Fourth International Science Symposium on Bio-logging

PROGRAM AND ABSTRACTS

Wrest Point Hotel and Conference Centre
Hobart, Tasmania, Australia

14-18 March 2011

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WELCOME!

Welcome to Hobart, Tasmania's harbour capital and Australia's gateway to the Southern Ocean and Antarctica. Founded in 1803 as a penal colony, and originally called Hobart Town or Hobarton, Hobart is Australia's second oldest capital city after Sydney. The original inhabitants of the area were the Mouheneener tribe, who were one of up to ten semi-nomadic tribes that occurred throughout the south-east region of Tasmania. Hobart extends along both shores of the Derwent River and its skyline is dominated by Mt Wellington (at 1271 metres). Mt Wellington is part of the Wellington Ranges and is known as Kunanyi to the indigenous people of Tasmania.

Hobart's connections with the Southern Ocean and Antarctica date back to the 18th century and the city has been the staging site for many of the early exploration and research expeditions to the Antarctic, including those of Mawson and Amundsen. Today, Hobart is the home port to both Australia's and France's Antarctic programs, as well as being a world-class centre for Antarctic and Southern Ocean education and research. Reflecting this history and focus for research, our first theme session is on our southern oceans and the application of bio-logging in better understanding the influence of oceanographic and climatic conditions on populations in the Southern Ocean.

Bio-logging research spans many species and applications, and in collecting data from a number of individuals we are often applying these data to questions at the population level and under multiple management regimes and changing environmental conditions. The three other theme sessions of the conference are focused on the application of bio-logging data to questions at the population level and to fishery, biodiversity and conservation management applications.

The Honourable John Kerin AM, CSIRO Board member, will open the conference on Monday morning. Mr Kerin has had a significant parliamentary career, holding Ministries for Trade and Overseas Development, Transport and Communications, Primary Industries and Energy and Primary Industry, as well as holding the Federal Government position of Treasurer. He was awarded a Member of the Order of Australia in 2001 and holds an honorary Doctorate in Science from the University of Tasmania. He is a Fellow of the Academy of Technological Sciences and Engineering and a Fellow of the Australian Institute of Agricultural Science and Technology.

The organisers would like to thank our sponsors, CSIRO's Wealth from Oceans Flagship, the Australian Antarctic Division, CSIRO Marine & Atmospheric Research, the University of Tasmania's Institute for Marine and Antarctic Science, Lotek Wireless Inc., the Tag-A-Giant Foundation, Star-Oddi and Vemco. We would also like to thank all of our vendors for their support of the conference. Thanks are extended to Matt Lansdell, Jacquie Donovan, Tanya Fisher and Toni Cracknell for their help in preparing for the conference. Matt and our volunteers Ben, Jess, Kilian and Marie will be helping you out throughout the conference – we thank them for their enthusiasm and assistance.

Once again, we welcome you all to Hobart and hope that you have an enjoyable stay whilst in Tasmania. We wish you all an invigorating and stimulating conference and look forward to all of the presentations making up the program.

Karen Evans, Barbara Block, Campbell Davies, John Gunn and Mark Hindell
Bio-logging 4 Steering Committee

SPONSORS

We gratefully acknowledge the sponsors of this symposium profiled below. Their kind support has allowed us to provide financial assistance to students and will help to ensure that Bio-logging 4 is a success.

Research by **CSIRO** (http://www.csiro.au/science/oceans.html) supports adaptive and flexible marine resource allocation – at increasingly finer time and spatial scales – for fisheries regulation, biodiversity conservation and balanced coastal zone management. With our partners we:

- assess and monitor the distribution of fishers, commercial species and biodiversity, and the impacts of natural processes and human activities
- deploy satellite, pop-up, archival and acoustic tags and analyse data to estimate movements, behaviour and trophodynamics of pelagic predators
- develop statistical methods for fishery independent surveys and observations
- conduct population, ecosystem and management strategy modelling
- engage with regional fisheries management organisations
- build capacity in Indonesia, Papua New Guinea and Pacific island nations.

Australian Government

Department of Sustainability, Environment, Water, Population and Communities
Australian Antarctic Division

The **Australian Antarctic Division** (http://www.antarctica.gov.au) leads Australia's Antarctic program. As a division of the Department of Sustainability, Environment, Water, Population and Communities, our charter is to ensure Australia's Antarctic interests are advanced. The Australian Antarctic program has four goals:

1. Maintain the Antarctic Treaty System and enhance Australia's influence in it
2. Protect the Antarctic environment
3. Understand the role of Antarctica in the global climate system
4. Undertake scientific work of practical, economic and national significance.

IMAS (http://www.imas.utas.edu.au) was created by the University of Tasmania in 2010 to encourage collaborative research in marine and Antarctic science between various parts of the University, CSIRO Marine and Atmospheric Research, the Australian Antarctic Division and other agencies.
IMAS aspires to be the leading institution for the study of high-latitude marine and terrestrial science.
IMAS is in partnership with the Government of Tasmania to deliver research and extension products for the betterment of Tasmania's aquaculture and fishing industries.

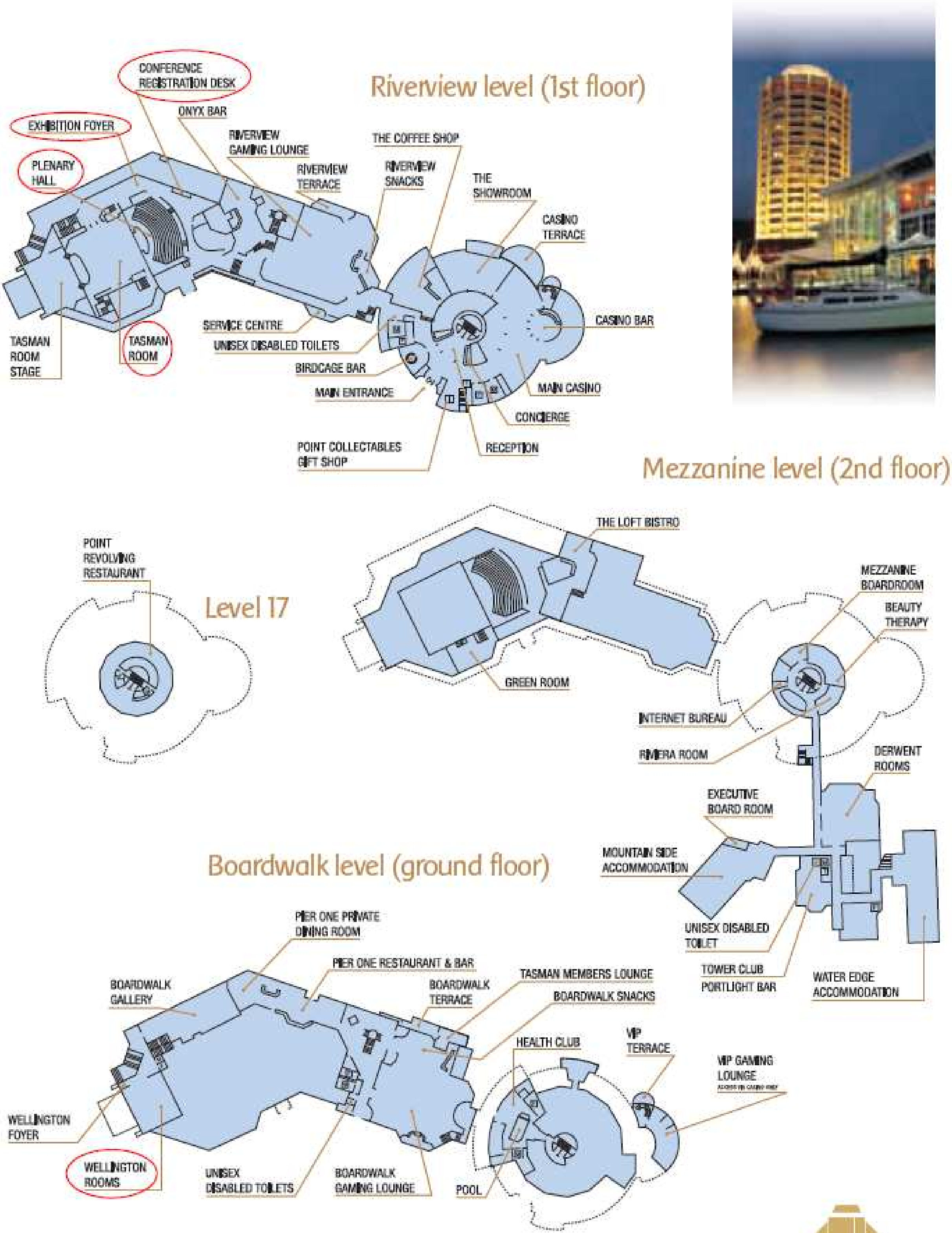
Lotek Wireless (http://www.lotek.com) is a world leader in the design and manufacture of fish and wildlife monitoring systems. Our innovative and internationally recognized radio, acoustic, archival and satellite monitoring solutions allow researchers to track animals, birds and fish of almost any size, in almost any environment.

Tag-A-Giant (TAG; http://www.tagagiant.org) is the world^{1}s only organization dedicated entirely to bluefin tunas. TAG supports the scientific research necessary to develop innovative and effective policy and conservation initiatives to ensure a future for northern bluefin tuna in the Atlantic and Pacific oceans. In the past decade, the team has placed 1,700 electronic tags on northern bluefins, providing 25,000 days of bluefin behavior in the Atlantic and over 64,000 tracking days in the Pacific.

Star-Oddi (http://www.star-oddi.com) has become recognized as one of the world's leading manufacturers of technology for research on the oceans and its living resources. Star-Oddi offers a wide range of environmental research equipment such as fish archival tags and other underwater data loggers.

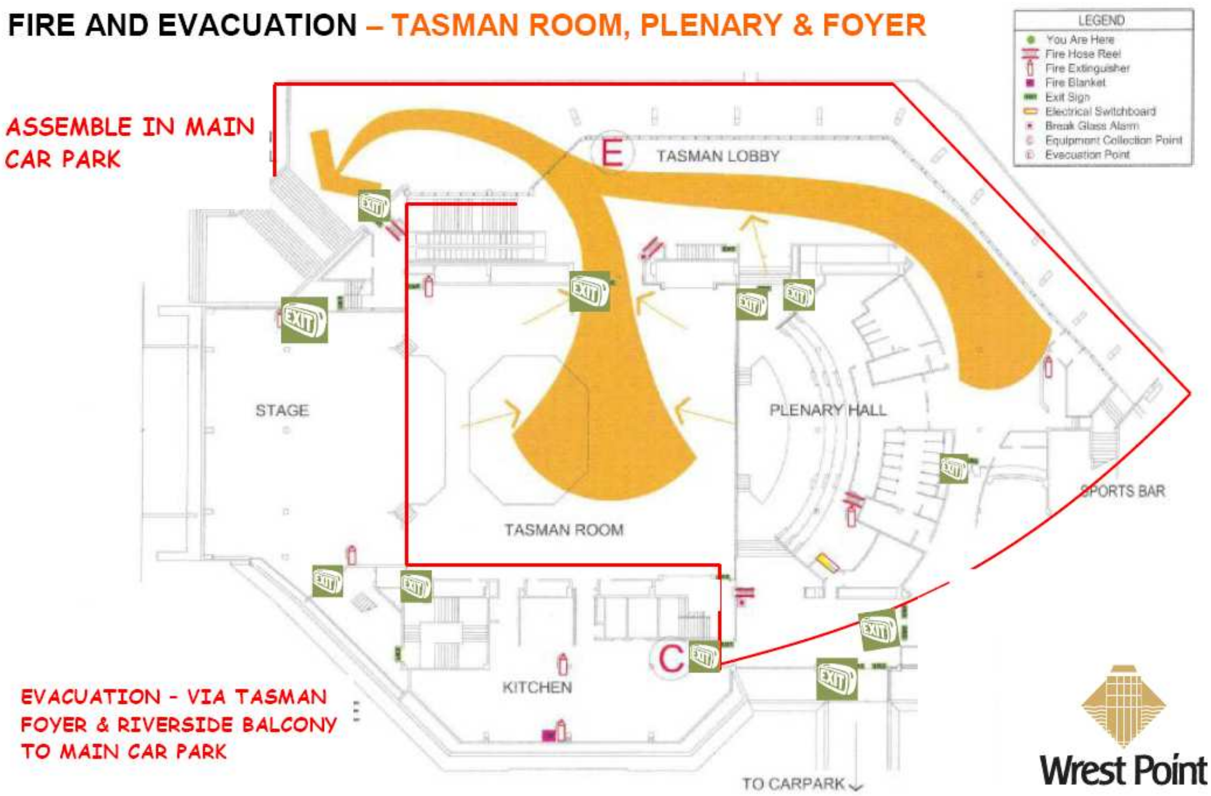
For over 26 years, **VEMCO** (http://www.vemco.com) has been designing and manufacturing underwater acoustic telemetry equipment for fisheries, biologists, and aquatic research specialists. They provide customized underwater acoustic telemetry and tracking equipment to scientists studying the behaviour patterns of marine and freshwater animals.

WREST POINT DIRECTORY



Wrest Point

EMERGENCY EVACUATION PLAN



GENERAL MEETING INFORMATION

Venue

Bio-logging 4 is being held at the Wrest Point Hotel and Convention Centre, situated on Hobart's waterfront in Sandy Bay. The main plenary of the conference will be held in the Plenary Hall, with posters being exhibited in the Tasman Room and trade exhibits located in the Tasman (exhibition) Foyer. The Wellington Room is available for break-out sessions and group discussions. Room for use of laptops for access to wireless internet is also available in the Wellington Room. Morning tea, lunch and afternoon tea will be held in the Tasman (exhibition) Foyer.

Wireless internet will be provided free of charge throughout the conferences areas. We request that delegates refrain from computer use in the Plenary Hall – room in the Wellington Room is available for use of laptops for access to wireless services.

Registration

Registration will occur at the conference registration desk located at the entrance of the Tasman (exhibition) Foyer. Any general questions regarding the conference should be addressed to the Registration Desk staff. The Registration Desk will be open during the following hours:

Sunday 13 March: 14:00-17:00
Monday 14 March: 07:30-17:00
Tuesday 15 March: 08:30-17:00
Thursday 17 March: 08:30-17:00
Friday 18 March: 09:00-17:00

Trade Exhibits

A range of trade exhibits will be located in the Tasman (exhibition) Foyer and will be accessible during the hours of the conference. Delegates are encouraged to take the time to have a look at these and talk to the representatives occupying the exhibits. A full list of companies with trade exhibits at the conference can be referred to on our trade exhibit page.

Oral presentations

Plenary sessions will be held on the Monday, Tuesday, Thursday and Friday of the conference. Oral presentations should be delivered on a CD or a clean USB memory stick to the Wrest Point Convention Centre A/V staff in the Speakers Preparation Room well in advance of assigned presentation times. Presenters scheduled in morning sessions must submit their presentations by 17:00 on the day before their presentation and those scheduled in afternoon sessions must submit their presentations by morning tea on the day of their presentation. The exceptions to this will be presenters on the Monday and Thursday mornings of the conference. Presentations for the Monday morning must be submitted in the afternoon between 14:00-17:00 on Sunday 13 March and those for the Thursday morning submitted no later than 17:00 on Tuesday 15 March.

Please ensure that your presentation does not exceed the allocated 15 minutes – you will be asked to leave the podium after 15 minutes regardless of whether you have finished your presentation or not.

Poster presentations

Posters will be on display for the entire conference in the Tasman Room. Posters may be hung on Sunday 13 March from 14:00-17:00 hours or on the morning of Monday 14 March from 7.30am until morning tea. All posters must be hung in their allocated positions by the start of morning tea on Monday 14 March. A Poster Evening cocktail function will be held on Tuesday evening from 17:30-19:30 in the Tasman Room. Poster presenters should stand with their posters during this event. This event is restricted to registered conference delegates only.

Icebreaker

A welcome cocktail function will be held on Monday 14 March from 18:00-20:00 at the Hobart Town Hall. Transport will be provided between Wrest Point and the Town Hall, with return back to Wrest Point after the function. If you require transport to the Town Hall from Wrest Point, buses will be at the main entrance to Wrest Point (main doors) at 17:30. Buses will be departing for return to Wrest Point at 20:00 from the Hobart Town Hall. There will be no additional transport provided, so delegates are encouraged to be at bus pick-up points on time. This event is open to registered conference delegates and paid guests.

Conference Dinner

The conference dinner will be held at Moorilla Estate on Thursday 17 March from 19:30-23:30. Transport from Wrest Point to Moorilla Estate will be provided via two ferries, the first departing at 18:00 and the second departing at 19:00. Your conference dinner ticket will state which ferry you have been allocated to. Scheduling of catering associated with ferry transport to Moorilla Estate requires that delegates depart Wrest Point on the ferry to which they have been allocated – please do not swap between ferries. Dinner tickets must be provided for access to the ferry – no ticket, no ferry, no dinner. Please ensure you are on the Wrest Point ferry jetty 15 minutes prior to your ferry's scheduled departure. Transport back to Wrest Point via a drop off point in the city centre will be provided with buses departing from Moorilla Estate at 22:15, 23:00 and 23:45. There will be no additional transport provided, so delegates are encouraged to be at departure points on time. This event is open to registered conference delegates and paid guests that have dinner tickets.

Workshops

A number of workshops are being held in association with the conference on Saturday 12 March, Sunday 13 March, Wednesday 16 March and Saturday 19 March. Please refer to our workshops page for further information on these.

Proceedings

The proceedings of the Fourth International Science Symposium on Bio-logging will be published in a scientific journal soon to be determined; the editor of Deep Sea Research II has expressed considerable interest. Please check our website for updates on this and details on requirements for contributions. We anticipate that the deadline for submission of abstracts for forwarding to the editor will be May 1, 2011.

Discounts for local tourist attractions

A number of companies have provided generous discounts on tourist activities and attractions for Bio-logging 4 delegates, associates and family members. A full list of companies and the discounts being offered has been provided on the conference usb stick provided in delegate conference bags. The conference organisers would like to thank all those companies offering discounts for their generosity.

Important phone numbers

Taxis - City cabs: 131 008; Taxi Combined 132 227
Public transport Metro info line: 132201
Emergency – ambulance, fire, police: 000

TRADE EXHIBITS

The following companies will be exhibiting at Bio-logging 4. We encourage delegates to visit our trade partners during the conference.

www.cls.fr; www.argos-system.org	**www.cefastechnology.co.uk**
www.desertstar.com	**www.ecotone.pl**
www.eonfusion.com	**email: dofleo@l-leo.com**
www.lotek.com	**www.sirtrack.com**
www.smru.st-andrews.ac.uk/Instrumentation	**www.technosmart.eu**
www.wildlifecomputers.com	

WORKSHOPS

A number of workshops discussing related topics to bio-logging will be held in association with the Symposium, providing an opportunity to progress particular aspects of bio-logging science and increase the level of scientific discussion across the bio-logging community. We hope delegates take the opportunity to participate in these.

Workshops to be held in association with Bio-logging 4 –

- **Bio-logged data management and sharing**

  Date: Wednesday 16 March 2011
  Venue: Freycinet Room, CSIRO Marine & Atmospheric Research, Castray Esplanade, Hobart
  Contact: Francesca Cagnacci (francesca.cagnacci@iasma.it)

- **CLIOTOP Working Group 2: linking the physiology, behaviour and distribution of top predators with environmental cues**

  Date: Saturday 19 March 2011
  Venue: Churchill Room, Salamanca Inn, Hobart
  Contact: Karen Evans (karen.evans@csiro.au)

- **Fine-scale on-animal movement sensing: methods, performance and limitations**

  Date: Sunday 13 March 2011
  Venue: Centenary Lecture Theatre, University of Tasmania, Churchill Avenue, Sandy Bay
  Contact: Mark Johnson (majohnson@whoi.edu)

- **Multivariate biologging: ensuring accuracy in describing animal energy budgets**

  Date: Saturday 12 March 2011
  Venue: University Club, University of Tasmania, Sandy Bay
  Contact: Peter Frappell (peter.frappell@utas.edu.au)

- **Objectively diving into the analysis of time-series depth recorder series and behavioral data records**

  Date: Saturday 12 March 2011
  Venue: Wellington Room, Wrest Point Hotel and Conference Centre, Sandy Bay
  Contact: Jamie Womble (jamie.womble@oregonstate.edu)

- **Tagging through the stages: technical and ecological challenges in observing life histories through bio-logging**

  Date: Wednesday 16 March 2011
  Venue: Wellington Room, Wrest Point Hotel and Conference Centre, Sandy Bay
  Contact: George Shillinger (georges@stanford.edu) or Helen Bailey (hbailey@umces.edu)

- **The use of visual media with data in bio-logging**

  Date: Wednesday 16 March 2011
  Venue: Auditorium, CSIRO Marine & Atmospheric Research, Castray Esplanade, Hobart
  Contact: Randall Davis (davisr@tamug.edu), Greg Marshall (gmarshal@ngs.org) and Katsufumi Sato (katsu@aori.u-tokyo.ac.jp)

SCIENTIFIC PROGRAM

THEME SESSIONS

1. Southern Ocean ecosystems

The Southern Ocean is a highly dynamic system, home to a large diversity of species. Weather, climate, ice extent, and ocean currents all influence the Southern Ocean which is considered to be undergoing unprecedented levels of change. This theme session focuses on how bio-logging can provide valuable insights into evaluating the influence of oceanographic and climatic conditions on individuals and populations in the Southern Oceans and how variability in this environment may affect Southern Ocean species into the future.

Moderators: John Gunn, Mary-Anne Lea

2. Fishery and biodiversity management applications

Collection of information on the spatio-temporal dynamics of the behaviour of species relevant to fisheries and environmental managers has been made possible through bio-logging science. Integration of such information into population assessments, spatially explicit management models and ecosystem models is difficult and as a result the uptake of such data into management applications has lagged somewhat. This theme session focuses on the integration of individual based bio-logging data in management tools and applications, new methods for the potential integration of these data into management tools and applications and future requirements of bio-logging science for input into management applications.

Moderators: Campbell Davies, Julian Metcalfe

3. From individuals to populations – inference of population dynamics from individuals

Bio-logging science focuses on the collection of often novel behavioural and biological information from the individual. However, regularly questions and issues associated with the collection of these data relate to populations and systems rather than individuals, requiring the inference of population level and system dynamics from individual based information. This theme session focuses on the use of bio-logging data collected at the level of the individual and the application of these data to address issues and questions relating to populations and systems.

Moderators: Barbara Block, Katsufumi Sato

4. Conservation biology

Data provided through bio-logging science can improve our understanding of the behaviour and biology of species of conservation concern and in doing so provide information important for the management of these species. This theme session focuses on the application of bio-logging science in understanding the biology and ecology of species of conservation concern and the associated development of tools relevant to conservation issues.

Moderators: Simon Goldsworthy, Nick Gales

5. Habitat modelling

Understanding habitats of importance and how the environment may influence the behaviour of species is critical to understanding how a changing environment may influence individuals and populations and what management measures may be required to sustainably manage populations in this changing environment. This theme session focuses on how bio-logging data may be used to better understand the relationships between individuals, their habitat and habitat use.

Moderators: Alistair Hobday, Toby Patterson

KEYNOTE SPEAKERS

Dr Christophe Guinet, Centre d'Etude Biologique de Chizé-CNRS, France

Christophe Guinet, currently Directeur de Recherche at the Centre d'Etude Biologique de Chizé-CNRS, France has been undertaking research in the field of marine biology for over 20 years, specialising in the behavioural and foraging ecology of marine mammals. His research in this field began in 1987, when he spent one year in British Columbia, Canada investing the ecology of killer whales. In 1991, he completed his PhD on the behavioural ecology of the Crozet Archipelago killer whales, and then undertook a two-year contract at Oceanopolis, Brittany, to investigate the ecology of bottlenose dolphins and grey seals occurring in the Molène Archipelago. In 1993, he obtained a research position in the seabird and marine mammal research group at CEBC-CNRS focused on understanding the consequences of environmental variability on the foraging and breeding performances of top marine predators, in particular marine mammals. To achieve this goal he is implementing multidisciplinary approaches relying on the use of a broad variety of loggers. Christophe is currently in charge of the French contribution to the international programs Southern Elephant seal as Ocean Samplers (SEaOS) and Marine Mammal Ocean Explorer- Pole to Pole (MEOP), in which over 100 SMRU CTD SRDLs have been deployed between 2003 and 2010, on both male and female southern elephant seals that use Kerguelen for breeding and moulting. He played a key role, with the SMRU engineer in developing the latest generation of seal oceanographic tags incorporating fluoremeter or oxygen sensors. Foraging success of these elephant seals is assessed by a number of methods relying on fine scale analyses on Argos-GPS track, dive, light and/or accelerometers data. On a more applied side he is involved in studying the operational interaction of killer whales and sperm whales with the demersal long line fishing of Patagonian tooth fish. He has published over 100 scientific papers, and supervised 3 post-doc, 18 PhD and 24 master students.

Dr. Sasha Hooker, University of St. Andrews, United Kingdom

Sascha Hooker is a marine ecologist at the Sea Mammal Research Unit at the University of St Andrews, UK. Sascha has been involved in research into the ecology and conservation of marine mammals since 1993. She has three main areas of research: the interaction between marine mammal behaviour and the surrounding environment, the application of this to map and protect productive ocean areas, and the physiological mechanisms underpinning diving behaviour. Sascha received her PhD in 1999 from Dalhousie University, Canada, where she studied the foraging ecology of northern bottlenose whales. She then obtained a post-doctoral fellowship with the British Antarctic Survey working on Antarctic fur seals in South Georgia, and most recently a Royal Society Dorothy Hodgkin Fellowship at the University of St Andrews. She has had a long interest in Biologging, from the trials of trying to attach TDRs to northern bottlenose whales, to the tribulations of using prototype oceanographic and digital camera tags on Antarctic fur seals.

Dr Ian Jonsen, Dalhousie University, Canada

Dr Ian Jonsen is a quantitative ecologist at Dalhousie University. He is the leader of a lab that studies the role that movement behaviour plays in shaping the population ecology of marine predators. His research focus is on understanding the movement behaviors and distribution of marine predators through the application of state-space models and related analytical methods that reveal hidden patterns in noisy electronic tracking data. The rapid advancement of electronic tracking and remote sensing technologies has yielded an impressive array of studies that provide important insight into the movements, habitat use, and distribution of predators in the continental shelf and open ocean realms. Knowledge of relationships between predator movements and physical ocean processes is lacking but essential for understanding distribution, for informing management policy and conservation programs, and for predicting responses to climate change. Ian was one of the principal investigators on the Census of Marine Life project Future of Marine Animal Populations (FMAP) and he is currently co-investigator on the Ocean Tracking Network (OTN) project which is conducting the world's most comprehensive and revolutionary examination of marine life and ocean conditions, and how they are changing as the earth warms.

Dr Graham Robertson, Australian Antarctic Division, Australia

Graham Robertson is a seabird ecologist at the Australian Antarctic Division. After spending half his working life as a botanist in arid Australia he switched to seabirds in the late 1980s when he completed an overwintering study on emperor penguins near Mawson station, Antarctica. Attracted by the conservation imperative, in the early 1990s he broadened his horizons to include research with longline fishing industries on methods to reduce their impact on migratory seabirds. His principal endevour is to develop science-based solutions to the problem of seabird mortality in longline fisheries and embed findings in conservation measures regulation. He has conducted research on all the longline fishing methods in the world that endanger seabirds - demersal autoline, demersal Spanish system and pelagic. In 2004 he was awarded a Pew Fellowship to research seabird avoidance methods with the Spanish method of deep water longlining. In 2007 he switched to pelagic longline fisheries. He has completed numerous experiments to expedite gear sink rates and is currently working with an Australian engineering company to develop an underwater bait setting system for tuna and swordfish fisheries. That research will come to a head in the spring of 2010 when he will complete a proof-of-concept experiment off Uruguay under worse-case scenario conditions for seabirds.

KEYNOTE ABSTRACTS

Linking the ecology of top marine predators with oceanography. The combination of biologging data with satellite derivated information

Christophe Guinet

Centre d'Etude Biologique de Chizé CNRS, 79 360 Villiers en Bois, France

guinet@cebc.cnrs.fr

Studying the foraging behaviour of top marine predators by establishing when and where they forage in relation to the oceanographic context is critical to understand how the natural variability of the marine environment and longer term changes induced by human activity could impact the foraging efficiency and consequently the demographic trajectories of these apex predators. To address this question, detailed information was needed on both instant foraging success and oceanographic conditions. Yet, the knowledge of fine scale foraging processes has been limited by a lack of information about feeding success. However in recent years considerable progresses have been achieved through biologging to first assess instant changes in foraging efficiency and second to measure local changes in an increasing number of oceanographic parameters. Several methods relying on the use of hall sensors, accelerometers, cameras…have emerged to quantify prey captures attempt or events and in some case to identify prey species. In the same time an increasing number of oceanographic parameters such as temperature, salinity, fluorescence, dissolved oxygen are recorded from large to fine scale making top marine predators an increasingly important source of data to monitor ocean state. The simultaneous combination of both approaches on the same individuals open a new area to better understand how the marine predators prey field is spatially structured in relation to local oceanographic conditions, while the global oceanographic context is provided by satellite information. New generations of loggers combining accelerometers, magnetometers, swimming speed and pressure allow investigating the 3D fine scale diving behaviour allowing assessing environmental stimulus, such as bioluminescence or acoustic clues that predators might use to locate their preys. However the massive amount of recorded information to be analysed constitutes one of the main challenge that biologging biologists are facing in the decade to come and it is increasingly critical to develop computational skills and to address the question of the needed data resolution to provide pertinent proxies of foraging success and oceanographic context.

From individuals to populations - movements, foraging, fitness and the comparative method

Sascha K. Hooker

Sea Mammal Research Unit, Scottish Oceans Institute, University of St Andrews, Fife, KY16 8YG, UK

s.hooker@st-andrews.ac.uk

Biologging data is recorded at the scale of behavioural observations, and yet most management-level decisions require information at the scale of the population. Studies must therefore capture enough variability to accurately describe the population and/or collect ancillary data to provide explanatory models of the variability observed. I discuss the study of animal movements – ranging from manipulative experiments of forest-dwelling rats, to the description of beaked whale and fur seal diving behaviour. Movements can be related to population consequences via life function (foraging success) and vital rates (individual success). Several biologging methods can identify different aspects of foraging, and I have used animal-attached cameras to provide visual-field (prey availability) measurements. These allow the classification of foraging signatures within fur seal diving behaviour, and can then be applied to much larger (potentially historical) TDR datasets. Identification of foraging locations and assessment of the stability of these over time and space is a key component for the identification and designation of pelagic marine protected areas. The relationship between foraging success and individual fitness is less studied but this level of detail is also becoming more important for accurate demographic assessment in conservation planning. Lastly, I suggest that beyond the population level, a comparative understanding of species differences will be key to developing a better understanding of physiological processes underlying diving behaviour.

A quantitative approach to animal movement ecology

Jonsen ID.

[1]Biology Department, Dalhousie University, Halifax, Nova Scotia, Canada.
[2]Bedford Institute of Oceanography, Fisheries and Oceans, Dartmouth, Nova Scotia, Canada.

*jonsen@mathstat.dal.ca

The study of animal movements and their implications for distribution, population dynamics, and biodiversity patterns has benefited tremendously from continued advancements in electronic tracking technologies over the past several decades. Only recently, however, have analytical tools for these behaviourally rich datasets begun to catch up. I will outline a general quantitive approach, based on Bayesian state-space models, for analysis of electronic tracking data. I will show how colleagues and I have applied these models to better understand marine predator movement behaviour and distribution patterns and how this work can inform conservation and management efforts. I will also outline plans for future research as part of the Ocean Tracking Network in Canada.

A particle on the road to ecologically sustainable fisheries

Robertson, G.

Australian Antarctic Division, Channel Highway, Kingston 7050 Tasmania, Australia

graham.robertson@aad.gov.au

Common sense dictates that the future of human societies depends on the maintenance of marine (and terrestrial) systems that are healthy and managed sustainability over the long term. The conventional indicators of marine health suggest our track record in achieving this goal leaves a lot to be desired. Advances in fish location technology and fishing gears, and increases in fleet sizes combined with increasing demand for seafood across the globe has resulted in a widespread decline in marine biodiversity. These changes have outstripped our capacity to integrate sustainable stewardship practices into fisheries policy and management. Impacts are not limited to target species - non-target species, such as seabirds, are also affected: 18 of the 22 species of albatrosses are endangered according to IUCN criteria principally due to bycatch in fisheries. Scientists have an important role to play in developing and implementing solutions to critical problems associated with fisheries. The presentation will a) allude to some of the issues that undermine sustainability, b) outline some of the lessons learnt during the course of working collaboratively with the fishing industry, c) provide case studies of the links between research and management and, d) summarise progress on a new technology to reduce (or eliminate) seabird mortality in tuna and swordfish longline fisheries. The talk is mainly aimed at scientists interested in working at the interface between wildlife conservation and the fishing industry.

