasmodium* lineages had been identified through blood smear morphology and/or phylogenetic analysis of the mitochondrial *cyt-b* gene. Our goal was to evaluate the significance of hepatic hemosiderosis and necrosis in Magellanic penguins infected with *Plasmodium* sp. and between *Plasmodium* lineages/species. Histological sections were analyzed under a microscope equipped with a digital system for image analysis. A high power-field of the center of each sample was captured, and eight additional images were captured 50 µm from this point, at 45° intervals, under the same lighting conditions. Areas of hemosiderin and reticulin fibers were semi-automatically outlined, under a maximum zoom of 50%. The percentage of the area occupied by hemosiderin and reticular fibers were respectively considered the index of hepatic hemosiderosis (IHH) and index of hepatic necrosis (IHN). The IHN of the control group was significantly higher than the positive group ($P < 0.001$), but no differences were detected regarding IHH. Among positive animals, there were no significant differences in IHH or IHN regarding individual history (age group, oiling, rehabilitation facility) or *Plasmodium* lineages/species. IHH and IHN were not correlated with the total period in captivity or captivity during summer (time of highest mosquito density). Hepatic hemosiderosis was probably related to other causes, such as infectious disease, parasitic and microbial infections, trauma, seasonal physiological changes, oiling, or starvation and refeeding syndrome to which the penguins may be subjected during winter migration or while on rehabilitation. Hepatic necrosis was significant between both groups, suggesting a relationship between this pathology and *Plasmodium* spp. Avian malaria is one of the most important diseases of captive penguins, and may seriously compromise the rehabilitation of Magellanic penguins. Further studies are still needed to clarify the mechanisms of this hypothesis (e.g., hypoxia due to mechanic obstruction of the hepatic vasculature, parasitic vasculitis leading to hepatic necrosis). Acknowledgements: FAPESP 2010/51801-5, CAPES.

The Folly or Wisdom of a Solar Powered Argos Tag for Penguins

Marco Flagg¹, Klemens Pütz²

¹Desert Star Systems LLC; 3261 Imjin Rd; Marina, CA 93933; USA, ²Antarctic Research Trust; Am Oste-Hamme-Kanal 10; 27432 Bremervörde; Germany

Batteries are a substantial weight contributor in Argos tags, in particular if long transmission endurance is required. Here, solar power can offer a significant advantage. An 1g solar panel can produce the same energy as stored in an AA size lithium battery weighing 18g every 300 hours of direct sunlight exposure. However, light in the sub-Antarctic region is limited. During 2015, we deployed five solar powered tags (26g, 300m max. depth) and five long endurance battery powered tags (105g, 300m max. depth) on King penguins in Tierra del Fuego. In 2016, 13 tags of a second generation solar powered design and 16 smaller battery powered tags (32g, 50m max. depth) were deployed on Rockhopper penguins in the Falkland Islands and on Isla de los Estados, Argentina. In addition, two solar tags were statically mounted at the tagging sites to provide baseline performance data. The tags demonstrated both endurance and survivability, but also the limitations of operating a solar powered design in a region with limited light. This presentation discusses solar tag performance as compared to battery tags, and throughout the seasons. It describes changes in the second generation design to boost available Argos position quality and provide a 'heartbeat' including light observations for Argos independent geo-positioning even under very limited light conditions. We conclude with proposed adaptations for third generation solar tags including optimizations for performance under very limited light conditions and reduction of weight to 14g to enable the tagging of juvenile and small species of penguin.

The new UNESCO Blue Patagonia Biosphere Reserve benefits 20 penguin colonies in Argentina

P. Garcia-Borboroglu^{1,2,3}, L. M. Reyes^{3,4}, M. Giaccardi³, F. Paura⁵, P. D. Boersma^{2,3}, M. E. Góngora⁴, V. Fratto⁶, N. Caloni⁷

¹National Research Council-CONICET, Argentina, ²University of Washington, U.S.A., ³Global Penguin Society, U.S.A./Argentina, ⁴Universidad Nacional de la Patagonia San Juan Bosco, Argentina, ⁵Secretaria de Turismo y Areas Protegidas del Chubut, Argentina, ⁶Patagonia D&M, ⁷Universidad Nacional de General Sarmiento

A Biosphere Reserve (BR) is an area designated by UNESCO to demonstrate innovative approaches to sustainable development where scientific knowledge and governance can reduce biodiversity loss, improve livelihoods and enhance social, economic and cultural values. The world network of BR includes 631 reserves in 119 countries, with only 15 in Argentina. The “Blue Patagonia Biosphere Reserve” designated in late 2015 includes 3.1 million hectares and is the largest one in the country (60% marine waters). It is located between 43°40’S and 45°35’S along 300 km of the Argentinean coast and its continental shelf. Within a high scenic value area, with almost 50 islands, peninsulas, bays and capes there are more than 60 locations with up to seven seabird species breeding together. Twenty colonies of Magellanic penguin (*Spheniscus magellanicus*), including the world’s largest one, is found within this Reserve. It includes more than 1 million adult penguins, representing almost 40% of the global populations. Sixty-seven coastal and seabird species breed in the area, including three cormorant species (*Phalacrocorax* spp.), 3 seagull species (*Larus* spp.) 3 terns (*Sterna* spp.), southern giant petrel (*Macronectes giganteus*), plovers and sandpipers (*Calidris* spp., *Tringa* spp.), and entire breeding area for the White-headed Steamerduck (*Tachyeres leucocephalus*). BR also includes 36 marine mammal species, 65 terrestrial birds, 31 terrestrial mammals, 83 fishes, 130 seaweeds, and 197 invertebrates. The Global Penguin Society fostered this initiative and worked with the Government to design and formalize its nomination. This BR is divided in three main zones: 1) Three Core areas for conservation, monitoring and non-destructive research that includes the world largest Magellanic penguin colony at Punta Tombo and the first National Marine Park of Argentina; 2) Buffer zones surrounding the core areas and 3) Transition areas are designated for activities to sustainably manage the area’s resources. The BR set a new standard for marine and coastal conservation in Argentina and seabirds are one of the main beneficiaries.

