BLS 6

THE 6TH INTERNATIONAL BIO-LOGGING SCIENCE SYMPOSIUM

Abstracts

Konstanz, Germany
Version 2017-10-01

Content

Oral Session: Physiology

Gerald Kooyman

The early years of archival recorders for marine vertrebrates

Scripps Institution of Oceanography
gkooyman@ucsd.edu

The first, basic dive recorder was a manometric tube applied by P. Scholander to harpooned finwhales in about 1939. This was the first quest to gain direct knowledge of the diving depth of an aquatic animal. Under more natural and unstressed conditions I applied similar diving devices to Weddell seals in 1963. Concurrently, I applied self-designed, Time Depth Recorders (TDR) that included the elements of time, depth and two dimensional profiles to the diving data. This first TDR's time duration was one hour. Up to the present there have been many evolutionary, steps along the way. These range from recording durations of over a year, with many added variables transforming the basic recorder to an archival one, yielding much of the behavioral and physiological history of the subject. Today recovery of the instrument is no longer necessary, and much of the information can be retrieved independently while never seeing the animal again. I will present many of these steps, especially those from the early years, and comment on other challenges; such as the various modes of attachment and limitation of the power source. As the biologging field progresses, access to the information will become more and more remote. There will be less stress from interaction of the investigator with the animal, and more complex management of the data will be necessary.

Arnold, Walter

Coping with tough seasons: winter hypometabolism of large ungulates

Research Institute of Wildlife Ecology, University of Veterinary Medicine
walter.arnold@vetmeduni.ac.at

Endothermic herbivores face during winter a two-fold problem: Cold increases the energetic cost of thermoregulation and at the same time the quantity and quality of the available food is considerably lower. Many ungulates react to this winter situation with a decrease of daily food requirements indicating a reduction of energy expenditure and a switch to body fat reserves as the major metabolic fuel. However, the mechanism that reduce energy expenditure during winter in these species have long been a matter of debate. We found in six non-hibernating large mammals (red deer, Przewalski horse, alpine ibex, chamois, roe deer, Svalbard reindeer) a reduction of daily mean heart rate during winter down to about half of the summer level, and a similar reaction even in a large bird (grey-leg geese). We identified as mechanism contributing to this phenomenon (i) a reduction of locomotor activity, (ii) of visceral organs, and, most importantly, (iii) of body temperature (Tb). The latter was found to be the most efficient reaction to decrease energy expenditure. So far, only hibernators and daily heterotherms are recognized as endothermic species that developed, in anticipation of the predictable energetic bottle-neck of winter, the ability to tolerate lower Tb. However, our results suggest that seasonal rhythms of Tb and hypometabolism during winter are ubiquitous among northern endotherms. Thus, classifying species into non-hibernators, hibernators, and species employing daily torpor is of little conceptual value because the differences leading to this classification simply result from the duration and extent of hypometabolism and its interaction with body size.

Itsumi Nakamura, Rui Matsumoto, Katsufumi Sato

Gigantothemy of whale sharks enables them to do extreme deep dives

Nagasaki University, Okinawa Churaumi Aquarium, University of Tokyo
itsumi@nagasaki-u.ac.jp

Gigantothermy is a strategy of large animals to maintain a constant body temperature by large thermal inertia due to their large body size. The whale shark (Rhincodon typus) is the world largest fish and known to dive exceed 1,900 m. Recent tracking study suggested their behavioral thermoregulation from extended surfacing duration after dives into colder water,

however, there is no empirical study that measured their body temperature directly under natural conditions. In 2015 and 2016, to quantify their body temperature change, we attached data-logger packages including body thermometers on three whale sharks (4.4 m, 7.0 m and 7.2 m in total length) and released from Okinawa, Japan. We also deployed pop-up satellite tags to record long-term temperature experience. The packages were automatically detached from the sharks and retrieved after 1-10 day deployments. Body temperatures were stable and had narrower range (± 3°C) than that of experienced water temperature (± 10°C) and never dropped under 23°C except during a deep dive just after release because of trauma (one individual stayed at 390 m depth, where water temperature was 14°C, for three hours after release and body temperature decreased to 19°C after the period). We calculated whole-body heat-transfer coefficients using heat-budget models to obtain the relationship between water and body temperature changes. Then we estimated body temperature of each shark from long-term water temperature experience using the heat-budget models. The sharks sometimes went into deep water over 1,400 m, where water temperature was 4°C, but returned to the surface within an hour and the estimated body temperature was always kept above 23°C. Gigantothermy of whale sharks may enable them to do extreme deep dives, however, they need to return to the surface before their body temperature decreased to 23°C. Body temperature of 23°C is probably important to maintain their performance.

Bethany L Clark, Ian R Cleasby, Ewan W Wakefield, Lucy A Hawkes, Stephen C Votier

Energy expenditure of travel in a wide-ranging central-place forager with a costly mode of flight

BLC, SCV: Environment and Sustainability Institute, University of Exeter, Penryn,
Cornwall, TR10 9FE • IRC, LAH: Centre for Ecology and Conservation, University of Exeter, Penryn, Cornwall,
TR10 9FE • EWW: Institute of Biodiversity, Animal Health and Comparative Medicine, University of Glasgow,
Glasgow, G12 8QQ
b.l.clark@exeter.ac.uk

The energetic cost of foraging forms a large part of the energy budget of many species and is particularly important for those provisioning offspring. Colonial breeders often travel vast distances to forage, and as such, many species have physiological or behavioural adaptions to reduce travel costs. These costs have been examined in soaring and gliding birds like albatrosses, but are not well studied in species with more costly modes of travel. Breeding northern gannets (Morus bassanus) are central-place foragers, travelling hundreds of kilometres in a single trip, but they often employ energetically expensive flapping flight. We

hypothesise that gannets reduce the cost of commuting flight by extracting energy from the environment in the form of lift. In 2015 and 2016, we simultaneously deployed GPS loggers and accelerometers along with either barometric pressure altimeters (n = 41) or video cameras (n = 23). Gannets alternate between flapping flight and gliding or soaring, with varying durations of each section. Time-matched accelerometry at 50 Hz and altitude at 1 Hz allow us to differentiate gliding and soaring, and we use bird-borne cameras to validate behavioural classification. Using overall dynamic body acceleration (ODBA) as a proxy for energy expenditure, we find that energy expenditure is higher during periods of altitude gain, but there is variation in ODBA within categories. We discuss the drivers of this variation in the energetic costs within different modes of flight in a central-place forager with a costly mode of flight.

Alina Evans, Boris Fuchs, Navinder J. Singh, Stephane Blanc, Andrea Friebe, Jon E. Swenson, Jon M. Arnemo

Body size determines depth and length of hibernation in free-ranging brown bears

Inland Norway University of Applied Sciences
alina.evans@hihm.no

During hibernation, animals undergo major reductions in body temperature and metabolic rate. The amplitude of metabolic rate reduction in hibernators is dependent on body size, small hibernators have a high metabolic rate when euthermic, making a drastic decrease in core temperature during torpor necessary to reach a very low metabolic rate. The lower magnitude of the decrease in core temperature during hibernation in bears, compared to other hibernators, is thought to be related to body size, although detailed studies on intra-specific variations in body temperature are lacking. Here we document, with data from 40 bears totalling 47 years, relationships between body mass and body temperature, hibernation duration, den exit date, and in a cumulative index of hibernation depth, with the smallest bears having lower body temperatures, hibernating longer, exiting later and saving more energy than large bears. These relationships were consistent across a range of masses from 30 to 233 kg. Our results demonstrate that body size, even in a large mammal, determines the cooling process of the bear as they enter the dens and lower the metabolic rate, with smaller bears, which have higher thermal conductance, having lower body temperatures.
Niels C. Rattenborg

First Evidence of Sleep in Flight

Avian Sleep Group, Max Planck Institute for Ornithology - Seewiesen, Germany
rattenborg@orn.mpg.de

Recent bio-logging studies have confirmed that many birds fly non-stop for days to months, but do they sleep in flight and if so how? When necessary, birds on land can sleep with one eye open, a behaviour associated with wakefulness in the opposite cerebral hemisphere and slow-wave sleep (SWS) in the other. Likewise, dolphins can swim during unihemispheric SWS. Thus, it is commonly assumed that birds alternate sleeping with the left or right hemisphere during long flights, permitting them to maintain aerodynamic control and environmental awareness, while obtaining enough daily sleep to maintain attention during wakefulness. We tested these assumptions in great frigatebirds (Fregata minor) flying over the ocean for up to 10 days, by recording GPS coordinates, flight altitude, head movements, and the electroencephalogram (EEG). We found that frigatebirds can sleep in flight for periods lasting up to several minutes, and usually do so at night while circling in rising air currents. Although SWS was more often unihemispheric in flight than on land, 28% was bihemispheric, demonstrating that unihemispheric SWS is not required for aerodynamic control. Instead, a relationship between the direction of flight and opposing interhemispheric asymmetries in EEG slow-wave (0.75-4.5 Hz) and gamma (30-80 Hz) activity, the later involved in visual attention, suggests that frigatebirds use unihemispheric SWS to watch where they are going. Despite being able to sleep on the wing, frigatebirds slept for only 0.7 h/day, 7.4% of the time spent sleeping on land. The low amount of sleep in flight indicates that the ecological demand for attention, even at night, usually exceeds that afforded by sleeping unhemispherically. Determining how frigatebirds maintain adaptive performance on little sleep may provide new perspectives for understanding the adverse effects of sleep loss typically experienced by other animals.

Nora M Weyer, Robyn S Hetem, Duncan Mitchell, Mike D Picker, Benjamin Rey, Andrea Fuller

Aardvark ecophysiology revealed by biologging: body temperature and activity patterns of an elusive mammal responding to drought

Brain Function Research Group, School of Physiology, Faculty of Health Sciences, University of the Witwatersrand, South Africa
weyer.nora@gmail.com

Aardvarks (Orycteropus afer) are keystone mammals in sub-Saharan Africa whose burrows provide shelter for numerous sympatric species. Aardvarks are nocturnally-active, solitary and elusive, so their ecophysiology is poorly understood. Much of their range is becoming hotter and drier with global climate change, with potentially severe impacts on aardvarks due to their large size (35 - 70 kg), longevity, slow reproduction, specialised diet, and non-migratory lifestyle. For three years, we studied the ecophysiology of free-living aardvarks in the Kalahari semi-desert, the hottest and driest region that they currently inhabit. We biologged body temperature and locomotor activity and remotely recorded body condition (camera traps) and vegetation productivity (MODIS-EVI). We also assessed aardvark diet (scat analysis). Kalahari aardvarks preyed primarily on harvester termites, termite abundance was dictated by grass availability and thus linked to rainfall. In arid but non-drought conditions, aardvarks met their minimum energetic needs, tightly controlled body temperature between 36 and 37°C, and were active nocturnally with high peaks of intense activity, presumably linked to digging. During drought conditions, body condition deteriorated, activity shifted to the daytime, and maximum and total daily activity declined. At this time, aardvarks exhibited high 24-h variability in body temperature (26 - 38°C), and often resorted to basking in the morning. Many aardvarks died during this period. Following subsequent rains, surviving aardvarks' body condition improved, body temperature was tightly controlled, and they resumed nocturnal foraging. Biologging, combined with measures of body condition and vegetation indices reflecting resource availability, allowed us to reconstruct patterns of physiological stress and subsequent recovery after drought. Future increases in drought frequency and intensity over Africa will likely threaten not only aardvark survival but also that of many species dependent on its burrows for refuge.

Oral Session: Avian Life History

Henri Weimerskirch

Seabirds foraging: the early-life stage and relationships with fisheries

Centre d'Etudes Biologiques de Chizé, UMR 7372 CNRS/Université de La Rochelle, 79360 Villiers-en-Bois, France.
Henri.WEIMERSKIRCH@cebc.cnrs.fr

Because of their large size, absence of fear toward humans and easy access to large colonies, seabirds have been the subject of many foraging studies since the first development of Biologging. Although many progresses have been made over the past 30 years on the studies of seabird foraging, several aspects still remain less well understood. The Early-life of marine animals is a critical, yet poorly known stage of the life history of marine animals. Over the past 5 years we developed a program trying to better understand how young animal forage in a completely known environment, investigating the ontogeny of foraging behavior, dispersal and learning processes, and their consequences in terms of selection and population dynamics, in several species of seabirds leaving in contrasted environment. I will review some of the progress made on these aspects. Today, several seabird groups such as albatrosses are among the most threatened animal species because of the development of fisheries worldwide. Naïve juvenile animals are probably the part of the population the most at risk, and I will illustrate the recent effort made to better understand the relationship between seabirds and fisheries by using new bio-logging methods.

Heather Vance, Peter T Madsen, Danuta M Wisniewska, Michael Ladegaard, Kristian Beedholm, Sascha Hooker, Mark Johnson

No time to waste: Echolocating predators have ultra-fast responses to acceleration cues from escaping prey

HV, SH, MJ: Sea Mammal Research Unit, University of St Andrews • PTM, DMW, ML, KB: Department of Bioscience - Zoophysiology, Aarhus University
hmv@st-andrews.ac.uk

The "arms race" between predators and prey places an evolutionary premium on fast sensory and locomotory responses. In the aquatic environment, startle responses of teleost fish to predators produce high-speed, rapid-acceleration, escape behaviours with response latencies reported as low as 5-10ms. To capture agile prey, predators must also have evolved rapid sensory and locomotory reflexes. However the reciprocal responses of predators to escaping prey are more difficult to measure as this requires tracking predator and prey movements simultaneously. Echolocating whales provide an excellent model system with which to test this hypothesis as their biosonar signals, and echoes from prey, can be recorded directly via animal-attached tags on some species. Visualisations of biosonar echoes from tagged wild harbour porpoise suggest that clicking rate and therefore depth of view may adapt quickly to escaping prey. We hypothesised that these responses are elicited by specific cues provided by escaping prey, e.g. sudden changes in speed or acceleration. To test this we equipped two harbour porpoises with fast sampling sound and movement tags (DTags). The porpoises were trained to wear eyecups and to track and intercept a spherical target containing a hydrophone and wideband accelerometer that were sampled synchronously. Targets were moved with a range of accelerations and speeds to quantify response latencies and thresholds at which responses were elicited. Synchronisation of echolocation signals recorded by the target and tag allowed us to precisely measure the latency of clicking rate and locomotory responses to target movement. We found highly stereotyped echolocation and locomotory responses throughout each of the >140 trials conducted, suggesting habituation was not a factor. Response latencies were within 300-500ms of the onset of target motion and appeared to be triggered by high target acceleration. Such rapid responses may enable toothed-whales to capture agile, high energy prey that would otherwise be inaccessible.

Nora M Weyer, Robyn S Hetem, Duncan Mitchell, Mike D Picker, Benjamin Rey, Andrea Fuller

Aardvark ecophysiology revealed by biologging: body temperature and activity patterns of an elusive mammal responding to drought

Brain Function Research Group, School of Physiology, Faculty of Health Sciences, University of the Witwatersrand, South Africa
weyer.nora@gmail.com

Aardvarks (Orycteropus afer) are keystone mammals in sub-Saharan Africa whose burrows provide shelter for numerous sympatric species. Aardvarks are nocturnally-active, solitary and elusive, so their ecophysiology is poorly understood. Much of their range is becoming hotter and drier with global climate change, with potentially severe impacts on aardvarks due to their large size (35 - 70 kg), longevity, slow reproduction, specialised diet, and non-migratory lifestyle. For three years, we studied the ecophysiology of free-living aardvarks in the Kalahari semi-desert, the hottest and driest region that they currently inhabit. We biologged body temperature and locomotor activity and remotely recorded body condition (camera traps) and vegetation productivity (MODIS-EVI). We also assessed aardvark diet (scat analysis). Kalahari aardvarks preyed primarily on harvester termites, termite abundance was dictated by grass availability and thus linked to rainfall. In arid but non-drought conditions, aardvarks met their minimum energetic needs, tightly controlled body temperature between 36 and 37°C, and were active nocturnally with high peaks of intense activity, presumably linked to digging. During drought conditions, body condition deteriorated, activity shifted to the daytime, and maximum and total daily activity declined. At this time, aardvarks exhibited high 24-h variability in body temperature (26 - 38°C), and often resorted to basking in the morning. Many aardvarks died during this period. Following subsequent rains, surviving aardvarks' body condition improved, body temperature was tightly controlled, and they resumed nocturnal foraging. Biologging, combined with measures of body condition and vegetation indices reflecting resource availability, allowed us to reconstruct patterns of physiological stress and subsequent recovery after drought. Future increases in drought frequency and intensity over Africa will likely threaten not only aardvark survival but also that of many species dependent on its burrows for refuge.

Shay Rotics, Sondra Turjeman, Michael Kaatz, Damaris Zurell, Martin Wikelski, Nir Sapir, Wolfgang Fiedler, Ute Eggers, Florian Jeltsch, Ran Nathan

Early-life behaviour predict first-year survival in a long-distance migrant

SR, ST, RN: Movement Ecology Laboratory, Department of Ecology, Evolution and Behavior, Alexander Silberman Institute of Life Sciences, The Hebrew University of Jerusalem, 91904, Jerusalem • MK: Vogelschutzwarte Storchenhof Loburg e.V., Chausseestr. 18, D-39279 Loburg • DZ: Swiss Federal Research Institute WSL Zuercherstrasse 111. CH-8903 Birmensdorf Switzerland • UE, FJ: Department of Plant Ecology and Nature Conservation, Institute of Biochemistry and Biology, University of Potsdam, Maulbeerallee 2, 14469 Potsdam, Germany • MW, WF: Department of Migration and Immuno-Ecology, Max-Planck-Institute for Ornithology, D-78315 Radolfzell, Germany • NS: Department of Evolutionary and Environmental Biology, University of Haifa
shay.rotics@mail.huji.ac.il

Early life conditions have long lasting effects on the individual morphology, skills, personality, and future survival. These effects are probably accentuated in juvenile migratory birds that face risky journeys shortly after fledging. However, early-life behavior has rarely been investigated as a predictor of subsequent survival. Using high-resolution GPS and body-acceleration lifetime data of juvenile white storks (Ciconia ciconia) we examined the links between the critical fledging-to-migration onset (FTM) period and subsequent first-year survival. We found that juvenile daily activity (estimated from overall dynamic body acceleration) increased linearly throughout the FTM period, the slop of this increase, termed activity increase rate (AIR) differed among individuals and served as proxy for behavioural development rate. Individuals with increased activity during FTM exhibited enhanced survival, and this relationship was stronger at high AIR values (an interaction effect). Thus the best-surviving juveniles exhibited high activity and AIR values. Individual pre-fledging activity was consistent with FTM activity and had an equivalent positive effect on survival. A higher activity may indicate a better physical condition, an improved acquisition of pre-migratory skills or a more proactive personality. We examined FTM duration as a proxy for pre-migratory experience and found a non-linear relationship where intermediate (rather than maximal) durations were linked to increased survival. Short durations were related to less pre-migratory experience, where individuals with prolonged FTM periods were also characterized by low AIRs, which presumably indicate slow development rate and skill acquisition and may therefore explain the unexpected decrease in survival at high levels of pre-migratory experience. Lastly, heavier nestling and those that hatched and migrated earlier exhibited higher survival. Our work demonstrated that various early-life attributes, and particularly activity properties, predicted the juvenile's fate. This implies that juvenile quality is manifested early in life and can illuminate subsequent individual differences in survival.

A.T.D. Bennett, R.F.H. Ribot, J. McEvoy, R. Pedler

How do nomadic waterbirds find water in the desert?

Centre for Integrative Ecology, Deakin University, Australia
andy.bennett@deakin.edu.au

In contrast to the seasonal, predictable movements and behaviours of migratory birds in Europe and North America, Australia's inland deserts have nomadic waterbirds that exploit ephemeral wetlands which are highly unpredictable in space and time. Following large rainfall events inland, these waterbirds move hundreds or thousands of kilometres from their coastal refugia into the desert, and if conditions are suitable they then breed there. How do they know when it has rained and where it has rained in the desert? This is an unsolved mystery of bird navigation with implications for understanding how birds respond to environmental change, and the role of learning and plasticity in navigational mechanisms. Using remote sensing, thermal imaging, aerial surveys from light plane, and over 110 satellite tracked black swans, pacific black duck and banded stilts, tracked during day and night, during flooded and arid periods in Australia, we summarize findings that advance understanding of this system. We reveal a range behavioural strategies for exploiting unpredictable inland wetlands including: (1) facultative nocturnal flight following heavy rainfall events, (2) an ability of birds to move to heavy rainfall events over 500 km distant, (3) much nocturnal flight, and throughout the night rather than around dawn and dusk as predicted from earlier work on waterbirds, and (4) sets of meteorological variables that can predict long distance departure. The implications of our findings for how waterbirds cope with the La Nina El Nino southern oscillation will also be discussed.

Jason Kerr

Quantification of head and eye movements in freely behaving mammals: seeing what they see

Center of Advanced European Studies And Research (caesar)
Jason.Kerr@caesar.de

Currently a major challenge in vision neuroscience is how an animals interaction with the environment can be understood in terms of neural activity. What makes this an especially

difficult problem is that the link between brain function and behavior can only be studied in a behaving animal, and as visually based decision making behaviors involve a combination of head movements, eye movements, and vestibular driven neuronal activity to guide behavior, studying the freely moving animal is paramount. Here I will describe ocular videography methods for accurately tracking head and eye movements from freely behaving Rodents, Carnivores and Scandentids, and computational approaches for rendering the environment from their point of view. I will also describe the disparate strategies these mammals use to maintain binocular alignment while tracking moving targets and estimating distances.

Oral Session: Marine Biologging

Alison K. Stimpert, Stacy L. DeRuiter, Selene Fregosi, Tetyana Margolina, John Joseph, Ari S. Friedlaender, John Calambokidis, Leah Lewis, Angela Szesciorka, Jeremy A. Goldbogen, Brandon L. Southall

Calling response of blue and fin whales to simulated and real naval MFA sonar

AKS: Moss Landing Marine Labs, California City • SLDR: Calvin College • SF, ASF: Oregon State University • TM, JJ: Naval Postgraduate School • JC: Cascadia Research Collective • LL, AS: Scripps Institution of Oceanography • JAG: Stanford University • BLS: Southall Environmental Associates
astimpert@mlml.calstate.edu

Several taxa rely on acoustic communication for important life history functions, including social communication, reproduction, and foraging. Many species have also shown sensitivity to anthropogenic noise, at times exhibiting changes in behavior including variation in call production. For marine species, most of this research has described population-level effects, since in many cases, challenges associated with identifying a calling individual in the wild prevent assessment of individual vocal responses to acoustic disturbance. Advancements in bio-logging technology and analyses now allow researchers to better address this issue. We expanded on response analyses that have focused on animal movements by evaluating acoustic behavioral response to naval mid-frequency active (MFA) sonar exposure in tagged baleen whales in Southern California (SOCAL BRS Project). Calls were manually identified by experienced analysts on the acoustic records of 34 tagged animals (7 fin whales (Balaenoptera physalus) and 27 blue whales (Balaenoptera musculus)). Where possible, an accelerometer technique was implemented to determine which calls were produced by the tagged animal, and in other cases, a combination of received level and signal to noise ratio was applied to use only the subset of calls most likely to have been produced by the tagged animal. In most cases, calling bouts were long relative to recording duration, without obvious changes in call rate, frequency, or amplitude. However two case studies illustrate dataset variation: one where response was clear (regular calling stopped when exposure began), and one where response was not evident (no difference in call properties before, during, or after exposure). We conclude that calling response amongst individuals is variable and may be context or behavior dependent, but that current deployment durations may not be enough to detect a small change in call rate. We also present simulation results estimating the dataset duration required to detect specified effects of sound exposure.