PROGRAM OVERVIEW

Time	Saturday 12 March		Sunday 13 March		Monday 14 March		Tuesday 15 March	Wednesday 16 March			Thursday 17 March	Friday 18 March	Saturday 19 March
	Workshops		Workshops			Wrest Point	Wrest Point	Workshops			Wrest Point	Wrest Point	
7:30	Wrest Point	University of Tasmania	University of Tasmania	Wrest Point	Registration	Registration		CSIRO	CSIRO	Wrest Point			Salamanca Inn
8:00							Arrival tea & coffee, poster and exhibit viewing				Arrival tea & coffee, poster and exhibit viewing		
8:30			Fine scale on-animal movement sensing: methods, performance and limitations			Welcoming	Plenary lecture: Graham Robertson	Bio-logged data management and sharing	The use of visual media with data in Bio-logging	Tagging through the stages: technical and ecological challenges in observing life histories through bio-logging	Plenary lecture: Sascha Hooker	Arrival tea & coffee, poster and exhibit viewing	
9:00	Objectively diving into the analysis of time-depth recorder series and behavioural data records	Multivariate biologging: ensuring accuracy in describing animal energy budgets				Plenary lecture: Christophe Guinet						Plenary lecture: Ian Jonsen	Clotop WG2: linking the physiology, behaviour and distribution of top predators with environmental cues
9:15							Theme 2 oral presentations				Theme 3 oral presentations		
9:45						Theme 1 oral presentations						Theme 4 oral presentations	
10:00													
10:15											Morning tea		
10:30						Morning tea	Morning tea					Morning tea	
10:45											Theme 4 oral presentations		
11:00						Theme 1 oral presentations	Theme 3 oral presentations					Theme 5 oral presentations	
13:00						Lunch/poster & exhibit viewing	Lunch/poster & exhibit viewing				Lunch/poster & exhibit viewing	Lunch/poster & exhibit viewing	
14:00				Trade set-up, submission of Monday morning oral presentations, poster set-up, registration		Theme 1 oral presentations	Theme 3 oral presentations				Theme 4 oral presentations	Theme 5 oral presentations	
15:30						Afternoon tea	Afternoon tea				Afternoon tea	Afternoon tea	
16:00						Theme 2 oral presentations	Theme 3 oral presentations				Theme 4 oral presentations	Theme 5 oral presentations	
17:15												Closing remarks & student awards	
17:30						Transfer to Hobart Town Hall	Poster cocktail evening, Tasman Room Wrest Point 5.30-7.30pm						
18:00						Icebreaker cocktail function, Hobart Town Hall 6-8pm					Transfer to Moorilla Estate		
19:00													
19:30											Conference dinner, Moorilla Estate 7.30-11.30pm		
20:00						Transfer to Wrest Point							
11:30											Transfer to Hobart/Wrest Point		

Workshops
Registration & set-up
Plenary sessions
Breaks & social events
* To be presented by co-author

ORAL PRESENTATION SCHEDULE

Time	Sunday 13 March	Monday 14 March	Tuesday 15 March	Wednesday 16 March	Thursday 17 March	Friday 18 March
7:30		Registration; Registration				
8:00			Arrival tea & coffee, poster and exhibit viewing		Arrival tea & coffee, poster and exhibit viewing	
8:15						
8:30		Welcoming	Plenary lecture: Graham Robertson		Plenary lecture: Sascha Hooker	Arrival tea & coffee, poster and exhibit viewing
8:45				workshops		
9:00		Plenary lecture: Christophe Guinet				Plenary lecture: Ian Jonsen
9:15			O2.06 Goldsworthy S		O3.20 Womble, J	
9:30			O2.07 Babcock, R		O3.21 Miller, P	
9:45		O1.01 Davis, R	O2.08 Hunter, E		O3.22 Lowther, A	O4.21 Caganacci, F
10:00		O1.02 Huckstadt, L	O2.09 Righton, D*		O3.23 Vincent, C	O4.22 Abecassis, M
10:15		O1.03 Teutschel, N	O2.10 Holland, K		Morning tea	O4.23 Strøm, H
10:30		Morning tea	Morning tea			Morning tea
10:45					O4.01 Vandenabeele, S	
11:00		O1.04 Dragon, A-C	O3.01 Sumner, M		O4.02 Berger, A	O5.01 Basson, M
11:15		O1.05 Lea, M-A	O3.02 Pedersen, MW		O4.03 Prieto, R	O5.02 Patterson, T
11:30		O1.06 Cotte, C	O3.03 Wisniewska, D		O4.04 Maxwell, S	O5.03 London, J
11:45		O1.07 Bestley, S	O3.04 Aguilar Soto, N		O4.05 Calambokidis, J*	O5.04 Irvine, L
12:00		O1.08 Hindell, M	O3.05 Madsen, P		O4.06 McConnell, B	O5.05 Ver Houf, J*
12:15		O1.09 Scheffer, A	O3.06 Rutz, C		O4.07 DeRuiter, S	O5.06 Call, K
12:30		O1.10 Viviant, M	O3.07 Read, A*		O4.08 Tancell, C	O5.07 Dettki, H
12:45		O1.11 Meulbert, M	O3.08 Battaile, B		O4.09 Metcalfe, J	O5.08 Goetsch, C
13:00		Lunch/poster, trade & art exhibition viewing	Lunch/poster, trade & art exhibition viewing		Lunch/poster, trade & art exhibition viewing	Lunch/poster, trade & art exhibition viewing
13:15						
13:30						
13:45						
14:00	Trade set-up, submission of Monday morning oral presentations, poster set-up, registration	O1.12 Peron, C	O3.09 Kuhn, C		O4.10 Fossette, S	O5.09 Randall, J
14:15		O1.13 Sakamoto, K	O3.10 Nakamura, I		O4.11 Joy, R*	O5.10 Pelletier, L
14:30		O1.14 Friedlaender, A	O3.11 Nordstrom, C		O4.12 Phillips, R	O5.11 Kawabe, R
14:45		O1.15 Kokubun, N	O3.12 Wheatley, K		O4.13 Focardi, S	O5.12 Hobday A
15:00		O1.16 Sato, K	O3.13 Williams, C		O4.14 Bradford, R	O5.13 Costa, D
15:15		O1.17 Harcourt, R	O3.14 Thierry, A-M		O4.15 Payne, N*	O5.14 Garrigue, C
15:30		Afternoon tea	Afternoon tea		Afternoon tea	Afternoon tea
15:45						
16:00		O2.01 Faustino, C	O3.15 McDonald, B		O4.16 Kovacs, K	O5.15 Jonson, M
16:15		O2.02 Eveson, P	O3.16 Cottin, M		O4.17 Shillinger, G	O5.16 Palacios, D
16:30		O2.03 Block, B	O3.17 Casper, R		O4.18 Simon, M	O5.17 Rogers P
16:45		O2.04 Hartog, J	O3.18 Fuller A		O4.19 Dassis, M	O5.18 Tosh C
17:00		O2.05 Tuck, G	O3.19 Fedak, M		O4.20 Lydersen, C	O5.19 Trites, A
17:15						Closing remarks & student awards
17:30		Transfer to Hobart Town Hall	Poster cocktail evening, Tasman Room Wrest Point: 5.30-7.30pm			
17:45					Transfer to Moorilla Estate	
18:00		Icebreaker cocktail function, Hobart Town Hall: 6-8pm				
19:00					Conference dinner, Moorilla Estate: 7.30-11.30pm	
20:00						
22:00						

Workshops
Registration &
Plenary
Breaks & social

*** To be presented by co-author**

ORAL PRESENTATION LISTING

Time	Allocation	Lead author	Title
Monday 14th March			
9:45	O1.01	Davis R	Classification of free-ranging Weddell seal dives based on three-dimensional movements and video-recorded prey capture.
10:00	O1.02	Huckstadt L	Habitat preferences of crabeater seals in a rapidly changing system, the western Antarctica Peninsula
10:15	O1.03	Teutschel N	Using statistical methods to determine individual foraging strategies using satellite telemetry parameters
11:00	O1.04	Dragon A-C	Understanding Foraging Decisions of Southern Elephant Seals in relation to Oceanographic Structures Using Hierarchical Hidden Markov Models
11:15	O1.05	Lea MA	Responses to ephemeral and seasonally predictable prey resources by Antarctic fur seals
11:30	O1.06	Cotte C	Biophysical identification of eddies of ecological interest from a marine predator outlook
11:45	O1.07	Bestley S	Integrative approaches for understanding environmental influences on winter sea-ice zone foraging of a deep-diving migratory mammal in the Southern Ocean
12:00	O1.08	Hindell M	Foraging habitats of top predators, and areas of ecological significance on the Kerguelen Plateau.
12:15	O1.09	Scheffer A	King penguins foraging movements in relation to oceanographic features at Kerguelen: consequences of inter-annual changes in the thermal structure
12:30	O1.10	Viviant M	From fine scale diving behaviour to a reliable predictor of foraging success in Antarctic fur seals.
12:45	O1.11	Muelbert M	Foraging habitats of southern elephant seals, *Mirounga leonina*, from the northern Antarctic Peninsula
14:00	O1.12	Peron C	Habitat models as tools to predict resource distribution and impact of future climate warming on seabirds
14:15	O1.13	Sakamoto K	Foraging strategy and energy expenditure of black-browed albatrosses in the open ocean.
14:30	O1.14	Freidlander A	Using multi-sensor suction cup tags to quantify the kinematics of lunge feeding in humpback whales (*Megaptera novaeangliae)* in the water around the West Antarctic Peninsula.
14:45	O1.15	Kokubun N	Foraging behaviour of Antarctic penguins detected by small accelerometers attached on their head.
15:00	O1.16	Sato K	Biomechanics and shallow dive angles of emperor penguins
15:15	O1.17	Harcourt R	The Australian Animal Tagging and Monitoring System (AATAMS)
16:00	O2.01	Faustino C	Bio-logging science into management policy
16:15	O2.02	Eveson J	Are archival tags useful for fisheries management?
16:30	O2.03	Block B	Using electronic tags to inform population assessment models of northern bluefin tuna
16:45	O2.04	Hartog J	Predicting tuna habitat for spatial fisheries management using electronic tags and ocean models.
17:00	O2.05	Tuck G	Utilising tagging information within an integrated assessment of a seabird population threatened by fishing interactions and habitat loss: the Lord Howe Island flesh-footed shearwater

Time	Allocation	Lead author	Title
Tuesday 15th March			
9:15	O2.06	Goldsworthy S	Correcting bycatch rates for encounter probability: using satellite telemetry data to model the distribution of foraging effort of a population of Australian sea lions to estimate and mitigate bycatch in a demersal gillnet fishery
9:30	O2.07	Babcock R	Including habitats in estimates of utilization distributions for reef fish
9:45	O2.08	Hunter E	A crab's eye view: electronic data storage tags reveal migration and behaviour patterns of the edible crab, *Cancer pagurus* L.
10:00	O2.09	Righton D*	It's an eel of a life: tracking *Anguilla anguilla* to the Sargasso Sea is not for the faint hearted (* presented by Metcalf J)
10:15	O2.10	Holland K	Double tagging allows for enhanced interpretive power of fish behavior and improvements in light-based geolocation modeling.
11:00	O3.01	Sumner M	A general Bayesian approach to location estimation and software for traditional and modern track analysis techniques.
11:15	O3.02	Pedersen MW	Individual based population inference using tagging data
11:30	O3.03	Wisniewska D	Acoustic and accelerometer cues to prey capture success in echolocating porpoises
11:45	O3.04	Aguilar de Soto N	Whales that click together, stick together: social cohesion in beaked whales and implications for female size
12:00	O3.05	Madsen P	Field metabolic rate estimates for large, deep-diving toothed whales using onboard multi-sensor Dtags
12:15	O3.06	Rutz C	Solid-state, animal-borne video loggers for medium-sized, free-flying birds
12:30	O3.07	Read A	Integrating observations of diving behavior and prey fields to study the foraging ecology of short-finned pilot whales *Globicephala macrorhynchus*
12:45	O3.08	Battaile B	Contrasting fine scale foraging behaviour of northern fur seals (*Callorhinus ursinus*) from two Bering Sea islands with dramatically different population trends
14:00	O3.09	Kuhn C	Changes in northern fur seal (*Callorhinus ursinus*) foraging behavior with dramatically increasing population density
14:15	O3.10	Nakamura I	Foraging dives of ocean sunfish *Mola mola* to search prey abundant depth
14:30	O3.11	Nordstrom C	Linking foraging northern fur seals (*Callorhinus ursinus*) with fine-scale oceanographic features: contrasting attributes from islands with opposing population trends.
14:45	O3.12	Wheatley K	Exploiting the bottom line: how Australian fur seals use *de facto* artificial reefs in navigation and foraging
15:00	O3.13	Williams C	Continuous blood lactate profiles in freely diving juvenile elephant seals
15:15	O3.14	Thierry A-M	Stress hormone affects incubation behaviour of male Adélie penguins *(Pygoscelis adeliae)*
16:00	O3.15	McDonald B	Venous PO2 profiles in diving California sea lions: How low do they go?
16:15	O3.16	Cottin M	Linking bio-logging and endocrinology – corticosterone and diving behaviour in Adélie penguins
16:30	O3.17	Casper R	The influence of diet on foraging habitat models
16:45	O3.18	Fuller A	Long-term biologging as a method to investigate the capacity of terrestrial mammals to buffer effects of climate change
17:00	O3.19	Fedak M	The MEOP International Polar Year Project: marine mammals exploring the oceans pole to pole

Time	Allocation	Lead author	Title
Thursday 17th March			
9:15	O3.20	Womble J	Contrasting prey fields influence multiple diving strategies of harbor seals (*Phoca vitulina richardii*)
9:30	O3.21	Miller PJO	The search for widely-applicable methods to measure body condition of diving animals: three at-sea metrics of body density validated in northern elephant seals
9:45	O3.22	Lowther A	Avoiding the crowds: combining fine-scale biologging and stable isotope biogeochemistry to assess the temporal stability of alternate foraging behaviours of adult female Australian sea lions
10:00	O3.23	Vincent C	Using individual grey and harbour seal habitat use and behavioural data for the design and management of protected areas
10:15	O4.01	Vandenabeele S	Thoughts on the energetics behind the 3% body mass recommended limit for devices on birds.
11:00	O4.02	Berger A	What can long-term and continuous acceleration measurements on wildlife telling us?
11:15	O4.03	Preito R	Satellite telemetry as a tool to help defining the International Whaling Commission management areas
11:30	O4.04	Maxwell S	Marine conservation and satellite telemetry: a review and framework for effective applications
11:45	O4.05	Calambokidis J	Use of multiple tag types to examine the risk of blue whales to ship strikes off southern California
12:00	O4.06	McConnell B	Fine scale interactions between harbour seals and operating tidal turbines.
12:15	O4.07	DeRuiter S	Effects of simulated military sonar on sound production by blue whales, sperm whales, Risso’s dolphin, and Cuvier’s beaked whale
12:30	O4.08	Tancell C	Using seabird tracking data for the identification of important marine areas in the Southern Ocean
12:45	O4.09	Metcalfe J	All washed up: a low-cost, “flotsam” method for retrieving archival tags from marine animals
14:00	O4.10	Fossette S	Spatio-temporal correlation between leatherback turtles and industrial fisheries in the Atlantic Ocean
14:15	O4.11	Joy R*	Identifying foraging habitat of lactating northern fur seals and the spatial overlap with commercial fisheries in the Eastern Bering Sea.
14:30	O4.12	Phillips R	Year-round tracking highlights key areas of fisheries interaction for a wandering albatross population in steep decline.
14:45	O4.13	Focardi S	The use of GPS and compass loggers to reconstruct high-resolution trajectories in Cory’s shearwaters (*Calonectris diomedea*) to investigate search strategies.
15:00	O4.14	Bradford R	The utility of broad-scale coastal sensor arrays in tracking continental scale movements of a top-order predator: Australia’s tracking of white sharks
15:15	O4.15	Payne N	Acoustic telemetry and accelerometry for understanding the population dynamics of a coastal giant.
16:00	O4.16	Kovacs K	From nursing to independence in the life of bearded seals (*Erignathus barbatus*)
16:15	O4.17	Shillinger G	Vertical and horizontal habitat preferences of post-nesting leatherback turtles in the South Pacific Ocean - Implications for conservation
16:30	O4.18	Simon M	Fast lunge or slow plow: behaviour and kinematics of filter feeding in balaenopterid and balaenid whales observed with multi-sensor tags
16:45	O4.19	Dassis M	Foraging areas of female Southern Sea Lions (*Otaria flavescens*) on La Plata River Estuary (Argentina-Uruguay)
17:00	O4.20	Lydersen C	Greenland sharks (*Somniosus microcephalus*) as predators of arctic pinnipeds.

Time	Allocation	Lead author	Title
Friday 18th March			
9:45	O4.21	Cagnacci F	Understanding processes of animal distribution: application of Wireless Sensor Networks to studies of habitat use
10:00	O4.22	Abecassis M	Modeling swordfish daytime vertical habitat in the North Pacific Ocean from pop-up archival tags
10:15	O4.23	Strøm H	Movements of three Northeast Atlantic populations of ivory gulls revealed by satellite telemetry
11:00	O5.01	Basson M	A likelihood for light-based geolocation
11:15	O5.02	Patterson T	Modelling behavioural switching vertical movement time series: dealing with statistical challenges and data volume
11:30	O5.03	London J	Beyond kernel densities: posterior predictive inference for animal space use and other movement metrics
11:45	O5.04	Irvine L	How well do 50% core areas encompass state space derived ARS regions from blue whale satellite tracks?
12:00	O5.05	Ver Hoef J*	Movement up and down: modeling dive depth of harbor seals from time-depth recorders. (* presented by London J)
12:15	O5.06	Call K	Modeling suitable foraging habitat for adult female northern fur seals (*Callorhinus ursinus)* and implications for conservation of a declining species
12:30	O5.07	Dettki H	How do GPS-collared moose deal with temperature induced heat stress across Scandinavia?
12:45	O5.08	Goetsch C	When is El Niño too hot to handle? Evidence of a tolerance threshold for a marine top predator.
14:00	O5.09	Randall J	Phenological change in marine systems: migratory timing in southern bluefin tuna, Thunnus maccoyii
14:15	O5.10	Pelletier L	Can thermoclines be a cue to distribution of prey for little penguins?
14:30	O5.11	Kawabe R	New perspectives into the reproductive traits of exploited marine fishes through electronic tags: revealing spawning history of multi-batch spawning species
14:45	O5.12	Hobday A	Summer residence at local feeding grounds in south-west Western Australia for age-1 southern bluefin tuna
15:00	O5.13	Costa D	Comparison of the foraging ecology of southern and northern elephant seals
15:15	O5.14	Garrigue C	Oceanic seamounts: a new humpback whale (*Megaptera novaeangliae*) habitat discovered using satellite tagging
16:00	O5.15	Johnson M	Eavesdropping on foraging: using passive echolocation to quantify deep-sea predator and prey interactions
16:15	O5.16	Palacios D	Habitat models for the northeast Pacific blue whale from satellite tracking and remote sensing
16:30	O5.17	Rogers P	Migration patterns and habitat preferences of the shortfin mako shark, *Isurus oxyrinchus*, in the Southern, Indian and SW Pacific Oceans
16:45	O5.18	Tosh C	Habitat utilisation by adult male southern elephant seals from Marion Island
17:00	O5.19	Trites A	Top predators partition the Bering Sea

POSTER PRESENTATION LISTING

Allocation	Lead author	Title
P1.01	Andrews-Goff V	Weddell seal dive behaviour and the influence of environmental variables and individual variability
P1.02	Broadbent H	Penguin CTD- tag: development of a miniature biologger to determine the use of physical microstructure by foraging penguins
P1.03	Cleeland J	The 'honeymoon' flights of the short-tailed shearwater (*Puffinus tenuirostris*).
P1.04	Goetz K	Overwinter movements and habitat preferences of an Antarctic predator
P1.05	Heerah K	Ecology of Weddell seals during winter: influence of ocean and sea-ice parameters on their foraging behaviour.
P1.06	Iwata T	Prey capture and three-dimensional dive path in free-ranging female Antarctic fur seals
P1.07	McIntyre T	Water column usage by female southern elephant seals from Marion Island.
P1.08	Suzuki I	Diving behavior and offshore activity budget during a foraging trip of a female South American sea lion (*Otaria fravescens*) off Isla de Lobos (Uruguay).
P1.09	Fujioka K	Habitat utilization of juvenile southern bluefin tuna (*Thunnus maccoyii*) in relation to oceanographic conditions in southern Western Australia
P2.01	Huveneers C	Assessing the impacts of berleying from shark cage-diving operators on the swimming behaviour of the white shark (*Carcharodon carcharias*)
P2.02	Noda T	Application of gyroscope for bio-logging study
P2.03	Riet Sapriza F	Foraging strategy of lactating South American sea lions (*Otaria flavescens*) and the indirect interaction with the Uruguayan artisanal and coastal bottom trawl fisheries
P2.04	Yamamoto K	Comparison of swimming patterns between rainbow trout (*Oncorhynchus mykiss*) and white spotted charr (*Salvelinus leucomaenis*) using acceleration data loggers under flowing-water conditions
P2.05	Lewis A	Unlocking the bio-logging potential of otoliths as natural tags: Disentangling environmental and physiological influences on otolith chemistry
P3.01	Akamatsu T	Scanning sonar of rolling porpoises during prey capture dives
P3.02	Chiang W	Horizontal and vertical movements of black marlin (*Istiompax indica*) near Taiwan determined using pop-up satellite tags
P3.03	Fais A	Search tactics of echolocating male sperm whales in a bimodal foraging mode
P3.04	Falcone E	Use of the LIMPET medium-duration satellite tag to identify areas of elevated risk for sensitive populations: fin whales (*Balaeanoptera physalus*) in the Southern California Bight
P3.05	Furukawa S	High energy costs of surface foraging but energy conservation during vertical excursions in dolphinfish
P3.06	Gallon S	Fine scale interactions between Southern elephant seals and their prey assessed by acceleration data loggers
P3.07	Gandra T	Satellite telemetry and tag recovery: potential use and limitations
P3.08	Gleiss A	Probabilistic or deterministic foraging? Fine scale movement patterns of whale sharks (*Rhincodon typus)* at Ningaloo Reef, Western Australia ascertained via dead-reckoning
P3.09	Goldbogen J	Dynamics of blue and fin whale maneuverability: three-dimensional kinematic analyses for assessing the effects of sound on behavior

Allocation	Lead author	Title
P3.10	Hanson M	The not-so-secret lives of mammal-eating killer whales: Dorsal fin-mounted satellite tags reveal some of their favorite haunts in the eastern North Pacific
P3.11	Horning M	A new tool for the determination of survival, causes of mortality and parturition in individual marine homeotherms: the Life History Transmitter
P3.12	Katsumata N	Streaked shearwaters (*Calonectris leucomelas*) more relied on the strong wind in day-time than night-time
P3.13	Kawatsu S	Swimming behavior of shark-eater sharks
P3.14	Kirkwood R	Winter foraging areas of different sized Australian fur seals in the shallow waters of Bass Strait – is there segregation?
P3.15	Kogure Y	Verification of the method to estimate body mass change of the flying bird by using accelerometer
P3.16	Le Vaillant M	King penguins learn air load management with age
P3.17	Mate B	Developing evidence that Sperm whales instrumented with ARGOS-GPS-TDR tags coordinate their foraging behavior
P3.18	Narazaki T	Fine-scale homing behaviour of a green turtle (*Chelonia mydas*)
P3.19	New L	Using biologging data to understand the population consequences of disturbance
P3.20	Pavlov V	New non-invasive design of dolphin telemetry tag; proof of concept
P3.21	Rasmussen M	New insight in diving and possible foraging behaviour of a white-beaked dolphin using an acoustic tagging system
P3.22	Ropert-Coudert Y	Exploring the determinants of individual foraging quality using penguins as a model
P3.23	Skinner J	Influence of environmental conditions, morphology, and tag size on lactating northern fur seal *Callorhinus ursinus* diving behavior
P3.24	Thiebot J-B	Natal dispersal and diving behaviour ontogeny in juvenile Emperor penguins *Aptenodytes forsteri* from Adélie Land
P3.25	Tyson R	Humpback whale (*Megaptera novaengliae*) mother and calf foraging behavior: insights from multi-sensor suction cup tags
P3.26	Miyazaki N	Biologging for long monitoring of animal behavior: preliminary study on milky storks in Malaysia
P4.01	Andrews R	New satellite-linked depth-recording LIMPET tags permit monitoring over weeks to months and reveal consistent deep nighttime feeding behavior of short-finned pilot whales (*Globicephala macrorhynchus*) in Hawai‘i
P4.02	Blanco G	Satellite telemetry reveals hot spot for conservation of East Pacific green turtles (*Chelonia mydas*) during internesting in Costa Rica
P4.03	Doko T	Evaluation of near-real time GPS-ARGOS collar performance by stationary tests and fitting on a free-ranging Asiatic black bear
P4.04	Duriez O	Flight dynamics and energetics of large raptors: combined use of GPS, accelerometer, electro-cardiogram, and video camera on free flying vultures
P4.05	Frost K	Using satellite telemetry to study temporal and spatial overlap of marine mammals and industrial activities in northwest Alaska
P4.06	Fuiman L	Economy of scale: The world’s largest fish closely manages its swimming costs
P4.07	Hayashi K	Do artificial fins improve swimming ability of a forelimb-lost sea turtle?
P4.08	Hoenner X	Enhancing Argos-derived locations accuracy through the use of state-space models
P4.09	Jaine F	Going with the flow: Horizontal movements of the plankton-feeding manta ray *Manta alfredi* and links to dynamics and productivity of the East Australian Current

Allocation	Lead author	Title
P4.10	Jensen F	Depth limits calls produced by deep-diving short-finned pilot whales (Globicephala macrorhynchus)
P4.11	Winsor M	Comparison of sperm whale (Physter macrocephalus) movements in the Gulf of Mexico before and after the Deepwater Horizon oil spill
P4.12	Leung, E	Size and experience matter: foraging behaviour of juvenile nationally critical New Zealand sea lions *(Phocarctos hookeri*)
P4.13	Mitani Y	Travelling behavior of northern fur seals during the breeding period in the Kuril Islands
P4.14	Page B	Using well-equipped Australian sea lions to assess habitat quality and inform the zoning of Marine Parks in South Australia.
P4.15	Rehberg M	Using necessity, ability and environment to explain the behaviors of a marine predator
P4.16	Schorr G	Satellite telemetry reaches new depths: a case study of the application of a new depth-linked satellite tag to Cuvier’s beaked whales
P4.17	Strauss W	Technological advances allow real-time quantification of selective brain cooling in artiodactyls
P4.18	Takahashi N	Swimming patterns and habitat use of Sakhalin taimen (*Hucho perryi*) in the Bekanbeushi River, Lake Akkeshi and an estuary in Hokkaido, Japan
P4.19	Takuma S	Habitats use and diving behaviors of male and juvenile loggerhead turtles, *Caretta caretta*
P4.20	Tanoue H	Feeding habits of Japanese lates detected by a fish-borne camera and a micro 3-axis accelerometer in the Shimanto River, Japan
P4.21	Whitney N	Fine-scale behavioral ecology of mating sharks in and around a protected breeding ground
P5.01	Adachi T	Fine-scale foraging behaviour of female northern elephant seals during the entire post-breeding migration
P5.02	Naito Y	Paradox of diverse divers into the deep depth: a new aspect of foraging behavior of northern elephant seals
P5.03	Bravington M	Development of a ‘day-night’ filter and a time-varying depth correction method for use in light-based geolocation
P5.04	Breed G	Particle filter methods for state-space analysis of animal tracking data
P5.05	Campbell H	The rhythm and rhyme of animal movement
P5.06	Couturier L	Habitat use, residency and site fidelity of manta rays, *Manta alfredi*, at Lady Elliot Island, Australia
P5.07	de Moustier C	A miniature acoustic transponder for simultaneous underwater animal tracking and habitat mapping
P5.08	Deppe L	Distributional and behavioural patterns of three sympatric albatross species during the non-breeding season
P5.09	Evans K	Free ranging ocean observation systems: maximizing use of ocean data collected from tags deployed on marine animals
P5.10	Foley D	Xtractomatic: easy access to environmental data for ocean habitat identification
P5.11	Gray T	Earth magnetic field augmented position estimation for marine animal tags
P5.12	Hazen E	The effect of a changing climate on Pacific top predators
P5.13	Kato A	Partial dynamic body acceleration as a proxy of prey encounter
P5.14	Lansdell M	A pelagic ecosystem observing system - collecting ecological information and deploying stomach-based acoustic tags using commercial fishing vessels
P5.15	Liebsch N	Quantifying 'at sea' resting behaviour of Harbour seals - clues to assessing foraging performance and habitat adaptation
P5.16	Photopoulou T	Assessing the uncertainty of SMRU CTD-SRDL dive profiles abstracted using the broken-stick algorithm

ABSTRACTS

O4.22 Modeling swordfish daytime vertical habitat in the North Pacific Ocean from pop-up archival tags

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Swordfish (*Xiphias gladius*) is one of the most valuable pelagic resources for Pacific Ocean longline fisheries. Obtaining a better knowledge of swordfish behavior is of primary importance for management. We present results from an 8-year long tagging study from 28 tags deployed on swordfish in the North Pacific, using Wildlife Computers pop-up archival transmitting tags. Tag deployments ranged from 10 to 180 days. Four fish were tagged by longline vessels in the central Pacific (CP fish), while all others were tagged by harpoon boats off San Diego, CA. Of these, 13 (eastern Pacific tags, EP fish) radiated away from California, while 5 remained in the vicinity of San Diego (SD fish), one of them for the full 180 days of the track. Classic diel movement (shallow at night, between 0–100 m, vs. deeper than 200 m during the day) was observed with the exception of occasional daytime basking occurring in the general area of the California current in the fall and winter. Five fish dove as deep as 1200 m. The temperature range for all fish combined was 3.2–28.8ºC with cooler temperatures experienced at depth during the day. On days without basking, swordfish had mean daytime depths varying between 133 m and 283 m for SD tags, 137 m and 490 m for EP tags, and 401 m and 665 m for CP tags, with relatively small daily standard deviations. Swordfish feed near the surface during the night and at depth during the day when their prey are more densely aggregated and less active. We developed generalized additive models to assess the separate and combined effects of oxygen, temperature and light on daytime foraging depth and to predict daytime foraging depth based on the location of the fish. Longitude and latitude explain about 60% of the variation in daytime mean depth.

P5.01 Fine-scale foraging behaviour of female northern elephant seals during the entire post-breeding migration

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Northern elephant seals spend three quarters of a year on two long-ranged migrations and exploit mesopelagic food resources. Fine-scale information on foraging behaviour would be important to enhance our understanding of their adaptation to mesopelagic environment. Recently-developed mandible accelerometers have provided fine-scale information on the foraging behaviour of marine mammals, but have limitations in the recording durations (2-3 days only) due to high sampling rate of acceleration, to study long-ranged migrations such as those of northern elephant seals. Here, we report the fine-scale foraging behaviour of female northern elephant seals during the entire post-breeding migration, using a new mandible accelerometer that is designed to detect and record certain acceleration signals (i.e. feeding signals) processed onboard. The new mandible accelerometers were attached on four post-breeding female seals at Año Nuevo, California, in February 2010, and recorded depth, temperature and number of feeding acceleration signals (processed from raw acceleration measured at 32 Hz) at 5 s intervals over the post-breeding migration (75.2±5.9 days). Our study seals showed feeding events (13.9±3.5 events per dive) in 84.9±4.0% of all recorded dives (3697.0±499.6 dives). Most of drift dives (C-type dives) showed no signs of feeding events. Feeding events occurred at the mean depth of 511.8±26.4 m, mostly in the bottom phase of the dives (89.9±1.2%). Number of feeding events per day was relatively low at the beginning and the end of the foraging trip, but was consistently high in the middle of the foraging trip. These results suggest that northern elephant seals spend a significant amount of time feeding on prey that is distributed ubiquitously in the mesopelagic zones of the Northern Pacific.

O3.04 Whales that click together, stick together: social cohesion in beaked whales and implications for female size

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Deep-foraging marine mammals, such as beaked whales, must combine foraging at depth with protecting young with presumably lower diving capabilities. Here, the social cohesion of Blainville's and Cuvier's beaked whales is studied with suction-cup attached acoustic recording tags (DTAGs). Limited data from multiple individuals tagged in the same group suggest that whales synchronize dives but forage separately at depth, re-joining for the silent ascent to the surface. To test this finding on a larger dataset of groups in which only one whale was tagged, we developed two methods for remote sensing untagged individuals from their echolocation clicks recorded at the tagged whale. The first method involves using the angle of arrival of clicks from untagged whales recorded on stereo tags to estimate the number of whales vocally active during 48 foraging dives in 12 tag deployments. The second method estimates the minimum depth of untagged whales from the time-delay between the direct arrival and the surface echo of their clicks. Results confirmed that whales tend to dive in a coordinated fashion and suggest that all vocally active whales in the group are diving deep, irrespective of the presence of juveniles in the group. We then tested if dives performed by whales tagged in groups with juveniles were shallower or shorter than dives in groups without juveniles. Results did not show that adults adjusted the duration (mean: 44min) or maximum depth (mean: 829 m) of their foraging dives to the presence of juveniles in the group. This lack of accommodation does not seem to extend to calves: visually observed mother-calf pairs perform short (10 min) dives limiting the foraging opportunities of the mother. It may therefore be beneficial to minimize the time before young animals can join the social group in foraging dives and this may explain the relative large size of beaked whale calves and females.

P3.01 Scanning sonar of rolling porpoises during prey capture dives

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Dolphins and porpoises have excellent biosonar ability, which they use for navigation, ranging and foraging. Due to the narrow beam width of the sonar signals, odontocetes are not able to search large volumes of water without scanning. Beam scanning behavior of dolphins and porpoises, like that used by bats, has been suspected for some time. The biosonar behavior, body orientation and head movements of 15 free-ranging finless porpoises *(Neophocaena phocaenoides*) were recorded using bio-logging techniques. The porpoises often rotated their bodies during mid-water and bottom dives and they used biosonar extensively. In particular, porpoises in rolling dives used short-range biosonar frequently, which was indicated by inter-click interval shorter than 10 ms. A sudden drop in swimming speed indicated that an individual turned around, which occurred 4.5 times more often during rolling dives than during upright dives. Continuous searching for possible prey during rolling dives suggests that porpoises enlarge the search area by changing the narrow beam axis of the biosonar with heading their bodies toward the targets. Porpoises searched not only at the bottom, but also while in mid water. This observation supports the notion that finless porpoises are opportunistic feeders targeting both benthic species and fish in the mid water column. We also observed head movements of ±2cm during both rolling and upright dives. Generally, head movements might also assist for instant assessment of the environment in any arbitrary direction by beam scanning and not just for prey searching and pursuit.

P4.01 New satellite-linked depth-recording LIMPET tags permit monitoring over weeks to months and reveal consistent deep nighttime feeding behavior of short-finned pilot whales (*Globicephala macrorhynchus*) in Hawai‘i

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Short-finned pilot whales are among the species that most frequently mass strand, and one recent mass stranding was temporally associated with naval sonar use off North Carolina. Their recently-discovered high-speed deep diving behavior may increase susceptibility to decompression sickness, but what little is known about their diving comes from short term (~ 1 day or less) recordings. Therefore, we developed a method of remotely attaching a new depth-recording satellite-linked tag (Wildlife Computers’ [WC] Mk10-A) in the LIMPET (Low Impact Minimally Percutaneous External-electronics Transmitter) configuration in order to monitor behavior for weeks to months. Short-finned pilot whales primarily feed on vertically migrating squid, so we hypothesized that whales would dive more deeply during the day than at night. In 2009 we deployed LIMPET Mk10-A tags on 8 individuals off the leeward (western) coast of the Island of Hawai‘i, with transmissions lasting 4- 47 (median 35) days. Dive data were relayed via satellite using WC’s new Behavior Log, providing maximum depth, duration, shape, and post-dive surface interval for dives > 20m. Whales spent most time on the leeward side within 50 km of shore, over water depths 300 - 2500 m., but 4 whales spent some time in the Alenuihaha Channel, a site of frequent shipping traffic and Navy training exercises. The majority of deep dives (>100 m) were made during nighttime, confirming short-term records documenting day-time behavior as primarily resting and socialization. In contrast to our hypothesis, there was little diurnal difference in the depths of deep dives. At night, whales regularly made long (mean: 11.5 min; maximum: 22.4 min) deep dives between 100 and 1168 meters (mean: 359 m). Now that we have successfully developed a longer-term depth-recording LIMPET tag, additional deployments will help elucidate seasonal and habitat specific variation in dive behavior and exposure to risk from anthropogenic activities.

P1.01 Weddell seal dive behaviour and the influence of environmental variables and individual variability

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The Weddell seal is one of the most studied Antarctic predators throughout the austral summer but outside this period very little is known of their general movement patterns, dive behaviour or the influence of the environment throughout this relatively harsh period. We deployed satellite relay data loggers on 13 adult female Weddell seals at Dumont d’Urville and the Vestfold Hills throughout 2006, 2007 and 2008 providing Argos locations, dive behaviour and haulout behaviour. Here we specifically discuss general dive behaviour and the influence of the environment and the individual on this behaviour. Cluster analyses identified three distinct types of dive behaviour: pelagic, benthic and a combination of the two, with seals generally diving to depths of 88m with a maximum dive depth of 904m. Dive durations on average were 9 minutes however the maximum duration recorded was 95 minutes. Unlike other seals, Weddell seals are not central place foragers and therefore do not demonstrate easily defined trips that leave and return to a central place. Instead Weddell seals haulout between diving bouts and these diving bouts range in duration from minutes to days. We examined the influence of environmental variables on the risk of each seal terminating a diving bout using fixed effects Cox proportional hazards models. The models identified that environmental variables including wind (speed and direction), temperature, ice concentration and bathymetric depth plus individual behaviour such as dive depth, bearing and bearing in relation to wind direction have an influence on these diving bouts.

O2.07 Including habitats in estimates of utilization distributions for reef fish

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The estimation of generalised population parameters is a key aspect of population biology and management across a wide range of contexts. In conservation and fisheries management of reef fish species assessments of spatial usage are often an important part of the decision making process of conservation zoning. Description of population-level movement based on acoustic tracking data of tagged fish commonly relies on GIS-based kernel density calculations from short term data sets. This often fails to consider the role of habitat or individual variation in spatial usage, are sensitive to subjectively derived smoothing parameters and do not take into account barriers to movement (e.g. land in the case of fish). These aspects potentially result in incorrect estimates of spatial usage and ultimately flawed spatial management decisions. We use data on the movements of a variety fish species collected at Ningaloo Reef to examine the application of GIS based methods to an alternative statistical approach which allows barriers to movement to be included and the role of habitat to be considered in the prediction of the utilisation distribution. We consider the effects on spatial and fisheries management of reef fish.

O5.01 A likelihood for light-based geolocation

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For many marine fish, light-based geolocation using twilight data from archival or pop-up tags is still the only way to estimate location. It is an inherently imprecise exercise because of short-term fluctuations in incident light, and the resulting uncertainty in location is big enough to need accounting for when reconstructing tracks and making inferences about habitat use. The key ingredient for any reliable geolocation-based statistical model of movement or habitat selection, whether Bayesian or "classical", is a valid likelihood function for each set of twilight data (i.e. a way to compute the relative probability of the observed data for any assumed location). However, the complex autocorrelations and non-Gaussian errors make it very difficult to devise and compute such a likelihood directly. Instead, we use data from moored tags to develop an approximate likelihood with correct confidence interval properties. This likelihood can then be computed directly from real tag data for state-space modelling of habitat use, or for constructing a movement track with appropriate uncertainty.

O3.08 Contrasting fine scale foraging behaviour of northern fur seals (*Callorhinus ursinus*) from two Bering Sea islands with dramatically different population trends.

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In the summer of 2009, we deployed 90 1st generation Wildlife Computers Mk10 Daily Diary tags on lactating northern fur seals. Tags contained 3 dimensional accelerometers and magnetometers as well as temperature and depth sensors. The deployments were split evenly between two islands in Alaska, Bogoslof and St. Paul. Fur seal populations on these two islands have undergone dramatic changes over the last few decades, but on opposite trajectories, with the Bogoslof population increasing and the St Paul population decreasing ~6% per year. The foraging strategy of the fur seals from the two islands is known to differ considerably at relatively large scales (i.e. average foraging trip is ~3 days for Bogoslof and ~7 days for St. Paul) but small scale details are not well known due to the coarse nature of most tagging studies that work under the data limitations of the ARGOS network. The Daily Diary units however, took data 16 times a second that, when combined with GPS data and the appropriate dead reckoning calculations, supplied fine scale information on location and relative activity between GPS points. This data provides us with insight into the activity budgets, foraging behaviour and energy expenditure of northern fur seals and may indicate differences in these factors that will help explain the disturbing declines in the Pribilof Islands and the dramatic increases at Bogoslof.

O4.02 What can long-term and continuous acceleration measurements on wildlife telling us?

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Modern wildlife collars are commonly used to obtain regular GPS location of animals to give information on home range size and migration paths. In most studies, only few GPS fixes per day are obtained due to the considerable amount of energy GPS fixes need. In contrast, measurements of acceleration need little energy, allowing a virtually continuous monitoring of animals. We present possibilities of analysing continuously measured acceleration data to draw conclusions to the animal´s behaviour. First part is a procedure for biorhythmic status diagnosis to identify systemic disorders and “stress loads” in wild animals by changes in total daily activity and in day- night relationships as well as a reduced coupling between the behavioural rhythm and the diurnal environmental periodicity. Secondly, we focus on the development of analysis methods to distinguish among several behaviours (like resting, calving, hunting) by detecting locomotion and activity patterns and combine them to understand the functional site of habitat use of animal. Such knowledge about what an animal is doing where and when is crucial for understanding habitat use as well as for detecting deviations from the norm, e.g. responses to disturbances or predators.

O1.07 Integrative approaches for understanding environmental influences on winter sea-ice zone foraging of a deep-diving migratory mammal in the Southern Ocean

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Knowledge of relationships between marine animal migrations, foraging and physical ocean processes is lacking, but forms a core goal of many studies. Southern elephant seals (Mirounga leonina) are an important Southern Ocean predator that undertake wide-ranging and deep-diving winter foraging migrations, a significant proportion within the Antarctic sea ice zone. Global tagging efforts in recent years using conductivity-temperature-depth satellite-relayed data loggers have collected an unprecedented in situ oceanographic dataset throughout these migrations. This presents a unique opportunity to quantify individual foraging responses to environmental influences, and to infer how individual behaviour can shape population ecology, a fundamental first step toward predicting responses in a zone highly sensitive to climate change. Here we aim to identify and quantify relationships between horizontal movement, diving and the physical environment within a cohesive Bayesian state-space modelling (SSM) framework. Currently, SSMs are a popular method for analysing tag data to discriminate putative ‘travelling’ and ‘foraging’ states, but commonly incorporate only information from horizontal movements. We aim to develop this method so the vertical (diving) component of movement and/or the environmental cues, as collected on board the tags, can both influence the probability of switching between states. We adopt a two-pronged approach. As a first step, the SSM in a hierarchical formulation is fit across individuals to estimate movement state. Relationships between horizontal movement, diving and environmental variables are then explored using generalized additive mixed-effect models. We focus on the Kergeulen and Macquarie Island ice zone migrants during 2004-2010. Preliminary results indicate that time spent at the bottom of a dive and ocean temperature at the dive bottom may present two useful tag-based indicators that vary between movement states, with seals spending more time at the bottom of dives in colder waters when foraging. Current work focuses on developing the modelling framework to incorporate such predictor variables. Simulation studies are being used to evaluate the sensitivity of the SSM to estimating parameters for known relationships, and these show promising results.

P4.02 Satellite telemetry reveals hot spot for conservation of East Pacific green turtles (*Chelonia mydas*) during internesting in Costa Rica.

