



International  
**PENGUIN**CONFERENCE

3 – 7 September 2007  
Hobart, Tasmania  
AUSTRALIA

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**International**  
**PENGUIN CONFERENCE**

**3 – 7 September 2007**  
**Hobart, Tasmania**  
**AUSTRALIA**

**Schedule and abstracts**

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## Sunday 2 September

17:00 - 19:30	Registration
17:30 - 19:30	Ice-breaker cocktail party
17:00 - 19:30	Posters

## Monday 3 September

08:00 - 10:00	Registration
08:45 - 09:30	Intro/welcome/opening

### Theme: Foraging ecology

9:30 - 10:00	Keynote: Bost et al. How do king penguins use the Antarctic Polar Front? Consequences of the dynamic of the frontal structure at a short and long term scale.
10:00 - 10:20	Dann et al. Foraging areas of little penguins during guard and post-guard stages of breeding: evidence of intraspecific competition and “halo” effect?
10:20 - 10:40	Dugger et al. Adélie penguin survival rates in the southern Ross Sea: has survival changed in three decades?
10:40 - 11:30	Morning Tea
11:30 - 11:50	Ainley et al. Sea ice and the winter journeys of Adélie penguins.
11:50 - 12:10	Emmerson et al. The influence of sea ice on foraging trip duration and Adélie penguin breeding success at Béchervaise Island.
12:10 - 12:30	Kokubun et al. Comparison of diving behaviour and foraging habitat use between chinstrap and gentoo penguins.
12:30 - 12:50	Toniolo et al. Foraging in three dimensions: what spatial data and diving behaviour can tell us about Adélie penguin foraging in the Ross Sea.
12:50 - 14:10	Lunch
14:10 - 14:30	Chiaradia et al. Changes in the diet of little penguins over a decade at Phillip Island, Victoria (1995-2005): the impact of mass mortality of a major prey, Pilchard.
14:30 - 14:50	Forero et al. Stable isotopes reveal seasonal and geographical variability in the feeding ecology of little penguin in the absence of pilchard.
14:50 - 15:10	Shaw et al. Sexual differences in the diet of little penguins <i>Eudyptula minor</i> at Phillip Island over 20 years.
15:10 - 15:30	Preston et al. Do little penguins selectively forage in shipping channels? A three-dimensional investigation of the foraging behaviour of little penguins ( <i>Eudyptula minor</i> ) breeding in the vicinity of a busy port.
15:30 - 15:50	Hoskins et al. Foraging behaviour and habitat selection in little penguins ( <i>Eudyptula minor</i> ) during the chick-guard stage of breeding.
15:50 - 16:10	Peter Thomas US ESA penguin listing.
16:10 - 17:00	Afternoon Tea
16:10 - 17:30	Mini workshop: Shaye Wolf, informal discussions re US ESA listing
17:00 - 19:30	Posters

## Tuesday 4 September

08:30 - 10:00	Registration
<b>Theme: Foraging ecology</b>	
09:00 - 09:30	Keynote: Ballard et al. The influence of competition and physical processes on penguin foraging strategies: A study of Adélie penguins at three colonies of radically different size.
09:30 - 09:50	Wienecke et al. Foraging strategies of king penguins from Heard Island during incubation.
09:50 - 10:10	Deagle et al. Studying penguin diet through genetic analysis of faeces: a case study on macaroni penguins ( <i>Eudyptes chrysolophus</i> ).
10:10 - 10:30	Hinke et al. Divergent responses of <i>Pygoscelis</i> penguins reveal common environmental driver.
10:30 - 11:30	Morning Tea
11:30 - 11:50	Steinfurth et al. Foraging behaviour of the Galapagos penguin, <i>Spheniscus mendiculus</i> : implications for conservation.
11:50 - 12:10	Skewgar et al. Surviving the winter: pelagic behaviour of Magellanic penguins.
12:10 - 12:30	Green et al. Winter energy expenditure of little penguins.
12:30 - 12:50	Salton et al. The effect of colony attendance during the non-breeding season on the breeding biology of the little penguin.
12:50 - 14:10	Lunch
14:10 - 14:30	Tierney et al. Evaluating and using stable-isotope analysis to infer diet composition and foraging ecology of Adélie penguins ( <i>Pygoscelis adeliae</i> ).
14:30 - 14:50	Cherel Y et al. Stable isotopes document seasonal changes in trophic niches and winter foraging individual specialization in penguins and fur seals.
14:50 - 15:10	Takahashi et al. Foraging strategies of krill-feeding chinstrap penguins determined using beak-angle loggers.
15:10 - 15:30	Miller & Trivelpiece Chinstrap penguins alter foraging and diving behaviour in response to krill size.
15:30 - 15:50	Mattern et al. Warm-water divers - spatial distribution of dive activity in chick-rearing Snares penguins <i>Eudyptes robustus</i> .
15:50 - 16:10	
16:10 - 17:00	Afternoon Tea
16:10 - 17:30	Mini workshop: Shaye Wolf, informal discussions re US ESA listing
17:00 - 19:30	Posters

### Wednesday 5 September

08:30 – 09:30	Registration <b>Theme: Conservation and management</b>
09:00 - 09:30	Keynote: Hemmings & Woehler The Antarctic legal regime and protection of Antarctic penguins in the Southern Ocean.
09:30 - 09:50	Geisz et al. Current levels and long-term trends of persistent organic pollutants in Adélie penguins.
09:50 - 10:10	Cannell et al. The diving behaviour of little penguins predisposes them to risk of injury by watercraft.
10:10 - 10:30	Borborglu et al. Planning and implementation of Coastal/Marine Protected Areas in Patagonia, Argentina: proposing alternatives to solve critical aspects.
10:30 - 11:30	Morning Tea
11:30 - 11:50	Barham P et al. Comparisons of success of distinct groups of African penguins ( <i>Spheniscus demersus</i> ): 1. differences in breeding success of birds that were and were not oiled in the Treasure oil spill in 2000; 2. survival and breeding success of hand reared orphaned chick.
11:50 - 12:10	Bricher et al. Population trends of Adélie penguin ( <i>Pygoscelis adeliae</i> ) breeding colonies: the effects of snow accumulation and human activities.
12:10 - 13:10	Lunch
13:30 - 16:30	Little Penguin Workshop
18:00 - 23:00	Conference Dinner, Royal Yacht Club of Tasmania



## Thursday 6 September

### Theme: Physiology and demography

09:00 - 09:30	Keynote: Chapman et al. Factors affecting growth and fledging mass of Adélie penguins off the western Antarctic Peninsula.
09:30 - 09:50	Roux et al. The heat is on: climate change accelerating the demise of African penguins in Namibia.
09:50 - 10:10	Le Bohec et al. Impact of climate changes on the breeding and survival of king penguins.
10:10 - 10:30	Chambers et al. The influence of regional ocean temperatures on timing of breeding in little penguins.
10:30 - 11:30	Morning Tea
11:30 - 11:50	Crawford & Underhill An altered carrying capacity of the Benguela upwelling region for African penguins <i>Spheniscus demersus</i> – implications for management.
11:50 - 12:10	Ludynia et al. Foraging African penguins reacting to sulphide eruptions and the use of penguin derived data for monitoring environmental changes.
12:10 - 12:30	Underhill et al. Patterns of moult seasonality of African penguins on Robben and Dassen Islands, South Africa.
12:30 - 12:50	Burghardt et al. A fully automated computer vision system for the biometric identification of African penguins ( <i>Spheniscus demersus</i> ) on Robben Island.
12:50 - 14:10	Lunch
14:10 - 14:30	Stockard et al. Extreme blood oxygen depletion in free-diving emperor penguins.
14:30 - 14:50	Trathan et al. Novel GPS shows penguins stay on the straight and narrow.
14:50 - 15:10	Boersma et al. Petroleum discharge no longer a major mortality factor for Magellanic penguins along Chubut coast.
15:10 - 15:30	Wolfaardt et al. Long-term restoration success of African penguins de-oiled following the <i>Apollo Sea</i> oil spill.
15:30 - 15:50	Pozzi et al. Magellanic penguins ( <i>Spheniscus magellanicus</i> ) population dynamics in Patagonia, Argentina.
15:50 - 16:10	Morris “Something special about spatial”: Optimal sampling methods for little penguins <i>Eudyptula minor</i> using spatio-temporal analyses.
16:10 - 17:00	Afternoon Tea
16:10 – 17:30	Mini workshop: Shaye Wolf, informal discussions re US ESA listing
19:00 - 21:00	Public lecture: Ellis et al. Conservation status of the world's penguins

## Friday 7 September

### Theme: Behaviour

09:00 - 09:30	Keynote: McGraw et al. Annual, sexual, size- and condition-related variation in the colour and fluorescent pigment content of yellow crest feathers in Snares penguins ( <i>Eudyptes robustus</i> ).
09:30 - 09:50	Nolan et al Ornamental colours as quality indicators in king penguins, <i>Aptenodytes patagonicus</i> .
09:50 - 10:10	Poisbleau et al. Breeding biology of the rockhopper penguin <i>Eudyptes c. chrysocome</i> at New Island, Falkland islands: New consideration on the intrinsic capacity of the A-egg.
10:10 - 10:30	Massaro et al. A paradox in brood reduction in crested penguins (genus <i>Eudyptes</i> ): is bullying responsible for the mortality of small, first-laid eggs?
10:30 - 11:30	Morning Tea
11:30 - 11:50	Ellenberg et al. Penguin personalities - consequences of individual stress-coping styles.
11:50 - 12:10	Clark & Boersma Male ecstatic display calls signal individual identity and quality in Magellanic penguins.
12:10 - 12:30	McInnes et al. The effect of brood composition on growth and fledging success in little penguins.
12:30 - 12:50	Viera et al. Empirical paradox: is aggressive behaviour of breeding king penguins costly?
12:50 - 14:10	Lunch
14:10 - 14:30	Davis et al. Feeding Chases in Adélie penguins ( <i>Pygoscelis adeliae</i> ): brood reduction or brood maximization?
14:30 - 14:50	Lescroel et al. Individual variation in long-term reproductive success among Adélie penguins of the Ross Sea: random process or difference in ability?
14:50 - 15:10	Peucker et al. Conservation genetics of the little penguin ( <i>Eudyptula minor</i> ).
15:10 - 15:30	Barbosa et al. Effects of intestinal parasites on the quality of chinstrap penguin offspring: an experimental approach.
15:30 - 15:50	Daniel et al. Synchronized parade in little penguins.
15:50 - 16:30	Closure, acknowledgements, announcement of 7 <sup>th</sup> IPC
16:30 - 17:00	Afternoon Tea



Map showing the location of the Conference venue at the University of Tasmania, Wrest Point hotel and the Royal Yacht Club of Tasmania (dinner venue). The city centre of Hobart is at the upper centre of the map.



**MEMBERS OF THE INTERNATIONAL STEERING COMMITTEE**

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ABSTRACTS OF ORAL PRESENTATIONS, KEYNOTES AND PUBLIC LECTURE

## SEA ICE AND THE WINTER JOURNEYS OF ADÉLIE PENGUINS

DAVID AINLEY<sup>1</sup>, VIOLA TONIOLO<sup>2</sup>, CLAIRE PARKINSON<sup>3</sup>, GRANT BALLARD<sup>4,5</sup>, PHIL TRATHAN<sup>6</sup>

<sup>1</sup> H.T. Harvey & Associates, San Jose CA USA; dainley@penguinscience.com

<sup>2</sup> Dept. of Geophysics, Stanford University, Stanford CA USA

<sup>3</sup> NASA Goddard Space Flight Center, Greenbelt MD USA

<sup>4</sup> PRBO Conservation Science, Petaluma CA USA

<sup>5</sup> School of Biological Sciences, University of Auckland, Auckland NZ

<sup>5</sup> British Antarctic Survey, Cambridge, UK

Over a 3-year period, 2003-2005, which included winters of both extremely high and extremely low sea-ice extent, we investigated the migration routes of Adélie penguins from two colonies of disparate phenology on Ross Island, southern Ross Sea. We acquired data by affixing GeoLocation Sensors to ~15 penguins each at both Cape Royds and Cape Crozier each year, with data retrieved from about half. Penguins departing breeding colonies early in the late summer were able to use a large-scale gyre in their passage to wintering areas (and return), often using polynyas as 'stepping stones.' Those that migrated late were obliged to winter in another area as dictated by ice motion, against which they had to travel on the return trip. Besides ice motion and polynyas, the other key factor in 'choice' of wintering area was availability of daylight. These migratory routes, which affect subsequent breeding phenology and success, have evolved as the pack ice portion of the Ross Sea has changed in extent during the Holocene. Currently, the Ross Island Adélie penguins undertake probably the longest migration of any of this species' colonies. As sea ice extent in the Ross Sea sector continues to change, we can expect altered migration routes by these penguins.

**THE INFLUENCE OF COMPETITION AND PHYSICAL PROCESSES ON PENGUIN FORAGING STRATEGIES: A STUDY OF ADÉLIE PENGUINS AT THREE COLONIES OF RADICALLY DIFFERENT SIZE**

BALLARD G<sup>1,2</sup>, AINLEY DG<sup>3</sup>, BARTON KJ<sup>4</sup>, LESCROËL A<sup>3</sup>, TONIOLO V<sup>5</sup>, LYVER P<sup>6</sup>, WILSON PR<sup>7</sup>

<sup>1</sup> PRBO Conservation Science – 3820 Cypress Drive, Petaluma, CA 94954 – USA

<sup>2</sup> School of Biological Sciences – University of Auckland – Auckland – NZ

<sup>3</sup> H.T. Harvey & Associates – 3150 Almaden Expressway – San Jose CA 95118 – USA

<sup>4</sup> Landcare Research – Private Bag 6 – Nelson – NZ

<sup>5</sup> Ocean Biogeochemistry Lab – Dept. of Geophysics – 397 Panama Mall  
– Stanford CA 94305-2215 – USA

<sup>6</sup> Landcare Research P.O. Box 40 Lincoln, 7640 Christchurch - NZ

<sup>7</sup> 17 Modena Crescent, Glendowie, Auckland - NZ

Using automated weighbridges and radio-frequency identification techniques to track adult condition, foraging trip duration, and meal sizes delivered to chicks over a 10 year period, we compared foraging strategies for breeders at three colonies of radically different size. At Cape Crozier (~140 000 pairs), Cape Bird (~50 000 pairs) and Cape Royds (~2000 pairs). Penguins at Cape Crozier adjusted foraging behaviours because of overall breeding propensity at the colony, indicating intraspecific competition for food and concomitant prey-depletion. Even during years of extreme impacts due to physical processes (i.e., giant icebergs), there was strong evidence of biological influences on penguin foraging tactics. By contrast, at Cape Royds and to a lesser extent at Cape Bird, physical processes (i.e. variation in fast ice extent) dominated. In years when ice conditions were favourable, there was no evidence for prey depletion, adult condition was maintained throughout the breeding season, and chicks received ample food loads. When fast ice conditions were unfavourable, penguins mostly chose not to breed, or failed early in the breeding season. We propose that large colonies exist (and are more stable) in areas where physical processes are typically most conducive to breeding and, ultimately, are size-limited by biological constraints, whereas smaller colonies may be small (and more dynamic) primarily due to physical limitations.

## **EFFECTS OF INTESTINAL PARASITES ON THE QUALITY OF CHINSTRAP PENGUIN OFFSPRING: AN EXPERIMENTAL APPROACH**

ANDRÉS BARBOSA, MARÍA JOSÉ PALACIOS & FRANCISCO VALERA

Departamento de Ecología Funcional y Evolutiva

Estación Experimental de Zonas Áridas, CSIC

c/General Segura, 1. E-04001 Almería, Spain

The knowledge about host-parasite interaction in birds is biased to ectoparasites and blood parasites, but little is known about the interactions involving intestinal parasites. This is also the case for penguins. Specifically, the study of intestinal parasite fauna in Antarctica is essential due to the low presence or the absence of other kind of parasites. In this study we investigate the effects of intestinal parasites, cestodes and nematodes, on the quality of the offspring of chinstrap penguin by means of the administration of antiparasites. The study was carried out in the Vapour Col rookery of chinstrap penguin in Deception Island, South Shetlands. In 22 selected nests with two chicks, we injected one of the chicks (experimental chick) with antiparasite for cestodes and nematodes and the other (control chick) was injected with a placebo. Before injection, chicks were measured and weighted. Two weeks later we re-captured the chicks and we measured and weighted them again. We found significant differences between experimental and control chicks. The chicks treated with antiparasites showed high body mass than the chicks treated with placebo. This suggests that intestinal parasites have negative effects on the growth of penguin chicks in Antarctica.



**COMPARISONS OF SUCCESS OF DISTINCT GROUPS OF AFRICAN PENGUINS (*SPHENISCUS DEMERSUS*): 1. DIFFERENCES IN BREEDING SUCCESS OF BIRDS THAT WERE AND WERE NOT OILED IN THE TREASURE OIL SPILL IN 2000; 2. SURVIVAL AND BREEDING SUCCESS OF HAND REARED ORPHANED CHICKS FROM THE TREASURE SPILL**

PETER J. BARHAM, LES G. UNDERHILL, ROBERT J. M. CRAWFORD <sup>B,C</sup>,  
and T. MARIO LESHORO<sup>D</sup>, DUNCAN A. BOLTON<sup>E</sup>, BARBARA J. BARHAM<sup>F</sup>  
<sup>A</sup>H H Wills Physics Laboratory, University of Bristol, Tyndall Avenue, Bristol BS8 1TL, UK.  
<sup>B</sup>Avian Demography Unit, Department of Statistical Sciences, University of Cape Town,  
Rondebosch 7701, South Africa.  
<sup>C</sup>Marine and Coastal Management, Department of Environmental Affairs and Tourism  
Private Bag X2, Rogge Bay 8012, South Africa.  
<sup>D</sup>Robben Island Museum, Robben Island 7400, South Africa.  
<sup>E</sup>Bristol Zoo Gardens, Clifton, Bristol, BS8 3HA, UK  
<sup>F</sup>Penguin datasystems, Bristol BS6 6QS, UK

More than 17, 000 African penguins (*Spheniscus demersus*) oiled when the MV Treasure sank in June 2000 were cleaned, rehabilitated and released. We find no significant differences between the breeding success on Robben Island from 2001 to 2006 of birds that have never been oiled and birds oiled in events other than the Treasure spill: fledging success averaged 61% in both groups of birds. However, birds oiled during the Treasure event had a significantly lower fledging success rate (43%). A large proportion of this reduced success is attributable to higher mortality of older chicks. Around 2,000 orphaned chicks were hand-reared and released following the Treasure spill. We report on the subsequent survival rate and breeding success of those individuals seen on Robben Island since 2001. The results confirm an earlier study, which found survival to breeding age of hand-reared chicks to be no different from that of naturally-reared chicks. Further, we show that the breeding success of captive reared chicks is at least as good as that of naturally reared chicks. Over a four-year period, pairs where at least one partner was a hand-reared chick produced an average of more than 1.6 chicks per year. Combining the data on survival with that on breeding success indicates that 1,000 hand-reared chicks will produce around 1,220 chicks themselves over their lifetimes, making this a worthwhile conservation intervention.

## **PETROLEUM DISCHARGE NO LONGER A MAJOR MORTALITY FACTOR FOR MAGELLANIC PENGUINS ALONG CHUBUT COAST**

P. DEE BOERSMA<sup>1</sup>, ESTEBAN FRERE<sup>2</sup> and PATRICIA GANDINI<sup>2</sup>

<sup>1</sup>Department of Biology, University of Washington, Seattle, Washington, USA

<sup>2</sup>Centro de Investigaciones de Puerto Deseado, UNPA,  
CONICET (Argentina) and Wildlife Conservation Society (NY)

We counted carcasses of Magellanic penguins by walking one to two kilometre segments of the coast of Chubut, Argentina at 8 to 17 sites in March between 1982 and 2007 (n=13 yrs). We found an average of 44.9% of the penguins were oiled between 1982 and 1990 (s.d. = 15.4, n = 8 years, 3115 penguins). The majority of dead adults (67% s.d. = 12.7, n = 888) between 1986 and 1990 had petroleum on 10% or more of their body. Of the dead fledglings, 38% were oiled (s.d. = 24.1, n = 611). Petroleum pollution was more important in adult deaths while starvation and predation were more important in fledgling deaths. The number of dead oiled adults dropped to 20% and fledglings to 8% in 1990. The number of dead penguins found dropped from 49/km in 1982 to 5/km in 2003 to 1/km in 2005. The decline in dead penguins reflects both their lower population size and a change in mortality from petroleum pollution on Magellanic penguins. Tanker lanes were moved 30 km farther offshore in 1997 but prior to this illegal dumping appeared to decline.

## **PLANNING AND IMPLEMENTATION OF COASTAL/MARINE PROTECTED AREAS IN PATAGONIA, ARGENTINA: PROPOSING ALTERNATIVES TO SOLVE CRITICAL ASPECTS**

PABLO GARCÍA BORBOROGLU<sup>1,2</sup>, LAURA REYES<sup>1,3</sup>, ALICIA TAGLIORETTE<sup>4,5</sup>.

<sup>1</sup>Centro Nacional Patagónico – CONICET, Argentina. [pgborbor@cenpat.edu.ar](mailto:pgborbor@cenpat.edu.ar)

<sup>2</sup>Wildlife Conservation Society.

<sup>3</sup>Universidad Nacional de la Patagonia San Juan Bosco.

<sup>4</sup>Universidad Nacional de la Patagonia Austral

<sup>5</sup>Fundación Patagonia Natural

It is widely accepted that design and implementation of coastal and marine protected areas (CMPA) should integrate biodiversity conservation, fisheries sustainability, tourism, education, recreational and cultural objectives, considering the socio-economic context and community values. Participatory planning is an important tool for success. However, in Latin America past dictatorial governments delayed citizen involvement in public issues. Our goal was to analyse international recommendations for successful planning and implementation in CMPA, including penguin colonies, within the Patagonian coastal zone based on the authors experience in planning processes coordination , and proposing alternatives to solve critical aspects. Crucial identified aspects include: political support, stake-holders involvement, inclusion of science, effective design, efficient governability, and regular monitoring. Social aspects that affect stakeholders involvement (acceptability, ignorance of CMPA benefits and limitations, opposed positions that difficult consensus, mistrust in participatory processes, late invitation of key stakeholders) require particular strategies for its resolution (sensitisation, information, processes based on rational negotiation, transparency from the beginning). Political instability, government vertical structure, and dilution of responsibility require the construction of a social mesh during the planning process that can hold the objectives beyond the government changes, the generation of co-management agencies, and the clear definition of roles, respectively. Finally, the resolution of environmental problems lies within the social field, where the post-normal science is the best approach to address these challenges.

**HOW DO KING PENGUINS USE THE ANTARCTIC POLAR FRONT ?  
CONSEQUENCES OF THE DYNAMIC OF THE FRONTAL STRUCTURE  
AT A SHORT AND LONG TERM SCALE**

CHARLES- ANDRÉ BOST<sup>1</sup>, CÉDRIC COTTÉ<sup>1</sup>, CHRISTOPHE BARBRAUD<sup>1</sup>, CHRISTOPHE GUINET<sup>1</sup>  
CELINE LE BOHEC<sup>2</sup>, YOUNG HYANG PARK<sup>3</sup>

<sup>1</sup>Centre d'Etudes Biologiques de Chizé, CEBC - CNRS, F-79360, Villiers en Bois, France.

<sup>2</sup>IPHC, CNRS-ULP, Département Ecologie, Physiologie et Ethologie  
23 rue Becquerel, F-67087 Strasbourg cedex 2, France.

<sup>3</sup>Département Milieux et Peuplements Aquatiques, Muséum National d'Histoire Naturelle,  
43 rue Cuvier, 75231 Paris Cedex 05, France.

How seabirds cope with the physical features of the southern ocean such as fronts have retained much attention. We investigate the use of mesoscale and fine-scale frontal zones by foraging king penguins studied by satellite tracking. Penguins adjusted their trips to the mesoscale dynamics of the Antarctic Polar Front (APF). During the central phase of the trip, intense foraging periods corresponded to high SST gradients associated with eddies. Most currents in the transit phase and also during speed-up episodes of the central phase were in the same direction as the penguins movements. This suggests that penguins used these currents while travelling towards the mesoscale frontal area where they are most likely to find prey concentrations. Better understanding of the functioning of oceanographic processes and structures in these areas is crucial to improve our knowledge on penguins foraging behaviour. At a long-term scale, a remarkable concurrent change was found between inter-year location of the APF and the foraging range of Crozet king penguins (n=14 years). A progressive change in swimming direction suggests a modification in prey habitat. Strong positive temperature anomalies in the South Indian Basin induced some large shifts in the localization of prey location and ultimately an abrupt decline (30%) in the king penguin population. These strong temperatures anomalies were independent of the 1997-98 ENSO occurrence.

## **A FULLY AUTOMATED COMPUTER VISION SYSTEM FOR THE BIOMETRIC IDENTIFICATION OF AFRICAN PENGUINS (*SPHENISCUS DEMERSUS*) ON ROBBEN ISLAND**

TILO BURGHARDT<sup>1,2</sup>, PETER J BARHAM<sup>1</sup>, NEILL CAMPBELL<sup>2</sup>, INNES CUTHILL<sup>3</sup>

RICHARD SHERLEY<sup>1,2,3</sup> & T MARIO LESHORO<sup>4</sup>

Departments of Physics<sup>1</sup>, Biological Sciences<sup>3</sup> and Computer Science<sup>2</sup>, University of Bristol, Bristol BS8 1TH, UK and <sup>4</sup>Robben Island Museum, Robben Island, South Africa

African penguins (*Spheniscus demersus*) carry a unique, unchanging configuration of spots on their chests. We have developed a biometric vision system that locates, extracts and employs this pattern information from photo and video to provide individual identification by remote, completely non-invasive observation. We will demonstrate the potential of our prototype system on Robben Island to detect the movements of all the penguins in a colony. In static mode the system identifies about 20% of the penguins passing the camera (the chests of most of the 80% that are not identified are occluded by other birds). The proportion of birds that are incorrectly identified is less than one in 1000. As birds tend to use the same paths every day it is probable that all birds using that path are seen and identified within a month. In dynamic mode the camera actively seeks out penguins capturing images of their complete un-occluded chests; thus significantly increasing the proportion of passing birds identified. We will also present early results on the movements of penguins from the initial deployment of the system as a 24/7 monitoring device on Robben Island. Finally, we will discuss how the system could be used in other species.

## **THE DIVING BEHAVIOUR OF LITTLE PENGUINS PREDISPOSES THEM TO RISK OF INJURY BY WATERCRAFT**

BELINDA CANNELL<sup>A</sup>, YAN ROPERT-COUDERT<sup>B</sup>, AKIKO KATO<sup>B</sup>

<sup>a</sup>Murdoch University, South St, Murdoch, Western Australia 6150

<sup>b</sup>National Institute of Polar Research, 1-9-10 Kaga, Itabashi-ku, Tokyo 173-8515, Japan.

Little penguins from Penguin Island were found to either dive to shallow depths of 1-5m or to depths of 8-10m. As they use coastal bays that are also used extensively for water-based recreation, we hypothesise that both the shallow and deep diving penguins can potentially be disturbed or injured by watercraft. TDRs were attached to six little penguins, and the dive patterns and activity were described for the shallow and deep diving penguins separately. Shallow diving penguins executed >1200 dives per day with average dive duration of 10 seconds and spent one third of their day at sea underwater. Almost two thirds of their dives were to depths within the top 2m. The deep diving penguins executed fewer dives but of longer duration and thus spent approximately half of their time at sea underwater. These penguins had longer post-dive recovery. All penguins travelled in the top 2m and could spend >20 seconds within this depth. Both groups spent periods of 3 minutes to more than one hour at a time on the surface. Little penguins dive when they are approached by boats, and results of autopsies of little penguins showed many had injuries that were likely to be caused by watercraft. Penguin Island is part of a rapidly growing region with increasing human usage of the coastal waters. We urge state and local government authorities to develop management strategies to ensure the survival of this population of little penguins.

## **THE INFLUENCE OF REGIONAL OCEAN TEMPERATURES ON TIMING OF BREEDING IN LITTLE PENGUINS**

L. E. CHAMBERS, M. J. CULLEN (DECEASED), P. DANN, P. C. COUTIN

Climate affects marine ecosystems, particularly through oceanographic factors, including El Niño events. For seabirds reproductive success has been shown to be influenced by variations in sea surface temperatures (SST). Using 31 years of data, recorded between 1968 and 1998, we examined relationships between the timing of breeding of little penguins *Eudyptula minor* and variations in SSTs off southern Australia. Additional data, covering the period 1999–2005, were used to test the performance of our predictive models. For the little penguins on Phillip Island, the model predicted an earlier start to egg laying in years when SSTs to the west of Bass Strait and off southern New South Wales were warmer than average during March. These regions are distant from the Phillip Island penguin colony and outside the daily foraging range of the birds. However, changes in these ocean temperatures are likely to influence the timing of little penguin breeding by altering the local abundance of prey items entering the waters surrounding Phillip Island in subsequent months.

## FACTORS AFFECTING GROWTH AND FLEDGING MASS OF ADÉLIE PENGUINS OFF THE WESTERN ANTARCTIC PENINSULA

ERIK W CHAPMAN<sup>1\*</sup>, WILLIAM R FRASER<sup>2</sup>, EILEEN E HOFMANN<sup>1</sup>

<sup>1</sup>Center for Coastal Physical Oceanography, Crittenton Hall 768, Norfolk, VA 23529 USA

<sup>2</sup>Polar Oceans Research Group, P.O. Box 368, Sheridan, MT 59749 USA

[chapman@ccpo.odu.edu](mailto:chapman@ccpo.odu.edu)

Modelling and statistical methods are used to investigate the influence of marine and terrestrial environmental variability on Adélie penguin (*Pygoscelis adeliae*) chick growth. The study is designed to assess hypothesized physical-biological mechanisms that underpin observed population trends among Adélie penguins off the western Antarctic Peninsula, a region that has experienced dramatic warming in recent decades. A 15+ year data-set of fledging-mass, breeding indices, and environmental data from colonies off Anvers Island located off the west Antarctic Peninsula was used to develop an individual-based energetics model (IBM) describing chick growth for this study. Simulations of this model were designed to investigate the sensitivity of chick growth to variability in 1) prey abundance and composition [Antarctic silverfish (*Pleuragramma antarcticum*) vs Antarctic krill (*Euphausia superba*)]; 2) size and age structure of prey populations; 3) lipid stores within the krill population (controlled by sea ice-phytoplankton dynamics); and 4) the presence of water in colonies (subsequently increasing chick thermoregulatory metabolic costs). Results highlight the complexity of factors (both marine and terrestrial) that affect important population parameters among top-predators in a marine system. Furthermore, results underscore the sensitivity of trophic linkages that connect primary production with top-predators to climate-induced alteration of the physical environment.



## CHANGES IN THE DIET OF LITTLE PENGUINS OVER A DECADE AT PHILLIP ISLAND, VICTORIA (1995-2005): THE IMPACT OF MASS MORTALITY OF A MAJOR PREY, PILCHARD

ANDRÉ CHIARADIA<sup>1</sup>, FIONA HUME<sup>1,2</sup>, LEANNE RENWICK<sup>1</sup> & PETER DANN<sup>1</sup>

<sup>1</sup> Research Department, Phillip Island Nature Park, PO Box 97, Cowes, Vic 3922, Australia.