Establishment of the IUCN Species Survival Commission PENGUIN SPECIALIST GROUP

P. Garcia-Borboroglu^{1,2,3}, P. D. Boersma^{2,3}, A. Chiaradia⁴, S. Ellis², P. Seddon⁵, A. Simeone⁶, P. Trathan⁷, L. Waller⁸, B. Wienecke⁹

¹Nat. Research Council-CONICET, Argentina, ²Global Penguin Society, U.S.A./Argentina, ³University of Washington, U.S.A, ⁴Phillip Island Nature Parks, Australia, ⁵University of Otago, New Zealand, ⁶Universidad Andres Bello, Chile,

⁷British Antarctic Survey, U.K, ⁸Cape-Nature, South Africa, ⁹Australian Antarctic Division, Australia

The International Union for the Conservation of Nature (IUCN) Species Survival Commission (SSC) has approved the establishment of the Penguin Specialist Group (PSG).

This group arose because a core of enthusiastic experts from around the world, active in penguin conservation and research, were keen to contribute their ecological and biological knowledge to further the conservation of all 18 species. The PSG synthesizes information on penguin biology to inform conservation actions. It also seeks to address international conservation issues (e.g., the illegal traffic of penguins, oil pollution, or negative interaction with fisheries in international waters). It will assist the Red List Authority (Birdlife) in revising Red Listing of penguins. Simon Stuart, Chair of the SSC, appointed Dee Boersma and Pablo Borboroglu (Popi) to serve as Co-Chairs of the group. The Global Penguin Society (GPS) fostered the initiative for PSG by engaging individuals and organizations to promote its establishment. The GPS is providing initial financial support and is seeking other support other national and international organisations involved in penguin conservation, research and/or advocacy. Globally, thousands of species are on the edge of extinction and threats to biodiversity are rapidly escalating. Penguins are amongst the most endangered taxa with over ½ of penguin species on the IUCN red list, making the PSG very timely. The group hopes to foster stronger global collaboration from all sectors of society in the conservation of penguins.

Establishing a sustainable management plan for the African penguin (*Spheniscus demersus*) species colony

Frieda Geldenhuys

MSc, Stellenbosch University, Department of Mathematical Sciences - Supervisor Prof. Cang Hui; Co-supervisor Prof. Martin Nieuwoudt (Sacema)

The African penguin is endemic to South Africa (breeding only in South Africa and Namibia). It is Africa's only extant penguin, except for the four species that breed at South Africa's Prince Edward Islands in the South-West Indian Ocean. Current colonies are under threats posing a serious issue to conservation and eco-tourism. Species such as these need to be conserved otherwise might face the threat of extinction. The penguins are also important as they play the role of an early warning system for environmental threats. By global standards, a population is considered unhealthy and in danger if it decreases to 10 percent of the former (pre-exploitation /decrease) levels. The African Penguin population is currently at about 14 percent its 1950s level, when the first official census was conducted and is still on a strong downward population trajectory. Some of the drivers of change include climate change, parasites, pollution (oiling), disease, food resources, predation risk and habitat interference. A huge component to it is the anthropogenic, human impact, especially with population expansion. A species distribution model, including a suitability map for the distribution of the penguins and modelling of the meta-community dynamics of regional colonies would be established in order to attend to these matters. It is a predictive, conceptual model of the abiotic (e.g. physical barriers, climate, lack of resources) and biotic (e.g. competition, predators, parasites) factors influencing habitat suitability controlling species distributions in space, time and scale. Other names such as habitat suitability, niche modelling, bioclimatic models, resource selection functions and spatial correlation models are used to describe the species distribution models.

Breeding performance of a new King Penguin colony in the Strait of Magellan, Chile

Claudia Godoy Reyes^{1,2}, Luis Muñoz Peralta^{1,2}, Pablo García Borboroglu^{1,3}

¹Global Penguin Society, ²Parque Pingüino Rey, Estancia San Clemente, Tierra del Fuego, Chile, ³CONICET Argentina

King penguins breed on sub-Antarctic islands between latitude 45° south and 55° south. Their populations have increased since the end of the last century following a drastic decline during the 19th and the beginning of the 20th century, but recent surveys also indicate that several large colonies have stabilized or decreased. More king penguins had been prospecting and visiting the coasts of Tierra del Fuego, southern Patagonia, to molt, and breeding was anticipated. A new King penguin colony was established at Bahía Inútil (53° 27'42" S, 69° 18'32" W), a bay to the east of the Magellan Strait, Chile during the 2009-2010 breeding season. Archaeological records indicate that local aboriginal groups used penguins as a source of food and material to make tools and weapons thousands of years ago. Since 2014 we are conducting a research and monitoring program to follow the evolution of this new colony, estimating breeding and non-breeding population size fluctuations, breeding phenology, breeding parameters and to determine chick mortality causes. Population size ranged from 20 in July to 160 individuals in November of 2015, where 40% of them were incubating. Compared to original reports, the number of breeders with eggs increased 4 to 40 in the last 5 breeding seasons. There are two main areas used by penguins to breed, molt or rest, one near the Marazzi River and the other one near the marine coast. The breeders always used the same area while non breeders can use both areas depending on weather conditions. Five molting periods were observed for breeders and non-breeders during the year. Complete breeding failure was observed for this colony until 2014-2015 season, where the first chick survived throughout the year. Most chicks died before 4 months of age. Cause of chick death was determined performing necropsies, by macroscopic findings: 60% of them showed lesions caused by infectious agents and others very likely died from starvation. The main predator registered in the past was the introduced american mink (*Neovison vison*), but predator control actions reduced this mortality. The grey fox (*Lycalopex griseus*) took abandoned eggs and dead chicks, but we didn't observed them attacking penguins. Monitoring of this new colony is helping to disentangle the main challenges King Penguins face to establish new colonies and recolonize breeding grounds.