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We attached tether satellite transmitters (Mk 10 PAT, Wildlife Computers) to 13 East Pacific green turtles nesting on Nombre de Jesus and Zapotillal beaches to identify movements and dive behavior and to determine high use internesting areas in need of protection in northwestern Costa Rica. A fixed Kernel density analysis showed that high-use areas during internesting periods were close to the nesting beaches and 25, 50, 75 and 95% UD polygons included 1.57, 4.5, 9.4 and 53.9 km2 respectively. Turtles performed short dives (2-10 min) mainly in the first 10 m of the water column U-dives were shallow (3-5 m) and their modal duration ranged from 8 to 23 min. Strong diel patterns occurred in diving behavior during internesting with a significantly larger amount of time at the surface during the night. The proportion of U-dives was significantly negatively correlated with surface time at night suggesting the turtles were floating at the surface as a resting strategy. The combination of movement and behavioral data indicated that the turtles were staying near the nesting beach during the interesting period. The depths of dives and depth of water in the area indicated that the turtles swam to the bottom during u-dives in the daytime. At night they rested at the surface. This high concentration of turtles, the presence of males, mating near the beach and extensive use of the area by resting turtles indicated that this small area was of great importance for East Pacific green turtles and a hot spot for conservation of this population.

O2.03 Using electronic tags to inform population assessment models of northern bluefin tuna

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Electronic tagging, genetics and microconstituent data have revolutionized the study of open ocean fish. Archival tags track where bluefin tuna go and provide estimates for population parameters, physiology, movement data and breeding information that can be incorporated into assessment models. We have formulated a novel seasonally and spatially explicit fisheries model that is fitted to conventional and electronic tag-track data, historic catch-at-age reconstructions and otolith microchemistry data on fish population mixing and migration to improve our capacity to assess past, current and future Atlantic bluefin tuna population sizes. We apply the model to estimate spatial and temporal mixing of the eastern (Mediterranean) and western (Gulf of Mexico) bluefin populations. The model reconstructs abundances from 1950 to 2008. Western stock and eastern stocks have been reduced to 17 and 33 % of 1950 levels respectively. Stock biomass estimates are sensitive to assessment methodologies and assumptions of life history traits. These parameters can also be informed by electronic tagging data. Stock-mixing depends on quarter, ontogeny and location and is predicted to be highest in the Western Atlantic. The model predicts that current western and eastern stock rebuilding policies of 1800 t and 13500 t fail to produce a recovery by 2025. If a bluefin tuna fishing ban were implemented, the western stock would not recover to levels that would produce maximum sustainable yield until 7 years after internationally agreed rebuilding timeline of 2022. Sensitivity analyses indicate various assumptions and assessment methodologies produce different estimates of spawning stock biomass. Similar work in the Pacific is improving our capacity for estimating population parameters such as natural mortality and fisheries mortality using archival tagging data from Pacific bluefin tuna. Successful management of bluefin tunas at sustainable levels is improved by electronic tag data which increases our understanding of their spatial structure, movements, and population mixing.

O4.14 The utility of broad-scale coastal sensor arrays in tracking continental scale movements of a top-order predator: Australia's tracking of white sharks.

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The Australian Animal Tagging and Monitoring System is a facility within Australia's Integrated Marine Observing System (IMOS). AATAMS, along with partner organisations, aims to enhance the Australian research community's ability to detect ecosystem responses to change in the marine environment by measuring key demographic parameters and foraging movements of select top predators in the Southern Ocean and along Australia's coast-line, the latter via a national network of acoustic receivers which detect and log data from tagged animals. We examine the utility of this system for tracking the coastal movements of white sharks (*Carcharodon carcharias*) in Australian waters by comparing results to other forms of tagging. The movements of acoustically tagged white sharks demonstrate broad-scale migrations across their Australian range consistent with data obtained from conventional tags, satellite tracking and archival tagging. Sharks bearing either acoustic tags or satellite-based tags have been recorded moving from the Neptune Islands in South Australia west across the Great Australian Bight and as far north in Western Australia as the Ningaloo Reef region, a return distance of 7,200 km. Sharks similarly tagged have been recorded moving from South Australia east to northern NSW and southern Queensland. Data from acoustic-tagged sharks were also consistent with estimated average swim speeds, previously identified common depth pathways used during coastal travel and in identifying habitat areas and patterns of temporary residency. These data provide considerable confidence in the suitability of such national scale acoustic receiver arrays for monitoring movements of such species in coastal and continental shelf waters. The long battery durations (up to 10 years) of acoustic tags and the ability to surgically implant them thereby minimising tag loss, provide considerable scope for examining ontogenetic variations in movement patterns and habitat use as well as long-term variations in movements in response to environmental parameters.

P5.03 Development of a 'day-night' filter and a time-varying depth correction method for use in light-based geolocation.

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Light-based geolocation using twilight data from archival or pop-up tags is still the only way to estimate location for many marine fish. This approach, however, relies on correcting the measured light data for depth to obtain light at the surface. Most depth correction methods used so far are very simple and assume constant correction coefficients over time. Part of our work to develop a likelihood for light-based geolocation, involved development of a depth correction model based on a Kalman filter. The correction coefficients vary over time, e.g. as the animal enters different water masses, and are estimated from the light data during daytime. This involves a first step for which we develop a hidden Markov model to estimate the probability of each observation being in day or night time. The day-night filter avoids 'manual splitting' of the data into day and night sections; it can be used for crude geolocation, and for analysing behaviour as a function of time of day. The day-night filter can also be used with light data where there is no need for depth correction, e.g. data from tags deployed on terrestrial animals.

P5.04 Particle filter methods for state-space analysis of animal tracking data.

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State-space models (SSMs) represent the most comprehensive approach for time-series analysis of animal tracking data. We develop and demonstrate a Sequential Importance Resampling (SIR) particle filter (PF) for fitting correlated random walk (CRW) models to 2-d animal tracking data in an SSM framework. CRW parameters were estimated by augmenting parameters to the state vector of the SIR. Thus, each Monte Carlo draw (particle) had an associated parameter vector θ. Parameter space was explored by jittering θ at each time step with noise drawn from mixed Normal distributions. We test the model on two simulations, one with parameters that drifted slowly on a sine wave and one that switched between two discrete states based on a transition probability. In both simulations, the model handled simulated observation error and tracked simulated parameters, though process noise occasionally confounded with structural parameters when parameters drifted slowly. Following this validation, we demonstrate the method on GPS data from 3 California sea lions. The results show animals switching between two discrete states when central place foraging, but during extended trips to sea, parameter estimates for autocorrelation and turn angle were intermediate and variable. The intermediate estimates were coincident with slower meandering and/or slower movement that were likely searches – a behaviour that is in between "foraging" and "travel," and was best interpreted as foraging mixed with travel. Although it has some limitations, this method holds great promise for future analysis of tracking data as it accommodates a wide variety of behaviourally informative models. Particularly important is the inclusion of time-varying parameters, including process noise, that accommodate non-stationary statistical properties of behaviour.

P1.02 Penguin CTD- tag: development of a miniature biologger to determine the use of physical microstructure by foraging penguins.

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The study of fine-scale linkages between foraging behavior and the physical microstructure of the marine habitat is necessary for understanding the effects of environmental change on penguins. Such studies will help define the importance of physical water mass features, such as frontal systems, currents, eddies, or ice edges, to the distribution and abundance of these foraging seabirds. We have developed a small, low-cost instrument that is capable of measuring physical features along with behavioral and geo-location data during penguin foraging trips. The biologger measures conductivity, temperature, pressure, light, acceleration, magnetic fields, wet/dry, and GPS. It is also equipped with a WiFi module for communication and a rechargeable battery for multiple deployments. To minimize cost and maximize salinity accuracy, a CTD sensor board was fabricated using printed circuit board (PCB) techniques on a liquid crystal polymer substrate (LCP). The sensor board consists of a novel conductivity cell, a thermistor, a piezoresitive pressure module and a wet/dry sensor. The shape and size of the biologger has been optimized for deployments on Adélie and Magellanic penguins (*Pygoscelis adeliae* and *Spheniscus magellanicus*) and is 95 x 30 x 16 mm. However, the circuit boards are of a modular design so that prototypes for different marine species can be developed. Preliminary results show that the sensors work as intended when packaged as a streamlined, back-mounted penguin tag.

O4.21 Understanding processes of animal distribution: application of Wireless Sensor Networks to studies of habitat use.

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Biologging, and especially those systems providing automated collection of animals' positions, has certainly revolutionized the way to study animals in their environment, moving the observation point to animals themselves. However, the opportunity to integrate knowledge on animal movement with information gathered from the environment, has thus far been largely overlooked, especially in terrestrial systems, where animal-borne data and environmental indices are often collected in separate steps. Inferences on how habitat variables affect animal behaviour are therefore derived from post-hoc modelling, where animal activity, presence or distribution are modelled against a series of habitat variables. While this approach allows us to describe habitats of importance for species, it often failed to ascertain the processes underlying habitat choice and animal distribution in the environment. We propose the application of wireless sensor networks (WSNs) technology to terrestrial systems to design and effectively undertake hypothesis-based field experiments on habitat use. WSNs devices are equipped with a low-power microcontroller unit (MCU) enabling on-board computation, a wireless communication interface, storage memory, and a set of sensors. Thanks to this instrumentation and appropriate software control, we can alter our perspective, reversing the direction of studies to also incorporate the effect of individual animals on habitats and each other: when certain environmental conditions apply (e.g., temperature range, proximity to key resources, proximity among individuals), the device is activated to acquire an intense set of animal-borne and other data, thus providing a robust and quantitative basis for hypothesis validation. We present the results of communication tests in challenging connectivity conditions and environments (e.g., tropical cloud forest, thick broad-leaved alpine forest), necessary to assess the feasibility of our approach in wildlife field studies. Despite the dense foliage and high humidity, the WSN functioned efficiently, communicating effectively at greater distances than expected, thus prospecting feasible and efficient applications to wildlife/habitat issues. The accurate estimate of the distance between nodes upon contact (animal vs animal or animal vs fixed station) remains one of the main challenges; however, the sensitivity of the system is already an improvement on other animal-borne devices used in space and habitat use studies (e.g., GPS). To conclude, we discuss challenges and potential of WSN systems to study critical interactions between animal and resources (e.g., winter habitat use of ungulates in the Alps; proximity of zoonotic urban foxes to human settlements).

O4.05 Use of multiple tag types to examine the risk of blue whales to ship strikes off southern California

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We deployed three types of suction-cup attached tags on blue whales to gain new insights into their vulnerability to ship strikes. Objectives included 1) identifying areas of overlap between whale distribution and ships, 2) examination of feeding and underwater behavior when in shipping lanes and 3) reaction to close approaches by ships. Deployments were made with a pole from a RHIB. Over 150 deployments of tags were made in the eastern North Pacific since 2000 with efforts in 2007 to 2010 focused in and around shipping lanes off southern California. Recent tag deployments focused on the Bioacoustic Probe, which recorded high quality digital acoustics; and the Wildlife Computers Mk10 Fastlock GPS tag which provided location information. All tags also recorded depth and a combination of other sensors. These tags revealed a number of key findings including: 1) locations of overlap between ships and whales tend to occur where shipping lanes overlap the continental shelf edge (areas of productivity where whales were feeding), 2) strong day/night differences in diving behavior indicating whales were often resting and not feeding close to the surface during the night and most vulnerable to ship strikes, 3) their movement at night are different than during the day putting them at danger even when their daytime feeding areas do not overlap directly with shipping lanes, 4) whales did not avoid closely approaching ships and in three of four very close approaches actually closed the gap to the whale, 5) some behavioral reactions to closely approaching ships, including spending more time at the surface, may make whales more vulnerable to ship strikes. Using a variety of tags highlighted not just the competing utility of different tags but the ways in which they can complement each other to provide a more complete picture about an important threat.

O5.06 Modeling suitable foraging habitat for adult female northern fur seals (*Callorhinus ursinus*) and implications for conservation of a declining species.

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Conservation of free ranging marine predators often relies on determining the habitat needs of a species and instituting protective measures in those areas identified as important. Defining suitable foraging habitats is crucial for the management of a declining species such as the northern fur seal. The aim of this study was to develop a habitat suitability model using locations of diving from 22 adult female fur seals instrumented on the Pribilof Islands during the 2004 breeding season. Ecological Niche Factor Analysis (ENFA) was used to model fur seal foraging in relation to sea surface temperature, bathymetry, sea surface height, and productivity. The first three factors from the ENFA explained 92% of the variance in the data set and were used to calculate the habitat suitability index and produce a predictive map defining four types of fur seal foraging habitat (optimal, suitable, marginal and unsuitable). The model was validated using k-fold cross-validation method (Boyce Index 0.91, SD ± 0.088). Walleye pollock is one of the top prey in the diets of fur seals. We determined the amount of pollock catch taken from each of the four habitats defined by the model. We found 83 % of pollock fished was taken from areas designated as optimal by the model and only 5% of the catch was taken in areas classified as marginal or unsuitable. Our model demonstrates a readily available and robust method for predicting important fur seal foraging habitat and identifying potential areas of interactions with fisheries.

O3.17 The influence of diet on foraging habitat models

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For central place foragers, such as lactating Antarctic fur seals (*Arctocephalus gazella*), reliable sources of prey are expected to be related to environmental features that enhance productivity in predictable temporal and spatial patterns. Marine mammal studies typically infer foraging ecology by combining foraging trip data from known individuals with dietary information from unknown animals, such as from scats collected at haul-outs. However, not all individuals within a population exploit similar prey types and these differences are often associated with different hydrographic features. Foraging habitat models may therefore be improved by considering environmental characteristics of core foraging areas (CFAs) with reference to specific predator-prey combinations. We hypothesized that CFAs of *A. gazella* would be better predicted in seals consuming monotypic diets than in seals consuming multiple prey types, and that CFAs would be poorly predicted by considering combined data from all seals. Bathymetry and multi-year (n = 24) mean sea surface temperature and variability were used as predictors of CFAs of nursing *A. gazella* at Heard Island using multiple logistic regression and classification tree analysis. The effect of prey types on the predictability of these models was explored by matching diet and foraging trip data of individual seals (n = 40). Differences in diet between seals were mirrored by their spatial behaviour. Environmental parameters were useful for predicting foraging activity of seals that consumed a single prey type with relatively specific habitat preferences, but not for those that consumed single or multiple prey types associated with more varied habitats. Ignoring individual variation in predator diet by pooling data probably contributes to the poor performance of foraging habitat models. Consideration of these differences is likely to identify those animals within a population vulnerable to particular environmental changes, and also improve predictions of the consequences of particular management strategies.

P3.02 Horizontal and vertical movements of black marlin (*Istiompax indica*) near Taiwan determined using pop-up satellite tags

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Black marlin (*Istiompax indica*) is a highly migratory apex predator distributed from tropical to temperate oceans. For almost 100 years, harpoon fishery has targeted the aggregations that form along the eastern waters off Taiwan. Information about vertical distribution and migratory movements of highly migratory species like tunas and billfishes are important for stock structure and assessment. However, in the Taiwan (northwester Pacific) this information is not available for black marlin. The basking behavior and existence of a harpoon fishery provided an excellent opportunity to deploy pop-up satellite archival tags (PSATs) via harpooning. PSATs were used to study the horizontal and vertical movements of 2 black marlins tagged in eastern Taiwan. Two PSATs (BKM I, II) released prematurely after periods ranging about 161 and 40 d. BKM (I) indicates almost 60% of the time was spent in the upper 10 m of the water column, relatively at the surface. This is confirmed by sea temperatures at or above 27°C of 95% of the time. Maximum recorded depth is 136 m and minimum temperature recorded was 18°C, overall temperature range is 18.0-29.4°C. This fish travelled a left round route to the Haina Island (Southern China), and straight-line distance of 1,800 km. BKM (II) displays more than 80% of the time during the night is spent with in 10 m at the surface. The highest frequented depth during day time diving is 60 m (14%) with the fish returning there at night for only 7% of the time. During the day the fish spends 56% in the upper 10 m. Night dives to depth occurred on six separate occasions with no apparent pattern or correlation to lunar illumination. This fish travelled a northeastern direction after released and straight-line distance approximately 500 km. Diel diving patterns also suggested basking behavior. Black marlin behavior makes them particularly vulnerable to surface fishing gear.

P1.03 The 'honeymoon' flights of the short-tailed shearwater (*Puffinus tenuirostris*).

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Short-tailed shearwaters (*Puffinus tenuirostris*) are a migratory species that depart northern foraging grounds in the Bering Sea to reach southern breeding colonies in eastern Australia by late September. Prior to egg-laying they embark on long foraging trips over sub Antarctic waters to improve body condition that has deteriorated during the trans-hemispheric migration. Whilst numerous studies highlight aspects of the foraging flights of Procellariiformes during the chick rearing period, very little is known about pre-breeding flights and foraging areas. As telemetry techniques have advanced, loggers have become smaller and less costly permitting tracking of small seabirds with large foraging ranges during the riskier pre-breeding period, where birds may not return to the colony if they choose not to breed. Using light-level geolocators, we aim to track 25 adults from their arrival at the southern Tasmanian colony in October to December (2010) when breeding commences, ultimately capturing the pre-investment 'honeymoon' flights. From recent preliminary telemetry studies evidence has pointed toward the use of three particular areas; the Polar Frontal Zone, Subantarctic Zone and The Australian shelf during both the pre-breeding and breeding periods. Few individuals have been tracked during the pre-breeding stage, however there is some indication that the flight paths and foraging characteristics are very different to those undertaken whilst chick rearing, when adults are provisioning young. We anticipate that adults will travel further distances to higher latitudes exploiting frontal systems and regions of high biological productivity due the reduced constraints of the pre-breeding period.

O5.13 Comparison of the foraging ecology of southern and northern elephant seals

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While southern elephant seals (SES) are distributed throughout the southern ocean, northern elephant seals (NES) are limited to the Northeast Pacific Ocean. SES feed at the same latitudes where they breed, while NES feed at higher latitudes than their breeding colonies. The foraging behavior of 167 female northern elephant seals (Año Nuevo and San Benitos Islds) and 55 southern elephant seals (Livingston Island, Antarctic Peninsula) were compared to see how the behavior varied between these different habitats. While the diving behavior was similar their movement patterns are quite different. Female NES forage primarily offshore (85%) while most SES forage on the continental shelf (86%). Over a foraging trip SES and NES traveled similar distances (SES 10,861 km ± 5791; NES 9,042 km ± 3710) and both rely on persistent large scale oceanographic features such as the North Pacific Transition zone for NES and the Polar Front for SES. Given the similarity of foraging behavior of these species it is quite surprising that NES breed at such low latitudes compared to where they forage. While SES forage in the areas more associated with their breeding sites. These differences are probably related to differences in available habitat as well as a greater presence of humans in the habitat of northern elephant seals.

O1.06 Biophysical identification of eddies of ecological interest from a marine predator outlook

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Oceanic frontal areas are dominated by an intense turbulence shaping both physical structures and marine life. This work proposes a multidisciplinary approach for understanding how mesoscale (eddies, 10-100 km) and submesoscale (filaments, 1 to 10km) processes influence marine foodwebs, particularly the foraging strategies of top predators. Marine predators are perceived as key organisms when studying such highly dynamic habitats, as they integrate the interactions between the physical environment and other marine life including plankton and fish. The aim is thus to characterise the dynamic environment of foraging predators and particularly the eddies used by predators compared to those which are only transited. Using Argos-CTD (Conductivity-Temperature-Depth) - Fluorometry transmitters and Argos-TD devices, we tracked trips of post-moulting and post-breeding elephant seals from Kerguelen within the frontal areas of the Southern Ocean and their interactions with mesoscale eddies and submesoscale filaments. We used Langrangian analyses from satellite data to track these physical structures and we also examined origin of water masses and temperature gradient. Our results indicate that elephant seals did not forage randomly in the dynamic field of the fronts. Contrasted behaviour of elephant seal based on the First-passage time method particularly highlight that the most intensive foraging occurred in cold eddies characterized by northward intrusion of water masses crossing circumpolar fronts creating locally strong thermal discontinuities. We have also investigated the aggregative aspect of eddies prospected/targeted by seals, that is fundamental in term of strategy of foraging predators and local development of foodwebs.

O3.16 Linking bio-logging and endocrinology – Corticosterone and diving behaviour in Adélie penguins

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The amount of energy that organisms can allocate to self-maintenance and/or reproduction largely depends on their foraging strategies. Underlying physiological mechanisms of animal behaviour are mainly controlled and regulated by endocrine processes. Because of the involvement of corticosterone (CORT, the stress hormone) in the control of energy metabolism, food intake and locomotor activity, recent studies seek to demonstrate the role of this hormone in foraging decisions and performance. To this aim, we instrumented control and CORT-treated Adélie penguins (*Pygoscelis adeliae*) with time-depth recorders and monitored them throughout successive foraging trips during the guard stage (Adélie Land, Antarctica). We found that foraging trips duration was similar between both groups. Dive durations, time spent at the bottom phase of dive and number of undulations per dive were significantly higher in CORT-birds than in controls. However, CORT-birds performed less dives than controls and spent many long periods without diving. Because CORT administration was associated with low foraging effort and long emerged periods, CORT-birds probably gained less energy than controls. Thus, CORT treatment apparently redirected the bird behaviour from costly activity (reproduction) to a behaviour promoting body maintenance. The association between bio-logging and hormonal manipulation could prove particularly helpful in understanding proximal factors that control foraging decisions of free-living animals in a changing environment.

P5.06 Habitat use, residency and site fidelity of manta rays, *Manta alfredi*, at Lady Elliot Island, Australia.

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Manta rays, *Manta alfredi*, frequently occur in coastal tropical areas and have a strong tourism potential. However, little information is currently available about their site fidelity and residency patterns and what factors influence their visitation patterns. Manta rays are frequently observed along the east Australian coast and appear to aggregate at specific sites. Over 40% of the manta rays identified at Lady Elliot Island, using photo-identification techniques, were resighted at least once at the same site over a three years period, suggesting some form of site fidelity by the species. Passive acoustic telemetry techniques were used to examine the residency and site fidelity patterns of Manta alfredi at Lady Elliot Island. Six acoustic receivers were moored around the island between June 2009 and February 2011 and a total of 16 acoustic transmitters were deployed on manta rays. Using a general linear mixed effects modelling approach, we analyse the visitation patterns of manta rays with respect to environmental and temporal parameters such as tide, water temperature, time of year and time of the day. The increased knowledge of manta ray habitat use, residency and site fidelity at key aggregation sites will inform management policies that will support eco-tourism and conservation of the species and its habitats.

O4.19 Foraging areas of female southern sea lions (*Otaria flavescens*) on La Plata River Estuary (Argentina-Uruguay)

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The southern sea lion (*Otaria flavescens*) population in Uruguay has declined severely during the past few decades. Hypotheses on the cause(s) include a decrease in prey availability which could be caused or exacerbated by environmental changes, increasing competition with other top predators and overlap with commercial fisheries. Breeding colonies in this area are within the La Plata River Estuary (LPRE), a hydrographically complex environment that supports an important fishery jointly administrated by Argentina and Uruguay. Although southern sea lions have been identified as a species for conservation, there is little information about its role in this ecosystem. As a result, the two countries developed a co-managed research project focused on the identification of foraging areas, at-sea movements and foraging behavior of adult females, the most vulnerable component in a decreasing population. A total of 22 females were instrumented at Isla de Lobos (N_{2007}=12; N_{2010}=10) with location only telemeters (n = 10) and with satellite-linked dive recorders (STDR-S16=6). The foraging area (ca. 30.000 km^2) was similar between 2007 and 2010 and was mostly located in the Uruguayan-Argentinean common fishery zone. Foraging occurred primarily in south-southeast quadrant on the continental shelf. Mean duration of foraging trips was ca. 5 days, reaching a maximum of 14 days. Most animals returned to the same area on successive foraging trips, and there was little overlap among individuals. Site fidelity to the rookery was high regardless of reproductive condition. Our results show that the main foraging areas of this species lie within the LPRE but are not coincident with the “high priority protected areas” This research will contribute to our understanding, management and conservation of the LPRE by including top predators.

O1.01 Classification of free-ranging Weddell seal dives based on three-dimensional movements and video-recorded prey capture.

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Animal-borne instruments that record video, audio and data on swimming performance and three-dimensional movements are providing new insights into the behavioral ecology of marine mammals at sea. The goal of this study was to classify and compare free-ranging dives of Weddell seals using the same 58 descriptors for 3-dimensional dive path and multivariate classification scheme that were originally used to classify dives from isolated ice holes (Davis et al., Mar. Ecol. Progress Ser. 264:109-122, 2003). The diving behavior of free-ranging seals (n =12, BM = 430 ± 69.0 kg) was studied in McMurdo Sound, Antarctica from 2001-02 in two locations: an inshore breeding area and offshore over deep water. A video data recorder (VDR) was glued to the fur of each seal for ca. five days before recovery. Prey capture events were identified from the video, and three-dimensional dive paths were computed from data for depth, compass bearing, and speed. More than half (56%) of all free-ranging dives were assigned to Type 1 (foraging) dives by the classification functions derived for isolated hole dives, and prey (principally Antarctic silverfish, Pleuragramma antarcticum) were captured during 84% of these dives. This confirms that Type 1 dives are the primary type of dive used for foraging by both free-ranging seals and those diving from an isolated hole over deep water. Seals whose foraging dives originated inshore and followed the bottom contour had to make longer dives and travel farther to reach depths (> 180 m) where silverfish commonly occur. Average dive duration (24.7 min) and distance traveled (1.95 km) for inshore foraging dives was 1.3-1.5 times greater than the average dive duration (16.7 min) and distance traveled (1.45 km) for offshore foraging dives. In addition, linearity of the seals' outbound and inbound swimming paths was significantly greater for inshore foraging dives. As a result, there is an additional energetic cost for foraging animals that aggregate inshore near certain breeding areas, and this may influence rookery quality.

P5.07 A miniature acoustic transponder for simultaneous underwater animal tracking and habitat mapping.

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We developed a prototype miniature underwater acoustic transponder that operates with a standard 160 kHz WASSP WBM-160F multibeam echo-sounder (ENL, Auckland, New Zealand). Each transponder has a unique coded reply that is clearly detectable in the receive sequence for a single sonar ping. In addition, the transponder has two as-yet unused channels available for optional sensors whose data could be encoded in the replies. Range and bearing of the replies from multiple transponders can be obtained in a single sonar ping cycle. This allows for the integration of acoustic mapping, animal tracking, and environmental sensing thus providing real-time environmental context to movement data. In a field test of this system, transponders were attached to the carapace of three red king crabs (*Paralithodes camtschaticus*) that were subsequently released in a small 35-m-deep basin in Womens Bay, Kodiak Island, AK. On three successive days post-deployment, the WASSP sonar was used to locate the crabs as they moved a few 100m within the basin. These results demonstrate the feasibility of real-time active acoustic tracking of mobile benthic animals whose acoustic target strength normally would not rise above the surrounding bottom echoes. While the crab experiment was done in 25-35 m water depth, the system was also successfully tested without animals at in deeper waters (to 190m). Future developments are needed to optimize the system for more mobile, midwater predators.

P5.08 Movement patterns and habitat preferences of two albatross species at a shared wintering site.

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Albatross species are considered globally at risk and facing numerous threats in both their marine and terrestrial environment. To implement effective conservation measures, we need to understand species specific spatio-temporal dynamics, based on which marine important areas can be identified and classified. We studied two albatross species that breed in close proximity on two islands belonging to the Chatham Island Group: the Chatham albatross, *Thalassarche eremita* and the Northern Buller's albatross, *T. bulleri platei*. Using Global Location Sensing (GLS) loggers, including salt water immersion sensors, we recorded the birds distribution during the non-breeding season. Both species showed a strong spatial overlap and similar movement patterns inside their South American wintering areas but did segregate on a temporal scale. Combining information on wintering movements with actual temperature recordings by the GLS loggers and remotely sensed sea surface temperature (SST), we were able to identify temperature as a determining factor for habitat selection.

O4.07 Effects of simulated military sonar on sound production by blue whales, sperm whales, Risso's dolphin, and Cuvier's beaked whale

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Whales and dolphins use sound for different functions including echolocation and social communication, and thus changes in sound production patterns are a likely component of any behavioral response to anthropogenic sounds such as military mid-frequency sonar (MFA). To simultaneously log whale and dolphin movements, sound production and reception, and anthropogenic sound exposure levels, we used Dtags (Woods Hole Oceanographic Institution) and bioacoustic probes (Greeneridge Sciences). Tags were deployed on wild, free-ranging cetaceans in Southern California waters. Tagged animals were then exposed to simulated MFA or, as a control, pseudo-random noise (PRN). In total, the August-September 2010 SoCal10 behavioral response study included 28 playbacks: 19 to blue whales (11 MFA, 8 PRN), 5 to fin whales (3 MFA, 2 PRN), 2 to a single sperm whale (1 MFA, 1 PRN), 1 to a Risso's dolphin (MFA), and 1 to a Cuvier's beaked whale (MFA). For this analysis we focus first on baleen whale call production and reception rates (particularly blue whale D calls and variable calls) in relation to sound exposure level, dive behavior, and lunge feeding rates. We then examine echolocation-based foraging behavior and social call production by the toothed whales as a function of sound exposure level. This rich dataset, including multiple cetacean species of conservation concern, provides insight into the wide potential range of responses to sound, and the dependence of those responses on ecological, social and behavioral context. Investigations like SoCal10 can help guide inferences for related topics, such as assessment of population effects of anthropogenic noise.

O5.07 How do GPS-collared moose deal with temperature induced heat stress across Scandinavia?

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Recent climate change models suggest considerable impact on peripheral ecosystems. The consequences for human societies may become evident in the future since climate change influence not only the factual climate conditions, but also change flora and fauna by affecting species' spatiotemporal distribution. Climate change may alter migration patterns of ungulate species such as moose (*Alces alces*). Moose as a species is extremely tolerant towards cold temperatures. In agreement with Bergmann's rule, its larger body size preserves heat and thus lowers the energy demand for thermoregulation. In contrast, moose can easily experience heat stress both during summer and winter. Heat stress can via an increased energy demand reduce overall activity. Further, apart from this effect, the utilization of habitats that reduce heat stress may additionally affect moose movement behavior. More and more ungulates are equipped with GPS-collars due to an increasing scientific demand on high precision positioning in a changing world. Often GPS-collars are equipped with additional sensors for measurement of e.g., activity or temperature. To date few studies have made use of this additional information. Between 2004 and 2010, we equipped 207 moose in nine populations from Southern to Northern Sweden with GPS-collars and recorded position and temperature every 60 minutes for one year. We first correlated the collar temperature readings with temperature data from nearest weather stations in the area, and second, correlated the temperature conditions and temperature changes to the movement pattern of each individual moose. We show that there is an offset between the temperature data of the weather stations and the collars, but that the relative temperature changes are reflected in the collar data. Further, changes in the movement pattern seem to indicate that moose in Northern Sweden, adapted to a lower annual mean temperature, are more affected by heat stress than moose in Southern Sweden.

P4.03 Evaluation of near-real time GPS-ARGOS collar performance by stationary tests and fitting on a free-ranging Asiatic black bear

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The wildlife researchers have used radio-telemtry, GPS collars, and ARGOS system to track animals as telemetry technologies. More recently, a new ARGOS system, namely GPS collar with ARGOS uplink (hereinafter referred to as "GPS-ARGOS"), was developed; this can collect highly accurate location data by GPS and remotely transmit collected data to satellites. Using this system, the users can collect tracked animals' movement location data remotely in near-real time through the Internet access and do not necessarily go to field for data collection. The objective of this study is to evaluate a GPS-ARGOS transmitter performance and investigate the potential applications for tracking terrestrial mammals inhabiting forests. The performance of GPS-ARGOS transmitter (model TGW-4580, 920g, Telonics Inc.) with an Argos uplink was tested. The collar was programmed 1) to collect location data (latitude and longitude) recorded by its internal GPS, temperature, altitude, and activity data, for every 4-hour per day and 2) to transmit above data through radio signals to satellites during fixed 6 hours every 3-day. The collar was placed at three points (S1, S2, and S3) in Tanzawa region, Kanagawa Prefecture, Japan, to test the effects of terrain (elevation angle) and degree of canopy closure, on the GPS fixes rate, the positional error, and ARGOS uplink success rate. Points S1 and S2 were set on a riverside located at a valley, and on a mountain ridge, respectively, in a mixed forest. Point S3 was set on the third-class triangulation point, whose coordinates were measured accurately. Moreover, the collar was deployed on a free-ranging bear to examine the fix rate, and the ARGOS uplink, and 106 location data was collected every four hours from 19th September to 23rd October 2009 in Tanzawa Mountain, Japan.

O1.04 Understanding foraging decisions of southern elephant seals in relation to oceanographic structures using hierarchical hidden markov models.

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The optimal foraging theory predicts that predators should adjust their movement's pattern in relation to prey density. Studies of predator movements therefore contribute in understanding foraging processes resulting from individual decisions taken in response to physiological and prey distribution constraints. Within the Southern Ocean polar frontal zone, female southern elephant seals (SES) concentrate their foraging activity in mesoscale eddies known to enhance the primary production with a likely effect on the spatial distribution of prey fields. The aim of this study was to investigate at fine temporal and spatial scales changes in the movement and diving patterns of elephant seals. In 2008-2009, eleven post-breeding females were fitted with new TDR recorders, sampling depth and temperature every 2 seconds, and Argos satellite - GPS data loggers at Kerguelen Island. We used a combination of two hierarchical Bayesian hidden Markov models (HBHMM) to probabilistically assign locations to one of two behavioural movement types. At the surface, movement pathways from Argos and GPS satellite-tag data were classified: each step and turn of the animals' trajectories was assigned to a behavioural state between two statistically distinct states: travelling and foraging. The second HBHMM model was developed within the vertical dimension: intensive foraging behaviour of the seals was identified taking into account their vertical speed along the water column. Environmental covariates, such as sea level anomalies and in situ temperatures, were also included in the models. Along the tracks, the most favourable foraging zones were found to be related to the presence of both cyclonic and anticyclonic eddies while at depth, foraging was found to be related to temperature. The results obtained provide the first synoptic view of the 3-dimension distribution of elephant seals' prey fields revealed by their foraging activity in response to oceanographic structures in a vast sector of the Southern Indian Ocean.

P4.04 Flight dynamics and energetics of large raptors: combined use of GPS, accelerometer, electro-cardiogram, and video camera on free flying vultures.

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Understanding precisely the flight of large soaring raptors was, so far, limited by the lack of adequate tools and by the difficulty to recapture wild raptors with vulnerable conservation status. This latter difficulty can be circumvented by studying flight of captive raptors, trained to fly freely in semi-natural conditions. The Rocher des Aigles in Rocamadour (France), overhanging a canyon, offers similar conditions to those encountered by wild raptors. In spring and summer 2010, five vultures from the Rocher des Aigles, belonging to three closely-related species (Griffon *Gyps fulvus*, Rüppell *G. ruppelli*, and Himalayan *G. himalayensis* vultures) were equipped with high precision GPS (measuring position, altitude, speed and bearing at a rate of 4 Hz), coupled with 3-D accelerometers (measuring wingbeats and body posture at a rate of 100 Hz), and electrocardiograms (to determine heart rate during soaring, gliding and flapping phases). One of these birds was also equipped with a miniature video camera directed backwards to analyse the inclination of the body when soaring and the movements of the tail. These data allowed us to analyse precisely the flight behaviour of these three species that underwent similar flight condition but had different body masses and wingspans (ranging from 5-8 kg). Captive vultures were able to fly as high as 1500m above ground, ascending at a speed of 10 $m.s^{-1}$ when soaring, and reaching the impressive horizontal speeds of 120 $km.h^{-1}$ when gliding. Using meteorological and wind data together with precise morphometrical measurements, we were able to compare the efficiency of using thermal ascending currents (climbing speed, diameter of soaring circles, number of wingbeats) between species. These results will help us better understand the constraints related to flight for prospection behaviour of wild vultures, and to plan adequate conservation actions.

P5.09 Free ranging ocean observation systems: maximizing use of ocean data collected from tags deployed on marine animals.

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In an effort to better utilize oceanographic data collected from electronic tags deployed on marine animals, we have developed a set of routines for the extraction, quality control and transfer of temperature profile data to the Global Temperature Salinity Profile Program (GTSPP). Inclusion of these data into the World Ocean Database by the GTSPP represents the first time that data derived from tags deployed on fish species have been submitted to the same procedures as Argo-float and XBT data for access and use by the global community. Data received from GPS capable pop-up satellite archival tags are automatically downloaded from Argos, decoded and uploaded to a central database. Routines extract temperature profile data in close (+/- 72 hours) proximity to GPS locations, which are then processed through data quality control routines developed for Argo-float and XBT data. Standard metadata fields are generated and the data and metadata uploaded to the GTSPP, and ultimately to the World Ocean Database. Further development of these procedures to include temperature profile data associated with Argos satellite locations will result in the expansion of the spatial coverage of temperature profile data available and importantly provide data from regions that have proven difficult for traditional oceanographic instruments, such as coastal regions and semi-enclosed seas.

O2.02 Are archival tags useful for fisheries management?

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The deployment of archival tags on commercially exploited fish species has become increasingly common over the past decade. Valuable information has been gained through this research on the spatiotemporal behaviour of individuals and populations, such as distributional range, migration patterns, depth distribution and diving behaviour. However, the use of archival tag data to inform management—which is often stated as the primary goal of the research—has been relatively uncommon. One reason is the lack of established analytical methods for doing so. Here we show how data from archival tags can be incorporated into a discrete-space discrete-time model for analysing conventional tag-recovery and fishery catch data. For a cohort of fish tagged in consecutive years, this model can provide year- and region-specific estimates of natural mortality and fishing mortality, region-specific estimates of abundance, and year-specific movement probabilities between regions. Archival tags provide the same information on mortality rates as conventional tags, but in addition they provide information about the movement of tagged fish between the times of release and recapture. We examined the value of including archival tag data in the model in terms of parameter precision using two versions of the model: one with a very general spatial structure (no restrictions on fish movement or fishing operations), and one that has movement and fishery dynamics resembling those for juvenile southern bluefin tuna (SBT). For both versions, we found archival tag data to be particularly beneficial when tagging in some regions and years is not feasible. In this case, increasing the proportion of archival tags led to significant improvements in the precision of the movement probability estimates and many of the fishing mortality estimates (those for regions and time periods where tagging did not occur). Furthermore, there were cases for which not all parameters were estimable unless archival tag data were included.