<sup>2</sup> Private Bag 10, New Norfolk, Tasmania, 7140, Australia

Two massive mortalities of Pilchards *Sardinops sagax* were recorded across southern Australia in 1995 and 1998. The 1995 disaster was one of the largest mortalities of a marine species ever recorded. Pilchard was an important component in the food web in this region, a main prey in the diet of several top predators and was Victoria's largest inshore fishery. Pilchard was a major prey for little penguins *Eudyptula minor* at Phillip Island, representing 80% to 100% of their diet at the beginning of breeding. Here, we examined the diet of little penguins from 1995 to 2005 (except 1997 and 1999) and chick growth (except 1997 to 2000) based on body mass recorded every 1-2 days from the end of the guard stage at Phillip Island. The composition of the diet in this study differed markedly from that reported before 1995. Pilchard had virtually disappeared from the diet. Anchovy *Engraulis australis* showed a substantial decrease in frequency of occurrence from 1995 to 2000 but returned to the diet and became a major food after 2001. Penguins had taken a temporal succession of juveniles of Red Cod *Pseudophycis bachus*, Barracouta *Thyrsites atun*, and Blue Warehou *Seriola lalandi*. Little penguins have had lower or higher than average breeding success since 1995, suggesting that the absence of Pilchards itself did not necessarily reduce the breeding success of little penguins. In the medium term, however, little penguins produced lighter chicks in the years following the Pilchard mortality that reduces first-year survival in the first year. These changes in the little penguin's diet are probably indicative of changes in the trophic structure of the local marine ecosystem after the 1995 massive pilchard mortality in southern Australia.

## **MALE ECSTATIC DISPLAY CALLS SIGNAL INDIVIDUAL IDENTITY AND QUALITY IN MAGELLANIC PENGUINS**

J. ALAN CLARK & P. DEE BOERSMA  
University of Washington, Department of Biology  
Box 351800, Seattle, WA 98195-1800, USA

Vocalizations are key to individual recognition and reproductive success, particularly in penguin colonies where high densities reduce the effectiveness of visual and olfactory clues. We investigated whether ecstatic display calls in male Magellanic penguins (*Spheniscus magellanicus*) signal individual identity and quality by evaluating 30 call parameters, including the main structural elements that comprise ecstatic display calls: huff syllables, bray syllables, and syllables produced during inspiration between huffs and brays. We present the first evaluation of inspiratory syllables in a penguin species. Calculating the potential for information coding showed that each non-dichotomous call parameter could code information. Discriminant function analysis showed that the whole call, and all three main structural elements, contained vocal signatures capable of coding information. Because call stability is critical for mate and parent-chick recognition, we tested calls recorded days, weeks, and years apart. We correctly classified over 97% of calls recorded on a single day to source individuals. Correct classification of calls remained high even when calls were recorded over the course of several weeks (95-100%) and over several years (87-96%). In addition, we found that several call parameters we measured covaried strongly with measures of male quality, including size, age, nest quality, and reproductive success.

## **AN ALTERED CARRYING CAPACITY OF THE BENGUELA UPWELLING REGION FOR AFRICAN PENGUINS *SPHENISCUS DEMERSUS* – IMPLICATIONS FOR MANAGEMENT**

ROBERT J. M. CRAWFORD & LES G. UNDERHILL

The carrying capacity of an ecosystem for a species is an input parameter that is required for some models that assess population viability. It may be modified by an altered structure or functioning of the ecosystem, brought about for example by fishing or environmental change. Hence it cannot necessarily be assumed that the pristine level of abundance of a species reflects the present-day carrying capacity of the ecosystem for that species. We used historical information and density-dependent responses to investigate changes in the carrying capacity of the Benguela upwelling ecosystem for African penguins *Spheniscus demersus*, a species categorised as Vulnerable. The carrying capacity was estimated to decrease from 1.5–2.5 million adult birds in the 1920s to 15–25% of this value from 1978–2006, as a result *inter alia* of increased competition for food with purse-seine fisheries and fur seals *Arctocephalus pusillus*. From 1988/89–2005/06, the per-capita recruitment of young penguins to a colony where nesting space was not limiting was significantly inversely related to the size of that colony, suggesting a density-dependent response related to food. From 1989–2004, the breeding success of penguins at the same colony was significantly positively related to the biomass of anchovy *Engraulis encrasicolus* and sardine *Sardinops sagax*, their main prey. After 2004, an eastward shift in the distribution of sardine placed much of this food source beyond the foraging range of breeding penguins. The number of penguins breeding off South Africa's west coast decreased by 50%, resulting in the overall population of the species attaining its lowest recorded value. Management of South Africa's purse-seine fishery will in future couple models of penguins and the fishery using the relationship between breeding success and fish biomass, in an attempt to ensure sufficient breeding success to maintain the population. The introduction of spatial management of fisheries to prevent excessive depletion of food around penguin colonies is also being investigated.

## SYNCHRONIZED PARADE IN LITTLE PENGUINS

TOM DANIEL<sup>1</sup>, ANDRÉ CHIARADIA<sup>2</sup>, MURRAY LOGAN<sup>1</sup>, GERRY QUINN<sup>1,3</sup> & RICHARD REINA<sup>1,4</sup>

<sup>1</sup> School of Biological Sciences, Monash University, Clayton, VIC 3800, Australia

<sup>2</sup> Research Department, Phillip Island Nature Park, PO Box 97, Cowes, Victoria, Australia,  
[achiaradia@penguins.org.au](mailto:achiaradia@penguins.org.au)

<sup>3</sup> Current address: School of Life and Environmental Sciences, Deakin University,  
Warrnambool, VIC 3280, Australia

<sup>4</sup> Presenter

Most penguins move in groups i.e. parade when arriving or departing from their colonies, but there is no information whether these groups are formed deliberately or randomly. We investigated the composition of Little penguin *Eudyptula minor* groups over four breeding seasons (2001 to 2004) using an automated penguin monitoring system (APMS) at Phillip Island, Australia. We concluded that a penguin group was composed of 5-10 individuals waddling through the APMS within 40 seconds intervals. We used an association matrix to determine the number of times any two birds crossed the APMS in the same group. The number of these group associations or 'synchronized parade' behaviour was determined for every possible pair of individuals, giving a total association value for each pair of birds during the post-guard stage of breeding. Penguin groups were formed non-randomly in years of high breeding success (2002 and 2003), but not in years of low breeding success (2001 and 2004). Age of birds was a significant factor in composition of groups. Little penguins with higher association values shared similar characteristics or 'quality', which in turn may increase the functional efficiency of their groups, especially if they are also foraging together. However, low association indices indicated that seeking the same associates was not a priority. It is costly for any animal to synchronize their attendance with the same individuals, so it could be beneficial for Little penguins to display synchronized parade behaviour in good breeding years but it could result in intra-specific competition for food during poor breeding years.

## FORAGING AREAS OF LITTLE PENGUINS DURING GUARD AND POST-GUARD STAGES OF BREEDING: EVIDENCE OF INTRASPECIFIC COMPETITION AND “HALO” EFFECT?

PETER DANN<sup>1</sup>, LEANNE RENWICK<sup>1</sup>, JULIE MCINNES<sup>1</sup>, ANDRE CHIARADIA<sup>1</sup>, ROGER KIRKWOOD<sup>1</sup>, EMMA BUICK<sup>2</sup>, JANOSCH HOFFMAN<sup>3</sup> & JOHN ARNOULD<sup>2</sup>.

<sup>1</sup> Research Department, Phillip Island Nature Park, PO Box 97, Cowes, Vic 3922, Australia.

<sup>2</sup>School of Life and Environmental Sciences, Deakin University, Melbourne, Australia.

<sup>3</sup>School of Biological Sciences, Monash University, Melbourne, Australia

One mechanism for the density-dependent regulation of seabird populations is the depletion of food through intense foraging around a seabird colony, particularly during chick rearing (“halo effect”). This depletion of food may limit breeding success and, consequently, recruitment and population size. We examined the role that intra-specific competition for food during the breeding season plays in determining the size of populations of little penguins *Eudyptula minor* in south-eastern Australia. Using satellite telemetry, we tracked up to 20 individuals during both chick guard and post-guard stages at three sites: Phillip Island (26,000 birds; 2005 & 2006, Rabbit Island (4,000 birds; 2005) and Notch Island (10,000 birds; 2006). We tested the hypothesis that, if prey availability declined during chick-rearing, the birds would forage in different areas or further away from the colony. Foraging ranges increased substantially between guard and post-guard stages in three of the four studies. Dietary information collected in 2005 indicated that changes in foraging range may be associated with changes in diet. At Rabbit Island in 2005, the foraging range of penguins increased dramatically and this was accompanied by a drop in the relative abundance of both sandy sprat *Hyperlophus vittatus* and anchovy *Engraulis australis* in their diets. In contrast, at Phillip Island in 2005, the foraging range did not change substantially and nor did the diets of penguins between guard and post-guard stages. We discuss these results in relation to colony size, breeding success and foraging behaviour.

## **FEEDING CHASES IN ADELIE PENGUINS (*PYGOSCELIS ADELIAE*): BROOD REDUCTION OR BROOD MAXIMIZATION?**

DAVIS, L.S.,<sup>1</sup> DAVIS D.M.M.,<sup>1</sup> JOHNSTONE, R.M.<sup>1</sup> & LICKLEY D.<sup>2</sup>

<sup>1</sup>*Department of Zoology, University of Otago, P.O. Box 56, Dunedin, New Zealand*

<sup>2</sup>*Science North, 100 Ramsey Lake Road, Sudbury, Ontario P3E 5S9, Canada*

Pygoscelid penguins exhibit a peculiar behaviour known as a *feeding chase*, whereby parents returning to the colony to feed crèche-age chicks will turn and run from their own chicks, often repeatedly, before feeding them. During the chases, adults may lead the pursuing chicks beyond the confines of the crèche or their sub-colony, thereby exposing them, apparently, to increased risks of predation by skuas. A review of hypotheses put forward to explain this phenomenon identified two as being the most promising: the Brood Reduction Hypothesis suggests that in times of poor food supply feeding chases will serve to prioritize feeding of the strongest chick (clutch size is typically two), facilitating brood reduction and increasing the prospects of fledging one chick; whereas the Brood Maximization Hypothesis suggests that feeding chases function to distribute food more equitably between chicks, thereby counter-acting the effects of sibling competition and any size disparities that may have arisen as a consequence of asynchronous hatching. The predictions of these two contradictory hypotheses are best differentiated under when food supply is limited. The grounding of the giant iceberg, B15, near the Adelie penguin colonies on Ross Island, Antarctica, provided a natural experiment by reducing the penguins' access to food. We monitored feeding chases at the Northern Colony at Cape Bird during the 2004/05 breeding season, when breeding success was dramatically impacted by the presence of the berg, and again in the 2005/06 season after the berg had moved away. We also had access to similar data collected during the 1990/91 season, well before the arrival of the berg. Our results show that feeding chases are consistent with the Brood Maximization Hypothesis but not the Brood Reduction Hypothesis. Benefits of brood reduction to a surviving chick will be most pronounced the earlier that it occurs and, in 2004/05, most brood reduction took place before the advent of feeding chases, which occur when the chicks start creching at about three weeks of age. Parents feeding single chicks were much less inclined to run away from their chicks. During feeding chases involving two-chick broods, both chicks typically got fed, even if larger chicks were able to monopolize the initial feedings. The distance covered during feeding chases was less during the 2005/06 season, when access to food was presumably better, suggesting that the extent of feeding chase behaviour is affected by the intensity of the chick's begging behaviour – in other words, the intensity of the sibling competition.

**STUDYING PENGUIN DIET THROUGH GENETIC ANALYSIS OF FAECES:  
A CASE STUDY ON MACARONI PENGUINS (*EUDYPTES CHRYSOLOPHUS*)**

B.E. DEAGLE<sup>1,2</sup>, N.J. GALES<sup>2</sup>, K. EVANS<sup>1</sup>, S.N. JARMAN<sup>2</sup>, S. ROBINSON<sup>2</sup>,  
R. TREBILCO<sup>1</sup>, M.A. HINDELL<sup>1</sup>

<sup>1</sup> School of Zoology, University of Tasmania, Box 252-05,  
Hobart, Tasmania 7000, Australia

<sup>2</sup> Australian Antarctic Division, Channel Highway  
Kingston, Tasmania 7050, Australia

Determination of penguin diet usually relies on the analysis of stomach-content remains obtained through stomach flushing; this technique is both invasive and logistically difficult. We evaluate the usefulness of DNA-based faecal analysis in a dietary study on chick-rearing macaroni penguins (*Eudyptes chrysolophus*) at Heard Island. Conventional stomach-content data were also collected, allowing comparison of the approaches. Prey-specific genetic tests were used to detect dietary DNA in faecal samples and isolated prey DNA was also sequenced. Euphausiid DNA was most commonly detected in guard stage of chick-rearing, and DNA from the myctophid fish *Kreftlichthys anderssoni* and amphipods was prevalent in samples collected in crèche stage; these trends followed those observed in the penguins' stomach contents. The proportion of sequences retrieved from the two dominant euphausiid prey species (*Euphausia vallentini* and *Thysanoessa macrura*) changed over the sampling period; again, this reflected the trend in the stomach content data. Simultaneous analysis of all prey DNA recovered revealed a higher diversity of fish prey than identified in the stomachs, but non-fish prey were under-represented. The ability of the DNA-based approach to detect temporal variation in the diet macaroni penguins indicates this non-invasive method will be useful for monitoring population-level dietary trends in future studies.

**ADÉLIE PENGUIN SURVIVAL RATES IN THE SOUTHERN ROSS SEAS:  
HAS SURVIVAL CHANGED IN THREE DECADES?**

DUGGER, KATIE M.<sup>1</sup>, DAVID. G., AINLEY<sup>2</sup>, GRANT BALLARD<sup>3,4</sup>, & MICHELLE HESTER<sup>5</sup>

<sup>1</sup>Department of Fisheries and Wildlife, Oregon State University,  
104 Nash Hall, Corvallis, OR 97331, USA

<sup>2</sup>H.T. Harvey and Associates, 3150 Almaden Expressway, Suite 145, San Jose, CA 95118, USA

<sup>3</sup>PRBO Conservation Science, Petaluma, CA 94970, USA

<sup>4</sup>School of Biological Sciences, University of Auckland, Auckland NZ

<sup>5</sup>Oikonos, P.O. Box 1932, Benicia, CA 94510, USA

New analytical techniques to estimate survival rates from mark-recapture data have created a unique opportunity to re-analyze adult Adélie penguin banding data from Cape Crozier, Antarctica, collected during the 1966/67 to 1969/70 breeding seasons. These data previously were treated using life history table analyses and Adélie penguin survivorship during a period of population decline was reported. Cape Crozier penguin populations have since increased and stabilized. Our objectives were to 1) estimate apparent survival for breeding adult Adélie penguins, banded during the 1960's using Cormack-Jolly-Seber (CJS) open population models; 2) compare survival estimates from the same early time period based on life-table analyses; and 3) compare estimates of earlier apparent survival with CJS estimates for 1996-2005. Model-averaged estimates of apparent survival for 1966/67 and 1967/68 (0.64, SE=0.11; 0.64, SE=0.09) were substantially lower than life-table estimates for similar age classes in 1967/68 (0.97), and all estimates of apparent survival at Cape Crozier from 1996 – 2005 (0.95 to 0.75), but were comparable to survivorship in 1974-75 (0.64). Differences in survival estimates across years and between estimation methods is likely related to the limitations of the life-table approach and annual environmental variation.



## **PENGUIN PERSONALITIES – CONSEQUENCES OF INDIVIDUAL STRESS-COPING STYLES**

URSULA ELLENBERG, THOMAS MATTERN & PHILIP J. SEDDON  
University of Otago, Dunedin, New Zealand

We tend to see members of non-human animal species as uniform entities, all sharing certain species-specific characters. However, what has been long known for people and demonstrated in various medical and psychological studies seems to be the case for other animals as well: Individuals appear to use different strategies to cope with environmental challenges – strategies that are quite similar to human personalities. Evolutionary this makes sense, individual variation in behaviour and physiology is a driving force for natural selection, with pressures that act on individual fitness causing differences in reproductive success and survival. While studying the effects of human disturbance on Yellow-eyed penguins we found inter-individual differences in behavioural, hormonal and heart rate responses that relate to reproductive parameters. Although responses to human proximity may vary intra-specifically depending on individual condition, time of year, previous experiences with humans and much more, there appears also to be an important general underlying trait that is independent of these factors. We review the different stress-copying styles, consider possible consequences, and discuss management implications.

## CONSERVATION STATUS OF THE WORLD'S PENGUINS

ELLIS, S.<sup>1</sup>, WOEHLER, E.J.<sup>2</sup>, SKEWES, E.<sup>3</sup>, AND BOERSMA, P.D.<sup>3</sup>

<sup>1</sup>International Rhino Foundation, USA, <sup>2</sup>School of Zoology, University of Tasmania

<sup>3</sup>University of Washington, USA

Penguins are among the most popular and well-studied avian groups, yet they face serious population decreases throughout their range. In order to provide substantive review and update of penguin status, a series of conservation assessment workshops has been held in conjunction with the various International Penguin Conferences. The data continue to show a relatively grim progression of threat status from 1988 to the present. In 2004, after the 5<sup>th</sup> International Penguin Conference in Ushuaia, Tierra del Fuego, Argentina, a 2-day Penguin Conservation Workshop was convened as a collaborative effort to (a) review the status, population trends and threats to each of the 17 penguin species, (b) to identify and prioritize key threats in each region and/or for each species, (c) necessary actions to deal with specific threats and (d) to identify how the penguin biology community can move ahead to address these priorities. The disconcerting decrease in most of the world's penguin species will be reversed only through immediate and affirmative action on the part of the global community of researchers, governmental entities, conservation organizations, and the general public. If we address the identified threats, undertake priority research needs using an interdisciplinary and integrated approach, and begin to implement appropriate conservation actions, we may have a chance at slowing or stopping the decreases in penguin populations. The plight of this important and charismatic taxonomic group is dire, and as importantly, is a clear reflection of the escalating crises facing the world's marine ecosystems.

## **THE INFLUENCE OF SEA ICE ON FORAGING TRIP DURATION AND ADÉLIE PENGUIN BREEDING SUCCESS AT BÉCHERVAISE ISLAND**

LOUISE EMMERSON, JUDY CLARKE & COLIN SOUTHWELL  
Australian Antarctic Division, Channel Highway, Kingston. Tasmania, 7050.

For some years now, we have been aware of the negative relationship between sea ice extent and breeding success that exists for Adélie penguins (*Pygoscelis adeliae*) inhabiting Béchervaise Island off the Mawson coast. The last four years have seen a continuation of this trend. These four years have been particularly poor for Adélie penguin reproduction due to extensive sea ice around the colony during the chick rearing period in January. Now that we have more representative data across the full spectrum of possible sea ice conditions we can explore the response of other biological parameters in relation to these ice conditions. One obvious response is the influence of sea ice on foraging trip duration, and how this parameter in turn is likely to influence breeding success. We examine 15 years of foraging trip duration data in relation to sea ice extent around Béchervaise Island to determine what it is about foraging trips that results in chick failure. In conjunction with detailed nest surveys we are able to examine the relationship between foraging trip duration and breeding success at a population level response as well as an individual nest response to determine which factors contribute to nest failure.

## STABLE ISOTOPES REVEAL SEASONAL AND GEOGRAPHICAL VARIABILITY IN THE FEEDING ECOLOGY OF LITTLE PENGUIN IN THE ABSENCE OF PILCHARD

MANUELA G. FORERO<sup>1</sup>, ANDRÉ CHIARADIA<sup>2</sup> & KEITH A. HOBSON<sup>3</sup>

<sup>1</sup>Estación Biológica de Doñana, Avda. María Luisa s/n, Pabellón del Perú,  
41013 Sevilla [gforero@ebd.csic.es](mailto:gforero@ebd.csic.es)

<sup>2</sup>Phillip Island Nature Park, PO Box 97, Cowes, Vic 3922, Australia.

<sup>3</sup>Environment Canada, 11 Innovation Boulevard, Saskatoon, Saskatchewan S7N 3H5, Canada.

The diet composition of little penguin (*Eudyptula minor*) on Phillip Island, Victoria, Australia, has changed substantially after a collapse in the Pilchard (*Sardinops sagax*) stock in 1995. We used stable isotope analyses (SIA) to evaluate geographical and seasonal variability in little penguin diet in the absence of Pilchard, once a major prey. We measured stable nitrogen ( $\delta^{15}\text{N}$ ) and carbon ( $\delta^{13}\text{C}$ ) isotope values from blood sample of adults and chicks in three different breeding colonies at different breeding stages in 2003 and 2004. We also measured stable isotope values in more representative prey species. The  $\delta^{15}\text{N}$  values of penguins showed a larger variation (from 10.3‰ to 19.7‰) than  $\delta^{13}\text{C}$  values (-21.1‰ to -18.2‰). The SIA indicated large differences in diet among colonies. Penguins at St Kilda (Port Phillip Bay) showed the highest  $\delta^{15}\text{N}$  and  $\delta^{13}\text{C}$  values, relying almost exclusively on anchovy (*Engraulis australis*). At Phillip Island (two breeding colonies), where diet was more diverse and individuals consumed a higher proportion of low trophic level prey, we found a significant effect of breeding stage, season and colony and their interaction. These models explained 56.3% and 67.7% of the  $\delta^{15}\text{N}$  and  $\delta^{13}\text{C}$  deviance, respectively. Variation among breeding stages was the more significant effect for both isotopes: adults and their raising chicks showed lower values of  $\delta^{13}\text{C}$  than adults during pre-breeding and incubation. For  $\delta^{15}\text{N}$  values, adults during the post-guard, and their chicks showed lower values than individuals during previous breeding stages. At St. Kilda, where diet was less diverse, segregation in stable isotopes among breeding stages and seasons was much lower than at Phillip Island. We discuss the relationship between population segregation in stable isotope values and variability both in individual body condition and breeding parameters among colonies.

## CURRENT LEVELS AND LONG-TERM TRENDS OF PERSISTENT ORGANIC POLLUTANTS IN ADÉLIE PENGUINS

H.N. GEISZ<sup>1</sup>, R.M. DICKHUT<sup>1</sup>, M.A. COCHRAN<sup>1</sup>, W.R. FRASER<sup>2</sup>, H.W. DUCKLOW<sup>3</sup>

<sup>1</sup> School of Marine Science, The College of William and Mary, Gloucester Point, VA 23062, USA

<sup>2</sup> Polar Oceans Research Group, Sheridan, MT 59749, USA

<sup>3</sup> Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA 02543, USA

Many organochlorine pesticides have been restricted or banned in the last 20-30 years, consequently levels of persistent organic pollutants (POP) in Adélie (*Pygoscelis adeliae*) penguin tissues should be decreasing. The primary objectives of this study were to: (1) evaluate current levels of POPs in Adélie penguins using samples collected from breeding populations surrounding Palmer Station and on Cape Crozier, Antarctica, and (2) evaluate long-term trends for POPs in Adélie penguins. Necropsies were performed on birds collected post mortem, and addled eggs were collected throughout the austral summer breeding seasons of 2004-2006. Trophic level, a key determinant of POP residues in an organism, was assessed using stable isotopes of carbon and nitrogen. Results indicate relatively volatile compounds, such as hexachlorobenzene (HCB), to be decreasing in bird tissues over time tracking HCB levels in air, yet bioaccumulation of less volatile contaminants, such as DDT residues, continues to persist. Comparative analysis of  $\Sigma$ DDT residues in Cape Crozier birds between 1964 and the present reveals a significant increase over time at the 90% confidence level, while there is no significant difference in  $\Sigma$ DDT residues in Palmer birds with time. Cape Crozier Adélie penguins were found to have higher  $\delta^{15}\text{N}$  values than Palmer Adélie penguins and accordingly, demonstrate elevated levels of  $\Sigma$ DDT.

## **WINTER ENERGY EXPENDITURE OF LITTLE PENGUINS**

J.A. GREEN<sup>1</sup>, L.R. HORNE<sup>1</sup>, P. DANN<sup>2</sup>, P.J. BUTLER<sup>3</sup> & P.B. FRAPPELL<sup>1</sup>

<sup>1</sup>Adaptational and Evolutionary Physiology Research Group, Department of Zoology  
La Trobe University, Bundoora, Victoria, 3070, Australia

<sup>2</sup>Phillip Island Nature Park, PO Box 97, Cowes, Phillip Island, Victoria, 3922, Australia

<sup>3</sup>Centre of Ornithology, School of Biosciences, University of Birmingham  
Edgbaston, Birmingham, B15 2TT, UK

The non-breeding winter period is a critical time for most penguin species as they recover from the previous breeding season and moult and prepare for the next. At Phillip Island, Victoria, Australia, the timing and success of breeding seasons is thought to be related to conditions at sea during the previous winter. We deployed data loggers in 11 male little penguins from Phillip Island to record heart rate, body temperature and diving depth throughout the winter. These data enabled us assess how this species modifies its physiology and behaviour to the variable demands of the winter period. The duration of foraging trips varied substantially from 1 to 35 days. Diving behaviour was variable including deep, shallow and benthic dives. Short trips (<1 day) had a high energetic cost whereas longer trips had a lower cost with the total cost of the trip decreasing with trip duration. Total daily energy expenditure tended to decrease as the winter progressed. Implications for the life-history and conservation of the little penguin will be discussed.

## THE ANTARCTIC LEGAL REGIME AND PROTECTION OF ANTARCTIC PENGUINS IN THE SOUTHERN OCEAN

ALAN D. HEMMINGS<sup>1</sup> & ERIC J. WOEHLE<sup>2</sup>

<sup>1</sup> Senior Fellow, Gateway Antarctic Centre for Antarctic Studies and Research,  
University of Canterbury, New Zealand

<sup>2</sup>School of Zoology, university of Tasmania

Five penguin species – *Aptenodytes forsteri*, *Pygoscelis adeliae*, *P. antarctica*, *P. papua* and *Eudyptes chrysolophus* – breed in the Antarctic Treaty Area (the area south of 60° S latitude) and constitute what we term here “Antarctic penguins”. At least some of these taxa appear already under pressure – IUCN criteria see *antarctica* as regionally, and *chrysolophus* as globally “Vulnerable”. All are likely to be impacted by sea-ice, temperature and ecosystem effects of climate change. Sufficient scientific information is now available for these taxa to understand the broad pattern of both breeding-season foraging movements and non-breeding dispersal in the Southern Ocean. Recent scientific studies have revealed movements of animals from some populations northwards out of the Antarctic Treaty Area, and thus beyond the formal area of application of, and protections accorded by, the 1959 *Antarctic Treaty* and the 1998 *Protocol on Environmental Protection to the Antarctic Treaty* (Protocol). Over part of the circumpolar area, penguins whilst north of the Antarctic Treaty Area may still be within the area of the *Convention for the Conservation of Antarctic Marine Living Resources* (CCAMLR). Whilst likely offering lesser protection for penguins than the Protocol, some protection is available, and CCAMLR has a capacity for further development. Penguins have been reported north of the CCAMLR area, although these may largely be vagrants. However, from 150° E – 50° W (from south of Tasmania to just north of the South Orkney Islands) the Antarctic Treaty and CCAMLR areas are coincident. Dispersal north of 60° occurs with some Ross Sea *forsteri*, and potentially with Balleny Islands *antarctica* and *adeliae*, South Shetland and South Orkney Islands *antarctica*, *adeliae*, and *papua* and others. Where this occurs, penguins move into high seas areas outside any current regional agreement – or into weak-agreement areas such as the Galapagos Agreement off western South America – wherein they appear to have no protection accorded them. Substantial and increasing human activities in the Southern Ocean surrounding Antarctica (marine harvesting, tourism, innocent-passage, and in the near-term future potentially bioprospecting and other commercial activities) may pose risks for penguins in areas where currently no capacity for consideration, or easy mechanisms for the elaboration of protection, is evident. As a public-policy issue, the fact that key Antarctic ‘charismatic mega-fauna’, including ‘classic’ high latitude breeders such as emperor penguins, are for part of their normal at-sea dispersal entirely unprotected by a much-vaunted Antarctic legal regime, may have high public interest. This paper examines these issues for the first time and suggests areas where protection of Antarctic penguins in the Southern Ocean may warrant further attention. It may thus contribute to further development of the existing Antarctic regime, existing non-ATS regimes (e.g. *Convention for the Conservation of Southern Blue Fin Tuna*, and the “Galapagos” Agreement) and/or identify further areas for consideration in the emerging high seas regimes immediately surrounding the Antarctic area, such as the putative *South Pacific Regional Fisheries Organisation* or the *Southern Indian Ocean Fisheries Agreement*.

## DIVERGENT RESPONSES OF *PYGOSCELIS* PENGUINS REVEAL COMMON ENVIRONMENTAL DRIVER

Jefferson T. Hinke<sup>1,2,\*</sup>, Kasia Salwicka<sup>3</sup>, Susan G. Trivelpiece<sup>2</sup>

George M. Watters<sup>4</sup>, Wayne Z. Trivelpiece<sup>2</sup>

1. Scripps Institution of Oceanography, UCSD, La Jolla, CA 92093

2. Antarctic Ecosystem Research Division, NOAA-SWFSC, La Jolla, CA 92037

3. Department of Antarctic Biology, Polish Academy of Sciences Warsaw, Poland 02141

4. Protected Resources Division, NOAA-SWFSC, Pacific Grove, CA 93950, USA

\* [jhinke@ucsd.edu](mailto:jhinke@ucsd.edu)

Responses of predators to environmental variability in the Antarctic Peninsula region exhibit divergent patterns owing to variation in geographic settings of colonies and predator life-history strategies. Five colonies of *Pygoscelis* penguins from King George Island and Livingston Island, South Shetland Islands, Antarctica, were examined to 1) compare the responses of sympatric congeners to recent changes in their Antarctic ecosystem and 2) assess underlying causes for such responses. We used linear regression and correlation analyses to compare indices of abundance, recruitment, and summer breeding performance of the Adélie (*P. adeliae*), gentoo (*P. papua*), and chinstrap penguins (*P. antarctica*). Abundance of Adélie and chinstrap penguins have declined by roughly 50% since the mid 1970s, but no trends are evident for gentoo penguins. Recruitment of Adélie penguins has declined by roughly 80%, but no such patterns are evident for gentoo penguins. Fledging success, however, has remained stable at all breeding colonies. The different trends in abundance and recruitment indices, despite generally similar indices of summer performance, suggest that winter conditions contribute to the divergent responses among the penguins. In particular, correlations between penguin and krill recruitment suggest that our study penguins live under an increasingly krill-limited system with disproportionate effects on juvenile survival.



**FORAGING BEHAVIOUR AND HABITAT SELECTION IN LITTLE PENGUINS (*EUDYPTULA MINOR*)  
DURING THE CHICK-GUARD STAGE OF BREEDING**

ANDREW J HOSKINS<sup>A</sup>, PETER DANN<sup>B</sup>, YAN ROBERT-COUDERT<sup>C</sup>, AKIKO KATO<sup>C</sup>,  
ANDRE CHIARADIA<sup>B</sup>, DAN P COSTA<sup>D</sup>, JOHN PY ARNOULD<sup>A</sup>

<sup>a</sup> School of Life and Environmental Sciences, Deakin University, 221 Burwood Highway, Burwood, Victoria,  
3125, Australia [ajhos@deakin.edu.au](mailto:ajhos@deakin.edu.au)

<sup>b</sup> Phillip Island Nature Park, PO Box 97, Cowes, Victoria, 3922, Australia

<sup>c</sup> National Institute of Polar Research, 1-9-10 Kaga, Itabashi-ku, Tokyo 173-8515, Japan

<sup>d</sup> Center for Ocean Health, University of California, 100 Shaffer Road,  
Santa Cruz, CA 95060, USA

Knowledge of the foraging areas of marine apex predators, and the factors influencing them, is central to understanding how their populations respond to environmental perturbations. While there is a large body of literature documenting the association of seabirds with areas of high marine productivity, there is little comparative information for species restricted to near-shore or continental-shelf areas. In the present study, the differences in foraging range and diving behaviour of little penguins from three breeding colonies (Rabbit Island, Kanowna Island and Phillip Islands) in central northern Bass Strait, southeast Australia, was investigated during the chick-guard stage using externally externally-attached devices (PTTs and TDRs). Although there were large individual variations, overall the mean maximum foraging range (16.9-19.8 km) and mean total distance travelled (41.8-48.0 km) were similar between the three colonies despite the differing bathymetric environments. Habitat selection analysis revealed individuals from all three colonies selected foraging areas within a narrow SST range (16.0-16.4°C). In addition, at the colony level, significant differences in mean dive depths (5.4-10.9m) and mean durations (13.2-28.6s) were found yet mean diving effort (936.3-964.3m·h<sup>-1</sup> vertical distance travelled) was similar. These findings suggest little penguins from all three colonies, although constrained by similar energetic boundaries, to be plastic in their foraging behaviour while foraging for similar prey.