Management challenges for the world's most accessible King penguin colony

Claudia Godoy Reyes^{1,2}, Luis Muñoz Peralta^{1,2}, Aurora Fernández Durán², Pablo García Borboroglu^{1,3}

¹Global Penguin Society, ²Parque Pingüino Rey, Estancia San Clemente, Tierra del Fuego, Chile

³CONICET Argentina

Responsible and sustainable tourism can help conserve and protect species and the environment, promote environmental awareness, and improve the welfare and livelihoods of local communities by supporting their local economies and creating decent jobs. Wildlife tourism encompasses non-consumptive interactions with wildlife but can cause significant disturbances to animals in their natural habitats when it is not properly managed. Wildlife tourism has been rapidly expanding, mainly in areas with iconic, accessible and predictable wildlife, such as penguins. In Chile there are several penguin colonies that are relatively accessible by land or sea, located in public or private land. In the Magallanes region, penguins are one of the main highlights of tourism. King penguins established a new colony at Bahía Inútil (53° 27' 42"S, 69° 18' 2"W), a bay to the east of the Magellan Strait. It is located on private land, within the Estancia San Clemente, and became the world's most accessible colony for this species. Number of penguins range from 20 up to 160 depending on the month. At the beginning, before landowners were aware, visitors came to the area without any control or regulation clearly disturbing the prospecting individuals. In 2011, landowners created the Parque Pinguino Rey (PPR), and organized the touristic operation. A Management Plan was designed and implemented since 2011 and it is updated in accordance to the increase in the number of visitors. Visitor numbers grew 170% in the second year, 90% in the third and 47% in the fourth year with a total of 26,000 visitors since it was opened to the public. PPR has 32 hectares, but penguins are only restricted to a specific coastal area. The size and distribution of the colony limits the number of visitors while new infrastructure was designed to allow alternative observation points. The Management Plan includes research and education programs, supported by the Global Penguin Society, allowing to integrate new information and conduct an adaptive management approach. An interpretive outdoor information center including the local "selknam" aborigin culture will be in place next season to add a socio-cultural dimension to this attraction. Visitor satisfaction and opinion polls will be undertaken to learn about their expectations and receive suggestions about services, activities, places and infrastructure that could contribute to their experience. The current challenge is to improve the visitor experience minimizing the direct and indirect effects on the colony and the area.

Novel movement and dive behaviour of an iconic marine predator: emperor penguins in the Eastern Ross Sea, Antarctica

Kimberly Goetz¹, Birgitte I. McDonald², Stefan Jendersie³, Gerald L. Kooyman⁴

¹National Institute of Water and Atmospheric Research Ltd, 301 Evans Bay Parade, Wellington, 6021, New Zealand,

²Moss Landing Marine Laboratories, 8272 Moss Landing Road, Moss Landing, CA 95039, ³University of Otago,

Department of Physics, PO Box 56, Dunedin 9054, NZ, ⁴Centre for Marine Biotechnology and Biomedicine, Scholander Hall, Scripps Institution of Oceanography, 9500 Gilman Drive no. 0204, La Jolla, CA 92093, USA

While there are several marine predators in the southern ocean, emperor penguins (*Aptenodytes forsteri*) are the largest avian species and perhaps the most iconic predator to inhabit Antarctic waters year-round. The development of data-logging technologies has allowed researchers to unlock the mystery of at-sea behaviour during the chick-rearing period. However, the remoteness and lack of information on moulting locations has hindered our ability to understand the migration to and from these areas. The association and reliance on pack ice make emperor penguins an ideal indicator species for climate change. As such, identifying important habitat and foraging areas is critical to address how predicted changes to the oceans climate might impact the survival of this top predator.

In this study, we use movement and dive data collected from 21 tagged emperor penguins in the Ross Sea to provide the first-ever qualitative and quantitative description of post-moult behaviour. Tracking data revealed that emperor penguins followed the approximate location and direction of the Ross Sea gyre, traveling east and then north along the shelf break before turning west following the edge of the South-east Pacific Basin before heading south and returning to the tagging location at Cape Colbeck. The average dive depth and duration for all penguins was 90.2 ± 77.8 m and 4.6 ± 2.3 mins, respectively. Significant clusters of deep dives were located both on the shelf and in areas furthest off the shelf while clusters of shallow dives were located in between. Significant clusters of longer dives were located at the furthest extent of travel. Dive rates were significantly higher during the day and twilight hours than at night and penguins showed a preference for foraging within the Antarctic surface waters or circumpolar deep water. During the austral winter, emperor penguins preferred areas that were located closer to ice edge, in shallower depths, closer to the southern boundary of the Antarctic circumpolar current, and over areas with less bathymetric slope than in fall. Overall, our study provides novel information on the ecology of emperor penguins during a stage in their life cycle when they are physically and energetically vulnerable and when they must find breathing holes, avoid predators, and forage to regain body mass before the winter breeding period.