Natacha Aguilar de Soto, Fleur Visseur, Peter Madsen, Peter Tyack, Graeme Ruxton, Jesùs Alcazar, Patricia Arranz

Deep diving beaked whales show how aggregating vocal animals can minimize predation risk

NAS, JA, PA: University of La Laguna, Canary Islands, Spain • FV: University of Leiden • PM: University of Aarhus, Denmark • PT, GR: University of St Andrews, Scotland
naguilar@ull.edu.es

A commonplace cost of aggregation for prey is ease of detection by predators. Here we show that aggregated beaked whales need not pay similar costs when confronted with attacks from killer whales. Acoustic and movement recording DTAGs attached to Cuvier's and Blainville's beaked whales showed that group members synchronize diving and vocal activity more than 98% in dives up to ~2 km depth. This remarkable collective behaviour means that groups of beaked whales are available for passive acoustic detection by killer whales for only up to 22% of the time, independent of group size. Moreover, diving group cohesion renders beaked whales surfacing locations unpredictable. We measured the separation between three pairs of whales tagged in the same groups, in Italy, Canary Islands and Azores, using the time-delay of the clicks emitted by one tagged whale and recorded at the tag carried by its companion. Whales in these pairs separated to forage from 6 to 1000m and reunited to initiate the ascent. They became silent at a mean depth of 760m in the ascent and travelled to the surface with an unpredictable direction and at low vertical speed. This behaviour results on a potential surfacing area of ~3.7 km². A group of 1 to 12 killer whales tracking acoustically beaked whales from the surface until beaked whale silence can search visually only 0.8% to 10% of this potential surfacing area. In sum, collective vocal and diving behaviour of beaked whales render their probability of acoustic detection by killer whales very similar for individuals and groups. Further, beaked whale behaviour during dive ascents reduces by >90% post-detection encounter probability by killer whales when compared to the usual ascent behaviour of other deep diving cetaceans. This anti-predatory costly behaviour of beaked whales may explain their vulnerability to predator-like naval sonar sounds.

Jeanne Shearer, Robin Baird, Daniel Webster, Heather Foley, Zach Swaim, Joel Bell, Andrew Read

Diving behavior of Cuvier's beaked whales (Ziphius cavirostris) off Cape Hatteras, North Carolina

JS, HF, ZS: Duke University Marine Lab • RB, DW: Cascadia Research Collective • JB: Naval Facilities Engineering Command Atlantic
jeanne.shearer@duke.edu

Cuvier's beaked whales make exceptionally long and deep dives to forage on bathypelagic prey. The species is of conservation concern because of strandings which have occurred in association with Navy training exercises employing tactical sonar. We used depth-transmitting satellite tags to study their diving behavior near Cape Hatteras, North Carolina and to generate baseline data for a behavioral response study. We deployed LIMPET tags on nine adult whales from 2014-2016, obtaining 3,266 hours of diving and surface data. Tag durations ranged from 2-60 days (median= 34). One tag recorded a dive to 3,567 meters, the deepest dive of any air-breathing vertebrate, although this observation should be interpreted cautiously because it is beyond the calibration range of the tag's pressure sensor. We observed characteristic diving patterns of the species, with deep foraging dives interspersed with series of shallow dives. Deep dives (>800 meters, n= 1,295) had an animal-weighted mean depth of 1,433 meters and duration of 58 minutes (max= 152.5 min), and occurred at 0.41 dives/hour. Shallow dives (<800 meters, n= 4,140) averaged 281 meters and 19 minutes. Dives at night were significantly shorter duration for both dive types. Surface durations averaged only 2.2 minutes, typical for this species. Final surface intervals prior to deep dives were significantly longer (4.7 minutes) than those following deep dives (2.3 minutes) or between shallow dives (1.9 minutes). The surface times are very short given the long duration of these dives, but longer surface intervals preceding deep dives indicate that they prepare for their dives prior to submergence. In addition, we estimated the bathymetry for deep dives with high quality Argos satellite locations (n= 25). Deep dives occurred in median water depths of 1,832 meters, with 40% within 100 meters of the sea floor and 68% within 300 meters, indicating that local bathymetry may influence foraging locations.

Pernille Tonnesen

Diving and echolocation skills precede active social communication in sperm whale calves

Aarhus University
pernille-t@bios.au.dk

Sperm whales are deep water, echolocating apex predators with a complex social structure and the biggest brains on the planet, but very little is known about the ontogeny of their diving, foraging, sensory, and communication skills. In highly social terrestrial species, social skills develop earlier than locomotor abilities. This may however not be feasible for sperm whales, who need locomotor skills from birth to breathe, dive, and suckle. To explore the social and physiological ontogeny of sperm whales, we deployed sound and movement tags (DTAG3) on three first year calves. Of these calves, only one engaged actively in social acoustic communication by emitting up to 26 codas. This indicates that calves do not emit acoustic cues to maintain and reestablish contact with adult whales, but likely track the ample passive acoustic cues emitted by the echolocating and communicating adults. However, diving capabilities were well-developed with the calves diving to maximum depths of 285, 337, and 662 meters during dives lasting up to 11, 31, and 44 minutes. During these dives, all the calves produced echolocation clicks and one calf additionally emitted two buzzes, suggesting that it attempted to forage. The interclick intervals of regular clicks (medians: 0.81, 0.46, and 0.42 s) and buzz clicks (medians: 0.03 and 0.02 s) are similar to those of adults (median: 0.49 and 0.02 s) indicating that the echolocation ability of first year calves may be well developed, whereas the sparsity and long duration (28 and 12 s) of buzzes may hint at the calf's inexperience in catching prey. Within this dataset, echolocation effort seemed linked to diving capacity and could relate to size or age. Collectively, these findings suggest that the maturation of locomotor, diving, and echolocation skills are favored over investment in developing social communication skills at an early age of sperm whales.

Christopher Monk, Robert Arlinghaus, Shin Nakayama

Mining the reality of adult perch (Perca fluviatilis) 24/7 at the scale of natural ecosystem using fine-scale acoustic telemetry

Leibniz-Institut für Gewässerökologie und Binnenfischerei • SN: Humboldt-Universität zu Berlin
arlinghaus@igb-berlin.de

Acoustic telemetry allows the assessment of fine-scale behavior of free ranging fishes in the wild, but very few applications covering entire seasons at the scale of entire ecosystems exist. Here, we present behavioural data collected in 3-D over the course of one year in a 25 ha natural ecosystem using piscivorous adult perch (Perca fluviatilis) as a case study. We asked four questions: (1) do perch show evidence of personality in the wild and how do consistent among-individual differences change with temperature as a key environmental driver of ectotherms, (2) are behavioural traits related to life-history traits, thereby forming a pace-of-life, (3) how to perch respond at the population-level to abiotic change, and (4) are selected personality types selectively removed by human predators (anglers)? We find strong evidence for consistent among-individual differences and that personality is most prominently expressed as the water warms towards summer. The way the perch use space and time is consistently related to fast-slow life history prototypes, such that individual with fast early growth and high reproductive investments are taking greater risks behaviourally. The population of perch is strongly governed by temperature and light, showing a precise timing in terms of activity and habitat choice with light penetration and greater activity and space use with warming temperature. Angling removes a large fraction of the adult piscivorous fish over just a few weeks of angling, and there is evidence that perch with a characteristic habitat choice are selectively targeted independent of where the anglers actually encounter the perch. Overall, our study showcases the rich understanding, both fundamental and applied, that can be gained by cutting edge biotelemetry in the wild.

David Righton

Extreme swimming: how eels migrate to the Sargasso Sea

Centre for Environment, Fisheries and Aquaculture Science (Cefas)
david.righton@cefas.co.uk

The marine migration of European eels is one of the greatest animal journeys. Rice-sized larvae hatch in the Sargasso Sea, drift thousands of km via ocean currents into shallow coastal and freshwater areas - where they grow to adulthood for decades - only to return to the Sargasso Sea, breed and die. Scientists have tried for decades to gain a greater understanding of the spawning migration of eels, but the duration and route of their migration are still uncertain because the difficulties of tracking eels for thousands of km across the Atlantic are considerable. Since 2006, we've been using electronic tagging techniques to map and characterize the oceanic migration of European eels across the Atlantic Ocean from their autumn departure from European rivers. To date, we've recovered data from more than 200 tagged eels, mapped more than 5000km of the spawning migration and collected a wealth of data on the mesopelagic environments that eels experience as they migrate. The insights from our tagging programme provide evidence that eels are extreme swimmers, a description that can be applied to all aspects of their spawning migration, their swimming speeds, vertical migrations, thermal experience and the timing of departure from their continental habitat. Our results provide a basis for exploring the factors that influence the population dynamics of eels, as well as providing a new paradigm for oceanic eel migration.

Wei-Chuan Chiang, Michael K. Musyl, Hsien-Chung Lin, Sheng-Ping Wang, Yuan-Shin Ho, Chi-Lu Sun, Gerard DiNardo

Movements and swimming behavior of five species of billfish in northwestern Pacific Ocean

WCC, YSH: Eastern Marine Biology Research Center, Fisheries Research Institute, Taiwan • MKM: Pelagic Research Group LLC, USA • HCL, SPW: Department of Environmental Biology and Fisheries Science, National Taiwan Ocean University, Taiwan • CLS: Center of Excellence for the Oceans, National Taiwan Ocean University, Taiwan • GDN: NOAA Fisheries, Southwest Fisheries Science Center, USA
wcchiang@mail.tfrin.gov.tw

Billfishes comprise some of the largest and most mobile apex predators widely distributed from tropical to temperate oceans. Because of their size and fighting ability, they are a popular gamefish worldwide but are incidentally caught as bycatch and for food in many global fisheries. To investigate their movement patterns, habitat preferences and vertical thermal niche, pop-up satellite archival tags (PSATs) were deployed on five species of billfish (black marlin, blue marlin, sailfish, striped marlin and swordfish) using harpoon, longline and set-net fishing gear in southeastern Taiwan. Linear displacements ranged from 73 to 3,579 km from deployment to pop-up locations with average speeds of 0.1 to 9.6 km/hour. Most probable tracks (MPTs) calculated by the Kalman filter suggest that swordfish moved south after release whereas black marlin undergo distinct seasonal movement patterns. For sailfish, all movements were confined to the East China Sea, and striped marlin moved to South China Sea. No seasonal movement patterns were observed in blue marlin but MPTs from the longest deployments revealed highly variable movement patterns. Regardless of tagging location or season of release, none of the tagged billfishes travelled to the central Pacific Ocean. Diving depths and ambient water temperature ranged from the surface to 737 m and from 6°C to 33°C. All species showed oscillatory dive behavior from the surface mixed layer to as deep as ~200 - 700 m and clear diel patterns occupying shallower depths at nighttime than during daytime. Comparative vertical niche is discussed for the species.

Oral Session: Models & Methods

Urška Demšar

Visual Movement Analytics in a 3D space

School of Geography & Sustainable Development at the University of St Andrews
urska.demsar@st-andrews.ac.uk

Recent developments and ubiquitous use of global positioning devices have revolutionised movement analysis, as we are able to collect increasingly larger movement data sets at increasingly smaller spatial and temporal resolutions. This talk discusses 3D visual representations of movement in the context of movement ecology. We first introduce volumetric aggregations in a space-time cube (a conceptual 3D space, where the bottom two dimensions represent geographic space and the third dimensions time), the so-called space-time densities. The densities are used in ecological context to visualise the dynamics of space use over time and to link these patterns to behavioural information obtained from other data. In the second part of the talk we introduce a 3D volumetric algorithm for a geometric model of space use and illustrate its use on real 3D trajectories (that is, trajectories where the location is given with three coordinates, including the elevation). We finish the talk by outlining some of the open challenges for visual movement analytics.

James K. Sheppard, Jeff A. Tracey, Darren Eng, Robert S. Sinkovits, Jun Zhu, Ronald R. Swaisgood, Robert N. Fisher

Spatiotemporal Behaviors and Habitat Use of Wildlife in 3D

San Diego Zoo Institute for Conservation Research, U.S. Geological Survey, San Diego Supercomputer Center
University of California, University of Wisconsin - Madison
jsheppard@sandiegozoo.org

Advances in biologging technologies are enabling the collection of bigger and more accurate data on the movements of free-ranging wildlife in space and time. Although many biologging devices record 3D location data with x, y, and z coordinates from tracked animals, the third z coordinate is typically not integrated into studies of animal spatial use. Disregarding the vertical component may seriously limit understanding of animal habitat use

and niche separation by constraining estimates of animal space use to a biologically unrealistic 2D "Flatland". We present novel movement-based kernel density estimators and computer visualization tools for generating and exploring 3D home ranges based on location data for terrestrial, aquatic, and avian wildlife research. We use GPS biologging data acquired from California condors as a case study to demonstrate the ecological insights and conservation management benefits provided by 3D home range estimation and visualization for a species with major vertical movements. This technique is extended by integrating a temporal dimension that enables the intersection of 3D space-use through time to be modeled for characterizing 3D spatiotemporal interactions between multiple individuals (e.g. conspecifics). We also match the 3D volumes of an animal's home range with 3D environmental covariates through time to build a detailed multidimensional picture of habitat use.

Sophie Bestley, Ian Jonsen, Roland Langrock, Théo Michelot, Theoni Photopoulou, Uffe Thygesen, Toby Patterson

Animal movement and prediction: modelling animal behaviour in a changing climate

SB: IMAS-Univ. Tasmania, Australia • IJ: Macquarie University Australia • RL: Bielefeld University Germany • TM: University of Sheffield UK • TP: Univ. Cape Town, South Africa • UT: Danish Tech. University, Denmark • TP: CSIRO Oceans and Atmosphere, Australia
sophie.bestley@utas.edu.au

For highly mobile marine predators, movement ecology fundamentally underpins the spatial distribution of populations and their response to change. Many researchers are interested in using individual-based electronic tracking data to explore and project species' movement under changing environments. The currently popular techniques (e.g. habitat selectivity, resource utilisation) correlate animals' use of space with environmental parameters but are generally blind to the processes that underlie animal movement patterns and interactions with their habitats. The open discussion at the third Climate Impacts on Top Predators (CLIOTOP) Symposium highlighted a notable lack of mechanistic or process-based modelling approaches. While there is value in characterising species' current habitat preferences, approaches that explicitly model movement dynamics, associated behavioural processes, and their ties to environmental features should be better able to provide robust projections of species' future distributions in a changing environment. The CLIOTOP Task Team 2016-06 "Modelling Animal Behaviour in a Changing Climate" is convened to address this key gap - and opportunity - for integrating a mechanistic understanding of how animals actually use

marine areas (e.g. for feeding, migrating, resting) into spatial models of species habitat utilisation and distribution. Early work of the group has delivered a fast method (using R interfaced to C++) to model movements of colony-based predators (Michelot et al, accepted, Ecology. DOI:10.1002/ecy.1880) using observational animal tracking datasets for estimation and simulation procedures. This framework incorporates external covariates and further work will focus on explicitly modelling environmental relationships. Concurrent efforts are exploring continuous-space parameterizations (using Template Model Builder), specifically random and correlated random walk models with an advection (drift) term for implementing an environmental bias, or a time-varying autocorrelation term to approximate search behaviour (where correlation is low). This presentation will overview task team work and plans for improving our current capabilities to project animal movements under a changing climate

Jonathan Handley, Andrea Thiebault, Andy Stanworth, David Schutt, Pierre Pistorius

Behaviourally mediated predation avoidance distorts signals of community structure obtained through a marine predator's diet

Nelson Mandela University
ppistorius@nmmu.ac.za

In the marine realm, much knowledge has been gained about what resources large predators utilise and where they acquire such resources, through dietary and tracking studies. The actual constraints associated with prey capture has, however, largely been neglected due to direct in situ observations for large marine predators remaining particularly challenging. Given the variation in functional links through which predator and prey interact, the aim of this study was to investigate factors influencing prey capture in an in situ context, using high definition bird-borne video cameras on a marine diving predator, the gentoo penguin Pygoscelis papua breeding at the Falkland Islands. Using 38 hours of video data obtained from 32 foraging penguins, in combination with a novel technique for analysing video data, we show that birds target prey when they are most discernable, and that prey defense, something that has entirely been ignored for pelagic penguin prey, influences prey capture and therefore overall diet composition. We conclude that prey defense behaviour can have a significant effect on a predator's diet. The use of the diet of marine predators as an indicator of community structure at the mid and lower trophic levels is common practice in marine ecological studies. Our results indicate that prey behaviour could be a significant source of bias in these studies.

Oral Session: Around Biologging

Kyler Abernathy, Berkenpas, E.J., Shepard, C.M., Henning, B.S., Turchik, A.J.

Animal-borne imaging systems as a standard methodology for verification and calibration of indirect measures of behavior

National Geographic Labs, National Geographic Society
kabernat@ngs.org

In the last half-century, the suite of tracking and bio-logging instruments (VHF tags, PIT tags, time-depth recorders, satellite positioning tags, environmental sensors, physiological sensors) and bio-sampling techniques (DNA, fatty-acids, stable isotopes) for the study of wildlife behavior and ecology has greatly expanded and diversified. Data from these tools and techniques have proven to be extremely valuable and have come to be heavily relied upon for management and conservation decision-making. The advantages obtained in the increased volume and type of data collected however, can come at the sacrifice of detail and context. The narrow and indirect nature of many of these data streams requires significant inference when connecting them to complex behavior. Many papers have been published proposing methods of interpolating behavior or measuring ecological processes from these types of data, but it is not always possible to confirm their accuracy. Animal-borne imaging entered the bio-logging field more than 25 years. Initially it often served as a tool of open discovery, providing direct views into the inaccessible portions of animals' lives and whatever that might reveal. As this technique has matured, the explicit behavioral detail and context available in visual data has demonstrated significant value for evaluating assumptions and interpretations applied to other measurements and models constructed from indirect measures of behavior. To date, animal-borne imaging systems have been deployed by a large number of practitioners, on over 100 wildlife species, many using this data for 'ground-truthing' applications. It provides valuable fine-scale data to improve study methods or apply the existing approaches with greater confidence - and potentially greater value - by reducing uncertainties in interpretation. We believe this use of the animal-borne imaging data to be the foundational application that will lead to the widespread application of this methodology.

David W. Winkler

Solar nano-tags for life-long monitoring of small animals on land and sea

TABER, Ecol and Evol Bio, Lab of Ornithology, Cornell University, Ithaca NY USA
dww4@cornell.edu

Recent improvements in photo-voltaic cells have allowed the design of radio transmitters that merely charge a capacitor and broadcast digital ID signals every second or so whenever the sun is shining, even on cloudy days. Because they lack a battery, these tags can be made less than 0.5 g in mass, and they have an active life longer than the lives of most animals on which they can be placed. These tags generally have not been designed to transmit high-powered signals, and detections are obtained if receivers can be placed within 1 to 2 km of the tags. The detection probabilities of small solar beeper tags can be increased substantially if the tags are deployed in the vicinity of receiver base stations or in areas covered by networks of receiver towers such as Motus. Tags so far have been operating at 434 MHz, and tags at other frequencies and upgrades to existing receivers in the Motus network in North America have been developed. We are also working toward an integration with receiver systems in the marine realm (agency buoy systems, ship-board monitoring systems, etc.) to increase the trackability of small marine life. On both sea and land, we are also working toward the integration of mobile receiver platforms, borne on larger birds with greater cargo capacity and similar life-cycle distributions, to gather GPS-referenced encounters with small solar tags and download these encounters via satellite, cell-phone or wi-fi networks. The same solar nano-tag architecture is being adapted for the gathering of solar geolocation data with remote data off-load and for the gathering and transmission of high volumes of sensor data (currently attitude, accelerometry, body temperature). These tags, with low power and low mass, are a key complement to the larger more sophisticated satellite tags that can be carried by larger animals.

Laura Stidsholt, Mark Johnson, Kristian Beedholm, Lasse Jakobsen, Signe Brinklø, Kathrin Kugler, Peter Teglberg Madsen

A 2-gram ultrasound and inertial sensing tag for studying the auditory scene and kinematics of echolocating bats

LS, KB, PTM: Zoophysiology, Department of Bioscience, Aarhus University, Aarhus, Denmark • MJ: Scottish Oceans Institute, University of St Andrews, St Andrews, Scotland • LJ, SB: Sound and Behaviour Group, Institute of Biology, University of Southern Denmark, Odense, Denmark • KK: Department of Biologie II, Division of Neurobiology, Ludwig Maximilians University, 82152 Martinsried, Germany

laura.stidsholt@bios.au.dk

Echolocating bats make up one in four mammalian species and play important roles in many ecosystems, but we know very little about their sensory ecology due to their inaccessible lifestyle as nocturnal fliers. The small body sizes of bats have made them poor candidates for using biologging techniques as a window into their ecology. In an attempt to overcome these problems, we have developed a 2-gram tag that records continuous ultrasound and movement data with a large dynamic range (79 dB) enabling recordings of high-intensity outgoing calls and weak returning echoes as well as a high sampling rate (250 kHz) to acquire the full spectral range of calls and echoes. The tag contains magnetometers and wide bandwidth triaxial accelerometers to measure fine-scale movement in three dimensions. In this study, we tested the tag on a European Noctule (Nyctalus noctula) during a target approach experiment in a flight room. Our recordings show both the outgoing call and clear echoes reflected off walls up to ten meters away and off the landing sphere (0.2 m diameter) at distances up to three meters. The accelerometer data enables the detection of behavioural events such as flying, grooming and eating. A sensor sampling rate some 40 times higher than the wing-beat rate enables investigation of how bats synchronous their calling and movement behaviours, and how they react to information in echoes. So, we have developed the first on-board tag that can record the primary sensory flow of bats concomitant with associated behaviors on a very fine time scale. The tag holds potential to substantially foster a deeper understanding of how behavior is guided by sensory inputs in the wild.