## COMPARISON OF DIVING BEHAVIOUR AND FORAGING HABITAT USE BETWEEN CHINSTRAP AND GENTOO PENGUINS

NOBUO KOKUBUN (1)\*, AKINORI TAKAHASHI (1,2), YOSHIHISA MORI(3)

KENICHIRO SHIMATANI (4), SHINICHI WATANABE (4) & HYOUNG-CHUL SHIN(5)

(1) Department of Polar Science, The Graduate University for Advanced Studies, Itabashi, Tokyo 173-8515, Japan, (2) National Institute of Polar Research, Itabashi, Tokyo 173-8515, Japan, (3) Teikyo University of Science and Technology, Uenohara, Yamanashi 409-0193, Japan, (4) The Institute of Statistical Mathematics, Minato, Tokyo 106-8569, Japan, (5) Korea Polar Research Institute, KORDI, Songdo Techno Park, Songdo-Dong 7-50, Yeonsu-Gu, Incheon 406-840, Korea. [\\*kokubun@nipr.ac.jp](mailto:kokubun@nipr.ac.jp)

Inter-specific comparison of foraging behaviour between congeneric species will facilitate the description of their differential ecological niches in an ecosystem. In 2006/07 season, diving location, dive depth and ambient temperature were recorded by two types of bird-borne GPS-Depth-Temperature data loggers (made by earth&OCEAN Technologies, 86g; Little Leonardo, 92g) deployed on 23 Chinstrap and 25 Gentoo penguins that are the congeneric species breeding sympatrically at Barton Peninsula, King George Island, Antarctica. Preliminary analyses suggest that foraging behaviour of two species were similar: there were no significant differences in mean diving depth and duration, foraging trip duration and maximum foraging range from the rookery (<35km) between the two species. Gentoo penguins, however, appeared to possess higher potential diving capability than compared with Chinstrap penguins (i.e. in terms of maximum diving depth and dive duration of Gentoos were deeper and longer than that of Chinstraps). Combining these behavioural data with environmental information including bathymetry, segregation of foraging habitats by the two penguin species will be examined.

## IMPACT OF CLIMATE CHANGES ON THE BREEDING AND SURVIVAL OF KING PENGUINS

Céline Le Bohec,<sup>1\*</sup> Joël M. Durant,<sup>2</sup> Michel Gauthier-Clerc,<sup>1,3</sup> David Grémillet,<sup>1,4</sup> Nils Chr. Stenseth,<sup>2,5</sup> Roger Pradel,<sup>6</sup> Young-Hyang Park,<sup>7</sup> Jean-Paul Gendner,<sup>1</sup> and Yvon Le Maho<sup>1</sup>

<sup>1</sup> Départements Écologie, Physiologie et Éthologie & Interactions Physique, Chimie et Vivant, Institut Pluridisciplinaire Hubert Curien – CNRS, IPHC, 23 rue Becquerel, 67087 Strasbourg Cedex 02, France

<sup>2</sup> Centre for Ecological and Evolutionary Synthesis (CEES), Department of Biology, University of Oslo, PO Box 1066 Blindern, 0316 Oslo, Norway

<sup>3</sup> Station Biologique de la Tour du Valat, Le Sambuc, 13200 Arles, France

<sup>4</sup> Percy FitzPatrick Institute of African Ornithology, NRF/DST Centre of Excellence, University of Cape Town, Rondebosch 7701, South Africa

<sup>5</sup> Institute of Marine Research, Flødevigen Marine Research Station, N-4817 His, Norway

<sup>6</sup> Centre d'Écologie Fonctionnelle et Évolutive – CNRS, CEFE, UMR 5175, 1919 Route de Mende, 34293 Montpellier Cedex 05, France

<sup>7</sup> Département Milieux et Peuplements Aquatiques – MNHN, USM 0402/LOCEAN, Muséum National d'Histoire Naturelle, 75231 Paris, France

\*[celine.lebohec@c-strasbourg.fr](mailto:celine.lebohec@c-strasbourg.fr)

We investigated the relationship between climatic variations at sea and breeding and survival in a population of undisturbed king penguins *Aptenodytes patagonicus* at Possession Island in the Crozet. Their overall breeding success was lower when the annual Southern Oscillation Index was lower. The breeding success was better under a high spring concentration in chlorophyll close to the colony. Adult survival was lower 2 years after warm Sea Surface Temperatures close to the ice zone, with a 10% variation in survival for a change in SST of only 0.3°C. Crozet king penguins forage in this zone during the austral winter, i.e. about 2000km south of their colony. Superimposed on their effort to travel to such remote foraging area, their energy demand is therefore further increased to find food despite the lower food resources resulting from high SST. The 2 year lag can be explained by a 1 year delay in krill depletion and a one year more delay for the reproductive cost to be paid by the bird. This effect of small sea temperature changes on one of the most important avian consumers of the Southern Ocean has to be considered when assessing the impact of warming on biodiversity according to the present climatic scenarios.

## INDIVIDUAL VARIATION IN LONG-TERM REPRODUCTIVE SUCCESS AMONG ADÉLIE PENGUINS OF THE ROSS SEA: RANDOM PROCESS OR DIFFERENCE IN ABILITY?

LESCROËL A<sup>1</sup>, BALLARD G<sup>2,3</sup>, BARTON KJ<sup>4</sup>, DUGGER K<sup>5</sup>, LYVER POB<sup>6</sup>,  
TONIOLO V<sup>7</sup>, WILSON PR<sup>8</sup>, AINLEY DG<sup>1</sup>

<sup>1</sup> H.T. Harvey & Associates – 3150 Almaden Expressway – San Jose CA 95118 – USA

<sup>2</sup> PRBO Conservation Science – Petaluma CA – USA

<sup>3</sup> School of Biological Sciences – University of Auckland – Auckland – NZ

<sup>4</sup> Landcare Research – 17 Private Bag 6 – Nelson Mail Centre – Nelson 7042 – NZ

<sup>5</sup> Oregon State University – Department of Fisheries and Wildlife  
104 Nash Hall – Corvallis OR 97331-3803 – USA

<sup>6</sup> Landcare Research – PO Box 40 – Lincoln 7640– Christchurch – NZ

<sup>7</sup> Ocean Biogeochemistry Lab – Dept. of Geophysics – 397 Panama Mall  
Stanford CA 94305-2215 – USA

<sup>8</sup> Landcare Research NZ (retired) – 17 Modena Crescent  
Glendowie – Auckland – NZ

In many species, a few individuals contribute most of the recruits to the next generation. It is unknown whether these inter-individual differences in reproductive success are the result of random processes or different abilities among individuals. We tested the hypothesis that differences in foraging tactics are responsible for the observed skews in reproductive performance in Adélie penguins. Working with marked individuals, we first calculated an index of breeding quality based on previous breeding success data. Then, using animal-attached data loggers and a computerized weighbridge, we tested the influence of individual quality on foraging effort, diving behaviour and foraging success at 3 colonies of the Ross Sea. Our inferential results indicate that inter-individual differences in foraging strategies may drive differences in reproductive success. More successful birds tend to perform shorter trips and deeper dives leading to higher feeding frequency and heavier food load, which, given the short breeding season in Antarctica, are likely to have a direct impact on offspring production. Causal relationships between those behavioural and reproductive traits, as well as the proximate mechanisms involved, still need to be clarified by further studies and experiments.

## FORAGING AFRICAN PENGUINS REACTING TO SULPHIDE ERUPTIONS AND THE USE OF PENGUIN DERIVED DATA FOR MONITORING ENVIRONMENTAL CHANGES

LUDYNIA, K.<sup>1</sup>, ROUX, J.-P.<sup>2</sup>, PEARD, K.<sup>2</sup> & S. GARTHE<sup>1</sup>

<sup>1</sup> Research and Technology Center Westcoast, University of Kiel  
Hafentoern 1, 25761 Buesum, Germany

<sup>2</sup> Ministry of Fisheries and Marine Resources, Lüderitz Marine Research  
PO Box 394, Lüderitz, Namibia  
[ludynia@ftz-west.uni-kiel.de](mailto:ludynia@ftz-west.uni-kiel.de)

African penguins (*Spheniscus demersus*) at Mercury Island, the largest breeding colony in Namibia, forage in the highly variable northern Benguela system. Within their foraging range of about 20 km, they have to face severe conditions including sulphide eruptions and Benguela Niño anomalies, both believed to further increase with continuing climate change. Although oceanographic conditions were completely different, penguins used the same foraging area in two consecutive years (2005 and 2006). Differences were noted in the diving behaviour and the prey composition between both years. During sulphide eruptions in 2005, birds had to dive deeper, feeding almost exclusively on Pelagic goby in hypoxic waters. In 2006, water temperatures were much higher and birds were feeding on more pelagic prey species. Temperature data derived from GPS temperature depth loggers attached to foraging penguins were used to model the temperature distribution within the foraging range at a very fine scale. Short term changes and inter-annual differences became apparent. Further logger deployments along the southern Namibian coast would facilitate an environmental monitoring focusing on small scale changes affecting the endangered population of African penguins in Namibian waters.

**A PARADOX IN BROOD REDUCTION IN CRESTED PENGUINS (GENUS *EUDYPTES*):  
IS BULLYING RESPONSIBLE FOR THE MORTALITY OF SMALL, FIRST-LAID EGGS?**

MELANIE MASSARO<sup>1</sup>, R. SCOTT DAVIDSON<sup>2</sup> & LLOYD S. DAVIS<sup>1</sup>

<sup>1</sup> Department of Zoology, University of Otago, P.O. Box 56, Dunedin, New Zealand

<sup>2</sup> Department of Biology, Duke University, Box 90338,  
Durham, North Carolina 27708-0338 USA

Present address of corresponding author:

M. Massaro, School of Biological Sciences, University of Canterbury,  
Private Bag 4800, Christchurch, New Zealand

[melanie.massaro@canterbury.ac.nz](mailto:melanie.massaro@canterbury.ac.nz)

Crested penguins (*Eudyptes* spp) have evolved a unique form of breeding in which the first of two eggs laid is much smaller than the second and has a higher likelihood of being lost during egg laying and incubation. The causes for this high egg mortality remain unclear. Aggression between territorial males early in the breeding season has been previously found to cause little or no egg mortality. However, aggressive attacks on incubating females during later stages of breeding have never been quantified, nor tested for their influence on egg mortality. We investigated this bullying behaviour in Snares penguins (*Eudyptes robustus*) and conducted an egg survival analyses to examine which factors influence egg mortality. During 120 hours of observation of 50 nests, we recorded a total of 300 bullying events in which females were repeatedly pecked, bitten and beaten with flippers. Generally, females did not fight back during these events, but assumed instead a defensive position to protect their clutch. Bullying events lasted from less than a minute to up to 55 minutes. In 38% of all events, neighbouring breeding males were identified as bullies, while single females bullied in 11.3% of all events and non-breeding pairs bullied in 12.7%. Significantly, a greater percentage of the small first eggs (34%) were lost than the large second eggs (4%). We found that (i) the presence of parents at the nest, (ii) the average duration of bullying events on the nest, and (iii) whether the other egg within a nest had hatched influenced egg mortality. Egg survival was highest when only females remained at the colony. Long, sustained bullying events directed towards an incubating female increased the risk of her eggs being lost. Additionally, when one of the two eggs within a nest had hatched, the other egg had a vastly increased mortality risk. We suggest that the prolonged nest attendance by breeding males well beyond egg laying, which is typical for crested penguins but not for other penguins, has evolved as an adaptation for preventing egg loss through bullying in crested penguins.

## **WARM-WATER DIVERS – SPATIAL DISTRIBUTION OF DIVE ACTIVITY IN CHICK-REARING SNARES PENGUINS *EUDYPTES ROBUSTUS***

THOMAS MATTERN<sup>1</sup>, KATTA LUDYNIA<sup>2</sup>, DAVE HOUSTON<sup>3</sup> & LLOYD S. DAVIS<sup>1</sup>

<sup>1</sup> Department of Zoology, University of Otago, P.O. Box 56, Dunedin, New Zealand

<sup>2</sup> Research & Technology Centre (FTZ), University of Kiel, Germany

<sup>3</sup> Department of Conservation, Wellington, New Zealand

The distribution of prey for penguins is often a result of physical oceanographic processes. This is particularly so for penguin species breeding in isolated oceanic areas like sub-Antarctic islands. Snares penguins are primarily planktivorous foragers that find their food in a pelagic environment where prey distribution is a product of currents and frontal systems. During the incubating phase of breeding, Snares penguins have been found to forage at the Subtropical Front which is located some 200 km east of the Snares. However, after the chicks have hatched the penguins' foraging ranges are restricted by nesting duties so that the penguins must find food closer to the island. A possible destination could be to the north of the Snares where a warm current transports nutrient-rich and productive water east towards the Subtropical Front. We examined the foraging and diving behaviour of female Snares penguins during the chick-guard stage using GPS dive loggers and combined geographical and dive data for spatial analysis. The results show a strong correlation of dive behaviour and sea surface temperature and underline the importance of warm water of sub-tropical origin for chick rearing Snares penguins.

**ANNUAL, SEXUAL, SIZE- AND CONDITION-RELATED VARIATION IN THE COLOR AND  
FLUORESCENT PIGMENT CONTENT OF YELLOW CREST FEATHERS IN SNARES PENGUINS  
(*EUDYPTES ROBUSTUS*)**

KEVIN J. MCGRAW<sup>1</sup>, MELANIE MASSARO<sup>2,3</sup>, AND TREVOR RIVERS<sup>1</sup>

<sup>1</sup> School of Life Sciences, Arizona State University, Tempe, AZ 85287-4501, USA

<sup>2</sup> Department of Zoology, University of Otago, PO Box 56, Dunedin, New Zealand

<sup>3</sup> Present address: School of Biological Sciences, University of Canterbury, Private Bag 4800, Christchurch,  
New Zealand

Biologists have shown much recent interest in the control and function of brightly coloured plumage ornaments in birds. The majority of attention has been paid to the signalling costs and benefits of the common pigmentary (e.g. carotenoid- and melanin-based) plumage colours. However, in penguins, the color of yellow crest feathers or head plumage patches is based on an unusual fluorescent pigment, presently thought to be in the class of pterin pigments, which are typically found as colorants in other animals like butterflies and amphibians. These yellow-orange colours may be used in sexual or social communication, but to date little is known about the signalling potential of such ornaments in penguins—i.e. how variable they are across individuals, between the sexes, among years, and in relation to an individual's body size or condition. We collected yellow crest feathers from adult male and female Snares penguins (*Eudyptes robustus*) in two years (2002 and 2003) and examined how feathers differed in color and pigment content as a function of year, sex, body size, and body condition. Unlike the pattern traditionally seen in birds, female Snares penguins displayed more pigment-rich crests than did males. In both years, more yellow feathers in females contained more yellow pigment. Birds of both sexes grew more yellow and pigment-rich feathers in 2002—a year in which birds were in better condition than in 2003. Yellower males also tended to be larger, heavier, and in better body condition, regardless of year. These results highlight the potential for yellow crests in Snares penguins to serve as a condition-dependent indicator to conspecifics; follow-up tests are now needed to determine whether or not this plumage trait is a signal of social status or attractiveness, as yellow-orange plumage patches appear to be in other penguin species.



## **THE EFFECT OF BROOD COMPOSITION ON FLEDGING SUCCESS IN LITTLE PENGUINS (*EUDYPTULA MINOR*)**

JULIE MCINNES<sup>1</sup>, TANIA BILLING<sup>2</sup>, PETER DANN<sup>1</sup>, RAOUL MULDER<sup>2</sup>

<sup>1</sup> Research Department, Phillip Island Nature Park, PO Box 97 Cowes, VIC 3922

<sup>2</sup> Department of Zoology, University of Melbourne, Parkville 3052

Resource allocation, sibling competition and rearing costs are important factors determining parental investment in offspring. In broods of sexually size-dimorphic species, fledging success may be affected by chick sex, brood composition and parental quality. The larger sex may profit from a competitive size advantage, but the high physiological demands of larger size may lead to increased mortality when resources are limited. Furthermore, the composition of a brood may affect the growth and survival of male and female chicks differently. Parental attributes may also contribute to variation in brood success through differences in resource acquisition and in allocation in response to begging behaviour within the brood. We studied the effect of chick sex and brood composition on fledging success in the little penguin (*Eudyptula minor*) over three breeding seasons at Phillip Island, Victoria. Adult females are 10% smaller than males, and produce clutches of two eggs. We found that brood composition, rather than chick sex alone influenced fledging success. Our results are discussed in relation to the survival of single and mixed sex broods.

## **CHINSTRAP PENGUINS ALTER FORAGING AND DIVING BEHAVIOUR IN RESPONSE TO KRILL SIZE**

AILEEN K. MILLER\* AND WAYNE Z. TRIVELPIECE

Antarctic Ecosystem Research Division, Southwest Fisheries Science Center,  
8604 La Jolla Shores Drive, La Jolla, CA 92037, USA

\* [aileen.miller@noaa.gov](mailto:aileen.miller@noaa.gov)

Penguins may exhibit plasticity in their diving and foraging behaviours in response to changes in prey availability. Chinstrap penguins are dependent predators of Antarctic krill in the Scotia Sea region. Both the sizes of krill found in penguin diets and acoustic estimates of krill biomass have fluctuated in recent years; we therefore examined the diet of chinstrap penguins in the South Shetland Islands in relation to their diving and foraging behaviour using time-depth recorders (TDRs) over 5 seasons: 2002-06. The average size of krill was negatively correlated to the number of penguins foraging on fish, night-time dive depths, and the proportion of foraging trips occurring overnight. In the year when krill were smallest, 2003, night-time dive depths were actually deeper than daytime dives. Based on these patterns, we suggest that when krill were small, penguins foraged more on myctophid fish. Further, the average krill size was negatively correlated to the amount of time chinstrap penguins spent foraging which suggests that penguins made this switch to fish with a cost: more time was spent at sea foraging.

# **“SOMETHING SPECIAL ABOUT SPATIAL”: OPTIMAL SAMPLING METHODS FOR LITTLE PENGUINS *EUDYPTULA MINOR*, USING SPATIO-TEMPERAL ANALYSIS**

JULIE RHONDA MORRIS

<sup>1</sup>Department of Ecology and Environment, Deakin University, Victoria, Australia

<sup>2</sup>Phillip Island Nature Parks, Research Department, Phillip Island, Victoria, Australia

[julie\\_morris34@hotmail.com](mailto:julie_morris34@hotmail.com)

To know the size a population is essential for the management, description and ecological analysis of a species. Nevertheless, in many cases it is difficult to establish exactly the limits of the distribution and the number of individuals within a certain population. Although several methods of sampling have been used to establish the size of colonies of little penguins, *Eudyptula minor* it has still not been established which method offers the best estimation of the abundance. In this investigation the effectiveness of frequently used census techniques were examined, through geostatistical tools and simulations. At the study site Cullen Cove in the Summerland Peninsular of Phillip Island, active burrow sites were mapped and vegetation cover of each burrow was identified. From December 2006 - January 2007 a Global Positioning System (GPS) was used to plot the active burrow points within the study site Cullen Cove. A total sample of 368 active burrows were identified in an area of approximately 23,046m<sup>2</sup>. The longitude and latitude GPS points were entered as a layer into ArcView 3.3 as well as an aerial photograph of the area. Simulations were arranged as layers in the GIS program ArcView 3.3 of point samples, quadrats and transects with different characteristics to find the optimal sampling type. Although the results showed that as the proportion was increased of sampled area the estimations improved independently of the used method, the desirable levels of precision influence considerably in the election of the sampling method. The limitation of resources and the impact caused by the permanence of the investigators in the colonies frequently condition the level of effort of optimal sampling. Pattern analysis showed that there is clumping within a population with these spatial statistics which could mean a variety of biological colonial factors are involved in the spatial array. Occupancy data was collected for two sites to estimate the best time to sample a population of little penguins. The percentage of breeding individuals was calculated from 2001/02 to 2005/06 breeding seasons and compared to the mean laying date. It was deciphered that a common calendar date would not be useful in determining when most of the breeding penguins were onshore. Instead a relationship between the mean laying date was found. Temporally it is optimal to sample two weeks either side of the mean laying date. Future studies developing the spatial pattern of burrowing seabird populations are necessary to better assess the density and abundance of little penguins on Phillip Island and the relationship between the maximum occupancy and the mean laying date.

**ORNAMENTAL COLOURS AS QUALITY INDICATORS IN KING PENGUINS,  
*APTENODYTES PATAGONICUS***

PAUL M. NOLAN<sup>1</sup>, MARION NICOLAUS<sup>2</sup>, F. STEPHEN DOBSON<sup>3</sup> & PIERRE JOUVENTIN<sup>4</sup>

<sup>1</sup>Dept. of Biology, The Citadel, Charleston, SC, USA

<sup>2</sup>Animal Ecology Group, University of Groningen, The Netherlands

<sup>3</sup>Dept. of Biological Sciences, Auburn University, AL, USA

<sup>4</sup>Centre d'Ecologie Fonctionnelle et Evolutive (C.E.F.E.), CNRS, Montpellier, France

We examined the relationship between ornamental color and individual quality in the king penguin by examining plumage and beak colours relative to sex, health, time of breeding, and body condition (mass corrected for body size). Individuals of this species are characterized by bright yellow-orange patches on their breasts and auricular body regions, and by orange, ultraviolet-violet (UV-V; 320-450 nm) reflecting beak spots. Breast and auricular plumage colours were significantly more saturated on early breeders and healthy individuals, respectively, while colours of sick birds were significantly brighter than those of healthy birds on both plumage patches. Health status also related significantly to hue and saturation in the yellow-orange wavelengths (450-700 nm) on the beak although not in the UV-V, where time of breeding related significantly to UV-V saturation. Brightness of all ornamental colours differed significantly between the sexes in healthy breeders, with females exhibiting the brightest feathers and males exhibiting the brightest beaks. We also found significant interactions between sex and health, with sick females displaying particularly bright reflectance from the beak in both the UV-V and longer wavelengths. These results suggest that beak and plumage colours in the king penguin are honest signals of condition, potentially functioning in pairing.

## CONSERVATION GENETICS OF THE LITTLE PENGUIN, *EUDYPTULA MINOR*

AMANDA J. PEUCKER<sup>1</sup>, PETER DANN<sup>2</sup>, CHRIS P. BURRIDGE<sup>3</sup>

<sup>1</sup> School of Life and Environmental Sciences, Deakin University  
P.O. Box 423, Warrnambool, Victoria, Australia.

<sup>2</sup> Phillip Island Nature Park, P.O. Box 97, Cowes, Victoria, Australia.

<sup>3</sup> Department of Zoology, University of Otago, P.O. Box 56,  
Dunedin 9054, New Zealand.

Little is known about the migration rates and habits of the little penguin (*Eudyptula minor*). Banding studies have provided some valuable information, including showing that fledglings can travel up to 1,000 km from their natal colony in the first year and that a few individuals have been found breeding outside their natal colony along this route. However, banding studies are labour intensive and now with the use of microchips the general public cannot be involved in returning information on marked birds. Genetic markers are a relatively easy way of investigating relatedness of colonies and hence rates of migration. Using 13 micro satellite loci (bi-parentally inherited) and mitochondrial PCR-RFLP (maternally inherited) techniques, we have studied colonies across the Australian range of the little penguin. We have found extremely interesting results whereby some regions have experienced higher migration rates indicated by genetic similarity between colonies, but others appear to be genetically distinct indicating very infrequent migration. Timing of breeding—influenced perhaps by sea surface temperatures and food availability—could be the isolating factor between such populations. These results have direct conservation implications for the species as it is increasingly exposed to localised human-induced disturbances.

**BREEDING BIOLOGY OF THE ROCKHOPPER PENGUIN *EUDYPTES C. CHRYSOCOME* AT  
NEW ISLAND, FALKLAND ISLANDS: NEW CONSIDERATION ON THE  
INTRINSIC CAPACITY OF THE A-EGG**

MAUD POISBLEAU<sup>1</sup>, LAURENT DEMONGIN<sup>1</sup>, IAN J. STRANGE<sup>2</sup> & PETRA QUILLFELDT<sup>1</sup>

<sup>1</sup> Max Planck Institute for Ornithology, Vogelwarte Radolfzell  
Schlossallee 2, 78315 Radolfzell, Germany

<sup>2</sup> New Island South Conservation Trust, New Island South  
Falkland Islands

In crested penguins (*Eudyptes* spp.), females lay two eggs, of which the second one (B-egg) is much bigger than the first (A-egg). But, usually only the chick hatching from the B-egg will fledge successfully. Therefore, many studies suggested that the insurance value of this A-eggs and even its intrinsic capacity to produce a fledging chick were very low. Nevertheless, despite the initial size and mass differences, A-eggs (and chicks) of macaroni penguins *Eudyptes chrysolophus* had the same survival and fledging sizes than B-ones when they were without sibling. The Rockhopper penguin *Eudyptes chrysocome* is the species with the longest survival of A-chicks, and for which a small percentage of pairs rear both of their chicks to the fledging stage. It is therefore possible to compare survival and growth between A- and B-eggs (chicks) in one-chick broods or in two-chicks broods. We followed experimentally manipulated A-, B- and AB-nests during the laying, incubation and growth periods at New Island, Falkland Islands. Both the incubation duration and the hatching success were not different between A- and B-eggs when they were initially alone in the nest whereas A-eggs had a longer incubation duration and a much lower hatching success than B-eggs when with a sibling. Similarly, A- and B-chicks had the same survival, size and mass growth and fledging sizes, mass and age when they were alone whereas their survival rate was too low in two-chicks broods to allow any other significant comparison during the rearing period. These results showed that A-eggs had theoretically the same potential to provide a fledging chick of good quality than B-eggs. The lower viability of A-egg may be explained by a preferential parental care for the larger egg and chick.

**MAGELLANIC PENGUINS (*SPHENISCUS MAGELLANICUS*)  
POPULATION DYNAMICS IN PATAGONIA, ARGENTINA**

LUCIANA M. POZZI<sup>1</sup>, PABLO GARCÍA BORBOROGLU<sup>1,2</sup>, P. DEE BOERSMA<sup>1,3</sup> &  
MIGUEL PASCUAL<sup>2,4</sup>

<sup>1</sup>Magellanic Penguin Project, Wildlife Conservation Society

<sup>2</sup>Centro Nacional Patagónico (CONICET)

<sup>3</sup>Department of Biology, University of Washington, Seattle, Washington 98195 USA

<sup>4</sup>Universidad Nacional de la Patagonia San Juan Bosco,  
Boulevard Brown S/N, (9120) Puerto Madryn, Chubut, Argentina

There are 63 breeding colonies of Magellanic penguin (*Spheniscus magellanicus*) along the Patagonian coast of Argentina with a minimum population size of 950 000 breeding pairs. Historical information suggests that penguin colonization proceeded in a northward direction during the last century. Current population trends are mixed. In Chubut province, some colonies are declining, including the largest Magellanic penguin colony in the world at Punta Tombo, and the northern most colonies at Península Valdés, are increasing. Spatially structured populations can be divided into population units. The balance between internal and external processes produce changes in populations and differentiates the population types described: sources, sinks, and pseudosinks. Punta Tombo was first colonized in the early 1920s and initially would have been a sink, attracting individuals from southern colonies. It probably turned into a pseudo-sink, becoming the largest Magellanic penguin colony in the world. This colony may have been a source for the colonies in the Península Valdés where breeding penguins were first seen in 1969. Population models, however, indicate that the numbers of breeding pairs found at Península Valdés colonies should be much lower than they are. We suggest that the northern colonies are still dependant on the southern colonies for their rapid growth.

**DO LITTLE PENGUINS SELECTIVELY FORAGE IN SHIPPING CHANNELS?  
A THREE-DIMENSIONAL INVESTIGATION OF THE FORAGING BEHAVIOUR OF LITTLE PENGUINS  
(*EUDYPTULA MINOR*) BREEDING IN THE VICINITY OF A BUSY PORT**

PRESTON, T.<sup>1,4</sup>, ROPERT-COUDERT, Y.<sup>2</sup>, KATO, A.<sup>2</sup>, CHIARADIA, A.<sup>3</sup>, DANN, P.<sup>3</sup>, REINA, R.<sup>1</sup>

1. School of Biological Sciences, Monash University, Clayton, Victoria 3800, Australia.

2. National Institute of Polar Research, 1-9-10 Kaga, Itabashi-ku, Tokyo 173-8515, Japan

3. Phillip Island Nature Park, P.O. Box 97, Cowes, Victoria 3922, Australia.

4 Corresponding author ([tiana.preston@sci.monash.edu.au](mailto:tiana.preston@sci.monash.edu.au)).

We investigated the three-dimensional foraging behaviour of little penguins (*Eudyptula minor*) breeding in an area adjacent to a busy port. Breeding little penguins from an urban colony in Port Phillip Bay, southern Australia were fitted with either satellite trackers or time-depth recorders during the 2006-07 breeding season. Foraging areas and diving behaviour were correlated with bathymetry. Penguins spent over 34% of time in areas including and immediately adjacent to shipping channels, although these areas comprised only 17% of the foraging zone. Examination of diving profiles suggested that feeding was predominately demersal. Penguins followed the topography of the sea floor, including troughs created by shipping channels. Use of the shipping channels implies the presence of the little penguins' major prey item, the southern anchovy (*Engraulis australis*) in these areas. Shipping channels appear to play an important role in the foraging of the little penguins from this urban colony, and we discuss the potential impacts posed by a proposal to deepen these channels through large-scale dredging.



## **THE HEAT IS ON: CLIMATE CHANGE ACCELERATING THE DEMISE OF AFRICAN PENGUINS IN NAMIBIA**

ROUX J-P.<sup>1</sup>, KEMPER J.<sup>2</sup>, PEARD K.R.<sup>1</sup> & UNDERHILL, L.G.<sup>2</sup>

<sup>1</sup> Ministry of Fisheries and Marine Resources, Lüderitz Marine Research,  
PO Box 394, Lüderitz, Namibia

<sup>2</sup> Avian Demography Unit, University of Cape Town, Rondebosch 7701,  
Cape Town, South Africa

The Benguela region is at a critical location in terms of global climate systems, and its marine environment is extremely vulnerable to climate change and/or increasing variability in climate. In the Northern Benguela, off Namibia, global climate change is expected to alter the frequency and amplitude of Benguela Niño anomalies in addition to inducing gradual increases in sea level, air and sea temperatures and influencing rainfall patterns. The African penguin *Spheniscus demersus* is presently classified globally vulnerable, and is considered endangered in the northern part of its range. The Namibian population has declined by more than 75% since the mid-20th century and has been decreasing at 2.5% per year between 1990 and 2005. Recent results relating environmental correlates with penguin demographic parameters, including breeding success, survival and recruitment, highlight the extreme sensitivity of this population to expected effects of climate change. Extrapolations of present population trends are deemed optimistic and the probability of African penguin extinction from the Northern Benguela during the 21st century is rated as high.

## THE EFFECT OF COLONY ATTENDANCE DURING THE NON-BREEDING SEASON ON THE BREEDING BIOLOGY OF THE LITTLE PENGUIN

MARCUS SALTON<sup>1</sup>, ANDRE CHIARADIA<sup>2</sup>, & RICHARD REINA<sup>1</sup>

<sup>1</sup> Monash University, Clayton, Victoria, Australia, Marcus.Salton@sci.monash.edu.au

<sup>2</sup> Research Department, Phillip Island Nature Park, Victoria, Australia.