Demography of the World's Largest Magellanic Penguin Colony in the Context of Regional Fisheries Management

N. J. Gownaris, P. D. Boersma

Department of Biology, University of Washington, Seattle, WA, 98195

Long-term studies of seabirds are rare but necessary to quantify changes in parameters controlling population size and understand their relation to oceanographic and anthropogenic forcings. Punta Tombo, Argentina represents the world's largest breeding colony (~200,000 breeding pairs) of Magellanic penguins (*Spheniscus magellanicus*). Though the overall trajectory of this species is uncertain, the Punta Tombo colony has declined an average of 1%/year since 1987. Anthropogenic threats to the colony have varied; currently the health of the population is thought to be intimately linked to food availability and hence climate variation and fisheries management.

Magellanic penguins both affect and are affected by what is deemed sustainable fish removal in Argentine waters. At Punta Tombo, where starvation is the largest driver of chick mortality, penguins rely heavily on Argentine hake (*Merluccius hubbsi*), Argentine anchovy (*Engraulis anchoita*) and squid to feed their young. The Argentine hake fishery, the largest fishery in Argentina, has been overexploited since the 1990's, and there has been pressure to expand the currently underexploited Argentine anchovy fishery. Some estimates place biomass removal of anchovy by Magellanic penguins off of the Patagonian shelf at two million tonnes annually, on the scale of the peak fisheries catch within the Argentine EEZ (mid-1990's). Changes to the population of Magellanic penguins are thus perhaps best thought of as a fisheries management issue.

Nearly 60,000 Magellanic penguins have been banded at Punta Tombo since the 1980's, the majority of which are known-age. For the past two decades, students and volunteers have recorded sightings of banded birds in the colony throughout the breeding season of September-March. Effort is estimated as the number of left flippers seen while searching in a given area of the colony. These data suggest strong differential survivorship among the cohorts followed. Furthermore, chick growth and survival has been regularly documented (daily to every 10 days) in several areas of the colony throughout the study. Using this wealth of information, a life history table is developed and considered in the framework of changing oceanographic conditions and fisheries trajectories. Ongoing changes in the region that have the potential to either benefit or detriment the Punta Tombo colony (i.e. climatic changes, development of new fisheries, marine protected area designation) make this a particularly timely study. This study may also provide an opportunity to guide future studies on long-lived seabirds by identifying how to best focus often limited resources so to sufficiently understand demography patterns.

Establishment of reference intervals for the 100 white blood cell count differential for the Adélie penguin (*Pygoscelis adeliae*) on Ross Island, Antarctica

Wray W. Grimaldi

Department of Zoology, University of Otago, Dunedin, New Zealand

A commonly ordered test in clinical laboratories is the complete blood count. This test affords a general picture of the health status of the individual. One aspect of this test is an evaluation of 100 white blood cells, known as the white blood cell differential. Having reference intervals (“normal ranges”) for the differential of a species is valuable. With this information, departures from normal values can be detected and health trends can be tracked. However, this type of basic health information is lacking for most avian species and particularly so for wild populations. In this study, reference intervals have been determined for the white blood cell differential in adult Adélie penguins (*Pygoscelis adeliae*) at Cape Bird, Ross Island, Antarctica. No statistically significant differences were found between male and female adults for this test. The results presented here can be used as reference intervals for the white blood cell differential for use in future studies on this seabird.

“Times, they are changing”: multiple-day to single-day foraging trips of incubating Southern Rockhopper Penguin (*Eudyptes c. chrysocome*) males at the Falkland (Malvinas) Islands

Sabrina Harris¹, Andrea Raya Rey^{1,2}, Klemens Pütz³

¹CADIC-CONICET Houssay 200, Ushuaia, Tierra del Fuego, Argentina, ²Wildlife Conservation Society, Amenábar 1595 of 19 C1426AKC CABA, Buenos Aires, Argentina, ³Antarctic Research Trust, Am Oste-Hamme-Kanal 10, D-27432, Bremervörde, Germany

Long-term monitoring of the behavior of breeding seabirds may provide insights into behavioral changes over time, which may ultimately be linked to modifications in their environment. This information may be used as an indicator for the impact of environmental changes affecting these populations. Southern Rockhopper Penguin (*Eudyptes c. chrysocome*) males are known to leave their nest shortly after egg-laying for up to three weeks to restore energy and to prepare for the fasting period while guarding the chicks after hatching. Foraging trips of males during incubation at “Rookery Valley” (51°36.036’S, 57°54.285’W), Falkland (Malvinas) Islands, were recorded with GPS-TDR devices in 2000 (n = 10), 2011 (n = 12), 2012 (n = 18) and 2013 (n = 14), and also at “Strike Off Point” (51°35.920’S, 57°55.695’W), about 1.5 km to the west of “Rookery Valley”, in 2013 (n = 13). All individuals made multiple-day trips in 2000, but only six of the tracked individuals in 2011, one in 2012 and two individuals in 2013. All other study birds performed short foraging trips with a duration of less than 24 hrs. During multiple-day trips individuals travelled further from the colony (≈250km versus <10km), spent more time foraging (17±3hs versus 8±3hs per day) and dived deeper than on one-day trips (48±14m versus 31±6m). Foraging efficiency (wiggles/min bottom time) and dive efficiency (bottom time/(dive + post dive duration)) were lower on multiple-day trips than on single-day trips (1.9±0.8 and 0.3±0.1 versus 3.5±1.1 and 0.4±0.1, respectively). Obviously, within a period of 10 years, individuals significantly changed their foraging behavior during incubation, which is assumed to be linked to improved food availability in the proximity of the breeding grounds, but may also, at least partly, be due to other factors that may have reshaped their behavior throughout the studied period.