P3.03 Search tactics of echolocating male sperm whales in a bimodal foraging mode

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When searching for food, echolocating bats and toothed whales modulate their acoustic sampling rate according to the distance over which they expect to find prey or obstacles. Both taxa use a low clicking rate while searching for prey, but change to fast clicking (called a buzz or creak) when attempting to capture prey. Acoustic recording tags on echolocating whales provide continuous measures of the depth of the whale, its clicking rate, and, via echoes returning to the whale, its distance to the sea-floor. Combining these data with the depths at which feeding buzzes are produced, provides and indication of where prey are encountered and presents an opportunity to study search tactics as a function of resource location. Male sperm whales off northern Norway forage over a wide depth range and display a dynamic foraging behaviour switching between shallow and deep dives, but it is unknown what factors influence the selection of the target food layer in each foraging dive. Here we use multi-sensor acoustic tags (DTAG) to compare the dynamic foraging tactics of male sperm whales to those of females in warmer waters for which shallow foraging is very rare. We show that male sperm whales, in contrast to females, echolocate during the ascent phase of dives without attempts to capture prey, suggesting that ascents are used to locate the food layer for the next dive. Males also start clicking earlier and click at higher rates in shallow dives than in deep dives indicating a shorter sonar inspection range. These results suggest that male sperm whales may decide on what food layer to target prior to diving on the basis of information acquired in the previous dives. The clicking rate of an echolocating predator may then be a useful indicator of how its prey resources are distributed in the water column.

P3.04 Use of the LIMPET medium-duration satellite tag to identify areas of elevated risk for sensitive populations: fin whales (*Balaeanoptera physalus*) in the Southern California Bight.

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The Southern California Bight (SCB) is a productive marine region extending 100nm off the southwestern United States. Fin whales are listed as endangered in the US and are believed to occur throughout the SCB in all months, at times in dense aggregations far from shore. They frequent areas not consistently covered during coastal visual surveys, thus population structure and local use patterns are not well known; however evidence suggests these fin whales may represent a discreet population sub-unit. The SCB is a region of elevated anthropogenic activity, including military training ranges, shipping traffic, and oil and gas extraction. Fin whales are the species most commonly implicated in large vessel collisions along the US West Coast, therefore there is a need to identify areas where aggregations of fin whales and vessel traffic are likely to co-occur, and for how long. The LIMPET (Low-Impact Minimally Percutaneous External-electronics Transmitter; Wildlife Computers' SPOT5) satellite tag allows us to monitor movements of individual whales for periods of weeks to months with multiple positions per day. In 2008-2009 we remotely deployed eight LIMPET tags on fin whales during marine mammal surveys at the US Navy's Southern California Offshore Range (SCORE), resulting in a total of 2,214 locations over periods ranging from 19-160 days, with up to 17 locations per day. While all but two whales made forays west or south, five ultimately returned, and the majority of all locations remained within the SCB, with extended periods in offshore regions of heavy shipping traffic. LIMPET data can be compared against military range boundaries, coincident vessel traffic maps, or other areas of interest to characterize exposure to elevated risk levels. It provides critical information for mitigating such risks to this population not attainable by other means, and demonstrates the utility of this technology for similar species.

O2.01 Bio-logging science into management policy

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There is currently a strong commitment to developing marine renewable energy by Governments, and the number of areas being leased for both demonstration and commercial renewable energy production projects is increasing. Some of these lease areas in the UK are also home to large numbers of grey (Halichoerus grypus) and harbour (Phoca vitulina) seals. Additionally, special consideration needs to be given to seals from Special Areas of Conservation. Two case studies are presented to illustrate how science and bio-logging can inform policy makers and environmental managers. The first case study used historic data to assess the potential for overlap between areas that are used by seals and those which have potential for energy production. Haulout survey and telemetry (at-sea) data were used to explore the extent of overlaps. Some lease areas clearly overlapped with seal breeding colonies, haulout sites and seal movements at-sea. Telemetry, visual and acoustic data were specifically collected for the second case study. Bio-logging data were analysed to look at seal movements and behaviour in relation to energy devices; and collision risk models were constructed, using the acoustic data to ground-truth the models. Local avoidance from energy devices was found but no gross displacement of animals. Information obtained at specific sites is of general applicability to the management of seals and marine renewables sites outside the UK.

O3.19 The MEOP International Polar Year Project: marine mammals exploring the oceans pole to pole.

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The polar seas form important links between all oceans. They play a critical role in the climate system and support vital ecosystems that contain important living resources. Despite its importance, the physical environment and ecosystems of the polar regions are still under-sampled and poorly understood. The IPY MEOP project was conceived to contribute significant new knowledge of polar marine mammals while simultaneously providing a rich new source of oceanographic data important for understanding their ocean ecosystem. MEOP involves teams from 10 countries, each funded by their own national agencies. Novel, miniature Conductivity-Temperature-Depth Satellite-Relay-Data-Loggers (CTD-SRDLs) were glued to the hair of more than 200 seals of 4 species (hooded seals in the Arctic and southern elephant, Weddell and crabeater seals in the Southern Ocean). The instruments recorded and transmitted the movement patterns and diving behaviour of the seals along with 2-4 physical hydrographic profiles per day. We use these data to describe the behaviour of these marine top predators in a physical environmental context (e.g. water masses, frontal structures, mixed layer depths and mesoscale eddies) and show how we can simultaneously monitor the changes in the body condition of the seals in relation to these. We also describe our strategy for making hydrographic data available to the wider ocean observing and climate modelling communities for use in their operational and delayed-mode ocean models and databases. MEOP collected >83,000 CTD profiles over 3 years. Many of these were from times and areas which are difficult to sample by other means, such as waters beneath the winter pack ice. The MEOP Project clearly demonstrates the value of using animal platforms to collect oceanographic data to study the ecological roles of marine mammals as well as for sustained, high resolution, year round, low cost observation of the Polar Oceans.

O4.13 The use of GPS and compass loggers to reconstruct high-resolution trajectories in Cory's shearwaters (*Calonectris diomedea*) to investigate search strategies.

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We investigate the search behaviour of Cory's shearwaters living in colonies on islands of southern Italy. The general aim of the research was the identification of IBAs but we are here interested in searching behavior and optimization of detection of targets which, in these pelagic birds, are represented by fishes or cephalopods. Birds were captured in the nest during incubation or chick rearing. Animals were fitted with a GPS or a compass logger and the device was recovered when the bird returned home after a foraging excursion. We performed a comparison of the movement parameters obtained using the two devices and we tried to establish 1) if these devices returned comparable information, 2) which search strategies were used by birds and 3) if birds optimized search efficiency by adopting a Lévy distribution of movements. Theoretical analyses have showed that Lévy walks can outperform other search strategies in term of efficiency (targets detected per unit time) η. Our analysis showed that there is heterogeneity in search strategy but that most of birds adopt a mixed strategy. Under this model an animal shifts from a "scanning" to a "reorientation" behavioral mode. During scanning, animals perform a continuous correlated random walk while reorientation breaks the directional persistence and the time among reorientation events follows a Lévy distribution. We used Bayesian analysis, adopting Monte Carlo Markov chain methods (MCMC) to recover with a very good precision both proportions of the two behavioral modes and the concentration parameter r of the wrapped Cauchy distribution characterizing the scanning mode. This approach allowed us to determine the Lévy exponent m which appears to be close to the value $m=2$ supposed to maximize η. We wish to emphasize the importance of technological improvements for the solution of both theoretical and practical issues.

P5.10 Xtractomatic: easy access to environmental data for ocean habitat identification

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Researchers and managers seeking oceanographic data to provide environmental context for their applications often face a bewildering array of formats and data sets. For those who know how to handle such data sets, acquisition and application of the data can be trivial; for those not so familiar with the techniques, the process may become an insurmountable obstacle. In order to increase the utilization of oceanographic data in the stewardship of marine resources, a tool has been developed that allows consistent and easy access to a diverse suite of marine environmental data. The Xtractomatic toolbox was originally developed to support the Tagging of Pelagic Predator (TOPP) program. Instead of downloading many large files, the Xtractomatic tools allow the researcher to effectively swim though the environment, extracting data along the way. The data is then imported directly into the researchers working environment, eliminating much of the hassle in dealing with multiple file formats. The original version was focused primarily on satellite data sets and extraction in only 3 dimensions (time and ocean surface). The second version offers in situ data such as profiles from ARGO floats, output from general circulation models, and allows for the arbitrary 4-dimensional extractions appropriate for such products. These tools can be especially helpful when using statistical methods such as correlated random walks, which require the generation and extraction of environmental data along many tracks. Several examples of how these are used to model ocean habitat based on electronic tag data are provided. Versions of Xtractomatic are currently available for Matlab, a commercial programming environment, and R, an open source statistics package

O4.10 Spatio-temporal correlation between leatherback turtles and industrial fisheries in the Atlantic Ocean.

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Bycatch resulting from turtles and fisheries interactions is generally considered as the main threat to sea turtles worldwide. The leatherback turtle, *Dermochelys coriacea*, performs the most extensive migrations of all sea turtle species and is therefore particularly at risk of interacting with fishing gears used by industrial fleets. Yet, to date, there has been no attempt to identify major areas where leatherback turtles meet fisheries at the scale of an ocean basin. Such comprehensive overview of leatherback habitat use is critical for implementing concerted conservation strategies. Here, we present the analysis of the movement patterns and habitat use of 108 satellite-tracked turtles throughout the Atlantic Ocean where some of the world's last major leatherback populations occur. We show contrasted patterns between both hemispheres. In the North Atlantic (NA) turtles disperse widely into the Northern and Equatorial Atlantic and in the Gulf of Mexico. In the South Atlantic, the turtles leave their central African nesting sites following a migration corridor, and show a narrower distribution range than in the NA, by either dispersing southwards along the African coast or by crossing the ocean basin to South American coastal habitats. In total, the turtles spent ~70% of their time in only 35% of their entire distribution range and only one turtle briefly crossed the equator. During their migrations, all turtles reached oceanic fronts where fisheries are known to concentrate. By superimposing turtle tracks with longline fishing effort data, we investigated seasonal patterns in leatherback habitat use and fisheries effort and spatio-temporally defined regions where interactions might be high. This study provides a solid scientific-based attempt for identifying areas where conservation strategies might be implemented to protect this species. By involving stakeholders from local communities to regional fisheries management organizations in this approach, consistent mitigation measures will be implemented to reduce turtle bycatch.

O1.14 Using multi-sensor suction cup tags to quantify the kinematics of lunge feeding in humpback whales (*Megaptera novaeangliae)* in the water around the West Antarctic Peninsula.

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Humpback whales (*Megaptera novaeangliae*) feed through extraordinarily energetic lunges during which they engulf large volumes of water equal to nearly 70% of their body mass. To understand the kinematics of lunge feeding, we attached high-resolution digital recording tags incorporating accelerometers, magnetometers, pressure and sound recording (Dtag) to whales feeding on euphausiids in fjords on the West Antarctic Peninsula. Instances of near vertical lunges gave us the unique opportunity to correlate the acoustic flow noise recorded on the tag with the signal from the accelerometer and changes in pressure to obtain a fine scale record of the body accelerations involved in lunging. This can then be applied to determine lunging events regardless of body orientation. We found that lunges contain extreme accelerations reaching 2.5 $m \cdot s^{-2}$ in certain instances, which are then followed by profound decelerations. However, humpback whales appear to differ from balaenopterid whales in the speed at which they are able to accelerate and the fact that they do not come to a complete halt when finishing a lunge. When animals are intensively feeding the inter-lunge interval is similar for both deep and shallow lunges suggesting a biomechanical constraint on lunges. However, the number of lunges per dive varies from one for shallow feeding (<25m) to a median of six for deeper dives that reach depths of over 350 meters. Different feeding patterns were evident in the kinematic record, for deep and shallow feeding bouts with the much greater mean turn rates occurring in shallow feeding. Our findings reveal how multi-sensor tag technology can be used to better describe the kinematics of baleen whale feeding and greatly augment our ability to understand their foraging ecology. This knowledge is particularly valuable for understanding how baleen whales in the Southern Ocean affect or may be affected by climate-driven changes in their prey.

P4.05 Using satellite telemetry to study temporal and spatial overlap of marine mammals and industrial activities in northwest Alaska

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Significant industrial developments are occurring in coastal and offshore waters of northwestern Alaska. At least eight species of marine mammals, both migratory and resident, use this region for feeding, reproducing, or molting. Until recently, broad generalizations were used to describe their presence or absence in impacted areas. To address the need for more detailed information, scientists and Inuit hunters have attached satellite-linked dive recorders (SDRs) to two species of cetaceans (beluga whales, n=23; bowhead whales, n=19) and three species of pinnipeds (spotted seals, n=12; ringed seals, n=41; bearded seals, n=11) from this region. Their movement data were overlaid on areas where industrial development is currently occurring (Red Dog lead/zinc mine port and Chukchi Sea outer continental shelf (OCS) oil and gas leases). The Red Dog port region was used only by ringed and bearded seals. OCS lease areas were used mainly by bowhead and beluga whales. Tagged bearded and ringed seals likely did not use the OCS area much because of the location and dates of tagging. Use of SDRs has made it possible to document distribution and movements of five marine mammal species that range widely in remote areas, and for which we previously had no detailed information about habitat use. However, while our results are informative, they are of limited use for quantitatively evaluating exposure to industrial activities because sample sizes are relatively small, the times and places where animals were captured and tagged may bias the results, and tracking durations have been relatively short. Nonetheless, this information can provide a powerful qualitative tool to demonstrate spatial and temporal overlap of marine mammals with industrial activities. Maps can show when and where the highest or lowest number of species or individuals may be present, and mitigation measures can be developed to minimize potential impacts.

P4.06 Economy of scale: The world's largest fish closely manages its swimming costs

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The largest animals in the oceans subsist on prey that are orders of magnitude smaller than themselves, challenging their ability to meet their energy demands. Whale sharks (*Rhincodon typus*) may be especially challenged by warm seas which elevate their metabolism and contain sparse prey resources. Using data from an attached video and data logger, we analyzed swimming characteristics of two whale sharks at Ningaloo Reef, Western Australia, and discovered four tactics they use to save energy and improve foraging efficiency: fixed, low power swimming; constant low speed swimming; gliding; and asymmetrical diving. These tactics increase foraging efficiency by 22 – 32% relative to swimming horizontally and help reconcile the energy-budget paradox of whale sharks. Other large, filter-feeding sharks and whales which share similar energetic challenges due to their extreme body size likely use similar tactics.

P1.09 Habitat utilization of juvenile southern bluefin tuna (*Thunnus maccoyii*) in relation to oceanographic conditions in southern Western Australia

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Habitat utilization by juvenile southern bluefin tuna (SBT, *Thunnus maccoyii*) in southern Western Australia was investigated through acoustic monitoring of fish tagged with acoustic transmitters during three austral summers (2004/2005, n = 79 fish, 2005/2006, n = 81, 2006/2007, n = 84). We deployed 70 listening stations in three cross-shelf lines and at coastal three lumps between December and March in 2004/05, and December and May in 2005/06 and 2006/07. In order to determine the oceanographic properties in relation to movement and residence times by tagged fish, we conducted CTD casts through the survey area, and recorded temperatures every 30 minutes using time depth recorders attached to listening stations. We observed that interannual and seasonal variability of the strength of three water masses (i.e. nutrient-rich sub-Antarctic water, sub-tropical water, and warm tropical Leeuwin Current) appeared to have a strong influence on fish habitat utilization and migrating timing. We conclude that when the sub-tropical water persists over summer, the fish spend most of their time at inshore topographic features, conversely when sub-tropical waters mix with nutrient-rich sub-Antarctic water in the region, SBT occur widely over the continental shelf, then quickly move out of the study area. This study shows that juvenile SBT move quickly in and out of local foraging habitats in response to fluctuations in oceanographic conditions, and suggests that water masses occurring over the continental shelf play an important role in determining productivity suitable for SBT foraging.

O3.18 Long-term biologging as a method to investigate the capacity of terrestrial mammals to buffer effects of climate change

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Uncovering the physiological plasticity available to long-lived terrestrial mammals to cope with predicted effects of climate change requires the measurement of physiological variables in free-living mammals. We have used biologging to measure variables such as core body temperature, selective brain cooling, respiratory evaporative heat loss, microclimate selection, vasomotor state, orientation behaviour, and locomotor activity in mammals in their natural habitats. In the face of increasing environmental heat load and aridity in Africa, large mammals may select cooler microclimates and shift activity from day to night, as we have shown for Arabian oryx and black wildebeest. Selective brain cooling, which inhibits evaporative heat loss and conserves body water, also may offer a key adaptation for artiodactyls, such as sheep and antelope, under future climate change scenarios. It also has been proposed that heterothermy allows large mammals to conserve body water, by storing heat during the day. However, we have shown that such heterothermy reflects a failure of homeothermy, mainly as a result of dehydration and starvation. Most studies to date report data collected for less than a year, but we need prospective long-term data collection if we are to determine the phenotypic plasticity available to mammals to cope with the thermal stress, aridity, food shortage and emerging pathogens consequent on climate change and anthropogenic land transformation. Long-term biologging provides a sophisticated tool for obtaining a mechanistic understanding of species' responses to environmental variability.

P3.05 High energy costs of surface foraging but energy conservation during vertical excursions in dolphinfish

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Comparing energy utilization among different movement style is the first step to understanding animal energy budget strategies, which is highly relevant in ecological impact in term of predatory pressure and ecosystem energy flow. Using simple biomechanical model, we compare the kinematic energy use for free-ranging negative buoyant fish during continuous tailbeat and tailbeat-and-gliding. Time-series data for depth, temperatures, swimming speed and tailbeat frequency were obtained from eight dolphinfish for 3.5 to 47.5 h in the East China Sea. Although the dolphinfish spent most of their time at the surface with continuous tailbeat, but they make frequent dives adapting the tailbeat-and-gliding. We found that the kinematic energy consumption rate (per second) during dive phase with tailbeat-and-gliding was lower than continuous tailbeat at the surface. This result is consistent with the hypothesis that an epipelagic predator utilizes tailbeat-and-gliding as a cost-efficient strategy. In contrast, burst events associated with feeding occurred at the surface, but during the dive phase, burst events was rare. Therefore, we hypothesize that dolphinfish while hunting at the surface utilizes more energy compared with the tailbeat-and-gliding strategy during the dive phase.

P3.06 Fine scale interactions between southern elephant seals and their prey assessed by acceleration data loggers

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Southern elephant seals (*Mirounga leonina)* range widely throughout the Southern Ocean and are associated with important habitats (e.g., ice edges, shelf) where they accumulate energy (prey) to fuel their reproductive efforts on land. Knowledge of their fine scale foraging behaviour, however, is limited. For the first time, acceleration loggers were deployed on the heads of three adult seals during a translocation study at Kerguelen Island. The loggers recorded depth every second and were carried for periods between 23 and 121 hr. Head movements were used to infer feeding events and then compared to foraging dives obtained from dive profiles (U-shaped dives). Acceleration data detected feeding events in 39 % to 54 % of dives whilst 67 % to 82 % of dives were classified as foraging dives when using dive profiles. This means that seals did not encounter prey in 20 % to 40 % of their foraging dives. Feeding occurred in bouts suggesting patchily distributed prey. These seals were also diving deeper when feeding and some acceleration profiles show continuous movements of the head between 500 and 800 metres suggesting the chase of a prey. Thus, studying acceleration profiles offers a better understanding of where and when a seal is feeding successfully. Overall our findings indicate that this new technique is promising as it more accurately detects feeding events and thus provides a better understanding of seal's foraging strategies. Such information is needed to better manage and sustain Southern Ocean resources.

P3.07 Satellite telemetry and tag recovery: potential use and limitations

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ARGOS telemetry has been widely used to monitor movements and behaviour from free-ranging, undisturbed top marine predators remotely. This technology, however, comes with certain restrictions, such as limited spatial accuracy and low resolution of diving parameters. Recent development of new biologging devices such as accelerometer tags (AT) provide more detailed information on the diving behaviour of marine predators such as body acceleration in up to three dimensions (i.e. surge, stroke and rolling). The major drawback is that these tags need to be recovered. In November 2009, ARGOS satellite tags (AST-SMRU, St Andrews) and 2-D AT (Little Leonardo, Japan) were deployed on two post-breeding female southern elephant seals on Elephant Island (EI - 61°13'S 55°23'W). Our aim was to obtain detailed information on their foraging behaviour whilst at sea during the post-breeding phase by combining environmental data (AST) and fine-scale animal movement information (2D-AT). Positions of the actual deployment sites were obtained via hand GPS compared to AST positions to help on future tag recovery. The AST positions were consistently "off" by up to 700m when compared to the original GPS deployment locations. The two females came back ashore in January 2010: one at Snow Island (SI - 62°50'S 61°24'W) and at EI when the tags moulted off. In February 2010, we were able to attempt to recover the tags in two "*in situ"* expeditions using the last AST positions receceived from each tag as guidelines. After searching for the tags for over one day on Snow Island and ten days on Elephant Island, however, none were recovered. In September 2010, both tags were still consistently transmitting the same locations for both SI and EI. Here we propose possible explanations for our results, and provide advice and recommendations for the success of future tag recovery.

O5.14 Oceanic seamounts: a new humpback whale (*Megaptera novaeangliae*) habitat discovered using satellite tagging

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Argos satellite-monitored tags were used to study local movements and migratory routes of the small endangered population of humpback whales in New Caledonia. Tags were deployed in 2007 (n = 12) and 2010 (n = 20) in the southern lagoon, an area thought to be the main breeding ground of this isolated population; the lagoon has been the site of dedicated surveys since 1996. Surprisingly, satellite tracks revealed numerous movements between the southern lagoon and two oceanic seamounts located to the south. These appear to be commonly used during the breeding season, suggesting that these habitats are of considerable importance for at least this population. The role of these seamounts as breeding ground was confirmed by boat surveys, which showed mating-related behaviours as well as a much higher density of whales than is observed in the southern lagoon. Satellite tracks revealed that whales take different paths when leaving New Caledonia: most of them immediately initiate southern migrations, while a few appear to be going to other un-identified breeding grounds as suggested by their northern and western movements. Several of these long-range movements included visits to other seamounts at various latitudes. The duration of the whales' stay at these geographic features suggest that they could be used according to their latitudes, as breeding grounds, navigational landmarks, resting places or even sites for supplemental feeding. In conclusion, satellite tagging revealed that seamounts represent an important and previously overlooked habitat that are used both as breeding grounds and during the southern migration. Thus, they are potentially very important and should be considered in the assessment and conservation status of other humpback whale populations worldwide.

P3.08 Probabilistic or deterministic foraging? Fine scale movement patterns of whale sharks (*Rhincodon typus)* at Ningaloo Reef, Western Australia ascertained via dead-reckoning.

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Movement patterns of individual animals are central to our understanding of how populations are likely to respond to features and changes in the environment and highly resolved data on such may provide insight into the mechanisms behind patterns of space use. Multi-sensor data-loggers now allow a range of behavioural, environmental and spatial parameters to be recorded, providing a more holistic view of the movements of tagged animals. Here, we present animal tracks reconstructed via solid-state magnetometers and accelerometers, i.e. dead-reckoning, in order to analyse fine-scale patterns of movement in whale sharks. We attached data-loggers to 8 individuals at Ningaloo Reef and recorded over 230 hours of data with sub-second resolution. Over periods of 24-48 hours whale sharks use patches at 2 distinct spatial scales which are hierarchically organised. This nested Area Restricted Searching is interspersed with long straight movement segments. The movement patterns are further contextualised with behavioural data from accelerometers. We will discuss foraging behaviour at fine spatial scales and examine the degree to which whale sharks move through their environment at random or use specific cues to help locate patches of productivity.

O5.08 When is El Niño too hot to handle? Evidence of a tolerance threshold for a marine top predator.

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The El Niño Southern Oscillation (ENSO) has the potential to impact many species of marine top predators, including northern elephant seals (*Mirounga angustirostris*), by altering prey distributions and oceanographic foraging cues. Female northern elephant seals exhibit two distinct foraging strategies during their biannual migrations: a westerly, pelagic foraging route focused on the North Pacific transition zone, and a northerly, coastal route through the California Current into the coastal Alaska downwelling region. Individual variation in foraging strategy could potentially buffer the population against climate changes, such as ENSO events. The aim of this study was to determine whether El Niño has a differential effect on the foraging success of coastal foragers as compared to pelagic foragers. During the 2009-10 El Niño, we satellite-tagged previously-tracked study animals with either coastal (n =8) or pelagic (n=9) foraging routes for the post-breeding spring migration. El Niño had no detectable impact on trip duration or the rate of mass gain, either between pelagic and coastal females or when pooled together (paired t-tests, p>0.05). During the severe 1997-98 El Niño (peak multivariate ENSO index (MEI) = 2.887), a previous study on this population by Crocker et. al. (MEPS 2006) found that trip duration increased while rate of mass gain decreased. However, our data suggests that the 2009-10 El Niño (peak MEI = 1.502) did not negatively impact female northern elephant seals. Further analysis may determine if the animals compensated for difficult El Niño conditions by modifying their foraging behavior or altering their diet. Given the difference in the strength of these El Niños, however, there may be a threshold severity, beyond which northern elephant seals can no longer compensate for changing conditions.

P1.04 Overwinter movements and habitat preferences of an Antarctic predator

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Weddell seals are important top predators in the Southern Ocean, yet very little data exist on their overwinter diving and foraging behavior when darkness and heavy ice cover prevail. To gain insight on both Weddell seal ecology and the oceanography of the Ross Sea during the winter, we outfitted 22 animals around Ross Island and up the Victorialand coast with Conductivity Temperature Depth - Satellite Relayed Data Logger (CTD-SRDL) tags. To date, over 80,000 dives and 5,000 CTD casts have been recorded. On average, Weddell seals dived to 132 m with a max dive depth of 868. While many seals spent a substantial amount of time in the area where they were tagged, several animals traveled over 1000 km from the tag deployment location: twice as far as shown in previous studies. Areas near Roosevelt and Coulman Islands appear to be important for Weddell seals as indicated by the increased diving per square kilometer. In fact, diving density, transit rate, and time spent in a given area reveal identical 'hotspots', possible foraging locations. While there appears to be some individual variation, Weddell seals prefer low slope (flat benthos) and water depths between 350 and 550 meters. Using the seal-generated temperature and conductivity casts, we also report the oceanographic conditions in these areas to gain a better understanding of Weddell seal habitat preferences and behavior in relation to oceanographic features. Obtaining information on how Weddell seals respond to their environment is necessary to predict how seal populations in highly dynamic systems are likely to respond to shifting environmental conditions associated with global climate change.

P3.09 Dynamics of blue and fin whale maneuverability: three-dimensional kinematic analyses for assessing the effects of sound on behavior

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The dynamics of underwater maneuverability are poorly understood for aquatic vertebrates, particularly for animals swimming in their natural environment. A maneuver is defined as a change in any of the following three parameters: direction, position, and orientation. These components are characterized by six degrees of freedom with respect to three orthogonal body axes, which consist of three rotational (roll, pitch, yaw) and three translational (surge, slip, heave) maneuvers. In order to examine the maneuverability of large rorqual whales, we attached high-resolution digital tags equipped with a (1) hydrophone, (2) pressure transducer, and (3) tri-axis accelerometer and magnetometer to blue whales (Balaenoptera musculus) and fin whales (Balaenoptera physalus). From these data, we quantitatively describe three-dimensional body kinematics for whales engaged in a variety of maneuvers (diving, feeding, and transit), and analyzed the extent to which rotations about the three orthogonal body axes were coupled with the estimated forward speed of the body. These data represent a first approximation for quantifying the large repertoire of maneuvering behaviors exhibited by rorqual whales, and also characterize maximum performance during extreme maneuvers (i.e. lunge feeding). Furthermore, our analysis generates a framework for understanding the fine-scale changes in locomotor behavior associated with anthropogenic sound such as simulated military sonar.

O2.06 Correcting bycatch rates for encounter probability: using satellite telemetry data to model the distribution of foraging effort of a population of Australian sea lions to estimate and mitigate bycatch in a demersal gillnet fishery

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Assessing the impacts of fishery bycatch on populations of threatened and protected species is challenging but of critical importance. Fishery observer data are typically used to assess rates of bycatch per unit of fishing effort, and then extrapolated across the fishery. However, bycatch rates provide an imprecise estimate of bycatch number as observer programs generally monitor a fraction of total fishing effort, are difficult to replicate and the underlying encounter probabilities (which determine bycatch rates) are generally highly heterogeneous and unknown for marine species. Australian sea lions (*Neophoca cinerea*) (ASL) are a threatened species endemic to southern Australia, and subject to incidental mortality (bycatch) in demersal gillnet shark fisheries. Bycatch has been identified as the key threatening factor for the species, and recently fishery closures have been introduced to mitigate bycatch impacts. To assess the risks to ASL subpopulations from bycatch mortality, data from four main sources were integrated and modelled: i) satellite tracking data to estimate distribution of foraging effort ; ii) survey data on ASL subpopulation size; iii) data from a dedicated ASL bycatch observer program and iv) detailed spatial data on the distribution of fishing effort. Satellite telemetry data from 210 individual ASL (157 adult females, 31 adult males, 22 juveniles), from 17 subpopulations, in conjunction with depth and distance from colony data, were used to develop statistical models of the distribution of foraging effort across the population of ASL. ASL mortality rates based on observer data were highly correlated with foraging density, enabling levels of bycatch mortality that would result from different distributions and levels of fishing effort to be estimated with confidence limits. We use this approach to estimate the impacts the current fishery is having on ASL populations, and evaluate the reduction in bycatch mortality that has resulted from recently introduced fishery closures.

P5.11 Earth magnetic field augmented position estimation for marine animal tags.

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Position estimation based on Earth's natural signals offers a means to obtain animal migration data even when out of the range of man-made signals such as satellites. A common practice in many tags is reliance on light measurements only, using the estimated noon time to obtain longitude and length of day for latitude. The limitation is that the length of day changes little with latitude around the times of the equinoxes. Further, the moments of sunrise and sunset (sun crossing the horizon) are hard to determine with precision in the context of changing cloud cover, water turbidity, or at high latitudes. This can manifest itself as large apparent north-south excursions in the animal track. The measurement of properties of the earth's magnetic field to augment light readings as a means to improve latitude estimates has first been proposed by Klimley and Mangan in 1994. The approach is now implemented in SeaTag-GEO, an archival tag introduced by Desert Star Systems LLC in 2010 that relies on measurements of the total intensity of the magnetic field. The method of light-magnetic position estimation implemented in the device is reviewed. Results from drifter and animal tagging projects are presented to support the discussion of position accuracy and availability, and its dependence on factors including geographic location, anomalies and environmental conditions. These projects include tagging of loggerheads in Florida, high latitude testing in Alaska, and tagging of sharks in the Galapagos. The paper concludes by explaining practical tagging issues and questions related to magnetic field sensing tags, including the magnetic influence of related tagging hardware and the opportunity for obtaining limited position estimates based on magnetic data only, such as in the absence of light in deep or turbid waters.

P3.10 The not-so-secret lives of mammal-eating killer whales: Dorsal fin-mounted satellite tags reveal some of their favorite haunts in the eastern North Pacific

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Three ecotypes of killer whales occur in the temperate coastal Eastern North Pacific Ocean. The stealthy mammal-eating type has been implicated to play a major role in shaping community structure in Alaska. The extent to which mammal-eating killer whales (n ~350) might play a role in the southern Gulf of Alaska and California Current Ecosystems is unknown. To date, their known ranges and prey preferences have only been assessed by biased photo ID efforts in protected or nearshore waters. Satellite-linked tags were used to assess the range and patterns of movements of mammal-eating killer whales. Tags were deployed on individuals in 12 unique social groups of transients in inland waters of Washington and southern British Columbia and three whales in coastal waters of Washington. Median duration of signal contact was 27 days (range 7-94 days). This relatively small number of whales made widespread use of inland and coastal waters. Most whales (12) generally ranged north of the tagging site, with 3 moving as far as southern Southeast Alaska, while the other three only ranged south into northern California, with one traveling to Monterey Bay. In all cases their seaward distribution was limited to the shelf break with a few whales exhibiting extensive use of this area. Other areas identified to have relatively high use by one or more whales included nearshore northern California/southern Oregon, canyon heads in Oregon and Washington, nearshore and shelf slope of central Vancouver Island, central eastern Vancouver Island, central Queen Charlotte Sound, and eastern Hecate Strait. Use of some of these areas was known from photo ID studies, but the more remote areas were not previously known to be important. Given this population of whales forages on marine mammals, and prey assemblages differ between these areas, a variety of marine mammal species are likely consumed throughout this range.

O1.17 The Australian Animal Tagging and Monitoring System (AATAMS)

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The Australian Animal Tagging and Monitoring System is a facility within Australia's Integrated Marine Observing System. AATAMS aims to enhance the Australian research community's ability to detect ecosystem responses to change in the marine environment by measuring key demographic parameters and foraging movements of select top predators in the Southern Ocean and along Australia's southern shores. Biologgers with high resolution sensors are deployed on large marine vertebrates to enhance collection of oceanographic data in the Southern Ocean and in Australian boundary currents, providing profiles of temperature and salinity from regions that are difficult to sample by other means (eg beneath winter sea ice and across cross shelf currents), and relating predator movements and behaviour to fine-scale ocean structure and variability. AATAMS contributes to the *National Backbone for Observing Boundary Currents* with deployment of CTD-SRDLS on predators in southern Australia, providing cross-shelf transects of vertical CTD profiles with high resolution and broad temporal and spatial coverage. AATAMS observes marine animals across a range or spatial and temporal scales in both vertical and horizontal space. Observation of predator movements, foraging ecology and vital rate responses integrate variability in the lower trophic levels and natural and anthropogenic physical environmental changes within the whole-system approach. Biologging of marine predators provides a means to sample the marine environment at unsurpassed resolution and spatial scales, at a fraction of the cost of other platforms. Ecological performance indicators of marine predators provide cost-efficient ways to monitor whole-of-system responses to oceanographic change. All data are freely available on the IMOS portal through the eMarine Information Infrastructure (eMII: http://imos.aodn.org.au/webportal/). Collaborative research efforts with partner institutions and their contribution of independently collected data to the total data pool suggest that co-investment in AATAMS is a highly attractive and cost effective approach for sustainable observation of biological and environmental marine systems.

O2.04 Predicting tuna habitat for spatial fisheries management using electronic tags and ocean models.

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Southern bluefin tuna (SBT) are a quota-managed species in the eastern Australian longline fishery, and there is a management need to reduce non-quota capture of this species. We developed a near-real time habitat prediction model for SBT which has been used since 2003 to support the spatial management of this species throughout the fishery. The predicted distribution of SBT habitat on the east coast of Australia is based on analyses of current satellite sea surface temperatures (SST), sub-surface temperatures from a CSIRO ocean model and pop-up archival tag temperature data for SBT. The model output divides the spatial extent of the fishery into three zones based on the expected distribution of SBT. These predictions are provided to managers of the fishery on a fortnightly basis, and a set of management lines that regulate spatial access to the fishery by longline fishers (based on quota holdings) are updated and distributed. We have also recently incorporated a seasonal forecast model (POAMA) into our habitat model, allowing us to generate predictions of SBT habitat out to 4 months. We compare the skill of this model with real time predictions made during previous fishing seasons. This seasonal forecasting offers both managers and fishers the potential to plan for restrictions, and strategically modify their fishing activities. Finally, we use future ocean predictions from the CSIRO Bluelink ocean model for the period 2062-2064 to consider the change in distribution compared to the present to explore the potential impact on fishers and managers of the future.

P4.07 Do artificial fins improve swimming ability of a forelimb-lost sea turtle?

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A project that purposes to recover swimming ability of an injured loggerhead turtle by attaching artificial fins was established by Sea Turtle Association of Japan. The injured individual (named 'Yu') that had lost both of its forelimbs was found in Kii Channel, Japan, in June 2008. Behavioral data, such as swim speed, depth, stroke frequency, and ambient temperature, was taken with animal-borne recorder to monitor changes in swimming ability of 'Yu' and similar-sized control turtle, in artificial lagoon located at Kobe airport from May to December 2009. The artificial fins were developed by Kawamura Gishi Co., Ltd. A total of 14 deployments was conducted, and the swimming ability was measured in relation with swim speed and stroke cycle frequency. Swimming ability was compared between the control and 'Yu' with and without the artificial fins. Without the artificial fins, average swim speed of 'Yu' was only 65% of the control turtle probably due to decreased thrust that could be produced by small asymmetrical forelimbs of 'Yu'. With the artificial fins, swimming ability seemed not to be improved at the beginning of the experiment, but after applying the artificial fins consecutively for 33 days, 'Yu' was able to swim fast as close to the control turtle at high stroke frequency. However, swim speed obtained at low stroke frequency was not as high as the control turtle. 'Yu' might have been adapted with artificial fins and learned to swim more efficiently after long-term application of the fins.

P5.12 The effect of a changing climate on Pacific top predators

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As top predators in marine systems are globally in decline due to overfishing and other anthropogenic threats, it is import to assess which species are at greatest risk and which habitats are most important for conservation. Climate change scenarios have predicted an average rise from 1-6° C by 2100 which could effect the habitat and distribution of many marine species. The tagging of Pacific predators (TOPP) project has tagged 4300 animals resulting in 268,000 data-days. We used spatially explicit habitat models (e.g. generalized additive mixed models) to examine present-day distributions and foraging habitat of 23 top predator species in the Pacific from 2001-2009 as a function of fixed bathymetric variables, sea surface temperature, wind, Ekman pumping, mixed-layer depth, and chlorophyll-a. Consequently we used high-resolution climate models from the Geophysical Fluid Dynamics Laboratory to predict potential habitat under future scenarios. We found changes in biodiversity and the potential for habitat compression throughout the Pacific highlighting a few important conservation corridors. While many top predators exhibit plasticity in behavior particularly with respect to temperature, the pelagic prey (e.g. deep scattering layers, schooling fish, krill) they feed upon are likely more sensitive to ocean changes and more closely linked to primary production. Increased frequency of El Niño / La Niña events and changes in timing and intensity of upwelling could further affect biodiversity and potential habitat in the north Pacific, particularly the critical habitat within the California current.

P1.05 Ecology of Weddell seals during winter: influence of ocean and sea-ice parameters on their foraging behaviour.

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Studying the foraging strategies of marine top predators can provide information on both how animals interact with their environment and the movement patterns of their prey. We studied for the first time in Terre Adélie the influence of environmental abiotic parameters (bathymetry, hydrology, sea ice, light intensity), on the winter foraging strategy of Weddell seals (*Leptonychotes weddellii*). A total of 8 seals were fitted with conductivity temperature depth satellite relayed data logger in Dumont d'Urville (~67°S, 140°E) during the austral winters 2007 and 2008. The tags transmitted positions and dive information over 165 ± 86 days. A total of 33000 dive profiles and 2424 CTD profiles were collected. The relationships between behavioural and environmental parameters were studied using Linear Mixed Effects models. Significant environmental influences on seal diving behaviour and habitat use were detected. The foraging success (measured by dive bottom time residuals) was higher in relatively shallow waters with a high bathymetry gradient and within sea ice of low to medium concentration. Weddell seals tended to favour Modified Circumpolar Deep Water. Our results are consistent with seals feeding primarily on *Pleuragramma antarctica* during winter and tracking the vertical diel migrations of these prey.