Unlike some seabirds that only attend their colony during the breeding season, Little penguins *Eudyptula minor* attend their colony year round at Phillip Island, Australia. This study examined the attendance patterns of Little penguins in the non-breeding seasons of 2002, 2003, 2004, and 2006. Penguins were marked with transponders and monitored continuously by an automated penguin monitoring system placed on the entrance of the colony. We compared number of visits, time spent ashore, and pair synchronisation with breeding success, laying date, nest fidelity and mate fidelity. We found attending the colony during the non-breeding season can improve a birds reproductive success. However, no relationship was found between colony attendance and a birds laying date, nor with nest fidelity or mate fidelity. Therefore, these findings suggest that the reproductive benefit achieved through attending the colony during the non-breeding season is not linked with the retention of a nest or mate; as was previously hypothesised.

## SEXUAL DIFFERENCES IN THE DIET OF LITTLE PENGUINS *EUDYPTULA MINOR* AT PHILLIP ISLAND OVER 20 YEARS

T.R. SHAW<sup>1</sup>, A. CHIARADIA<sup>2</sup>, P. DANN<sup>2</sup> & M.N. BESTER<sup>1</sup>

<sup>1</sup>Department of Zoology and Entomology, University of Pretoria  
Pretoria, 0002, South Africa

<sup>2</sup>Research Department, Phillip Island Nature Park  
PO Box 97, Cowes, Victoria, 3922, Australia  
[trshaw@zoology.up.ac.za](mailto:trshaw@zoology.up.ac.za)

Little penguins *Eudyptula minor* exhibit sexual dimorphism in bill size and sexes differ significantly in swimming speeds, dive depths and dive durations. Sexual differences in the diet of little penguins at Phillip Island, Victoria, Australia, were examined over 12 breeding seasons, between 1985 and 2006. The weighted relative occurrence of each prey species was calculated and compared between breeding stages and over time. Adult fish comprised the majority of the diet, followed by cephalopods, crustaceans, and postlarval fish. Sexual differences were evident in prey composition monthly and annually, and between breeding stages, with males consuming more fish and females taking more crustaceans, especially during pre-breeding and incubation. Fish consumption was highest during the guard and post-guard stages, which could be related to prey availability and nutritive value, ultimately influencing fledging success. Although prey species richness was similar, male penguins fed on larger prey items than females, with variation at monthly and annual scales. Both sexes seem to have comparable foraging strategies; however, differing prey availability and diving depths may result in slight dietary divergences between the sexes, influenced by differences in energy requirements at certain times of the breeding cycle.

## **SURVIVING THE WINTER: PELAGIC BEHAVIOUR OF MAGELLANIC PENGUINS**

ELIZABETH SKEWGAR\*, DANIEL GRUNBAUM, P. DEE BOERSMA (University of Washington, USA),  
ALEJANDRO SIMEONE (Universidad Andrés Bello, Chile)  
[\\*skewes@u.washington.edu](mailto:skewes@u.washington.edu)

Magellanic penguin adult survival is generally high, and adult mortality is thought to be mainly from starvation during the winter. To better understand winter survival and habitat use, we created an energetic model of winter behaviour, using satellite telemetry of birds in both Argentina and Chile during the austral fall and winter. To interpret behaviour from this location data, we first extracted statistical descriptions of different behaviours from telemetry of other birds during highly-constrained breeding season foraging trips. Based on distance from colony, trips to sea were divided into outbound, inbound, and foraging activities. Differences observed in travel speed and turning angle between satellite observations were hypothesized to result from different ratios of transit, resting, and foraging behaviour during different activities. Inbound tracks showed the straightest path and highest travel speeds (transit). Outbound tracks had somewhat more turning and slower travel speeds (transit, resting). Foraging showed the least consistent directionality and lowest travel speeds (foraging, resting). We then used these statistical descriptions to assign behaviours within the winter tracks, and assessed the energetic consequences and foraging habitat. The model combines these data to explore how birds respond to environmental variation when unconstrained by breeding activities.

## FORAGING BEHAVIOUR OF THE GALAPAGOS PENGUIN, *SPHENISCUS MENDICULUS*: IMPLICATIONS FOR CONSERVATION

ANTJE STEINFURTH<sup>\*1,2</sup>, HERNAN VARGAS<sup>2,3</sup>, RORY WILSON<sup>4</sup> & DAVID MACDONALD<sup>3</sup>

<sup>1</sup>Research- and Technology Centre, University Kiel, Hafentörn 1, 25761 Büsum,  
Germany, [steinfurth@ftz-west.uni-kiel.de](mailto:steinfurth@ftz-west.uni-kiel.de)

<sup>2</sup>Charles Darwin Research Station, Puerto Ayora, Santa Cruz, Galápagos, Ecuador

<sup>3</sup>Wildlife Conservation Research Unit, University of Oxford, Tubney House, Abingdon Road,  
Tubney, Oxon OX13 5QL, UK

<sup>4</sup>Rory Wilson, Biological Sciences, University of Wales Swansea, Singleton Park  
Swansea SA2 8PP, Wales, UK

The endangered Galápagos penguin (*Spheniscus mendiculus*), is endemic to the Galápagos archipelago with a population of around 2000 individuals. In 2004 and 2005, we studied the movements and diving behaviour of foraging Galápagos penguins during their breeding season to examine space-use at sea. Twenty-three penguins from the main nesting sites were fitted with GPS-depth units and an additional 13 penguins were equipped with depth-temperature recorders. Birds moved between 1.0 and 23.6km (mean =  $5.2 \pm 4.8$ km) from the nest, tending to remain close to the coast and concentrated foraging in a strip of sea within 1.1km of the shore. Foraging trips lasted a mean of  $8.4 \pm 2.0$  hours. Although the deepest dive was 52.1m, birds spent, on average, 90% of their time underwater at depths less than 6m. Applying the maximum values for movement to calculate space use, the Galápagos penguin exploits a maximum volume of water of  $< 1.4\text{km}^3$  (almost 90 times less than that predicted for its mass) and thus utilises only a fraction of the total potentially-available upwelling area within the Galápagos archipelago. These results are put into context with current conservation and management issues in the Galápagos Marine Reserve.

## EXTREME BLOOD OXYGEN DEPLETION IN FREE-DIVING EMPEROR PENGUINS

T.K. STOCKARD, J.U. MEIR, C.L. WILLIAMS, & P.J. PONGANIS

Center for Marine Biotechnology and Biomedicine, Scripps Institution of Oceanography,  
University of California San Diego, La Jolla, CA 92093-0204 USA

The astonishing diving capabilities of emperor penguins (*Aptenodytes forsteri*) are largely attributable to enhanced oxygen stores, control of depletion of those stores, and extreme hypoxemic tolerance. We investigated the latter with novel technology for monitoring intravascular oxygen tension ( $P_{O_2}$ ). Penguins were instrumented with indwelling venous or arterial electrodes that continuously logged  $P_{O_2}$  to a backpack recorder as the birds dove freely at a field camp isolated dive hole. Intravascular  $P_{O_2}$  (from dives lasting 1-23 min.) declined at varying rates, and revealed that blood  $O_2$  stores are not depleted at the aerobic dive limit (ADL). End-of-dive values in 31% of dives were  $< 20$  mm Hg, and in some cases dropped to as low as 2-6 mm Hg. This exceptional hypoxemic tolerance is far greater than in other birds, and is matched only by that found in forcibly submerged seals. It is an essential adaptation enabling these birds to strip nearly all the  $O_2$  from both the respiratory and blood stores. Such tolerance implies that emperor blood must have a higher oxygen affinity (= lower  $P_{50}$ ) than most birds, and suggests that the emperor penguin may also have other compensatory physiological adaptations to hypoxemia.

## **FORAGING STRATEGIES OF KRILL-FEEDING CHINSTRAP PENGUINS DETERMINED USING BEAK-ANGLE LOGGERS**

AKINORI TAKAHASHI (1,2)\*, NOBUO KOKUBUN (2), YOSHIHISA MORI (3),  
AKIKO KATO (1,2), HYOUNG-CHUL SHIN (4)

(1) National Institute of Polar Research, Itabashi, Tokyo 173-8515, Japan *atak@nipr.ac.jp*

(2) Department of Polar Science, The Graduate University for Advanced Studies  
Itabashi, Tokyo 173-8515, Japan

(3) Teikyo University of Science and Technology, Uenohara, Yamanashi 409-0193, Japan

(4) Korea Polar Research Institute, KORDI, Songdo Techno Park, Songdo-Dong 7-50  
Yeonsu-Gu, Incheon 406-840, Korea

Precise measurement of feeding activities will advance our understanding of foraging strategies of marine birds. Recently developed beak-angle loggers (or IMASEN, intra-mandibular angle sensor; Wilson 2003, Simeone & Wilson 2003) have provided a unique opportunity to examine the foraging behaviour of free-ranging penguins by monitoring their beak-opening activities. We applied this technology on chinstrap penguins breeding near King Sejong Station, King George Island, Antarctica, in the 2006/07 austral summer. We successfully recorded beak-opening activities of 8 birds during foraging trips together with diving depth and body movement (acceleration). Using beak-angle and depth records, feeding (when penguins were underwater) and breathing (when penguins were at the surface) activities were described in relation to their diving behaviour. Preliminary results showed that deeper dives contributed disproportionately to the total amount of feeding, and that the number of breathing at the surface was related to the depth and duration of the dives. These records will allow us to explore foraging strategies of krill-feeding chinstrap penguins at the fine (< 1 s) temporal scale.

## EVALUATING AND USING STABLE-ISOTOPE ANALYSIS TO INFER DIET COMPOSITION AND FORAGING ECOLOGY OF ADÉLIE PENGUINS (*Pygoscelis adeliae*)

MEGAN TIERNEY <sup>1,2</sup>, COLIN SOUTHWELL <sup>2</sup>, LOUISE EMMERSON <sup>2</sup>, & MARK HINDELL <sup>1</sup>

1. Antarctic Wildlife Research Unit, School of Zoology/Antarctic Climate and Ecosystems Cooperative Research Centre, University of Tasmania. Tasmania, 7001

2. Department of the Environment and Heritage, Australian Antarctic Division, Channel Highway, Kingston. Tasmania, 7050

We investigated whether diet composition determined from stable-isotope analysis (SIA) was similar to that determined from conventional stomach content analysis for Adélie penguins (*Pygoscelis adeliae*). We used SIA to compare diet composition of adults and chicks, and to evaluate intra- and inter-annual variations in diet and foraging ecology of adults. Diet determined from SIA closely mirrored that determined from stomach contents at the broad taxonomic level (i.e. fish vs. krill). Diet composition did not differ between adults and chicks, but the more depleted  $\delta^{13}\text{C}$  values of adult blood suggests adults may forage for themselves and provide their chicks with food from different locations. Adult  $\delta^{13}\text{C}$  signatures varied intra-annually with the most depleted values measured during the arrival period followed by incubation, guard and then crèche.  $\delta^{15}\text{N}$  analyses indicated that krill and fish were being consumed prior to arrival at the breeding colonies and during incubation foraging trips, while the primary prey consumed during chick-rearing differed between years. This study demonstrates the usefulness of SIA for monitoring diet and foraging areas of Adélie penguins at broad resolutions, particularly during periods when it is not possible to use conventional dietary techniques.



## FORAGING IN THREE DIMENSIONS: WHAT SPATIAL DATA AND DIVING BEHAVIOUR CAN TELL US ABOUT ADÉLIE PENGUIN FORAGING IN THE ROSS SEA

TONIOLO V.<sup>1,3</sup>, D.G. AINLEY<sup>2</sup>, G. BALLARD<sup>3,4</sup>, & A. LESCROËL<sup>2</sup>

<sup>1</sup> Ocean Biogeochemistry Lab, Dept. of Geophysics, 397 Panama Mall,  
Stanford CA 94305-2215, USA

<sup>2</sup> H.T. Harvey & Associates, 3150 Almaden Expressway, San Jose CA 95118, USA

<sup>3</sup> PRBO Conservation Science, Petaluma CA, USA

<sup>4</sup> School of Biological Sciences, University of Auckland, Auckland, NZ

Prey distribution in the ocean is non-continuous and, therefore, predators must first locate prey patches before then maximizing their feeding in these areas, especially during the breeding season when parental demands add to the need for foraging efficiency. Foraging areas of penguins can be determined using satellite transmitters to examine individual tracks and assuming that spatial and temporal clusters of positions (“foraging clusters”) represent areas of prolonged feeding. In 2005 a new tag combined an Argos tracking device with an archival time-depth recorder (TDR) so that spatial and diving data could be collected simultaneously, thus to match penguin positions with specific foraging and diving behaviours. At Cape Crozier, Antarctica, we deployed Argos and Argos/TDR tags on 10-30 randomly chosen breeding Adélie penguins (*Pygoscelis adeliae*) during each austral summer 2000-2001 to 2006-2007. The tags were deployed for a single foraging trip per bird starting on median hatch day and ending ~5-10 days past mean crèche day. We compared the foraging tracks of Argos-only and Argos/TDR tags to see if the foraging clusters calculated from the Argos data matched locations of foraging dives recorded by the TDRs. Preliminary results from the Splash tags show that foraging clusters were always associated with foraging dive behaviour, but that foraging dives were also made in areas not identified as foraging clusters. We conclude that Argos data are useful for measuring foraging locations, but when using Argos-only tags some foraging locations are lost.

## **NOVEL GPS SHOWS PENGUINS STAY ON THE STRAIGHT AND NARROW**

TRATHAN PN, BISHOP CM, MACLEAN G, BROWN P, FLEMING A, COLLINS MA  
British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, UK

Marine predators are thought to follow complex scale-dependent search strategies when seeking patchy and unpredictable prey. However, fine-scale information about these strategies has hitherto been difficult to obtain for most diving predators that often remain at the sea surface for only limited periods of time. Using novel, low-powered, archival GPS, we followed the fine-scale at-sea behaviour of female king penguins breeding at South Georgia during their long incubation foraging trips. Our tags recorded these foraging tracks at very high resolution, with one or more positions obtained between most dives over considerable periods of the trip. Foraging pathways were generally linear but exhibited occasional though infrequent area restricted search patterns, consistent with the low-density, widely dispersed prey of king penguins. Penguins focussed most of their foraging effort north of the Antarctic Polar Front where they slowed down, increased their dive effort and increased their degree of turning. With this new technology we were able to more accurately determine typical distances travelled, speeds and the degree of meandering in the foraging path. We were also better able to identify the meso-scale oceanographic features exploited by these foraging penguins.

## **PATTERNS OF MOULT SEASONALITY OF AFRICAN PENGUINS ON ROBBEN AND DASSEN ISLANDS, SOUTH AFRICA**

LES G UNDERHILL<sup>1</sup>, ANTON C WOLFAARDT<sup>1,2</sup>, ROB JM CRAWFORD<sup>1,3</sup>

<sup>1</sup>Avian Demography Unit, Department of Statistical Sciences  
University of Cape Town, Rondebosch 7701, South Africa

<sup>2</sup>Western Cape Nature Conservation Board, Private Bag X5014  
Stellenbosch 7599, South Africa

<sup>3</sup>Marine and Coastal Management, Department of Environmental Affairs and Tourism  
Private Bag X2, Roggebaai 8012, South Africa

Regular moult counts, made throughout the year, are available for African penguins on Robben Island since 1988, four years after the colony there started, and for Dassen Island since 1994, soon after the *Apollo Sea* oil spill of June 1994. These moult counts, together with breeding data, enable fine-scale comparisons between years and islands to be made, especially in relation to biomass of sardine and anchovy, the main prey species of the African penguin. We find that moult is far more tightly synchronized than breeding. We note that eggs or chicks may be abandoned if food supplies become short during a breeding attempt, but that moult cannot be abandoned once started. We suggest that moult, rather than breeding, might be the critical event in the annual cycle of African penguins and that moult needs to take place at the time when food supply is most reliable. The strategy of penguins in South Africa to moult between September and January may therefore have evolved to coincide with a relatively predictable, but distant, source of food, and not necessarily be dictated by the breeding period. This moult period coincides with the spawning period for sardine and anchovy which generally takes place over the Agulhas Bank, from 30–130 km offshore. This area is out of reach of penguins breeding on these two islands, which have a feeding range limit of about 20 km, but it would be accessible to non-breeding penguins acquiring fat reserves for their moult. The idea that moult is the event which dictates the annual cycle contradicts the hypothesis of David Lack, that breeding should take place at the period of greatest reliable food availability.

## EMPIRICAL PARADOX: IS AGGRESSIVE BEHAVIOUR OF BREEDING KING PENGUINS COSTLY?

VIERA\*, V. M.<sup>1,2</sup> ([VANESSA.VIERA@BIO.ULaval.CA](mailto:VANESSA.VIERA@BIO.ULaval.CA)), GROSCOLAS, R.<sup>2</sup> & CÔTÉ, S. D.<sup>1</sup>

<sup>1</sup> Département de Biologie et Centre d'études nordiques, Université Laval, Québec, Qc, Canada.

<sup>2</sup> Département d'Ecologie Physiologie et Ethologie, IPHC, CNRS, France

One of the most neglected areas in the physiology of aggression is the study of the energetic costs of aggressive behaviour under natural conditions. Over the last decade, however, interest in relating different types of behaviours to energy expenditures (E.E.) has rapidly increased. We determined activity budgets in 145 breeding king penguins (*Aptenodytes patagonicus*) during 15 m focals, and simultaneously recorded heart rate (HR). HR induced by each behaviour was converted into E.E. using an equation developed for breeding king penguins. Territory defence and comfort were the main behavioural variables explaining the variation in HR. The energy cost of territory defence was 20 kJ/hr whereas the cost of body comfort averaged 30 kJ/hr. From the mean daily HR, the total daily energy expenditure (DEE) of breeding King penguins was estimated at 3400 kJ. As a result, territory defence and comfort behaviours accounted for 77 kJ/day (2% of DEE) and 101 kJ/day (3% of DEE), respectively. Variations in E.E. between individuals were mainly explained by different levels of resting metabolic rate. Although the King penguin defends its territory very actively, the associated E.E. appears limited. As 'professional' fasters, King penguins seem to have developed behavioural strategies allowing energy saving during breeding.

## FORAGING STRATEGIES OF KING PENGUINS FROM HEARD ISLAND DURING INCUBATION

BARBARA WIENECKE\*, STEVE CANDY\*, PETER DANN#, SIMON JARMAN\*, GRAHAM ROBERTSON\*

\* Australian Antarctic Division, 203 Channel Highway, Kingston TAS 7050

# Phillip Island Nature Park, Cowes, Phillip Island VIC 3922

In the summer of 2003/04, a large-scale study of the marine ecosystem was conducted in the Heard Island region. The study aimed to investigate the relationships among oceanography, primary and secondary production, mesopelagic fish and squid, and land-based predators, such as fur seals and penguins. This talk focuses on the three dimensional foraging space utilised by breeding king penguins *Aptenodytes patagonicus*. Over the study period, 50 king penguins were equipped with satellite trackers to determine their foraging area and find out whether "hot spots" exist where the birds may feed preferentially. All birds also carried time-depth recorders to log their activity patterns at sea. The analyses of these data sets is undertaken by using new software that is being developed to link the satellite with for example bathymetric information. This is useful for the characterisation of the more important foraging areas of king penguins from Heard Island. Dive data analysis was based on bout analyses, ie investigating sets of dives performed by an individual, rather than combining the information of all dives performed during a foraging trip. We investigated whether different bout types could be identified and how they were distributed over the duration of the whole foraging trip.

## LONG-TERM RESTORATION SUCCESS OF AFRICAN PENGUINS DE-OILED FOLLOWING THE *APOLLO SEA* OIL SPILL

A.C. WOLFAARDT <sup>1,2</sup>, L.G. UNDERHILL <sup>2</sup>, A.J. WILLIAMS <sup>1,2</sup>

<sup>1</sup>Western Cape Nature Conservation Board, [awolfaardt@capenature.co.za](mailto:awolfaardt@capenature.co.za)

<sup>2</sup>Avian Demography Unit, Department of Statistical Sciences, University of Cape Town

The bulk ore carrier *Apollo Sea* sank southwest of Dassen Island in June 1994. Heavy fuel oil washed ashore at both Dassen and Robben Islands, contaminating about 10 000 African penguins. Approximately 50% of these birds were successfully de-oiled and released back into the wild. Our study documents the systematic follow-up of de-oiled African penguins after the *Apollo Sea* oil spill over a period of 10.5 years, from 1994 until 2005, to assess the restoration success (percentage of de-oiled birds that attempt breeding after release) of cleaning oiled African penguins. Previous studies focused mostly on the post-release survival, and rehabilitation success, of the oil spill victims over a three to five year period. This study examines the extent to which African penguins are successfully restored into the breeding population, how successfully they breed, and whether they experience any long-term costs of reproducing.

## List of posters presented

Author(s)	Poster title
Adornes et al.	Anthropogenic debris ingested by Magellanic penguins ( <i>Spheniscus magellanicus</i> ) in southern Brazil
Ainley et al.	Paradigm lost, or is top-down forcing no longer significant in the Antarctic marine ecosystem?
Angelier et al.	Corticosterone and foraging effort in a diving seabird: the Adélie penguin
Angelier et al.	Kidnapping of chicks in Emperor penguins: a hormonal by-product?
Ballerini et al.	A population model for the Adélie penguin <i>Pygoscelis adeliae</i>
Ballerini et al.	Adélie penguins' demographic parameters: the influence of large scale environmental variables and local food availability
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ABSTRACTS OF POSTER PRESENTATIONS

**ANTHROPOGENIC DEBRIS INGESTED BY MAGELLANIC PENGUINS  
(*SPHENISCUS MAGELLANICUS*) IN SOUTHERN BRAZIL**

ANDRÉA C. ADORNES<sup>1</sup>, PAULA L. CANABARRO<sup>1</sup> & VALERIA RUOPPOLO<sup>2\*</sup>

\*Corresponding Author: [vruoppolo@uol.com.br](mailto:vruoppolo@uol.com.br)

<sup>1</sup>Centro de Recuperação de Animais Marinhos - Museu Oceanográfico "Prof. Eliézer de C. Rios", Fundação Universidade Federal do Rio Grande (CRAM – MO, FURG). Rua Cap. Heitor Perdigão 10, CEP 96200-970, Rio Grande, RS [andreacram@hotmail.com](mailto:andreacram@hotmail.com)

<sup>2</sup>International Fund for Animal Welfare (IFAW), Emergency Relief Team

After the breeding season, Magellanic penguins (*Spheniscus magellanicus*) leave their colonies in Argentina and migrate north to southern Brazil. In this study, we verify the presence of anthropogenic debris in the stomachs of Magellanic penguins found washed ashore in the state of Rio Grande do Sul, southernmost Brazil. From April 2005 to November 2006 birds were collected in the area between 'Lagoa do Peixe' (31° 15'37.8"S 50°58'4.8"W) and 'Chuí' (33°45'03"S 53°23'48"W). Stomachs were extracted and were classified according to anthropogenic debris found as: 1) stomachs without anthropogenic debris, 2) with 'nylon', 3) with 'plastic fragments', and 3) with 'nylon + plastic fragments'. Eighty-two stomachs were examined, 19.51% (16/82) of which contained anthropogenic debris. Nine stomachs contained 'nylon', while three and four respectively contained 'plastic fragments' and 'nylon + plastic fragments'. All specimens (53.4% females and 46.6% males) collected were juveniles. The harmful effects of ingesting anthropogenic debris include, e.g., reduction of stomach storage capacity, decrease of digestive efficiency and reduction in feeding stimulus. However, it is not possible to attribute the birds' death only to the ingestion of these objects.

## PARADIGM LOST, OR IS TOP-DOWN FORCING NO LONGER SIGNIFICANT IN THE ANTARCTIC MARINE ECOSYSTEM?

D AINLEY<sup>1\*</sup>, G BALLARD<sup>2</sup>, S ACKLEY<sup>3</sup>, LK BLIGHT<sup>4</sup>, JT EASTMAN<sup>5</sup>, SD EMSLIE<sup>6</sup>, A LESCROËL<sup>1</sup>,  
S OLMASTRONI<sup>8</sup>, SE TOWNSEND<sup>9</sup>, CT TYNAN<sup>10</sup>, P WILSON<sup>11</sup>, E WOEHLE<sup>12</sup>

<sup>1</sup>*H.T. Harvey & Associates, 3150 Almaden Expressway, San Jose CA 95118 USA*

<sup>2</sup>*PRBO Conservation Science, Bolinas CA 94924 USA; and Ecology, Evolution, and Behaviour, School of Biological Sciences, University of Auckland, NZ*

<sup>3</sup>*Civil & Environmental Engineering, Clarkson University, Potsdam NY 13699 USA*

<sup>4</sup>*Procellaria Research and Consulting, 944 Dunsmuir Road, Victoria BC V9A 5C3 CAN*

<sup>5</sup>*Biomedical Sciences, Ohio University, Athens OH 45701 USA*

<sup>6</sup>*Biology and Marine Biology, University of North Carolina, Wilmington NC 28403 USA*

<sup>8</sup>*Dipartimento Scienze Ambientali, Università di Siena, Via Mattioli 4 53100 Siena, IT*

<sup>9</sup>*709 56<sup>th</sup> Street, Oakland CA 94609 USA*

<sup>10</sup>*P.O. Box 438, West Falmouth MA 02574 USA*

<sup>11</sup>*17 Modena Crescent, Auckland NZ*

<sup>12</sup>*School of Zoology, University of Tasmania, Sandy Bay, Tasmania AU 7000*

[\\*dainley@penguinscience.com](mailto:dainley@penguinscience.com)

Investigations of the ecological structure and processes of the Southern Ocean in recent years almost exclusively have taken a bottom-up, forcing-by-physical-processes approach relating various species' population trends to climate change. Just 20 years ago, however, researchers focused on a broader set of hypotheses, in part formed around a paradigm positing interspecific interactions as central to structuring the ecosystem (forcing by biotic processes, top-down), and particularly on a "krill surplus" caused by the removal from the system of more than a million baleen whales. Since then, this latter idea has disappeared from favour with little debate. Moreover, it recently has been shown that concurrent with whaling was a massive depletion of finfish in the Southern Ocean, a finding also ignored in deference to climate-related explanations of ecosystem change. We present two examples from the literature, one involving gelatinous organisms and the other involving penguins, in which climate has been used to explain species' population trends but which could better be explained by including species interactions in the modelling. We conclude by questioning the almost complete shift in paradigms that has occurred and discuss whether it is leading Southern Ocean marine ecological science in an instructive direction.

## **CORTICOSTERONE AND FORAGING EFFORT IN A DIVING SEABIRD: THE ADÉLIE PENGUIN**

FRÉDÉRIC ANGELIER, CHARLES-ANDRÉ BOST, MATHIEU GIRAudeau, GUILLAUME BOUTELOUP,  
STÉPHANIE DANO & OLIVIER CHASTEL

Centre d'Etudes Biologiques de Chizé, Centre National de la Recherche Scientifique  
F-79360 Villiers en Bois, Deux-Sèvres, France.

Because endocrine mechanisms are thought to mediate physiological and behavioural responses to intrinsic or extrinsic stimuli, they are especially interesting to understand how animals adapt their foraging decisions to energetic demands of reproduction. Thus, the hormone corticosterone deserves specific attention because of its major connections with metabolism, food intake and locomotor activities. We examined the relationships between baseline corticosterone levels and foraging behaviour and foraging success in the Adélie penguin, *Pygoscelis adeliae*. Data were obtained from free-ranging penguins during the brooding period at Adélie Land, Antarctica, by using satellite transmitters and time-depth-recorders. The birds were weighed and blood sampled before and after a foraging trip (pre-trip and post-trip corticosterone levels, respectively). Penguins with elevated pre-trip corticosterone levels spent less time at sea and stayed closer to the colony than penguins with low pre-trip corticosterone levels. These short trips were associated with a higher foraging effort in terms of diving activity and a lower foraging success than long trips. This therefore suggests that penguins with elevated pre-trip corticosterone levels maximized the rate of energy delivery to the chicks at the expense of their body reserves. Moreover, corticosterone levels decreased during a foraging trip. This decrease might either result from the restoration of body reserves during the foraging trip or from a break in activity at the end of the foraging trip. This study demonstrates for the first time in a diving predator the close relationships linking foraging behaviour and baseline corticosterone levels. We suggest that slight elevations in pre-trip corticosterone levels might play a major role in breeding effort by facilitating foraging activity in breeding seabirds.

## KIDNAPPING OF CHICKS IN EMPEROR PENGUINS: A HORMONAL BY-PRODUCT?

ANGELIER F: Migratory Bird Center, Smithsonian Institution,  
Box 37012, Washington DC 20013-7012, USA  
ANGELIER F, BARBRAUD C PRUD'HOMME F AND CHASTEL O  
Centre d Etudes Biologiques de Chize, CNRS, 79360 Villiers en Bois, France  
LORMEE H: ONCFS, 79360 Villiers en Bois, France

The function and causes of kidnapping juveniles are little understood because individuals sustain some breeding costs to rear an unrelated offspring. Here we focus on the proximal causes of this behaviour in emperor penguins (*Aptenodytes forsteri*), whose failed breeders often kidnap chicks. We experimentally tested the hypothesis that kidnapping behaviour was the result of high residual levels of prolactin (PRL), a hormone involved in parental behaviour. Penguins with artificially decreased PRL levels by bromocriptine administration kidnapped chicks less often than control penguins. Within the bromocriptine treated group, kidnapping behaviour was not totally suppressed and the probability of kidnapping a chick was positively correlated to PRL levels measured before treatment. During breeding, emperor penguins have to forage in remote ice-free areas. In these birds, PRL secretion is poorly influenced by chick stimuli and has probably evolved to maintain a willingness to return to the colony after a long absence at sea. Therefore, penguins that have lost their chick during a foraging trip still maintain high residual PRL levels and this, combined with colonial breeding, probably facilitates kidnapping. We suggest that kidnapping in non-cooperative systems may result from a hormonal by-product of a reproductive adaptation to extreme conditions.

## **ADÉLIE PENGUIN'S DEMOGRAPHIC PARAMETERS: THE INFLUENCE OF LARGE SCALE ENVIRONMENTAL VARIABLES AND LOCAL FOOD AVAILABILITY**

T. BALLERINI<sup>1</sup>, G. TAVECCHIA<sup>2</sup>, S. OLMASTRONI<sup>1</sup>, F. PEZZO<sup>1</sup>, S.FOCARDI<sup>1</sup>

<sup>1</sup>Dipartimento di Scienze Ambientali "G.Sarfatti", Università degli Studi di Siena, Siena, Italia

<sup>2</sup>IMEDEA, CSIC-UIB, Mallorca, Espana

Population fluctuations typically correspond to a change in sex- and/or age-specific demographic parameters. Detailed information on population dynamics can thus be gathered monitoring survival and reproduction of the individual in the population. Individual based data on presence-absence and reproductive success for the Adélie penguin *Pygoscelis adeliae* breeding at Edmonson Point were collected from 1994 to 2004 for the CCAMLR Ecosystem Monitoring Programme, by means of visual observations and automatic identification system. Demographic parameters were estimated in relation to individual characteristics (sex and age), and environmental variables (food availability, sea-ice extent and Southern Oscillation Index). Demographic parameters and the influence of the environmental covariates considered were obtained through logistic regressions. The annual survival probability did not vary between males and females but changed significantly over time and according to the age of the birds. Results showed also that mortality increased in relation to extreme sea-ice extent values. On the contrary climatic variables did not affect the breeding success, that varied principally according to a local food availability index.

## **A POPULATION MODEL FOR THE ADÉLIE PENGUIN *PYGOSCELIS ADELIAE***

T. BALLERINI<sup>1</sup>, G. TAVECCHIA<sup>2</sup>, S. OLMASTRONI<sup>1</sup>, F. PEZZO<sup>1</sup>, S.FOCARDI<sup>1</sup>

<sup>1</sup>Dipartimento di Scienze Ambientali "G. Sarfatti", Università degli Studi di Siena, Siena Italia

<sup>2</sup>IMEDEA, CISC-UIB, Mallorca, Spain

Adélie penguin's populations showed contrasting trends in continental Antarctica with respect to the Antarctic Peninsula. The different long-term trends are likely to be due to the influence of local environmental variables in one or more demographic parameters. Using individual-based information collected from 1994 to 2004 for the CCAMLR Ecosystem Monitoring Programme by Italian National Antarctic Programme at Edmonson Point (Ross Sea, Antarctica) we estimated the sex- and age-specific demographic parameters and investigated the influence of different environmental variables on their variability. We found that survival was negatively associated with extreme values of the sea-ice and that reproductive success varied in relation to the local availability of food. We built an age-structured population model incorporating these estimates in order to describe the observed dynamics and predict the long-term trend of the population. The model well matched the observed dynamics and predicted a decline of the local population. Perturbation analyses showed that adult survival is the demographic parameter that most affects the population growth rate. The current model may be an efficient tool to explore population trajectories in relation to different scenarios of environmental changes.