The South African Association for the Marine Biological Research's African Penguin Story. Past, present and future

Gabrielle Harris, Kelly de Klerk

South African Association for Marine Biological Research

SAAMBR has held penguins since the 1980's. In those years it was a fairly common occurrence for public to bring stray stranded penguins to us for rehabilitation. A group of these charismatic penguins found a permanent home and we began to exhibit the birds in our Sea World facility. Over the years our family grew, and legislation at the time even allowed some of the rescues to find homes abroad. With this species becoming endangered, the laws changed, as did our conservation imperative. Our goal became to create a successful breeding colony. At this point we moved facilities, so our rookery design bore our goal in mind. We set ourselves the task of working alongside other facilities and taking an active role in the creation of an assurance population of these birds. Our breeding has been extremely successful. Our colony is now at its maximum. Currently we are managing our population by pricking eggs. We look forward to working with authorities and scientists to participate in the survival of the species in the wild. This paper will document SAAMBR's story.

Exsitu management of African Penguins– Can lessons learned assist with insitu management?

Gabrielle Harris, Kelly de Klerk

South African Association for Marine Biological Research

The following is a list of questions that we have formulated as a result of rescuing, rehabilitating and keeping penguins in our facility for over 30 years. Some theories are based on anecdotes and others on experience over the years. We believe these questions all have potential relevance to the plight of the African Penguin *insitu*. Some of the questions are as follows:

1. What is the effect of temperature on breeding success? What is the optimal shape and design of nest boxes?
2. How 'imprinted' is too imprinted? Is being habituated a good or a bad thing?
3. If we bred for release, what would serve as optimal management in this process? Is it possible to release fledglings?
4. What is the effect on immunity for hand-reared versus parent-reared chicks?
5. Do male and female penguins experience different stress levels? What does this mean in the wild?
6. Is there a tipping point in numbers where social breeding behaviour is inspired?

This poster will outline our experience in our laboratory type situation where variables are limited in relation to *insitu* situations, and theorise about the possible impact these lessons may have in the wild.

Flexible boundaries Marine Protected Area for year-round conservation of the African penguin in Algoa Bay Authors

Brigitte M.C. Heylen¹, Lorien Pichegru²

¹EMBC+ International Master in Marine Biodiversity & Conservation, Ghent University, Belgium, ²DST/NRF Centre of Excellence at the Percy FitzPatrick Institute & Coastal and Marine Research Institute at the Nelson Mandela Metropolitan University, South Africa

African penguin *Spheniscus demersus* populations' show continued declines since the second half of the previous century. Their abundance is substantially linked with the presence of their main prey, i.e. small pelagic fish. Therefore, conservation efforts should include ensuring adequate local food availability. In this perspective, Marine Protected Areas (MPAs) have been identified as a valuable tool in an Ecosystem Approach to fisheries. To accomplish this, MPAs can be designated with zones under different regulations and/or flexible boundaries. In Algoa Bay, South Africa, experimental purse-seine fishing closures have been alternating between St. Croix and Bird Island every three years from 2009 onwards. As a consequence, foraging effort decreased at the no-take zones but benefits are limited when fishing pressure intensifies at the reserve boundaries.

In this study, we delineated the spatial overlap and potential competition between small-pelagic fishery activities and African penguins year-round in Algoa Bay. Existing datasets from 2008-2015 contain information on foraging behaviour, morphometrics, and reproductive success of birds equipped with GPS-time-depth recorders. This data, together with new collected data, was used to calculate trip duration, surface path length at sea, maximum distance from the colony, diving effort, and chick growth. Diving behaviour was estimated by calculating diving rate, average dive depth, and dive duration. Data of fisheries catches was provided by the Department of Agriculture, Forestry and Fisheries. Generalised Linear Models showed that foraging behaviour was influenced by colony, fishing effort, closure, time of the year, sex, and mass of their clutch. Mapping Kernel density estimates of the foraging range revealed the potential areas of conflicts between penguins and fisheries.

In general, results show that penguins in Algoa Bay remained in the same area whole year round. However, spatial and temporal differences in foraging behaviour indicate that some areas could be placed under adaptive fishery management with flexible boundaries.

Loss of feathers and poor plumage quality in juvenile Magellanic penguins admitted to rehabilitation in Southeastern Brazil

Renata Hurtado¹, Renata C. C. Bhering¹, Luis Felipe Mayorga¹, Ralph Eric Thijl Vanstreels²

¹Institute of Research and Rehabilitation of Marine Animals (IPRAM), Cariacica, Brazil, ²Laboratory of Wildlife Comparative Pathology (LAPCOM), Department of Pathology, School of Veterinary Medicine and Animal Science, University of São Paulo (FMVZ-USP), São Paulo, São Paulo, Brazil, 05508-270

The Institute of Research and Rehabilitation of Marine Animals (IPRAM) is a non-profit organization that rehabilitates Magellanic penguins rescued along the coast of southern Bahia, Espírito Santo and northern Rio de Janeiro states (Southeastern Brazil). Most penguins admitted at IPRAM for rehabilitation are juveniles (>95%) and the majority are in critical condition, with severe dehydration, hypothermia and cachexia. While most penguins are received in winter-spring (July to October, peaking in August), a smaller number of individuals is received during summer (November to March). These penguins admitted in summer months are often in a relatively better body condition, however they frequently present abnormalities in their plumage, with feathers appearing worn down and brittle, and often entire patches of feathers are missing. From 34 Magellanic penguins admitted from October to December 2015, 16 (47%) had one or more patches of feather-loss. Patches of feather-loss were irregular and asymmetric, being most frequently present in the lower back, followed by higher back, flanks, head, chest, wings and neck. In some cases all feathers had been completely lost and skin was entirely exposed; in other cases, down feathers grew to form a furry coat in areas where feathers had been lost. In areas where feathers had not been entirely lost, the remaining feathers the barbules broken irregularly and the shaft was exposed and worn down. Other feathers were often discoloured and brittle, appearing “old”; patterns of discoloration were sometimes consistent with areas that would have been exposed to the sun while birds were floating at sea. There were no statistical differences between individuals with or without poor plumage quality with regards to: age group, body condition, behavioural score, body mass, body temperature, ectoparasites, oropharyngeal lesions or external wounds. All individuals admitted during that period were juveniles, and most were emaciated (62%) and quiet/alert (56%). Ectoparasites (chewing lice – *Austrogoniodes* sp.) were seen in 41% of the penguins, whereas oropharyngeal lesions and external wounds were seen in 47% and 53%, respectively. It is unclear to us what causes such a high frequency of poor plumage quality in juvenile penguins admitted during summer months, but hypotheses to be considered include natural wear, chronic malnutrition (associated with hypoproteinemia and anaemia), hormonal dysfunction, excessive ectoparasite load, exposure to pollutants, and viral infections. Considering the clinical presentation and progression, we are confident however that these cases are not consistent with the “feather-loss disorder” described in wild Magellanic penguins in Argentina, and suspect that different aetiologies are at play.