Pauline Goulet, Rene Swift, Peter Madsen, Mark Johnson

Development of a miniature animal-borne echosounder to characterise the prey field and predator-prey interactions of marine predators

University of St Andrews - Sea Mammal Research Unit

pg48@st-andrews.ac.uk

How predators find, select and capture prey are central themes in ecology, but for many aquatic animals, information on these is difficult to obtain. Echolocating toothed whales are an exception, sound and movement tags on some whales record echoes from prey enabling quantification of prey density and behaviour, as well as selection and capture tactics of the predator. Here we describe the development of a miniature biomimetic animal-borne echosounder with the goal of extending this capability to non-echolocating marine animals. The 10x5x4 cm tag contains an efficient piezo-composite sonar transducer transmitting at 1.5 MHz and a matched acquisition system. The echosounder is integrated with GPS, accelerometers, magnetometers and depth sensors, and can record continuously for up to 2 months. Due to size and power constraints, our design is limited to a single frequency and single beam precluding the target size and species discrimination information obtained by multi-frequency fisheries sonars. However, we show using data from echolocating cetaceans that information about prey behaviour and type can be obtained using a high ping rate in a single frequency sonar, leading us to optimize our design for ping rates of 50Hz. Although the centre frequency generated by this sonar is well beyond the hearing range of seals, sonars also produce low frequency sidebands. To reduce the audibility of these, we modified signal shape and filtering, using measurements of the output levels in the hearing range of seals to refine the design. Deployments on captive seals are now underway to test for behavioural responses when the sonar is active. If the tags pass audibility testing, they will be deployed on free-ranging southern elephant seals. The combination of sensors will potentially provide unique simultaneous information on where animals find prey, how they move to acquire it, and, via body condition proxies, the benefit they get from it.

Markus Horning, Bruce Mate, Andrew Gilbert, Russ Andrews, Melinda Holland, Kim Holland

The Argos Alliance: working towards keeping the critical Argos wildlife tracking system viable

MH: Alaska SeaLife Center • BM: Oregon State University • AG: Biodiversity Research Institute • RE: Marine Ecology and Telemetry Research • MH: Wildlife Computers, Inc. • KH: Hawaii Institute of Marine Biology

markush@alaskasealife.org

The continued viability of Argos, one of the most important global wildlife tracking systems used since 1978, is in extreme jeopardy. SARSAT, which provides emergency beacon locations for search and rescue and is used by many wildlife biologists for field safety is also threatened. The Argos Alliance of users and manufacturers was formed to address this challenge and to provide a voice to the scientific community in ensuring support for an essential tool for ecological studies. The Argos satellite telemetry system locates and collects data from mobile transmitters, and is dedicated to scientific, environmental and human safety applications. Argos platform transmissions are received by satellites in polar Low Earth Orbits (LEO). These features make the Argos system uniquely suited for wildlife telemetry studies: (1) global coverage, (2) low power required to reach LEO satellites, (3) burst transmissions as short as 1/8 second can yield data and locations even under difficult circumstances, such as infrequent short surfacing in aquatic species, (4) ultra-miniaturized transmitters under 3 grams are available. Argos currently uses receivers aboard six LEO satellites: four are operating many years past their design life, two satellites have a design life into early 2018. Only two replacement missions are currently scheduled to fill a potential complete gap in coverage in 2018. These new satellites would become operational in mid-2018 and early 2019. A U.S. CDARS launch with Argos and SARSAT receivers has been pushed back to 2022 due to funding cuts. If it does not launch before existing satellites fail, coverage could drop to just two of three minimally required orbits, resulting in increased latency and reduced data recovery opportunities. This may critically limit functionality of a telemetry system key to essential ecological studies. The Argos Alliance seeks the input, participation and support from the Biologging Community towards keeping Argos viable!

David March, Marc Torner, Albert Miralles, John Allen, Joaquín Tintoré, Baptiste Mourre, Ohiana Revuelta, Emma Heslop

Gliding Turtles: an integrated multi-platform experiment to monitor sea turtle movements using ocean gliders

SOCIB
dmarch@socib.es

Long-endurance autonomous underwater vehicles (AUV) are promising new observing platforms for tracking marine animals. The potential of ocean gliders to measure biophysical parameters in a 3D space offers an unprecedented opportunity to understand behaviour patterns. In this work, we present a real-time multi-platform experiment aimed at characterizing the three-dimensional space used by a tracked loggerhead. We integrated: (1) GPS satellite tags to monitor loggerhead movements; (2) an ocean glider to provide biophysical information along the path of the tracked turtle; (3) remote sensing and numerical models to obtain mesoscale products; (4) drifting buoys to validate numerical models of currents; and (5) AIS antennas, to monitor ship-based activities. Our approach offers new opportunities to better understand fine-scale spatial dynamics of sea turtle behavioural movement in relation to oceanographic features and human activities; and demonstrates the use of adaptive sampling with ocean gliders to track moving features in near-real time.

Oral Session: Animals as Oceanographers

Dorian Cazau, Julien Bonnel, Christophe Guinet

Sampling Southern ocean environmental parameters with bio-logged southern elephant seals

DC, JB: ENSTA Bretagne - Lab-STICC (UMR CNRS 6285), 2 rue François Verny, 29806 Brest Cedex 09, France •
CG: Centre d'Etudes Biologiques de Chizé, UMR 7372 Université de La Rochelle-CNRS,Villiers-en-Bois, France
cazaudorian@outlook.fr

Bio-logged Southern Elephant Seals (Mirounga leonina, SES) are efficient, cost-effective, autonomous samplers of Southern Ocean environmental parameters. They have been widely solicited to fill a "blind spot" in the Southern Ocean sampling coverage, with the collection of 90 % of the oceanographic data (e.g. temperature, salinity, light, fluorescence) available south of 60° S since 2004. Within our inter-disciplinary project, we describe our last findings in extracting both meteorological (e.g. above-surface wind speed and direction) and oceanographic (e.g. wave period) parameters using bio-logged SES of Kerguelen Islands. In particular, we consider acoustic data collected using an acousonde 3A stuck on the back of SES, as well as more classical head-mounted GPS and accelerometer data. First, we performed above-surface wind speed estimation based on the underwater ambient noise recorded by the SES. Although the swimming activity of SES implies a strong low-frequency self-generated noise, wind speed estimation has been performed within a 2m/s margin of error (Cazau et al., JAOT, 34:207-223, 2017). Second, we used accelerometer and magnetometer data to show that SES are good ocean surface followers. They float passively in harmony with the swell, and they tend to orientate their heads with the prevailing wind behind. This makes them a good proxy for oceanographic data collection. We identified noticeable pair-wise correlation relations between SES heading (i.e. yaw) and wind speed angle. We also performed mean wave period estimation with a rms-error below 2 s based on the SES vertical displacement. The obtained results are important, as current operational meteorological and oceanographic systems require reliable in-situ data to calibrate satellite estimations. Such results are also fully complementary to oceanographic data traditionally collected by the SES and drifters, making SES as an even more integrative and complete oceanographic samplers of Southern Ocean environmental parameters than previously anticipated.

Gil Bohrer

New method for measuring wind and air speed from high resolution GPS tags in thermalling birds

Ohio State University
bohrer.17@osu.edu

Birds move across the earth, travelling locally around breeding sites and globally across continents and oceans during migrations. Global data about animal movements are indispensable to understanding how to protect and manage wildlife. In parallel to advancements in understanding and interpreting the movement patterns themselves, incorporating the effects of environmental variables that are contextual to the movement is becoming an increasingly popular and productive approach in movement ecology. Tools such as Movebank's Env-DATA provide access to large global datasets of such environmental variables. The environment is constantly changing and each environmental variable varies with characteristic temporal and spatial pattern. Especially for fast-changing variables such as wind speed, turbulence and precipitation, the spatiotemporal resolution of the available data may not be appropriate, and too coarse to provide useful source of information for analysis of the movement decisions of the animals. Flying animals in particular can optimize their travel distance, speed and energetic costs only by responding to the changing wind speed, direction and uplift. Because of the wind-patterns' high frequency and large small-scale variability knowledge about the instantaneous local wind conditions that affect flying animal is not available through the coarse global gridded datasets. We have developed an approach to determine wind speed and direction from tracks of thermalling birds. The closed-loop shape of the thermal circling flight provides an opportunity to estimate the wind-driven displacement of the bird. By assuming that over the short course of the thermalling circle the wind speed is uniform, we can use the multiple displacements for all points around the thermalling loop to provide an unbiased estimate for the wind speed and the air speed of the bird. We tested our method with data of thermalling White Storks. Air-speed analysis provided insight into high altitude flight strategy by Himalayan Griffon Vultures.

Rob Harcourt, Clive McMahon, Ian Jonsen Mark Hindell, Simon Goldsworthy, Frédéric Bailleul, Fabien Roquet, Guy Williams, Sara Labrousse, Sophie Bestley, Christophe Guinet

Australia's Integrated Marine Observing System Animal Tracking Facility seals as oceanographer's program comes of age

Macquarie University
robert.harcourt@mq.edu.au

The Integrated Marine Observing System Animal Tracking Facility (IMOS ATF) aims to enhance the Australian research community's ability to detect ecosystem responses to change in the marine environment by measuring physical data and foraging movements of marine predators in the Southern Ocean and along Australia's southern shores. Since 2009, 334 SMRU CTD SRDLs have been deployed on southern elephant seals, Weddell seals, Australian sea lions and New Zealand and Australian fur seals collecting over 160,000 oceanographic profiles. This oceanographic data from the Southern Ocean and across Australian boundary currents, includes profiles of temperature and salinity from regions that are difficult or impossible to sample by other means such as beneath winter sea ice and across cross shelf currents in remote regions. Together with ARGO, Satellite Animal Tracking (SAT) provides the most comprehensive overview of ocean state across space and time. These observations form the major part of Australia's sustained contribution of ocean observations to the Global Ocean Observing System (GOOS) and Southern Ocean Observing System (SOOS) in the Southern Ocean. The data has been used to relate predator movements and behaviour to fine-scale ocean structure and variability. Observations of predator movements and foraging behaviour can be used to integrate variability in the lower trophic levels and natural and anthropogenic physical environmental changes within the whole-system approach. Here I present the highlights of the past eight years of data collection from both the Southern Ocean and Australia's southern coasts, including discovery of new sources of Antarctic Bottom Water, improvement of southern ocean state models and ice processes, and new insights into habitat use and feeding ecology of these seals. All data presented here are freely available on the IMOS portal through the Australian Ocean Data Network: http://imos.aodn.org.au/webportal/) and provided to the MEOP portal as part of our international collaborative research effort.

Kim Holland, Carl Meyer

Sharks as oceanographers: Near-real time oceanographic profiles from free-swimming fishes

Hawaii Institute of Marine Biology, University of Hawaii
kholland@hawaii.edu

A new generation of electronic tags has been developed that is capable of collecting and transmitting ocean temperature and dissolved oxygen profiles from free-swimming sharks. These tags also provide GPS-derived geolocation positions associated with the oceanographic profiles, thereby enhancing their utility for incorporation into operational oceanographic databases. Transmissions from tags mounted on the dorsal fins of sharks are relayed either through the Argos satellite system or through recently developed land-based receivers that greatly enhance data throughput. Communication infrastructure has been implemented to allow "machine to machine" transfer of the data such that the oceanographic profiles are being made available to end-users in near-real time. Tags deployed on tiger sharks in Hawaii are providing ocean profiles on a near daily basis with some profiles having maximum depths as deep as 800 meters. In this presentation we will describe the components of the system and illustrate the types of data that are being produced.

S.E. Simmons, D.P. Costa, B. Wallace, N. Bax, Y. Shin. P. Miloslavich, M. Andersen Garcia

How Biologging can contribute to measurements of essential ocean variables as part of a global ocean observing system

US Marine Mammal Commission • DPC: University of California Santa Cruz, USA • BW: Conservation Science Partners, Inc., USA • NB: Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia • YS: Institut de Recherche pour le Développement, France • PM: University of Tasmania, Australia • MAG: NOAA Office of International Affairs, USA
ssimmons@mmc.gov

The Biology and Ecosystem Panel of the Global Ocean Observing System (UNESCO/IOC/GOOS) is responsible for identifying Essential Ocean Variables (EOVs) for biological components of the oceans. Increased and better focused sustained ocean observations supported by the international scientific, governance and policy communities are needed to (a) determine and monitor appropriate trade-offs between conservation and

sustainable use globally, (b) effectively mitigate or manage adverse changes including climate change, and (c) predict and prepare for potential future changes. Here we present a transparent, repeatable process to identify EOVs for biology and ecosystems that are both relevant for society and technologically feasible to collect. We used a Driver-Pressure-State-Impact-Response (DPSIR) model to (1) identify the scientific and societal drivers and pressures that require sustained biological and ecological observations based on the mission and mandates of 24 relevant international bodies and conventions, (2) evaluate the state of observations through an on-line survey to more than 100 observing programs, and (3) analyze the impact and feasibility of the variables currently measured via a literature search determining how many publications address each of the drivers and pressures for each of the variables. Eight initial EOVs, were identified with abundance and distribution of fish, marine turtles, sea birds and marine mammals among them. The EOVs require community input/buy-in and we invite such from this audience. We will describe the specification sheets developed for these EOVs, highlighting the supporting and sub variables that could be informed by biologging data, and suggest ways to begin implementation. The aim is to build on existing efforts to achieve a globally standardized, open access and sustained observing system, including biologging data, which will deliver societal benefits by informing national reporting activities such as the World Ocean Assessment, Sustainable Development Goal 14 and Aichi targets, among others.

Theresa R. Keates, Raphael M. Kudela, Rachel R. Holser, Luis A. Huckstadt, Samantha E. Simmons, Daniel P. Costa

Marine mammals as oceanographers: Chlorophyll measurements using tagged northern elephant seals

TRK, RMK, RRH, LAH, DPC: University of California Santa Cruz • SES: United States Marine Mammal Commission
tkeates@ucsc.edu

Marine habitat models regularly incorporate chlorophyll data derived from satellites, but analyses utilizing in situ data are invaluable given the inherent limitations and potential errors of remote sensing. In situ oceanographic data derived from animal-mounted sensors enable investigation of habitat use in relation to environmental variables at the same spatiotemporal scale of the animal's movement. Northern elephant seals (Mirounga angustirostris) were equipped with CTD tags (conductivity-temperature-depth sensors) with integrated fluorometers as part of a long-term study in the North Pacific Ocean. These tags collect high resolution chlorophyll fluorescence data throughout the seals' foraging

migrations at lower cost than traditional ocean sampling platforms. While valuable insights have been gained from fluorometer tags deployed on marine mammals in the Southern Ocean, very few deployments have been conducted in the north Pacific. We compared chlorophyll data derived from lab-calibrated fluorometers deployed on elephant seals migrating through the north Pacific to concurrent satellite estimates of chlorophyll. Surface chlorophyll readings from fluorometer tags showed a linear relationship to satellite data comparable to observations previously published. In situ chlorophyll fluorescence values were often higher than estimates from satellite algorithms at chlorophyll concentrations higher than 1 μg/L. Poor agreement between tag and satellite in regions of interest with high chlorophyll where elephant seals are likely foraging warrants detailed investigation. Data from seal-mounted tags additionally showed subsurface chlorophyll maxima not detectable by surface scanning satellites (mean depth 46 m). These maxima are critical determinants of pelagic productivity. In situ chlorophyll data from animal-mounted fluorometer tags, which document three dimensions of the water column at high resolution, can provide environmental data from areas of ecological importance a top predator utilizes.

Oral Session: Ecology & Environment

Dominique Berteaux, Sandra Lai

Satellite tracking of the Arctic fox on the Canadian Arctic sea ice

Canada Research Chair on Northern Biodiversity, Université du Québec
dominique_berteaux@uqar.ca

The Arctic fox is the most widespread mammal species in the Arctic, where it is a key predator of the tundra. The species feeds on cyclic lemmings and has also long been known to forage on the sea ice, but until recently formidable logistic challenges prevented any study of its winter ecology. We asked when, how and why Arctic foxes use the sea ice. We tracked (Argos) >110 individuals year-round during 10 years around North Baffin Island, Canada. Individuals could cover thousands of km on the sea ice during winter, at high and sustained travel rates reaching 90 km/day. They could detect carrion from unexpected long distances (> 10 km), and they sometimes met at hotspots of fox activity gathering up to 12 individuals. However, despite these strong movement abilities, most individuals retained their tundra territory during winter, making short commuting trips to the sea ice rather than engaging in long-distance resource tracking. Although foxes live in pairs, extraterritorial excursions of pair members were not synchronized and they foraged independently when on the sea ice. This wealth of new data generated by satellite tracking has opened many original research avenues at the individual, population and ecosystem levels. We now intend to use GPS tracking and accelerometers to fine tune our understanding of the predator-prey interactions in which Arctic foxes are involved. Arctic biodiversity is in rapid transition due to climate change and socio-economic development, bio-logging is an indispensable tool to monitor, understand, and sometimes anticipate ecological changes in the North.

Lei Cao

Are declining populations of wild geese in China "prisoners" of their natural habitats?

State Key Laboratory of Urban and Regional Ecology , Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences
leicao@rcees.ac.cn

While wild goose populations wintering in North America and Europe are mostly flourishing by exploiting farmland, those in China (which seem confined to natural wetlands) are generally declining. Telemetry devices were attached to 67 wintering wild geese of five different species at three important wetlands in the Yangtze River Floodplain (YRF), China to determine habitat use. 50 individuals of three declining species were almost entirely diurnally confined to natural wetlands, 17 individuals from two species showing stable trends used wetlands 83% and 90% of the time, otherwise resorting to farmland. These results confirm earlier studies linking declines among Chinese wintering geese to natural habitat loss and degradation affecting food supply. These results also contribute to explaining the poor conservation status of Chinese wintering geese compared to the same and other goose species wintering in adjacent Korea and Japan, western Europe and North America, which feed almost entirely on agricultural land, liberating them from winter population limitation.

David Sims

The Global Shark Tracking Project: Worldwide analysis of pelagic shark space-use and interactions with fisheries

Marine Biological Association of the UK / University of Southampton
dws@mba.ac.uk

Overfishing is arguably the greatest ecological threat facing the oceans. Globally it is estimated that between 63 and 273 million sharks are captured by fisheries annually, yet for many species, particularly oceanic pelagic sharks taken by high seas fishing vessels, the catches remain largely unregulated with poor monitoring and data reporting. Effective shark conservation for wide-ranging oceanic species is hampered by basic knowledge gaps about how sharks move and where they aggregate across population ranges, and precisely where they overlap with fishers. The Global Shark Tracking Project was initiated to address these

issues by assembling unique global datasets of satellite tracks of pelagic sharks and commercial fishing vessels. Forty shark research groups from 21 countries have now joined together to form the Global Shark Tracking Project Consortium with objectives to: (1) map shark and vessel distributions globally, (2) relate them to the changing ocean environment, and (3) identify any hotspots and quantify overlap between sharks and fisheries. Currently the database comprises satellite tracks of over 2,000 pelagic sharks and 50,000 fishing vessels. In this presentation we will describe research leading to this project, the database and analytical methods used, and will provide the first results from analyses of the global data. The talk will also explore the future role of combining fine-scale fish and vessel telemetry to inform the ocean-scale management of high seas fisheries.

Ana M M Sequeira

Habitat complexity drives global movement patterns of marine vertebrates

University of Western Australia
ana.sequeira@uwa.edu.au

Movement is a fundamental feature of animal's lives that is influenced by both intrinsic (phylogeny, life history) and extrinsic (environmental) factors. The relative importance of these factors in determining movement patterns remains unclear and has hampered the development of a general theoretical framework for the field of study. To identify unifying patterns in movement across apex marine predators ("megafauna") and to quantify the relative importance of both extrinsic and intrinsic factors as drivers of movement, we synthesized movement data from the largest satellite telemetry dataset yet assembled for these taxa. This data spanned three decades (1985 - 2015) and comprises 50 species including sharks, turtles, flying and swimming birds, true and eared seals, cetaceans, sirenians and polar bears and with distributional ranges across tropical, temperate, and polar regions. We analysed this global dataset of ~ 2.8 million tracked locations and show that complex differences across individual movement patterns were primarily explained by the interaction between the intrinsic characteristics that define a species and a single extrinsic factor: the habitat through which they move. Individuals that predominantly occupied oceanic waters displayed less variable patterns in movement than those with a strong affinity for continental shelves. This difference in movement patterns is likely due to the greater diversity of micro-habitats available on the shelves, highlighting the critical role of preferred habitat in the ecology and evolution of marine megafauna.

D. P. Costa, L. A. Hückstädt, L. K. Schwarz, A. S. Friedlaender, B. R. Mate, A. N. Zerbini, A. Kennedy, N.J. Gales

Assessing the potential exposure of migratory animals to disturbance

Dept of Ecology & Evolutionary Biology, University of California, Santa Cruz, CA 95060 • Marine Mammal Institute, Oregon State University, Newport, OR 97365 • National Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA Fisheries, Seattle, WA, 9
costa@ucsc.edu

While many studies have examined the sensitivity of marine animals to underwater noise an essential component of any risk assessment is the likelihood that individuals of a given population will be exposed to that disturbance. An essential component of risk assessment is identification whether individuals will be exposed to a risk. This requires information on the proportion of the population exposed, for how long, and during what activity (i.e., feeding, migrating, and breeding). Using satellite telemetry data for humpback and blue whales feeding and migratory regions in Antarctica, California, and Bering Sea, we modeled the potential exposure of individuals to an acoustic disturbance. Foraging and transit regions along the tracks were identified and using a switching state space model the time spent foraging in each region calculated. A simulated seismic survey was randomly placed (100 iterations) within the habitat of each of species and the amount of time individual animals were exposed determined. A large disturbance (i.e. 100 km) only exposed 6% of the population of humpback whales in Antarctica and 19% blue whales off California. In contrast, humpback whales in the Bering Sea experienced high exposure with only a 5 km disturbance. This approach can be used to develop a framework for estimating the likelihood that a given animal population would be exposed to disturbance and to develop general risk assessment guidelines. Output from this exposure model can be used to evaluate the potential effect of disturbance on an animals energy budget in terms of energy expended but not acquired and how that would effect on offspring growth and survival.