## **ESTIMATING THE ABUNDANCE OF EMPEROR PENGUINS AT INACCESSIBLE COLONIES USING SATELLITE IMAGERY**

SHANNON M. BARBER-MEYER <sup>1,2</sup>, GERALD L. KOOYMAN <sup>1</sup>, AND PAUL J. PONGANIS <sup>1</sup>

<sup>1</sup> Scripps Institution of Oceanography, University of California, San Diego, Scholander Hall, Center for Marine Biotechnology and Biomedicine, 9500 Gilman Drive, La Jolla, CA 92093

<sup>2</sup> Corresponding author: shannonbarbermeyer@gmail.com, 619-225-1269, fax 858-534-1305

Emperor penguin (*Aptenodytes forsteri*) populations are useful environmental indicators due to the bird's extreme reliance on sea ice. We used remote sensing technology to estimate adult bird abundance at two inaccessible emperor penguin colonies in the Ross Sea, Antarctica. We performed supervised classification of 12 panchromatic satellite images of the seven known Ross Sea colonies. We used regression to predict adult bird counts at the inaccessible colonies by relating the number of pixels classified as "penguin" in the satellite images of the accessible colonies to corresponding known adult bird counts from aerial or ground counts. While our analysis was hampered by excessive guano and shadows, satellite imagery can be used to differentiate between relatively small (<5,000 adult birds) and larger colonies (>5,000 adult birds). Remote sensing technology is logistically less intense and less costly than aerial or ground censuses and is useful in documenting large emperor penguin population changes.

## **LANDSCAPE EFFECTS ON THE DISTRIBUTION OF ADÉLIE PENGUIN COLONIES AT CASEY, EAST ANTARCTICA**

PHILLIPPA K. BRICHER\*, ERIC J. WOEHLE\*\* & ARKO LUCIEER\*

\*School of Geography & Environmental Studies, University of Tasmania

\*\*School of Zoology, University of Tasmania

Colony-scale investigations of the distribution of Adélie penguins have historically been based on individual measurements within limited numbers of breeding colonies. Here, geographic information systems (GIS) are used to generate spatial data of landscape variables at two breeding localities from fine-scale digital elevation models and weather data. Individually, the landscape attributes have little power to predict the distribution of Adélie penguin colonies. However, decision tree models derived from them predict the presence or absence of nesting birds with up to 84.5% accuracy. Beyond a few key limits, such as avoiding steep slopes and areas with low solar radiation, simple rules to describe the distribution of Adélie penguin colonies are not easily derived, as habitat suitability appears to be driven by complex interactions between landscape attributes. The colonies occur on hilltops, valley bottoms and the sides of hills, facing almost all directions, and with varying degrees of wetness.

## **IS DIET RESPONSIBLE FOR POOR YELLOW-EYED PENGUIN CHICK SURVIVAL ON STEWART ISLAND?: A DIETARY ANALYSIS USING STABLE ISOTOPES AND BOMB CALORIMETRY**

TIFFANY BROWNE, CHRIS LALAS, THOMAS MATTERN, YOLANDA VAN HEEZIK  
University of Otago, P.O. Box 31, Portobello, Dunedin. [ithaki@xtra.co.nz](mailto:ithaki@xtra.co.nz)

The yellow-eyed penguin (*Megadyptes antipodes*), one of New Zealand's rarest penguin species, breeds at very low densities on Stewart Island in southern New Zealand. On Stewart Island there are a lower number of nests and poorer reproductive success than on outlying Codfish Island. Chick mortality predominately occurs during the guard phase, with starvation contributing to many deaths. This study compares the diet during the breeding season of yellow-eyed penguins on Stewart Island and Codfish Island. We examine diet in three ways: (1) by identifying prey from stomach samples using otoliths and other diagnostic remains, and calculating the total number, length and mass of prey items; (2) by using bomb calorimetry to determine the nutritional value of each diet sample; and (3) by using stable isotope analyses ( $\delta^{15}\text{N}$  and  $\delta^{13}\text{C}$ ) on blood samples from breeding adults and feathers from chicks and fledglings to determine potential differences in diet and foraging areas between the two main locations. We aim to identify whether dietary differences may be contributing to the poor reproductive success typical of Stewart Island birds.

## FACTORS INFLUENCING THE FORAGING RANGE OF THE LITTLE PENGUINS

EMMA BUICK

Deakin University, Australia

Foraging ranges of little penguins (*Eudyptula minor*) have been touched on in many studies. However, the factors that influence its foraging range have not been explored. Therefore, during the 2005/06 and 2006/07 breeding season, the influence of sex, body size and various morphometric characteristics on the foraging range of little penguins during the guard and post-guard stages were investigated at five geographically isolated colonies (Phillip Island, Rabbit Island, Kanowna Island, Notch Island and St Kilda) using satellite telemetry. Three indices of foraging range were explored: total distance travelled from the colony (km); maximum distance travelled from the colony (km); and, the number of grid cells (1 km<sup>2</sup>) used during 90% of time spent at sea (min). The most influential factors affecting the foraging range were flipper length and colony. Individuals with larger flippers travelled greater distances, and it is probable that local differences in oceanography influenced the foraging areas of individuals. Furthermore, the degree of foraging range overlap (%) between the sexes at each colony and between breeding pairs was explored to determine if sexual segregation in foraging areas occurred. Mean bill depth difference within breeding pairs was examined to determine if sexual dimorphism was associated with resource partitioning. The results indicated sexual segregation in foraging areas between the sexes in each colony, with further segregation occurring between partners. Partners who were more sexually dimorphic showed a greater overlap in foraging range as their dimorphic features probably allowed them to partition foraging depth as well as prey type/size. Detailed studies examining all dimensions of factors affecting the foraging range of little penguins are required in order to fully understand with confidence the factors that influence the little penguins foraging range.

## **SPOT THE DIFFERENCE: PROCESSING PENGUIN PATTERNS**

TILO BURGHARDT, PETER J BARHAM, & NEILL CAMPBELL

Departments of Physics, and Computer Science, University of Bristol, Bristol BS8 1TH, UK

We have developed a fully automated, non-invasive computer vision system for the real-time identification of individual penguins. Our method uses unique variations in camouflage patterns created early in the development of individual animals. The system implements a sequential identification strategy integrating the subtasks of species detection, pose normalisation and biometric pattern matching along a recognition pipeline. Initially, our generic system is trained to the appearance of a species by boosting weak visual classification rules into one strong classifier allowing species detection in previously unseen imagery. If animals are found in a frame then their camouflage patterns are extracted and may be corrected by selected projective transforms to allow for variations in pose and orientation. Finally, the system applies a robust histogram metric to compare normalised feature distributions in these patterns with a population database. This reveals the identity of individuals present in particular images. We will discuss how the system can be applied to a range of species (to date is has only been fully tested on African penguins) and how it may be extended to extract a wealth of data such as anatomical measurements on specific animals as well monitoring the behaviour of individuals and their mutual interactions.

## LINKS BETWEEN *P. ANTARCTICA* ROOKERIES, CRYOSOL CHARACTERISTICS AND CLIMATE CHANGE ON THE WESTERN SHORE OF ADMIRALTY BAY, KING GEORGE ISLAND

Ricardo Burgobraga<sup>1,2</sup>, Ulisses Franz Bremer<sup>1,2</sup>, Francisco Eliseu Aquino<sup>1</sup>

<sup>1</sup> Núcleo de Pesquisas Antárticas e Climáticas, Dep. Geografia,  
Universidade Federal do Rio Grande do Sul,  
Porto Alegre, RS, 91.501-970, Brasil

<sup>2</sup> Antarctic and Southern Ocean Coalition(ASOC)/Núcleo Amigos da Terra Brasil  
(FoE Brazil), Porto Alegre, RS, 90.405-120, Brasil

Soil formation and composition, under the influence of penguin colonies, may reflect meteorological and oceanographic conditions, such as the 50 year +2.5°C warming trend for the Antarctic Peninsula and the registered decrease of sea ice extension, observed at Admiralty Bay – setting for the *Antarctic Specially Protected Area Western Shore of Admiralty Bay* (ASPA 128), King George Island. This work explores the links among ornithogenic cryosol composition; the local and regional air temperature warming trends and the frequency increase of warmer winters with less extensive sea-ice development, at the four local *Pygoscelis antarctica* breeding colonies. The observation of soil profiles from these sites also show phosphatization levels to be shallower than neighboring larger *P. adeliae* colonies. Such correlations may help explain species and biological diversity distribution patterns of maritime Antarctic terrestrial ice-free ecosystems, supporting existing monitoring efforts and conservation developments envisioned by the *Antarctic Specially Managed Area of Admiralty Bay* (ASMA No.1) management plan.

## DID PENGUIN FLIPPER SHAPES EVOLVE FROM DIETARY PREFERENCE OR BODY SIZE?

André Chiaradia<sup>1</sup>, Ken N. G. Simpson<sup>2</sup>, David Beaune<sup>3</sup> and Yan Ropert-Coudert<sup>4</sup>

<sup>1</sup> Research Department, Phillip Island Nature Park, PO Box 97, Cowes, Victoria, Australia,  
[achiaradia@penguins.org.au](mailto:achiaradia@penguins.org.au)

<sup>2</sup> Penguin Study Group, Victorian Ornithological Research Group, Melbourne, Australia

<sup>3</sup> Terres Australes et Antarctiques Françaises, Crozet Archipelago

<sup>4</sup> National Institute of Polar Research, 1-9-10 Kaga, Itabashi-ku, Tokyo 173-8515, Japan

Diving and flying require different body adaptations. Penguins have optimised underwater propulsion at the expense of aerial flight, becoming exclusively and extremely efficient divers. Penguins have a diverse diet, foraging on prey with different mobility and vertical distribution. Expecting that such pursuits would lead to specific morphological adaptation, we examined the flipper aspect ratio, flipper-loading and foraging behaviour in relation to the main prey in the diet of several penguin species. Flipper measurements, mainly obtained from museum skins (in full knowledge of shrinkage), were collected for 17 species (6 genera) and compared with published information on diet and diving parameters. Penguins have one of the highest aspect ratio (15, SD=1.6) and flipper loading (5 g/cm<sup>2</sup>, SD=2.1) among birds. In the analysis, penguins were grouped according to their main diet and genus. We found that the flipper aspect ratio and loading were positively related to body mass. They were significantly higher for *Aptenodytes* but not significantly different among the other genera. Flipper aspect ratio was not significantly different among penguins with fish, crustacean or mixed-diet, even after controlling for body mass and flipper loading. We suggest that the shape of penguin flippers may have evolved with body size rather than as a direct response to dietary preferences.

**PRIVATE PENGUINS: VISUAL ISOLATION AND YELLOW-EYED PENGUIN  
(*MEGADYPTES ANTIPODES*) NEST SITE SELECTION**

RYAN D. CLARK<sup>1,2\*</sup>, RENAUD MATHIEU<sup>1</sup>, AND PHILIP J. SEDDON<sup>2</sup>

<sup>1</sup> Spatial Ecology Research Facility, School of Surveying,  
University of Otago, Dunedin, New Zealand

<sup>2</sup> Department of Zoology, University of Otago,  
PO Box 56 Dunedin 9054, New Zealand

[\\*rydclark@gmail.com](mailto:*rydclark@gmail.com)

A fundamental goal of avian habitat restoration programmes is to maximise the amount of optimal nest sites. For yellow-eyed penguins (*Megadyptes antipodes*), an optimal site may be one that provides solitude from conspecific neighbours. *M. antipodes* commonly select well-concealed and widely spaced nest sites that provide protection from the sun and are often completely visually isolated. Minimised visual contact between neighbours can reduce disturbances and may improve reproductive success. We aimed to determine the relative importance of visual isolation and overhead cover in nest site selection of *M. antipodes*. We compared the maximum distance of visibility and amount of overhead cover of nests with random sites in flax, scrub, and forest habitats. In forest habitat random sites were visible from a greater distance than nests, which were visible from a greater distance than both flax and scrub sites. In all habitats, nests had at least twice the amount of overhead cover of random sites. Selection for overhead cover may lead to visual isolation in flax and scrub, while in forest, visual isolation may be more important, as overhead cover is readily available. Habitat restoration programmes for *M. antipodes* should therefore aim to establish forest canopies with dense understory vegetation.



**SEX-SPECIFIC DESERTION AND COMPENSATORY CARE IN KING PENGUINS,  
*APTENODYTES PATAGONICUS***

CORBEL H., DONDELINGER C., GACHOT-NEVEU, H. & R. GROSCOLAS  
DEPE/IPHC, UMR 7178 CNRS-ULP, 23 rue Becquerel  
67087 Strasbourg, Cedex 2, France

Reproductive tactics are the outcome of an evolutionary game with both the partner (ability to care) and the population (mating opportunities). Biparental King penguins have high divorce rates and a breeding cycle lasting more than one year. After fledging a chick in summer, late breeding attempts mostly fail and result in high mating opportunities during next spring, sex-ratio being biased towards males. We tested the hypothesis that female desertion should occur in spring with males partially compensating for it. Chicks (n=23) were marked at the onset of moult, c.a. 1 month before fledging. The frequency and mass of meals until chicks fledged allowed for the calculation of daily provisioning rates. Chicks and adults were sexed using molecular techniques. 60% of chicks were mono-parentally cared, 70% of deserting parents being females. Females equally deserted male and female chicks and did not compensate for the abandon of males. Males preferentially deserted male chicks and their degree of compensation varied from none (male chicks) to full (female chicks). Thus, in King penguins, divorce is mostly initiated by deserting females. Higher lifetime reproductive success in females may account for the higher value of female chicks and sex-specific allocation in deserted males.

## COULD THE CURRENT STOMACH FLUSHING TECHNIQUE BE A VEHICLE FOR TRANSFERRING PATHOGENS FROM ONE SICK PENGUIN TO ANOTHER?

MEAGAN DEWAR & CAROL SCARPACI  
Department of Ecology and Sustainability  
PO BOX 14428 (St Albans Campus) Victoria University,  
MCMC 8001 Victoria, Australia.  
[meagan.dewar@students.vu.edu.au](mailto:meagan.dewar@students.vu.edu.au)

Understanding the dietary requirements of animals is fundamental to ecological studies. The current non-lethal method that is generally implemented by penguin biologist to determine the diet of penguins requires researchers to flush the stomach of penguins as described by Wilson (1984). The technique requires a tube to be inserted down the oesophagus to the stomach and filled with water. The researcher then induces regurgitation by applying pressure to the stomach of the penguin. The concern is that the same tube is used consecutively for each penguin flushed without the tube being cleaned between penguins. Therefore, we are addressing a concern for the transfer of pathogens from one penguin to another via the stomach flushing tube. According to the literature, pathogenic species of bacteria have been isolated from penguins, including *Pasteurella multocida* (Avian cholera), *Pasteurella haemolytica* Type T, *Salmonella* spp, *Chlamydia* spp, *Staphylococcus* spp, *Streptococcus* spp, *Neisseria* spp, *Campylobacter rectus*, *Erysipelothrix rhusiopathiae*, and *Corynebacterium spheniscorum*. The objective of this research project is to document the microflora of an urban population of little penguins (*Eudyptula minor*) and provide strategies to improve the current technique of stomach flushing of avian species to prevent cross contamination of microorganisms from bird to bird, or from bird to human (zoonosis). In this study, we collected microbial swabs from a) mouth, b) faecal, c) regurgitation sample, d) stomach flushing tube from little penguins and inoculated them on 3 growth media to determine the type of micro-organisms present in each of these environments. The findings indicate the presence of micro-organisms in each environment studied. As a result, we have proposed a list of strategies to prevent cross contamination of pathogens between penguins that are utilized in dietary studies (stomach flushing). The strategies proposed are simple to implement, cost effective, feasible in the field (considering the nature of this work) and do not significantly maximize the period of the time the animal needs to be handled.

## **PERSONAL PROTECTIVE EQUIPMENT FOR RESEARCHERS WORKING WITH WILDLIFE... PREVENTING ZONOSIS**

MEAGAN DEWAR & CAROL SCARPACI  
Department of Ecology and Sustainability  
PO BOX 14428 (St Albans Campus) Victoria University,  
MCMC 8001 Victoria, Australia.  
[meagan.dewar@students.vu.edu.au](mailto:meagan.dewar@students.vu.edu.au)

Researcher handling animals or animal products are at risk of being exposed to zoonotic diseases. Zoonosis is defined as an infectious disease of animal origin that can be transmitted to humans. These diseases can be transmitted through bites, scratches, droplets, parasites, infected blood and bacteria samples. Therefore, when working with animals or animal products, researchers need to take precautions to prevent zoonosis. The objective of this poster is to discuss the types of zoonotic disease wildlife biologists may come into contact with accompanied by the types of personal protective equipment that can be implemented by field biologists to provide protection against zoonotic diseases. These strategies are realistic in the field (e.g. gloves with grip that allow wildlife biologists to handle animals, but provide protection from bites), cost effective and portable.

**BREEDING NUMBERS AND SUCCESS OF *EUDYPTES* PENGUINS AT MARION ISLAND,  
AND THE INFLUENCE OF MASS AND TIME OF ARRIVAL OF ADULTS**

BRUCE M DYER<sup>1</sup>, ROBERT JM CRAWFORD<sup>1</sup>, JOHN COOPER<sup>2</sup> AND LES G UNDERHILL<sup>2</sup>

<sup>1</sup>Marine and Coastal Management, Department of Environmental Affairs and Tourism,  
Private Bag X2, Rogge Bay 8012, South Africa

<sup>2</sup>Avian Demography Unit, Department of Statistical Sciences, University of Cape Town,  
Rondebosch 7701, South Africa

At subantarctic Marion Island, there was substantial correlation in the numbers of adults breeding at study colonies of macaroni penguins *Eudyptes chrysolophus* over 26 years, as there was also for eastern rockhopper *E. chrysocome filholi* penguins over 22 years, suggesting over-wintering conditions may influence the proportions of birds breeding. For both species, the time of arrival of females for breeding, and for rockhopper penguins the mass of females on arrival, was significantly related to breeding success. Therefore, over-wintering conditions may also affect breeding success. Trends in breeding success between study colonies were more strongly correlated for macaroni penguins than for rockhopper penguins. Macaroni penguins have a greater foraging range than do rockhopper penguins when breeding, and may be more influenced at this stage by wider-scale environmental phenomena. For macaroni penguins, breeding success was significantly correlated with mass of chicks at fledging. For both species, mass on arrival of males was significantly correlated with that of females. Although both species had low masses on arrival after the *El Niño* Southern Oscillation event of 1997/98, there was no significant correlation in mass on arrival between the two species. It is likely that at Marion Island their over-wintering grounds are different.

## **AN ABRUPT RECENT SHIFT IN ADÉLIE PENGUIN DIET BASED ON STABLE ISOTOPE ( $\delta^{13}\text{C}$ AND $\delta^{15}\text{N}$ ) ANALYSIS OF EGG SHELL**

STEVEN D. EMSLIE<sup>1</sup> AND WILLIAM P. PATTERSON<sup>2</sup>

<sup>1</sup>Department of Biology and Marine Biology, University of North Carolina,  
601 S. College Rd., Wilmington, NC 28403

<sup>2</sup>Saskatchewan Isotope Lab, Department of Geological Sciences,  
114 Science Place, University of Saskatchewan, Saskatoon SK S7N 5E2, Canada

We analysed a ~38,000-year time series of over 220 Adélie penguin eggshell from abandoned colonies in three major regions of the Antarctic for  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ . We found that eggshell exhibited enriched isotopes throughout most of this record, probably due to a diet based primarily on fish, with no significant variation with known climatic events. However, our results also indicated an abrupt shift to lower-trophic prey in penguin diet within the past ~200 years. Analysis of historic eggshell from Scott's hut at Cape Evans, Ross Island, helps constrain the timing for this shift. These eggs, gathered by members of the Scott or Shackleton parties between 1911-1917, have isotope ratios similar to modern eggshell, indicating that the dietary shift had occurred in the Ross Sea by this time. We posit that penguins began only recently to rely on krill as a major portion of their diet, in conjunction with the removal of baleen whales and krill-eating seals during the historic sealing and whaling era. Our results support the 'krill surplus' hypothesis that predicts excess krill availability in the Southern Ocean following this period of exploitation.

**PENGUIN POPULATION DYNAMICS IN HASWELL ARCHIPELAGO AREA  
ASP 127, EAST ANTARCTICA**

MARIA GAVRILO<sup>1</sup> & YURI MIZIN<sup>2</sup>

<sup>1</sup>AARI, 199397, Saint-Petersburg, 38 Bering St., Russia; [m\\_gavrilo@mail.ru](mailto:m_gavrilo@mail.ru)

<sup>2</sup>RAE, 199397, Saint-Petersburg, 38 Bering St., Russia; [y\\_mizin@mail.ru](mailto:y_mizin@mail.ru)

Fieldwork was carried out in Davis Sea, East Antarctica within the ASPA 127 – Haswell Archipelago, during seasons 1999/2000, 2003/2004 and 2006/2007. Published and RAE archival data for the period 1956–1970, and 1994 are also used. Two penguin species breed in the area including *Pygoscelis adeliae* and *Aptenodytes forsteri*, while *Eudyptes chrysolophus* was recorded as vagrant in 1999/2000 and *Pygoscelis antarctica* – in 2003/2004. Most complete data obtained for the emperor penguins. During period of 1956–1970, the breeding population was relatively stable and varied within 14–20,000 birds. After a break in observations, the population was found decreased by at least twice – only 7,000 breeding adults in 1994. Then, during 1999–2006 population estimate was 7–11,000 adults with apparent tendency to increase (highest numbers in 2006). Thus, between two periods of stable/fluctuating population dynamics falling on 1950–70s and 1990–2000s it was a period of population decrease. More fragmentary data on Adelle penguin suggest the similar tendency: 1960–1970s population totalled 41–44,000 adults, while in 1999–2006 it is estimated at ca. 31,000 birds with increasing trend observed on smaller islands recently. Longer series is needed to reveal the trend more accurately. Possible reasons for observed changes are discussed including climate change, human impact as well as effect of survey methods. The study is supported by the sub-program “Research of Antarctica” of Russian Federal Program “World Ocean”.

## ECOSYSTEM-BASED MANAGEMENT OF THE ANTARCTIC KRILL FISHERY TO PROTECT PENGUINS AND OTHER KRILL PREDATORS

VIRGINIA GASCÓN GONZÁLEZ<sup>1</sup>, RODOLFO WERNER KINKELIN<sup>2</sup> & MARK STEVENS<sup>3</sup>

<sup>1</sup> Policy Advisor, <sup>2</sup> Science Advisor & <sup>3</sup>US Advisor

Antarctic Krill Conservation Project, Washington, DC, USA - [www.krillcount.org](http://www.krillcount.org)

Antarctic krill (*Euphausia superba*), a widespread species with circumpolar distribution, is central to the Antarctic marine food web, as most organisms are either direct predators of krill or are just one trophic level removed from it. The climate in Antarctica is warming rapidly, especially around the Western Antarctic Peninsula that acts as a major spawning nursery and recruitment area for Antarctic krill. This warming results in reduced extent and duration of seasonal sea ice, which in turn impacts krill recruitment and puts krill availability for predators in jeopardy.

Adélie (*Pygoscelis adeliae*), chinstrap (*P. antarctica*), macaroni (*Eudyptes chrysolophus*) and gentoo penguins (*P. papua*) are dependent to a great extent on Antarctic krill. In addition to macaroni penguins being listed as vulnerable on IUCN's Red List of Threatened Species and gentoo penguins categorised as near threatened, individual colonies of other penguin species in Antarctica may be of concern despite not being included in the IUCN Red List. For example, analysis of long-term population data from both the South Shetland and South Orkney Islands has revealed consistent decreases in both Adélie and chinstrap penguin numbers over the past 20 to 30 years. It is thought that these population decreases may reflect the influence of reduction in prey availability linked to large-scale climate forcing. The Antarctic krill fishery has been the largest fishery in the Southern Ocean since the late 1970s. Krill catches occur entirely in the South West Atlantic, concentrating within 100km of known breeding colonies of Adélie, gentoo, chinstrap and macaroni penguins. This implies a complete overlap between the area of fishing operations and the foraging ranges of these predators. Thus, the combined effect of climate change and fishing operations (seemingly in expansion) is of concern in relation to the decrease of individual breeding populations of penguin species in this area.

Fishing for krill in the Antarctic is subject to the management regime established by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). CCAMLR was a pioneer in formulating an ecosystem approach to fisheries management, intended to maintain the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources. CCAMLR negotiations were prompted, in significant part, by the related concerns over the possible impacts that krill fishing might have on the Antarctic marine environment.

CCAMLR has established a program to monitor the health of top predator populations in the Antarctic ecosystem: the CCAMLR Ecosystem Monitoring Program (CEMP). This program was initiated in 1986 to detect significant changes to the ecosystem, particularly to krill predators, and to signal when such changes were the consequences of fishing. The program is restricted to monitoring a few selected krill predators and is established in only a few areas. CCAMLR could become a model of the full application of ecosystem-based management. However, the full implementation of the ecosystem approach to krill fisheries management is still at an incipient stage. For example, CCAMLR still needs to establish krill catch limits for small management units, so as to distribute the effort geographically in a way that avoids localised depletion of krill and minimises impacts on predator populations. In order to account for the requirements of krill predators and the effects of climate change, a feedback management procedure needs to be implemented to allow management measures to be adjusted in response to ecosystem monitoring. Full development of a feedback management scheme will require expanding the CEMP (as monitoring data are currently not available for many of the areas that are regularly fished), obtaining better estimates of abundance and krill consumption rates of krill predators, and gaining more information on important aspects of krill biology and ecology.

## **AN INVESTIGATION INTO THE EFFECTS OF FLIPPER BANDING AFRICAN PENGUINS *SPHENISCUS DEMERSUS***

SHANNON HAMPTON<sup>1</sup>, PETER RYAN<sup>2</sup>, LES UNDERHILL<sup>1</sup>

<sup>1</sup> Avian Demography Unit, University of Cape Town, South Africa 7700 [shampton@botzoo.uct.ac.za](mailto:shampton@botzoo.uct.ac.za)

<sup>2</sup> Percy FitzPatrick Institute, University of Cape Town, South Africa 7700

The vast majority of what is known about population dynamics of penguins is as a direct result of the flipper bands, however a concern exists that the bands are negatively impacting on the welfare of various species of penguins. We investigate the effect of banding on African penguins *Spheniscus demersus* by comparing the difference in yearly return rates and foraging trip durations of individuals that have been injected with a subcutaneous transponder only, and those which have transponders and a stainless steel flipper band. There was no significant difference between the return rates of banded and unbanded birds after a year ( $\chi^2_1 = 1.50, P=0.22$ ). The majority of foraging trips were between 10 and 14.99 hours for both banded and unbanded birds (38.17% and 44.88% respectively). Banded individuals spent on average an hour longer out of the colony than unbanded however this difference was not significant ( $t = -0.37, P= 0.85$ ). These results are preliminary results and will be strengthened by continued research and observation. The evidence to date does not suggest that flipper banding should be discontinued, although a precautionary stance should still be in place while the long term effects of banding African penguins is investigated.



## **FIRST INTERNATIONAL ASSESSMENT OF COASTAL POLLUTION AND OILED PENGUINS**

GUILLERMO HARRIS<sup>1,2,3</sup>, MARCELA COLOMBINI<sup>1,2</sup>, JOSÉ L. ESTÉVES<sup>1,2</sup>, PAULA GONZÁLEZ<sup>1,2</sup>, LUCIANA M. POZZI<sup>1,2</sup>, JOSÉ M. MUSMECI<sup>1,2</sup> & HORACIO OCARIZ<sup>1,2</sup>.

<sup>1</sup>Fundación Patagonia Natural, Puerto Madryn, Chubut, Argentina

<sup>2</sup>Project ARG/02/G31- UNDP-GEF

<sup>3</sup>Wildlife Conservation Society

In 1995, Fundación Patagonia Natural (FPN), an Argentinian NGO based in Patagonia, organized the First National Assessment of Coastal Pollution in Argentina. The goal was to invite as many people as possible to participate in an effort to walk as much of the coastline as feasible, recording oiled seabirds and assessing the type and abundance of garbage encountered. The task was completed on a single day, September 6, at a time when Magellanic penguins (*Spheniscus magellanicus*) begin returning to their colonies from winter migration. People from Governmental and Non Governmental Organizations, Universities, Research Centres and volunteers walked appointed sections of the coast. Overall, a total of 3219 people participated and walked a combined distance of 2110km. In 2007, FPN decided to organize a repeat of this event, and is leading the Second National Assessment of Coastal Pollution, and is planning to repeat the effort every two years. Furthermore, in 2009, FPN hopes to work with partner organizations to organize the First International Assessment of Coastal Pollution. The goal is to expand the assessment to the coasts of other southern hemisphere countries of America, Africa, Australia, New Zealand, and Antarctica, focusing on shores frequented by penguins of the various species.

## LEUCOCYTOZOOM IN YELLOW-EYED PENGUINS

HILL, A.G., ALLEY, M.R., GARTRELL B.D., NORMAN, R.J., HOWE, L.  
New Zealand Wildlife Health Centre, Institute of Veterinary,  
Animal and Biomedical Sciences, Massey University,  
Palmerston North, New Zealand.

Yellow-eyed penguins *Megadyptes antipodes* are an endangered endemic bird of New Zealand and the Subantarctic islands. We investigated the role of the haemoparasite *Leucocytozoon* in recent outbreaks of chick mortality on Stewart Island. All (7) chicks tested and 10 of 11 adults were infected. Haemoparasitism is a cause of both sporadic deaths and mass-mortality in captive and wild penguins throughout the world. Major mainland and offshore colonies were therefore sampled and were analysed by a multi-haematozoa PCR to identify infection and establish prevalence at a population level. Further, we will identify the *Leucocytozoon* at a species level by DNA sequencing to allow comparison with an endemic *L. tawaki* infection found in nearby Fiordland crested penguins; and thereby establish if this mortality is due to disease emergence or cross-species infection.

## AT-SEA TIME BUDGET FOR GENTOO PENGUINS DURING WINTER

JEFFERSON T. HINKE<sup>1,2,\*</sup>

1. Scripps Institution of Oceanography, UCSD, La Jolla, CA 92093

2. Antarctic Ecosystem Research Division, NOAA-SWFSC, La Jolla, CA 92037

\* [jhinke@ucsd.edu](mailto:jhinke@ucsd.edu)

Winter periods (April – September) may represent an important bottleneck for penguin populations in the South Shetland Islands. To study behaviors and patterns of habitat use by gentoo penguins (*Pygoscelis papua*) during winter, archival temperature tags were attached to post-molt adults in February 2005 and 2006 at Admiralty Bay, King George Island and Cape Shirreff, Livingston Island. Eight tags were recovered from 4 penguins in November 2005 and from 4 penguins in November 2006. Trip frequency was nearly daily throughout the winter and trips occurred primarily during daylight hours, tracking the seasonal cycle of day length. However, there was more individual variation in trip duration during late winter than early winter. Trip duration appears to depend weakly on day length and the daily wind regime, while trip initiation may depend on air temperature. Similar trip durations across individuals during early winter suggest that adults take full advantage of available daylight, possibly to restore mass lost during the molt. Late winter trips are more variable across individuals, possibly related to pre-breeding activity or local resource availability. Similar behaviors during early winter suggest that this period may be critical, and conditions that limit foraging trips during this time may help determine over-winter survival.