Comparative breeding biology of the Northern Rockhopper Penguin *Eudyptes moseleyi* on Gough and Nightingale Islands

Rukaya Johaadien¹, Antje Steinfurth¹, Richard B. Sherley², Richard Cuthbert^{3,4}, Trevor Glass⁵, Peter Ryan¹

¹Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch, 7700, South Africa,

²Environment and Sustainability Institute, University of Exeter, Penryn, Cornwall, TR10 9FE, United Kingdom, ³Royal Society for the Protection of Birds, The Lodge, Sandy, Bedfordshire, SG192DL, UK, ⁴Wildlife Conservation Society, PO Box 277, Goroka, Eastern Highlands Province, Papua New Guinea, ⁵Tristan Conservation Department, Edinburgh of the Seven Seas, Tristan da Cunha, South Atlantic, TDCU 1ZZ

Northern Rockhopper Penguins *Eudyptes moseleyi* are listed as Endangered due to an estimated 57% decrease in breeding numbers over the past 37 years. The Tristan da Cunha archipelago and nearby Gough Island in the central South Atlantic Ocean host approximately 85% of the species' global population. Despite long-term human exploitation in the form of penguin egg collection and guano harvesting, numbers in the Tristan group have been considered stable since the 1970s. In contrast, based on census data, numbers at Gough Island have decreased by approximately 90% since the 1950s and are still believed to be in decline.

In order to investigate these contrasting regional trends in light of differences in breeding behaviour, this study compared aspects of the species' breeding biology on Nightingale Island (Tristan group) and Gough Island based on data gathered from five colonies in the 2012/13 and 2013/4 breeding seasons. On Nightingale, breeding success was 6.5% lower and 40-day old chicks were 47% lighter than on Gough Island. Interestingly, both A and B eggs were on average 10 cm³ larger on Gough than on Nightingale, although egg size was found to be unrelated to breeding success.

Applying a deterministic matrix model to our results, combined with data derived from the literature, suggests that populations on both islands are in decline. Assuming all other factors are comparable, the noted difference in breeding success between islands yields an approximately four times greater population decline on Nightingale than on Gough Island.

We further infer from our results that the observed decline of penguins on Gough Island is likely unrelated to conditions during breeding. To verify these findings, population trends and chick fledging mass on both islands should be monitored in the long term, while efforts to mark individuals for future survival studies would be beneficial in the short term.

Use of trail cameras to monitor chick and nest survivals in chinstrap penguins *Pygoscelis antarcticus* on King George Island

Jeong-Hoon Kim¹, Jin-Woo Jung¹, Yeong-Doek Han², Won Young Lee¹, Hosung Chung¹, Han-Gu Choi¹

¹Division of Polar Life Sciences, Korea Polar Research Institute, Incheon 406–840, Republic of Korea, ²Department of Biological Sciences, College of Natural Sciences, Inha University, Incheon 402-751, Republic of Korea

To compare the population monitoring efficiency we investigated the fluctuations of number of chicks per nest and active nests in chinstrap penguins *Pygoscelis antarcticus* at Narebski Point in Barton Peninsula on King George Island, during the 2013/2014 breeding season by camera monitoring (n = 117 nests from 4 subcolonies) and visiting research (n = 245 nests from 12 subcolonies). There was no significant difference in fluctuations of mean number of survived chicks before they join the crèche. However, survival probability of nests estimated from camera monitoring was higher than that estimated from visiting research. Both research methods had advantages and disadvantages for population monitoring, respectively. We could estimate the clutch size and hatching success by visiting research. But frequency of visit was restricted by weather condition and research interval considered to reduce disturbance from researchers. To count the chicks during the late guard phase was also difficult because some chicks left their nest temporarily when researcher approached near colony. The daily numbers of chick and active nest were estimated accurately by analysing sequential pictures provided from the trail cameras, but we could not collect reproductive data derived from clutch size and hatching success. Although meteorological changes and predation had no effect on chick or nest survival during the research period, time-lapse digital photography was useful for understanding the relationship between those factors. The sampling investigations conducted by both monitoring methods were also useful for estimating the number of fledged chicks per the whole colony (1.41 chicks, n = 2,378 nests). It was similar to estimated values from both investigations (1.44 ± 0.680 chicks for visiting research, 1.44 ± 0.676 chicks for camera monitoring). We suggest that camera monitoring combined with visiting research conducted at the egg laying or incubation stage would be an efficient research method for counting chicks and active nests during the chick guard phase by overcoming their respective disadvantages.

Balancing the needs of guests, penguins and keepers in a new exhibit

Jen Kottyan, Jess Phillips

The Maryland Zoo in Baltimore

With a new state of the art exhibit, balancing the guest experience, the penguin needs, and the zoo's penguin breeding season needs posed to be a bit of a challenge that was unable to be predicted during the design process.