O1.08 Foraging habitats of top predators, and areas of ecological significance on the Kerguelen Plateau.

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Avian and mammalian predators play a key role in the ecosystem of the Kerguelen Plateau, both with respect to structuring the marine community and its response to anthropogenic influences such as climate change and commercial fisheries. A powerful way of identifying regions that are particularly important ecologically is to identify Areas of Ecological Significance (AES), regions that are utilized by multiple predator species. Such concentrations of foraging activity are indicative of enhanced primary and/or secondary productivity. These are regions that require particular management efforts, and which are of considerable importance in the development of ecological models and climate monitoring systems. This study integrates tracking and diving data from a suite of predator species collected as part of both the French and Australian Antarctic programs. Data were used from Macaroni and King Penguins, Southern Elephant seals, Antarctic fur seals and Black-browed albatross from Isles Kerguelen and Heard Island. The estimated path of each animal was derived using State-Space Models, which also allocated each location to either "transit" or "search" behavioural modes. For diving species, dive depth data were temporally allocated along the path, providing information on 3 dimensional habitat use. AES for each species, and for the combined suite of predators were identified using Kernel Density analysis. The role of bathymetry, ocean circulation and other environmental factors underlying the AESs were established using deterministic models, which can be used to predict predator foraging habitats across the entire plateau.

O5.12 Summer residence at local feeding grounds in south-west Western Australia for age-1 southern bluefin tuna

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Estimating the abundance, or even generating an abundance index, of a population or species requires that the fraction of the population that is surveyed is known. Juvenile (age-1 and 2) southern bluefin tuna (SBT, *Thunnus maccoyii*) are found along the west and south coast of Western Australia, and are presumed to move from west to east during the austral summer. Thus, an acoustic survey was developed to estimate the juvenile SBT population moving along the south coast. Using acoustic tags and listening stations we show that during the austral summer, juvenile SBT remain local, presumably in areas where forage is available. Fish tagged on the west coast in December and January over the last three years were only rarely detected on the south coast (3 of 155). Thus, by mid-summer, local residency appears prevalent. However, movements to the south coast must occur earlier in the season in order for fish to appear on the south coast – a hypothesis we are testing in the present year. This seasonal variation in fish movements has significant implications on estimating an abundance index, particularly if influenced by interannual environmental variation.

P4.08 Enhancing Argos-derived locations accuracy through the use of state-space models

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Estimating accurate locations of tracked animals is paramount to determine their home ranges and ultimately implementing effective spatial and threat-based management. Fastloc-GPS technology provides good spatial accuracy but is expensive while the older ARGOS technology is cheaper but less accurate. The most widely used technique to overcome this limited accuracy is to fit a state-space model (SSM) to ARGOS-derived locations. State-space models fit Correlated Random Walk (CRW) models to animal movement data to produce predicted locations. However, few studies have verified predicted locations of SSMs against highly accurate estimates from Fastloc-GPS data. For this study, we deployed seven Satellite Relay Data Loggers (SRDLs) on adult female hawksbill turtles (*Eretmochelys imbricata*) nesting in Groote Eylandt (Northern Australia) and we fit a two state-switching CRW model to our ARGOS data. We compared the accuracy of locations obtained from the filtered ARGOS data and those obtained from a SSM against the Fastloc-GPS data. Distances and bearings were compared during the migration period while home range sizes (50% Kernel Density Estimation) were compared within internesting and foraging habitats. The 68^{th} percentile ARGOS location errors were similar to those published in previous studies of marine animals LC-3 0.34 km, LC-2 0.39 km, LC-1 0.60 km, LC-0 2.62 km, LC-A 5.08 km, LC-B 6.73 km. Locations estimates obtained from the SSM were more accurate than those obtained by filtering ARGOS locations (1.72±1.56 km, 5.80±9.36 km respectively). Home ranges obtained through the SSM were 1.15 to 13.98 larger than those calculated using GPS locations with good spatial overlapping of areas mostly used by turtles whereas ARGOS-derived locations resulted in more diffuse habitat use areas. We therefore recommend the use of SSMs to enhance accuracy of ARGOS data sets and consequently provide more precise information to policy makers for the protection of wildlife

O2.10 Double tagging allows for enhanced interpretive power of fish behavior and improvements in light-based geolocation modeling.

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The volume of ocean within 10 K of a floating object can legitimately be described as a specific habitat type that is actively selected by several tuna species. The attractiveness of this habitat is so strong that it has been suggested that deployment of large numbers of artificial floating objects (FADs) could constitute an 'ecological trap' that could negatively impact stock viability. Not only is association with FADs a phenomenon of intrinsic interest in understanding fish behavior but, because FADs have become dominant in world fisheries, understanding this phenomenon has direct implications for improved resource management. Here we use newly developed visualization and analysis software to present a novel data set obtained from 8 yellowfin tuna caught at FADs and double tagged with acoustic pingers and archival tags that recorded depth, temperature and light level data. Using two tag types yielded insights significantly beyond what could have been obtained with only one tag type. These fish displayed multiple periods of FAD residency (determined by acoustic pingers) interspersed with absences ranging from a few days to several weeks. Distances traveled during these absences were calculated using light based geolocation and depth distributions during residence and absence were obtained from time series data from the recovered archival tags. Characteristic shifts in depth habitat are evident. In future, these differences could be used to quantify the amount of time that tagged yellowfin associate with FADs with concomitant increased vulnerability to capture. Not only do these data shed light on the influence of FADs on the horizontal and vertical aspects of yellowfin habitat selection (thereby addressing the 'ecological trap' hypothesis), but the ability to 'anchor' horizontal movements models with periodic known positions allowed for improved parameterization of light based geolocation techniques that can now be applied to other data.

KEYNOTE From individuals to populations - movements, foraging, fitness and the comparative method

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Biologging data is recorded at the scale of behavioural observations, and yet most management-level decisions require information at the scale of the population. Studies must therefore capture enough variability to accurately describe the population and/or collect ancillary data to provide explanatory models of the variability observed. I discuss the study of animal movements – ranging from manipulative experiments of forest-dwelling rats, to the description of beaked whale and fur seal diving behaviour. Movements can be related to population consequences via life function (foraging success) and vital rates (individual success). Several biologging methods can identify different aspects of foraging, and I have used animal-attached cameras to provide visual-field (prey availability) measurements. These allow the classification of foraging signatures within fur seal diving behaviour, and can then be applied to much larger (potentially historical) TDR datasets. Identification of foraging locations and assessment of the stability of these over time and space is a key component for the identification and designation of pelagic marine protected areas. The relationship between foraging success and individual fitness is less studied but this level of detail is also becoming more important for accurate demographic assessment in conservation planning. Lastly, I suggest that beyond the population level, a comparative understanding of species differences will be key to developing a better understanding of physiological processes underlying diving behaviour.

P3.11 A new tool for the determination of survival, causes of mortality and parturition in individual marine homeotherms: the Life History Transmitter.

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We are developing the second generation implantable, satellite-linked Life History Transmitter. LHX tags are intraperitoneally implanted and record sensor data throughout the life of the homeotherm host. Following post-mortem extrusion, the positively buoyant tags uplink via Argos aboard NOAA satellites to provide data on time and date of mortality. Through controls and deployments on 27 Steller sea lions (*Eumetopias jubatus*) leading to data returns from nine animals we demonstrated that (1) post-mortem data recovery is viable from implanted, archival satellite-linked transmitters, (2) data recovery probability from dual-tagged individuals is 0.98, (3) implant surgeries are well tolerated and do not alter post-release foraging behavior, (4) post-release survival of implanted animals up to 3 years is not affected by tags or procedures, (5) ante- to post-mortem temperature data and time to onset of transmissions allows the classification of events into traumatic deaths from predation, versus non-traumatic events from any number of causes (i.e. disease, starvation), (6) tags provide spatially explicit data on individual mortality with a temporal resolution of 1 day and a spatial resolution for predation events of approximately 10km, (7) LHX tags provide end-of-life locations suitable to determine large-scale emigration patterns, (8) post-mortem cooling rate data can be used to estimate end of life body mass for non-acute events. These results have provided the first direct, quantitative measure of predation on an upper trophic level marine mesopredator, the endangered Steller sea lion. 2nd generation LHX tags will be suitable for host masses of at least 20 kg, and will incorporate on-board algorithms for detection of parturition. This will yield post-mortem data on age at primiparity and lifetime reproductive success in individual female homeotherms. The combination of data on survival, predation and parturition from individual animals will allow inferences on factors influencing forcing in homeotherm populations.

O1.02 Habitat preferences of crabeater seals in a rapidly changing system, the western Antarctica Peninsula

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The western Antarctica Peninsula (wAP) is considered one of the most biologically productive areas of the Southern Ocean, where the Antarctic krill dominates mid-trophic levels of ecosystem, and is thought to shape the dynamics of the entire system. The wAP is one of the fastest warming regions in the world and, unlike most of the Antarctic continent, it is also experiencing a shortening of winter, with anticipated effects on the entire wAP marine ecosystem. The crabeater seal (*Lobodon carcinophaga*) is considered a specialist predator, preying principally on Antarctic krill, although some fish can be included in the diet as well. Among the responses that crabeater seals might exhibit to this fast warming are changes in their foraging behavior, patterns of movement and at-sea distribution. We utilize data on habitat utilization and diving behavior in order to determine the relationship between specific foraging behavior and oceanographic features. We deployed Satellite Relay Data Loggers-CTD (SRDL-CTD) on 10 crabeater seals in 2007, which allowed us to examine the movement and diving behavior of the seals, as well as measure oceanographic properties of the water column. We created simulated tracks (correlated random walks), to compare areas utilized areas versus areas that were not utilized by the seals. GLMMs were used to create habitat models based on diving behavior (residual First Bottom Time, rFBT) and the combination of animal derived oceanographic data complemented with data from a 3D Regional Oceans Modeling System (ROMS) model. The best habitat models, as identified from AIC values, considered water column structure and surface oceanographic variables (e.g. current velocity, warm water intrusions, and mixed layer depth). Our results showed that the foraging habitats utilized by crabeater seals in the wAP corresponded to coastal environments with a southward flow at depth, away from warm water intrusions, and slightly positive SST.

O2.08 A crab's eye view: electronic data storage tags reveal migration and behaviour patterns of the edible crab, *Cancer pagurus* L.

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Despite the growing commercial value of temperate water crab fisheries, important gaps in our understanding of the biology and ecology of exploited species remain. Until recently, bio-logging devices have not been applied routinely to crustaceans on a large scale because historically the unit cost of archival tags has been relatively high coupled with the perceived problems of tag loss due to moulting. However, tag costs have reduced considerably in recent years and by targeting larger animals (which moult less frequently) early in their inter-moult period, the potential to retrieve large quantities of high quality behaviour data now potentially outweigh the risks associated with tag loss. Here we describe the results from a successful large-scale application of electronic data storage tags (DSTs) to the edible crab *Cancer pagurus* L., one of the most important commercial fisheries in the U.K. We released 145 DST-tagged crabs (129 female, 16 male, carapace width 138 – 288 mm), at 5 sites in the English Channel and Celtic Sea between August 2008 and March 2010. With data records ranging from 8 to 575 days, 41 DSTs (28%) have been returned to date. Movement patterns reconstructed using the "tidal location method" revealed varying levels of migration following an east to west axis, with little evidence of west-east migration in any location or at any time of year. The data provide insights into habitat occupancy, and activity patterns related to diurnal, tidal and reproductive cycles, notably a 6-7 month sedentary period from late November onwards, associated with egg-brooding. The results are discussed in relation to marine spatial planning, and will contribute biological parameters to population dynamics models addressing management of crabs on a wider scale.

P2.01 Assessing the impacts of berleying from shark cage-diving operators on the swimming behaviour of the white shark (*Carcharodon carcharias*).

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The white shark (*Carcharodon carcharias*) is a distinctive species which occurs world-wide in coastal temperate and subtropical regions. The combination of slow life history characteristics and world-wide concerns regarding their population status has prompted their protection across a number of jurisdictions. Research on the movement patterns of white sharks has identified that there are specific sites such as pinniped colonies which may represent important habitat for the white sharks. Some of these pinniped colonies that have significant white shark activity are also targeted by ecotourism operators such as in Australia, South Africa, Mexico and California, where lucrative and expanding industries have developed around cage-diving activities. These sites are also areas where white sharks are most vulnerable to interactions and interferences from human activities. During cage-diving activities, operators commonly use berley (mixture of minced fish and blood) to attract sharks close to the boat for viewing. The impact of berleying activity on the behaviour of white sharks is unknown and requires further investigation to ensure that appropriate management arrangements are established to minimise the impacts of the cage-diving industries worldwide. A Vemco Radio-Acoustic Positioning (VRAP) system was deployed off North Neptune Island, South Australia to investigate the movements of white sharks during berleying activities. The VRAP system enables fine-scale modeling of the swimming behaviour of the tagged sharks through continuous recording of positions and depths within 1 m accuracy. Ten white sharks were externally tagged with continuous V16P between November 2009 and December 2010. Whereas some individuals did not remain within the study site and left a short time following tagging, others showed some level of residency and evidence of time partitioning between two berleying vessels. Results from the project will provide data that will help managers to ensure a sustainable cage-diving industry minimising the impacts of the industry on white shark populations.

O5.04 How well do 50% core areas encompass state space derived ARS regions from blue whale satellite tracks?

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Many analytical tools of varying complexity have been developed to identify important habitat from satellite tracks of animals. Creating home ranges from individual tracks is a common practice and the associated 50% ‘core’ area is assumed to identify the most important habitat for the animal. State space models allow the user a much more precise measure of important areas by identifying specific points in a track which exhibit Area Restricted Search (ARS). We used a state space switching model to regularize blue whale satellite tracks collected in six different years to test how much of the area described by the ARS locations was contained in the 50% core area. Preliminary results indicate that the core areas were typically larger than the ARS areas, however an average of 55% of the ARS area was not included in the core area. While the core areas were typically defined by one or two relatively large areas, the ARS areas were typically smaller, but usually composed of three or more separate patches. The core areas typically overlapped with the largest of the ARS patches or multiple patches that were close together, however there were often two or more ARS patches, which were not contained in the core area. As that the core area is a more coarse way of identifying important areas from tracking data, it is surprising there is not more overlap with ARS patches. State space models are labor intensive, however they yield precise estimates of the areas, which are important to the animal being tracked. The ease of producing core areas based on home ranges is appealing, and it would be easy to assume that all important areas would be covered using the coarser measurement, but it appears that this is often not the case.

P1.06 Prey capture and three-dimensional dive path in free-ranging female Antarctic fur seals.

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Determination of when, where and how marine top predators feed and how much they consume is important for understanding their foraging strategies. Previous studies have used various methods (e.g. stomach temperature measurement) to determine when prey capture events occur in marine predators. However, the limited applicability and time resolution of these methods has hindered further understanding of fine-scale foraging processes. The aims of this study therefore were: (1) to detect prey capture events using acceleration records obtained from underwater mouth opening events, (2) to examine the relationship between mouth opening and the three-dimensional dive paths of free-ranging Antarctic fur seals *Arctocephalus gazella,* using acceleration and/or geomagnetic data loggers. We studied 10 female Antarctic fur seals at Bird Island, South Georgia, in the austral summer of 2009, when they fed on a diet mainly comprising Antarctic krill, together with a small proportion of fish. We attached data loggers to the lower jaw of each animal for to detect mouth opening and to the dorsal fur to reconstruct the three-dimensional dive paths of the seals. Mouth openings were recorded as specific high frequency (3Hz) movements, determined from an accelerometer attached to the mandible. Mouth openings occurred 10 times per dive (>2m) on average (n = 10 seals) and occurred mostly (83%) in the bottom phase of the dives. Although it was impossible to determine whether mouth openings resulted in successful prey capture, we suggest that mouth openings could indicate relative feeding rate or at least attempted prey capture events. Three-dimensional dive paths were reconstructed for each dive. Combining the information on mouth opening with the three-dimensional dive paths, we show that Antarctic fur seals perform meandering movement during their dives where they encounter patches of prey.

P4.09 Going with the flow: Horizontal movements of the plankton-feeding manta ray *Manta alfredi* and links to dynamics and productivity of the East Australian Current.

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Movements and distributions of large and highly mobile marine megafauna are known to be commonly influenced by oceanographic processes. This is especially true of plankton-feeders, for which food resource availability and abundance directly relate to the dynamics of water masses within an area. In eastern Australia, the inshore manta ray *Manta alfredi* seasonally migrates along the eastern seaboard to aggregate at particular geographical locations. The drivers for such movements and their patterns remain uncertain. This study focuses at examining the links between the movements of *M. alfredi* along the east Australian seaboard and the spatio-temporal variability of the East Australian Current, with the hypothesis that the temporal physical dynamics along the coast dictate movements of animals. We monitored occurrences and movements of manta rays at various spatial and temporal resolutions using photographic-identification (photo-ID), acoustic and pop-up archival satellite telemetry methodologies. To date, 415 individuals were identified using photo-ID techniques, with 29 animals re-sighted several times at sites located 380 to 500 km away from original sighting location. In addition, we deployed 20x V16 acoustic tags and 10x Mk10-PAT satellite tags on some of these animals to examine their horizontal movements patterns at finer temporal resolutions. Our results strongly suggest seasonal movements of animals along the eastern Australian seaboard directly related to the dynamics and productivity of the East Australian Current, with a tendency to aggregate in regions of high seasonal upwelling frequency. It is suggested that animals minimize energy expenditures using the East Australian Current to travel southward and the inshore counter-current to move northward, and stop at areas of high biological productivity along the way to optimize energy intake.

P4.10 Depth limits calls produced by deep-diving short-finned pilot whales (*Globicephala macrorhynchus*).

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Toothed whales rely heavily on sound to echolocate prey and communicate with conspecifics and a variety of biologgers have proven essential in studying the behavior and ecology of these animals. The short-finned pilot whale (*Globicephala macrorhynchus*) is a highly social deep diving toothed whale. Individuals socialize at the surface but leave their social group in independent pursuit of prey at depths of up to 1000m. Little is known about how extreme pressure affects the capacity for pneumatic sound production in deep-diving species with a limited air supply, but the advent of acoustic recording tags has made it viable to investigate this in free-ranging animals diving to great depths. To study the physiological effects of increasing hydrostatic pressure on acoustic communication in these animals, suction cup tags logging sound, depth and orientation (DTAGs) were attached to pilot whales off the coast of Tenerife, Spain. Tonal calls produced by tagged individuals during deep dives were identified using acoustic and angle-of-arrival cues. Tagged whales produced tonal calls during deep foraging dives at depths of up to 800 meters. The pattern of call use suggests that these calls serve to maintain or re-establish acoustic contact with the surface group after deep dives. Call output and call duration decreased with depth despite the increased distance to conspecifics at the surface, indicating that the energy content of calls is restricted at depths where lungs are collapsed and the air volume available for sound generation consequently limited by ambient pressure. These weak calls at depth are inherently short-range and therefore susceptible to masking. The population of pilot whales in Tenerife is the subject of a substantial whale watch industry where vessels repeatedly approach whales for prolonged, short-range encounters, increasing background noise and potentially affecting the acoustic contact mechanisms between foragers and the social group at the surface.

O5.15 Eavesdropping on foraging: using passive echolocation to quantify deep-sea predator and prey interactions.

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Numerous aquatic predators from fish to marine mammals use a combination of forward thrust and buccal suction to capture prey. But many prey species also have sensory systems, coupled to fast-acting motor muscles, capable of detecting the fluid movements generated by striking predators. Despite the apparent universality of these aquatic foraging interactions, capture and evasion are difficult to observe in the wild and little is known about the ranges over which prey can detect and evade predators compared to the ranges over which predator strikes are effective. Echoes from prey insonified by echolocating beaked whales tagged with DTAG acoustic recording tags have provided the first detailed view of predator-prey interactions in the deep sea. As beaked whales approach prey for capture, they produce buzz sounds comprised of rapid sequences of echolocation clicks. Dorsally-located tags receive both the out-going click and echoes from objects in front of the whale which can then be ranged during buzzes with centimetre accuracy and update rates as high as 300 Hz. Here we use this echometric method to examine the movements of prey during 500 buzzes made by five Blainville's beaked whales, *Mesoplodon densirostris*, foraging at 500-1200m depth. We show that up to 40% of prey detect the approaching whale and attempt to escape leading to individual capture success rates as low as 75%. Strong transients in the acceleration rate or jerk of the tagged whale occur in almost all buzzes and coincide, in some buzzes, with sudden increases in closing speed. These jerk transients occur when prey are 0.5-2 m from the whale's rostrum and seem to indicate strikes. Prey escape attempts also coincide with the whale jerk transients suggesting that prey cue their escape bids to the sudden increases in fluid movement when whales strike. Strikes may offer an efficient indication to prey of impending predation but leave little time for escape. Escape speeds of up 4 ms^{-1} were measured suggesting length-specific speeds of more than 10 BLs^{-1} for the prey sizes typically ingested by this gape-limited predator. Although such detailed measurements can only be made on certain echolocating mammals, insights into the relative timing of strikes and evasion may be applicable to many aquatic predators and prey.

KEYNOTE Developing an analytical framework for the Ocean Tracking Network: What can we learn from encounters between animal-borne receivers and acoustic-tagged animals?

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The Ocean Tracking Network is an unprecedented global project that aims to provide a permanent platform to monitor the movements and interactions among numerous acoustically tagged marine species. Most of OTN activities currently focus on the deployment and use of fixed arrays of acoustic receivers that will record both the passage of acoustic tagged animals and oceanographic data on continental shelves around the world. However, a small pilot project based on the Scotian Shelf of Atlantic Canada that uses grey seals (*Halichoerus grypus*) as roving acoustic receivers (bioprobes) offers an intriguing alternative for collecting acoustic tracking data on other marine species. As grey seals undergo extensive foraging trips of several months and over much of the Scotian Shelf, they have the potential to encounter both resident and migratory acoustic tagged species, recording the time and location of these encounters. Records of encounters will be made at an individual animal level and at a much finer spatio-temporal resolution than fixed receiver arrays. These spatial encounter data are entirely novel and a focused effort is required to determine and develop appropriate statistical methodologies for their analysis. We describe initial steps in the development of an analytical framework for spatial encounter data, including spatial mark-recapture and spatial point pattern analyses, and detail the kinds of questions that may be addressed and the challenges that must be overcome.

O4.11 Identifying foraging habitat of lactating northern fur seals and the spatial overlap with commercial fisheries in the Eastern Bering Sea.

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The population of northern fur seals in the Pribilof Islands, Alaska has declined dramatically during the past two decades, and continues to decline without any obvious reason. Arresting the decline of the species requires an understanding of their foraging strategy, where successful foraging is dependent on finding sufficient prey in a dynamic oceanic environment. Physical and biological features undoubtedly influence northern fur seal movements, and have already been shown to vary with location and time, but identification of these influences and how that relates to changes in behaviour remains poorly understood. In this study, we propose a general methodology to relate the patterns in high resolution movement time series to northern fur seal behavior with the central goal being the estimate of movement parameters on an appropriate time scale to provide direct links to behavior. A state-space particle filter with state augmentation is used to estimate the movement parameters. We applied this methodology to data from eleven archival tags attached to lactating northern fur seals from a declining rookery in the Pribilof Islands. Our fitted movement parameters show distinct time-evolving changes in fur seal behavior, matching well what is observed in the original data set. The analysed behaviour states were then matched spatially and temporally to a set of environmental variables, and modeled using a generalised regression model for both linear and non-linear inference. We found female at-sea behaviour was strongly influenced by bathymetry, and time of day, and less strongly influenced by commercial groundfish catch. Our analyses suggest that active foraging states are highest during the early morning period, and transiting behaviour characterised the afternoon periods. When northern fur seals were in areas where large commercial groundfish catches were also reported, females shifted to higher probabilities of active foraging behaviour. Our analysis is the first analysis to link high resolution foraging behaviour of northern fur seals to commercial groundfish fisheries. It shows a potential for a improving our understanding of the potential overlap with fisheries and has implications for species conservation.

P5.13 Partial dynamic body acceleration as a proxy of prey encounter

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The capacity to identify when, how much and what type of prey free-ranging animals feed is essential in ecological studies as foraging activity accounts for a substantial part of the time/activity budgets of animals. In addition, the amount of energy a parent can ingest conditions to a large extent the amount of energy it can allocate to its offspring and thus contribute to its breeding success. Several methods to estimate the food ingestion of diving animals have been proposed in the past; e.g. measuring jaw movements, oesophagus or stomach temperature probes, underwater filming. However, those methods are rather invasive and/or not applicable to smaller species. The acceleration measurements can provide a good index to estimate energy expenditure of various animals, called Overall/Partial Dynamic Body Acceleration (ODBA/PDBA). We propose here a novel approach in which PDBA is used as a proxy of prey encounter in diving seabirds. To test the validity of this method, we simultaneously measured the beak movement and body acceleration of a king penguin and confirmed that beak opening events were observed concurrently to an increase in the PDBA in 93% of the cases. We then examine PDBA patterns during the diving activity of 4 species of free-ranging penguins (king, Adélie, African and little) to identify thresholds at which the PDBA can serve as a reliable proxy of prey encounter.

P3.12 Streaked shearwaters (*Calonectris leucomelas*) more relied on the strong wind in day-time than night-time.

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Previous studies on Procellariiform seabirds breeding on islands in the Southern Ocean showed that the birds rely on winds to reduce flight power. Strong wind blew in those areas through a whole year, whereas wind condition in the temperate regions is generally mild. The streaked shearwaters (*Calonectris leucomelas*) breed on islands in the temperate regions in Japanese and South Korean archipelago. To investigate the effects of wind on their flight performance, the stroking behavior of 24 streaked shearwaters breeding on Sangan Island, Iwate, Japan (39°18' N, 141°58' E), were recorded during their foraging trips in September 2008-2006 using accelerometers (M4-D2GT, 18g; Little Leonardo. Co. Ltd. Tokyo, Japan). The flight ratio (= flight time / data length) was generally high and did not differ between 1-day foraging trips (64.0-95.1 %, N=20 trips) and long (>2 days) foraging trips (80.2-90.2 %, N=9 trips). The glide ratio (= glide time / flight time) also did not differ between 1-day (37.5-87.5 %) and long foraging trips (37.1-63.4 %). The glide ratio was higher in day-time (60-70 %, for 6:00-17:59) than in night-time (46–57 %, for 18:00-5:59) in long foraging trips. At the nearest weather station (6 km from study site), there was a tendency that the wind speed was higher during day-time (averaged on 3.2±1.8 m/s) than night-time (averaged on 2.0±1.0 m/s). These results suggest that streaked shearwaters relied on the strong wind in day-time. Similar to the Procellariiform seabirds breeding on island in the Southern Ocean, streaked shearwaters appear to use wind to reduce flight power for transit.

New perspectives into the reproductive traits of exploited marine fishes through electronic tags: revealing spawning history of multi-batch spawning species.

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Individual-based spawning history is a key element of population dynamics and has profound implications on the management and conservation of exploited marine fishes. However, spawning is difficult to examine in natural conditions. In this paper, we describe consecutive spawning behaviour of the flatfish *Paralichthys olivaceus* as recorded by a time-depth recorder. A total of 15,035 vertical swimming behaviours of 6 fish were classified using k-means clustering, of which 0.9 % of the behaviours could be classified into a cluster that was characterized by high vertical swimming speed. These speeds were more than about 5 times greater than that of other behaviour clusters. More interestingly, the data revealed that behaviours in this cluster occurred regularly with an interval of one day, which corresponds well with the spawning cycle in simulated environmental conditions. We note that this behavioural pattern never occurred for the fish whose ovaries were not mature at recapture. Introducing electronic tagging may lead to the increase in the precision of the stock assessment in multi-batch spawning fishes.

P3.13 Swimming behavior of shark-eater sharks.

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Kaneohe Bay, Hawaii, USA, is a natal ground for the scalloped hammerhead shark, *Sphyrna lewini*. According to anecdotal information, 90% of the hammerhead pup population in this natal ground is depleted prior to the time they depart Kaneohe Bay and adapt to a pelagic habitat. Such high mortality may be caused by starvation and/or predation. We used advanced data loggers (D2GT) with an automatic time-scheduled release system to evaluate prey-predator interactive behavior. It is generally extremely difficult to monitor the behavior of predators and their prey, however, if logger-equipped pups are consumed by large predators and the instruments are subsequently expelled, we can retrieve the data logger and obtain behavioral data. In this study, we provide details regarding the swimming behavior of some large predators obtained by such a method. Our field studies in Kaneohe Bay were conducted in August and October of 2007, and July/August of 2008. We attached data loggers (M190L-D2GT) to record depth, temperature, and 2-axis acceleration with devices for data recovery (time-scheduled releasing mechanism, float, and VHF transmitter) to pups using a dissolvable suture technique. Devices were attached to 17 pups in total, of which we successfully retrieved 16 data loggers. Eight of the 16 devices were not retrieved immediately at their scheduled release time. Nonetheless, after several days, a signal was finally detected and the devices were retrieved. The recording time for each predator ranged between 32-64.8 hours. Maximum temperature was 0.31-1.49°C higher than the ambient water temperature recorded from free-swimming pups. Stroke frequencies were 0.50-0.81Hz and they did V-shaped submergence of 12-200 second cycle, which happened more frequently at night than at day (e.g. individual HI0801: 1028=at night, 281=at day). Aside from this pattern, some predators descended without stroking, namely prolonged gliding.

P3.14 Winter foraging areas of different sized Australian fur seals in the shallow waters of Bass Strait – is there segregation?

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Intra-specific competition within marine mammals for prey resources may be reduced by the ability of larger animals to dive deeper and for longer, or by those not tied to dependant young foraging further afield. In southeastern Australia, Australian fur seals of all sizes forage year-round in Bass Strait, a shallow (<80m) basin the depths of which can be plumbed by even small juveniles. Given seals or all sizes can target prey throughout the basin, how do they share the resources? Do foraging areas of different age/size groups overlap or are they segregated? We attached platform transmitter terminals to adult males (>180 kg, n = 11), adult females (60 – 90 kg, n = 14) and juveniles (25 – 50 kg, n = 38) at one colony, Seal Rocks, and compared their foraging ranges during winter months. In winter, males and juveniles have the option to forage more broadly but females must forage near to colonies to regularly return and nurse their pups. Results suggest that while there is considerable individuality, smaller seals tended to forage closer to the coast and in shallower waters than did larger seals. With the physiological ability to forage in central Bass Strait, why do the smaller seals remain near the coast? Reasons could relate to exclusion of smaller seals by larger seals to potentially more profitable offshore resources, and/or body size influencing prey specialization. For instance, smaller seals could browse better than larger seals in the high profiled, rocky bottomed, coastal waters.

P3.15 Verification of the method to estimate body mass change of the flying bird by using accelerometer

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European shags fly with continuous wing stroking. Theory suggests that their wing stroke frequency should be proportional to the square root of body mass. We developed a new methodology using animal-borne accelerometers to estimate temporal changes in their body mass at a fine scale during foraging trips. But the accuracy of this methodology has not been tested. In addition, this methodology is based on an assumption that wind condition does not influence their stroking patterns. To verify this methodology, we carried out field experiments at the Isle of May, Scotland, in breeding seasons in 2008, 2009 and 2010. First, we deployed both GPS logger and accelerometer on 16 birds, and recorded wind speed and direction at the highest place on the island in the three seasons. Second, we conducted weight-dropping experiment in 2010, in which we deployed an additional weight of 84 g simultaneously with an accelerometer (11 g) on 4 birds with body mass ranging from 1.86 kg to 2.15 kg (mean = 2.01 kg) and later detached only the added weight. Then we compared the differences in wing stroking frequencies between weighted and unweighted flights. The first experiment showed that when the birds were in cruising flights, ground speed obtained from GPS tracks varied widely from 9 to 27 m/s, while air speeds, calculated by deducting wind effect from ground speed, were kept within a relatively narrow range from 11 to 19 m/s. It means birds controlled their wing stroke frequency within a narrow range independent of wind condition. In the second experiment, birds stroked their wings at the frequency 2.2 % higher in weighted than unweighted flights. It corresponded well with the prediction based on mean body mass and the added weight ({(2016+84)/2016}0.5 = 1.021). Our results support the methodology using wing stroke frequency to estimate changes in body mass, and it will become a useful tool for studying the foraging strategy of free-ranging shags.

O1.15 Foraging behaviour of Antarctic penguins detected by small accelerometers attached on their head

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Precise quantification of feeding rates is necessary for understanding the foraging strategies of marine top predators. When penguins feed on prey such as swarm of Antarctic krill, they should move their head actively, thus the head movement will facilitate us to quantify their feeding rates. In this study we aimed to examine the utility of head movement of Antarctic penguins to estimate their feeding rates. The field study was conducted on both chinstrap and gentoo penguins breeding at King George Island, Antarctic Peninsula Region from December 2009 to February 2010. We investigated their head movement by two types of deployments: 1) attaching small accelerometers on the head and back simultaneously, on 8 chinstraps and 6 gentoos and 2) attaching the accelerometer on the head and a camera logger on the back simultaneously, on 3 chinstraps and 5 gentoos. Main prey item was Antarctic krill (>99% in wet weight) for the both species. During diving, penguins occasionally moved their head actively coincident with slow fluctuation (<0.3 Hz) of body angle at the bottom phase of the dives. The active head movement was then extracted by high-pass (5 Hz) filtering of acceleration signals and was counted with a threshold acceleration amplitude >1.0 G. The number of the head movement was correlated with the number of the pictures with prey during each dive. The correlation was higher than that of number of depth wiggles and the number of picture with prey. If we assume the number of head movement per diving bottom duration as feeding rates, the feeding rates did not differed between the species (chinstrap: 0.44±0.11 /s, n=7 trips, gentoo: 0.45±0.10 /s, n=8trips, GLMM, p=0.56). These results suggest that the head movement would be a good indicator of feeding rates for chinstrap and gentoo penguins.

O4.16 From nursing to independence in the life of bearded seals (*Erignathus barbatus*)

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Bearded seals are a little known ice-associated, arctic pinniped. They are benthic feeders that tend to remain in shallow areas where sea ice is available as a resting platform, but young animals are rarely observed in areas favoured by adults following dispersal from birthing areas. In this study we instrumented 13 pups late in the nursing period (60-109 kg) with Sea-Mammal-Research-Unit SRDLs and followed them through their first year of life (12-367 d). Home-range size increased during the first 2 months, then decreased exponentially throughout the tracking-records (i.e. pups became more sedentary). Total track length ranged from 443 – 15,712 km and max-distance from tagging-sites ranged from 17- 297 km. Time spent diving increased markedly during the first two months, stabilizing at ~16 h/d while haul-out time decreased from ~12 h/d to little or no time hauled out. However, the pups did spend ~8 h/d at the surface, presumably sleeping a considerable portion of this time. Dive depth increased markedly during the first 2 months to a mean of 80m, and subsequently decreased systematically until the pups were ~200 d of age when most dives were 20-30 m deep. The deepest dive recorded during the study was 375 m (60 d old pup). The average number of dives per day was 188 (range 10-380).Dives lasted an average of 4.3 min and approximately 1/3 dives was benthic. No diel rhythms were observed during any light regime (e.g. total light, total darkness or in-between periods). All off-shore excursions took place in regions with free-floating pack-ice. But, first-passage-time analyses in combination with Mixed-effects Cox-Proportional-Hazard models suggested that age, water depth and distance to the nearest coastal glacier played significant roles in the attractiveness of particular areas, while sea-ice concentration was not influential. The latter result was particularly surprising for the young of this species.

O3.09 Changes in northern fur seal (*Callorhinus ursinus*) foraging behavior with dramatically increasing population density

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The recent colonization of Bogoslof Island (Alaska, USA) by northern fur seals provided a unique opportunity to examine the impact of increasing population density on the at-sea behavior of a central place foraging pinniped. Since 1980, when the first two pups were recorded, the population has grown 43% per year with 17,574 ±843 pups born in 2007. While growth continues, recent counts (2005 and 2007) show a slowing to approximately 13.0% per year. To examine how this rapid increase in population density impacted individual foraging behavior, 50 female fur seals were tracked using time-depth recorders and satellite transmitters in 1997, 2005, and 2006. Dive bouts were not different among years and were characterized by short (44.3 ±30.1s), shallow dives (11.7 ±8.2m). Females increased the percent time spent at sea by 29.4% between 1997 and 2005/2006 (51.1 ±0.1%, 65.9 ±0.03% and 67.2 ±0.05%, respectively). From 1997 to 2005, trip durations nearly doubled (1.2 ±0.8d vs. 2.1 ±0.5d) and maximum distance travelled increased (51.2 ±44.3km vs. 137.3±17.8km); but both parameters remained consistent between 2005 and 2006. Finally, total foraging area increased over 400% from 1997 to 2005/2006. The increased foraging area and time at sea combined with the recent slowing of population growth suggest that increased intraspecific competition may have led to localized resource depletion around Bogoslof Island. However, Bogoslof Island fur seals still expend significantly lower foraging effort compared to other larger local colonies, which are currently declining. For example, in 2006, St. Paul Island fur seals spent over 77% of their time at sea, travelled twice the maximum distance (> 300km), and had trips that were 2.6 times longer. As northern fur seals are listed as depleted, comparisons between Bogoslof Island and declining colonies with greater foraging effort may provide important insight for determining conservation goals for this species.

P5.14 A pelagic ecosystem observatory system - deploying stomach-based acoustic tags and collecting ecological information using the global reach of commercial fishing vessels

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Advances in oceanographic and meteorological prediction have largely been driven by the availability of global observing networks. Ecological research is at the cusp of this revolution – there is a broad understanding of many important processes and models are available to represent these in an integrated way. However, there is no large-scale ecological observing network for marine systems, thus detailed data for marine species is expensive to obtain and data on important parts of the marine ecosystem are limited. The global reach of commercial fishing provides a platform for developing a broad-scale ecological monitoring system. For instance, Australia's tuna fishery operates throughout the year, covering the majority of the Coral and Tasman seas. Developing an inexpensive and easy to use system for collecting ecological information from these vessels of opportunity could spark a revolution in our understanding of marine ecological systems. We have commenced development of a prototype system for taking ecological observations in marine ecosystems at a variety of levels of organization. This system, designed to be incorporated with commercial longline fishing gear, includes 5 components:
i) a low-cost surface based buoy with sensors, communications and data storage capability;
ii) temperature and depth sensors on the fishing gear, communicating via acoustic modem with the buoy;
iii) a tag deployment method allowing in-situ deployment of electronic tags on fish “captured” by longline fishing gear, with an in-line digital camera to record species information;
iv) a stomach retention system enabling tags to remain in the animal's gut for long periods of time;
v) a database and visualization system to poll the buoys from a central location, log data, and provide some basic analysis tools.
We present developments in components iii) and iv), including a pilot study on tuna to test the stomach retention system for acoustic tags. Collecting physical, ecological and behavioural variables all at the same scale will facilitate interpretation of habitat use.