## **SPHENISCIDAE AND THE CITY: LITTLE PENGUINS IN ST KILDA**

ZOE M HOGG, TIANA PRESTON.  
Earthcare St Kilda Inc., Victoria, AUSTRALIA

A colony of little penguins live on a breakwater built in 1956 around St Kilda Harbour. St Kilda is a seaside suburb close to the centre of Melbourne Australia. Part of the breakwater is open to the general public but this does not deter habitation and breeding. The penguins live deep in the rock structure of the breakwater and feed almost exclusively in Port Phillip Bay. Many aspects of the colony have been recorded and analysed. The colony has been visited twice a month by research teams since 1986. During this time the number of penguins has grown from 100 to 1025. The poster shows details of this growth along with the catch rate and average mass of the birds.

## **THERMOREGULATORY COSTS DURING BREEDING IN THE LITTLE PENGUIN**

LYNDAL R. HORNE, JON A. GREEN AND PETER B. FRAPPELL

Adaptational and Respiratory Evolutionary Physiology Research Group,  
Department of Zoology, La Trobe University, Melbourne, Victoria, 3086, Australia

While primarily adapted for life at sea, little penguins (*Eudyptula minor*) are constrained to breed and moult on land. Little penguins are known to be very sensitive to prolonged heat exposure, so assessing their heat tolerance is particularly important in the context of global warming and climate change. While burrows generally offer some protection against the environment, the use of artificial burrows can intensify the heat due to solar radiation. We therefore assessed the thermoregulatory responses of little penguins from Flinders Island (Tas), Penguin Island (WA), Kangaroo Island (SA) and Phillip Island (Vic) using open-flow respirometry. Phillip Island penguins were found to be most sensitive to heat; exhibiting an increase in thermoregulatory costs above 27°C. Temperatures at Phillip Island often exceed 27°C over the summer, during the penguin breeding season. The temperature and humidity of natural burrow were monitored over the summer using data loggers (i-buttons). These burrow temperatures in conjunction with respirometry values were used to estimate the thermoregulatory costs during breeding. The implications of climate change on little penguin energetics will also be discussed.

**SEPARATE AND EQUAL: HUSBANDRY AND MANAGEMENT ASPECTS OF TREATING LITTLE PENGUINS *EUDYPTULA MINOR* FOR *MYCOBACTERIUM AVIUM* AT OMAHA'S HENRY DOORLY ZOO**

BARBARA HOWARD<sup>1</sup>, THOMAS CURRO, DVM<sup>3</sup>, FRANCOIS LAMPEN, BVSC<sup>4</sup>,  
STEVEN HINRICHS, MD<sup>2</sup>, DOUGLAS ARMSTRONG, DVM<sup>1</sup>

<sup>1</sup> Omaha's Henry Doorly Zoo, 3701 S. 10<sup>th</sup>, Omaha, NE 68107

<sup>2</sup> Nebraska Public Health Laboratory, University of Nebraska Medical Center,  
984080 Nebraska Medical Center, Omaha, NE, 68198

<sup>3</sup> Six Flags Great Adventure Wildlife Safari, Hwy 537, Jackson, NJ 08527

<sup>4</sup> PO Box 15718, East Lynn 0039, South Africa

The husbandry and management of penguins in captivity can be a challenge due to their susceptibility to respiratory problems. Managing penguins outdoors adds yet another layer to the complexity. In January 2004, a female little blue penguin *Eudyptula minor* was diagnosed via histopathology and culture with *Mycobacterium avium* complex. Over subsequent months multiple birds were diagnosed with the disease, which presented clinically primarily as a respiratory disease. The entire colony was eventually placed under quarantine and started on treatment. The treatment consisted of a combination of three oral antimicrobials: clarithromycin, ethambutol and rifampin. The drug intake as well as daily vitamins and prophylactic treatment for avian malaria were closely monitored. Treatment was administered continuously for nine months. No adverse effects to the treatment were noted. The treatment was successful in controlling symptoms of the disease but was unsuccessful in clearing the disease from the population. A single bird developed lesions and symptoms three months following the conclusion of treatment. The risk of transmission to other birds, particularly cold climate penguins, was a concern and was minimized with appropriate management protocols and facility modification that will be presented in detail. To date, no transmission to other groups has occurred.

## FORAGING HABITAT OF THE ADÉLIE PENGUIN, AT DUMONT D'URVILLE IN ADÉLIE LAND (EAST ANTARCTICA)

A. JAEGER<sup>A</sup>, C. VALLET<sup>B</sup>, P. KOUBBI<sup>B</sup>, C.-A. BOST<sup>A</sup>

<sup>a</sup> Centre d'Etudes Biologiques de Chizé UPR 1934 du-CNRS, 79360 Villiers-en-Bois, France.

<sup>b</sup> Laboratoire d'Ichtyologie Marine de l'Université du Littoral, Boulogne sur Mer, France.

Few studies have been carried out on the influence of the physical marine parameters on the at-sea distribution of penguins. This concerns especially the Adélie penguin *Pygoscelis adeliae*. Previous work has documented some influences of sea-ice extent and dispersion or bathymetry. However, very few information is available about the influence of hydrological characteristics on habitat use and foraging preferences. We studied the at-sea movements of satellite-tracked Adélie penguins over 3 summers (n=11, 10, and 13 birds successfully tracked in 2004, 2005 and 2006, respectively). Oceanographic surveys were performed at the same time using the 65m vessel "Astrolabe" in the penguins' foraged range in Adélie land sector (136°11' - 142°02'E), physical parameters were continuously recorded. In addition, diet analysis of tracked penguins was performed in 2004-2005 by using water-off loading method. The penguins foraging habitat showed large inter-annual variations in relation with changes in water density. Overall penguins concentrated their foraging effort on the edges of a wide canyon connected to oceanic waters which support important concentration of their major preys: *Euphausia superba* and *Pleuragramma antarcticum*. Adélie penguins also foraged preferentially in denser and colder seawater potentially favourable to prey aggregations.

# FACTORS INFLUENCING THE DISTRIBUTION OF LITTLE PENGUIN *EUDYPTULA MINOR* BURROWS ON PHILLIP ISLAND, VICTORIA, AUSTRALIA

ROSALIND JESSOP<sup>1</sup>, OLIVIA HALTMEIER<sup>2</sup> & TWIGA VAN DER WERF<sup>2</sup>

<sup>1</sup>Phillip Island Nature Park, Victoria, Australia

[rjessop@penguins.org.au](mailto:rjessop@penguins.org.au)

<sup>2</sup> Van Hall Institute, The Netherlands.

Little penguins *Eudyptula minor* nest in burrows in a variety of soil and vegetation types. At Phillip Island, the landscape of penguin colonies has been modified over time and knowing more about why little penguins choose particular areas to breed would assist the development of a habitat management plan. This study examined the effect of nest characteristics such as nest type, soil type, hole shape and orientation, surface slope and roof vegetation type on the timing of breeding of the little penguins breeding in the Penguin Parade area of the Phillip Island Nature Park. The study also investigated the influence of distance from the coastline, human and penguin walkways on the density of little penguin nests. Factors affecting the timing of breeding were:

- a. the type of vegetation above the burrow: penguins nesting under *Boobialla Myporium insulare* bred earlier than other birds
- b. the slope of the ground: penguins bred earlier if nest entrances were angled at 25 to 35 degrees and
- c. orientation of the burrow entrance: penguin with burrows facing west bred earlier.

Burrows were most dense between 30 and 120m of the shoreline. Human walkways did not appear to effect burrow density. Penguin burrows were most dense nearest penguin walkways.



## **RAPID INCREASE IN ADÉLIE PENGUIN POPULATIONS IN THE LÜTZOW-HOLM BAY**

AKIKO KATO & YAN ROPERT-COUDERT  
National Institute of Polar Research, Japan

The Adélie penguin, *Pygoscelis adeliae*, an important component of the Antarctic marine ecosystem, is closely associated with sea ice and thought to be affected by global warming. Ten breeding populations along the Soya Coast of Lützow-Holm Bay have been monitored since the 1960s by the Japanese Antarctic Research Expedition. In most colonies, moderated increases in population sizes were observed in the late 1980s with a rapid increase from the mid 1990s. Frequent sea-ice break-ups occurred in the mid 1980s and since the late 1990s in Lützow-Holm Bay. During this period, sea-ice condition around the colony was not severe in summer and both chick growth and chick survival rates were high. We believe that changes in sea ice condition have induced the population increase through enhanced subadult survival and prey availability. These recent trends stress the importance of continuing population monitoring programs in the forthcoming years in relation to environmental changes.

**WHAT'S AGE GOT TO DO WITH IT?  
PATTERNS OF MOULT SEASONALITY OF AFRICAN PENGUINS IN NAMIBIA**

KEMPER, J.<sup>1</sup>, ROUX, J-P.<sup>2</sup> & UNDERHILL, L.G.<sup>1</sup>

<sup>1</sup> Avian Demography Unit, University of Cape Town, Rondebosch 7701,  
Cape Town, South Africa

<sup>2</sup> Ministry of Fisheries and Marine Resources, Lüderitz Marine Research,  
PO Box 394, Lüderitz, Namibia

African penguins *Spheniscus demersus* acquire their adult plumage during the first (juvenile) moult after fledging and become indistinguishable from sexually mature adults. However, African penguins do not reach sexual maturity until they are three years or older. Counts of moulting juvenile and adult penguins and information derived from banded individuals were used to describe juvenile and adult moult seasonality patterns and to examine the relationship between age and timing of moult of African penguins in Namibia. Despite a protracted breeding season, juvenile penguins in Namibia showed a monomodal seasonal moult pattern with a peak during the austral mid-summer and few moulting birds during winter. Juvenile penguins were found to moult into adult plumage at the age of 12 to 23 months. The timing of fledging dictated its age at juvenile moult, determined which moult season it moulted in and influenced the timing of moult within the season. Age at juvenile moult appeared to be constrained by minimum age, moult seasonality and plumage wear. Moult seasonality of penguins in adult plumage in Namibia was bimodal. This pattern was linked to breeding seasonality. Penguins younger than four years moulted in early January, at the same time as juvenile penguins. Birds older than six years moulted four months later, in early May. Penguins aged between four and six years either moulted early or late. These were likely to be individuals making the transition from non-breeder to breeder. The relationship between age and moult seasonality provided the means of assigning juvenile recruits to specific age groups and allowed estimates of the number of sexually mature penguins in a population.

## WHEN TO BREED? BREEDING SUCCESS IN RELATION TO EGG-LAYING DATE AT FOUR AFRICAN PENGUIN BREEDING LOCALITIES IN NAMIBIA

KEMPER, J.<sup>1</sup>, UNDERHILL, L.G.<sup>1</sup>, ROUX, J-P.<sup>2</sup>, BARTLETT, P.A.<sup>2</sup>, CHESSELET, Y.J.<sup>2</sup>, JAMES J.A.C.<sup>2</sup>, JONES, R.<sup>2</sup>, UHONGORA, N-N.<sup>2</sup> & WEPENER, S.<sup>2</sup>

<sup>1</sup> Avian Demography Unit, University of Cape Town  
Rondebosch 7701, Cape Town, South Africa

<sup>2</sup> Ministry of Fisheries and Marine Resources, Lüderitz Marine Research  
PO Box 394, Lüderitz, Namibia

African penguins *Spheniscus demersus* in Namibia bred throughout the year with breeding peaks varying between localities. Breeding success of African penguins was investigated at the four main breeding localities in Namibia, spanning c. 150 km of coastline and supporting 96% of the Namibian penguin population. These localities differ in a number of aspects, particularly oceanographic features, local food availability, nesting habitat, predation intensity and topography. Monthly counts of nest containing eggs or chicks were used to describe breeding seasonality patterns at each locality. In addition, nest contents of a total of 2 780 nests were monitored between December 1996 and April 2004 at these localities. Egg-laying date was the most important determinant of breeding success. Nests initiated at the end of October at Mercury, Ichaboe and Halifax Islands had the best probability of producing fledglings than at any other time of the year; at Possession Island the best probability was one month earlier. The timing of breeding roughly coincided with the period of maximum probability of nest success at Mercury, Ichaboe and Possession Islands. However, at Halifax Island, the timing of peak breeding corresponded to a modelled nest survival probability less than half the maximum. This mismatch is probably the result of a combination of climatic and trophic factors and seasonal predation pressure and contributes to the poor breeding success at Halifax Island compared to the other localities.

## BREEDING SUCCESS OF YELLOW-EYED PENGUINS ON STEWART ISLAND AND OFF-SHORE ISLANDS

SANDY KING<sup>1</sup>

Yellow-eyed Penguin Trust, PO Box 5409, Dunedin, New Zealand

[yeptrust@gmail.com](mailto:yeptrust@gmail.com) [www.yellow-eyedpenguin.org.nz](http://www.yellow-eyedpenguin.org.nz)

<sup>1</sup> [sdk@callsouth.net.nz](mailto:sdk@callsouth.net.nz)

The yellow-eyed penguin (*Megadyptes antipodes*) is endemic to New Zealand. Breeding populations exist on the south-east coast of the South Island, Stewart Island and outliers, and the subantarctic Auckland and Campbell Islands. The total population is estimated at approximately 2000 pairs, of which 460 are found on the South Island. Until the late 1990s, it was proposed that a similar number existed on Stewart Island. A survey by the Yellow-eyed Penguin Trust in 1999-2001 found only 125 pairs on Stewart Island, and another 80 pairs on close outliers. Few juveniles were observed during the survey, indicating poor breeding success. Breeding success on Stewart Island has been consistently low over four years of study (0% - 33%), while that on off-shore islands has ranged from 27% - 63%. The above findings prompted the Trust and Department of Conservation to initiate a study into factors affecting breeding success on Stewart Island and its off-shore islands. In the absence of a mustelid population (the main predators of penguin chicks on the South Island), the study looked for evidence of penguin predation by the large feral cat population on Stewart Island but found none. However, the study did identify starvation and disease as significant causes of chick mortality.

## **CONSTRUCTION OF A NOVEL NEBULIZING CHAMBER FOR IN EXHIBIT USE WITH MAGELLANIC PENGUINS (*SPHENISCUS MAGELLANICUS*)**

KATHLEEN LARSON & AMANDA SHAFFER  
Point Defiance Zoo & Aquarium

Point Defiance Zoo & Aquarium faced a severe outbreak of aspergillosis in the penguin and puffin populations during the summer of 2006. A novel nebulizing chamber for use on main display was constructed to allow inhalant therapy while minimising the stress associated with treatment. The chamber was built from an artificial rock (21 inches in height) previously used as a burrow, and closely cut Plexiglass sheets (from Optix Acrylic sheet, 0.093 inches, 36 by 48 inches) that formed the base and door. The different pieces were joined together using industrial-strength Velcro, and the chamber was made vapour and water-proof with weather stripping and duct tape. For easy use on exhibit, a Nebulair Portable Veterinary Ultrasonic Nebulizer was attached with Velcro inside the chamber. The combination of a portable nebulizer and an aesthetically pleasing nebulizing chamber allowed consistent and effective treatment on exhibit.

## IMPORTANCE OF APPLYING PROTOCOLS FOR THE REHABILITATION OF MAGELLANIC PENGUINS (*SPHENISCUS MAGELLANICUS*)

ALICE T. MEIRELLES LEITE<sup>1</sup>, ANDRÉA C. ADORNES<sup>1</sup>, JOSÉ MARIA BARREDO<sup>2</sup>,  
VALERIA RUOPPOLO<sup>\*2</sup> & RODOLFO P. SILVA-FILHO<sup>1, 2</sup>

\*Corresponding Author: [vruoppolo@uol.com.br](mailto:vruoppolo@uol.com.br)

1- Centro de Recuperação de Animais Marinhos - Museu Oceanográfico "Prof. Eliézer de C. Rios",  
Fundação Universidade Federal do Rio Grande (CRAM – MO, FURG). Rua Cap. Heitor Perdigão 10, CEP  
96200-970, Rio Grande, RS.

2- International Fund for Animal Welfare (IFAW), Emergency Relief Team [www.ifaw.org](http://www.ifaw.org)

Each year hundreds of distressed Magellanic penguins show up on beaches from Southern Argentina to Southern Brazil. These birds are typically found emaciated, oiled or tangled in fishing tackle. On the Brazilian coast the majority are juvenile birds but adults are also present. The Oceanographic Museum in Rio Grande, Brazil, began receiving these birds in 1974, and in 1997 a proper facility for marine animal rehabilitation (CRAM) was established. In 10 years since, CRAM has experienced a significant increase in survivability of birds from 40% in the early years to an annual average of 80%. This due to the development and application of practical and effective rehabilitation protocols for penguins. These protocols address the primary issues that these birds face including emaciation, severe dehydration, hypothermia, immune suppression, anaemia and secondary problems associated with these conditions. The rehabilitation of wild animals has a time frame to be accomplished, which can be called: *window of opportunity*. If missed, the incidence of secondary problems related to captivity (e.g. aspergillosis, pododermatitis, loss of feather integrity etc.) increases and the release rate, conversely, declines. This fact emphasizes the importance of applying efficient treatment protocols. This paper will discuss the development of CRAM's protocols and how they can be used as a tool by other institutions that rehabilitate Magellanic penguins to significantly increase and maximize survivability.

## **A COMPARISON OF THE BREEDING SUCCESS OF AFRICAN PENGUINS IN ARTIFICIAL NEST BOXES AND AT NATURAL SITES AT ROBBEN ISLAND, SOUTH AFRICA DURING 2005 AND 2006**

TM LESHORO<sup>1</sup>, PJ BARHAM<sup>2</sup>, BJ BARHAM<sup>3</sup>, LG UNDERHILL<sup>4</sup>, RJM CRAWFORD<sup>5</sup>,  
BM DYER<sup>5</sup> AND L UPFOLD<sup>5</sup>

<sup>1</sup>Robben Island Museum, Private Bag X, Robben Island 7400, South Africa

<sup>2</sup>HH Wills Physics Laboratory, University of Bristol, Tyndall Avenue, Bristol BS8 1TL, UK

<sup>3</sup>Penguin Datasystems, Bristol BS6 6QS, UK

<sup>4</sup>Avian Demography Unit, Department of Statistical Sciences,  
University of Cape Town, Rondebosch 7701, South Africa

<sup>5</sup>Marine and Coastal Management, Department of Environmental Affairs and Tourism  
Private Bag X2, Rogge Bay 8012, South Africa

At many of its breeding localities, African penguins *Spheniscus demersus* are no longer able to nest in burrows because former guano scraping removed the substrate in which they burrowed to bedrock. At Dassen Island, it was found that 20%, 30% and 35% respectively of eggs from nests on surface, under rocks and in burrows produced fledged young. Burrows have a more constant microclimate than surface nests: relative humidity is higher, air temperatures fluctuate less, wind effect is negligible and birds are not exposed to direct sunlight. At Robben Island, where habitat is generally unsuitable for burrowing, only 1.2% of birds nested in burrows in 1992. Recent decreases in the overall population of African penguins have sparked efforts to decrease mortality and improve reproductive success. At Robben Island, 58 artificial nest boxes have been laid out for penguins. Many have been occupied. Five pairs used the boxes in 2005, 18 in 2006 and by the end of July 2007, 16 were in use. In 2005, pairs breeding in the nest boxes fledged an average of 1.40 chicks per breeding attempt compared to an average of 0.78 elsewhere. In 2006, the respective values were 1.12 and 0.55. These results suggest that breeding success can be markedly improved through the provision of suitable nest sites for African penguins.

## **LITTLE PENGUIN CONSERVATION**

N LONGHI

Perth Zoo, Western Australia

Perth Zoo promotes little penguin conservation in a variety of ways including keeper talks and interpretative signage. Visitors are given the opportunity to learn about the penguins and the threats affecting wild populations. Perth Zoo's school education program runs a 'Cool Penguin' class that explores the effects of human activities on little penguins. This successful education experience encourages positive actions to protect little penguins and their fragile habitats. In conjunction with the Department of Environment Conservation (DEC), Perth Zoo has recently commenced rehabilitating injured wild little penguins. The efforts of Perth Zoo staff and DEC will result in our first release of a rehabilitated wild little penguin towards the end of 2007. By creating awareness of current conservation issues, Perth Zoo encourages visitors to become more active in the conservation of our native fauna.



## **FISH OTOLITHS FROM ORNITHOGENIC SOILS FOR INVESTIGATING HOLOCENE ADÉLIE PENGUIN DIET VARIATION IN VICTORIA LAND, ANTARCTICA**

LORENZINI S.<sup>1</sup>, OLMASTRONI S.<sup>2</sup>, SALVATORE M.C.<sup>3</sup> & BARONI C.<sup>1</sup>

<sup>1</sup>Dipartimento di Scienze della Terra, Università degli Studi di Pisa,  
Via S. Maria 53, 56126 Pisa, Italy

<sup>2</sup>Dipartimento di Scienze Ambientali "G. Sarfatti", Università degli Studi di Siena,  
Via Mattioli 4, 53100 Siena, Italy

<sup>3</sup>Dipartimento di Scienze della Terra, Università di Roma "La Sapienza",  
P.le A. Moro, 5, 00185 Roma, Italy

Paleodiet studies on ornithogenic soils are valuable for investigating the relationship between eco-environmental trend of Adélie penguins and global environmental changes. Ornithogenic soils consist of accumulation of droppings, feathers, egg fragments and bird remains. Their thickness depends on the age of establishment: the thicker the soil, the older the colony. Organic soils occur in active Adélie penguin colonies and at their margins, thus testifying to the presence of abandoned nesting sites. Abandoned (relict) Adélie penguin colonies have been discovered in Victoria Land (Antarctica) in areas where penguins do not breed at present. Soils retained in relict colonies have been radiocarbon dated and supplied relevant data on the Holocene environmental history of Victoria Land. Being resistant to digestion and erosion, hard parts of penguin prey such as fish bones, otoliths and squid beaks are preserved in ornithogenic soils. Otoliths allow the identification and size-estimation of prey eaten. More than 1000 otoliths (about 500 individuals) have been identified as *Pleuragramma antarcticum* (85%), *Pagothenia* sp. (2.2%) *Trematomus bernacchii* (1.7%), *Trematomus scotti* (0.2%); about 10% of the otoliths remained unidentified. Frequency distribution of *P. antarcticum* sizes shows that 73.6% was 40-80 mm. Their age ranges from about 8000 yrs BP to the present.

## THE ANTARCTIC SITE INVENTORY: LONG-TERM BREEDING BIRD SURVEYS ALONG THE ANTARCTIC PENINSULA

HEATHER J. LYNCH, WILLIAM F. FAGAN & RON NAVEEN\*

*Department of Biology,*

*University of Maryland, College Park MD USA 20742*

*\*Oceanites, Inc., P.O. Box 15259, Chevy Chase, MD 20825 USA*

The Antarctic Site Inventory (ASI) is a large-scale program of observational monitoring research managed by the nonprofit foundation Oceanites, Inc. Since 1994, the ASI has made 754 visits to 116 sites located throughout the Peninsula. Accumulated ASI data hint at significant changes in the populations of the three *Pygoscelis* species, particularly along the southwestern coast of the Peninsula, where there is strong evidence for decreasing Adélie and chinstrap penguin populations and increasing populations of gentoo penguins. In addition, the ASI has documented the southward expansion of the gentoo penguin breeding range, with the establishment of a new gentoo colony at the Yalour Islands (65°14'S, 64°10'W). In this poster, we detail the spatial and temporal coverage of the Inventory, what kinds of data the Inventory collects, and how these data are being used to model spatiotemporal changes in the *Pygoscelis* penguin populations of the Antarctic Peninsula.

**FINE-SCALE DIVING BEHAVIOUR DURING FORAGING IN BREEDING KING PENGUINS  
*APTENODYTES PATAGONICUS* AT ISLES KERGUELEN: A 3 YEAR STUDY**

MCGOWAN T.<sup>1</sup>, HINDELL M.<sup>1</sup>, CHARRASSIN J.-B.<sup>2</sup>, BOST C.-A.<sup>3</sup>

<sup>1</sup>Antarctic Wildlife Research Unit, University of Tasmania, Hobart, Australia

<sup>2</sup>Muséum National d'Histoire Naturelle, Paris, France

<sup>3</sup>Centre d'Etude Biologique de Chizé, CNRS, Chizé, France

Developing methods to quantify foraging effort and success has been the central aim of much research into the foraging behaviour of marine mammals and seabirds. This is important for understanding how inter-annual variability in key oceanographic features influence predator/prey interactions and the flow on effects to population trajectories. We studied king penguin *Aptenodytes patagonicus* foraging behaviour at Isles Kerguelen during summer over three contrasting years (1998-2000) in relation to environmental parameters, using swimming speed and associated foraging characteristics, as proxies for prey encounter events. Both environmental (sea temperature) and behavioural (swim speed and diving depth) data were collected simultaneously using speed-time-temperature-depth recorders (STTDR), and were therefore acquired at the same temporal and spatial scales. Data were collected by 19 brooding birds: 9 in 1998 and 5 in each of 1999 and 2000. Mean foraging trip durations were 7 days and 1447 dives in 1998, 8 days and 1672 dives in 1999, and 9 days and 1545 dives in 2000. It was therefore possible to investigate the fine-scale foraging behaviour of king penguins on a dive-to-dive basis in response to prey distribution and in relation to the thermal structure of the water column.

**PREDATION OF AFRICAN PENGUINS (*SPHENISCUS DEMERSUS*) BY CAPE FUR SEALS  
(*ARCTOCEPHALUS PUSILLUS PUSILLUS*) AT DYER ISLAND:  
IMPLICATIONS FOR CONSERVATION**

A. B. MAKHADO, L. G. UNDERHILL & R. J. M. CRAWFORD

African penguins are endemic to southern Africa, where they breed in three regions: southern Namibia, South Africa's Western Cape Province and Nelson Mandela (formerly Algoa) Bay in the Eastern Cape Province (Shelton et al. 1984) at about 27 localities. The total population decreased by 90% in the 20th century; the breeding population in the Western Cape by 45% between 2004 and 2006. A massive decline has been recorded at Dyer Island, where numbers breeding fell from about 23 000 pairs in the late 1970s to about 2 000 pairs from 1997 onwards. Around Dyer Island, Cape Fur Seals (*Arctocephalus pusillus*) prey on penguins. Systematic observations of predation were conducted from June–December 2004, when 13% of adult penguins at the island were killed. This is considered unsustainable. Predation by seals on seabirds in the Benguela system is almost wholly undertaken by subadult male seals. It is anticipated that removal of these animals will substantially reduce the mortality of penguins at the island.

## **DECLINE FOR A DELICACY: ARE DECREASING NUMBERS OF YELLOW-EYED PENGUINS ON STEWART ISLAND A RESULT OF COMMERCIAL OYSTER DREDGING?**

THOMAS MATTERN, URSULA ELLENBERG & LLOYD S. DAVIS

Department of Zoology, University of Otago, P.O. Box 56, Dunedin, New Zealand

The numbers of the endangered yellow-eyed penguins on New Zealand's third largest island, Stewart Island, have been declining considerably over last four years, primarily as a result of low reproductive success. Interestingly, yellow-eyed penguins on adjacent Codfish Island seem to flourish. Here, high nest densities and high reproductive success indicate that the Stewart Island problem is a local issue. Chick starvation on Stewart Island points towards a food related and, thus, sea-based problem. Between 2004 and 2006, we compared foraging ranges and diving behaviour of breeding yellow-eyed penguins from both islands and found that their foraging areas did not overlap. Moreover, the size of the marine areas utilised for foraging by penguins from Stewart Island were only a fraction (ca. 20.4 km<sup>2</sup>) when compared with the foraging grounds of penguins from Codfish Island (ca. 540.0 km<sup>2</sup>). As a primarily benthic forager, the yellow-eyed penguin depends on an intact benthic ecosystem. The foraging activities of penguins from Stewart Island coincide with the only remaining biogenic reefs within their foraging range. Hence it seems likely that the degradation of the benthic habitat by commercial oyster dredging is limiting viable foraging habitat for the penguins and facilitates intra-specific competition for food.

## **MICROFILARIAE IN THE GALÁPAGOS PENGUIN (*SPHENISCUS MENDICULUS*)**

JANE MERKEL\*†, HUGH I. JONES‡, NOAH K. WHITEMAN\*, NICOLE GOTTDENKER†, HERNAN VARGAS§, ERIKA K. TRAVIS†, R. ERIC MILLER†, AND PATRICIA G. PARKER\* †

\*Department of Biology, 223 Research Building, 8001 Natural Bridge Road,  
St. Louis, Missouri 63121

†Saint Louis Zoo, One Government Drive, St. Louis, Missouri 63110.

‡Department of Microbiology, University of Western Australia,  
Nedlands, 6907, Western Australia

§Wildlife Conservation Research Unit and Department of Zoology,  
University of Oxford, OX1 3PS, UK.

Galápagos penguins (*Spheniscus mendiculus*) live in small, isolated populations primarily on the westernmost Galápagos Islands of Fernandina and Isabela in the Galápagos Islands, Ecuador. Blood was collected from 298 Galápagos penguins during 4 seasons including two cool, dry seasons (August 2003 and 2004) and two hot, wet seasons (March 2004 and February 2005). Blood smears were examined for the prevalence and intensity of haemoparasites. Microfilariae parasites were found but no other haemoparasites were present. Microfilariae prevalence in the penguins during the four sampling seasons was 13.8%. Male penguins had higher prevalences than females. There was no relationship between body mass and either prevalence or intensity of parasitism. No seasonal differences in prevalence of microfilariae were detected. Blood smears from flightless cormorants in the same habitat were found to have microfilariae at 42% prevalence. DNA sequence data from the mitochondrial cytochrome c oxidase subunit I gene were consistent with morphological findings and together demonstrate that the penguins and cormorants are infected with the same species of microfilariae. Ongoing work will attempt to trace the origin of these infections.

**YELLOW SPOT - A NEW MORPHOLOGICAL TRAIT OF GENTOO PENGUINS  
(*PYGOSCELIS PAPUA ELLSWORTHII*) IN ANTARCTICA**

R. METCHEVA<sup>1</sup>, V. BEZRUKOV<sup>2</sup>, K.DIMITROV<sup>1</sup>, M. BELTCHEVA<sup>1</sup>, P.ZEHTINDJIEV<sup>1</sup>, Y. YANKOV<sup>3</sup>

<sup>1</sup> Institute of Zoology, Bulgarian Academy of Sciences, 1, Bd.Tzar Osvoboditel  
1000 Sofia, Bulgaria

<sup>2</sup> Taras Shevchenko National University of Kyiv, 64, Volodymyrska Str., Kyiv, 01033, Ukraine

<sup>3</sup> Bulgarian Antarctic Institute, 15, Bd.Tzar Osvoboditel  
1000 Sofia, Bulgaria

A new trait, a spot-like coloration of the bill, observed on the upper mandible of Gentoo (*Pygoscelis papua ellsworthii*). Three breeding colonies were investigated at three different geographical points at Antarctic Peninsula – Livingston Island, South Shetlands (62°38' S), Wiencke Island (64°52' S), and Petermann Island (65°10' S). The “yellow spot” was presented with different frequencies at these three points: 20%, 51%, and 30%, respectively. The spot varied from 1 – 2 mm to 20 – 25 mm, with different colours (from white to red, with yellow, orange and pink intermediate forms). The trait was recorded among the chicks over two months and adult birds (normal and moulting) of both sexes (identified by DNA markers). Some plausible reasons for the beak spot appearance are suggested. The investigations of melanin and carotenoid levels, effects of parasitism, and heredity are considered as powerful approaches to reveal the nature of this variable morphological trait.