The penguins had much more space inside the nest room, roughly four times the amount than in the previous exhibit. With that, the penguins were spending much more time inside the nest room instead of out on exhibit, which created an issue for the visitor experience.

To solve this problem, the Maryland Zoo in Baltimore re-evaluated its approach to the penguins breeding season.

In the past, penguins were given access to their nest room and nest boxes twenty four hours a day, seven days a week, all year round, regardless of if we were in breeding season or not. The zoo decided to make a slight change to that to create a better experience for the visitors.

During non breeding seasons (April-early Sept) the penguins nest boxes were left in place, however, they were turned around so they could not gain access to the insides of the boxes. Keepers would also shift them outside onto the main exhibit first thing in the morning. At the end of the day, keepers would give them access to the main nest room again, where pairs could still protect and claim the territory where their nest box was. During breeding season (Sept to March), the nest boxes were turned back around so the pairs had access to the insides, and the penguins were given the choice of going out on to exhibit or remaining inside the nest room where they could lay eggs and rear chicks.

This small change in the penguins breeding season proved to be beneficial for the guest experience while also being something that the penguins seemed to handle very well.

Avian Malaria

Jen Kottyan, Ellen Bronson, Jess Phillips

The Maryland Zoo in Baltimore

The Maryland Zoo in Baltimore has a novel approach to avian malaria detection that they have been using for over 30 years, enabling the colony to be managed successfully without the use of antimalarial prophylaxis. Early detection of avian malaria in African penguins is vital to the health and success of a large breeding colony. Keepers are diligent in looking for signs that a penguin may be ill, such as changes in appetite or behavior. All new penguins to the colony, whether they are hatched at the zoo or brought in from another location are added to the malaria monitoring group for a total of two years through two mosquito seasons. Blood samples are collected from the group once weekly from April until November. The Zoo's veterinary technicians scan a blood smear of each penguin for 20 minutes each for the presence of malarial organisms in the red blood cells. If a penguin has Plasmodium organisms on the blood smear, the individual penguin is treated with Chloroquine and Primaquine for ten days. Each individual is treated for a total of three times if Plasmodium spp. are detected on the blood smear. We allow each penguin to become infected while we closely monitor them, and treat them for the first three infections under close monitoring. After that they will also become infected but are able to handle the infection and gain life-long immunity to the parasite. With the overall good success of this process, we are able to avoid giving prophylactic drugs to each penguin in our large colony for their entire lives. However, it involves a large investment in effort and expertise from our staff to be able to achieve success. This surveillance system also allows us to monitor the species and prevalence of Plasmodium spp. that circulate in our colony and region over time and monitor for new malarial species and other blood parasites that may occur.

Environmental variability drives shifts in the foraging behaviour and reproductive success of an inshore seabird

Nicole D. Kowalczyk¹, Richard D. Reina¹, Tiana J. Preston², André Chiaradia²

¹School of Biological Sciences, Monash University, Clayton, VIC 3800, Australia, ²Research Department, Phillip Island Nature Parks, PO Box 97, Cowes, Vic 3922, Australia

Marine animals forage in areas that aggregate prey to maximize their energy intake. However, these foraging 'hot spots' experience environmental variability, which can substantially alter prey availability. To survive and reproduce animals need to modify their foraging in response to these prey shifts. By monitoring their inter-annual foraging behaviours, we can understand which environmental variables affect their foraging efficiency, and can assess how they respond to environmental variability. Here, we monitored the foraging behaviour and isotopic niche of little penguins (*Eudyptula minor*), over three years (2008, 2011, and 2012) of climatic and prey variability within Port Phillip Bay, Victoria, Australia. During drought (2008), penguins foraged in close proximity to the Yarra River outlet on a predominantly anchovy (*Engraulis australis*) based diet. In periods of heavy rainfall, when water depth in the largest tributary into the bay (Yarra River) was high, the total distance travelled (km), maximum distance travelled (km), distance to core-range (km), and size of core- and home-ranges (km²) of penguins increased significantly. This larger foraging range was associated with broad dietary diversity and high reproductive success. These results suggest the increased foraging range and dietary diversity of penguins were a means to maximize resource acquisition rather than a strategy to overcome local depletions in prey.

Additionally, using GPS biologgers and data from a Ship of Opportunity, we assessed the fine-scale habitat utilisation of the little penguin (*Eudyptula minor*) around the Yarra River plume. We assessed how environmental conditions within the core and home foraging ranges of this inshore seabird differed to environmental conditions in the nearby, accessible, but non-utilised range (i.e. non-foraging range). Penguin foraging ranges consistently occurred in waters with significantly higher Chl-a, turbidity, temperature and lower salinity than non-foraging ranges. High Chl-a biomass was likely the key determinant of penguin distribution as Chl-a rich areas are known to aggregate prey.

Our results demonstrate the significance of the Yarra River in structuring predator-prey interactions in this enclosed bay, as well as the flexible foraging strategies of penguins in response to environmental variability. This plasticity is central to the survival of this small ranging, resident seabird species.

Stable isotope analysis of Adélie penguin chick mummies from the Ross Sea region, Antarctica

Allyson Kristan, Steven D. Emslie

Department of Biology and Marine Biology, Univ. of North Carolina, 601 S. College Rd., Wilmington, NC 28403 USA

We conducted stable isotope analysis of ^{13}C and ^{15}N on eight Adélie penguin (*Pygoscelis adeliae*) chick mummies recovered from excavations of abandoned colonies in the Ross Sea region, Antarctica. Radiocarbon analysis indicates that these mummies date from ~6000 to 1000 cal. years before present (B.P.) after correcting and calibrating for the marine carbon reservoir effect. Our objective was to estimate diet and isotopic fractionation in this species by analysing two to four tissues from each individual, including bone, feather, skin, and toenail where available. We also included analysis of these tissues from five modern chick carcasses from the Ross Sea region for comparison to past data on diet and fractionation. Results of these analyses are presented here and provide a framework for similar analyses of whole or partial carcasses and mummies recovered from future sites in Antarctica or other regions.