O1.05 Responses to ephemeral and seasonally predictable prey resources by Antarctic fur seals

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During the non-breeding phase of the annual cycle, marine predators are free to forage without the central place foraging constraints imposed while rearing offspring. For these species, the selection of foraging regions during the winter period is also influenced by climatic conditions and associated large scale fluctuations in marine productivity and therefore, prey availability. The Antarctic fur seal (*Arctocephalus gazella*) which has a circumpolar distribution from ~46 to 65ºS, and a diverse array of preferred prey, make ideal models for assessing the importance of seasonal resource predictability to foraging and future breeding success. Since 2008, ~80 geolocation tags have been deployed annually on adult females at Bird Island (South Georgia); Marion Island (n=30) and Cape Shirreff (Antarctic Peninsula, n=20). The seals occupy a behavioural continuum after breeding is complete, ranging from migratory (1 trip) to central place foraging (up to 9 trips). Cape Shirreff females which are larger than those from other populations made a single, migratory trip (~11000-13000 km), while seals from both Bird and Marion Islands made 1 to 9 trips over the same period. Behavioural state ('foraging' or 'transit') during these trips was determined by state-space modelling at 12h and 24h time scales, and was used to determine regions of persistent foraging (>3d consecutive foraging state) and more ephemeral foraging (<3d). Our choice of 3d was based on a natural break in the data. The proportion of foraging days per individual and per population were examined in relation to foraging regions distinguished by environmental characteristics (bathymetric gradient, vertical velocity and sea surface temperature), by their distance from the -1.8ºC isotherm (a proxy for sea ice extent) and the 500m bathymetric contour (shelf break) and in relation to the dietary isotopic signatures of whiskers from seals from the various populations.

P4.12 Size and experience matter: foraging behaviour of juvenile nationally critical New Zealand sea lions (*Phocarctos hookeri*)

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Population declines in various sea lion species have been attributed to poor juvenile survival, with foraging ability playing a critical role in survival during periods of low prey availability. The endemic New Zealand sea lion (Phocarctos hookeri) is the rarest and most highly localized sea lion in the world. It is listed as nationally critical in NZ and as vulnerable and predicted to decline by the International Union for Conservation of Nature. This study investigated the foraging behaviour of 2-5 year-old NZ sea lions in the subantarctic Auckland Islands. Time-depth recorders were deployed on a total of 19 male and female juveniles from January-February 2008-2010. Smaller, younger animals had higher dive rates (dives/hour) than larger, older animals. Maximum dive depth, duration and bottom time increased with age and mass, with males having higher foraging abilities than females. However, with the exception of 5 year-old males, these juveniles were unable to dive to reported adult female dive depths and durations, possibly limiting their available foraging habitat. Smaller, younger animals do not have the foraging ability of larger, older animals as they have lower aerobic dive capacity and less foraging experience. Given these additional constraints, juvenile NZ sea lions appear particularly vulnerable to environmental and anthropogenic perturbations and this needs to be considered in the management of this species.

P3.16 King penguins learn air load management with age

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Diving efficiency of marine animals is primarily determined by their physiological and mechanical characteristics. This efficiency is expressed through parameters such as wing or feet beats, buoyancy, or body angle, all of which can be modulated according to resource availability and diving depth, including current, and the targeted maximum depth. Here we investigated through these parameters how foraging abilities can increase with an individual's age and experience. Long-lived seabirds, such as deep-diving penguins, are good models to study behavioral changes in diving over the course of aging. During the austral summers of 2008 to 2010, we deployed small accelerometers on young (5 year old) and middle-aged (8-9 year old) king penguins breeding in a colony of the Crozet Archipelago, Indian Ocean. There were no differences between the two age classes in classical dive parameters such as maximum depth, total dive duration and duration of each dive phase. Acceleration was recorded along the longitudinal and dorso-ventral axes of birds at 16 Hz and pressure was measured every second. Young king penguins flap their flippers at a higher frequency during the descent phase than middle-aged birds. In addition, older breeders flap their flipper harder during the ascent, suggesting that young individuals loaded more air than they needed. Learning to optimally manage air loading could be the determinant factor explaining the improvement of foraging performances with age.

P2.05 Unlocking the bio-logging potential of otoliths as natural tags: Disentangling environmental and physiological influences on otolith chemistry

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Otoliths, the calcium carbonate 'earstones' common to all bony fish, have gained increasing prominence in the published literature as natural bio-loggers of lifetime movements. Incremental growth, incorporating elements from the surrounding water, produces a temporally resolved chemical record of ambient conditions experienced by the fish. However, a fundamental assumption of otolith studies is that the within-fish transport chemistry of metals is either largely unaffected by physiology, or that any physiological variations are smaller than environmental variations. For some elements, this assumption is currently being challenged. Presented within the context of otolith chemical profiles for wild plaice (*Pleuronectes platessa* L.), with 'known migrations' reconstructed from archival tagging data, we here communicate the results of an experimental study investigating the relationship between blood and otolith chemistry in plaice. Blood trace metal concentrations of 30 males and 30 females were sampled monthly over an annual cycle, to examine how changes in reproductive development and blood chemistry are expressed in the growing otolith. Significant seasonal changes in physiology (condition, gonadosomatic index and plasma protein) were related to trace metal concentrations in the blood and otoliths, as measured by secondary ion microprobe spectrometry (SIMS) and inductively coupled plasma-mass spectrometry (ICP-MS). An isotopically-derived ($\delta^{18}O$) temporal model of otolith growth was used to precisely time-match otolith analyses with concomitant environmental and physiological data. The results are discussed with reference to the viability of using otolith microchemistry as a natural marker of fish movements in the open ocean, and the potential applications of such spatial-temporal information in fisheries management.

P5.15 Quantifying 'at sea' resting behaviour of Harbour seals - clues to assessing foraging performance and habitat adaptation

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Research investigating the resting behaviour of marine mammals, e.g. cetaceans and pinnipeds, has centred on studies of electroencephalograms and eye state to assess the occurrence and extent of resting in captive animals. The three distinct behaviours related to resting within the different groups of marine mammals are similar: resting at the surface, underwater 'swim-rest' and submerged inactive periods. However, they are not displayed equally in all species and age classes. In this study we focus on 'at sea' resting behaviour of free ranging Harbour seals. In contrast to cetaceans all seals depend on land for breeding and moulting but only partially for resting (to very different extents depending on seal species). Nonetheless, seals seem obliged to rest at sea and here we show how rest can be identified and quantify this resting behaviour to assess; (1) what triggers the behaviour and (2) its effect on foraging performance. 4 adult male Harbour seals (32 foraging trips) were equipped with dead-reckoning loggers to measure fine-scale movements and body orientation in three dimensions and Satellite-Transmitters on the island of Rømø in Denmark. Based on the data recorded at 5 second intervals, active and passive diving could be distinguished based on body tilt angles and vertical velocities and analyzed in relation to progress and duration of foraging trips as well as time between consecutive foraging trips. We found that throughout the foraging trip, longer active periods with decreasing dive durations (decreasing efficiency) alternate with shorter passive periods with increasing dive durations. Seen over the duration of a foraging trip and consecutive periods of active and passive diving, the dive durations however still decrease in most cases. This indicates a state of exhaustion, which seems to limit the duration of a foraging trip and causes the seal to return to its haul-out site.

O5.03 Beyond kernel densities: posterior predictive inference for animal space use and other movement metrics

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The analysis of animal movement and resource use has become a standard tool in the study of animal ecology. Telemetry devices have become quite sophisticated in terms of overall size and data collecting capacity. Statistical methods to analyze movement have responded in kind, becoming ever more complex, often relying on state-space modeling. Estimation of movement metrics such as utilization distributions (UDs), however, have not followed suit, relying primarily on kernel density estimation. Here we consider a method for making inference about space use that is free of all of the major problems associated with kernel density estimation of UDs such as autocorrelation, irregular time gaps, and error in observed locations. Our proposed method is based on a data augmentation approach that defines use as a summary of the complete path of the animal, which is only partially observed. As opposed to other Bayesian movement modeling papers we use an importance sampling as the basis of our computation instead of Markov Chain Monte Carlo (MCMC). This allows processing of large numbers of animals. We demonstrate the predictive approach by estimating behavioral metrics such as trip distances, variations in speed during a trip and spatial maps of diving intensity for female northern fur seals in the Pribilof Islands, Alaska and harbor seals in the Cook Inlet region of Alaska.

O3.22 Avoiding the crowds: combining fine-scale biologging and stable isotope biogeochemistry to assess the temporal stability of alternate foraging behaviours of adult female Australian sea lions

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Typically the use of costly biologging technology provides short-term behavioural data on a small subset of animals. Collection of data is often restricted by the life history stages of animals (moult stage, seasonal migration etc). Stable isotope biogeochemistry is becoming a popular tool to infer longer-term population-level processes. This technique can be used to extend our understanding of inter-individual variation in foraging behaviour over longer timescales. We temporally synchronised 10s resolution dive records and GPS data collected from 20 adult female Australian sea lions (*Neophoca cinerea*) across seven colonies, overlaying the resultant track onto a 9 arc-second bathymetry map. The density of positions interpolated at 80% of maximum dive depth were used to identify feeding locations. Whiskers collected from the same individuals were serially subsampled for stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope ratios. We assume that 1) variation in $\delta^{13}C$ and $\delta^{15}N$ along a whisker reflected historical temporal variation in the location and trophic level of foraging behaviour and 2) the isotope ratios could be assigned to the geographic location identified using geospatial data. Finally we extrapolated inter-individual variation to inter-colony differentiation using stable isotope ratios collected from >60% of pups at each colony as proxies for maternal values. We identify two distinct, temporally-stable alternate behavioural ecotypes characterised by near-shore and off-shore foraging. Animals that were tracked for multiple foraging trips exhibited a tendency to return to the same area (often the same benthic feature) to feed. Individual foraging behaviour displayed seasonal variation but remained constrained to an ecotype. The presence of inter-individual differences extended to intra-colony segregation of foraging behaviour. Our data raises interesting questions regarding the ontogeny of foraging behaviour and causes of intra-sexual resource partitioning. Combining biologging data from a subset of individuals with stable isotope chemistry provides a powerful tool for resolving population-level ecological processes.

O4.20 Greenland sharks (*Somniosus microcephalus*) as predators of arctic pinnipeds

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The behaviour of Greenland sharks and their potential impacts on seal populations in the high Arctic marine ecosystem of Svalbard, Norway, were studied based on shark stomach content analyses and data from accelerometers and pop-up satellite tags deployed on the sharks. Stomach contents of sharks ranging in body mass from 136-700 kg (N=45) showed that 40% of the sharks had eaten seals. Only two of these stomachs contained carnivorous invertebrates indicative of carrion feeding. Accelerometer (N=7; W2000L-PD2GT Little Leonardo Co., Tokyo, Japan) deployments documented an average swim speed of 0.34 (±0.03) ms^{-1} and a mean tail beat frequency of 0.15 (±0.01) Hz. Least-cost swimming speed for fishes is generally higher than 1 body length per second, while the speed for these extremely slow swimming Greenland sharks corresponds to 0.1 body length per second. Bursts were recorded, where the speed and tail beat frequency were twice the average, but this "high-speed" swimming is still considerably below what is sufficient to capture an alert, healthy seal. Since phocid seals sleep with both cerebral hemispheres simultaneously, and do so at the surface and in the water column, we suggest that the Greenland sharks kill seals by approaching with stealth and capturing them while they sleep. Most of the satellite pop-up tags (N=20; MK-10 PAT, Wildlife Computers, Redmond, WA, USA) were released within 300 km of the tagging sites, with the longest documented movement being 1,000 km (over a period of 69 days). A total of 1462 days of tracking data showed that the sharks occupied the water column from the surface down to 1560 m and stay in water with an average temperature of 3.4 °C (range 0-7.4°C). This study has documented that Greenland sharks are a significant source of mortality for Arctic seals that should be incorporated into future arctic ecosystem studies.

O3.05 Field metabolic rate estimates for large, deep-diving toothed whales using onboard multi-sensor Dtags

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Large deep-diving toothed whales are apex predators in mesopelagic ecosystems, where they likely exert a significant top down effect on lower trophic levels. To understand their role in mesopelagic food webs in terms of biomass turnover and ecological foot print, information on the field metabolic rate (FMR) of these large predators is critical. Normal approaches for deriving FMR, such as double labeled water or calibrated heart rate techniques, are impractical at best because these large elusive animals cannot be captured or restrained. Accordingly, there are vastly different guesstimates of their FMRs ranging from very low to very high values compared to normal mammalian scaling, and such different estimates consequently lead to very different conclusions on the role of these animals in mesopelagic ecosystems. Here we use onboard, multisensor Dtags to quantify key parameters for estimating FMR in four species deep diving toothed whales. Tag placements lasting from 3 to 24 hours on 8 pilot whales, 3 sperm whales, 7 Blainville's beaked whales and 5 Cuvier's beaked whales provided ventilation rates using depth, accelerometer and acoustic cues. Lung volumes were estimated from changes in body acceleration during ascent and descents, and oxygen extraction was evaluated on the basis of breath-hold times and the buffering capacity of blood. We show that the mass specific metabolic rates of 1Watt/kg in sperm whales is very close to mammalian scaling predictions, whereas the 4 watts/kg in pilot whales is much higher than predicted and more than twice the FMR estimates of the two similar sized beaked whale species. These different FMR estimates match the ecophysiology, foraging behaviour and locomotor capabilities of the four different species of toothed whales, and help to explain the niche segregation and differences in oceanic distribution of deep diving toothed whale species across vastly different mesopelagic prey energy densities.

P3.17 Developing evidence that Sperm whales instrumented with ARGOS-GPS-TDR tags coordinate their foraging behavior

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Obtaining extended detailed information from instrumented whales is important to better understand whale behavior and interpret responses to anthropogenic noise. However, it has been difficult to achieve due to either short attachment times or poor spatial/temporal resolution. In 2007-8, we tagged sperm whales in the Gulf of California, Mexico with Wildlife Computers TDR-PAT-MK-10 tags. The tags sent Fastloc-GPS locations and summary dive data (shape, duration and depth) as Argos messages for dives >10min and >10m depth. Tags were released from the whales, floated to the surface, and recovered to download high resolution TDR and GPS data to describe resting, foraging, and traveling behaviors. Whale dives differed from very consistent without diurnal pattern for a week to highly variable to 1200m for 28d. Fast zigzag vertical patterns during dives may reflect foraging attempts on Humboldt squids. From multi-day coordinated surface movements, whales appeared to be associated (in the same social unit), although synchronous surfacings and dive depths were not usual. One of the associated whales often dove deeper, suggesting possible group foraging on a “bait ball” of squid and sharing the more physiologically demanding role of "guarding" the escape of squids into the depths at the bottom of the prey aggregation. This is the first multi-day application of tags combining these advanced sensors on whales and the first direct evidence of possible coordinated group foraging. Group foraging may explain the basic reason why sperm whales form social units. Previous tagging studies suggest that male associations are more temporal. However, even short-term foraging associations may be valuable. With more development, GPS/TDR tags with advanced sensors may provide the longer detailed records needed to assess the possible effects of anthropogenic sounds on large whales during future controlled-exposure experiments (CEEs) lasting up to 60d, allowing for control periods and multiple experimental sound exposures.

O4.04 Marine conservation and satellite telemetry: a review and framework for effective applications

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Satellite telemetry has emerged as one of the most prominent technologies in marine science and is a powerful conservation tool given the spatial nature of many management strategies. Despite resources applied to this costly technology, however, telemetry has yet to be used on a large scale to effectively drive conservation and management decision-making. We reviewed over 80 peer-reviewed articles focused on the satellite tracking of marine mega-fauna in major conservation and ecological journals in order to determine: (1) the focus of conservation telemetry studies; (2) the global distribution of studies; (3) how the rate and focus of conservation telemetry studies have changed over time; and (4) the level of quantification and resulting conservation impacts. The majority of studies focused on bycatch or protected areas, though only 40% of studies quantified telemetry study components, making outputs unable to adequately inform management. We found a significant increase in the number of conservation studies through time, and an increase in studies focused on bycatch. We found uneven geographic distribution of studies, with study sites in North America, Europe and Australia comprising over 56% of studies reviewed, with 34.4% of studies occurring in South America, Africa and Asia; Antarctica accounted for the remaining studies. Sea turtles were the most common focus of studies (55.6%), followed by seabirds (36.1%) and marine mammals (8.3%). Very few studies focused on impacts of climate change or tourism and many studies lacked solid recommendations resulting from telemetry outputs. Based on our review, we detail an empirically-based framework that (1) emphasizes how resource managers can use telemetry as a powerful management tool, and (2) guides researchers who employ telemetry in conducting studies in a cost-effective way that maximizes aid to management decisions.

O4.06 Fine scale interactions between harbour seals and operating tidal turbines

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The preferred habitat of the rapidly-expanding marine renewable energy industry and harbour seals overlaps. Underwater turbine arrays thus may cause risk of death or detrimental behavioural change. We investigated the behavioural and population response of harbour seals to the establishment and operation on a 1.3 MW Seagen turbine at Strangford Lough Narrows, Northern Ireland. Our hypotheses were that an operating turbine will (H1) reduce passage rate through the 1 km wide Narrows; (H2) alter the route of passages. SMRU GPS/GSM tags provided high resolution track and dive data from three tagging (n=12, 11 and 12) deployments: before, during establishment, and during operation of the turbine. H1: there was no significant of change in population transit rates in the three deployments. H2: there was evidence turbine avoidance once it was operational – but such avoidance had little effect on distance swum. We recorded 10 passages within this buffer whilst the turbine was turning. We estimate that, on average, each seal in Strangford Lough makes such close passages 7.4 times per year. However, systematic surveys for dead animals recorded failed to show any resulting trauma or death. This fine-scale investigation relies on the use of GPS/GSM tags technology. The results are being used by both the regulatory authorities and the marine renewables industry to formulate mitigation strategies that are both appropriate and efficient.

O3.16 Venous PO_2 profiles in diving California sea lions: How low do they go?

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It is essential to understand the magnitude of O2 store depletion and the physiological mechanisms underlying the aerobic dive limit (ADL) if we are to interpret and understand dive limits, foraging ecology, and the ability of these marine mammals to adapt to changes in prey distribution secondary to environmental change and overfishing. The California sea lion (*Zalophus californianus*) is an excellent model species because both its dive behavior and total body O2 stores have been extensively studied. In this study we took advantage of maternal foraging trips of California sea lions to document venous PO2 profiles while diving using a backpack partial-pressure of O2 recorder. In August 2010 we captured, instrumented (PO2 data logger, time depth recorder, and radio transmitter), and recaptured 6 lactating California sea lions. We obtained venous PO2 profiles from 3513 dives from 5 females. 32.5% of the dives were between 1 and 3.5 minutes and 3.9% were greater than 3.5 minutes. Venous blood O2 was not depleted during routine short dives (<3.5 min). However, in dives over 5 minutes, venous PO2 values regularly got below 10 mmHg, and in some cases as low as 5 mmHg. The sea lions' ability to continue diving with PO2 values less than 10 mmHg for over two minutes and the lack of consistent extended surface intervals following these dives, suggest that sea lions have greater tolerance to hypoxia than suspected. These data will be used to develop an experimental approach to assess the ADL and O2 store depletion in this and other otariid species.

P1.07 Water column usage by female southern elephant seals from Marion Island

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We describe the water column usage of female southern elephant seals from Marion Island tracked between 2004 and 2008. Most animals displayed positive diel vertical migration, evidently foraging pelagically on vertically migrating prey. Mean dive depths were deeper and longer during post-moult migrations, when compared to post-breeding migrations. Mean dive depths (± SD) during post-moult migrations were 560 ± 170 m during the day and 394 ± 153 m at night. Mean post-breeding dive depths were 517 ± 163 m during the day and 359 ± 143 at night. Mean post-moult dive durations (± SD) were 30.9 ± 11.1 min during the day and 24.9 ± 10 min at night, while post-breeding dive durations were 23.3 ± 7 min during the day and 16.11 ± 5.3 min at night. Overall, females from Marion Island tended to dive deeper and for longer periods of time, when compared to reported results from tracked females from other populations. We present a refinement of a previously reported method to identify dives that represent increases in forage effort. This method is based on a combination of dive type analyses and the calculations of relative amounts of time spent at the bottom of individual dives. Results from this analysis indicate that female elephant seals from Marion Island tend to display lower levels of forage effort in close proximity to the island, but that foraging does take place on an opportunistic basis throughout their migrations.

O4.09 All washed up: a low-cost, "flotsam" method for retrieving archival tags from marine animals

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A major limitation with using archival tags on fish and other animals in the open sea is the need for tags to be physically retrieved so that the recorded data can be recovered. This limitation has, in part, been overcome with the development of pop-up satellite archival transmitter (PSAT) tags that float to the sea surface and transmit information via Argos. However, PSAT tags are still quite large and comparatively expensive, and Argos has a restricted data transmission capacity that prevents large datasets from being recovered. However, particularly in shelf seas, surface-floating objects have a high chance of drifting to the coast where they can be recovered and returned by members of the public. Such opportunistic recovery of PSAT tags, previously deployed on basking sharks in UK waters, indicated that recovery rates by this route could be in the region of 20-30%. We have further tested the concept of a "flotsam" method of tag recovery using small archival tags with added flotation and show that this is both effective and economical. It also makes it feasible to tag species for which there has not previously been a reliable route for tag recovery (e.g. non-commercial species) and can yield tags from individuals that would not otherwise have been recovered (e.g. after predation). We present results from oceanographic modelling studies, from sea-going experiments with dummy tags, and from the first large-scale deployments of flotsam tags with silver eels, cod, jellyfish and sea turtles. We show that, in addition to enhancing data recovery, flotsam tags can provide fascinating new insights into predation events.

The search for widely-applicable methods to measure body condition of diving animals: three at-sea metrics of body density validated in northern elephant seals

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Many diving animals undergo substantial changes in their body density, which are the result of changes in lipid content over their annual fasting cycle. Because the size of the lipid stores reflects an integration of foraging effort (energy expenditure) and foraging success (energy assimilation), measuring changes in body density is a good way to track body condition and net resource acquisition of free-ranging animals while at sea. In this study, we experimentally altered the body density and mass of 3 free-ranging elephant seals by remotely detaching weights and floats while monitoring their swimming speed, depth, and 3-axis acceleration with a high-resolution data-logger. Body density was estimated using three different models of hydrodynamic gliding performance during drift dives, prolonged glides, and intermittent glides. Density estimated using the three methods for estimating body density agreed well with each other, and also showed strong positive correlation with body density estimates obtained from isotope dilution body composition analysis over density ranges of 1015-1060 kg m^{-3}. All 3 hydrodynamic models were within 1% of, but slightly greater than, body density measurements determined by isotope dilution. All three methods make use of speed during passive motion by the animal, but each analyses a different specific behavioural sequence. A suite of different validated methods increases the potential for at least one method to be applicable over a wide range of freely-diving animals which may exhibit diverse swimming and gliding behaviour patterns during diving.

P4.13 Travelling behavior of northern fur seals during the breeding period in the Kuril Islands

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During the lactation period, northern fur seal (Callorhinus ursinus) females travel to distant foraging areas to transport energy back to an offspring. The costs associated with travelling to foraging patches must be compensated by energy gain in the patches encountered. Therefore, data on swimming effort during travelling as well as foraging success of female is valuable for predicting maternal investment and the female's reproductive success. Recent technological advances now allow fine-scale movements of animals to be monitored in multi-dimensions. To monitor the multi-dimensional movements of northern fur seals at high resolution, we deployed 3D data loggers (Little Leonardo, Tokyo, Japan), which can record 3-axes of acceleration and geomagnetism, depth, swim speed and temperature, and GPS loggers (Wildlife Computers, Seattle, USA) on 6 lactating females in the Kuril Islands of far eastern Russia in 2006. Acceleration data was used to detect stroke and body angle, allowing us to infer the different type of behaviors: stroking, gliding, rolling, and porpoising. Swim speed was estimated by propeller rotation, excluding one female whose propeller fouled with kelp. 3D data loggers recorded 1-3 trips per seal during 5-8 monitoring days. Seals displayed epipelagic diving during night and mean deep dive depth (>10m) was 13.7-24.2 m. Average swim speeds during descent, bottom and ascent phases of deep dives were 1.6 m/s, 1.5 m/s, and 1.7 m/s, respectively (n=5). Seals spent most of the foraging trip time (84.2-95.1 %) engaged in shallow diving (<10m) and surface behaviors. During surface swimming, the seals almost always spun on their long axis in a cycle of about 3 s. Seals stroked continuously during spinning, however, the stroke amplitude was much less than that during deep dives, and swim speed during daytime surface activity was 0.4-0.6 m/s. These results revealed that seals might decrease travelling cost by reducing stroke power.

P3.26 Biologging for long monitoring of animal behavior: preliminary study on milky storks in Malaysia

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Biologging science that uses advanced digital technology has brought new insights into animal behavior in situ by providing sophisticated information on animal behavior measured by the miniaturized acceleration loggers in fine scale. This technique has been broadly used to investigate diving behavior of aquatic animals and flying behaviors of avian animals by measuring stroking and fluttering movements and/or body angles in fine scale time resolution. These sophisticated measurements were enabled by high speed sampling of the multi-axes accelerations of animal movement, and consequently this high speed sampling (i.e. 32Hz) limits the observation period of animal behavior within a few days. Shortness of recording period makes it difficult for us to use the acceleration logger for the conservation study of wild animals, which often requires long term monitoring of behavior including feeding, resting, habitat use and etc, since those activities change in weekly, monthly, seasonally or yearly scales. In order to overcome above difficulty we tested to establish a new long term monitoring logger system on animal behavior using acceleration logger. Animals conduct specific movements related with particular behaviors that are usually discernable each other. These specific movements appear in the acceleration signals in different forms in terms of signal frequency and amplitude, which would allow us to transform acceleration data into simple and compressed data form, and therefore extension of recording period of monitoring logger will be enabled. We preliminarily tested the idea to discern several behaviors using acceleration data obtained from the semi-wild milky storks in Zoo Negara, Kuala-lumpur, Malaysia. We could distinguish some behaviors such as flying, walking and feeding in surge acceleration signals. This allowed us to develop an algorism for data compression.

O1.11 Foraging habitats of southern elephant seals, Mirounga leonina, from the Northern Antarctic Peninsula

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Elephant Island (EI) provides southern elephant seals (SES) breeding there with potential access to foraging grounds in the Weddell Sea, the Frontal zones of the South Atlantic Ocean, the Patagonian shelf and the Western Antarctic Peninsula (WAP). Quantifying where seals from EI forage provide insights into the types of important habitats available. Thirty-two SES were equipped (6 sub-adult males-SAM and 26 adult females-AF) with SMRU CTD-SLDRs during the post-breeding (PB 2008, 2009) and post-moulting (PM 2007, 2008, 2009, 2010) trips to sea. Striking intra-annual and inter-sex differences in foraging areas emerged. Most of the PB females remained in the region of EI within 150 km. Only one animal travelled down the WAP. In contrast, all of the PM females travelled down the WAP and foraged near the winter ice-edge. Most PM males remained close to EI , in areas similar to those used by adult females several months earlier. One male spent the early part of the winter foraging on the Patagonian Shelf. The waters of the NAP contain abundant resources to support the majority of the Islands' SES for the summer and early winter, such that the animals from this population have shorter migrations than those from most other populations. Sub-adult males are certainly taking advantage of these resources. However, females did not remain there over the winter months, instead they used the same waters at the ice-edge in the southern WAP that females from both KGI and SG used. T-S profiles analysed suggest an association between adult females and regions close to the shelf break where deeper, nutrient rich surface waters (1°-2° C, 34,6-34,75 psu), usually associated with upwelling of Circumpolar Deep Water (CDW) occur. This is clearly preferred feeding habitat for this species, and one that is likely to experience changes with continued warming of this region.

P5.02 Paradox of diverse divers into the deep depth: a new aspect of foraging behavior of northern elephant seals

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Respiration and feeding are essential events for animals to survive. Marine mammals are unique since they perform those events in two spheres, obtaining oxygen in the atmosphere and prey in the marine-sphere while most of animals do those in the single sphere and thus called aquatic animals and terrestrial animals. This split system has been generally explained by the rich marine production, consequently large prey mass. Many marine mammals however dive into deep waters enduring anoxia risk where the marine production is extremely low. This paradox of deep divers might be explained by foraging success in the depth as trade off with anoxia risk. Female northern elephant seals are the excellent model to study this paradox because they are well known deep (500-700m) and continuous diver. Unfortunately, however, feeding behavior of marine mammals is still difficult to study and puzzle of paradox left as it is. Recently we developed the long term feeding recorder using jaw accelerometer technique for detection of feeding events and deployed the recorders to four post-breeding female northern elephant seals to investigate the above questions. Four seals conducted normal diving behavior. Active feeding events (29425-75195 and 14.88±12.61-17.99±10.62/dive) were observed at the dive bottom during successful observation days (55-68 days). None of the feeding events was found in the drift dives. Spiky signals in the raw surge acceleration data (sampled with 32Hz intervals for 60h) suggested that they adopted suction feeding mode. Our newly obtained findings based on the direct measurement of feeding signals may allow us to investigate the above question.

O3.10 Foraging dives of ocean sunfish *Mola mola* to search prey abundant depth

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Ocean sunfish (*Mola mola*) are the largest teleosts (up to 2,000 kg) and one of the gelatinous plankton feeders. Jellyfish blooms have recently increased and caused human problems, especially in fishery. Ocean sunfish possibly have top-down effects on jellyfish populations, but little is known about their foraging ecology. Recent satellite and acoustic tracks of ocean sunfish have revealed their large horizontal and vertical movements, but fine-scale foraging behavior is still unknown. In July 2010, we deployed data-loggers (W1000-3MPD3GT; Little Leonardo Co., Japan) on four ocean sunfish (84-164 cm in length) caught by set-net off the coast of Sanriku, Japan for a period of 8-9 hours to record depth, magnetic, accelerometer, temperature and speed under natural conditions, available to construct 3-dimensional tracks of the fish. The ocean sunfish stayed at shallow depth (<10 m) for 15-55% of track time and sometimes made dives to depths of over 10 m. The dives were observed 1-7 times among individuals and mean dive duration was 22.2 ± 6.9 min. During staying shallow depths, they swam continuously at mean swim speeds of 0.4-0.7 m s-1 with stroking frequencies of 0.3-0.5 Hz. During the dives, they also swam continuously, but sometimes slowed down with maneuver, possibly related to feeding behavior on gelatinous plankton. The feeding behaviors were observed during all dive phases (descent, bottom and ascent) mean 12.4 ± 7.7 times a dive at mean depth of 102 ± 40 m, which is coincident with existence of pycnocline at depth of 30-80 m in summer off the coast of Sanriku below which zooplankton is abundant. These data suggest ocean sunfish actively dove for searching prey abundant depths. Frequent feeding behaviors suggest they consumed a large amount of jellyfish during their foraging dives and might have great top-down effects on jellyfish populations.

P3.18 Fine-scale homing behaviour of a green turtle (*Chelonia mydas*)

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Many satellite tracking studies showed sea turtles are capable of reaching remote targets. However, their navigation mechanisms remain unclear. In this study, fine-scale movements of a homing green turtle were examined by using a 3-D logger (W1000-3MPD3GT, Little Leonardo Co.), which enabled us to reconstruct 3-D movements via depth, speed, tri-axis magnetism and tri-axis acceleration recordings. In July 2010, a 3-D logger and a satellite tag (MK10-AFB, Wildlife Computers) were deployed on a gravid green turtle, which were transferred to an oceanic release site 150 km away from the nesting beach at Moheli Island, Comoros. Satellite tracking data showed the turtle returned to the island 79 hours after the release, and spent 34 hours in the waters around the island before returning to the nesting beach. By using the 3-D track of the entire homing trip reconstructed, straightness index of the horizontal track was calculated on an hourly basis. The turtle travelled linearly during the oceanic travel toward the island (straightness index, mean ± SD = 0.94 ± 0.09) whereas the track was more sinuous while moving around the island (straightness index = 0.62 ± 0.24). During the oceanic travel, the turtle undertook a large number of subsurface dives (≤ 4 m, n = 1824) during daytime whereas in night-time it performed some gradual ascent dives (depth = 20.8 ± 1.6 m, n = 30) to the depth, where it possibly reached neutral buoyancy. Such diel diving pattern suggests the use of different navigation strategies during daytime and night-time. After reaching the vicinity of the island, enigmatic behaviours were recorded: the turtle gyrated continuously (ca. 3 times min-1) at the surface for < 30 minutes. Considering that the turtle headed toward the beach after those behaviours, it might be possible that this newly-described gyrating behaviour play some roles in short-range navigation.

P3.19 Using biologging data to understand the population consequences of disturbance

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There is growing public concern about the impact of changes in the behaviour of animals that are caused by human disturbance. Although the immediate consequences of these changes are rarely fatal, they can affect important demographic process, such as survival and reproduction, and these effects could have important consequences for conservation because of the large number of individuals that may be subject to disturbance. One particular area of concern is the impact of acoustic disturbance on marine mammals, and we focus here on this issue, although we believe that the methodology we will describe has much wider applicability. We show that data from studies of the behaviour of animals collected using telemetry can be combined with data on reproductive success obtained from long-term studies to fit sophisticated models of the effects of changes in behaviour on population processes. We illustrate this with data from southern elephant seals and show how the hypothetical exclusion of animals from a preferred foraging area can affect body condition, and the consequences of this for pup survival and seal colony dynamics. We also show how the same model framework can be extended to other marine mammal species that adopt an income breeding strategy, rather than the capital breeding strategy used by elephant seals.

P2.02 Application of gyroscope for bio-logging study

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In a previous study, accelerometer and magnetometer have been used to estimate the attitude of animals (pitch, roll, and yaw). Pitch and roll are normally estimated from the gravity measurement projected on the sensor axis of accelerometer. Yaw is estimated from the magnetometer measurement with the aid of the pitch and roll estimate from the accelerometer. However, since accelerometer also senses the linear acceleration (not gravity) caused by the animal body movements, an assumption is used that the change of linear component is more frequent than the change of gravity, so that the linear component is removed by low-pass filtering. However, this assumption is violated when the change of gravity is frequent, for example when animals perform rapid rotation. Therefore, it is impossible to monitor rapid rotation (and accurate linear acceleration) by the previous method. On the other hand, many animals exhibit high maneuverability which involves rapid rotation to achieve their tasks. Therefore, rapid rotation should be an important indicator to be monitored to understand the movement and behavior of animals. In addition, accurate estimation of linear acceleration should be effective for better understanding of the movement. In this study, gyroscope, which directly measures the angular velocity with high frequency (100-200 Hz), was used to estimate accurate rotation and linear acceleration of animals. When angular velocity is time-integrated, it indicates attitude, which can be used for the estimation of gravity and the isolation of linear acceleration. However, since the measurement noise also accumulates so that the estimation of attitude by the gyroscope becomes less accurate with the time. In this study, the error was corrected by integrating magnetometer and accelerometer measurement using sensor fusion technique. The effectiveness of the gyroscope for Bio-logging application was tested by using animals (Fish, Sea turtle) in field and laboratory experiments.

O3.11 Linking foraging northern fur seals (*Callorhinus ursinus*) with fine-scale oceanographic features: contrasting attributes from islands with opposing population trends

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Northern fur seals breeding in the eastern Bering Sea are declining at the Pribilof Islands (St. Paul and St. George Islands) and increasing at Bogoslof Island. The marked divergence in population trajectories may be linked to regional differences in ocean productivity created by dynamic oceanographic features such as temperature structure and thermoclines. We sought to identify the physical mechanisms controlling summer feeding by northern fur seals by collecting and analyzing environmental parameters in reference to differences in population sizes and trajectories. We deployed Wildlife Computers Mk-10 “F” tags on 87 lactating northern fur seals (44 St. Paul, 43 Bogoslof) during July – September, 2009. External temperature and depth were recorded every second for 173,348 dives, allowing for high-resolution reconstruction of the water column along GPS-derived foraging tracks. No overlap in foraging areas was detected despite the potential for range overlap. First passage time analysis (FPT) quantified the spatial scale of foraging for individual seals with St. Paul animals doubling their foraging scale (mean radius = 11 km) compared to Bogoslof seals (mean radius = 6km). Appropriately scaled environmental covariates such as bathymetry, mixed layer depths, and thermocline strength will be tested using Cox-proportional hazard models to evaluate their influence on northern fur seal foraging patterns, which in turn ultimately affects population trends for this piscivorous top-predator.

P4.14 Using well-equipped Australian sea lions to assess habitat quality and inform the zoning of Marine Parks in South Australia

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The outer boundaries of South Australia's Marine Parks have recently been declared, but planning for the location of habitat protection and sanctuary zones is occurring now. Metrics being used to determine the location of these zones are largely anthropocentric. We aim to identify critical foraging habitats of Australian sea lions and incorporate these habitats into the marine planning process. At Dangerous Reef, South Australia, we used GPS telemetry and National Geographic Crittercams to map the fine-scale distribution of foraging effort of female sea lions and to record footage of their habitats and foraging effort. Habitat and prey associations were integrated with remotely-sensed (acoustic swath and video mapping) benthic habitat data and baited remote camera surveys of prey abundance and diversity. This enabled fine-scale comparisons of the habitats and prey that are most and least valued by sea lions. Anthropocentrically derived data were compared with habitat value indices, derived from sea lion tracking and Crittercam data. Countless pelagic fish were seen on the Crittercam footage, but sea lions exclusively used benthic prey and traversed extensive areas of sea grass and sand without feeding, but demonstrated clear preferences for two habitat types; sparsely vegetated sandy swales (octopus/skates/flatheads/prawns) and complex rocky reefs (leatherjackets/red rock cod), where they searched in crevices and under boulders or employed sit-and-wait tactics from underwater vantage points. The baited remote cameras indicated that the prey of sea lions were least abundant around their colonies, where crabs and benthic sharks, which were not preyed on by sea lions, were profuse. This approach has improved our understanding of the critical habitat needs of sea lions, and highlighted the value of using apex predators to identify key habitats and areas of biological production to assist the marine park planning process.