Karen Lone, Kit M. Kovacs, Christian Lydersen, Mike Fedak, Magnus Andersen, Phillip Lovell, Jon Aars

Aquatic behavior of polar bears (Ursus maritimus)

KL, KMK, CL, MA, JA: Norwegian Polar Institute • MF, PL: Sea Mammal Research Unit, University of St.Andrews

karen.lone@npolar.no

Polar bears are ice-associated marine mammals that routinely swim and dive while hunting seals or whales, or when accessing submerged food (i.e. algae, cadavers). They also swim when in transit (e.g. moving between denning and feeding sites) if ice is not available as a transport platform. Despite the highly aquatic nature of polar bears, their aquatic behaviour is poorly documented. This study quantified time spent in the water by deploying devices with saltwater switches on female polar bears in Svalbard, Norway, (N= 57, 2005-2017). Saltwater switches were either integrated directly in ARGOS or Iridium satellite-linked collars (19 SMRU, 31 Telonics) or Mk9-TDRs (N= 25, Wildlife Computers) were glued onto collars. In the course of every day at least 30% of the instrumented bears spent time in the water. During May, June and July 75% of the bears had contact with water daily. Considering monthly records, over 90% of the bears were in the water April-October. There were marked seasonal patterns in aquatic behaviour, with bears spending more time in water in summer (June-August) than at other times of year. The lowest monthly mean time in water occurred in March (2.1%, range 0-10%) and the highest in July (9.4%, range 0-31%). Reproductive status had a profound impact on time in water: Females with cubs-of-the-year spent less time in water than females with yearlings or those without cubs from April (den emergence) until mid-summer, consistent with small cubs being particularly vulnerable to hypothermia and drowning. From July to September, coastal bears spent more time in water than did bears known to make offshore excursions, but some of the latter undertook notably long-distance swims. For offshore locations, the probability of swimming and time spent swimming decreased with increasing ice concentrations. SMRU instruments also recorded depth, all bears with >100 dives (N= 13/19) dove to >6m.

Luciana C. Ferreira, Michele Thums, Ben Radford, Andre S. Afonso, Adam Barnett, Richard Fitzpatrick, Neil Hammerschlag, Fabio H.V. Hazin, Michael Heithaus, Rory McAuley, Jessica Meeuwig, Mahmood Shivji, John Stevens, Bradley Wetherbee, Mark G. Meekan

Scale and habitat-dependent movement behaviour of a large marine predator

LCF, MT, BR, MM: Australian Institute of Marine Science, Perth, Australia • LCF, JM: School of Biological Sciences, University of Western Australia, Perth, Australia • AA, FH: Universidade Federal Rural de Pernambuco, Recife, Brazil • AB, RF: College of Marine and Environmental Sciences, James Cook University, Cairns, Australia • NH: Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, USA
MH: School of Environment, Arts, and Society, Florida International University, North Miami, USA • RMA: Department of Fisheries, Government of Western Australia, Perth, Australia
MS, BW: The Guy Harvey Research Institute, Nova Southeastern University, Fort Lauderdale, USA • JS: CSIRO Marine and Atmospheric Research, Hobart, Australia
BW: Department of Biological Sciences, University of Rhode Island, Kingston, USA
l.ferreira@aims.gov.au

For top-order predators in marine systems, identification of the intrinsic and extrinsic drivers of movement patterns is usually hampered by the limited sampling that can be achieved by any individual study. We sought to overcome this problem by pooling all available tracking data sets (n=130) for a keystone predator, the tiger shark (Galeocerdo cuvier) from Atlantic, Pacific and Indian oceans, in order to define the major environmental predictors of movement and space use throughout most of the species range. Movement-based kernel methods and generalised additive mixed models were applied to define predictors of utilisation distributions and migratory movements. Geographically weighted regression (GWR) was then used to test for spatial non-stationarity in the relationship between values predicted from the models and those generated by kernel methods. Bathymetry and sea-surface-temperature were identified as the major drivers of utilisation distributions and migration patterns of tiger sharks of both sexes in different ocean basins, however, the strength of the relationship with these drivers varied greatly among regions and the explanatory power was relatively low. Although this may have been due to missing biological covariates in models, notably food availability, individual variability and spatial resolution of both response and explanatory variables appear to be the main drivers. The combined results of additive mixed models and GWR suggested that the relationships between sharks and the environment occurred at finer scales at certain locations on the shelf than in the open ocean, suggesting that movement patterns were both scale- and habitat-dependent. This implies that the physical processes that aggregate food occur at different spatial scales in each of these habitats and our analyses indicate locations where further research and high-resolution tracking and environment data are required to reveal these underlying patterns.

Oral Session: Behavioural Ecology Marine

Katsufumi Sato

Animal movements affected by physical conditions

Atmosphere and Ocean Research Institute, University of Tokyo
katsu@aori.u-tokyo.ac.jp

Gravity acting on an aquatic animal is almost counteracted by buoyancy. As amount of air and lipid in the body fluctuates, total body density deviates around that of surrounding water. Since the first accelerometer was deployed on king penguins in 1996, we have monitored swimming efforts of free-ranging animals in relation to conditions of animals. Diving penguins stopped beating flippers during the final stages of ascent. Propulsive swim speeds of penguins were about 2 m s-1, however, gliding speeds increased after flipper beating stopped. The acceleration during the passive ascent can be attributed to increased buoyancy from the expanding air volume (following Boyle's law) in the body. Estimated air volume inhaled at the surface was positively related with dive depth, which indicates penguins controlled inhaling air volume according to their intended dive depth. On the other hand, Weddell seals were observed to exhale before dives, which means their body density would be affected mainly by the amount of fat. To investigate the effect of body density on stroke effort, accelerometers were deployed on breeding females during lactation. At early lactation, fatter females exhibited only stroke-and-glide swimming. As breeding females consumed its energy stores and their fat layer was depleted, prolonged gliding in descent and continuous stroking in ascent was observed with thinner females. Seals changed swimming gait according to seasonally changing body density. Accelerometers are available for flying animals. Shearwaters and albatrosses mainly relied on soaring, and were passively drifted during resting on the water surface. High-resolution GPS loggers on birds provided zig-zag flight paths and drift movements, which should include information on ocean surface winds and currents. Interspecific comparison indicated that movements of many animals are sensitive to physical conditions. Using this characteristic, we are inversely analyzing animal movements to extract physical conditions of animals and their surrounding environments.

Taylor K Chapple, Salvador J Jorgensen, Oliver JD Jewell, Paul E Kanive, Gregory B Skomal, Martin Wikelski, Barbara A Block

A once in a while predator: Low expense and high rewards dictates feeding behavior in white sharks (Carcharodon carcharias)

TKC, BAB: Stanford University • SJJ: Monterey Bay Aquarium • OJDJ: Dyer Island Convervation Trust, Murdoch University • PEK: Montana State University • GBS: University of Massachusetts • MW: Max Planck Institute for Ornithology and University of Konstanz
tchapple@stanford.edu

Organisms must acquire more energy than they expend in order to grow and reproduce, meaning that energy from prey consumption must exceed the metabolic losses due to metabolism and activity. Metabolism has been demonstrated to be a major factor constraining the diet of terrestrial carnivores and limiting the size of those to approximately 1 ton, after which they can no longer satisfy their energy demands. Whereas no extant terrestrial carnivores exceed this size, there are multiple marine predators that do, allowing a test of the generality of this prediction. Here, we study the foraging behavior of the white shark (Carcharodon carcharias), a marine mammal-eating predator that can grow to at least 2 tons. We deployed a mixture of speed- (n= 8) and camera-equipped (n= 27) biologging tags and ingested stomach temperature tags (n= 9) on large free-swimming white sharks (estimated mass= 85-1500 kg) from three distinct global populations to understand their foraging behavior. Direct measurements of swimming speed from external tags revealed white sharks to swim significantly slower (98 ± 25 cm/s) than previously assumed, likely resulting in lower metabolic rates. Across 150 hrs of video and 1,078 hours of stomach temperature data we observed only one natural feeding event, despite encountering potential prey on many occasions. This feeding event was represented by a large increase in visceral temperature, indicating ingestion of a high-caloric prey item. We suggest that the high rewards of its mammalian prey, coupled to a low metabolic rate, in comparison to terrestrial carnivores, allows white sharks to be highly selective in their foraging behavior and grow to such extraordinary sizes.

Clive R. McMahon, Sophie Bestley, Christophe Guinet, Robert Harcourt, Ian Jonsen, Guy Williams, Mark A. Hindell

A decade of tracking seals reveals meso-pelagic prey will be harder to find in a warming Southern Ocean

Sydney Institute of Marine Science • IMAS University of Tasmania Hobart • Centre d'Études Biologiques de Chizé • Department of Biological Sciences Macquarie University Sydney • Department of Biological Sciences Macquarie University Sydney

clive.mcmahon@utas.edu.au

Despite their importance in Southern Ocean food webs, very little is known about the factors influencing the distribution of meso-pelagic fish and squid. To quantify how the vertical distribution of meso-pelagic prey varies in response to ocean properties we examine diving behaviour data from two predators, southern elephant seals and Weddell seals. We use (i) 13 years of tracking and diving behaviour data from a total of 290 seals tagged in the Southern Indian Ocean between 2004 and 2016, and (ii) CTD data collected concurrently either by the seals or ARGO floats (a total of 170,047 CTD casts). To ensure a focus on meso-pelagics we only included seal dives that were classified as pelagic hunting dives, based on the dive profiles and distance to the ocean floor. Water temperature at 400m (T400, selected as the overall mean dive depth) varied substantially among different oceanographic zones, as defined by the mean frontal positions (Orsi et al, 1996), and among years. Vertical distribution of prey appeared related to ocean temperature, with the depth of pelagic hunting dives varying to remain below the 4°C isocline. Meso-pelagic prey appeared to move deeper in all zones in the years with the warmest T400. The responses of the seals varied among the zones. In sea-ice and over the Antarctic continental shelf, dives were relatively shorter, and lengthened in warmer years, whereas in oceanic zones this pattern reversed. We discuss the implications of both changes in the prey distribution in years of contrasting ocean temperatures, and the response of the predators to these changes within the context of long-term climate change in the region.

Jana Jeglinski, Sarah Wanless, Stefan Garthe, Stephen C Votier, Keith C Hamer, Martin Wikelski, Jason Matthiopoulos

Roaming the seas: immature Northern gannets reveal the connectivity of the gannet metapopulation with mobile phone GPS tags

JJ: Institute for Biodiversity, Animal Health and Comparative Medicine, University of Glasgow • SW: Centre for Ecology and Hydrology • SG: Research and Technology Center FTZ Büsum, University of Kiel • SCV: Environment and Sustainability Institute, University of Exeter • KCH: University of Leeds • MW: Max Planck Institute for Ornithology, Radolfzell • JM: Institute for Biodiversity, Animal Health and Comparative Medicine, University of Glasgow
jana.jeglinski@glasgow.ac.uk

The movement patterns of immature animals are still largely unknown, yet can be highly relevant for key life history decisions and can influence the dynamics of populations. Northern gannets experience a prolonged phase of immaturity and display strong site fidelity once they start breeding at around age five. Limited GPS tracking data shows that some immature gannets "prospect", i.e. visit different breeding colonies during the breeding period, possibly investigating potential future breeding sites. Ring resightings show that some gannets breed in colonies different from their natal colony, corroborating the fact that gannet colonies operate as a metapopulation, a network of colonies linked through a flux of immature individuals deciding on their future breeding site. However, the scale of prospecting movements and thus the degree of connectivity between colonies has to date not been quantified. We use novel biologging technology to track the prospecting movements of immature northern gannets for the first time on a metapopulation scale to investigate the connectivity of the gannet metapopulation in the North-Eastern Atlantic. We deployed 31 GPS GSM tags, using the mobile phone network to transmit data, for up to 2 months on 2-3 year old immature gannets in three colonies in Scotland, Wales and Germany. Linking tracking data with data on the distribution, size and population trend of all breeding colonies, we answer three key questions on the scale, selectivity and territoriality of prospecting movements: (1) Over which spatial scales do prospecting movements operate, (2) Do prospectors visit colonies of specific size or trend and (3) Are prospecting ranges of immatures captured in different colonies overlapping? Our study provides novel data on the nature and mechanisms of colony connectivity and improves our understanding of the dynamics of the Northern gannet metapopulation.

Oral Session: Marine Reptiles & More

Mark G. Meekan, Phillipa J. Wilson, Michele Thums, Scott D. Whiting, Kellie L. Pendoley, Charitha B. Pattiaratchi

Shedding light on the in-water behaviour of neonate flatback turtles (Natator depressus)

The University of Western Australia • Australian Institute of Marine Science, Department of Parks and Wildlife • Pendoley Environmental
M.Meekan@aims.gov.au

After hatching, neonate turtles entering the water are thought to orientate away from shore using a combination of wave direction and visual cues such as low light on the horizon. Artificial light interferes with this process, attracting hatchlings at sea, but the relative importance of natural to anthropogenic cues to their dispersal is unknown and how predation rates might be impacted due to lingering around lights. Here, we used passive acoustic telemetry to track the in-water movement of flatback turtle hatchlings dispersing through nearshore waters off Thevenard Island, Western Australia. Turtles dispersed in the presence and absence of artificial light through an acoustic receiver array where we concurrently measured a range of oceanographic variables including currents and wave parameters. We used GAMMs to identify the most important cues influencing the bearing, variance in bearing (measure of disorientation), rate of travel and time spent in the array of turtles and assessed predation by examining specific movement behaviours. We show that artificial light slowed their rate of travel, increased the amount of time spent in nearshore waters and increased the variance in bearing, regardless of oceanography. Under ambient conditions, ocean currents affected the bearing of hatchlings as they left the shore, but when light was present, this effect was diminished, showing that turtles actively swam against currents in their attempts to swim towards the light, thus likely exacting energetic consequences. Predation rates were higher when artificial light was present, especially around man-made structures like jetties. We have shown that light pollution disrupts the natural dispersal cues of turtle hatchlings, causing them to linger and become disoriented in the near shore. This is the first study to measure predation associated with this pervasive threat and the increase in mortality we document may have detrimental effects on the survivorship and resilience of turtle populations.

Ohiana Revuelta, Ricardo Sagarminaga, Brendan J. Godley, David March

High resolution diving behavior of juvenile loggerhead sea turtles during oceanic phases in the Western Mediterranean Sea

OR: Balearic Islands Coastal Observing and Forecasting System (SOCIB), Balearic Islands, Spain • RS: ALNITAK, Spain • BJG: Centre for Ecology and Conservation, University of Exeter, Cornwall, UK • DM: Balearic Islands Coastal Observing and Forecasting System (SOCIB), Balearic Islands, Spain
orevuelta@socib.es

The westernmost part of the Mediterranean Sea (from the Alboran Sea to the Balearic Islands) host important developmental and foraging grounds for juvenile loggerhead sea turtles (Caretta caretta). These individuals experience strong differences in biological and physical oceanographic conditions in the area. Hence, description of their diving patterns is needed to better understand vertical characteristics of foraging habitats, and species distributions across different environmental gradients. The use of bio-logging techniques have given new insight into the behavior of sea turtles. In this study, we attached time depth temperature recorders (TTDRs) equipped with a pressure sensor for dive depth measurements and temperature sensors, to five juvenile loggerhead during their oceanic phases in the Western Mediterranean Sea, from 2015 to 2017. Dive profiles were relayed via satellite in the format of continuous depth records at 5-min intervals. We summarized vertical movements and determined dive parameters to analyze seasonal and spatial variations. We investigate the influence of ecosystem dynamics on turtles diving behavior by integrating dives with oceanographic variables. Differences in vertical behaviour related to seasonality and oceanographic variables may provide scientifically based data for the conservation and management of this species.

Michele Thums, Jason Rossendell, Marji Puotinen

The impact of tropical cyclones on migrating flatback turtles and the potential energetic consequences

MT, MP: Australian Institute of Marine Science • JR: Rio Tinto Pilbara Ports
m.thums@aims.gov.au

Tropical cyclones generate heavy seas that regularly cause physical damage to marine and coastal tropical ecosystems. Their detrimental effects on coastal marine vertebrate breeding habitat has received some attention in the ecological literature (sea bird and turtle nesting

sites), however our understanding of the effects of cyclones on the at-sea phase of such animals remains largely unexplored. Here, we modelled maximum likely significant wave heights every hour during tropical cyclones over three seasons along the migratory paths taken by 35 satellite tracked flatback turtles from nesting beaches in Western Australia to their foraging grounds, up to 1300 km away. The aim was to quantify the extent to which heavy seas during cyclones disrupted turtle trajectories and diving behaviour and exposed them to cool water. 56% of migrating turtles may have been exposed to extreme conditions during a single cyclone, with potential impacts from several others. A detailed reconstruction of maximum possible seas (significant wave height - Hs) along the migratory paths showed that in some cases turtles deviated notably from their paths just as conditions worsened (Hs up to 8m), and then returned to their route once conditions returned to normal. Analysis of the CTD data from the turtle tags showed that during this time the turtles dived deeper and were exposed to cooler water resulting from mixing by the cyclone. We assessed the extent to which deviation from their migratory paths would delay their arrival at foraging grounds and whether there could be potential energetic impact from time spent in cooler water, given that sea turtles are ectotherms. Both effects could be compounded by the fact that turtles are energetically weakened by the breeding season. This work has important implications given that the most intense cyclones are predicted to become more prevalent in the future.

Kate L. Mansfield, Milagros L. Mendilaharsu, Nathan F. Putman, Maria A.G. dei Marcovaldi, Alex E. Sacco, Yonat Swimmer

First satellite tracks of South Atlantic sea turtle "lost years": trans-equatorial and seasonal implications for population connectivity

University of Central Florida • Projeto TAMAR Fundación PRO-TAMAR • University of Miami • NOAA Fisheries PIFSC
kate.mansfield@ucf.edu

In the South Atlantic Ocean, few data exist regarding the in-water behavior of young oceanic sea turtles. We characterized the movements and dispersal of yearling loggerhead turtles from Brazilian rookeries using novel telemetry techniques, testing for differences in dispersal during different periods of the sea turtle hatching season that correspond to seasonal changes in regional currents. We outfitted 19 laboratory-reared oceanic-stage juvenile sea turtles (10-26 cm carapace length) with 9.5-gram solar-powered satellite tags and tracked their movements for up to 120 days. We released tagged turtles early, mid- and late-hatching season to correspond to seasonal changes in regional ocean circulation. Using

passive oceanographic drifters as controls, we experimentally tested and modeled whether turtles passively drift with currents or actively disperse. Tag and drifter data indicate net turtle movement was an interaction between turtle behavior (orientation and swimming) and ocean circulation. Turtle movements coincided with seasonal latitudinal shifts in currents. Turtles transited south early-hatching season, experiencing strong southward currents while orienting to the southeast. Late hatching season, turtles uniformly moved northwards, actively orienting to remain offshore in a current regime favoring shoreward, northward, and trans-equatorial transport. The timing of post-hatchling behavior exposes the young turtles to seasonally-varying ocean conditions, resulting in a diversity of dispersal trajectories leading individuals into the Northern Hemisphere or further into the South Atlantic. Such migratory route diversity may ultimately buffer the population against environmental changes or anthropologic threats, fostering population resiliency.

Nicolas Courbin, Aurélien Besnard, David Grémillet, Clara Péron, Matthieu Authier, Claire Saraux, Jérome Fort

Resource tracking specialization overrides site fidelity in a marine predator inhabiting a stochastic environment

NC, DG: CEFE / CNRS • AB: CEFE / EPHE • CP: IRD • MA: Université de la Rochelle • CS: IFREMER • JF: LIENSs / CNRS
nicolas.courbin@cefe.cnrs.fr

In environments with relatively stable prey distribution, predators generally have a high foraging behaviour consistency and specialization. In such environments, habitat use consistency increases with spatial consistency, however, and both behavioural mechanisms are confounded. The determinants of foraging specialization therefore remain unclear: Are birds specialized on a given prey type because they repeatedly visit the same foraging spots (i.e., site fidelity) or do they track particular prey types occurring continuously in the same areas (i.e., prey fidelity as well as site fidelity)? We related the foraging habitat selection of 75 Scopoli's shearwaters (Calonectris diomedea) to their site fidelity and diet composition during the breeding season, between 2011 and 2015, at the Marseille archipelagos in the Western Mediterranean with a highly dynamic prey distribution at the short-term scale. Using GPS data, we assessed the at sea foraging tactics of birds with resource selection functions including the daily spatio-temporal distribution of abundance of zooplankton and biomass of three small fish species: sardine, anchovy and sprat. We found a low foraging habitat selection consistency at the individual level due to the use of two main trip patterns: 1) generalist trips, shearwater searching for anchovy, sprat and zooplankton, and 2) trips

specialized on zooplankton only. As expected in stochastic environments, we showed that foraging selection consistency and specialization were decoupled from site fidelity. We corroborated the foraging habitat selection pattern of shearwaters with their level of diet specialization based on isotopic analyses from feathers that distinguished between zooplankton and small fish food sources. We demonstrated that in stochastic environments, predators can actively track their prey and that resource tracking specialization overrides site fidelity.

Taiki Adachi, Yasuhiko Naito, Daniel P. Costa, Patrick. W. Robinson, Luis Hückstædt, Rachel Holser, Akinori Takahashi

A deep-diving seal expands whiskers for active prey-sensing in the dark ocean

TA: The University of Tokyo • YN, AT: National Institute of Polar Research (NiPR) • DPC, PWR, LH, RH: University of California Santa Cruz (UCSC)
im.taiky@gmail.com

Visual sense in diving predators is often of limited use underwater, especially in the deep, dark marine environment. Therefore, pinnipeds, which do not echolocate as odontocete cetaceans do, are expected to rely largely on vibrissal system to locate prey by following hydrodynamic trails. However, it remains unclear whether pinnipeds use vibrissal system in nature. Here, we monitored whisker movements of a deep-diving pinniped, a female northern elephant seal, by deploying a newly-developed video camera on the cheek of the seal. We also attached newly-developed mandible accelerometers that incorporate light sensors to another two seals, considering the effect of bioluminescence (visual cue of prey) to foraging success. The movie lasted for 93 min, covering four complete dives (< 473 m) at nighttime during oceanic migration. The seal mostly kept whiskers closed at shallow depths (for 93.7% of time at < 350 m) where no sign of prey appeared in the movie. The seal often expanded whiskers at deep depths (for 46.4% of time at > 350 m), suggesting that it started to use vibrissal system for active prey-sensing once reaching a certain depth. In fact, this depth matches where prey footage appeared (e.g. escaping fish with or without bioluminescence) although only 0.6% of movie frames included the prey footage. The importance of vibrissal system for prey-sensing in the dark environment is also corroborated by another results from the mandible accelerometers that show only 20% of feeding events accompanied bioluminescence although most bioluminescence (> 90%) occurred with feeding events, suggesting the occasional contribution of bioluminescence as visual cue to foraging success. Our results demonstrate that seals rely on the active prey-sensing using vibrissal system, probably in addition to visual sense in the occasional existence of

bioluminescence, giving an important implication for the sensory modality of pinnipeds that exploit the deep, dark ocean.