**COMPARATIVE POPULATION AND MONITORING RESEARCH ON GENTOO PENGUINS  
(*PYGOSCELIS PAPUA*) IN ANTARCTICA – FROM ITNAS TO COSGEN PROJECTS**

R. METCHEVA<sup>1</sup>, V. BEZRUKOV<sup>2</sup>, K.DIMITROV<sup>1</sup>, M. BELTCHEVA<sup>1</sup>,  
P.ZEHTINDJIEV<sup>1</sup>, K. PAVLOVA<sup>3</sup>, Y. YANKOV<sup>4</sup>

<sup>1</sup> Institute of Zoology, Bulgarian Academy of Sciences, 1, Bd.Tzar Osvoboditel  
1000 Sofia, Bulgaria

<sup>2</sup> Taras Shevchenko National University of Kyiv, 64, Volodymyrska Str., Kyiv, 01033, Ukraine

<sup>3</sup> Department “Microbial Biosynthesis and Biotechnology”, Institute of Microbiology, Bulgarian Academy of  
Sciences, 26, Maritza Blvd. 4002 Plovdiv,

<sup>4</sup> Bulgarian Antarctic Institute, 15, Bd.Tzar Osvoboditel  
1000 Sofia, Bulgaria



## **A REVIEW OF THE DISEASE STATUS OF ROYAL AND KING PENGUINS ON MACQUARIE ISLAND**

GARY D. MILLER AND GEOFFREY R. SHELLAM

Discipline of Microbiology and Immunology,  
School of Biomedical, Biomolecular and Chemical Sciences, M502,  
University of Western Australia, Crawley, WA, 6009 Australia

A number of studies have confirmed the presence of viral, bacterial and parasitic infectious agents in Antarctic and subantarctic penguins. Here we present the results of serological testing for antibodies to infectious bursal disease (IBD) and Newcastle disease on king and royal penguins and Subantarctic skuas from Macquarie Island. We sampled 150 adults of each species plus 26 young of the year (YOY) king penguins and 23 YOY skuas. Similar studies by Morgan et al. from the 1970s discovered antibodies to Newcastle disease virus in 6% of royal penguins, but none in other species. Morgan et al. did not test for IBD. We will compare our current results with the published records of 30 years ago as well as with recent studies from other subantarctic islands and the continental Antarctic sites. In view of current models of climate change, the status of disease on subantarctic islands may predict what we may expect to see on the continent in the future.

## **CYCLES OF *EUPHAUSIA SUPERBA* RECRUITMENT EVIDENT IN THE DIET OF PYGOSCELID PENGUINS AND NET TRAWLS IN THE SOUTH SHETLAND ISLANDS, ANTARCTICA**

AILEEN K. MILLER\* AND WAYNE Z. TRIVELPIECE

Antarctic Ecosystem Research Division, Southwest Fisheries Science Center,  
8604 La Jolla Shores Drive, La Jolla, CA 92037, USA

\* [aileen.miller@noaa.gov](mailto:aileen.miller@noaa.gov)

Size and sex/maturity stages of Antarctic krill *Euphausia superba* taken from chinstrap and gentoo penguin *Pygoscelis antarctica* and *P. papua* diet were compared to those from scientific net surveys in the South Shetland Islands from 1998-2006 in order to evaluate penguin diet as a sampling mechanism and to look at recent trends in krill populations. Both penguin diet and net samples revealed a 4-5 year cycle in krill recruitment with one or two strong cohorts sustaining the population during each cycle. Penguin diet samples contained adult krill of similar lengths to those caught in nets; however, penguins rarely took juvenile krill even when small krill were observed in the nets. The greatest differences between penguin and net samples were therefore at the beginning of each cycle when krill were smallest (1998 and 2002). Penguin diet samples also contained more females when the krill population was dominated by large adults at the end of the cycles (2000-2001 and 2005-2006); net samples showed greater proportions of males in these years. These patterns are comparable to those reported elsewhere in the region and are likely driven by the availability of different sizes and sexes of krill in relation to the colony.

## DIVING BEHAVIOURS OF THE CHINSTRAP PENGUINS IN RELATION TO BREEDING STAGE AND SEX

YOSHIHISA MORI (1)\*, AKINORI TAKAHASHI (2), NOBUO KOKUBUN (3), & HYOUNG-CHUL SHIN(4)

(1) Teikyo University of Science and Technology, Uenohara,  
Yamanashi 409-0193, Japan moripe@ntu.ac.jp

(2) National Institute of Polar Research, Itabashi, Tokyo 173-8515, Japan

(3) Department of Polar Science, The Graduate University for Advanced Studies  
Itabashi, Tokyo 173-8515, Japan

(4) Korea Polar Research Institute, KORDI, Songdo Techno Park, Songdo-Dong 7-50  
Yeonsu-Gu, Incheon 406-840, Korea

The chinstrap penguin, *Pygoscelis antarctica* is a monogamous species, and the male and the female in a pair makes foraging trip in turn during the incubation and chick guarding periods. In the incubation period, the male and the female forage for their own needs, whereas in the chick guarding period, they also need to forage for their chicks. This suggests that foraging strategy in diving behaviour may change between the incubation and chick guarding periods. In addition, sex difference in diving ability due to difference in body size predicts that the foraging strategy should differ between males and females. Therefore, it is expected that foraging efforts such as dive duration, dive depth, number of dives in a bout are different between sexes and/or breeding stages. We recorded diving behaviours of 5 pairs and 9 pairs of incubating and chick guarding chinstrap penguins, respectively, in King George Island, Antarctica. We will examine whether there are any differences predicted in diving behaviour between breeding stages and sexes.

## **THE ANTARCTIC SITE INVENTORY AND ANTARCTIC TREATY SITE MANAGEMENT**

RON NAVEEN, Oceanites, Inc., P.O. Box 15259, Chevy Chase, MD 20825 USA  
HEATHER J. LYNCH, Department of Biology, University of Maryland,  
College Park MD USA 20742

Under the auspices of the U.S. nonprofit organization, Oceanites, Inc., the Antarctic Site Inventory began fieldwork in 1994 to examine whether opportunistic visits can be used to effectively and economically detect changes in those physical and biological features of the Antarctic Peninsula being visited repeatedly by ship-based tourists, and to determine how best to minimize or avoid possible environmental impacts of tourism and non-governmental activities along the Peninsula. At the 29<sup>th</sup> and 30<sup>th</sup> Antarctic Treaty Consultative Meetings in 2006/07, Parties adopted tourist visitation guidelines for 13 key visitor sites on the Antarctic Peninsula, relying almost exclusively on the biological data and site-descriptive information contained in the Inventory database. This poster delineates how Inventory data are collected in the field, compiled and made available to various users (government officials, scientists, the tourism industry, and the general public), and, ultimately, translated into useful management guidelines under the Antarctic Treaty.

## **STATUS OF CRESTED PENGUIN POPULATION BETWEEN ISLA TERHALTEN AND ISLA RECALADA, CHILE**

DAVID A. OEHLER, STEVE PELIKAN, W. ROGER FRY,  
LEONARD A. WEAKLY JR & MANUEL MARIN

Coastal reconnaissance, by boat, was conducted along the coast of Chile between Isla Terhalten and Isla Recalada to determine the breeding locations of rockhopper (*Eudyptes c. chrysocome*) and macaroni (*E. chrysolophus*) penguins and to count the numbers of nest occupied during the early incubation period. Outer islands were surveyed, between 52°20'S and 55°26'S, visiting known locations of rockhopper and macaroni penguin colonies and expanded searches of adjacent islands. A yacht based observation of 1,000 rockhopper penguin nests was recorded at Isla Terhalten. A total of 145,000 rockhopper and 4,500 macaroni nests were documented in 18 breeding colonies at Isla Noir. One previously unreported breeding colony of macaroni penguin was found on Leonard Island and no rockhopper or macaroni penguins were observed within historical breeding colonies at Isla Recalada. This survey suggests the population of these penguins may be shifting towards the southern island of the study area.

## THE USE OF OTOLITHS IN ESTIMATING FISH PREYED BY ADÉLIE PENGUINS

S. OLMASTRONI, F. PEZZO, B. SPRUGNOLI, S. FOCARDI

Dipartimento di Scienze Ambientali "G. Sarfatti", Università degli Studi di Siena

Via P.A. Mattioli 4, 53100 Siena, Italy

Monitoring the feeding ecology of higher marine top predators is a crucial aspect of research in the Antarctic. Adélie penguin has been reported as a krill eating species, but also fish plays an important role during chick rearing period, especially in the Ross Sea region. In order to identify fish species eaten by Adélie penguins breeding in the area of Terra Nova Bay (Ross Sea) analysis of 324 otoliths contained in 20 stomach contents were carried out. Samples were collected at Edmonson Point (11) and Inexpressible Island (9) during 2000/01 summer season (CCAMLR Ecosystem Monitoring Programme). Fish content was composed of 179 individuals and identified in 4 species, of which 95% was *Pleuragramma antarcticum*. The mean size of *P. antarcticum* predated was 63.78 mm ( $n=58$ ; range 38.98-185.74;  $SD=30.98$ ). Frequency distribution of sizes showed that 48.28% was between 40 and 50 mm. The comparison between locations confirmed *P. antarcticum* represented the higher percentage of species eaten in both colonies. At Inexpressible Island a higher numbers of individuals were preyed with respect to Edmonson Point ( $n=145$  and  $n=34$ ,  $p<0.001$ ) but that penguins of Edmonson Point were eating larger fish.

**FALKLAND ISLANDS PENGUIN CONSERVATION:  
BIOLOGICAL STUDIES AND MONITORING OF POPULATION AND HEALTH STATUS THROUGH  
LOCAL, REGIONAL AND INTERNATIONAL COLLABORATIONS**

Falklands Conservation, Falkland Islands Government, New Island Conservation Trust (Falklands), Max Planck Institute for Ornithology (Germany), Instituto Superior de Psicologia Aplicada (Portugal), Antarctic Research Trust, Edinburgh Zoo (UK), University of Washington (USA), Wildlife Conservation Society (USA).

Submitted on behalf of all the organisations by HELEN OTLEY, Environmental Officer, Falkland Islands Government, Stanley, Falkland Islands FIQQ 1ZZ, UK ([hotley.planning@taxation.org.fk](mailto:hotley.planning@taxation.org.fk))

The Falkland Islands holds significant proportions of the world's population of the southern rockhopper penguin, Magellanic penguin and gentoo penguin, as well as a few king penguin colonies and a handful of breeding macaroni penguin pairs. In addition, the Falkland Islands is an important site for numerous bird species, marine mammals, and land and marine invertebrates and plants. For a small island in its remote setting, the Falklands community finds it challenging to address all its biodiversity issues. Securing the required scientific support, expertise and funding can be difficult. However, through local, regional and international collaborations, the Falklands community has made many significant achievements in penguin conservation. Our five penguin species island-wide population monitoring programme is in its 21<sup>st</sup> year, we have assessed how the penguin species interact with our domestic fishing fleets, we have conducted basic biological studies of four penguin species, as well as having satellite tracking data for three penguin species during and post-breeding. There is also an on-going assessment of the wildlife diseases present in our penguin populations. We are managing our growing nature tourism industry so that breeding penguins are not disturbed by visitors. The southern rockhopper penguin is the most critical penguin conservation issue in the Falkland Islands. Again, collaboration is the key and scientists working in the Falkland Islands have joined forces with scientists studying rockhopper penguins on Tristan da Cunha and Gough Island as well as on islands that belong to Chile and Argentina. During 2008, all the scientists concerned will be developing a South Atlantic Rockhopper Penguin Action Plan, with complementary research and conservation programmes to be initiated across the region.

## PHYLOGEOGRAPHY OF THE LITTLE PENGUIN *EUDYPTULA MINOR*

AMANDA J. PEUCKER<sup>1</sup>, PETER DANN<sup>2</sup>, CHRIS P. BURRIDGE<sup>3</sup>

<sup>1</sup> School of Life and Environmental Sciences, Deakin University  
P.O. Box 423, Warrnambool, Victoria, Australia.

<sup>2</sup> Phillip Island Nature Park, P.O. Box 97, Cowes, Victoria, Australia.

<sup>3</sup> Department of Zoology, University of Otago, P.O. Box 56,  
Dunedin, New Zealand.

The little penguin, *Eudyptula minor*, occurs along the southern coastline of Australia, around New Zealand and on associated islands. A phylogeographic study of the species by Banks *et al.* (2002) indicated a division of the species into two clades: one consisting of two Australian and two Otago (NZ) individuals, and the other clade containing eight individuals from non-Otago New Zealand. There was limited support for the sub-species division of the non-Otago individuals proposed by Kinsky and Falla in 1976. We collected samples from across the entire Australian range of the little penguin (n=84) and added further New Zealand individuals (n=111). We confirm the findings of Banks *et al.* of two clades, however, we now have more detailed geographic information regarding their distribution, and comment on their likely origins. The division of sub-species does not appear to be clear, although individuals from the Chatham Islands, approximately 800km east of Christchurch, appear somewhat distinct.



## **DOG TRIAL: PROTECTING LITTLE PENGUINS FROM FOX PREDATION**

AMANDA J. PEUCKER<sup>1,3</sup>, PHILIP DUGUESCLIN<sup>2,3</sup>, IAN FITZGIBBON<sup>3,4</sup>,  
KRISTIE KING<sup>1,3</sup>, ALLAN MARSH<sup>5</sup>, DAVID WILLIAMS<sup>1,3</sup>

<sup>1</sup> School of Life and Environmental Sciences, Deakin University,  
P.O. Box 423, Warrnambool, Victoria, Australia.

<sup>2</sup> Department of Sustainability and Environment, Julia Street, Portland, Victoria, Australia.

<sup>3</sup> Warrnambool Coastcare/Landcare Group, P.O. Box 558, Warrnambool, Victoria, Australia.

<sup>4</sup> Warrnambool City Council, P.O. Box 198, Warrnambool, Victoria, Australia.

<sup>5</sup> Swampy's Multigrain Free-range Egg Farm, Atkinsons Lane, Warrnambool, Victoria, Australia.

Since 2004, there have been frequent fox and dog predation events on Victoria's Middle Island decimating the little penguin population from 600 to a few individuals. Den fumigation, fox shoots and baiting are part of an expensive and ongoing exercise that still did not stop the foxes accessing the island and killing seabirds. In December 2006, a unique trial was held on the island whereby a Maremma guard dog was placed on the island for one month. Maremma are Italian guard dogs bred to guard sheep and other flock animals from predators. The dogs used in this trial had been guarding local free-range chickens from foxes for several years. There were no birds killed on the island whilst the trial was in place. No fox prints were found in the surrounding area whilst the dog remained on the island but were found both pre- and post-trial. The penguins continued to breed successfully and a natural increase in arrival numbers was observed. The trial was deemed a success and a further 12-month trial was started in May 2007. Maremma could be used in other conservation programs to assist in the protection of other species under localised threat from introduced predators.

# **INVESTIGATING VARIABILITY IN THE BREEDING CHRONOLOGY OF ADELIE PENGUINS AT BÉCHERVAISE ISLAND FROM 1990 TO 2006**

RHONDA PIKE, COLIN SOUTHWELL, LOUISE EMMERSON  
Australian Antarctic Division, 203 Channel Highway, Kingston, Tasmania 7050

This paper provides a description of the variability in timing of breeding season events of Adelie penguins at Béchervaise Island in East Antarctica. Breeding chronology events described were: arrival, female departure date for first foraging trip, male departure date for second foraging trip, hatch date and crèche date. We wanted to determine whether these events occur at the same time every year and if they are regularly timed irrespective of when the breeding season starts. We compared the mean dates and the variance associated with the means for each breeding chronology event and also compared the periods of time between events across all seasons. There is considerable variation in timing of breeding events across all seasons and length of time between events, with no patterns or general trends in mean date of events or the associated variance over the 16 years incorporated in the study. The findings from this study may be used to establish factors affecting breeding success of Béchervaise Island Adelie penguins, and for assessing impacts of environmental changes on the penguin population. Results from this study are potentially important for determining the best time to conduct surveys and how variation in survey dates may affect conclusions drawn.

**BEACH ATTENDANCE IN MAGELLANIC PENGUINS (*SPHENISCUS MAGELLANICUS*):  
HOW AGE AND ENVIRONMENTAL VARIABLES AFFECT ABUNDANCE?**

LUCIANA M. POZZI<sup>1,2</sup>, MIGUEL PASCUAL<sup>1,3</sup> AND P. DEE BOERSMA<sup>2,4</sup>

<sup>1</sup>Universidad Nacional de la Patagonia San Juan Bosco, Boulevard Brown S/N, (9120)  
Puerto Madryn, Chubut, Argentina

<sup>2</sup>Magellanic Penguin Project, Wildlife Conservation Society

<sup>3</sup>Centro Nacional Patagónico (CONICET)

<sup>4</sup> Department of Biology, University of Washington, Seattle, Washington 98195 USA

Seabirds' demographical processes are often studied in colonies during breeding, but little information is available on non-breeding birds. Magellanic penguins often return to rest on beaches at breeding colonies several years before they breed. Since 1983, over 55,000 penguins have been banded as chicks at Punta Tombo, (44° 02'S 65° 11'W), the largest continental colony of this species in the world. We read bands and counted juvenile and adult penguins to assess beach attendance in relationship to environmental variables between December 2001 and February 2004. Beach attendance differed among age classes. More banded three-year-old birds than banded two or one-year-old birds were seen. One-year old birds were more common on the beach in late January and early February than in December or late February. Both juveniles and adults were seen in larger numbers in the afternoons than in the mornings. Adult penguins, including breeding and non-breeding birds, were more common on the beach when air temperature was high than low. We found more than 5000 adults attending the beach on hot days.

## **MAKING TRACKS: SWIMMING BEHAVIOUR OF BREEDING MAGELLANIC PENGUINS**

GINGER A. REBSTOCK & P. DEE BOERSMA

Department of Biology, University of Washington, Seattle Washington, USA

We tracked at-sea movements of breeding Magellanic penguins at Punta Tombo, Argentina, 1996-2007, using the Argos satellite system. We received more locations for the most distant parts of each trip (> 80% of the trip distance). Penguins swim to some foraging area, feed in this area, then return to the colony, rather than foraging equally along the entire track. Penguins swam fastest, day or night, when returning to the colony while raising chicks ( $1.42 \pm 0.029$  m/s). Outbound speeds during all stages and inbound speeds during incubation were intermediate, with daytime speeds ( $1.20 \pm 0.015$  m/s) greater than night time speeds ( $0.90 \pm 0.018$  m/s). Foraging speeds were slower, with daytime speeds ( $0.81 \pm 0.015$  m/s) faster than night time speeds ( $0.64 \pm 0.016$  m/s). Similarly, penguins meandered most within the foraging areas and least when inbound. Magellanic penguins may search for prey and stop to rest when outbound, but return rapidly and directly when feeding chicks. Penguins spent more time in the foraging areas when they foraged farther from the colony ( $r^2 = 0.25 - 0.53$ ), because they must feed themselves to replace the energy used to get to distant foraging areas (mean = 117 km, max = 585 km).

## EFFECT OF FIRE ON LITTLE PENGUINS AT SEAL ISLAND, SOUTH-EASTERN AUSTRALIA

LEANNE RENWICK<sup>1</sup>, PETER DANN<sup>1</sup> & SALLY THOMPSON<sup>2</sup>

<sup>1</sup>Phillip Island Nature Park, PO Box 97, Cowes, Vic 3922, Australia

<sup>2</sup>School of Life and Environmental Sciences, Deakin University, Melbourne, Australia

On 24 October 2005, lightning started a fire on Seal Island, 15km east of Wilsons Promontory, Victoria. The fire burnt 90% of the island over the next 4 days, before it was extinguished by Phillip Island Nature Park research staff and volunteers on 28 October. The island is predominantly coastal tussock grassland with some patches of coastal headland scrub and fringing cliff herbland (succulent dominated) on steeper areas close to the water. The grassland was most affected by the fire. Most Little penguins were incubating eggs and at least 90% of their breeding area was burnt. The penguins bred both in subterranean burrows and under *Poa* tussocks. Many burrows collapsed either during or immediately after the fire front passed and the nesting sites under tussocks were entirely destroyed in most cases. Responses of the penguins to fire were surprisingly inappropriate and un-adaptive. Many dead birds were found either in burrows (often collapsed) or within metres of burrows. Penguins nesting under vegetation appeared to remain until they were severely burnt (observed several times) or killed. The relative contributions of burns and asphyxiation were not determined. 92 penguins were found sheltering under rocks along the shoreline. Most had obvious burns, usually of the feet and legs. At least 360 penguins were incinerated and a further 178 were found alive, most with injuries. The significance of this mortality will be discussed in terms of estimates of the population size of the island and the management of fire in little penguin colonies.

## WINTER FORAGING AREAS OF ADÉLIE PENGUINS IN THE WESTERN ANTARCTIC PENINSULA REGION

CHRISTINE A. RIBIC<sup>1</sup>, WILLIAM R. FRASER<sup>2</sup>, AND ERIC ERDMANN<sup>3</sup>

<sup>1</sup>USGS Wisconsin Cooperative Wildlife Research Unit,  
Dept. Wildlife Ecology, University of Wisconsin, Madison, Wisconsin, USA.

<sup>2</sup>Polar Oceans Research Group, Sheridan, Montana, USA.

<sup>3</sup>Dept. Wildlife Ecology, University of Wisconsin, Madison, Wisconsin, USA.

The transition from summer to winter over the western Antarctic Peninsula (WAP) shelf region is characterized by a substantial and significant decrease in primary production and phytoplankton biomass. This results in a food web that during polar winter is decoupled from the more common summer state of high water column primary production. Despite these conditions, however, a majority of apex predators remain in the WAP during winter, including several species whose numerical abundance alone accounts for much of the regional apex predator biomass. To investigate some of the processes that may sustain these large predator populations during winter, we examined the foraging movements of Adélie penguins (*Pygoscelis adeliae*) in the U.S. Southern Ocean Global Ocean Ecosystem Dynamics (U.S. SO GLOBEC) study grid near Marguerite Bay. This was done by using Platform Terminal Transmitters (PTTs) attached to penguins during cruises in autumn/winter 2001 and 2002, and tracking their positions using the ARGOS satellite constellation. In 2001, 8 and 12 PTTs were deployed on male and female penguins, respectively. The tags recorded penguin locations for an average of 62 days (s.e. = 34 days) between 8 May and 3 December 2001. In 2002, 21 and 15 PTTs were deployed on male and female penguins, respectively. These tags recorded locations for an average of 73 days (s.e. = 50 days) between 12 April 2002 and 29 January 2003. Winter sea ice conditions were significantly different between the two years and this affected the area over which penguins were able to forage within the study grid. In winter 2001, the ice edge extended north only to about 64 degrees south latitude while in winter 2002, the ice edge extended beyond 61 degrees south latitude, or the northern tip of the WAP. During both winters, penguin foraging locations converged on a large coastal polynya found at the southern end of Adelaide Island, Marguerite Bay. However, during winter 2002 the Adélie penguins, females in particular, were able to extend their foraging to other polynyas within and beyond the SO GLOBEC study grid. Sea ice is one of the key variables mediating access to regions in the WAP where predictable winter prey concentrations may occur; and female Adélie penguins may be particularly dependent on heavy sea ice conditions to forage successfully.

## **EFFECTS OF IMPLANTABLE HEART RATE DATA LOGGERS ON LITTLE PENGUINS (*EUDYPTULA MINOR*)**

W.J. RITCHIE, J.A. GREEN<sup>1</sup>, P. DANN<sup>2</sup> & P.B. FRAPPELL<sup>1</sup>

<sup>1</sup>Adaptational and Evolutionary Physiology Research Group, Department of Zoology  
La Trobe University, Bundoora, Victoria, 3070, Australia

<sup>2</sup>Phillip Island Nature Park, PO Box 97, Cowes, Phillip Island, Victoria, 3922, Australia

Externally attached bio-logging devices can impede an animals foraging performance, particularly in highly streamlined animals such as penguins. As an alternative, recent studies have used abdominally implanted data loggers to gain new insight into penguin foraging, with no detectable negative effects. However, these studies have focused on larger species and little is known of the effects of an equivalent sized device in a smaller species. We investigated the effects of small abdominally implanted heart rate loggers (HRDLs) on the foraging behaviour of free-ranging little penguins (*Eudyptula minor*) during the winter non-breeding period. We used passive implanted transponder (PIT) tags and an automated data recorder to record the duration and timing of foraging trips in implanted and control groups. We also investigated subsequent breeding success following the HRDL's removal. Individual birds showed highly variable foraging patterns, but the HRDL and control groups undertook very similar foraging behaviour. We found no detectable effects of the HRDLs on % time spent at sea, foraging trip duration, number of foraging trips undertaken and "in" and "out" times from the colony. Unfortunately, the 2006-2007 was a poor breeding season, with insufficient data available to compare breeding success.

## **AUTOMATIC MONITORING OF PENGUIN POPULATION (AMPPOP): CIRCUMPOLAR MONITORING OF THE BIOLOGY OF KEY-SPECIES IN RELATION TO ENVIRONMENTAL CHANGES**

YAN ROPERT-COUDERT<sup>1)\*</sup>, DAVID AINLEY<sup>2)</sup>, GRANT BALLARD<sup>3)</sup>, AKIKO KATO<sup>1)</sup>, PHIL LYVER<sup>4)</sup>, SILVIA OLMASTRONI<sup>5)</sup>, COLIN SOUTHWELL<sup>6)</sup>, AKINORI TAKAHASHI<sup>1)</sup>, PHIL TRATHAN<sup>7)</sup>, PETER WILSON<sup>8)</sup>, & YVON LE MAHO<sup>9)</sup>

1) National Institute of Polar Research, Kaga 1-9-10, Itabashi-ku, Tokyo 173-8515, Japan

\* Corresponding author: [yaounde@nipr.ac.jp](mailto:yaounde@nipr.ac.jp)

2) H.T. Harvey and Associates, 3150 Almaden Expressway, Suite 145,  
San Jose, CA 95118, USA

3) 4990 Shoreline Highway, Stinson Beach CA 94970, USA

4) Landcare Research Ltd, P.O. Box 69, Lincoln, 8152, Christchurch, New Zealand

5) Dipartimento di Scienze Ambientali "G. Sarfatti", Università degli Studi di Siena  
Via P.A. Mattioli 4, 53100 Siena, Italia

6) Australian Antarctic Division, 203 Channel Highway, Kingston, Tasmania 7050, Australia

7) BioSciences Division, British Antarctic Survey, High Cross, Madingley Road  
Cambridge CB3 0ET, UK

8) 17 Modena Crescent, Glendowie, Auckland, New Zealand

9) Institut Pluridisciplinaire Hubert Curien, UMR 7178 CNRS-ULP, 23  
rue Becquerel, 67087 Strasbourg Cedex 2, France

Among the top-predators of the Southern Ocean, variations in penguin population can be used as an indicator of climatic changes. However, penguin populations show conflicting trends and the fundamental mechanisms driving their dynamics remain largely unidentified. A coordinated effort, therefore, is required in the monitoring and analysis at different sites, both in following individuals over the complete breeding season and in tracking them at sea where they feed. We propose to define and use a standard population monitoring protocol for penguin populations that would deliver large quantitative sample sizes of year-round biological information about penguins breeding performance (Automatic Identification systems) and at-sea activity and distribution (bio-logging) with minimum disturbance for the population studied. By standardizing the monitoring procedures used by different research groups, we will provide a circumpolar network of information on the status of penguin populations. We hope that other teams will find our project inspiring and join our effort to homogenize the monitoring procedure of penguin populations all over the Antarctic continent.



**UPDATE ON THE IFAW PENGUIN NETWORK:  
PRESENTING GOALS AND ACHIEVEMENTS SINCE 2001**

VALERIA RUOPPOLO<sup>\*1</sup>; BARBARA CALLAHAN<sup>1,2</sup>; RODOLFO P. SILVA-FILHO<sup>1,3</sup>; SERGIO R. HEREDIA<sup>4</sup>; KAREN GRIOT<sup>5</sup>; RICARDO MATUS<sup>6</sup> & JAY HOLCOMB<sup>1,2</sup>

\*Corresponding Author: [vruppolo@uol.com.br](mailto:vruppolo@uol.com.br)

- 1- International Fund for Animal Welfare (IFAW), Emergency Relief - [www.ifaw.org](http://www.ifaw.org)
- 2- International Bird Rescue Research Center [www.ibrrc.org](http://www.ibrrc.org)
- 3 - Centro de Recuperação de Animais Marinhos [www.furg.br/museu](http://www.furg.br/museu)
- 4- Fundación Mundo Marino [www.fundmundomarinero.org.ar](http://www.fundmundomarinero.org.ar)
- 5- Fundación Aquarium [www.mdpaquarium.com.ar/fundacion](http://www.mdpaquarium.com.ar/fundacion)
- 6- Natura Patagonia [www.naturapatagonia.cl](http://www.naturapatagonia.cl)

Since 2001, IFAW has been involved in the rescue and rehabilitation of over 2,200 penguins throughout South America, through the development of the *IFAW Penguin Network*. The main purpose of the Network is to bring together organizations working with penguins in the region and to help them to increase the number of rescued animals; standardize rehabilitation protocols and collect and combine data in an effort to quantify and document the animals affected by oiling. The goal is to understand the effects of oiling on penguins and to mitigate these effects through rehabilitation, research and prevention. Ten institutions divided into three categories compose the network: six rehabilitation facilities, three research institutions and two reporting institutions. The members are distributed between Argentina, Brazil, Chile and Uruguay. Banking oiled feathers and images of the individual birds is one of the ongoing projects, with the goal of determining the source of the oil affecting the birds along their migration route. Recent developments include a dedicated IFAW penguin banding program ([www.ifaw.org/penguinband](http://www.ifaw.org/penguinband)) and the participation of member institutions in responses like the *Eider* spill, in Chile and the *Cabo Virgenes* mystery spill, in Argentina.

## **CABO VÍRGENES MYSTERY OIL SPILL RESPONSE: CHALLENGES AND LESSONS LEARNED**

VALERIA RUOPPOLO\*<sup>1</sup>; BARBARA CALLAHAN<sup>1,2</sup>; SERGIO R. HEREDIA<sup>3</sup>; RODOLFO P. SILVA-FILHO<sup>1,4</sup>; CARLA POLESCHI<sup>5</sup>; JORGE PERANCHO<sup>6</sup>; JAY HOLCOMB<sup>1,2</sup>

\*Corresponding Author: [vruoppolo@uol.com.br](mailto:vruoppolo@uol.com.br)

- 1- International Fund for Animal Welfare (IFAW), Emergency Relief - [www.ifaw.org](http://www.ifaw.org)
- 2- International Bird Rescue Research Center [www.ibrrc.org](http://www.ibrrc.org)
- 3- Fundación Mundo Marino [www.fundmundomarino.org.ar](http://www.fundmundomarino.org.ar)
- 4 - Centro de Recuperação de Animais Marinhos [www.furg.br/museu](http://www.furg.br/museu)
- 5- Fundación Patagonia Natural [www.patagonianatural.org.ar](http://www.patagonianatural.org.ar)
- 6- Dirección de Fauna/Consejo Agrario Provincial de Santa Cruz

In early May 2006, several hundred oiled Magellanic penguins washed ashore in the Cabo Vírgenes Nature Reserve, in Argentina. The IFAW ER Team responded in collaboration with local authorities in Rio Gallegos, where the local sailing club facility was adapted to treat 224 Magellanic penguins. The problems related to rehabilitating penguins in cold weather conditions combined with limited facilities were insurmountable. The birds had difficulty regaining their natural waterproofing, which forced the team to transport 195 penguins 2,700km north, to San Clemente del Tuyú, where Fundación Mundo Marino maintains an appropriate penguin rehabilitation facility, in a warmer climate. The goal of this paper is to present the case report, emphasizing challenges faced to rehabilitate penguins in remote locations and cold environments.

# **INTERACTIONS BETWEEN MOLE SNAKES *PSEUDASPIS CANA* AND AFRICAN PENGUINS *SPHENISCUS DEMERSUS* ON ROBBEN ISLAND, SOUTH AFRICA**

RICHARD B SHERLEY<sup>1</sup> AND LES G UNDERHILL<sup>2</sup>

<sup>1</sup> School of Biological Sciences and Department of Computer Sciences,  
University of Bristol, Woodland Road, Bristol BS8 1UG, UK.

<sup>2</sup> Avian Demography Unit, University of Cape Town,  
Rondebosch 7701, South Africa.