O5.16 Habitat models for the Northeast Pacific blue whale from satellite tracking and remote sensing

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The population of blue whales (Balaenoptera musculus) inhabiting the Northeast Pacific moves seasonally from summer/fall areas in central and southern California to winter/spring areas off western Baja California, the Gulf of California, and near the Costa Rica Dome (CRD), an offshore oceanographic feature in the eastern tropical Pacific. State-space models with switching behavior were applied to the satellite tracks of 92 animals tagged over the period 1994-2007 to obtain best-location estimates at regularly sampled intervals and to characterize movement behavior as either 'area-restricted search' (ARS, an indication of foraging) or 'transiting' between foraging patches. Remotely sensed oceanographic variables extracted at each location were used as predictors of whale behavioral states (ARS vs. transiting) in a suite of habitat models including generalized additive models with mixed effects and non-parametric multiplicative regression models. The best overall predictors of ARS behavior were cool-to-intermediate sea-surface temperatures, proximity to the shelf break, and high chlorophyll-a concentrations. A secondary ARS peak was associated with the warm, offshore, deep waters in the proximity of the CRD, a low-latitude region where chlorophyll-a reaches intermediate values and where other evidence suggests that whales feed. These findings indicate that ARS behavior is associated with upwelling regions, both near the shelf and offshore, and thus support the notion that blue whales exploit environments with large euphausiid standing stocks throughout the year. The likelihood of ARS behavior in response to environmental variables was captured by hump-shaped or otherwise nonlinear functions in multidimensional space. This response indicates that blue whales optimize ARS behavior along environmental gradients, making it a useful measure of ecological performance.

O5.02 Modelling behavioural switching vertical movement time series: dealing with statistical challenges and data volume

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Electronic tagging has amply demonstrated the complexity of vertical movements displayed by marine animals. Electronic tags record at high sampling frequencies for long periods. Statistical analysis is therefore complicated both by the volume of data recorded and the complexity of the animal behavioural observed. Further, fine scale data of depth through time is often difficult to use for quantitative description of behavioural states which may occur over longer time scales. Here we explore the statistical challenges of analysis of vertical movement signals and present a Hidden Markov model (HMM) which is used to determine behavioural switching from daily summaries of proportion of time at depth. Using data summaries reduces the computational burden and also allows for consideration of behaviours which occur over time-scales longer than the sampling interval. The HMM model assumes a compound stochastic process which alternates between two Poisson processes with different rates. We demonstrate this HMM approach using data from southern bluefin tuna. Application of our model includes predicting sightability of marine animals during visual surveys and behavioural analysis of summarised data from satellite tags. Importantly, this technique presents a rigorous approach to quantitative detection of behavioural shifts in vertical movement data.

P3.20 New non-invasive design of dolphin telemetry tag; proof of concept

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The impact of devices attached to animals remains a challenge in telemetry studies of dolphins. It was supposed that the hydrodynamic design of a tag could provide stable attachment to the dorsal fin by means of resultant hydrodynamic force appearing at a dolphin's swimming. To verify this hypothesis the computer fluid dynamics (CFD) study of the tag performance and its impact on dolphin hydrodynamics was carried out. A virtual model of the tag attached to the dorsal fin as well as a model dolphin body presenting authentic geometry of common dolphins were constructed. The dolphin model without the tag was used as a reference object to calculate tag impact as regards drag, lift, and moments coefficients. Flow around the models was simulated for the range of velocities as well as the ranges of pitch and yaw angles. It was shown that in 33 of 35 CFD scenarios the streamlined shape of tag generates the lift force that facilitates keeping a tag attached on the fin. Tag-associated drag coefficient does not exceed 4%, which indicates low impact. Data obtained confirm the supposition that appropriate tag design can keep a tag attached without additional measures like pins or suction cups. Practical questions of the new tag deployment are discussed.

O4.15 Acoustic telemetry and accelerometry for understanding the population dynamics of a coastal giant

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Giant Australian cuttlefish *Sepia apama* form a unique breeding aggregation in northern Spencer Gulf, South Australia each austral winter. A strongly male-biased operational sex ratio has lead to the development of spectacular mating behaviour and displays, and the aggregation has been of conservation concern for several decades. Annual density-based surveys are currently used to monitor inter-annual variation in population size; however a lack of temporal information (with respect to individual residence) hinders effective management of this population. We used a combination of acoustic telemetry and accelerometry to estimate residence times for both genders, and to estimate field metabolic rate during breeding. The relatively brief residence periods of individuals suggest an underestimated population size, and gender differences in breeding durations suggest that the adult sex ratio is unbiased (M:F = 1:1). For an animal that likely catabolises 30-40% of its own body proteins during breeding, estimates of field metabolic rate correlate well with estimates of breeding durations. In this study, biotelemetry provided valuable information on population dynamics that will assist management of this unique aggregation.

O3.02 Individual based population inference using tagging data

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We consider a hierarchical population model which couples multiple individual analyses. The approach relies on mixed effects modelling as known from statistical theory. Any type of model can be used at the individual level with the requirement that maximum likelihood estimation of model parameters is possible. Using a quadratic approximation to the individual log-likelihood functions admits exact solutions to the otherwise difficult integrals of the hierarchical model. Provided that the quadratic approximation is reasonable this approach has a number of advantages: 1) calculations at the individual level are carried out once independently of each other, and can therefore be run in parallel. If new datasets arrive it is not necessary to run the individual model again for the old datasets. 2) the computational burden of joining individual estimates is insignificant since closed-form expressions for the population parameters are available. 3) it is possible to identify individuals which deviate from the rest of the population. This feature makes it possible to uncover potential sub-population structures within the tagged population.
Here, we present an application of the hierarchical framework to acoustic telemetry data from tagged pike in a lake. Velocities are derived from telemetry locations as displacement per time unit. A continuous-time hidden Markov model (HMM) is formulated for the individual movement behaviour, which relates to velocity. Using “time of day” as covariate, the switching rates of the HMM are estimated with maximum likelihood and used to calculate the stationary distribution of the behavioural state. Feeding the individual parameter estimates and their uncertainty to the hierarchical model we find that day time behaviour differs from night time behaviour for the population. Furthermore, we identify individuals in the population which display a deviating movement behaviour.

O5.10 Can thermoclines be a cue to distribution of prey for little penguins?

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The use of top predators as bio-platforms is a modern approach to monitor the status of marine ecosystems and can help us understand how physical changes in the environment may influence the activity of these predators. In this context, we equipped 26 little penguins (*Eudyptula minor*) with miniaturized bio-logging devices at the chick rearing period during November and December 2005. These bio-loggers measured simultaneously temperature profiles in the waters of Bass Strait, Australia, as well depth and acceleration in two axes to determine diving behaviour and prey encounter of the little penguins. We aimed to (1) examine changes in the thermal structure of the water column over time, especially regarding the presence/absence of thermoclines, (2) examine possible links between physical environment and prey availability, and (3) infer the consequences of such a relationship on foraging strategies of penguins. Our data showed that a thermocline was present in the foraging zone during the first 3 weeks of the 5-week study, which coincided with penguins having a successful prey encounter. The situation changed markedly during the last two weeks of the study period as thermoclines were no longer detected in the diving data, coinciding with increased foraging effort and lower prey encounter. This lower hunting success suggests that the thermocline was absent from the water column, which may result from a mixing of the water column due to the inflow of oceanic water masses into the strait. Overall, thermoclines could represent temporary markers of enhanced food availability for little penguins onto which they should adjust their breeding cycle.

O1.12 Habitat models as tools to predict resource distribution and impact of future climate warming on seabirds

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Seabird populations of the southern ocean are responding to climate change since the last decades and projected warming is expected to cause dramatic changes in marine top predator populations over the next century. Using extensive satellite tracking datasets of white-chinned petrels (*Procellaria aequinoctialis*) at Kerguelen Island and king penguins (*Aptenodytes patagonicus*) at Crozet Island, we modelled the relationships between oceanographic parameters and seabirds foraging distribution during the breeding period. A hierarchical modelling procedure was applied to quantify these relationships and to make spatially explicit predictions of foraging habitat using past, present and future oceanographic conditions. Our models revealed strong influences of sea-surface temperature and primary productivity on the foraging distributions of both species. White-chinned petrels followed the seasonal increase in Antarctic krill (*Euphausia superba*) abundance associated with the retreat of sea-ice, whereas king penguins targeted cold, nutrient-rich water masses of the polar frontal zone to feed on myctophids fish. The models' outputs provide insight into the distribution and abundance of these two main food resources of the southern ocean and can thus be used to predict the impact of future climatic changes on resource availability to marine top predators. As the prevailing future climate models predict continued ocean warming, seabirds will have to adjust their foraging behaviour and habitat utilisation to cope with the associated oceanographic changes. Using our models, we projected the foraging distribution of king penguins under the future prediction of sea surface temperatures till 2100, according to the IPCC scenario. We found a southward shift of the penguins' foraging zones of 40 km per decade on average which will double the foraging range by the end of this century. Consequently, successful reproduction is likely to be compromised and population size negatively affected if birds are not capable to adapt to these environmental changes.

O4.12 Year-round tracking highlights key areas of fisheries interaction for a wandering albatross population in steep decline

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Although declines in many albatrosses and large petrels have been attributed to incidental mortality, it is often difficult to determine which fisheries are responsible because many are unobserved, and even if bird bycatch is recorded, sample sizes are usually limited and bycatch rates are highly variable (by season, time of day, vessel, gear type etc.). Wandering albatrosses at South Georgia showed a decline of 1.8% p.a. from all-island surveys in 1984 and 2004; at the main site, Bird Island, annual monitoring indicates a 50% drop since the 1960s (1% p.a. to the late 1990s; 4% p.a. thereafter). In comparison, the other two main breeding populations (in the Indian Ocean) have shown some recent recovery after earlier declines. Here we combine data from a variety of sources (tracking studies, a synthesis of global fishing effort, band recoveries and demographic monitoring), to identify and characterise the main threats to the South Georgia population. Breeding frequency and success has increased since the late 1970s, providing no evidence of environmental deterioration. In contrast, survival of adults decreased by 1-2%, and of juveniles approximately halved since the mid 1990s. Tracking data indicate that adults from South Georgia have probably the widest nonbreeding distribution of any albatross. A composite map of year-round distribution produced by weighting tracking data from birds of different sex and status according to the duration of, and proportion of the total population in each phase/breeding stage, was compared with the global distribution of fishing effort, to identify particular regions where fisheries interaction (and risk to birds) was greatest. Many of these corresponded to areas of high wandering albatross band recovery rates. This is critical information that can be used to pressure specific national and international fisheries bodies into better addressing bird bycatch issues.

P5.16 Assessing the uncertainty of SMRU CTD-SRDL dive profiles abstracted using the broken-stick algorithm

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Using animal-borne satellite-linked sensors is an effective way of studying the behaviour of wide-ranging, deep diving marine predators. The collection and delivery of telemetry data is constrained in its quantity and resolution, by the battery life of the instruments, and the bandwidth of the satellite system used. This means that the behavioural and environmental data are, by necessity, compressed and abstracted when they are received for analysis. The algorithm used to abstract dive profiles on board these instruments is the broken-stick, which selects the four time/depth pairs of maximum inflection. Under the current abstraction regime, dive profiles are made up of six points; two at the surface, and four at depth, at irregular intervals. Here we develop a method for reconstructing a confidence zone around two-dimensional dive profiles made by southern elephant seals (Mirounga leonina) from the abstracted data delivered by Conductivity Temperature Depth Satellite Relay Data Loggers (CTD-SRDL), by reverse engineering the abstraction algorithm. This method is used to quantify the uncertainty surrounding abstracted profiles. The construction of a confidence zone around abstracted dives forms the first of a two-part mechanistic model whereby data abstraction and compression/decompression procedures represent the observation model which link observed dives to the true, underlying diving process, as defined by known physiological constraints and behavioural characteristics of diving, obtained from more detailed data.

O4.03 Satellite telemetry as a tool to help defining the International Whaling Commission management areas

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Compared with other baleen whales, studies on the North Atlantic (NA) sei whale (*Balaenoptera borealis*) have been sparse since the mid 1980's and great uncertainty persists about their stock structure, migratory patterns and destinations. The International Whaling Commission (IWC) proposed three management areas for the NA sei whale, with boundaries based on statistical convenience and historic catch data that may not represent biological stocks. Several lines of evidence indicate that two sei whale stocks exist in the western NA, one with its centre of summer abundance off eastern Nova Scotia and the other in the Labrador Sea. The Nova Scotia stock seems to migrate south along the continental shelf during autumn, possibly wintering off the Gulf of Maine and Georges Bank. There is no information on the dispersal or winter habitat of animals that summer in the Labrador Sea. Between 2008 and 2009, seven sei whales were successfully instrumented with satellite transmitters off the Azores (Portugal) during their northward summer migration. Mean tracking time was 45,9 days (ranging from 17 to 75 days) and minimum recorded travel distance varied between 2005 and 6025 km (mean = 3570,6 km). Satellite tracks enabled us to link sei whales migrating through the Azores to the presumed Labrador Sea stock. One additional whale tagged in September moved in a southeastern direction, indicating that the whales may be wintering somewhere southeast of the Azores. The data illustrate that these whales utilize at least two and possibly the three management areas proposed by the IWC for NA sei whales, challenging the value of the present boundaries. Selection of appropriate management units is critical to the conservation of animal populations and satellite tagging is a powerful tool to describe the structuring of subpopulations. We discuss how comprehensive tagging programs can help designing ecologically meaningful management areas.

O5.09 Phenological change in marine systems: migratory timing in southern bluefin tuna, *Thunnus maccoyii*

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Southern bluefin tuna (*Thunnus maccoyii*, SBT) are a commercially valuable, quota-managed fish species exploited throughout the southern oceans. SBT undertake annual large-scale ocean basin migrations and Australian fishing effort is concentrated in the summer nursery grounds of the Great Australian Bight (GAB). Juvenile SBT return to this region annually, however, little is known about the migratory cues involved. International management of this species at a level which would maintain sustainable recruitment remains a key challenge for the fishery. However, the synergistic effects of overfishing and climate change, as well the complexities of large-scale seasonal movements and ocean connectivity, present difficulties in establishing an understanding of the ways in which the distribution and phenology of this species may change in the future. Historical archival tag data (n=124) was used to investigate variation in migratory timing spanning a period from 1993-2006. Relationships were found between this migratory timing and environmental variables including sea surface temperature and chlorophyll concentrations. Juveniles travelled further in their winter migration in the Indian Ocean when temperatures were warmer and chlorophyll concentrations were lower. There were also trends for fish to leave these grounds earlier in years characterized by lower chlorophyll concentrations. Summer seasons in the GAB were again related to temperature and chlorophyll, with juvenile SBT leaving later when temperatures were lower and variation in chlorophyll higher. With climate change predicted to result in decreased productivity in the Indian Ocean and increased wind-driven upwelling in the GAB, these results indicate that juvenile SBT may spend longer in the GAB fishery area over summer and travel further west in their winter migration in the future. Although more work is required in order to understand this complex system, this study provides insight into the migratory behaviour of this species and potential impacts of future climate change.

P3.21 New insight in diving and possible foraging behaviour of a white-beaked dolphin using an acoustic tagging system

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Relatively little is known about how free-ranging dolphins use their echolocation. The aim of this study was to investigate echolocation, diving and possible foraging behaviour of free-ranging dolphins. We deployed an acoustic tag (A-tag, W20-AS, Little Leonardo) with a suction cup on a white-beaked dolphin (*Lagenorhynchus albirostris*) in Icelandic waters. The tag system consists of stereo acoustic event recorder (A-tag), a time-depth-recorder (DST milli, Star Oddi) and a VHF transmitter (MM110, Advanced Telemetry Systems). The tag was on the animal for 13 hours and 40 minutes and provided the first insight in echolocation behaviour of a free-ranging white-beaked dolphin. The tag registered 161 dives. The dolphin dove to a maximum depth of 44 m, which is about the depth of the bay where the dolphin was swimming. Dives were divided in U-shaped and V-shaped dives based on duration (U-shaped dives > 50 % bottom time comparing with the maximum depth in a bout and V-shaped dives < 50 % bottom time). The dolphin used shorter click intervals in U-shaped dives (130 ms) compared to those used in V-shaped dives (164 ms). The maximum dive time was 78 s. The dolphin was in acoustic contact with other dolphins about five hours after it was released. It stayed with other dolphins for the rest of the tagging time. Possible foraging attempts were found based on the reduction of click intervals from about 100 ms to 2-3 ms, which suggests a prey capture attempt. We found 19 possible prey capture attempts. Among them 47 % of the capture attempts occurred at the maximum dive depth. In conclusion A-tags provide a useful small tool for studying how free-ranging dolphins use echolocation. More studies on free-ranging white-beaked dolphins are needed to provide a fuller picture of how these dolphins use biosonar in their daily life.

O3.07 Integrating observations of diving behavior and prey fields to study the foraging ecology of short-finned pilot whales *Globicephala macrorhynchus*

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In several areas of their range short-finned pilot whales engage in depredation of captured fish from pelagic longline fisheries. To better understand the ecological context of such behavior, we are studying the foraging ecology of pilot whales off Cape Hatteras, North Carolina. This is an area where depredation and entanglement occur frequently in a pelagic longline fishery directed at bigeye and yellowfin tuna (Thunnus spp.). In the first phase of this work, we deployed 15 digital acoustic tags (Dtags) on adult pilot whales to examine baseline foraging behavior away from longline gear. The sex of seven tagged whales was determined from biopsy skin samples. While the tags were deployed, we made synoptic measurements of the physical environment using ADCP and CTD sensors. We also measured the acoustic volume backscatter of potential prey using calibrated EK-60 echosounders (38 and 120 kHz). This initial phase of field work was completed in September, 2010, so analysis and integration of these data streams are ongoing. We deployed tags for periods from 0.5 to 18.1h, with a total recording time of over 113h (mean 7.6h). The tagged whales dove to 900m and made prey capture attempts at depth. We identified prey capture events from echolocation buzzes on the acoustic records on the tags. Four whales carried tags overnight, spanning both crepuscular periods, thus providing observations of their reactions to diel changes in the vertical distribution of prey. Initial analysis of the tag records of these four whales indicates that they matched their dives to the depth of the deep scattering layer as it migrated vertically through the water column. In the next phase of this work we plan to tag whales in the vicinity of pelagic longline fishing gear to observe their reaction to the presence of captured tuna.

P4.15 Using necessity, ability and environment to explain the behaviors of a marine predator

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Behaviors of a foraging predator are shaped by its ability to forage, the necessity of foraging and the environment with which it interacts. Knowledge of all three factors is important in understanding the implications of remotely observed behavior. We studied this interaction of behavior with necessity, ability and environment for Steller sea lion pups over their first winter (November – April, age 5 – 10 months) in Prince William Sound, Alaska. We captured and recaptured 20 sea lions, logging diving and swimming behavior using Mk9 TDRs (Wildlife Computers, Inc.) and measuring changes in morphological and physiological parameters. Because we estimated, using visual observations and stable isotope trends, that all sea lions were suckling throughout this study, necessity of foraging during this period was solely as supplemental nutrition or training for future independent foraging. Sea lion pups experienced rapid growth during this period (mass gain 30 ± 13 kg, lipid mass gain 18 ± 9 kg, n =20). Despite large lipid mass increase, most pups became less buoyant by April (buoyancy change -6.6 ± 8.3 N), but buoyancy did not predict descent speeds during deep (>50 m) dives (P = 0.614, F=0.262). Pups also did not push their aerobic dive activity, with most dives remaining below cADL (85 ± 15%, n = 20). Lack of interaction between dive parameters and physiological measures suggest pups are not pushing their abilities. Pups exhibited a strong, significant seasonal peak in nocturnal diving and activity (e.g., bout depth, time submerged), with behavior patterns similar to those observed in previous studies of older, likely independently foraging, Steller sea lions. Characteristics of monitored behavior suggest sea lion pups are not yet pushing their ability to forage, and evidence of suckling demonstrates fully independent foraging is not yet necessary, yet sea lion behavior responds to seasonal environmental cues.

P2.03 Foraging strategy of lactating South American sea lions (*Otaria flavescens*) and the indirect interaction with the Uruguayan artisanal and coastal bottom trawl fisheries

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The population of most sea lion species is declining or stable. The population of South American sea lions (Otaria flavescens) in Uruguay is not the exception and it is declining at annual rate of 2.3%. The factors that are causing the decline are unknown; however, it may be a result of interactions and competition for resources with the fisheries. The objectives of the present work were to determine: a) the foraging areas and diving behavior of lactating sea lions, b) the diet of sea lion, c) an index of resource overlap between the diet and the fisheries catch, d) the spatial-temporal overlap between sea lions foraging areas and the operational areas of artisanal fisheries and coastal bottom trawl fisheries. We used i) satellite telemetry and time-depth-recorders (TDR), ii) indexes of overlap (Morisita-Horn, Colwell-Futuyma, and impact-resource-overlap-index), iii) global information system, and iv) traditional method to determine the diet. Scats (n=52) were collected during the summer at Isla de Lobos and otoliths and cephalopods beak were identified. Ten lactating sea lion were instrumented with satellite and TDR tags during the austral summer. Females conducted benthic dives of short duration (mean±SD, 1.9±0.7min.) and to shallow depths (20.5±7.7m.). Foraging trips lasted 1.3±0.8d and the trip did not exceed the continental shelf (>50m of depth). The scat analysis indicated the most abundant prey were cephalopods and stripped weakfish (*Cynoscion guatucupa*); however, the principal contribution of biomass to the diet was accounted by whitemouth croaker (*Micropogonias furnieri*), cutlassfish (*Trichiurus lepturus*), Brazilian codling (*Urophysis brasiliensis*) and argentine croaker (*Umbrina canosai*). The indexes of Morisita-Horn (0.84) and Colwell-Futuyma (0.73) reported a high level of overlap, whilst the impact-resource-overlap index showed a moderate to high level of overlap. The results of the present work may have implication for the management of sea lions and the Uruguayan fisheries.

O2.09 It's an eel of a life: tracking *Anguilla anguilla* to the Sargasso Sea is not for the faint hearted

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European eels (*Anguilla anguilla*) undertake a ca. 5,000 km spawning migration from Europe to the Sargasso Sea, during which they develop to sexual maturity from adolescence under conditions of starvation and extreme exertion. Eel stocks fluctuate naturally, but stocks across Europe have declined by 95% in the last 30 years and the causes are uncertain. The conditions that eels experience during their migration, the threats they face and the types of behaviours that they exhibit are therefore of direct interest to those interested in conserving this species. However, the difficulties related to tracking eels in the Atlantic Ocean have driven many scientists to distraction. Satellite tag technology offers a solution but, until recently, the sizes of available tags have precluded tracking animals as small as European eels. Here we present information about the migratory behaviour of female European eels during their spawning migration, based on data collected with miniaturized PSATs and with archival tags. We have been able to track eels up to five months and >2000km from release. Eels migrated towards the Sargasso Sea at speeds consistent with previous acoustic tracking research (5 km d-1 to 25 km d-1). During their oceanic migration, eels adopted a diel vertical migration pattern, ascending rapidly into shallow water (~200m) at dusk and returning rapidly into deep water (up to 1200m) at dawn. Due to the large depth change at dawn and dusk, eels experienced a temperature gradient of up to 5°C twice per day and a pressure change of up to 100 bar. Across the sampled population, geographic migration was observed between 1.5°C and 12°C. We will discuss how further improvement of methods of tag attachment and miniaturization of PSAT tags renders it entirely realistic to record the entire spawning migration to the Sargasso Sea.

KEYNOTE A particle on the road to ecologically sustainable fisheries

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Common sense dictates that the future of human societies depends on the maintenance of marine (and terrestrial) systems that are healthy and managed sustainability over the long term. The conventional indicators of marine health suggest our track record in achieving this goal leaves a lot to be desired. Advances in fish location technology and fishing gears, and increases in fleet sizes combined with increasing demand for seafood across the globe has resulted in a widespread decline in marine biodiversity. These changes have outstripped our capacity to integrate sustainable stewardship practices into fisheries policy and management. Impacts are not limited to target species - non-target species, such as seabirds, are also affected: 18 of the 22 species of albatrosses are endangered according to IUCN criteria principally due to bycatch in fisheries. Scientists have an important role to play in developing and implementing solutions to critical problems associated with fisheries. The presentation will a) allude to some of the issues that undermine sustainability, b) outline some of the lessons learnt during the course of working collaboratively with the fishing industry, c) provide case studies of the links between research and management and, d) summarise progress on a new technology to reduce (or eliminate) seabird mortality in tuna and swordfish longline fisheries. The talk is mainly aimed at scientists interested in working at the interface between wildlife conservation and the fishing industry.

O5.17 Migration patterns and habitat preferences of the shortfin mako shark, *Isurus oxyrinchus*, in the Southern, Indian and SW Pacific Oceans

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We used satellite tags to investigate the migration patterns, and habitat preferences of shortfin makos in the Southern (SO), Indian (IO) and SW Pacific Oceans (PO). Eleven makos were tracked for up to 680 days. Several were highly migratory, and moved >20,000 km. One shark migrated from shelf waters in the Bonney Upwelling region off SE South Australia, to an oceanic area ~1500 km SSE of Madagascar, Africa. Temperature and pressure sensors on tags indicated that makos had broad thermal tolerances of 7–28 °C, and minima were mostly experienced during deep dives in the SO. Tagged sharks generally oscillated between depths of 5–160 m in shelf waters, and max depths of 400–800 m were recorded in oceanic habitats. Makos have several key oceanic and shelf habitats, and clear affinities for areas of benthic and thermal complexity, including seamounts, shelf slope canyons and SST fronts. We identified several important habitats for makos, included the mid-shelf and shelf break waters of the Great Australian Bight and SW Western Australia, the subtropical front in the SO and IO, and the NE IO, south of Java, Indonesia. Our findings indicate there is considerable potential for integrating electronic tagging of this species in future programs developed to assess the impacts from multiple jurisdictional fisheries and monitor the impacts of climatic change on pelagic ecosystems and other top predators.

P3.22 Exploring the determinants of individual foraging quality using penguins as a model

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Early studies using data-logging devices on free-ranging animals were mostly directed at a subset of individuals in a population that were either chosen randomly or at least of known basic information, such as or sex. In all cases, a large intra-individual variability in behaviour and performance has often been noted. Other intrinsic parameters, like age and experience, as well as physiological condition, must play a role in explaining why some individuals always seem to perform better than others. This remains a challenging question to address but thanks to advances in automatic identification/monitoring and molecular techniques we have now explored the foraging and breeding activity of known-age breeding king (Aptenodytes patagonicus) and little penguins (Eudyptula minor). Young birds appear to be biomechanically less efficient in managing buoyancy or in organizing their underwater time. Older birds, in contrast, appear to counteract their decreasing physical ability with their accumulated experience. Yet, age has only weak effects on hunting efficiency and then do not fully explained foraging performances. This may be due to our non-longitudinal sampling effort and to the fact that actual chronological age and biological age, estimated from telomeres length, are not linearly correlated. In other words, the determinants of individual quality would probably better be explained by measuring experience at molecular levels.

O3.06 Solid-state, animal-borne video loggers for medium-sized, free-flying birds

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Recently, first studies successfully deployed miniaturised video cameras on wild, free-flying birds, collecting detailed behavioural data in places and contexts where conventional observation techniques fail. Here, we describe the development of a new generation of solid-state video loggers that are cheap, light-weight, programmable and easy to use, and that overcome many problems associated with earlier transmission-based technologies. Our units weigh ca. 13 g (fully packaged) and record up to 90 min of video footage (640 x 480 pixels; 19.7 frames-per-second) on a 4-GB micro-SD card. Loggers are fitted with a micro-processor that enables duty-cycling of the unit, for example: (i) to switch the logger into standby for an initial habituation period (to allow the bird to recover from trapping/tagging); (ii) to schedule recording to coincide with the species' presumed activity peaks (to increase the likelihood of documenting rare, or interesting, behaviours); and/or (iii) to record footage in evenly spaced, short recording bouts (to accumulate quantitative, standardised 'daily-diary' data). Loggers contain a VHF radio-tag (battery life ca. 5-15 weeks) to enable positional tracking of the bird before, during and after scheduled video shoots, and to aid logger recovery for video-download. Units can be manufactured at comparatively low cost (component costs ca. 145 USD, plus ca. 215 USD for the VHF radio-tag) and are easily refurbished after recovery, making the technology suitable for projects on modest research budgets. A pilot study in 2009/2010, with logger deployments on 19 wild New Caledonian crows (*Corvus moneduloides*), demonstrated that our new technology is field-worthy and can generate rich datasets on the foraging behaviour, habitat use and social interactions of an elusive bird species that is otherwise difficult to study. The young field of wildlife video-tracking is maturing quickly, and in only three years, technology has advanced sufficiently to enable cost-effective, quantitative field studies.

O1.13 Foraging strategy and energy expenditure of black-browed albatrosses in the open ocean

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Albatrosses fly many hundreds of kilometers across the open ocean to find their prey. To better understand their foraging strategy, we investigated (i) whether such long-distance flying is energetically reasonable and (ii) how albatrosses actually locate their prey. To address these questions, we deployed several types of data loggers on free-ranging black-browed albatrosses (*Thalassarche melanophrys*) over a single foraging trip during the chick-guarding period, at Bird Island, South Georgia. First, we deployed the combination of accelerometers and electrocardiogram recorders and examined the relationship between wing flapping and heart rate (as a proxy of energy expenditure). During flight, the number of wing flaps per minute linearly correlated with heart rate. However, 97% (median) of flight was spent gliding and heart rate during gliding was almost the same as that when resting on the water, suggesting that moving in the air to be energetically similar to resting on the water. Secondly, camera loggers were used to record information about the individual's environment during a foraging trip. The still images recorded from the loggers showed that some albatrosses actively followed a killer whale (*Orcinus orca*), possibly to feed on food scraps left by this diving predator. The camera images, together with the depth profiles, showed that the birds dived only occasionally, but that they actively dived when other birds or the killer whale were present. This association with diving predators or other birds may partially explain how albatrosses find their prey more efficiently in the apparently 'featureless' ocean, with a minimal requirement for energetically costly diving or landing activities. Taken together, these results indicate that albatrosses may maximize foraging efficiency by flying long distances across the open ocean.

O1.16 Biomechanics and shallow dive angles of emperor penguins

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Air-breathing animals are assumed to choose vertical pitch angles for transit between the surface and depth to maximize the proportion of time spent foraging. To assess this assumption, we deployed data loggers to record swim speed, depth, 2-axes accelerations (stroking effort and pitch angle) and temperature on 10 emperor penguins making foraging trips from the Cape Washington colony (74°39' S, 165°24' E). During trips of 7.9 to 19.7 days, the maximum dive depth of each bird ranged from 357.5 to 513.5 m. Penguins usually started descent with shallow pitch angles (ca. -30°), and after 100 m depth they kept their pitch angles steep around -70°. According to an energetic calculation, considering metabolic energy and work against mechanical forces (drag and buoyancy), vertical transit is the optimal way to descend to the foraging depth. However, a shallower angle can decrease thrust force in comparison with vertical descent. Penguins may adopt shallow pitch angles at shallow depths where buoyancy was and thrust requirements are highest. Near the maximum dive depth, penguins made their pitch angles shallower and swam horizontally presumably to search and capture prey. Penguins kept their pitch angles steep during the first half of ascent, but stopped beating their flippers and made prolonged glides to the sea surface during the last part of ascent. During the prolonged glides, they changed their pitch angle from steep to shallow. The increase in buoyancy during final ascents allowed gliding penguins to move horizontally without stroking.

O1.09 King penguins foraging movements in relation to oceanographic features at Kerguelen: consequences of inter-annual changes in the thermal structure

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Environmental variability is known to influence the distribution of mid-trophic level species that are prey for diving predators such as penguins. The king penguin (Aptenodytes patagonicus) is one of the key avian diving predators of the Southern Ocean. To exploit locations that have enhanced prey availability, penguins are thought to dynamically alter their foraging behaviour in response to both the prey and the environmental conditions encountered.
In this study we examined the foraging behaviour of king penguins breeding at Kerguelen island in relation to oceanographic and environmental variability. King penguin at-sea movements have been monitored since 1998 in this locality. Special focus was set on the breeding season 2010, characterized by exceptionally long foraging trips and low reproductive success. We used Argos and GPS tracking together with time-depth-temperature recording to follow the movements of king penguins during foraging trips directed towards the Polar Front, which is known to be an important foraging area for marine predators as their prey aggregates near to associated oceanographic features. To identify feeding areas we analysed both the animals surface movements and their diving behaviour. To identify feeding events during the dives, we used indices from penguin underwater movements during the bottom phase of their dives. Combining the observed foraging behaviour with environmental data we studied how animals adjust their horizontal and vertical movements in response to their environment, and how hydrological conditions influenced their feeding behaviour. The thermal structure of the ocean in years such as 1998 and 2010 appear to have an important influence on prey distribution and consequently on foraging. A comparison with previous years highlights the influence of environmental variability on the foraging behaviour of penguins. The observed dependence on temperature could be critical in terms of potential changes in the thermal structure of the ocean influenced by climate change.

P4.16 Satellite telemetry reaches new depths: a case study of the application of a new depth-linked satellite tag to Cuvier's beaked whales

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The application of small, dorsal fin-attached satellite transmitters which can collect data over periods of weeks to months will vastly improve our ability to study the movements and diving behavior of small and medium- sized odontocetes. This is particularly true for difficult to study species and populations, such as beaked whales, for which baseline data on habitat use, ecology, and biology is critically needed for management decisions. Three prototype dive-depth recording, Low Impact Minimally Percutaneous External-electronic Transmitter (LIMPET) tags were deployed on Cuvier's beaked whales (*Ziphius cavirostris*) in 2010- one in Hawai'i, and two on a navy training range in southern California- with the ultimate goal of collecting baseline data and determining impacts from anthropogenic activities. The median transmission duration of these tags was 54 days (range = 8 -90 days, one tag still transmitting), with a total of more than 46 days of dive data collected. Combined with movement data obtained from Argos locations, this represents the longest behavioral data set for beaked whales to date. Multiple dives to depths greater than 2,000 m (deepest = 2,832 m) were recorded from two individuals, as were several dives over 90 minutes in length (longest = 115 min), representing the deepest dives recorded for any marine mammal and longest dives recorded from cetaceans. For the individuals tagged in southern California, they also confirm previous observations that the time spent at the surface between dives greater than 50m is typically very short (median = 1.7 min, range = 0.1 – 41.3). The ability to collect such detailed data over extended spatial and temporal scales will be essential to understanding the behavioral ecology of difficult to study species such as beaked whales, and for understanding changes in behavior during exposure to anthropogenic events.

O4.17 Vertical and horizontal habitat preferences of post-nesting leatherback turtles in the South Pacific Ocean - Implications for conservation

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Leatherback turtles are the largest and widest ranging turtle species, and spend much of their time in the offshore pelagic environment. However, the high seas have thus far received little management attention to protect their ecosystems and biodiversity. During 2004-2007, 46 female leatherback turtles were tagged with satellite transmitters at Playa Grande, Costa Rica (Pacific Ocean). In this study, we analyzed the vertical and horizontal habitat preferences of leatherback turtles in the South Pacific Ocean. Turtles exhibited short, shallow dives during their migration southward (mean depth = 45 m, mean duration = 23.6 min), followed by deeper, longer dives (mean depth = 56.7 m, mean duration 26.4 min) in the South Pacific Gyre that probably indicated searching for prey. We integrated the horizontal movements with remotely-sensed oceanographic data to determine the turtles' response to the environment, and applied this information to recommendations for conservation in the pelagic environment. A generalized additive mixed model applied to the daily turtle travel rates confirmed that slower travel rates occurred at cooler sea surface temperatures, higher chlorophyll-a concentration and stronger vertical Ekman upwelling, all of which are considered favorable foraging conditions. The southern terminus (35-37□S) of the leatherback tracks was also in an area of increased mesoscale activity that might act as a physical mechanism to aggregate their prey, gelatinous zooplankton. However this could also act as a thermal limit to their distribution. This characterization of leatherback habitat use could aid the development of management efforts within the South Pacific Ocean to reduce mortality of leatherback turtles from fisheries interactions.

O4.18 Fast lunge or slow plow: behaviour and kinematics of filter feeding in balaenopterid and balaenid whales observed with multi-sensor tags

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Marine mammals have developed several distinct bio-mechanical strategies to acquire prey within the constraints of breath-hold dives. Baleen whales employ two foraging techniques: discrete lunge feeding on elusive prey by balenopterids, and continuous ram filtration of plankton by balaenids. These two strategies involve very different flow regimes and we hypothesized that different gait and swim speeds would be adopted to support each technique. To test this, we tagged bowhead and humpback whales with DTAGs sampling three-axis accelerometers and magnetometers, pressure sensors and sound. This fast-sampling sensor-array provided fine-scale information about the kinematics and swimming behavior by these two species during prey capture. Lunge feeding humpback whales use a stroke-and-glide gait in all dive phases to reduce oxygen consumption and so increase time at foraging depth. Each feeding lunge is achieved with 2-4 fluke strokes (0.5Hz fluking rate) which serve to expand the buccal cavity with prey-laden water and accelerate the engulfed water. With a mean of 3 lunges per dive humpbacks filter about 1000 tons of water per hour of foraging. Bowhead whales also use a stroke-and-glide gait during descent and ascent, but change to a continuous slow fluking gait (0.12Hz fluking rate) when feeding. This gait enables a slow but steady speed of less than 1ms-1 despite the drag from the large filter apparatus. Filtered volume increases no-more than linearly with speed while drag increases with the square of speed. Thus such slow swimming may represent an optimum point in the effort-gain trade-off. With a filtering rate of 3.2m3s-1, foraging bowheads filter about 6000 tons of water per hour. We conclude that bowhead and humpback whales are not only morphologically specialized to different prey and feeding techniques, but they also employ very different gaits and swim speeds to maximize energy returns during discrete and continuous filter feeding.

P3.23 Influence of environmental conditions, morphology and tag size on lactating northern fur seal *Callorhinus ursinus* diving behavior

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Northern fur seal (NFS; *Callorhinus ursinus*) pup production on the Pribilof Islands, U.S.A., has been declining at 6% per year while numbers along the Kuril Islands, Russia are near their historical high. One hypothesis for the decline on the Pribilofs is reduced prey availability – potentially studied through examining differences in foraging behavior. With a goal of comparing these populations, our objective here was to describe the influence of environment, morphology, and datalogger size on individual behavior. During summers of 2005 through 2008, 43 lactating female NFSs were captured, weighed, and equipped with an assemblage of dataloggers (total weight, 35g – 1200g) including at least one time-depth recorder. Generalized linear models were used to examine the influence of year, day of year, tide height, moon illuminance, atmospheric pressure, seal length, and tag frontal surface area (FSA) on dive behaviors. Response variables included: proportion of time in water (PIW), dive rate, post-dive surface interval (PDSI), bout duration, depth, ascent and descent rate, bottom time and dive duration. We included all permutations of the main effects as candidate models for each response. Candidate models within 2 AICc of the best model were considered important and model averaging was used. Moon illuminance was found to have a strong influence on behavior as seals tended to dive deeper and longer during brighter moonlit nights. PDSIs tended to be shorter and bouts longer for larger seals. Model predictions suggested that increasing tag FSA from 3 cm2 to 31 cm2 resulted in a 70% increase in PIW, 21% increase in dive depth, 8% decline in dive duration, and a 13% and 17% increase in descent and ascent rates, respectively. Based on these results we suggest that environment, seal morphology, and tag size should be considered in future studies using individual NFS dive behavior to examine differences on a population scale.