Oral Session: Marine Macroecology

Barbara Block

Biologging in the Blue Serengeti: Past, Present and Future

Hopkins Marine Station – Stanford
bblock@stanford.edu

Biologging for fish and sharks has changed in a revolutionary fashion over the last 50 years. In the late 1970s we could keep track of a tuna, swordfish, marlin or white shark for 3-5 days with a ship, a crew and one acoustic tag. Fast forward to 2017- and we routinely use a suite of electronic tags: archival, pop-up and fin mounted satellite tags, acoustic and camera tags- which provide new information about large pelagic fish movements, ecology, physiology, kinematics, and behaviors in relationship to oceanographic environment for multiple years. These biologging tags provide environmental intelligence that is revolutionizing our understanding of how pelagic species use high seas and coastal ecosystems. The major biologging advancement for the gill breathing community was the development of geolocation techniques- the ability to estimate a daily position from sensor derived light, pressure and sea surface temperature data and astronomical algorithms. By estimating positions we for the first time have been able to visualize the sub-surface sojourns of giant bluefin tunas and lamnid sharks and we can now define their habitat utilizations, foraging and spawning behaviors in detail. The evolution of database efforts provides access to these unique data sets that enables the integration of spatial and temporal movement data sets, and habitat preferences into novel fisheries physiology and ecosystem models. The in situ data these tags generate are also now used for operational ocean modeling. Together, these biologging data sets provide a foundation for developing current and future MPAs and new approaches to marine biological observation networks. The intensity of fishing pressure is increasing, and the need for utilizing observing technology to protect pelagic fish and sharks is intensifying. A piece of biologging's future lies in developing technology and integrating analyses that will prevent the decline of pelagic fish biodiversity by improving our capacity to protect the high seas- our Blue Serengeti –one of the largest habitats on Earth.

Frida Lara Lizardi

Shark connectivity among insular sites in the Eastern Tropical Pacific

Migramar & Pelagios Kakunjá
fridalara131289@gmail.com

Studying the effects of marine protected areas (MPAs) for sharks is important to design efficient management strategies. Long-distance movements of sharks within and between MPAs create strong challenges for resource managers in multiple jurisdictions. Shark movements between the MPAs of the Eastern Tropical Pacific (ETP: Revillagigedo, Cocos, Malpelo and Galapagos) have been studied for years, however little is known about which areas support connectivity between these sites and the existence of marine corridors or "swimways". Here we use network analysis to determine the most connected sites that link these MPAs. We used a large dataset, both spatially and temporally, of detections in an extensive array of acoustic receivers to describe how Galapagos sharks (Carcharhinus galapagensis) and silky sharks (Carcharhinus falciformis) use specific sites and MPAs as important stepping-stones during their region-wide movements in the ETP. The frequency of movements was compared according to the distances travelled for each species. Networks and their metrics were performed for each species. Significant differences between the species were found, silky sharks presented more complex networks migrating distances of 2,200km, whereas Galapagos sharks had a range distribution maximum of 800 km. Although long-distance dispersal was not common (less than 1% of movements), these movements across MPAs highlight the need for cooperation between jurisdictions to ensure sharks receive sufficient protection.

Adrian C Gleiss, Karissa O'Lear, Garry Ogston, Jeff Whitty, Matthew Hipsey, David L Morgan

Quantifying behavioural thermoregulation of an ectothermic predator in a thermally dynamic environment

ACG, KOL, JW, DM: Murdoch University • GO, MH: University of Western Australia
adrian.gleiss@gmail.com

Temperature arguably represents the most crucial environmental variable, since it is tightly linked to performance in ectotherms and highly spatially and temporally heterogenous. As a result, the selective use of temperature to manipulate physiological rates is cited as a common driver of habitat selection, yet it is rarely tested. Among the most common rates

animals are thought to alter, is the reduction of metabolic rates by selecting cool resting temperatures and maximising their foraging success through the selection of temperatures that maximise locomotor performance. Here, we develop a method to quantitatively assess thermoregulatory behaviour, by combining physiological measurements (activity, metabolism) coupled to a hydrological model and apply it to the temperature selection of juvenile bull sharks in the Fitzroy River, Western Australia. Using random walk simulations, we show that potential benefits of thermoregulation change temporally over both diel and seasonal scales. Whereas resting in cool deep waters offers energetic savings regardless of season, locomotor performance is maximised at intermediate temperatures. Measurements of activity through accelerometers and depth selection using bio-loggers on free-ranging bull sharks revealed that thermoregulatory behaviour explained changes diving behaviour during periods of high temperatures, suggesting sharks utilised deep cool waters to decrease their body temperature whilst foraging. Despite vast changes in available temperatures and scope for sharks to improve physiological rates beyond those observed, activity rhythms appeared largely determined by ambient light and sharks maximised physiological rates within this constraint.

Briana Abrahms, Kylie Scales, Elliott Hazen, Steven Bograd, Robert Schick, Patrick Robinson, Daniel Costa

Mesoscale ocean complexity facilitates energy gain in a top predator

BA, EH: National Oceanic and Atmospheric Administration (NOAA), Southwest Fisheries Science Center • KS: University of the Sunshine Coast, School of Science and Engineering • RS: Duke University, Nicholas School of the Environment • PR, DC: University of California Santa Cruz, Department of Ecology and Evolutionary Biology
briana.abrahms@noaa.gov

Electronic tags provide insight into a key question in ecology: How do foraging animals select resources, and thereby how does the distribution of resources structure animal distributions and trophic interactions? However, links between spatial and behavioral ecology and fitness consequences are limited because the outcomes of individual resource selection decisions, such as energy intake, are rarely measured. In the open ocean, convergent mesoscale features (~10-100 km) like fronts and eddies aggregate prey, driving vertebrate distributions and interactions through bottom-up processes. These productive features are known to attract predators, yet their role in providing energy transfer to top

predators is unknown. We investigated the selection of mesoscale features by deep-diving northern elephant seals (Mirounga angustirostris) in the Pacific Ocean, and quantified the corresponding energetic gains from the seals' resource selection patterns. We assembled a diverse range of bio-logging and oceanographic datasets, including satellite tracking data (N = 142 adult females), time-depth dive recorders, daily body fat estimates, and time-matched ocean circulation. To reliably identify convergent mesoscale features, we computed Finite-Size Lyapunov Exponents (FSLE) at 4-day intervals, which measure the backward-in-time separation of initially nearby water parcels. We found that during post-molting migrations, northern elephant seals clearly selected for areas with higher FSLE activity and greater mesoscale structural complexity, measured by FSLE spatial standard deviation. While absolute FSLE did not influence daily energy gain, energy gain increased significantly with increasing FSLE spatial standard deviation, suggesting that areas of mesoscale complexity may concentrate prey fields, even at depth where northern elephant seals forage. Our results show that areas of complex and energetic physical structures not only attract top predators as foraging hotspots, but also lead to increased energy transfer across trophic levels. Such understanding is critical for assessing how changes in the environment and resource distribution will affect individual fitness and community dynamics.

Alex Hearn

The Galapagos Marine Reserve as a regional hub for highly mobile sharks

Universidad San Francisco de Quito (USFQ)
ahearn@usfq.edu.ec

The Galapagos Marine Reserve (GMR) was created to protect native and endemic species that inhabit the islands and their surrounding waters. However, on a region-wide scale it also provides partial protection for marine migratory species that move through its waters. Among these species, sharks are of particular interest, due to concerns about their populations globally, and because they often occupy top predator ecological niches. In 2006, we began a long-term research program to understand how sharks utilize the GMR and established the MigraMar network with other oceanic island research groups in the Eastern Tropical Pacific (ETP). Using a combination of acoustic and satellite tagging, we have tracked the movements of more than 250 hammerhead, silky, blacktip, tiger, Galapagos and whale

sharks in the GMR. These sharks tend to aggregate at specific coastal "hotspots" within the reserve, displaying diel patterns of site fidelity, and utilizing offshore waters at night. All species displayed a high degree of philopatry to GMR waters, while in all cases except Galapagos and blacktip sharks, residency was interspersed with infrequent long distance movements to other MPAs in the region or elsewhere. While this information has been used in marine zoning efforts to protect sharks within the GMR, our results highlight the need for innovative, transboundary solutions to the conservation of these wide-ranging species. Our studies showcase the importance of a collaborative approach towards understanding the spatial ecology of highly mobile species.

Oral Session: Behavioural Ecology

Andrew Seth Gersick, Ariana Strandburg-Peshkin, Frants Havmand Jensen, Kay Holekamp, Mark Johnson

Long-distance communication and movement coordination in wild spotted hyenas

ASG: Department of Ecology and Evolutionary Biology, Princeton University, U.S.A. • ASP: Department of Evolutionary Biology and Environmental Studies, University of Zurich, Switzerland • FHJ: Aarhus Institute of Advanced Studies, Aarhus University, DK • Michigan State University, East Lansing, MI, USA • Scottish Oceans Institute, University of St. Andrews, St. Andrews, Fife, UK
agersick@princeton.edu

Behavioral coordination is least understood in those cases that most resemble human cooperation - behaviors that persist across long timescales and great distances, in heterogeneous groups characterized by differentiated social roles and relationships. Here we investigate how communication and movement interact in the collective behavior of wild spotted hyenas (Crocuta crocuta), social carnivores that live in complex, hierarchically organized groups of multiple weakly related matrilines. Because of intense within-group competition over food, hyenas disperse widely to forage, but they come together rapidly for collective defense of prey against lions, or in territorial conflicts with neighboring clans, via long-distance recruitment calls known as whoops. We combine collars that simultaneously track the positions, vocalizations, and activity patterns of multiple hyenas within a clan with targeted playback experiments to investigate how information spreads through these dispersed groups over multiple spatial and temporal scales. At a local scale, we investigate what factors determine whether hyenas respond to recruitment calls, including whether they recognize calls from their clanmates and whether their decisions are mediated by genetic and dominance relationships. We then assess how recruitment events relate to the long-term ranging patterns of hyenas throughout their territory.

Guillaume Bastille-Rousseau

Optimizing wildlife crossings positioning using GPS telemetry: A case study with elephants in Kenya

Colorado State University
gbr@colostate.edu

The African continent is experiencing rapid and expansive infrastructure development. Numerous major development corridors are proposed over the continent, which include the construction of different linear features such as roads, railroads, and pipelines. Linear features are widely recognized to impact wildlife movement, which can alter population densities and ecosystem functions. One way to mitigate the adverse effects of such features on wildlife is to incorporate crossings (e.g. overpass and underpass) in the features to mitigate adverse effects on movement. Despite an increasing amount of fine-scale data on animal movement, such information is rarely used when deciding where to locate wildlife crossings. We used an extensive tracking dataset from over 140 African elephants in Northern Kenya living in the vicinity of the planned Lamu Port-South Sudan-Ethiopia-Transport (LAPSSET) corridor. As proposed, this economic corridor will intersect with over 60% of known elephant ranges. We apply these data to identify critical junctions in the corridor for ecosystem wide connectivity. We first quantified the number of crossings along the corridor, aggregated in short 200 meter segments. We also converted each elephant trajectory to a "network of movement" using a newly developed approach based on network (or graph) theory. This network allows the extraction of metrics such as degree and betweenness centrality over the landscape. We compared how these more complex network metrics related with the simpler crossing count sums and found similarity between degree and the crossing count metrics. We then developed an algorithm based on Integer Linear Programming that optimized the positioning of wildlife crossings by taking into account the importance of each segment for elephant movement and their proximity. Finally, we apply this to the elephant data in the LAPSSET corridor to illustrate application of this approach.

Mate Nagy*, Andrea Flack*, Wolfgang Fiedler, Iain Couzin, Martin Wikelski

Collective migration in juvenile white storks

MN, IC: Dept. of Collective Behaviour, Max Planck Inst. for Ornithology, Dept. of Biology, Uni. Konstanz, MTA-ELTE Statistical and Biological RS, Hungarian Acad. of Sciences • AF, WF, MW: Dept. of Migration and Immuno-Ecology, Max Planck Inst. for Ornithology, Dept. of Biology, Uni. Konstanz
mnagy@orn.mpg.de

Many birds that migrate long-distance use their atmospheric or social surroundings to minimize migration costs. Soaring migrants exploit columns of warm, rising air (thermals) to cover large distances with minimal costs. The specific mechanisms of exploiting social cues as well as the ecological and energetic consequences of sociality during migration remain unclear. Theoretical work has shown that collectively migrating groups can consist of a small group of actively navigating individuals while the greater part of the group adopts socially facilitated movement behaviour. Here we use the White Stork (Ciconia ciconia), a most suitable model, to study further the impact of sociality on costs, pattern and success of long-distance journeys. Using high-resolution GPS and accelerometer data we not only expose the individual differences between flock members, but also elucidate the organisation of decision-making in a flock of freely migrating storks. We identified leaders and followers using fine detail analyses of flock structure and inter-individual interactions. A small subset of the birds, characterized by finding and leading the path through the thermals, guided a larger group of followers that mainly copied the movements of the birds ahead. Yet, this following behaviour came at a cost, as investing more energy impacted their long-distance migration. Followers stopped early, while leaders overwintered much further to the south. A better understanding of how social factors influence movement and dispersal of migratory species is of highest importance for developing effective conservation strategies.
NOTE: * these authors contributed equally to this work

Daniel Sankey

Why the flock? Multi-level selective benefits of coordinated group flight

Royal Holloway, University of London
daniel.sankey.2016@rhul.ac.uk

For many birds, coordinated group flight is a successful evolutionary strategy. Behavioural ecologists have proposed that three major selective pressures govern the evolution of group

flight, for each of which, different flocking patterns (or, types) may have evolved in response. Firstly, when risk of predation is high, tightly coordinated collective swarming patterns may maximise predator confusion effects. Second, when food resources are patchily distributed in space, a cluster travelling flight type may maximise information acquisition to individuals. Finally, in response to energetic constraints, some species have evolved V-formation flight types, which minimise energy consumption. It is thought that these 3D structures may emerge from relatively simple interactions with just a few close neighbours (also known as interaction rules). We now know much about how responses to neighbours and/or the aerodynamic environment can interact to achieve these mechanisms in groups of birds in flight (Using GPS), and how the energetic costs of flight vary according to flock position (Using GPS / Accelerometery). However, the majority of this work is conducted in one ecological context, implicitly assuming that the interaction rules of individuals are fixed. So we still have little or no understanding of how a change in context could elicit an adaptive response by individuals (i.e. the rules may have plasticity). Using a flock of homing pigeons, we aim to modify the risk (released near to woodland - predator territories), information (release from familiar/unfamiliar locations), group composition (bold and shy individuals), and energetic (release individuals with faster or slower group members) context. These experimental manipulations will allow us to understand how mechanisms (at the individual level) and 3D flock structure (at the group level) change according to social and environmental context, how these changes may fit the function.

Rachel R. Holser, Patrick W. Robinson, Sarah H. Peterson, Luis A. Hückstädt, Daniel P. Costa

Influence of a large-scale oceanographic anomaly on northern elephant seal foraging behavior

University of California, Santa Cruz
rholser@ucsc.edu

During late 2013, a large-scale mass of anomalously warm (> +3°C) water, nicknamed "the Blob", developed in the eastern North Pacific around the Transition Zone Chlorophyll Front (TZCF).These warm surface temperatures persisted through 2015 and corresponded with an extreme drop in chlorophyll content and a northward shift of the chlorophyll maximum, substantially impacting productivity across hundreds of kilometers. The TZCF is a critical foraging habitat for large populations of apex predators, making this disturbance a unique opportunity to examine varying ocean conditions and their impact on top predators. Our understanding of ocean variability has improved substantially thanks to remote technology, such as ARGO floats, which collect subsurface physical data (i.e. salinity and temperature)

without using large research vessels. Similarly, animal-borne oceanographic instruments allow us to collect high density water column data in biologically relevant areas at the scale of the animals' behavior. Instruments carried by adult female northern elephant seals (Mirounga angustirostris) (n=24) measured the three-dimensional extent of the warm anomaly in addition to corresponding shifts in foraging behavior exhibited by this top predator. The oceanographic data collected by the seals show that the surface warm anomaly penetrated deeper into the water column than initially thought, with temperatures 2-5°C above average down to ~300 m depth. Adult female elephant seals tracked during their February-April migration in 2014 and 2015 (n=40) showed a clear northeastward shift (4°N latitude and 10°E longitude) in their spatial distribution as compared to tracks collected from 2004-2013 (n=203), indicating a behavioral response to these unusual environmental conditions. Evidence from climate models suggests that future conditions in the North Pacific could closely resemble those seen during this anomaly. Understanding the response of top predators to the Blob gives us insight into the future distribution and behavior of these species under a changing climate.

Ana Teresa Marques, Carlos David Santos, Frank Hanssen, Antonio-Romàn Muñoz, Alejandro Onrubia, Martin Wikelski, Francisco Moreira

Wind farms act as wide exclusion zones in movement corridors of Black kites

ATM: Centro de Ecologia, Evolução e Alterações Ambientais, Faculdade de Ciències da Universidade de Lisboa, Portugal • CDS, MW: Department of Migration and Immuno-ecology, Max Planck Institute for Ornithology, Germany • FH: Norwegian Institute for Nature Research, Norway • ARM: Departamento de Botànica, Facultad de Farmacia, Universidad de Valencia, Spain • AO: Fundaciòn Migres (CIMA), Spain • FM: REN Biodiversity Chair, CIBIO/InBIO Associate Laboratory, Universidade do Porto, Portugalç
ateresamarques@gmail.com

Wind-farms are responsible for negative impacts on wildlife, birds in particular. Soaring bird species are known to change their flight trajectories to avoid direct contact with wind turbines, a behaviour that can lead to functional habitat loss. In this study we identified and quantified the displacement effect of wind turbines at a critical bottleneck, the Strait of Gibraltar. In particular, we tested if the area used by soaring birds is reduced due to the avoidance of wind turbines. State-of-art GPS-GSM tracking devices were used to study the movements of 140 Black kites (Milvus migrans) in an area populated by wind turbines (n=160), during the post-breeding migration period of 2012 and 2013. Seventy-seven thousand GPS locations were used to estimate the Utilization Distribution (UD) of our study area, applying dynamic Brownian bridge movement models. The UD was then analyzed in the light of orographic and thermal uplift spatial distribution (modelled by the INTACT

Micrositing GIS tool) and the distance to the wind turbines. The three studied variables had a significant effect on birds UD. Birds avoided flying through areas closer than 880m from the wind turbines, regardless of their uplift conditions, and no effect was observed beyond that distance. Also, between 15 and 19% of the area suitable for soaring in the study region was affected by the presence of wind turbines. Our results suggest that the aerial habitat loss caused by wind turbines should be acknowledged as a potential impact from wind-power generation and that soaring flight predictive modelling can be an important tool to the micro-siting of new wind turbines.

Pritish Chakravarty, Gabriele Cozzi, Arpat Ozgul, Kamiar Aminian

An accelerometer-based behaviour recognition model as a tool to investigate meerkat dispersal

PC: Ecole Polytechnique Fédérale de Lausanne • GC, AO: University of Zürich • KA: Ecole Polytechnique Fédérale de Lausanne
pritish.chakravarty@epfl.ch

Movement data could enable explicit investigation of dispersal in a cooperatively breeding mammal, the Kalahari meerkat (Suricata suricatta). Though the use of GPS can provide broad-scale location information, fine-scale, long-term behaviour may only be obtained through high-frequency inertial sensor data. This data, however, cannot be directly used, and needs to be converted into a sequence of biologically meaningful activities. Our goal was to develop an accelerometer-based model to recognise four such activities - vigilance, resting, foraging, and running. To this end, collars containing a tri-axial accelerometer sampling at 100 Hz were designed, and 8 data-sets of 3 hours each were collected on seven Kalahari meerkats. Reference activity was obtained by labelling simultaneously recorded videos. The acceleration-data time series was divided into two-second windows with 50% overlap. For each window, five features based on the acceleration mean, standard deviation, frequency content and activity-specific events were computed. These features were then put through a decision tree based on the Naïve-Bayes classifier to distinguish between the four activities of interest. Ten-fold cross-validation was used to quantify model performance. Static versus dynamic activity classification was achieved with >97% sensitivity, specificity and precision. All three metrics were >95% for vigilance versus resting classification, and >93% for running versus foraging classification. The use of only five features with a relatively simple classification scheme based on bio-mechanical considerations, coupled with basic machine learning, was able to achieve these high classification rates. This model could now be used to analyse activity budgets, and obtain

proxies for key biological factors such as alertness levels (vigilance), food intake (foraging), and energy expenditure. Integrating the behavioural sequences obtained with this activity recognition model with GPS data could shed more light on how individual dispersing meerkats make decisions as they traverse their surrounding physical and social landscape.

Oral Session: Terrestrial Biologging

Meg Crofoot

Tracking the Social Lives of Animals

Department of Anthropology, University of California at Davis
mccrofoot@gmail.com

Just as technological advances catalyzed molecular biology's transformation into computational biology, rapid innovation in biologging and remote sensing is changing the way we study social behavior. In species ranging from protists to primates to people, vast amounts of detailed, noisy data about the behavior of individual beings in social contexts can be collected using GPS traces, proximity-logging tags, camera traps, UAVs, cellphones and online social networks platforms. The similarity of these data unite the interests of researchers from fields as disparate as animal ecology, computer science and anthropology, and offer the promise of understanding the emergence and functioning of social systems at a resolution and scale never before possible. Yet, our ability to collect data now far outstrips our ability to make sense of it. To truly transform our study and understanding of social systems we must develop a common framework for analyzing the interactions—from dyad to group to population— that comprise the sociome.

Dedan Ngatia, Paul Webala, Adam Ferguson

Movement and parasite ecology of domestic dogs: implications for wild carnivores disease dynamics in rural Laikipia, Kenya

DN: Mpala Research Centre, Kenya • PW: Maasai Mara University, Kenya • Field Museum of Natural History, Chicago
dedan.ngatia@gmail.com

Domestic dogs represent an ecologically important host and reservoir for many wildlife diseases known to impact endangered carnivores (e.g., canine distemper virus and rabies), yet so far, the role of domestic dogs in carnivore disease transmission dynamics in Africa remains extremely limited. One particular area of research lacking for domestic dogs in Africa, and vital to understanding disease transmission patterns, is general movement

patterns and spatial ecology of these animals in rural communities. Using GPS tracking devices combined with laboratory analysis of pathogens (parasites and diseases), this study addressed questions of how spatial ecology of domestic dogs varies based on functional role of animals and across time and how these variations influence parasite burden for a population of domestic dogs living along Kenya's human-wildlife-livestock interface. A total of 50 dogs were fit with satellite tracking collars on two communally owned properties, Koija and Il Motiok, located in Laikipia County, Kenya. Ectoparasites were collected and analyzed to help explain parasites diversity in dogs. Home ranges and movement patterns were estimated using home range tools in the program ArcGIS 10.1. Two factor ANOVA and simple regression analysis were used to statistically examine patterns of or related interactions between daily distances/home range sizes and parasite abundance data. Spatial patterns indicated that both herding and home dogs maintained close associations with their home bomas, although individuals utilized multiple bomas throughout the study period. Results from all seasons indicated that domestic dogs infrequently moved into surrounding conservancies, with dogs found along conservancy borders showing more frequent incursions. This study provides one of the most in-depth assessments of domestic dog ecology and parasite abundance along Kenya's human-wildlife-livestock interface and also provides vital information for effective management of carnivore communities since some interactions were recorded between wild carnivores and domestic dogs.