Robben Island, South Africa, supports the second largest breeding colony of African penguins *Spheniscus demersus* worldwide and is unique as the only island in southern Africa where any species of snake breeds. The mole snake *Pseudaspis cana* is a large, non-venomous, diurnal species endemic to sub-Saharan Africa. The population on Robben Island has probably been isolated since the end of the last Ice Age, c. 10-12,000 years ago, as they are both morphologically and behaviourally different from mole snakes found on the Western Cape mainland. On Robben Island, the Cape golden mole *Chrysocloris asiatica* probably constitutes the major prey species. However, Mole Snakes here are also known to consume the eggs and nestlings of seabirds, such as gulls, oystercatchers and penguins. In particular, it is believed that many of the larger individuals supplement their diet by consuming the eggs from unoccupied penguin nests following abandonment by the breeding adults. Here we report a series of field observations made on the interaction between a large adult mole snake and a pair of nesting African penguins. This is believed to be the first documented recording of a mole snake attempting to seize the contents of an occupied penguin nest.

## MIXED SPECIES, AGE CLASSES, IN THE 1972 WINTER WRECK OF *EUDYPTES* PENGUINS IN BASS STRAIT AND NORTHWEST TASMANIAN WATERS

KEN N. G. SIMPSON

Penguin Study Group, Victorian Ornithological Research Group, Melbourne, Australia

Correspondence: P.G. Box 420, Yarra Junction, Victoria 3797, Australia, [spinebi114@bigpond.com](mailto:spinebi114@bigpond.com)

A winter wreck of *Eudyptes* penguins occurred in 1972, off the north-western coast of Tasmania, and King Island's western beaches, Australia, between 1 July and 20 September. Of 26 penguins reported, 19 were lodged with Queen Victoria Museum & Art Gallery, Launceston, Tasmania. Increasingly decomposed over the collection period, all were preserved: 16 as skins or desiccated mummies; two in spirit; one skull; representing the major specimen collection from any *Eudyptes* penguin wreck in Australia to date. Examination (July-August 2006 and subsequently) has confirmed six of ten penguins originally labelled 'Fiordland *E. pachyrhynchus*'. Two were re-identified as 2-3 year old Snares penguins *E. robustus*; two others are potentially so. There are seven juvenile (includes one skull), and one 2-3 yr old Moseley's rockhopper penguin *E. moseleyi*; also one adult Eastern rockhopper penguin *E. chrysocome filholi* (2<sup>nd</sup> known Australian record). A few dead little penguins *Eudyptula minor* were recorded. Whether this 'mixed-species foraging flock' of differently-aged *Eudyptes* penguins was genuinely together at sea, or separately dispersed, is not known. Several other SE Australian mixed-species penguin wrecks are also under investigation. Meteorological and marine circumstances surrounding such wrecks may contribute to knowledge of winter pelagic dispersal and foraging areas of these species.

## **RAPID POST-MORTEM CHANGE TO DISTAL UNDER-FLIPPER PATTERNS IN *EUDYPTES* PENGUINS: CONFLICT BETWEEN FIELD OBSERVATIONS AND MUSEUM SKINS**

KEN N. G. SIMPSON

Penguin Study Group, Victorian Ornithological Research Group, Melbourne, Australia

Correspondence: P.O. Box 420, Yarra Junction, Victoria 3797, Australia, or, spinebi114@bigpond.com

Recent distal underflipper pattern (UFP) study of several *Eudyptes* penguins, some fresh, some long-dead, has helped clarify an anomaly, where rapid UFP changes were noticed over hours or days. Considerable individual complexity and variability of 'single-, double- or triple-pronged' UFPs already exists in *Eudyptes*, causing observer confusion in penguin identity, especially of young individuals. Two different and variable levels of distal 'patterning' operate together when the penguin is alive or freshly dead: (1) the 'normal' bird feather pattern, i.e. melanin pigmentation of the feather rachis, 'operates' perpetually, alive or long dead. (2) subcutaneous fluids, diffused in life through and between the pigment 'prongs', add to and blur the overall darkness of the distal UFP, persisting if a dead penguin is kept wet, is frozen when fresh, or retained in alcohol, but is virtually absent in fully dried specimens. A skew thus exists in appearance of distal UFPs of living and dead *Eudyptes* penguins: field observation distortion versus sharp-edged museum definition. This recognition has resolved several recent *Eudyptes* identifications. Terms are suggested: 'Observable UFP' for the 'fuzziness' of distal UFPs of living and wet-preserved *Eudyptes* penguins, and 'Residual UFP' for feather melanin of dried flippers of beach derelicts or museum study skins.

**TE RERE YELLOW-EYED PENGUIN RESERVE:  
A CONSERVATION PROJECT IN SOUTHERN NEW ZEALAND**

FERGUS SUTHERLAND

Yellow-eyed penguins (*Megadyptes antipodes*) are restricted to south eastern New Zealand and its nearby sub Antarctic islands. Penguin numbers are low and they may be the rarest penguin in the world. Penguin survival has been threatened on the mainland of New Zealand by the clearing of their forest nesting habitat for farming. An example of a conservation project to save a forest habitat is the Te Rere Reserve set up by the Forest and bird Protection Society in the Catlins region. The paper traces the development of this reserve, explaining how its management has evolved and discusses the progress of the penguins in the reserve following a major fire that occurred there in 1995.

**WHO CONTROLS THE FOOD IN MAGELLANIC PENGUINS (*SPHENISCUS MAGELLANICUS*):  
PARENTAL PREFERENCE OR SIBLING COMPETITION?**

D. O. THAYER, E. A. SKEWGAR AND P. DEE BOERSMA  
Department of Biology, University of Washington

To maximize lifetime fitness, long-lived seabirds balance investment in current versus future offspring, contending with fluctuations in prey availability. Each year, Magellanic penguins lay one clutch with two eggs. In years with more food, pairs can fledge two chicks. When prey is scarce, one or no chicks may survive. The interests of parents and chicks in food allocation are not identical in two-chick broods. To test if parents or chicks control feeds and to analyze which behaviours control food allocation, we observed 89 feeding sessions of two-chick broods and 31 of one-chick broods in three field seasons (2003, 2005 and 2006) at Punta Tombo, Argentina. After foraging at sea, parents return to their nest and regurgitate food to chicks. We measured total mass gain for each chick and calculated mean mass of food delivered per regurgitation. We also counted begging vocalizations by chicks, parents' turns, and interruptions of feeds by chicks. In two-chick broods, second chicks had greater mass gain per feeding session and feeding sessions were five minutes longer than in one-chick broods. Single chicks received the same number of regurgitations as both chicks in two-chick broods, but the mass of food per regurgitation was smaller for single chicks.

## OXYGEN ISOTOPIC EVIDENCE FOR THE EVOLUTION OF THE PENGUIN HUMERAL PLEXUS

DANIEL B. THOMAS, R. EWAN FORDYCE AND RUSSELL FREW\*

Geology Dept., University of Otago, Dunedin, New Zealand.

\*Chemistry Dept., University of Otago, Dunedin, New Zealand.

Penguins are warm-blooded birds that spend much of their lives in heat-sapping cold water. Wings and feet are potentially significant as regions of heat-loss, with physiological adaptations present in both extremities that mitigate hypothermia. For example, blood flows over the humerus in a set of parallel arteries that are associated with multiple veins. Heat from the divided arterial flow is expected to convect across the vessel walls, and return vein-ward to the core of the body. Hot outward-flowing arterial blood sheds heat to cool inward-flowing venous blood; thus, a counter current heat exchange is formed by the humeral plexus, restricting the flow of heat to more distal wing regions. The consequent thermal gradient established along the wing affects the ratio of oxygen isotopes incorporated into bone phosphate. Isotopes, as reflected in  $\delta^{18}\text{O}$  values of skeletal elements, provide a proxy for local blood temperature during growth. The strength of the thermal gradient is a function of the efficiency of the humeral plexus, and oxygen isotopes can be used to observe the evolutionary history of the humeral plexus in Spheniscidae. The  $\delta^{18}\text{O}$  thermal proxy is currently being calibrated using modern species, and *Megadyptes antipodes* and *Eudyptula minor* have been analysed thus far.



## **HANDLING OF WILD *SPHENISCUS DEMERSUS* (AFRICAN PENGUIN) CHICKS**

ALEXANDER E. THORNTON  
The Evergreen State College, Olympia, WA, U.S.A

The proper handling of the *Spheniscus demersus* (African penguin) from the time of hatching until they fledge into their juvenile plumage ('Blues'; at approximately 60 days old) is vital to ensure safety and to avoid imprinting. In addition to describing the correct way to hold a chick's head, two types of handling will be discussed here- basic holding and during forced-feeding.

## **EXPOSURE TO INFECTIOUS DISEASES IN MAGELLANIC PENGUINS FROM PATAGONIA: A SUMMARY FOR THE LAST DECADE**

MARCELA M. UHART and CAROLINA A. MARULL, Field Veterinary Program, Wildlife Conservation Society, Argentina; WILLIAM B. KARESH and ROBERT A. COOK, Field Veterinary Program, Wildlife Conservation Society, USA; FLAVIO QUINTANA, Centro Nacional Patagónico (CONICET)-WCS, Argentina; ESTEBAN FRERE and PATRICIA GANDINI, Univ. Nac. de la Patagonia Austral-WCS, Argentina and RORY WILSON, Institute of Environmental Sustainability, Univ. of Swansea, UK.

Magellanic penguins (*Spheniscus magellanicus*) are the most abundant seabird species along the Patagonian shores in Argentina. However, current changes in the marine ecosystem they depend on could affect their long-term survival. Commercial fisheries, tourism, oil exploration and drilling, mining, industrial and urban development are of growing concern. Establishing baseline health parameters allows us to predict the effects of environmental changes reflected on biological indicators. Penguins are good sentinels of marine environmental health: they forage in specific areas and on specific prey, reflecting the condition of marine resources. Because of their colonial nature, they are particularly susceptible to catastrophic events and disease epidemics. Their annual migration exposes them to a variety of threats in areas of difficult management and monitoring. In an effort to understand the effects of long-term environmental stressors on Patagonia shorebirds, we began monitoring Magellanic penguin health along the coastline in 1993. Serological evidence of infectious disease exposure to infectious laryngotracheitis, avian encephalomyelitis, avian influenza, avian reovirus, infectious bursal disease, infectious bronchitis virus, paramyxovirus types 1, 2, and 3, avian adenovirus, *Salmonellosis*, *Chlamydiosis* and *Aspergillosis* will be presented. Spatial and temporal variations in pathogen exposure will be discussed in relation to their implications for Magellanic penguin conservation.

## **PATTERNS OF MOULT SEASONALITY OF AFRICAN PENGUINS ON ROBBEN AND DASSEN ISLANDS, SOUTH AFRICA**

LES G UNDERHILL<sup>1</sup>, ANTON C WOLFAARDT<sup>1,2</sup>, ROB JM CRAWFORD<sup>1,3</sup>

<sup>1</sup>Avian Demography Unit, Department of Statistical Sciences  
University of Cape Town, Rondebosch 7701, South Africa

<sup>2</sup>Western Cape Nature Conservation Board, Private Bag X5014  
Stellenbosch 7599, South Africa

<sup>3</sup>Marine and Coastal Management, Department of Environmental Affairs and Tourism  
Private Bag X2, Roggebaai 8012, South Africa

Regular moult counts, made throughout the year, are available for African penguins on Robben Island since 1988, four years after the colony there started, and for Dassen Island since 1994, soon after the *Apollo Sea* oil spill of June 1994. These moult counts, together with breeding data, enable fine-scale comparisons between years and islands to be made, especially in relation to biomass of sardine and anchovy, the main prey species of the African penguin. We find that moult is far more tightly synchronized than breeding. We note that eggs or chicks may be abandoned if food supplies become short during a breeding attempt, but that moult cannot be abandoned once started. We suggest that moult, rather than breeding, might be the critical event in the annual cycle of African penguins and that moult needs to take place at the time when food supply is most reliable. The strategy of penguins in South Africa to moult between September and January may therefore have evolved to coincide with a relatively predictable, but distant, source of food, and not necessarily be dictated by the breeding period. This moult period coincides with the spawning period for sardine and anchovy which generally takes place over the Agulhas Bank, from 30–130 km offshore. This area is out of reach of penguins breeding on these two islands, which have a feeding range limit of about 20 km, but it would be accessible to non-breeding penguins acquiring fat reserves for their moult. The idea that moult is the event which dictates the annual cycle contradicts the hypothesis of David Lack, that breeding should take place at the period of greatest reliable food availability.

## **PARASITISM IN LITTLE BLUE PENGUINS (*EUDYPTULA MINOR*) AND CORRELATIONS WITH BODY CONDITION, SURVIVAL AND BREEDING SUCCESS**

MONIQUE JANSEN VAN RENSBURG<sup>1</sup> & DIANNE BRUNTON<sup>1</sup>

<sup>1</sup>*Ecology & Conservation Group, Institute of Natural Resources,  
Massey University, Auckland, New Zealand*

There has been evidence suggesting that large parasite loads in little blue penguins (*Eudyptula minor*) are detrimental to the health of individuals, especially during periods of starvation. Therefore parasitism may be an important factor influencing population numbers under increasing anthropogenic pressures. To explore blue penguin parasite loads and how these correlate with body condition and breeding success, we investigated external and internal parasites in penguins on Tiritiri Matangi Island (New Zealand). Non-breeding season parasite prevalences were explored through examination of penguins upon their nightly arrival, and necropsy of penguin carcasses. Breeding season research included: monitoring nest success with and without treatment for nest-associated parasites; examination of chick parasite load; and comparing loads from different nest types. Examinations yielded a diversity of ectoparasites, some which were also known vectors for blood parasites. Necropsies revealed a range of intestinal parasites. We will report on these parasite prevalences and associated bird-host health parameters.

**EVALUATION OF THE IMPACT OF TOURISM ON THE BEHAVIOUR, BREEDING SUCCESS AND CHICK GROWTH OF MAGELLANIC PENGUINS IN PENINSULA VALDES, ARGENTINA: PRELIMINARY RESULTS**

CECILIA VILLANUEVA<sup>1</sup>, MARCELO BERTELLOTTI<sup>1</sup> & BRIAN WALKER<sup>2</sup>

<sup>1</sup>Centro Nacional Patagonico (CENPAT – CONICET), Puerto Madryn, Argentina

<sup>2</sup> Fairfield University, Fairfield, CT, USA

[villanueva@cenpat.edu.ar](mailto:villanueva@cenpat.edu.ar)

In the last decade, there has been increasing tourism activity in Argentine Patagonia focusing on wildlife visitation. As a consequence of its growth, there is a concern about the effects that ecotourism may have on wild populations. We measured the effect of human visitation on the normal behaviour, breeding success and chick growth of Magellanic penguins in a breeding colony located in Peninsula Valdes, Chubut, Argentina. During different stages of the breeding season, we carried out experimental visits to penguins in two areas of the colony that do or do not experience tourist disturbance. We recorded the response distance at which penguins changed their behaviour. The penguins in the visited area allowed people to approach closer before responding than did penguins in the non-tourist area. No clear pattern was found comparing the breeding stages and reproductive success did not differ between areas. Growth data were fitted to Generalized Richards Growth Model and were compared by Likelihood Ratio Test for both areas. The growth curves of the chicks were similar for tarsus, wing and bill length. These results suggest that penguins in the visited area may be habituated to people. However, since this is the first season of the study, complementary data -like physiological parameters- should also be incorporated.

## TESTING METHODS TO ESTIMATE ABUNDANCE IN A MAGELLANIC PENGUIN COLONY

CECILIA VILLANUEVA<sup>1</sup>, MARCELO BERTELLOTTI, PATRICIA DELL'ARCIPRETE & ANA PARMA  
Centro Nacional Patagonico (CENPAT – CONICET), Puerto Madryn, Argentina  
[villanueva@cenpat.edu.ar](mailto:villanueva@cenpat.edu.ar)

Estimating population sizes is essential for many ecological analyses. However, in many cases it is difficult to establish accurately the limits of the distribution of a population or the number of individuals. Although several sampling methods have been used to establish the size of Magellanic penguin colonies, their relative performance has never been assessed. In this study, we tested the efficiency of three sampling methods frequently applied in Patagonia using geostatistical tools and simulation-estimation trials. We generated a virtual colony with spatial parameters estimated for a real colony of Magellanic penguins located at Peninsula Valdes, applying *kriging* interpolation techniques. On this virtual colony three sampling methods were applied using a range of sampling fractions from 1% to 25% of the area covered: random sampling with quadrats of 100m<sup>2</sup>, systematic sampling with quadrats of 100m<sup>2</sup>, and systematic sampling with fixed-width transects. Simple design-based estimators were used assuming that the area occupied by the colony was known. Systematic sampling with quadrats gave the most accurate estimates for any given sampling fraction.

## **THE ABANDONMENT OF AFRICAN PENGUIN CHICKS ON DYER ISLAND, THEIR RESCUE, REARING AND RELEASE**

LAUREN WALLER, NOLA PARSONS, VENESSA STRAUSS, LES UNDERHILL

During October and November 2006, about 700 African penguin chicks were removed from Dyer Island and taken to SANCCOB to be raised for release into the wild. The main moult period for adult African penguins on Dyer Island is from Oct – Dec. Had these chicks been left, they would have starved to death when their parents began their moult. Some adults were in the initial moult phases while sitting on eggs. Abandonment of end of season chicks in African penguins is not an unusual activity. What is unusual, is that so many chicks were involved. Some chicks were metal or rubber banded, so the success of this removal and release programme can be monitored in future. Penguin breeding activity will continue to be monitored on the Island. The poster will detail the removal of the chicks, their rearing at SANCCOB, and subsequent release at Dyer and Robben Islands.

## **ARTIFICIAL PENGUIN BURROWS ASSIST IN CONSERVATION OF AFRICAN PENGUINS, DYER ISLAND, SOUTH AFRICA**

LAUREN WALLER, WILFRED CHIVELL, LES UNDERHILL

Dyer Island is a 20 ha island off the southern coast, Western Cape, South Africa. It used to be the site of one of the largest breeding colonies of African penguin in South Africa. Due to competition for food resources, shifting fish stocks, oiling, and predation, the numbers of breeding African penguins have rapidly declined from about 25 000 breeding pairs in the 1970s, to about 2500 breeding pairs in 2006. Habitat destruction has also played a role in the decline of penguin numbers. Like many of the off shore islands in southern Africa, Dyer Island was extensively used as a source of guano and the guano was scraped from the 1800s till as late as the 1980s. This practice has fortunately been stopped with the islands being proclaimed a provincial nature reserve. The impact of this habitat destroying activity however, is still visible today. Without the soft guano in which they would have burrowed, the penguins are now forced to lay their eggs on the surface. This exposes the adults to heat stress, and when they move off the nest to cool down at the sea, their eggs and chicks are exposed to predation by Kelp Gulls. An artificial housing project has been initiated to provide alternative nest sites for the African penguin. We describe the nest used, the manner in which they have been placed on the island, and present preliminary findings.



## UNCOMFORTABLY CLOSE? THE EFFECT OF HUMAN VISITS TO BEACH GROUPS OF KING PENGUINS AT MARION ISLAND

WHEELER, M., DE VILLIERS, M.S. & MAJIEDT, P.A.  
Avian Demography Unit, Department of Statistical Sciences  
University of Cape Town, Rondebosch, South Africa  
[mbause@adu.uct.ac.za](mailto:mbause@adu.uct.ac.za)

Beach groups of penguins disturbed by humans may exhibit increased levels of alertness or aggression and may even stampede, potentially trampling eggs or chicks in adjacent groups. The response may be influenced by the duration of human visits. A total of 32 standardised single-person approaches were made to breeding (guarding phase) and non-breeding groups of king penguin (*Aptenodytes patagonicus*) on six beaches at Marion Island. Two types of approaches were made, with a person standing 5-m from the perimeter of the group for 1 minute and then retreating (short disturbance) or moving around for a further 5 minutes before retreating (long disturbance). The approach distances at which birds first started to move away and at which 50% of the group had moved away were recorded. The frequency and intensity of displays, and parent-chick interactions, were compared before, during and after approaches. Non-breeding groups were more likely to move away from the approaching person. Birds reacted more during the approach than during the time the person spent at the group. Behaviours reverted to pre-approach levels within a few minutes after the pedestrian left the immediate area. Since penguins may be more sensitive to disturbance during other phases of the breeding cycle, the minimum approach distance of 15m to breeding birds recommended in the Prince Edward Islands Management Plan should be maintained.

## WHAT'S UP? THE EFFECT OF HELICOPTER FLIGHTS ON THE BEHAVIOUR OF GENTOO PENGUINS AT MARION ISLAND

WHEELER, M., DE VILLIERS, M.S. UNDERHILL, L.G. & MAJIEDT, P.A.  
Avian Demography Unit, Department of Statistical Sciences,  
University of Cape Town, Rondebosch, South Africa  
[mbause@adu.uct.ac.za](mailto:mbause@adu.uct.ac.za)

On Marion Island, personnel and their equipment are transferred from ship to island by helicopters. Flight operations may negatively impact penguins, especially during sensitive breeding stages. Since birds may perceive helicopters as potential threats, they may become more vigilant and this may affect their behaviour. Quantitative behavioural observations of gentoo penguins (*Pygoscelis papua*) were made before (control) and during logistic flight operations coinciding with the guarding and the brooding stages of this species. Observations were made at colonies within 1.5 km of the permanent research base. On non-flight days, guarding birds were more likely to be standing than brooding birds, but were not significantly more alert. On flight days, birds at both stages were more likely to be alert ( $p < 0.001$ ) and to be standing during flights than on non-flight days. Birds were significantly more likely to react during flights close to the colony than flights at greater distances. The proportion of alert birds usually returned to control levels within a few minutes after flights stopped, but the proportion of standing guarding birds remained higher on flight days, even in the absence of helicopter activity. Higher levels of vigilance might be energetically costly and standing up by brooding birds exposes chicks to the elements. Minimisation of flight operations near gentoo penguin colonies during the breeding season is recommended.

## THE INFLUENCE OF FOOD ON THE POPULATION ECOLOGY OF AFRICAN PENGUINS

PA WHITTINGTON<sup>1</sup> & RJM CRAWFORD<sup>2</sup>

<sup>1</sup>Avian Demography Unit, Department of Statistical Sciences  
University of Cape Town, Rondebosch, 7701, South Africa

<sup>2</sup>Department of Environmental Affairs and Tourism, Marine and Coastal Management  
Private Bag X2, Rogge Bay 8012, South Africa

African penguins *Spheniscus demersus* feed mainly on sardine *Sardinops sagax* and anchovy *Engraulis encrasicolus*. Fluctuations in the sizes of several African penguin colonies during the past 50 years are thought to be a consequence of major changes in abundance and distribution of these two fish species. Once breeding, African penguins exhibit strong mate and breeding site fidelity. Juvenile African penguins wander widely and were four times more likely than adults to be found at non-natal/breeding colonies. Young birds also travelled greater distances on average and were recorded up to 1720 km from their natal colony. Post-fledging dispersal could allow first-time breeders to select localities where they will settle to breed, a mechanism which may enable them to cope with regime changes in prey populations. In regions and periods of food scarcity, age at first breeding is delayed and breeding attempts may be skipped. Postponement of breeding may enhance survival and thereby facilitate a rapid response to improved feeding conditions. Annual adult survival, estimated to be 0.82 at Robben Island, did not vary greatly over periods of reasonable food abundance, but at times of extreme food scarcity was estimated to fall to a maximum of 0.72. The future survival of the species will depend on ensuring that recruitment to the breeding population at least offsets mortality.

## **LITTLE PENGUINS: PREDATORS IN A SOUTH AUSTRALIAN FISHERY**

ANNELISE WIEBKIN<sup>1,2</sup>, BRAD PAGE<sup>1</sup>, SIMON GOLDSWORTHY<sup>1</sup>, DAVID PATON<sup>2</sup> AND TIM WARD<sup>1</sup>

<sup>1</sup>SARDI Aquatic Sciences, 2 Hamra Rd, West Beach, SA 5024, Australia

<sup>2</sup>Environmental Biology, The Department of Earth and Environmental Science,  
The University of Adelaide, North Tce, Adelaide, SA 5000, Australia

The feeding ecology of little penguins in South Australia was investigated between 2004-2006 to better understand their role in the trophodynamics of the marine ecosystem surrounding Australia's largest volume fishery, the South Australian sardine fishery (TAC for 2005 51,100t). Penguins from several colonies across the region consumed a high biomass (70-96%) of fishery target species (sardines and anchovies) throughout the year. These species were found to be important for the onset of breeding, chick growth and fledging success. When anchovy biomass was reduced in the diet, prey species of lower energy values were consumed. Penguin foraging areas overlapped with the fishery area however each targeted different sized fish. The penguins consumed juvenile sardines and anchovies that were 6 months to a year from recruiting to the fishery. Sustained local depletions of these target species through fishery exploitation could reduce the abundance of juveniles available to little penguins for the maintenance of their populations.

**CONSERVATION OF THE BLUE PENGUIN *EUDYPTULA MINOR* ON THE WEST COAST,  
SOUTH ISLAND, NEW ZEALAND**

KERRY-JAYNE WILSON<sup>1,3</sup>, SOL HEBER<sup>2</sup>, ROBYN BLYTH<sup>1</sup>, LAURA MOLLES<sup>1</sup>,  
HELEN CHAMBERS<sup>3</sup> & JILL COTTON<sup>3</sup>

<sup>1</sup>Bio-Protection & Ecology Division, Lincoln University, Lincoln, Canterbury, New Zealand

<sup>2</sup>Centre for Nature Conservation, Georg-August University, von-Siebold-Str. 2,  
37075 Göttingen, Germany

<sup>3</sup>West Coast Blue Penguin Trust, RD1, Runanga, West Coast

This project was initiated by local residents who noticed a decrease in the numbers of blue penguins (*Eudyptula minor*). Research is undertaken by Lincoln University, but this project is equally dependent on the commitment of local residents. Since 2004, we have surveyed for penguin presence along 310km of the 450km long Westland coastline, with detailed surveys in areas where penguins seemed most numerous. Colonies are small, with penguins absent from large areas of apparently suitable coast. Selected colonies are monitored annually and control of introduced mammal predators at some colonies began in July 2007. Westland penguins lay a single clutch with no evidence of replacement laying. Chicks fledged from 66% of eggs laid with a mean of 1.18 chicks fledged per breeding pair. Only 38% of suitable burrows were occupied, suggesting a recent decrease in numbers. Threats to penguins vary among colonies, introduced predators, road kills, dogs and land development appear to be the major threats.

## CONSERVATION AND MANAGEMENT OF LITTLE PENGUINS IN NORTHWEST TASMANIA

A.WIND\* & P. MARKER\*\*

\*Coastal and Marine Facilitator, Cradle Coast NRM, PO Box 338,  
Burnie, Tasmania 7320 [awind@cradlecoast.com](mailto:awind@cradlecoast.com)

\*\*School of Zoology, University of Tasmania, Private Bag 05,  
Hobart, Tasmania 7001 [pfmarker@utas.edu.au](mailto:pfmarker@utas.edu.au)

Numerous colonies of little penguins are present along the northwest coast of Tasmania. A baseline survey of little penguins was undertaken in 1999/00 that established the presence and absence of colonies from Point Sorell to Wynyard, North West Tasmania. The colonies were found to range in size from approximately 10 – 2200 breeding pairs. Most of these colonies are found within the narrow coastal zone, sometimes no more than 100m wide. There are many threats to these colonies, including inappropriate management and development, habitat loss and modification, domestic and feral animals. Other major urban threats include cars and trains. Coastcare and “Friends Of” penguin volunteer groups began establishing in 1996 to conserve and enhance penguin habitat by revegetation, weeding, penguin protection fencing, installing artificial penguin burrows, construction of designated beach accesses and public education. These groups have received funding from the Australian Government through the Natural Heritage Trust for local projects to help manage the coast and protect the penguins. There are now over nine community groups working cooperatively with Local Councils and the Parks and Wildlife Service, looking after penguins and their coastal habitat in NW Tasmania. These groups are supported through Cradle Coast Natural Resource Management.

## PROTECTING PENGUINS UNDER THE U.S. ENDANGERED SPECIES ACT

SHAYE WOLF<sup>1</sup>, KASSIE SIEGEL<sup>2</sup> AND BRENDAN CUMMINGS<sup>2</sup>

<sup>1</sup> Center for Biological Diversity, 1095 Market Street, Suite 511,  
San Francisco, CA 94103, USA; [swolf@biologicaldiversity.org](mailto:swolf@biologicaldiversity.org)

<sup>2</sup> Center for Biological Diversity, P.O. Box 549, Joshua Tree, CA 92252, USA

Ten penguin species are currently under consideration for listing as “threatened” or “endangered” under the United States Endangered Species Act (ESA): emperor (*Aptenodytes forsteri*), southern rockhopper (*Eudyptes chrysocome*), northern rockhopper (*E. moseleyi*), Fiordland crested (*E. pachyrhynchus*), erect-crested (*E. sclateri*), macaroni (*E. chrysolophus*), white-flippered (*Eudyptula albosignata*), yellow-eyed (*Megadyptes antipodes*), African (*Spheniscus demersus*) and Humboldt (*S. humboldti*) penguins. These species face significant threats from changing environmental conditions and reduced food availability as a result of human-induced global warming and industrial fishing. We discuss the ESA listing process, the protections it provides, and how the ESA’s statutory prohibitions against “jeopardy” and “take” of listed species might apply to greenhouse-gas-generating actions of U.S. federal agencies. The ESA remains highly relevant to species preservation in a changing climate, providing mechanisms to address both mitigation (reducing greenhouse gas emissions) and adaptation (wildlife management in a changing climate).

## ASPERGILLOSIS IN PENGUINS: DIAGNOSTICS AND PREVENTION AT A MARINE ANIMAL REHABILITATION CENTER, IN BRAZIL

XAVIER, M.O.<sup>1</sup>; RUOPPOLO, V.<sup>2\*</sup>; OSÓRIO, L.G.<sup>1</sup>; LEITE, A.M.<sup>3</sup>

ADORNES, A.C.<sup>3</sup>; SILVA-FILHO, R.P.<sup>2,3</sup>;

\*Corresponding Author: [vruoppolo@uol.com.br](mailto:vruoppolo@uol.com.br)

1- Universidade Federal de Pelotas

2- International Fund for Animal Welfare (IFAW) – Emergency Relief [www.ifaw.org](http://www.ifaw.org)

3- Centro de Recuperação de Animais Marinhos (CRAM) - Museu Oceanográfico

“Prof. Eliézer de C. Rios”, Fundação Universidade Federal do Rio Grande (MO, FURG).

Rua Cap. Heitor Perdigo 10, CEP 96200-970, Rio Grande, R.S. - Brazil

*Aspergillosis* is one of the major causes of death in penguins during rehabilitation. Indoor disinfection is essential to control *Aspergillus*, reducing the number of conidia to susceptible birds. This article describes two years of aspergillosis casuistic in *Spheniscus magellanicus* at CRAM (Brazil - 32°S 52°W), considering the implementation of a disinfection schedule with chlorhexidine on the second year. Along the period of study, CRAM received 52 *S. magellanicus*, and 23% (12/52) died. Necropsies were performed and tissue samples collected for histological and microbiological examination. Samples of indoor air were collected by sedimentation with Agar Sabouraud dextrose. During the second year, the floor was disinfected daily, and all equipment, objects, walls and roof were weekly disinfected. From the 12 dead animals, *aspergillosis* was confirmed in five, each one of the cases in the first year of this study. Granulomatous nodules were observed mainly on air sacs and lungs. On histopathology, septate and branching hyphae were found. Two species, *A. fumigatus* and *A. flavus*, were identified by mycological culture. The results of air samples demonstrate that the disinfection program was statistically effective in reducing *Aspergillus* conidia concentrations indoors ( $p=0,025$ ). This paper points out the importance of aspergillosis during the penguins' rehabilitation process, and emphasizes the need for disinfecting facilities to help preventing aspergillosis.