More than just survival: broad-scale marking of African penguins to help assess and advise on conservation measures

Katrin Ludynia¹, Richard Sherley², Nola Parsons³, Keri-Lee Dobbie³, Natasha Ayres³, Lorien Pichegru⁴, Barbara Barham⁵, Cuan McGeorge⁶, Lauren Waller⁶, Kate Campbell^{1,7}, Stephen van der Spuy³

¹Department of Biological Sciences & MA-RE Institute, University of Cape Town, South Africa, ²Environment and Sustainability Institute, University of Exeter, Penryn, Cornwall, UK, ³SANCCOB, Cape Town, South Africa, ⁴DST/NRF Centre of Excellence, Percy FitzPatrick Institute, University of Cape Town & Coastal and Marine Research Institute, Mandela Metropolitan University, Port Elizabeth, South Africa, ⁵School of Biological Sciences, University of Bristol, UK, ⁶CapeNature, South Africa, ⁷Animal Demography Unit, University of Cape Town, South Africa

Marking of animals is often used in ecological studies and can assist conservation management decisions. The most common use of marked individuals is in capture-mark-recapture (CMR) studies to estimate survival. CMR data can also be used to estimate recruitment of juveniles into the breeding population or movement of individuals between colonies. In penguins, (metal) flipper bands were commonly used in many species but have been mostly replaced by subcutaneous Passive Integrative Transponders (PITs), which, in addition to the CMR data mentioned above, can also be used for information on breeding phenology and information on mass when used in combination with automated readers and weigh bridges. Ideally, disturbance should be minimised, especially with endangered species like the African penguin, and automated systems to read PITs are desirable. However, the deployment of PITs requires handling which allows for the opportunity to gather additional data (e.g. morphometric measurements, feathers). We here present how the marking of African penguins on a meta-population scale is being used to advise and assess conservation measures. Morphometric measurements obtained during PIT deployments are used to sex adults and to calculate body condition indices (BCI) of adults and fledglings. These can be used to compare conditions between breeding colonies, at a colony over time and relationships between BCI and recruitment, breeding success and survival. BCI can provide insight into the efficacy of conservation measures such as the removal and rehabilitation of abandoned chicks, fishing exclusion zones and other colony-based interventions. Feather samples taken during deployment are also being used to sex the birds as well as for stable isotope and stress hormone analyses. Long-term individual marking will also help to understand the influence of individual phenotypic variability on population dynamics. The resighting of marked individuals helps to assess survival and recruitment of African penguins and gives important information on their movements between colonies, which will help in conservation initiatives like rehabilitation and release of birds, translocation and establishments of new colonies. We here present the study design and methodology applied, results of inter-colony and inter-annual comparisons of BCI as well as first results on survival and movement of marked African penguins from most of the main breeding colonies in South Africa. We will outline how this information will be used to advise on and assess conservation measures to stop the current decline of this endangered species.

Aspects of the reproduction, endocrinology, semen characteristics and cryopreservation in African penguin (*Spheniscus demersus*)

P.S. Mafunda^{1,2}, A. Kotze^{2,3}, L. Maree^{1,2}, G. Van der Host^{1,2}

¹Department of Medical Bioscience, University of the Western Cape, Private Bag X17, Bellville 7535, South Africa,

²Department of Research and Scientific Services, National Zoological Gardens of South Africa, 323 Boom Street, Pretoria, 0001, ³Genetics Department, University of the Free State, Bloemfontein, South Africa

In the marine environment, penguins have been described as curators and serve a critical role in ecological balance. The African penguin (*Spheniscus demersus*) is undergoing a rapid population decline, mainly due to disturbances in their natural habitat. The penguin species was up-listed from vulnerable to endangered on the IUCN Red List for Threatened Species in 2010 and thus urgent conservation action is required. Integral to long-term conservation action is basic knowledge of its reproductive biology. The main aim of this investigation was to evaluate techniques for the collection of semen in African penguin and to determine sperm quality in order to cryopreserve sperm for in vitro fertilization (IVF) purposes of captive and wild populations. Little is known about the general biology of most of this species, including the fundamentals of reproductive physiology. Twelve (six females and six males, $n=4$ were breeding pairs) captive African penguins were monitored for hormone (estradiol, testosterone, progesterone) levels prior to and after the egg laying period. Semen was collected once a week during the breeding season from one captive African penguin. Ejaculates ($n=33$) were obtained over two breeding seasons (Jan-Feb and Jun-Oct) and evaluated for semen volume, sperm concentration, sperm function (sperm motility) and sperm morphology. Estradiol levels showed a biphasic pattern in three of the four breeding females. Semen volume ranged from 0.01 to 0.1 ml, sperm concentration from 977.9 to 7291.6 $\times 10^6$ /ml and total number of sperm per sample ranged from 3.42 to 481.16 $\times 10^6$. The percentage total motility was between 40.1 and 80.4%. Sperm quality and semen parameters were similar across all samples collected over breeding seasons. In comparison to fresh semen, percentage total motility of thawed semen decreased to 24.7% after two hours in liquid nitrogen. Since spermatozoa differ notably in their morphology within species, phase-contrast microscopy, scanning electron microscopy and transmission electron microscopy were used to examine structural abnormalities. This research represents a critical step in the conservation and long-term survival of the African penguin.