Alison Parton, Paul G. Blackwell

Inferring animal movement and behaviour in continuous time from irregular and noisy GPS observations

University of Sheffield
aparton2@sheffield.ac.uk

Observations of animal movements from GPS trackers are typically sampled at irregular times and in the presence of spatial error. Mechanistic modelling of movement often ignores observation error and is formulated in discrete time, despite the inevitable problems with time scale invariance. A natural solution is to define movement in continuous time, yet the uptake of such modelling has been slower than that of its discrete counterparts. The lack of continuous time implementation is often excused by a difficulty in comprehension. We aim to bolster this usage by presenting a continuous time movement model with interpretable parameters, similar to those of popular discrete time models that use turning angles and step lengths. Movement is defined by a joint bearing and speed process, with parameters dependent on a continuous time behavioural switching process,

creating a flexible class of movement models. Inference is carried out using Markov chain Monte Carlo, augmenting observed locations with a reconstruction of the underlying, unobserved movement process. This method is presented using GPS data from reindeer (Rangifer tarandus) and a lesser black-backed gull (Larus fuscus) to identify and make inference about multiple movement behaviours. In the case of the reindeer movement, a "stationary" state is identified in which observed movement arises only as an artifact of observation error.

Hansoo Lee

Migratory Bird Tracking in East Asia for Monitoring of Highly Pathogenic Avian Influenza by using GPS-Mobile Telemetry

Korea Institute of Environmental Ecology
hslee0509@gmail.com

Migratory birds are the major factor of long range transmission of Highly Pathogenic Avian Influenza (HPAI) in East Asia. Thus, since 2012, government of South Korea has started "Migratory Bird Surveillance Program" to prevent HPAI transmission from wild birds to domestic animals. The program tracks potentially high-risk waterbird species such as ducks, geese and gulls in Korea, China, and Mongolia. The tracking of migratory birds have been conducted by using newly invented WildTrackers manufactured by KoEco. The WildTracker is based on the GPS (Global Positioning System) combined with WCDMA (Wideband Code Division Multiple Access) mobile phone system. Wild birds were captured by different methods in each countries, and deployed WildTracker to the captured birds. The devices record GPS data every two hours including geographical coordinate, speed, and altitude. As the result of long range tracking of waterbirds shows, each species has own specific migratory behavior. The geese and ducks were using relatively regular migratory course, but the gulls were using very irregular courses. Due to the fast moving waterbirds, they could be a potential HPAI vector among migration countries. Thus, the cooperative research work for the migratory birds in East Asia is necessary to prevent measures of HPAI.

Oral Session: Modelling & Engineering

Camrin Braun

A new hidden Markov method for determining movements from archival tags deployed on marine animals

MIT/WHOI Joint Program in Oceanography
cdbraun@mit.edu

hile the number of marine animals being tagged continues to grow, current satellite tracking techniques largely constrain meaningful inference to largescale movements of surface-dwelling species and are prone to significant error. The paradigm in fish tracking is to use light and sea surface temperatures to estimate animal movements, largely disregarding the oceanographic profiles collected by the tag. Oceanographic data and high-resolution models are constantly improving and are becoming widely available and accessible. We developed a likelihood approach for 3D in situ measurements collected by tagged animals that leverages advances in oceanographic data to improve estimates of marine animal movements. These likelihoods are leveraged within an existing, but modified, state-space hidden Markov model (HMM). We compare the model and several other geolocation techniques to estimate movements of 4 double-tagged sharks. The double-tagging experiment facilitated comparison of model results to known tracks. The model developed here (HMMoce) and GPE3 (a proprietary HMM) exhibited as much as 6-fold improvement in pointwise error compared to traditional geolocation approaches. The performance of the newer HMM methods was similar, but HMMoce produced the lowest mean error in 3 of 4 cases. In a data removal experiment that simulated less surface occupation, HMMoce's ability to leverage 3D oceanographic data to generate likelihoods proved useful. The results demonstrate the applicability of the HMMoce model to marine animals, particularly those that do not frequent the surface layer during crepuscular periods. The model is available as an open-source R package, HMMoce, that uses a state-space HMM approach and leverages available tag and oceanographic data to improve position estimates derived from electronic tags.

Marielle van Toor

Integrating conditional movement models with environmental data for quantitative null models in movement ecology

Linnaeus University, Kalmar
marielle.vantoor@lnu.se

Remote animal tracking gives researchers unique insights into the life of individuals, and with the rapid advancement of tracking technologies and the increasing rate at which location data can be collected, these insights are becoming more and more detailed. In addition, the capabilities of on-board sensors to register e.g. acceleration, body temperature, proximity to other individuals, and heart rate allow us to collect information that surpasses the pure location data. Consequentially, the availability of animal movement data is increasing at an accelerating pace, and so is the level of detail in the questions we can address using such data. In many cases, however, movement data in itself cannot easily be tested against null hypotheses in a quantitative way, or under different sets of assumptions. Null hypotheses for migratory routes or patch connectivity, for example, are often restricted by the lack of conditional movement models that retain the properties of empirical movement. As a consequence, drawing conclusions for entire populations from few individuals is not always appropriate, or can only provide limited insight. A novel approach to conditional movement models, the empirical Random Trajectory Generator (eRTG), can overcome these limitations and provide alternative routes to observed movement while maintaining its geometric properties. By combining the eRTG with different movement modes as well as environmental information such as habitat suitability, wind, or land cover, we can derive ecologically relevant predictions of e.g. landscape connectivity within the range of bar-headed geese, disease transport by mallards, or seed dispersal by fruit-eating bats. Hypotheses can then be tested against such predictions quantitatively using empirical observations from the field. We think that when combined with additional environmental information, the eRTG can serve as a flexible basis to derive quantitative and, with respect to movement, realistic null hypotheses under a diversity of assumptions.

M.A. Hindell, Y. Ropert-Coudert, I. Jonsen, B. Raymond, R.R. Reisinger, H. Bornemann, J.-B. Charrassin, B. Danis, L. Huckstadt, L. Torres, P.N. Trathan, A.P. Van de Putte, S. Wotherspoon, RAATD data contributors

The SCAR Retrospective Analysis of Antarctic Tracking Data

Institute for Marine and Antarctic Studies • CEBC-CNRS • Macquarie Univeristy • Australian Antarctic Division • CEBC-CNRS • Alfred Wegner Institute • L'Ocean UPMC • Université Libre de Bruxelles • Univeristiy of California Santa Cruz • Universtiy of Oregon et al.
mark.hindell@utas.edu.au

The SCAR Retrospective Analysis of Antarctic Tracking Data (RAATD) project is a multi-species synthesis of movement data of Antarctic predators intended to identify Areas of Ecological Significance. These areas are defined as being used by multiple air-breathing predator species and therefore indicative of high biodiversity and abundance of lower trophic organisms. The study therefore aims to provide: (i) a greater understanding of fundamental ecosystem processes in the Southern Ocean, (ii) facilitate future projections of predator distributions under varying climate regimes, and (iii) provide input into spatial planning decisions for management and conservation authorities. Since April 1 2016, RAATD has accumulated almost 3 million at-sea locations from 17 species of seabirds and marine mammals, using GPS, light level geolocation, and ARGOS satellite tracking devices. Importantly, these data come from 49 separate data contributors from 10 countries, who have agreed to share their hard won data with the Antarctic tracking community. The analytical framework of RAATD consists of (i) developing a habitat utilization model for each species, (ii) application of this model towards global predictions of important habitat based on colony locations (where appropriate) for that species, and then (iii) compilation of these species-specific predictions to identify Areas of Ecological Significance. We will present an overview of the dataset and highlight some of the analytical challenges and successes involved in our multi-species synthesis.

Hannah J Williams, Rory Wilson, Emily Shepard, Olivier Duriez, Peter Ryan

Quantifying Performance in Flight using Tri-axial Magnetometry

Swansea University • Université de Montpellier • FitzPatrick Institute of African Ornithology, University of Cape Town
hannahwilliams1805@gmail.com

Researchers are increasingly deploying accelerometers within animal-attached loggers to investigate the performance, behaviour and energy expenditure of free-living animals. Another sensor commonly deployed alongside the accelerometer is the magnetometer. This has been primarily used in dead-reckoning or inertial measurement tags, but little beyond that. I examine the potential of magnetometers for helping elucidate the behaviour of animals by quantifying patterns of rotation, with a particular focus on the use of magnetometers to examine movement in the dynamic soaring of albatross and the thermal soaring of vultures. Measures of bank angle derived from the magnetometer show how Gyps vultures reduce their bank angle through the thermal climb, in response to changing limitations within the thermal environment. This demonstrates how magnetometry-based methods of deriving bank angle provide new opportunities for quantifying soaring performance. More broadly, this work demonstrates how magnetometer-based techniques and metrics can enhance our capacity to identify and examine animal behaviour, either when used alone, or in concert with tri-axial accelerometry, given the complementary yet distinct information that can be obtained from the two sensor types.

Shoko Sugasawa, Will T Schneider, Christian Rutz

Validating image-tracking of fine-scale head movements with head-mounted miniature accelerometers: a case study with tool-using New Caledonian crows

Centre for Biological Diversity, School of Biology, University of St Andrews, Scotland, UK
ss244@st-andrews.ac.uk

Birds use their heads and bills in a wide range of behaviours that are essential for survival and reproduction, including foraging, courtship and nest building. The measurement of fine-scale head movements can potentially provide important insights into these behaviours, but presents major methodological challenges. Recent advances in image-tracking technology

allow the semi-automated extraction of kinematic information from high-quality video footage. We recently developed an image-tracking algorithm that can map – with minimal human supervision – fine-scale head movements of tool-using New Caledonian crows. These birds use bill-held sticks to extract prey from deadwood and vegetation, exhibiting a remarkable degree of dexterity. To cross-validate our image-tracking approach, we fitted a temporarily-captive subject with a miniature, head-mounted, tri-axial accelerometer. The device was extremely light-weight, and attached reversibly for the brief duration of our experiment. Both accelerometry and image tracking revealed subtle, yet highly structured, motions during tool deployment, capturing key aspects of the crow's behaviour. Image-tracking approaches like ours can be used with animals that are too small and light-bodied to carry data loggers. More generally, our study provides an example of how bio-logging technology can be used to validate purely-observational methods.

Roxanne S. Beltran, Patrick W. Robinson, Taiki Adachi, Akinori Takahashi, Yasuhiko Naito, Amy L. Kirkham, Michelle R. Shero

Combining time-depth recorders and jaw accelerometers to reconstruct the year-round feeding behavior of adult, female Weddell seals Leptonychotes weddellii

RSB, ALK: University of Alaska Fairbanks • PWR: University of California Santa Cruz • TA: University of Tokyo • AT, YN: National Institute of Polar Research • MRS: University of Alaska Anchorage
roxanne.beltran@gmail.com

To determine how seasonal variation in temperature and photoperiod influence the year-round diving behavior of adult, female Weddell seals in the Ross Sea, Antarctica, we deployed flipper-tag time-depth recorders (n=57 seals, Lotek, 6 second sampling interval, recovered 39-436 days later) and raw jaw accelerometers (n=5 seals, Little Leonardo, 2-axis at 20 Hz, recovered 2-4 days later). We obtained data from 135,000 dives (519 with time-matched jaw data) across 5,642 seal days from 2013 to 2017. Foraging success was higher during summer (maximum mass gain 2kg day-1) than previously shown in winter (maximum 0.5kg day-1), even when accounting for the energy expended on winter thermoregulation and gestation. During a two-week period in summer, we observed a surprising shift in dive depths of most seals, with dives shallowing from >400 meters to <150 meters one week and returning to >400 meters one week later. Depth-wiggles in each dive were a strong predictor of jaw motion events (n=519 dives, R2=0.42) and therefore provide a proxy for feeding effort. Presumed feeding efficiency was higher during the shallower summer diving period (mean±SD 3.0±0.6 wiggles min-bottom-time-1) than the deeper summer diving

period (2.3±0.5, p<0.05) and winter period (1.7±0.4, p<0.05). The shift in summer dive depths may be documenting fish distribution changes of several hundred vertical meters coinciding with the seasonal phytoplankton bloom, revealing a new pattern in a difficult-to-study prey field. In summer (November-February), seals dived less frequently (41 dives day-1) than winter (June-August, 63 dives day-1, p<0.0001), and dived slightly shallower but for similar durations. While summer dives were almost exclusively pelagic, winter dives were bimodal with more shallow, pelagic dives centered around local midnight and deep, benthic dives centered around local noon. Together, these data suggest marked seasonal differences in prey fields and foraging behaviors, which could explain rapid summer mass gain in Weddell seals.

Oral Session: Policy & Public Outreach

Ortwin Renn

Pathways to sustainable futures: the role of early warning signals

International Institute for Advanced Sustainability Studies (IASS) in Potsdam, Germany
orenn1951@googlemail.com

The United Nations Sustainable Developments Goals (SDGs) have been adopted as general guidelines for the global transformation process towards a more sustainable condition of human societies. The SDGs refer to ecological, economic, social and cultural goals that are further structured in subgoals and indicators. Most of them allow monitoring the changes only after they have occurred. However, in complex and highly interconnected contexts, we need early warning signals that tell us whether we move into the desired direction and if there is still time to shift to more sustainable practices once deficits become visible. Biomarkers could play a major role in serving as warning signals for ecological changes and pending disasters. The paper will illustrate the need and relevance of early warning signals in monitoring transformation processes and highlight some examples from the ecological as well as socio-economic domain.

Francesca Cagnacci, Lee Belbin, Peter Desmet, Holger Dettki, Bernie McConnell, Peggy Newman, Alessandro Oggioni, Ferdinando Urbano, Sarah Davidson

A future for a common bio-logging language? Data standards and interoperability in the bio-logging world

FC: Fondazione Edmund Mach, Research and Innovation Centre • LB: CSIRO, Australian Antarctic Division • PD: Research Institute for Nature and Forest • HD: Swedish University of Agricultural Sciences, Wildlife, Fish and Environmental Studies • BMC: Scottish Oceans Institute, University of St Andrews • PN: Museum Victoria, Atlas of Living Australia • AO: CNR IREA • FU: freelance DB developer • SD: Max Planck Institute for Ornithology
francesca.cagnacci@fmach.it

Data collected by animal-borne electronic devices follow few norms and standards, in part because they are provided by a large and growing number of device manufacturers and

collected for a wide range of purposes. The lack of standard variable names and definitions, file formats and data transfer protocols hinders our ability to document, archive and share data and increases the chance of errors in data management, interpretation and analysis. However, a coded and smooth transfer from sensors to data repositories is possible with current technologies. Although sensors differ in design and purpose, most scientifically relevant information can be described using a finite set of variables along with metadata about the sensor, animal, and deployment, paving the way to interoperability between repositories. A common bio-logging "grammar" and "vocabulary" would be of paramount relevance for data persistence and re-use, for example to track humans' footprint and address present and future questions pertaining biodiversity conservation. On this basis, the International Bio-Logging Society set as one of its goals "the standardization of data protocols to make the various marine and terrestrial databases interoperable" and started a working group to find common ground and approaches to progress towards a more "standardized" bio-logging world. We present here the main lines of this ambitious endeavor, that will have far-reaching benefits for the biologging community, and call for a common and shared support to assure its success.

Maria P Dias, Ana P B Carneiro, Cleo Small

The Seabird Tracking Database - using tracking data for marine conservation

MPD, APBC: BirdLife International • CS: RSPB
maria.dias@birdlife.org

The Seabird Tracking Database was created by BirdLife International in 2004 with the aim of compiling all possible tracking data that could be used to understand the movements of albatrosses and petrels, identify areas where overlap with fishing effort was highest and help reducing their mortality due to by-catch. A call was made for data sharing and, in an unprecedented response, scientists worldwide joined the initiative and contributed their datasets. Thirteen years later, the database has been expanded to cover all seabird species and is now a preeminent example of cooperation between scientists, conservationists and policy makers. More than 170 researchers, from 22 countries, contribute their datasets. It now holds over 10 million data points for 113 species. Albatrosses and petrels are still the group best represented, followed closely by penguins and gannets. By joining datasets collected by different teams, in several colonies and for multiple species is now possible to have a much more comprehensive approach in tackling the major conservation problems faced by seabirds, such as by-catch and overfishing. Here we will present an overview of the major conservation achievements, present status and future challenges of the Seabird

Tracking Database, with a particular emphasis on the major gaps and on the tools developed by BirdLife International to analyse the data and to connect tracking data with oceanographic variables, through a new webtool. Some of the most relevant conservation outputs of the Seabird Tracking Database will also be briefly presented as examples of this collaborative effort. Finally, we will show how these efforts have been contributing to achieving Aichi Target 11, which required the designation of 10% of the world's oceans as Marine Protected Areas by 2020.

Roland Kays, Troi Perkins, Brandon McDonald, Rob Dunn, Lea Shell, Philip Roetman, Heidy Kikillus

Citizen science enables pet cat tracking on a global scale

RK, TP, BMD: North Carolina Museum of Natural Sciences and NC State University • RD, LS: North Carolina State University • PR: Discovery Circle, University of South Australia • HK: Victoria University of Wellington, Wellington, New Zealand
rwkays@ncsu.edu

Pet cats are estimated to kill billions of small mammals and birds each year and thus may have a negative impact on global biodiversity. However, the spatial extent of their hunting not well known. Cat spatial ecology has direct management implications, as conservation actions would be different if cats roam widely and use natural habitats and protected areas than if they stick close to home, hunting common urban animals. Furthermore, cat movement patterns are likely to vary spatially with factors such as predation risk, development level, habitat type, and climate. We used a citizen science approach to track over 800 pet cats in four countries with inexpensive GPS data loggers, using Movebank for data storage and sharing. On average, cats had very small home ranges, averaging a few hectares. The largest ranging cats were younger, un-neutered, or in New Zealand. Our cat tracking has generated substantial media interest, and we always emphasize the importance of keeping cats indoors. Our ongoing work includes a cat personality survey, isotopic analysis of diet, and a habitat preference study. Together, these approaches will help us understand where and why pet cats are the greatest threat to biodiversity. We welcome new collaborators from around the world interested in adding their region to our global cat study by sharing protocols and best practices.

Babette Eid

MaxCine: On the road with the storks and the European blackbirds

Max Planck Institute for Ornithology
beid@orn.mpg.de

Children usually have the clearest ideas when it comes to the big questions in life: "Daddy, how did the universe come to be? Why is there life? Why do swallows migrate to Africa?" In science, we sometimes don't ask these questions — because they are too big, too difficult and too lengthy. But it is the answer to these questions - which really brings us further in science. At our institute, we want to ensure that we always keep the big questions in mind, and above all the questions that our children will have to deal with in the long term. How can we protect the animals? How can we preserve migration routes? How can we secure the foundations of the natural world for future generations? Other institutions gather wise old men on their advisory boards. We want to have children on our advisory board, who point us again and again to the essential issues and are not satisfied with our evasive answers. Our youngsters of the MaxCine-Team will present the project "MaxCine goes South", a 10-days journey with our tagged storks from lake Constance to Barcelona and the ongoing project "Should I stay or should I go", where they accompany a study on European blackbirds in all of its aspects throughout Europe.

Ippei Suzuki, Yoshio Takei, Marty KS Wong, Ryan Milne, Simon Moss, Katsufumi Sato, Ailsa Hall

An animal-borne blood sampler to understand the endocrinal response in submerged phocid seals

IS, KS: Atmosphere and Ocean Research Institute, the University of Tokyo (Current organisation: Field Science Center for Northern Biosphere, Hokkaido University) • YT, MKSW: Atmosphere and Ocean Research Institute, the University of Tokyo • RM, SM, AH: Sea Mammal Research Unit, Scottish Oceans Institute, St. Andrews University
ipsuzuki@gmail.com

An animal-borne blood sampler was developed to study physiological adaptation of breath-holding animals for efficient use of oxygen. The sampler can obtain two separated 5 mL blood samples triggered by time, depth and acceleration sensors. The device was attached on a captive harbor seal Phoca vitulina and two grey seals Halichoerus grypus to validate the

performance of device attachment and water submergence by measuring stress and cardiovascular hormones. The levels of stress hormones were measured between the conditions with and without the blood sampling device while animals were on land. The plasma levels of stress hormones were lower in harbor seals when samples were obtained using the device than that by restraining the animal (23.9±5.5 vs. 61.1±13.8 fmol/ml for adrenocorticotropic hormone, p<0.05 and 109.4±12.2 vs. 146.4±25.9 ng/ml for cortisol, p=0.078). This result shows that the newly developed animal-borne blood sampler is a powerful tool to study endocrine regulation in diving animals without handling stress during blood sampling. The plasma levels of three types of cardiovascular hormones, atrial natriuretic peptide (ANP), arginine vasopressin (AVP) and angiotensin II (AngII), were compared in grey seals while the animals were either on land or in the pool (<1.6 m in depth). The results showed that seals in water tended to have increased plasma ANP (p=0.069) and decreased plasma AVP (p=0.074), but there was no change in plasma AngII. Our previous study showed that bottlenose dolphins did not show any changes in these hormones. Thus, this study suggests that semi-aquatic phocid seals might retain some cardiovascular responses to gravitational effects like fully terrestrial mammals as seals have both terrestrial and aquatic life cycles, resting and nursing pups on land and foraging in water. Further analysis on metabolic hormones while animals were diving would be presented with simultaneous respirometry measurements.

Julie van der Hoop, Mark Johnson, Natacha Aguilar de Soto, Frants Jensen, Laia Rojano Doñate, Danuta Wisniewska, Peter T. Madsen

Respiratory rates in free-swimming odontocetes as a measure of field metabolic scaling

Aarhus University, Aarhus, Denmark
jvanderhoop@bios.au.dk

Inertial sensors from biologging tags are often used to estimate energetics and field metabolic rates (FMR) in free-ranging animals. Breathing frequency, another common, relative indicator of metabolic rate, can be inferred from acoustic and inertial sensors on tags. Mass-specific metabolic rates of animals scale allometrically to the power of 0.7, large animals have lower mass-specific energy requirements than small animals. Yet, recent data suggest the scaling exponent of marine mammal FMR to be ~0.5. This hypothesis is hard to test for many large marine mammals such as toothed whales (odontocetes) due to their size, habitat and inaccessibility. Biologging tag deployments on animals across orders of

magnitude in body size offer a unique opportunity to test these scaling hypotheses. Here we test the hypothesis that if FMR scales by powers of 0.7 or 0.5, respiratory rates should in turn scale by either -0.3 or -0.5 assuming tidal volume scales with body mass. To determine how breathing rate scales with body mass (M, kg) in free-swimming odontocetes, we analyzed DTAG deployments from seven species: harbor porpoises, bottlenose dolphins, and Blainville's beaked, Cuvier's beaked, short- and long-finned pilot, and sperm whales. We detected instances of breathing from acoustic and depth records of the tags. We estimated allometric coefficients from the grand mean respiratory rate per species, and a combination of measured and estimated body masses. We found that respiratory rate scales as $M^{-0.21(\pm0.14)}$ across odontocetes of 60 to 40,000 kg. This result suggests FMR scales with $M^{0.79}$ (=1-0.21), but rests on the assumption that tidal volume scales with body mass. This scaling result may reflect the relatively large lungs in small, coastal toothed whales, or species-specific foraging ecology and physiological adaptations. Expanding this analysis to include baleen and other toothed whale species, we will present a phylogenetic analysis of respiratory patterns across Cetacea.