P4.17 Technological advances allow real-time quantification of selective brain cooling in artiodactyls

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The artiodactyls are a group of mammals that posses a carotid rete, a network of thin-walled vessels, located within the cavernous sinus at the base of the brain. These structures facilitate selective brain cooling, a hypothalamic temperature below that of arterial blood temperature, via rapid heat exchange between warm arterial blood entering the carotid rete, and cool venous blood, draining from the nasal mucosa into the cavernous sinus. Selective brain cooling is believed to attenuate the drive for evaporative heat loss, providing an important water conservation mechanism, and possibly providing a selective advantage to past and present climate change in artiodactyls. We have developed implantable temperature tags that, for the first time, provide real-time measurements of carotid arterial, jugular venous, and hypothalamic brain temperatures in free living animals. Temperature data from these tags are saved to a data logger and a copy of the data is transmitted via a GSM network to a server for real-time download. These temperature tags were implanted and tested in eight Dorper sheep under laboratory conditions. In this paper we provide details on this newly developed technology, show some of our initial results, and explore possible ways in which this technology could contribute to the field of conservation physiology.

O4.23 Movements of three Northeast Atlantic populations of ivory gulls revealed by satellite telemetry

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The ivory gull *Pagophila eburnea* is one of the most threatened seabird species in the world, but also one of the most poorly known. High levels of contaminants, illegal hunting and reduction of its main habitat, the sea ice, are identified as the major threats. In Canada, ivory gull populations have declined dramatically (80-85%) during the last 20 years, while the status of the species in the rest of its distributional area (Greenland, Svalbard/Norway and Russia) is not properly assessed. Here we use Argos-compatible PTTs to track flyways and wintering grounds of ivory gulls breeding in Greenland, Svalbard and Russia during 2007 to 2010. Birds from North Greenland, Svalbard and NW Russia make extensive use of the northern Barents and Kara Seas ice-edges during the post-breeding period before moving westward (on a loop flyway) to the northern Fram Strait. Subsequently they follow the ice-edge southwards around the southern tip of Greenland ending up in northern Labrador Sea and southern Davis Strait. This area is the main known wintering grounds for the species and here they also mix with ivory gulls from the Canadian populations. However, some birds from all three Northeast Atlantic populations moved eastward after the post-breeding period and ended up in the North Pacific where a smaller wintering area exists. During the pre-breeding migration the birds followed the same route back again making extensive use of the northern Fram Strait ice-edge before returning to their breeding colonies. In addition to discovering the bi-directional migration pattern of Northeast Atlantic populations of ivory gulls, the tracking data also show how movements and habitat use vary in response to sea-ice concentrations, food availability and breeding cycle.

O3.01 A general Bayesian approach to location estimation and software for traditional and modern track analysis techniques

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Many existing techniques for estimating location confound problems of location accuracy with simplistic track representations and under-utilization of available data. An extensible software package for applying traditional techniques such as speed filtering and time spent estimation is presented. This software enables the application and exploration of various techniques. These include filtering, time-spent / residency gridding, projection transformation and GIS integration. A novel Bayesian approach is introduced for the more general problems faced by different tagging techniques. This approach integrates all sources of data including movement models, environmental data and prior knowledge. This general framework is illustrated by application to satellite tag data and light-measuring archival tag data. Model runs from this approach result in very large databases of samples from Markov Chain Monte Carlo (MCMC) simulations and techniques for summarizing these are illustrated. This flexible and extensible system helps solve issues of location uncertainty with a full path representation and provides spatial estimates for multiple animals. The relation between archival tag data and ocean circulation is used to illustrate the potential application of archival tag data for location estimation for diving animals in a manner similar to commonly used SST methods. Two applications for improving the application of at-depth oceanographic data as a location source are presented:

a) Diving profiles from elephants seals are compared with 4D oceanographic data sets of salinity and temperature.

b) A proxy model for subsurface temperature to ocean height is discussed that allows the comparison of lag-corrected temperatures to sea surface height (SSH) products.

This approach provides a number of important improvements to the derivation of location from various types of tag data by integrating disparate information sources in a systematic way. These applications, along with existing and in-development software, help bridge the divides between various analytic techniques traditionally employed for animal tracking.

P1.08 Diving behavior and offshore activity budget during a foraging trip of a female South American sea lion (*Otaria fravescens*) off Isla de Lobos (Uruguay)

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A single foraging trip of a female South American sea lion (standard length: 184 cm, body mass: 109.6 kg) breeding on Isla de Lobos (Uruguay) was tracked using a satellite transmitter (SPOT 5; Wildlife Computers Inc., USA), and its diving behavior was recorded using a three-axis accelerometer with magnetometer to reconstruct 3-dimensional dive profile and a propeller to record its swim speed (W2000L-3MPD3GT; Little Leonard Ltd., Japan). The trip duration was approximately 4.7 days, and 85 % of the trip (96.6 hours) was recorded by the accelerometer, with the cumulative horizontal distance covered of 425.5 km and the maximum straight distance from the island of ca.115 km. The foraging behavior was divided into three categories; vertical dive (>5 m), surface swim and surface rest. The percentage of each category was 53.8 %, 32.4 % and 13.7 %, respectively. Total recorded number of the dives was 1,285. The number of diurnal dives was 650 and that of nocturnal dives was 635. There was no significant difference in mean dive depth (22.1±4.6 m vs. 21.8±4.4 m, $P > 0.05$), while the mean diurnal dive duration was slightly but significantly longer than nocturnal one (149.1±34.7 sec vs. 142.2±43.6 sec, $P < 0.05$). The percentage of the cumulative surface resting duration during day was 3.2 % and that during night was 21.4 %, with the maximum resting periods reaching 0.7 hour during daytime and 2.5 hours at night. In addition, the temperature data showed several complex thermal inversions around this ocean area, with differences of ca. 2ºC at depths deeper than 10 m. This finding suggests that animal-borne instruments can record oceanographic variables that reveal mesoscale features that would not be revealed by satellite information. Some changes in diving behavior corresponding to this thermal inversion were also observed.

P4.18 Swimming patterns and habitat use of Sakhalin taimen (*Hucho perryi*) in the Bekanbeushi River, Lake Akkeshi and an estuary in Hokkaido, Japan

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Sakhalin taimen (*Hucho perryi*) is the biggest salmonid in Japan and critically endangered. Adults migrate between rivers and coastal seas, but their habitat use of each area is unknown. To better understand their habitat use and to develop a conservation program, it is necessary to investigate their activity patterns in the different habitats. We investigated the swimming behavior of Sakhalin taimen using acceleration data loggers with radio/acoustic tags. The acceleration data loggers recorded two-axis acceleration to monitor swimming behavior, and the radio/acoustic tag was used to locate the tagged fishes. The tags were retrieved using a time-scheduled release system that allowed the loggers to be located using VHF radio signals. The investigation was conducted in May 2009 and 2010 in eastern Hokkaido, Japan in the Bekanbeushi River, Lake Akkeshi (a brackish water lake), and a connecting estuary. Six adult Sakhalin taimen were caught in Lake Akkeshi, and released at the lake after tagging. After 67-97 hours, all tags were recovered, and the data were retrieved. Two of the fishes moved up the river, and the rest remained in the lake or estuary. The fish that remained in the lake or estuary swam actively from sunset to dawn, while the two that entered the river swam continuously for 7-11 hours and then stopped moving. The fish in the lake or estuary appeared to move in the darkness, while the fish in the river were sedentary during both the day and night. This difference of swimming behavior may have been due to differences in environmental conditions such as water velocity, amount of material like fallen wood in the water, or space available for movement.

P4.19 Habitats use and diving behaviors of male and juvenile loggerhead turtles, *Caretta caretta*

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Loggerhead turtles are known to change their diet and habitat from oceanic to neritic as they grow. However, their foraging behaviors are largely unknown especially in oceanic environments. To examine habitats and diving behavior of loggerhead turtles in oceanic areas, we used Argos satellite tags. We attached SRDL tags (SMRU) to two adult males (SCL: 83.5 ± 7.0 cm) and four juveniles (SCL: 63.6 ± 4.2 cm) in summer 2009. Study area is off Sanriku coast (N39°21, E142°00), > 600 km far from nesting grounds, so they are considered to migrate for foraging. SRDL tags record horizontal position, temperature and also dive profiles. Mean tracking duration was 167.8 ± 144.4 days. However, transmission of the two males stayed within neritic areas all times were stopped in 17 and 22 days. For the four juveniles, high use areas were calculated from mean daily location using fixed kernel density estimation (KDE). They remained in oceanic areas (> 200m) during most of tracking periods and two high use areas were detected (35 - 40°N, 140 - 150°E and 28 - 40°N, 155 - 173°E). Mean daily dive depth of the four juveniles was shallow (13.6 ± 8.7m, n = 813). But, one juvenile changed its diving behavior dramatically during May and July 2010. This turtle dove >100 m in the open ocean, where bathymetric depth was several thousand meters, for 17 times. Maximum depth recorded was 332m, the deepest record for this species. The area, where the turtle repeated deep dives, was coincident with high use areas. It was found the high use areas revealed by fixed KDE corresponded to the location near the seamounts. Therefore, the turtle possibly foraged deep oceanic prey where upwellings exist. Our result suggested the possibility of using wide range of depth up to 300m by juvenile turtles.

O4.08 Using seabird tracking data for the identification of important marine areas in the Southern Ocean

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The wandering albatross (Diomedea exulans) has amongst the most widely dispersed foraging ranges of any seabird. The huge range, generally entailing long looping flight paths, and lack of obvious centres of distribution during oceanic trips make it difficult to identify the marine areas of greatest importance to this species, many of which are likely to be large regions of the high seas, beyond the boundaries of national jurisdiction.
A suite of tracking analyses was applied to data from Platform Terminal Transmitters deployed on adult birds during chick-rearing at Bird Island, South Georgia, collected in ten breeding seasons from 1991 to 2004. This showed that although high seas regions were important in most years, the locations of key areas were not consistent from year to year. Far greater consistency, both between individuals and between years, was seen in use of areas within 200km of the colony that were genuine feeding areas; the result was not a consequence of frequent crossing of tracks during departure and return to the colony. Although appropriate ecosystem management in the transient high seas areas identified is clearly desirable, high priority should also be given to improved protection of these nearer shore zones, which already fall within national legislative frameworks. Relatively small changes to existing management schemes may therefore have more impact on species conservation than previously recognised.

P4.20 Feeding habits of Japanese lates detected by a fish-borne camera and a micro 3-axis accelerometer in the Shimanto River, Japan

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Information about feeding habits has become critical for conservation of wild animals and ecosystem-based management in recent decades. However, it is unjustifiable to kill an endangered fish such as a Japanese lates, Lates japonicus, simply to reveal its stomach contents. Here, we developed a way to determine feeding habits of the species without killing by using a micro-digital still camera (DSL) and a 3-axis micro-accelerometer (ORI380-D3GT) attached to the dorsum of the Japanese lates. To identify feeding events from the 3-axis acceleration records, feeding behavior of Japanese lates in captivity were recorded by a high-speed video camera and the D3GT. The high-speed images showed that the fish were opening its mouth with a quick downward movement (less than 0.17 s) of the mandibles and taking in a prey via suction feeding. This movement was also simultaneously recorded by significant change of the 3-axis records obtained by the D3GT. We attached D3GTs and DSL named as a fish-borne camera with an automatic releasing system to the dorsum of a wild adult Japanese lates together with an acoustic transmitter, and released them in the Shimanto River. After retrieving the loggers, the DSL have taken a total 4563 underwater images from the fish during 5 hrs. These photos showed that the fish spent most of time to stay in deep, while it has sometimes moved between surface and bottom of the river. When the fish encountered artificial structures, fishing gears and other Japanese lates, it stayed and swam around them. The 3-axis accelerometer revealed that the fish showed the same pattern of feeding events as those in captivity in sandy bottom around the deep region of the Shimanto River. We confirmed that the 3-axis accelerometer and the fish-borne camera were very useful for detecting feeding habits of Japanese lates.

O1.03 Using statistical methods to determine individual foraging strategies using satellite telemetry parameters

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Despite advances in satellite telemetry, the development of analytical methods to identify individual based foraging strategies has proven difficult because of some inherent difficulties associated with telemetry data. Researchers have characterized different foraging strategies by eye instead of applying mathematical approaches to distinguish between groups. This study uses a quantitative analysis of numerous telemetry parameters, state-space modeling metrics and foraging success data to evaluate individual foraging strategies in adult female elephant seals. Seals were instrumented with Argos or GPS satellite biologgers twice per year, post-molt and post-breeding 1998-2010 (n= 171). Upon visual inspection of tracking data, adult females travel in one of three general migration paths: Westerly, along the North Pacific Transition Zone; North Westerly into the Subarctic Gyre; or North through the California Current into the Coastal Alaska downwelling region. To distinguish if these strategies can be identified using an analytical approach, a multivariate model that applied principle component analysis and cluster analysis with multi-scale bootstrap resampling was used to group satellite telemetry and behavioral parameters. Specifically, parameters utilized were track shape, outgoing and incoming angles from the rookery, and habitat use (on-shelf/off-shelf/ecoregion). State-space modeling techniques identified foraging versus transiting locations in these habitats. Lastly, body composition and mass gain were used as a metric for foraging success. The model identified eight different foraging strategies-- more than were identified by visual techniques. This method provides a more robust means of identifying individual foraging strategies using satellite telemetry data.

P3.24 Natal dispersal and diving behaviour ontogeny in juvenile Emperor penguins Aptenodytes forsteri from Adélie Land

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The juvenile phase is a critical period for seabirds during which they have to care for themselves and develop skills for both foraging and anti-predator behaviours. The ontogeny of foraging behaviour and dispersion at-sea of post-fledging penguins remains however poorly documented. Emperor penguins are largely confined to waters that are covered at least seasonally by sea-ice. In this study, we were interested in documenting the natal dispersion movements of juvenile emperor penguins, and the ontogeny of their diving behaviour. In December 2009, 6 SPLASH tags were attached to fledged penguins from the Pointe Géologie colony (66°78 S, 140°08 E), Adélie Land. These tags transmitted diving data histograms and location through Argos weekly, during an average of 98 (24–253) d. Juveniles rapidly headed northwards and 4 of them reached latitudes as north as 55°S in the Polar Frontal Zone in mid-January and stayed there until mid-February. Then, the two still tracked juveniles headed southward, up to 65°S (mid-April). Afterwards, the last tracked individual showed a westward migration of 2700 km close to the Antarctic shelf slope, along the pack ice edge. Transmission ceased in August. Activity data from the first weeks showed that juveniles were readily capable of diving up to 150–200 m during 5 min, with the majority of dives below 10 m. During winter juveniles dived typically 80–100 times a day, 200 m deep during 6–7 min (up to 250 m and 9 min). This study points out the importance of the Polar Frontal Zone area for emancipating juveniles. It also shows that they are dependent on the sea-ice edge during winter when their diving performances stabilize. Local sea-ice conditions may therefore not only affect the breeding part of the population but may also be fundamental for the survival of the juvenile emperor penguins.

O3.14 Stress hormone affects incubation behaviour of male Adélie penguins (*Pygoscelis adeliae*)

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Life-history theory predicts the existence of trade-offs between reproduction and survival, since organisms have access to limited resources. Moreover, global climate changes may affect the availability and predictability of food resources, causing nutritional stress during periods of high energy demand such as breeding. Corticosterone (CORT), the main stress hormone in birds, is described as mediating resource allocation, allowing animals to adjust their physiology and behaviour to changes in the environment. In this study, we examined the effects of experimentally elevated CORT levels on parental investment during incubation in a long-lived seabird species, the Adélie penguin. Incubation behaviour was measured with dummy eggs that recorded temperature and changes in egg angles. Here we show that elevated CORT levels affect both parental investment during the incubation period and reproductive success in Adélie penguins. CORT-implanted males deserted their nests more often (64% vs. 7% for controls) and earlier (14.7days ±0.9 vs. 21.5±1.8) than controls. CORT-implanted penguins that did not desert their nest incubated for a longer period, but the reproductive success was not affected by the treatment. Moreover, CORT-implanted males with dummy eggs incubated at lower temperature compared to controls. Egg rotation rates did not differ between the two groups. To our knowledge, this is the first experimental study investigating how the stress hormone affects incubation behaviour in a seabird species. The results support the hypothesis that CORT participates in the allocation of available energy: elevated baseline CORT levels induced a decrease in energy allocation during reproduction to the benefit of self-maintenance and future reproductions. Low incubation temperatures in CORT-implanted penguins might alter embryonic development and chicks' body condition at hatching, with possible consequences on chick growth and survival. Further work is needed to evaluate the relationships between CORT levels and breeding performance of seabirds over the long term.

O5.18 Habitat utilisation by adult male southern elephant seals from Marion Island

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Sub-Antarctic Marion Island lies approximately 440km's due east of the intersection between the Andrew Bain fracture zone and the Southwest Indian ridge. The interaction of the Antarctic Circumpolar current with this bottom topography creates a region of intense eddy formation and high levels of mesoscale variability that is readily observed on the sea surface. The movements of adult southern elephant seal males from Marion Island seem to be independent of sea-surface characteristics. Thirteen adult male southern elephant seals were instrumented in 1999, 2002 and 2007. All thirteen animals were tracked for longer than 70 days. Five of the 13 animals hauled out on either Crozet or Kerguelen Island during the breeding season. Four of the 13 animals returned to Marion Island. Maximum distances from Marion Island ranged between 20km's (track duration=205days) and 2820km's (track duration=275days). A large amount of individual variability was displayed in foraging tactics and habitats used. In contrast to other populations adult male southern elephant seals do not show any signs of using benthic habitats. Adult male seals were prone to utilising a single locality for an extended period of time. As a result, sea-surface temperatures and chlorophyll concentrations varied within areas of restricted movement. Areas of restricted movement coincided with bathymetric features, frontal zones or areas where these features interact. These localities may be characterised by a range of prey species that change with changing environmental characteristics or by unique fauna that are determined by the unique conditions created by the interactions of ocean currents with bathymetric features. The availability of prey, avoidance of competition and large energy requirements of adult male southern elephant seals may drive observed variability in foraging behaviour by adult male southern elephant seals.

O5.19 Top predators partition the Bering Sea

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We tracked the movements of pinnipeds (northern fur seals) and seabirds (thick billed murres and black legged kittiwakes) breeding on the Pribilof Islands (central Bering Sea) and Bogoslof Island (southern Bering Sea) to determine where these central place foragers feed relative to the constraints of distance from land, environmental conditions, and availability of food. A total of 115 fur seals, 128 murres and 106 kittiwakes were equipped with GPS and activity tags. Results from 2008 and 2009 showed no overlap in foraging areas for black-legged kittiwakes or thick-billed murres breeding on the two Pribilof Islands despite the islands being within foraging distance of each other. Nor was there any overlap between the foraging areas for seabirds from Bogoslof Island compared to those from the Pribilofs. Foraging ranges of northern fur seals were much greater than those of the seabirds, but also showed segregation of feeding areas by breeding sites between and within islands. None of the birds or mammals tagged on Bogoslof Island (along the chain of Aleutian Islands) crossed into the Gulf of Alaska, and neighbouring colonies of birds and mammals appeared to avoid overlapping their feeding areas. The distinct segregation of feeding areas by breeding colonies and the similarities in segregation between both groups of central place foragers implies a common set of selective mechanisms related to compass orientation of breeding colonies, competition within and between species, predation risk, and energetic constraints associated with distance, prey size and energy content. Our data suggest that immediate environmental conditions may have less effect on habitat selection compared to colony orientation and the longer term selective forces related to foraging costs and predictability of annual environmental conditions. This implies that existing breeding colonies in the Bering Sea may be poorly adapted and unable to respond favourably to global warming and environmental change

O2.05 Utilising tagging information within an integrated assessment of a seabird population threatened by fishing interactions and habitat loss: the Lord Howe Island flesh-footed shearwater

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The flesh-footed shearwater *Puffinus carneipes* is a medium-sized seabird with a single eastern Australian population breeding on Lord Howe Island. Observations of flesh-footed shearwater bycatch in Australian waters have been recorded on both Japanese and Australian longline fishing vessels. In addition, substantial reductions in colony size have occurred on the island due to housing development. As a consequence of these sources of mortality, concerns have been expressed about the population's sustainability. As knowledge of the overlap in foraging distributions and longline fleets was limited, archival geolocation recorders (Lotek LTD 2400) were placed on breeding and non-breeding birds in 2004/05. These studies indicated that breeding birds inhabit waters mainly to the west of Lord Howe Island during October to May. The birds then migrate to waters surrounding Japan during the Austral winter. While in the Northern Hemisphere, the birds' distribution shows high concentrations in areas that overlap with the Japanese domestic longline fishery.
This paper presents a quantitative impact assessment that integrates information on the foraging distributions, biology, oceanography, fishing interactions, and impacts from housing development. The tagging data are used within the model to inform predictions of at-sea distributions. The birds' breeding distribution is assumed to be a function of time of year, sea surface temperature and longitude. Given the predicted locations, the model then uses observations of bycatch from the Australian longline fishery to predict the probability of catching a bird, given various operational characteristics. While bycatch levels are currently greatly reduced within the Australian longline fishery, results suggest that continued monitoring of bycatch from domestic and international fisheries is needed to ensure that incidental mortality does not return to levels predicted in the late 1990s. In addition, on-land mortality in the form of reduced nesting habitat and incidental mortality may be having a substantial impact on this population.

P3.25 Humpback whale (Megaptera novaengliae) mother and calf foraging behavior: insights from multi-sensor suction cup tags

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On May 19th, 2010 we attached non-invasive high-resolution digital acoustic recording tags (Dtags), which incorporate accelerometers, magnetometers, pressure and sound recording simultaneously to an adult humpback whale (Megaptera novaengliae) and her calf foraging on euphausiids in Wilhelmina Bay along the Western Antarctic Peninsula. The Dtags remained on the animals overnight and logged 18 hours of concurrent recordings. We used TrackPlot to make and synchronize a pseudo-track of each whale's dive behavior and movements. Using the acoustic flow noise recorded by the tag correlated with the signal from the tags accelerometer and changes in pressure, we documented extreme decelerations (ca. 2.5 m•s-2) indicative of foraging lunges on both tags. Both animals executed foraging lunges, however, the mother foraged more intensively than the calf throughout the tag records (N = 852 foraging lunges and N = 130, respectively). Additionally, the female foraged consistently throughout the night, while the calf executed 91.5% of its lunges between 17:00 and 21:00. The female's mean (± SD) inter-lunge interval was longer than the calf's (45.98 ± 7.15 sec, 33.76 ± 12.70 sec, respectively; $P < 0.0001$) and was consistent throughout the night ($y = 0.000003x + 45.93$, $r2 = 0.00003$). When the calf was not foraging it would sometimes still dive in synchrony with its mother, who was actively lunging, while other times it would coast in the upper water column or engage in social behavior. While the animals appeared to be diving in synchrony with one another for much of the tag duration, we used the acoustic records of each Dtag to confirm if the animals were within close proximity of one another, e.g., a call from one whale recorded within <1 sec on the other's tag. Our results provide the first simultaneous Dtag records of balaenopterid mother and calf diving and foraging behavior.

O4.01 Thoughts on the energetics behind the 3% body mass recommended limit for devices on birds

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Animal-attached telemetry technology has provided pivotal information on the biology of wild animals, especially those that operate in areas that are difficult to access. Since seabirds spend so much time at sea, they are prime candidates for this approach. However, in some cases, externally-attached devices have been shown to affect birds deleteriously. No studies have documented the energetic cost of flight associated with carrying telemetric devices even though volant animals have to contend with both drag and additional weight. Currently, bird workers tend to use Kenward's (2003) recommendation, that attached devices should be no more than 3% of the bird's body mass. We used a freeware, web-based program (Flight version 1.22) to compute the cost of flight for 80 species of seabird from 8 major groups (Alcidae, Diomedeidae, Hydrobatidae, Laridae, Phalacrocoracidae, Procellariidae, Sternidae and Sulidae) under specified conditions including the effect of increasing payloads to examine how this affected the calculated energetic cost of flight for normal flight patterns at altitudes close to sea level. Devices representing 3% of the bird's body mass resulted in a higher than 3% increase in energy expenditure for flight (generally around 5%) without even accounting for increases due to drag. This effect differed between seabird groups and even between species within groups. The work considers allometric effects and flight types (e.g. continuous flapping versus flap-gliding) as well as the percentage time spent flying by the different seabird groups to outline elements that are important for seabird workers to consider. The method is readily applicable to any volant species of bird and we suggest that researchers working with external devices on birds do so as standard practice.

O5.05 Movement up and down: modeling dive depth of harbor seals from time-depth recorders

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Ordered categorical data are pervasive in environmental and ecological data, frequently arising from practical constraints imposed at the time of data collection. Often, the constraints require discretizing a continuous variable into ordered categories. A great deal of data have been collected toward the study of marine mammal dive behavior using Time-Depth Recorders (TDRs), which often discretize a continuous variable such as depth. Additionally, data storage or transmission constraints may also necessitate the aggregation of data over time intervals of a specified length. The categorization and aggregation create data that are a time series of ordered multi-category counts, which present challenges in terms of statistical modeling and practical interpretation. We introduce an intuitive strategy for modeling such aggregated, ordered categorical data allowing for inference regarding the category probabilities and a measure of central tendency on the original scale of the data (e.g. meters), along with incorporation of temporal correlation and overdispersion. We demonstrate the method in an analysis of TDR dive depth data collected on harbor seals in Alaska. The primary goal of the analysis is to assess the relationship of covariates, such as time of day, with number of dives and maximum depth of dives. We also introduce novel graphical summaries of the data and results.

O3.23 Using individual grey and harbour seal habitat use and behavioural data for the design and management of protected areas

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Grey seals (*Halichoerus grypus*) and harbour seals (*Phoca vitulina*) in France are protected by national law, and both are listed as "species of Community interest" within the European Union. Following the EU "Habitats Directive", their distribution and habitat use must be described in order to design Special Areas of Conservation (SACs). Twenty grey seals and thirty harbour seals have been (and continue to be) tracked with Argos and GPS/GSM tags since 1999 from the main colonies in France, in order to describe their movements and activity. Individual home ranges were estimated using kernel densities (ArcView) and diving behaviour was compared to local bathymetry as well as sediment type. Overall, grey seals moved further distances (100s of km) and spent approximately 65% of their time in SACs located in France and UK, compared to harbour seals which moved on average only 10s of km and spent 85% of their time in SACs all located in France. Grey seals showed extensive individual variation in movements with home ranges overlapping much less than those of harbour seals. Grey seals also used a wider variety of habitats – in terms of bathymetry and sediment type – than harbour seals. In summary, there is greater individual variation in grey seals. Thus a greater tagging effort (sample size) is required to attain the same precision of population parameters that is obtained from harbour seals.

O1.10 From fine scale diving behaviour to a reliable predictor of foraging success in Antarctic fur seals

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Studying the foraging behaviour of apex predators is necessary to understand how environmental changes may affect foraging success and ultimately both reproduction and survival. Recording foraging events in marine predators has become possible thanks to recent developments in bio-logging, but is still difficult to apply to a large number of individuals in practice. The aim of this study was to establish reliable and simple predictors of the foraging success in Antarctic fur seal (*Arctocephallus gazella*) based on diving data. We thus investigated the diving adjustments associated with foraging success. On Kerguelen Islands, seven individuals equipped with accelerometers and four others with hall sensors provided simultaneous recordings of mouth opening events (i.e. considered as Prey Capture Attempts, PCA) and dive profiles. Of the 5384 dives recorded, 55,4 % where associated with PCA, and 81.9% of PCAs occurred in the bottom phase of the dive. Fur seals were found to spend more time foraging at the bottom of dives when they encountered a prey shortly after the research started. This effect was detected only for dives shallower than 55m. Independent of diving depth, transits times (back to surface) were shortened with increasing foraging success by higher flipper stroke frequencies and/or steeper dive angles. Depth variations during the bottom phase of the dive and steps also provided a good indication of foraging activity. The understanding of these fine scale diving adjustments allowed to establish reliable predictive models of foraging success at three different temporal scales (dive, dive bout, day) based on diving patterns only. The models were established on half of the dives and tested and validated on the second part of our data set. These statistical models will ultimately be implemented to assess changes in foraging success along the trajectory of fur seals fitted with GPS and TDR loggers.

O3.12 Exploiting the bottom line: how Australian fur seals use de facto artificial reefs in navigation and foraging

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Understanding how animals use their habitat for various behaviours is crucial to developing adequate ecosystem management strategies. The use of man-made structures as shelter, foraging areas or navigational cues has been documented in numerous terrestrial vertebrate species. However, while artificial reefs are well known to increase both the density and biomass of epibiota and to attract fish, the use of under-water anthropogenic structures by marine mammals has received little attention. The Australian fur seal represents the greatest marine predator biomass within south-eastern Australia and, thus, plays an important role in the structure and function of this commercially important ecosystem. Previous satellite tracking and dive behaviour studies have revealed this species forages almost exclusively on benthic prey within the shallow continental shelf of Bass Strait, a region considered to be nutrient poor. Little is known, however, of the factors that influence its habitat use, the distribution of its prey and its impact on the ecosystem. Using fine-scale GPS tracking, the at-sea movements of 36 adult females provisioning pups from Kanowna Island (northern Bass Strait) were monitored for 1-8 foraging trips. Thirty-nine percent of females spent between 5 – 50% of their foraging trips in association with gas/oil pipelines and sea-floor power cables. Video footage from animal-borne cameras on individuals confirm these structures act as de facto artificial reefs and that the seals had improved foraging success within their vicinity. Our results suggest that man-made structures enhance conditions on the Bass Strait seabed affecting lower trophic levels, which has a cascading effect by attracting higher trophic levels such as fur seals. These findings will increase our understanding of how pinnipeds interact and navigate through their environment and has implications for modelling habitat use, human-interactions and population dynamics.

P4.21 Fine-scale behavioral ecology of mating sharks in and around a protected breeding ground

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The annual mating aggregation of nurse sharks (*Ginglymostoma cirratum*) in the Dry Tortugas, FL (USA) has been the subject of 18 years of ongoing study and has been the subject of a seasonal closure by the National Park Service since 1998 due to its significance for shark reproduction. Since 2008, we have expanded our ability to monitor these animals by tagging them with three-dimensional acceleration/depth/temperature data-loggers that can reveal continuous, fine-scale aspects of their behavior for days at a time. We applied data-loggers to 12 adult sharks for periods of 17 to 111 h (58 + 37 h, mean + SD). Ten of the twelve animals were simultaneously tagged with coded acoustic transmitters to acquire the sharks' location from an array of acoustic receivers and thus provide spatial context to acceleration data. Mating and other behaviors (e.g. swimming, resting, diving, fast-starts, and rolling) were clearly identifiable from acceleration data and presented distinct patterns of behavior. Despite their reputation as a nocturnal species, most shark mating events took place during the day and in shallow (< 4 m) water. Females typically spent their time resting or milling in the shallows, often within the shark protection zone, whereas males spent their time swimming in relatively deep (20 - 30 m) water outside of the protection zone making only occasional forays into the shallows, presumably to seek mates. One female showed repetitive diving behavior between the surface and 30 m for 27 h after tagging before resuming shallow resting and mating behavior. Although reproductive female sharks bear a larger energetic burden than males overall, our results indicate that male sharks may expend significantly more energy than females during the mating season.

O3.13 Continuous blood lactate profiles in freely diving juvenile elephant seals

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We report the first record of continuous blood lactate profiles during diving in a juvenile northern elephant seal using an implantable lactate sensor. The sensor consisted of lactate oxidase immobilized in a gel membrane coupled to a PO2 electrode. The sensor is based on the reaction: Lactate + O2 → pyruvate + H2O2. When lactate and O2 in the blood react with the enzyme, the remaining O2 is detected by the electrode and produces an O2-dependent current (ilmo). A second PO2 electrode, the reference electrode, detects ambient O2 and produces an O2-dependent current (io). Lactate concentrations were derived by subtracting the reference current from the lactate-modulated current: io - ilmo. The lactate sensor was inserted in the extradural vein of juvenile elephant seals from the Año Nuevo rookery near Santa Cruz, CA, USA. Seals were released either on the other side of Monterey Bay or off a boat over the Monterey Bay canyon. Seals returned to Año Nuevo rookery within a few days. Lactate values were recorded before, during and after dives of one juvenile northern elephant seal. Lactate concentrations briefly increased after every dive, up to 6 mM, but returned to baseline values before the next dive, even in dives as long as 30 minutes.

P4.11 Comparison of sperm whale (*Physter macrocephalus*) movements in the Gulf of Mexico before and after the Deepwater Horizon oil spill

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Implantable tags with UHF radio transmitters, providing locations and surfacing counts, were deployed on 13 sperm whales (*Physeter macrocephalus*) 80-86 days after the Deepwater Horizon drilling rig explosion in the Gulf of Mexico. The whales were tagged 15-100 km from the rig site and have provided an average of 0.8 locations per day. Eleven tags are still transmitting as of this writing (9/29/2010) and data from these tags are being compared with locations from 52 whales tagged in 2001-2006 to determine changes in habitat utilization and possible avoidance of contaminated areas.

Preliminary comparisons indicate some deviations from areas visited in previous years. There is a higher concentration of locations from three whales towards the eastern edge of previously determined ranges. Additionally, another animal has moved into deeper waters to the south and west, which also contains very few locations from previous years.

Home ranges and core areas are being analyzed to determine if these whales are avoiding contaminated areas and/or if their locations vary systematically from those determined from whales tagged in previous years. Water depth preferences, swimming speeds, and male/female differences in home ranges will be analyzed after sufficient data are received. Locations are classified as either transit or meandering to determine possible feeding sites, which will be compared to areas visited in previous years and areas of oil contamination.

O3.03 Acoustic and accelerometer cues to prey capture success in echolocating porpoises

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To understand the foraging ecology of free-ranging animals, it is essential to establish where, when and how animals feed, as well as how foraging success compares to the effort invested. Studying the behavior of aquatic predators is particularly challenging. However, recent studies using animal-borne multi-sensor tags on several species of echolocating toothed whales have identified acoustic cues and accelerometer signatures possibly indicative of feeding events. Tag recordings of beaked whales, in particular, contained sequences of echoes that were interpreted as stemming from ensonified prey. The present study had the dual purpose of verifying those findings in a controlled environment, and examining what types of movements generate the acceleration signatures. A goal was to assess if combined acoustic and acceleration cues form a reliable indicator of prey capture attempts and their success. We applied DTAG-3 tags to three trained harbor porpoises during captures of dead fish and approaches to artificial targets. The tags sampled sound on two channels at 500 kHz and triaxial accelerometers at 200 Hz. To look at the details of the feeding events we used tag-synchronized high speed underwater cameras. The tags recorded echoes from prey at ranges of up to five meters. We confirm that high repetition rate buzzes are associated with close target encounters in porpoises as has been found in echolocating bats and show that distinct acceleration signatures are present during prey acquisition, but not during trials with artificial targets. Comparison with the synchronized images indicates that the acceleration signals occur when the animal strikes at prey and so are an excellent proxy for foraging. The stereotypicity of the acoustic and accelerometer signatures across individuals and species may enable onboard detection of foraging events in long term tags on free-ranging toothed whales.

O3.20 Contrasting prey fields influence multiple diving strategies of harbor seals (*Phoca vitulina richardii*)

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Precipitous declines in pinniped populations in the North Pacific Ocean have highlighted the need for an understanding of predator-prey relationships in marine ecosystems. Knowledge of pinniped foraging behavior in relation to prey fields is essential for understanding how temporal and spatial variability in prey resources may influence the behavior of individuals. Pinnipeds may respond to reduced prey availability by traveling greater distances to forage, diving deeper, and increasing diving intensity. Each potential response to changes in prey availability may result in increased energetic costs and ultimately fitness-level consequences. Our primary objectives were to determine how harbor seals adjust their diving behavior relative to prey fields in distinct oceanographic regions in Glacier Bay National Park, Alaska, where seals have declined by up to 12.4%/year from 1992-2008. Diving behavior and foraging areas were determined for juvenile and adult female seals (n=25) using time-depth recorders and telemetry. Prey fields were assessed with hydro-acoustic surveys. Nonmetric multidimensional scaling of dive behavior variables revealed three dominant gradients associated with diving intensity, dive depth, dive duration, and percent bottom time. Hierarchical clustering partitioned seals into three distinct behavioral dive groups based upon differences in diving behavior. Seals in group 3 dived the deepest (mean = 37.1, max = 326.0m), had the highest diving intensity, lowest % bottom time, longest trip durations (10.7± 5.0 hr), and foraged in upper and central GB in deeper waters with lower prey densities (mean = 17.1± 30.5m2/nmi2). In contrast, seals in groups 1 and 2 dived shallower (mean = 24.8, max = 208.0m), had lower dive intensities, shorter trip durations, and foraged in lower GB in shallower waters with higher prey densities (mean= 121.2 ± 322.1 m2/nmi2). The emergence of multiple diving strategies by harbor seals suggests that seals respond to contrasting prey fields in different oceanographic regions of Glacier Bay.

P2.04 Comparison of swimming patterns between rainbow trout (*Oncorhynchus mykiss*) and white spotted charr (*Salvelinus leucomaenis*) using acceleration data loggers under flowing-water conditions

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Japan’s northern island of Hokkaido is famous for its undeveloped rivers. Recently, a native species, white spotted charr, was replaced by an invasive introduced species, rainbow trout. Rainbow trout might have outcompeted white spotted charr for food and habitat, however, the cause of this replacement is not known. To better understand how these species interact and compete, behavioral differences between the two species were examined in this study using acceleration data loggers in a flow channel. The study was conducted at a flow channel in Hokkaido University from August to September in 2010. An acceleration data logger (M190L D2GT) was attached to the base of the dorsal fin of one white spotted charr and of one rainbow trout. Each fish swimming in the channel was monitored by the data logger and a video camera simultaneously. Flow velocity was configured in five levels. Movement acceleration data were extracted using IFDL version4 (WaveMetrics, Inc., USA) and used in frequency analysis. As the flow velocity increased, the rainbow trout swam actively and increased the amplitude of its tail beat, while the white spotted charr remained at the bottom of the tank without actively moving and showed no change in its average tail-beat amplitude. These behavioral differences will presumably affect the habitat selection of both species and could explain why rainbow trout have been able to replace white spotted charr.

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