Michael S. Painter, Vlastimil Hart, Justin A. Blanco, John B. Phillips, E. Pascal Malkemper

The Use of Bio-loggers for Studies of Magnetoreception in Free-roaming Mammals

MSP, VH: Czech University of Life Sciences, Department of Game Management and Wildlife Biology • JAB: United States Naval Academy, Department of Electrical and Computer Engineering • JBP: Virginia Tech, Department of Biological Sciences • EPM: University of Duisburg-Essen, Department of General Zoology
mipainte@vt.edu

Spontaneous magnetic alignment behavior (SMAB), in which animals position their body axis in fixed alignments relative to magnetic field lines, has been shown in several classes of vertebrates and invertebrates. Although these spatial responses appear widespread, the functional significance and sensory mechanisms underlying SMAB remain unclear. An intriguing example comes from observations of wild red foxes (Vulpes vulpes) that show a ~four-fold increase in hunting success when predatory "mousing" attacks are directed towards magnetic north-northeast. However, similar to previous observational studies of SMAB in free-roaming vertebrates, direct evidence for the involvement of magnetic cues, and field-based experiments designed to characterize the biophysical mechanisms mediating SMAB are lacking. Here we report a new approach for studies of SMAB using tri-axial accelerometer and magnetometer bio-loggers attached to semi-domesticated red foxes. Accelerometer data were recorded from 415 ground-truth events of three behaviors

exhibited by an adult red fox. A 5-Nearest Neighbor classifier was developed for behavioral analysis and performed with an accuracy of 95.7% across all behaviors. To evaluate the generalizability of the classifier, data from a second fox was tested yielding an accuracy of 66.7%, suggesting the classifier can extract behaviors across multiple individuals. A similar classification approach was used to identify the fox's magnetic alignment using two 8-way classifiers with differing underlying assumptions to distinguish magnetic headings in eight equally spaced 45° sectors. The magnetic heading classifiers performed with 90.0% and 74.2% accuracy, suggesting a realistic classifier performance range when classifying an independent data set of equal sample size. We are continuing to develop "magnetic ethograms" in which the behavior and magnetic alignment of free-roaming animals can be extracted from raw sensor data. These techniques provide the basis for future studies of SMAB where direct observation is not necessary and will offer exciting opportunities to characterize the sensory mechanisms mediating SMAB.

André Chiaradia, Akiko Kato, Richard Reina, Fran Ramírez, Isabel Afán, Bruce Deagle, Simon Jarman, Sonia Sanchez, Catherine Cavallo, Ross Holmberg, Leanne Renwick, Peter Dann, Graeme Hays, Claire Saraux, Yan Ropert-Coudert

How bio-logging is revolutionising our understanding of the marine life cycle of the smallest of all penguins

AC, SS, CC, RH, LR, PD: Research Department, Phillip Island Nature Parks, Australia • AK, YRC: Centre d'Etudes Biologiques de Chizé, CNRS, France • RR, SS, CC, RH: School of Biological Science, Monash University, Australia • FR, IA: Estación Biológica de Doñana, Sevilla, Spain • BD: Australian Antarctic Division, Australia • SJ: Centro de Investigação em Biodiversidade e Recursos Genéticos, Universidade do Porto, Portugal • GH: Centre for Integrative Ecology, Deakin University, Australia • CS: French Research Institute for Exploitation of the Sea, Ifremer, UMR MARBEC, Sète, France
achiaradia@penguins.org.au

A few decades ago, we imagined the life of penguins in the ocean as mysterious, enigmatic and fanciful. The development of bio-logging combined with ingenious ecological tools and DNA-sequencing techniques are revealing the mysteries of penguins' lives at sea. We can now track penguins foraging (GIS), measure their underwater activity ("Fitbits"), log their daily movements with automated stations ("toll gates") and pinpoint the isotopic or DNA signatures of their prey. At a greater spatial scale, using satellite remote sensing, we can discover how changes in ocean currents, temperature and productivity are affecting penguin foraging. All this hi-tech help is very timely for little penguins. Like most seabirds, little penguins are facing significant challenges at sea. Most little penguins live in south-eastern Australia, which is one of the world highest marine biodiversity areas. It is also one

of five hot-spots on the planet where the sea temperature has already increased beyond 2°C. Here, we showcase how bio-logging combining with ecological tools are revealing in which way little penguins are responding to changes in their 3D marine environment over the last two decades. Acceleration and GPS data are identifying potential "important penguin areas" to provide better marine spatial management and ensure their future food security. Isotopic dietary analysis detected dramatic changes in penguins' diet due to a massive prey mortality. Scat DNA is revealing new prey items like sea jellies, placing little penguins accurately in their food web. We have new ways to get environmental data by using ocean currents and connectivity analysis. It shows the nutrients transported into the penguin feeding areas are coming from an area many times larger than their foraging zone. Thus, bio-logging and associated ecological tools are helping us to help them by understanding the effect of rapid environmental changes in the marine environment of penguins.

Workshop 1: Integrating data collected by animals into the Ocean Observing System

Lars Böhme

Integrating data collected by animals into the Ocean Observing System

University of St. Andrews
lb284@st-andrews.ac.uk

Today marine animals help to collect marine observations in some of the harshest environments on the planet, through the use of animal-borne instruments. For example, the international MEOP (Marine mammals Exploring the Ocean Pole-to-pole) consortium, originally formed during the International Polar Year in 2008-2009, equipped more than 1000 animals with instruments capable of delivering oceanographic data in near real-time. Since its formation MEOP delivered several hundred thousand hydrographic profiles. Some of the tagged species travel thousands of kilometres continuously diving to great depths of more than 1000m. These instruments are continuously improving and more systematic quality control procedures are developed. Data standardisation across manufacturers and research projects are now consolidating animal borne instruments as a robust tool to collect oceanographic data in Polar Regions. The goal of this workshop is to synthesise the current state of integrating animal-borne instruments and their data into the Ocean Observing System. The workshop will include several presentations followed by discussions.

Workshop 2: Movement Ecology of avian, terrestrial and marine systems of the Galapagos Islands

Sebastian Cruz

Max Planck Institute for Ornithology
scruz@orn.mpg.de

The aim of the Galapagos bio-logging session is to synthesise the current state of knowledge on the movement ecology of avian, terrestrial and marine systems, and generate discussion on future directions for integrating research and conservation using telemetry systems.

The workshop will begin with several key presentations from experts with a long trajectory in the Galapagos Islands. After which we will begin discussion session which will revolve around the following:

- Establish a Galapagos Movement Ecology consortium
- Gather a list of projects for consortium could tackle (based on existing data and expertise) and set priorities and responsibilities
- Define projects that complement the existing data and knowledge pool, but need funding and/or being conducted in the first place.
- Set the next assembly target for the consortium. Evaluation and reassessment.

Trillmich, Fritz

Towards understanding the role of interspecific interactions within the dynamic marine ecosystem: Galapagos as an opportunity

University of Bielefeld
fritz.trillmich@uni-bielefeld.de

Marine ecosystems are highly complex. Currents, eddies, fronts, differences in salinity, a shifting thermocline and dial vertical migration constitute the environment in which animals move about to find food and avoid predators. Local enhancement, increased foraging

efficiency through attraction to foraging conspecifics, likely plays an important role in many marine vertebrate species. However, attraction to or avoidance of other species and interspecific interactions may be equally important. Within a narrow geographical range, the Galapagos Islands offer substantial oceanographic complexities and high inter-annual variability associated with El Niño. Currently, a diverse array of marine vertebrates (sharks, fish, turtles, seabirds, pinnipeds, whales) is studied within the archipelago. These species could serve as oceanographic platforms to increase our understanding of spatial and temporal dynamics of the oceanography while providing information about distributions at sea and those of prey species. Connecting the information on distribution and movement of these species will enable us to study to what extent and how this movement information is used interspecifically and pinpoint the marine areas in most need of protection. Are animals of other species attracted to areas of seabird feeding frenzies? Do such multi-species foraging aggregations happen particularly around current eddies and fronts? How stable are aggregations in space and time? How do top predator distributions and activities influence other species' habitat choice? How do interactions change with El Niño or general ocean warming? We suggest joining forces and data of scientists working in the Galapagos to learn more about the environment, interactions among species, and the ways in which different species use information about features of the marine environment from observing activities and movements of other species. Such integrated understanding of a diverse array of species within a complex marine environment may serve as a paradigm to understand biological interactions within marine ecosystems more generally.

Guillaume Bastille-Rousseau

Walking with giants: Movement ecology of Galapagos tortoises

Colorado State University
Guillaume.Bastille-Rousseau@colostate.edu

Animal movement strategies including migration, dispersal, nomadism, and residency are shaped by broad-scale spatial-temporal structuring of the environment, including factors such as the degrees of spatial variation, seasonality and inter-annual predictability. Animal movement strategies, in turn, interact with the characteristics of individuals and the local distribution of resources to determine local patterns of resource selection with complex and poorly understood implications for animal fitness. Here we present a multi-scale investigation of animal movement strategies and resource selection. We consider the degree to which spatial variation, seasonality, and inter-annual predictability in resources drive migration patterns among different taxa and how movement strategies in turn shape

local resource selection patterns. We focus on adult Galapagos giant tortoises (Chelonoidis spp.) as a model system since they display many movement strategies and evolved in the absence of predators of adults. Specifically, our analysis is based on 63 individuals among four taxa tracked on three islands over six years and almost 106 tortoise re-locations. Tortoises displayed a continuum of movement strategies from migration to sedentarism that were linked to the spatio-temporal scale and predictability of resource distributions. Movement strategies shaped patterns of resource selection. Specifically, migratory individuals displayed stronger selection toward areas where resources were more predictable among years than did non-migratory individuals, which indicates a selective advantage for migrants in seasonally structured, more predictable environments. Our analytical framework combines large-scale predictions for movement strategies, based on environmental structuring, with finer-scale analysis of space-use. Our results highlight that assessing the potential benefits of differential behavioral responses first requires an understanding of the interactions among movement strategies, resource selection and individual characteristics.

Diego Ellis Soto

Determining daily and seasonal activity patterns of Galapagos Tortoises: An intra- and interspecific comparison

Max Planck Institute for Ornithology, Radolfzell, Yale University
dellis@orn.mpg.de

Galapagos tortoises are the largest terrestrial ectotherms worldwide. Despite their iconic status, little is known about their ecology. We quantified daily and annual activity patterns in four Galapagos tortoise species (Chelonoidis hoodensis, Chelonoidis donfaustoi, Chelonoidis porteri and Chelonoidis vandenburghi) with distinct body sizes. We focus on sex and age differences in these sexually dimorphic species that were sampled on three islands using acceleration and GPS data. We employ a novel algorithm that classifies activity into a binary variable (i.e. active, inactive) based on a Gaussian mixed process. While the timing of daily activity did not vary among tortoise species, males and females within each species displayed distinct daily activity patterns. Overall daily activity was higher during the hot season when compared to the cold season. Furthermore, giant tortoises appear to be heat limited during the warmest hours of the day during the hot climatic season in Galapagos. Both sexes of C. hoodensis, the smallest Galapagos tortoise, were the only taxon showing heat limitation during the cool season implying year round thermal sensitivity towards high temperatures. Furthermore, juvenile and sub adult individuals were more active during the

day all year round when compared to adults. Male tortoises residing on islands with distinct altitudinal gradients had similar timing of activity on a seasonal basis. The activity of sub adult and juvenile tortoises varied less than adult activity across seasons and years. Overall, annual patterns of activity differed more within species than across species. These large intra- specific differences in niche partitioning of activity can imply different adaptations between the sexes towards environmental, especially thermal constraints. This approach of sampling and classifying activity budgets across multiple individuals at the same time can be applies to other taxa and is of special relevance for the study of daily and inter-annual activity in wild animals.

Workshop 3: Heart Rate Measurements in Mammals, Fish and Birds

Representative of Star-Oddi
star-oddi@star-oddi.com

This workshop aims to bring together experts and users from different fields that have an interest in, are planning on, or have used Star-Oddi's implantable heart-rate and temperature sensors, or any other ECG or heart-rate sensors. Workshop objectives will focus on explaining the fundamental principles of ECG derived heart-rate measurements, how it is possible to program the loggers, implant the loggers and how to verify and process the data to get the most out of your measurements. The workshop will start off with a theoretical and practical overview of the sensors, it will then go on to discuss working examples, including presentation from users who have successfully used the loggers in different animal models, such as fish, mammals and birds. Third session will go through signal processing and validation methods of the acquired data. Finally, the workshop will be wrapped up with a discussion on the benefits and shortcomings of heart rate measurements and how it is possible to move forward in the field.

Workshop 4: A future for a common bio-logging language? Discussions about data standards and interoperability in the bio-logging world

Francesca Cagnacci, Sarah Davidson

FC: Fondazione Edmund Mach, Research and Innovation Centre • SD: Max Planck Institute for Ornithology

francesca.cagnacci@fmach.it

A goal of the International Bio-Logging Society is to "standardize data protocols to make the various marine and terrestrial databases interoperable". Data collected by animal-borne electronic devices follow few norms and standards, in part because they are provided by a large and growing number of device manufacturers and collected for a wide range of purposes. The lack of standard variable names and definitions, file formats and data transfer protocols hinders our ability to document, archive and share data and increases the chance of errors in data management, interpretation and analysis. Although sensors differ in design and purpose, most scientifically relevant information can be described using a finite set of variables along with metadata about the sensor, animal, and deployment. The goal of this workshop will be to discuss the current state of biologging data progress towards a more "standardized" bio-logging world. We welcome participation from bio-loggers, manufacturers, database operators and data-sharing advocates.

Workshop 5: Communication and Movement in Animal Groups

Ariana Strandburg-Peshkin, Frants Jensen, Andy Gersick, Gabriela Gall

AS, GG: University of Zürich • FJ: Aarhus Institute of Advanced Studies, Aarhus University, Høegh-Guldbergs Gade 6B, 8000 Aarhus C, Denmark • AG: Princeton Inversity

arianasp@gmail.com

The movements of social animals are often driven by active communication among group members. At the same time, signals and signaling behavior frequently appear specifically adapted to solve problems imposed by species specific patterns of spatial and spatiotemporal organization. Thus the linkage between movement and communication may hold critical answers to questions about the evolution and mechanics of both coordinated movement and the behavioral systems within which coordination occurs. Previous research on communication in social species has relied largely on studies of individual signalers and receivers. Advances in technology such as high-resolution GPS tracking and small audio recorders are now creating unprecedented opportunities to study the interplay between acoustic communication and movements of entire animal groups in the wild. With these new opportunities come new challenges. Beyond providing vastly larger, more granular datasets, what new questions can these new methods open up for exploration? What new technical, computational, and analytical challenges do these new capabilities create, and how can we address them? Tackling these challenges will require collaboration across a range of fields, including animal communication and bioacoustics, collective behavior, movement ecology, and machine learning, and will require development of new analytical tools.

This workshop will bring together a diverse group of researchers with a wide variety of specialties, with the aim of developing a research strategy to address how communication and movement interact across animal systems. We will seek to identify the key questions in this field, discuss common challenges across systems and how we can begin to address them, and explore future opportunities. The ultimate goal is to establish a network of researchers in this area and to lay the groundwork for future collaborative ventures.

Workshop 6: Advances in Bio-Logging to study animal flight

Olivier Duriez

CEFE, Montpellier Univ., France
olivier.duriez@univ-montp2.fr

The miniaturization of Bio-loggers is currently revolutionizing the research on animal flight. Tags being smaller and smaller, and incorporating the latest sensors (accelerometers, magnetometers, light sensors…), it becomes possible to track flying animals remotely at high resolution, from large soaring birds, to tiny birds, bats and even insects. In this workshop, we aim at presenting some recent technological developments in the field of Bio-logging, or new analytical methods, that allowed discoveries about animal flight dynamics, or on behaviour, physiology or sensory ecology in flying animals from a large range of taxa and size.

Todd Katzner, Raphaél Arlettaz, Melissa A. Braham, Jonathan C. Hall, David Brandes

Bio-Logging Flying Wildlife for Conservation Management

US Geological Survey
tkatzner@usgs.gov

The field of bio-logging has its roots in tracking terrestrial animals for wildlife management. In recent years though, most significant advances in the field have been towards understanding ecology of animal movement, rather than to the application of this information for management. Nevertheless, there is an urgent and growing need for evidence-based conservation guidance. Here we illustrate application of recently developed movement ecology tools towards an urgent conservation problem - predicting the range expansion of reintroduced and critically endangered species. California condors were extirpated from the wild in 1987, captive bred, and reintroduced in the 1990s. Because movement of large soaring birds is constrained by availability of environmental updraft, we predicted condor range expansion as a response to suitable updraft availability. Wing loading of 39 free-flying California condors averaged 7.031 kg/m2 (SD = 0.97), suggesting an average minimum sink speed of 0.886 m/s. The proportion of modeled thermal updraft

estimates that were greater than that minimum sink speed was very high in August (94%), but low in January (<1%). In contrast, the proportion of modeled orographic updraft above that minimum sink speed was less variable, at 7% in August and 9% in January. Our updraft models were effective at predicting movements of condors tracked by GPS telemetry collected on 39 condors between November 2013 and April 2016. Together these patterns suggest that although thermals are stronger forms of updraft, condor range expansion may be limited by the availability of orographic updraft. Extrapolated to the full modeling extent, updraft models predicted large portions of California and Oregon that are likely to be colonized by California condors, as well as areas they are unlikely to use, as they expand their distribution. This study illustrates how both basic ecological studies and applied ecology can benefit by incorporating new bio-logging tools for conservation management.

Ran Nathan

Live-and-learn or learn-and-live? How functional performance improves with experience in juvenile birds and impacts their lives

Movement Ecology Lab, Hebrew Univ. of Jerusalem, Israel
ran.nathan@mail.huji.ac.il

Felix Liechti, Erich Bächler, Steffen Hahn, Kiran Dhanjal-Adams

Miniaturized multi-sensor loggers can put light on flight time, altitudes and social behaviour

Swiss Ornithological Institute
felix.liechti@vogelwarte.ch

Miniaturized multi-sensor loggers allow now year-round recording of different features beside ambient light for positioning, and enlarge the information collected within individual flights substantially. We equipped several species of small long distance migrants with one gram multi-sensor data loggers. The logger (SOI GDL3pam-V2.2) records in intervals of a few minutes ambient light intensity for common geolocation, acceleration for behavioural activity, air pressure for altitude determination and tag temperature. From these composite

data we can reconstruct accurate flight budgets and altitude profiles over a whole year. Apart from its own value the combination of light, atmospheric pressure and activity allows improving the positioning, especially during periods where geolocation by light is unreliable. Because recent studies have proposed to use tag temperature measurements to detect flight stages, we investigated whether or not changes in measured tag temperature does allow differentiating between stationary and movement periods. In addition, some individuals who migrated within the same flock did allow estimating empirically the range of accuracy in geolocation. While geolocation by light has revolutionized the research of small migratory birds, the future advent of multi-sensor loggers will enlarge and complete our information on year-round behavioural patterns in small bird migrants and hopefully, many other species.

Susanne Åkesson, Evans TJ, Shiomi K, Shamoun-Baranes J, Bouten W, Lötberg U

Long return flights by lesser black-backed gulls during breeding: search for breeding locations or foraging opportunities?

Lund University
susanne.akesson@biol.lu.se

Prospecting for future breeding sites after failed breeding is an important life-history decision in long-lived birds. Still we largely miss information under what conditions and over what distances prospecting movements are performed by individual birds. We have used GPS loggers with remote data downloading to track the prospecting return movements of lesser black-backed gulls from two colonies at the Swedish east coast of the Baltic performed after nest failure during the breeding period. Here we investigate the occurrence of prospecting return flights, comparing birds from the two colonies as well as investigating differences between sexes. We classified long-distance trips leading to marine foraging areas and others leading to sites on land and compared how birds explored the two types of site. The lesser black-backed gulls covered substantial distance exceeding hundreds of km per trip, and which lasted from several days to one month. We found differences in time spent away and distances covered during prospecting flights trips between the two colonies, but no difference between sexes. Our tracking data provide novel insights that lesser black-backed gulls from the two colonies cover a substantial part of the Baltic during prospecting flights trips performed after nest failure, with high overlap in area use in the southern part of the Baltic including both foraging areas at sea and locations on land.

Judy Shamoun-Baranes, Kees Camphuysen, Emiel van Loon, Bart Hoekstra, Willem Bouten

Adapting fine-scale flight behaviour to the aerial environment

JSB, EVL, BH, WB: University of Amsterdam • KC: NIOZ
shamoun@uva.nl

Birds may use different strategies to power their flight and reduce flight costs. Depending on their eco-morphology, some species may adjust their flight mode along a continuum from continuous flapping to soaring flight. While soaring flight is less costly from a metabolic perspective, the energy needed to power flight must be provided by the environment. Gulls are highly versatile fliers that use a spectrum of flight modes. In addition, some species, such as the Lesser black backed gull (Larus fuscus) are omnivorous, foraging at sea as well as on land, where atmospheric dynamics and thus opportunities for soaring flight may differ greatly. Using high resolution GPS tracking and tri-axial accelometry we studied the propensity of gulls to use different flight modes, whether this differed over land compared to flight over sea and quantified the environmental envelope used by gulls for different flight modes. We found that gulls spent most of their time in flight using energetically costly flapping flight and utilized different sources of lift to power soaring flight. Using high-resolution tracking data and fine-scale environmental models we show how birds adapt their flight behaviour to landscape features and land-air interactions. We discuss the energetic and ecological consequences of plasticity in flight behaviour and implications for life history traits in this opportunistic species.

Anders Hedenström, Gabriel Norevik, Kajsa Warfvinge, Arne Andersson, Johan Bäckman, Susanne Åkesson

A bio-logging solution to a riddle: common swifts are airborne for 10-months between breeding seasons

Centre for Animal Movement Research, Department of Biology, Lund University, Sweden
anders.hedenstrom@biol.lu.se

The common swift (Apus apus) is adapted to an aerial life-style, where food and nest material are captured in the air. Observations, or rather lack of them, had led scientists to hypothesize that swifts may stay airborne for their entire non-breeding period, including migration into sub-Saharan Africa. Mainly juvenile common swifts occasionally roost in trees or buildings before autumn migration when weather is bad. In contrast, North American

chimney swift (Chaetura pelagica) and Vaux's swift (C. vauxi) regularly settle to roost in places like chimneys and buildings during migration and winter. Observations of common swifts during the winter months are scarce and any roost-sites have never been found in sub-Saharan Africa. In the breeding season, non-breeding individuals usually spend the night airborne, while adult nesting birds roost in the nest. We equipped common swifts with a new type micro data-logger with accelerometer to record flight activity (year 1-2), and with a light-level sensor for geolocation (year 2). Our data show that common swifts are airborne for >99% of the time during their 10-month non-breeding period, some individuals never settled, but occasional events of flight inactivity occurred in most individuals. Apparent flight activity was lower in daytime than in night-time, most likely due to prolonged gliding episodes in daytime when soaring in thermals. Our data on flight activity also revealed that twilight ascents, previously observed during the summer, occur throughout the year. Other swift species, like Alpine swifts (Tachymarptis melba) also seem to remain airborne for most of the non-breeding period. Together these results have important implications for understanding physiological adaptations to endure prolonged periods of flight, including the need to sleep while airborne.

Wolfgang Fiedler, Andrea Flack, Inge Müller, Jan Taylor, Paul Schaeffer, Martin Wikelski

Heart rate and accelerometry logging of free living white Storks from nestling period to the first part of migration

WF, AF, IM, MW: Max Planck Institute for Ornithology • JT: University of Bialystok • PS: Miami University, Ohio
fiedler@orn.mpg.de

20 White Stork (Ciconia ciconia) nestlings have been equipped with GPS-GSM-Loggers and implanted heart rate loggers in NE Poland. It was possible to follow the birds' tracks and heart rate recordings through their late nestling phase, fledging, preparation to migration and migration up to the first 1200 km. The method has been proven to be valid and without harm for the birds.

Hannah Williams

Quantifying performance in flight using tri-axial magnetometry

Dept. of BioSciences, Swansea University, UK
hannahwilliams1805@gmail.com

Yossi Yovel

Active sensing on-board a flying platform - how bats maintain efficient echolocation in flight

Tel Aviv University
yossiyovel@gmail.com

Bats are amazing aviators, able to navigate over hundreds of kilometers on a single night. Unlike birds, bats rely on emitting self-produced (sound) energy for sensing their environment while flying. This imposes several serious sensorimotor challenges such as: (1) Timing the emission of sound signals. (2) Overcoming the noise which results from the immense increase in body temperature during flight, and (3) Stabilizing the sensory acquisition system despite the body jitter which results from flapping flight. I will present a bio-logging approach to study how bats deal with these challenges. Using miniature sensors, we record acceleration, sound and body temperature on-board bats free-flying in the wild or in the laboratory. We find that (1) Bats synchronize their echolocation signal emission to their wing-beat, probably in order to reduce echolocation costs. I will also show preliminary results on using ECG recordings on-board a flying bat as a proxy for energy expenditure. (2) Bats adapt echolocation signal parameters to cope with sensing difficulties arising from flight-dependent physiological constraints such as body temperature. (3) Bats maintain their head stable despite body jitter to stabilize sensory acquisition. Sensing while flying thus induces different types of noise (e.g., movement, thermal) which must be dealt with. Bats do so by synchronizing and adapting their sensory demands to flight and new bio-logging technology allows studying this in free-flying animals for the first time.

Olivier Duriez

CEFE, Montpellier Univ., France
olivier.duriez@univ-montp2.fr

The use of bio-logging to study raptor vision in flight

Poster

Posters are sorted here by family name of the first author. In the poster exhibition they are sorted by the affiliation of the first author (as given in the abstract submission form). Poster numbers follow the order in the exhibition and can be used to quickly find a poster at the conference.

Poster # 164

Sara Abalo-Morla, Jesús Tomás, Adolfo Marco, Vicente Marco, Ohiana Revuelta, Jose Luis Crespo, Eduardo Belda

Long dispersal and large home ranges of loggerhead sea turtle post-hatchlings in the Mediterranean basin

Research Institute for Integrated Management of Coastal Areas, Universitat Politècnica de València, C/Paranimf nº 1, E-46730, Gandía (Valencia), Spain (et al.)
sabalo@epsg.upv.es

Several nesting of loggerhead sea turtle (Caretta caretta) have been recorded in the Mediterranean Spanish coast during the last years, out of its known nesting range. Despite that loggerhead stocks are well studied in many aspects, there is little information about habitat use of post-hatchlings. Our aims are to describe, for the first time in the Mediterranean, the behaviour and habitat use of post-hatchling loggerhead sea turtles, as well as to identify the dispersal areas at this life stage. We satellite tracked 19 headstarted post-hatchlings (aged 9-24 months, size range (SCL): 13.3-29.1 cm) from three clutches laid during 2015-2017. We filtered location data excluding high-speed and land locations, and used a distance-angle rate filter (DAR) of Douglas Argos-filter algorithm (DAF). We assessed home range size estimations using the Brownian bridge method (BBMM). We computed the entire home range (95%) and the core area activity (50%). Our findings showed that post-hatchlings have large dispersal areas (mean: 30,257 km2, SD: 19,013 km2) and large core areas (mean: 6,174 km2, sd: 3,922 km2). This approach showed that overall, post-hatchling dispersion by the western Mediterranean exhibitits low selection pattern, since tagged turtles used different areas. In fact, the used areas changed over time. These results may support the described sea turtle oceanic nursery paradigm. However, we observed a higher use of high productivity areas, as Alboran and Balearic seas. The distribution in more productive areas could be related to the selection of more suitable habitats. Indeed, we observed dispersion to warmer areas during the coldest months during monitoring period.

Marta Acacio, Phil Atkinson, Gary Clewley, Joao Paulo Silva, Aldina Franco

A light weight GPS/GSM system to track animal movement and behaviour with high spatial and temporal resolution

MA, AF: University of East Anglia • PA, GC: British Trust for Ornithology • JPS: University of Lisbon and University of Porto
a.franco@uea.ac.uk

There are currently multiple devices available for tracking animal movement and behaviour. The most convenient devices are archival and remotely transmit the data, avoiding the need to re-trap the animal to recover the data. These devices vary in weight, dimensions and may include different types of sensors depending on the species of animal being tracked. A partnership between the British Trust for Ornithology, the Universities of East Anglia, Lisbon and Porto created a new GPS/GSM solar powered device that is lightweight, can measure three-dimensional locations, has flexible programming schemes for collecting and transmitting data remotely and can measure environmental variables at the individual level. Here, we describe the design, performance and limitations of the system. We also present results of a testing procedure deigned to measure the accuracy of the GPS, altitude and accelerometer measurements. We compare the results of the test with data obtained from 20 individually tracked White Stork Ciconia ciconia to show how our system performs in field conditions. Our devices starts at 12g and include a GPS receiver, micro-processor, solar panel, power management system and a battery. It has a temperature sensor and a tri-axial accelerometer to monitor animal behaviour. The devices can be remotely programmed via GPRS, fixes are taken at user-programmable intervals depending on time of day (e.g. day/night), battery level and whether the tag is inside or outside of a geofence. Data can be seen and downloaded in near real-time using www.movebank.org.

Poster # 13

Timo Adam, Vianey Leos-BarajasRoland Langrock, Floris M. van Beest

Multi-scale modeling of animal movement data using hierarchical hidden Markov models

TA, LR: Bielefeld University • VLB: Iowa State University • FMVB: Aarhus University
timo.adam@uni-bielefeld.de

Hidden Markov models are prevalent in the field of statistical ecology, where they provide a versatile framework to infer behavioral modes (e.g. resting, foraging or traveling) from various types of animal movement data. Due to substantial advances in bio-logging technology, such data can nowadays be collected at much finer temporal scales than only a few years ago. Behavioral modes, however, do not necessarily manifest themselves at the fine scales at which the data are collected, but may effectively operate on much cruder scales. To address the mismatch between data resolution on the one hand and biologically meaningful resolution on the other hand, we discuss a modeling framework that allows to jointly infer behavioral modes at multiple temporal scales. By connecting multiple (fine scale) hidden Markov models using an additional (crude scale) Markov chain, we propose a methodology that opens up new possibilities in the field of animal movement modeling. The suggested approach is illustrated by modeling vertical movements of a harbor porpoise (Phocoena phocoena) throughout its natural habitat, the northeastern part of the North Sea.

Poster # 97

Pedro Afonso, David Abecasis, Jan Reubens, Frederick Whoriskey

Towards an aquatic animal telemetry network in Europe

PA: IMAR/MARE - University of the Azores, Portugal • DA: CCMAR, University of the Algarve, Portugal • JR: Flanders Marine Institute, Oostende, Belgium • FW: OTN - University of Dalhousie, Canada
pafonsopim@gmail.com

Although there is a large and growing number of marine researchers based in Europe that use marine biotelemetry as a tool, they lack either a formal or informal organizational

structure. This impedes data sharing, reduces funding opportunities, removes the scientific benefits that could result from working within a network of researchers using common equipment, and obscures the higher community voice that come with it. The European Tracking Network (ETN) is an effort to promote and bring together this community as part of the EU H2020 AtlantOS project, a large-scale effort that aims to foster increased and sustainable transatlantic ocean observation. In this paper, we present an overview on the past and present status of the scientific production regarding marine biotelemetry based on a bibliographic research. We show that there have been a substantial increase in the number of publications on marine telemetry and a concomitant increase in the number of species, tools, researchers, institutions, and international consortia involved in these studies. These data show the opportunity to tackle the current mismatch between the science and the networking efforts of European based marine biotelemetrists.

Poster # 76

Austin Allen, Leigh Klatsky, Randall Wells, Jay Sweeney

Movement and Dive Behavior of Offshore Bottlenose Dolphins (Tursiops truncatus) Near the Bermuda Pedestal

Duke University Marine Laboratory
austin.allen@duke.edu

The behavior of offshore bottlenose dolphins (Tursiops truncatus) in deep water and near oceanic islands is not well known. Using satellite-linked, time-depth recorders (TDRs), we investigated the movements and dive behavior of offshore bottlenose dolphins in the deep waters surrounding the Bermuda Pedestal. Published satellite-linked telemetry data for dolphins tagged off Bermuda in 2003 included dives to >450 m, lasting for >5 min, while they circumnavigated Bermuda and moved among nearby seamounts. Following this study, in May 2005, three dolphins were outfitted with satellite-linked TDRs. Location and depth data were transmitted for 13-46 days. The dolphins traveled mean daily distances of 54 - 62 km/day, with a mean water depth of 1,575 m. All three dolphins spent a considerable amount of time within a 40 km radius of Bermuda, associating with several seamounts. Two of the dolphins subsequently traveled to distant seamounts, reaching distances as far as 275km northeast of Bermuda. Regular night-time dives (2100 - 0259 h local time) occurred to depths greater than 100 m (7.9% of night-time dives) and in some cases greater than 900 m. Night-time dive durations >3 min were common, and some dives exceeded 11 min in

duration. Dives <50 m were recorded evenly across all hours, while dives >50 m were recorded most often at night (46-49%), with very few made during the day (2-11%, 0900 - 1459 h local time), indicating a diel dive cycle. The dive patterns of bottlenose dolphins in Bermuda waters correlate with the reported nightly vertical migrations of mesopelagic prey along the steep-sided Bermuda Pedestal. The extreme depth and duration of recorded dives and the elevated hematocrit values sampled, reveal the deep-diving capabilities of offshore bottlenose dolphins. These findings also demonstrate the physiological differences between offshore and shallow-water ecotypes of bottlenose dolphins.

Poster # 108

Samantha Andrzejaczek, Adrian C. Gleiss, Charitha B. Pattiaratchi, Karissa Lear, Mark G. Meekan

The ups and downs of the tiger shark – an up-close view of their behaviour

SA, CBP: IOMRC and UWA Oceans Institute, The University of Western Australia, School of Civil, Environmental, and Mining Engineering, M470, 35 Stirling Highway, Crawley, WA 6009, Australia • SA, MGM: Australian Institute of Marine Science, Indian Ocean Marine Research Centre (IOMRC), University of Western Australia (M470), 35 Stirling Highway, Crawley, WA 6009, Australia • ACG, KL: Centre for Fish and Fisheries Research, School of Veterinary and Life Sciences, Murdoch University, Murdoch, WA, Australia
samantha.andrzejaczek@research.uwa.edu.au

Tiger sharks (Galeocerdo cuvier) are a keystone predator in the food chains of many tropical reef systems worldwide. Recently, cameras deployed on these sharks have provided new insights into their behaviour, including feeding on a wide variety of prey species and continuous cycles of ascent and descent through the water column. Here, we deployed CATS camera and diary tags on 26 tiger sharks at Ningaloo Reef, Western Australia in order to investigate hunting strategies and the drivers of movement patterns. These tags were clamped to the dorsal fin and recorded both physical parameters such as depth and temperature, and, through the use of accelerometers, in situ measurements of animal trajectory and locomotion, which enabled calculation of dive geometry and swimming energetics. These data were compared with behaviours recorded simultaneously by video cameras. Preliminary results have shown that our tags have recorded a number of predator-prey interactions, swimming strategies as well as recovery from the process of tag application. Our data have demonstrated the suitability and effectiveness of these tags as a means to link the processes of locomotion and behaviour of these animals.

Poster # 10

Kagari Aoki, Katsufumi Sato, Saana Isojunno, Tomoko Narazaki, Patrick J. O. Miller

Does buoyancy affect optimal swim speed? High-speed transits to depth in negatively buoyant long-finned pilot whales

KA, KS, TN: Atmosphere and Ocean Research Institute, University of Tokyo • SI, PJOM: Sea Mammal Research Unit, University of St Andrews
aokikagari@gmail.com

To maximize foraging duration at depth, diving mammals are expected to use the lowest-cost optimal speed during descent and ascent transit. Two biomechanical models have been used to explain optimal swim speed: the external work model and the actuator disc model. The external work model calculates the cost of transport based on power (buoyancy and drag force acting on swimming animals) x animal's speed. The model predicts optimal speed is not affected by buoyancy, but that optimal speed would be affected by the basal metabolic rate and drag of animals. The actuator disc model estimates the power consumed in order to counter gravity and drag forces by employing actuator-disc theory, which has been widely used for flying animals. The model predicts that optimal speed is positively related to basal metabolic rate and increases with deviations from neutral buoyancy. Here we outfitted 16 deep-diving long-finned pilot whales with multi-sensor data loggers and tested weather buoyancy affects optimal speed. Hydrodynamic gliding models showed negative buoyancy of tissue body density (1038.8 ± 1.6, $\pm 95\%$ credible interval) of tagged pilot whales and similar diving gas volume with other deep-diving toothed whales (34.6 ± 0.6 ml kg-1, $\pm 95\%$ credible interval). Using these values, we calculated changes in total body buoyancy with depth during active swimming of ascent phases. Indeed, we found a negative correlation between buoyancy and swim speed within ascents as animals travelled faster at depth when gas was more compressed, which indicates that buoyancy affected their optimal swim speed. The intercept of this correlation was 2.3 ± 0.15 ($\pm 95\%$ confidence interval) m s-1, our estimate of the optimal speed of pilot whales at neutral buoyancy.

Poster # 67

Ayaka Asada, Scott A. Eckert, Randall W. Davis

Diving and foraging behavior of leatherback sea turtles (Dermochelys coriacea) nesting on St. Croix, US Virgin Islands

AA, RWD: Department of Marine Biology, Texas A&M University at Galveston • SAE: Biology and Natural Resources Department, Principia College
asadasteak@gmail.com

Sandy Point National Wildlife Refuge, St. Croix, US Virgin Islands supports nesting by approximately 200 leatherback sea turtles. With its offshore waters designated as Critical Habitat in 1978, the 2.4 km long nesting colony in the refuge has been monitored since 1982. Many of the females have been tagged, so their interannual nesting behavior and success are known. Each female typically lays six clutches of eggs separated by about 10 days at sea which enables researchers to attach and recover instruments. Previous research in 1989 using a time-depth recorder showed that leatherbacks dive continuously with durations averaging 12-14 minutes and are the deepest diving sea turtle with a maximum dive depth of 1,300 m. However, the motivation for such dive behavior remains poorly understood. In this study, we attached video and data recorders (VDRs) to three females during May of 2016-17. The VDRs recorded three dimensional dive behavior and feeding events. The animals' movements at sea were recorded in near real time by satellite telemetry. After laying, females remained within 120 km of St. Croix, often moving into the Virgin Islands Trough or around the south side of the island at an average swim speed of ca. 1 m s-1. Maximum dive depth and duration were 505 m and 25 min. We video recorded the turtles feeding on the Atlantic sea nettle (Chrysaora quinquecirrha), Moon jelly (Aurelia aurita), Pelagic tunicate (Salpa aspera), and Giant fire salp (Pyrosoma spp.) at an average depth of 34 m (maximum foraging depth 75 m). However, rather than intensive foraging, feeding appears to be opportunistic leaving us to speculate that the dive and movement behavior of leatherbacks during the internesting periods is necessary for maturation of the next clutch of eggs while avoiding sharks that patrol the nearshore waters of the nesting beach.

Jessica M. Aschettino, Dan Engelhaupt, Amy Engelhaupt, Michael F. Richlen, Joel T. Bell

Humpback whale affinity for shipping channels near the mouth of the Chesapeake Bay can prove fatal

JMA, DEMRF: HDR • AE: Amy Engelhaupt Consulting • JTB: Naval Facilities Engineering Command, Atlantic
jessica.aschettino@hdrinc.com

Humpback whales (Megaptera novaeangliae) are known to frequent the coastal waters of the mid-Atlantic United States (U.S.), particularly the mouth of the Chesapeake Bay, during the winter months. This region is also heavily utilized by both U.S. Navy and commercial shipping vessels, increasing the risk for interactions with large ships. In 2015, the U.S. Navy initiated a multi-year study including satellite-linked tagging techniques as a means to better understand how humpback whales utilize these waters, with a focus on the nearby "W-50" training area, and shipping channels. From December 2015 to February 2017 thirty-five Wildlife Computers LIMPET-configured tags were deployed on humpback whales near the mouth of the Chesapeake Bay. Tags transmitted 2.7 - 43.8 days (mean=13.7). Whale locations were overlaid onto shipping channels and the W-50 area to assess habitat use. Location data showed that nearly all whales occurred within, or in close proximity to, the shipping channels at some point during tag deployment. Approximately 25.3% of all filtered locations occurred within shipping channels and 8.7% occurred within the W-50 area. In addition, 9 of 105 catalogued humpback whales (8.6%) had evidence of propeller strikes, one of which was a deceased whale previously tagged with locations within and near the shipping channels. In April 2017 the U.S. National Oceanic and Atmospheric Administration declared an unusual mortality event for humpback whales along the Atlantic east coast from Maine to North Carolina due to a larger-than-normal number of deaths in this area (n=42) since 2016. Ten of the 20 dead whales examined had evidence of injuries sustained from vessel strikes. To date, the findings from this study demonstrate that a substantial number of humpback whales frequent high-traffic areas near the mouth of the Chesapeake Bay which may be a contributing factor to an increase in vessel interactions and associated fatalities in this region.

Poster # 237

Ines Aster, Christian Sperger, Daniela Trobe, Johannes Fritz

Campaign against illegal bird hunting in Italy: Whole population GPS data-logging of a Northern Bald Ibis release population allows to define hot-spot poaching areas in Italy

Waldrappteam, LIFE+ Northern Bald Ibis
iaster@waldrapp.eu

Illegal bird hunting is one of the major threats of migrating birds, even within the European Union. The European LIFE+ project aims to reintroduce a migratory European population of the continentally extinct, critically endangered Northern Bald Ibis (Geronticus eremita). Hunting during the autumn migration period is the major mortality cause for the release population, which currently consists of more than 70 individuals. All birds are equipped with GPS-tags. Bio-logging allows to quantify the threat of illegal hunting and to define hot-spot areas where actions should be taken primarily. This is shown by an analysis of the hot-spot areas in Italy, in combination with the distribution of other relevant variables regarding the distribution of hunting activities, executive bodies and other co-variables. After mid-term of the six-year LIFE project, there are indications that a campaign causes a decrease of hunting as a mortality cause. The definition of hot-spot areas allows to optimize and intensify the campaign. The project is implemented with 50 % contribution of the LIFE financial instrument of the European Union (LIFE+12-BIO_AT_000143, LIFE Northern Bald Ibis). Ines Aster is financed by the Austrian Research Promotion Agency (FEMtech Praktika fÜr Studentinnen 2017, FFG Project Number 862469).

Poster # 110

Robert Klaus Bauer, Mariana Travassos Tolotti

MARBEC (MARine Biodiversity, Exploitation and Conservation), more than 30 years of experience in marine biologging

IRD, UMR Marbec (IRD, IFREMER, CNRS, UM), Avenue Jean Monnet, CS 30171, 34203 Sète Cedex, France
robert.bauer@ird.fr

Biologging has become an important tool for investigating the behaviour of animals within the context of their physical environment. As leading pioneers in marine biologging, our scientists at MARine Biodiversity, Exploitation and Conservation (MARBEC), a joint research unit by IRD, IFREMER, CNRS, and the Université de Montpellier, in France, developed numerous applications over the past 30 years, that significantly improved our understanding of the behavioural ecology of marine mammals, sea birds, sea turtles and diverse marine fish species. The objective of this poster is to give a short overview about current biologging projects at MARBEC that include among others:

(1) habitat use of dorades in coastal lagoons of the Northwestern Mediterranean Sea (project: SB-Tag)

(2) vertical behaviour of Atlantic bluefin tuna with implications to stock-abundance assessment (project: BLUEMED)

(3) devlopment of physiological state bio-loggers (project: POPSTAR)

(4) spatial ecology of tropical seabirds (project: TOPINEME & MAFALDA)

(5) post-release mortality rates of bycatch species of commercial long liners (project: SELPAL)

(6) bull-shark habitat use (project: ECORECO)

Poster # 111

Robert Klaus Bauer, Jean-Marc Fromentin, Tristan Rouyer, Géraldine Perez, Manuela Capello

Vertical dynamics of Atlantic bluefin tuna with implications to aerial surveys

IRD, UMR Marbec (IRD, IFREMER, CNRS, UM), Avenue Jean Monnet, CS 30171, 34203 Sète Cedex, France
robert.bauer@ird.fr

Atlantic bluefin tuna Thunnus thynnus (ABFT) are highly migratory, opportunistic predators that forage throughout the water column up to more than 1000 meters. However, their surface activity, especially during feeding events on schools of small epipelagic fish such as sardines and anchovies, makes them easily detectable from afar. Scientific aerial surveys, targeting surfacing tuna schools, have proven to be a useful method for the development of fisheries-independent abundance indices, needed to complement problematic fisheries-dependent indices that are affected by regulatory measures. However, the amount of non-surfacing schools during such surveys remains unknown. Variations in the vertical behaviour of ABFT could therefore affect the reliability of thus derived abundance indices. To assess this source of uncertainty, we deployed 24 pop-up archival tags in 2015 & 2016 to investigate the vertical behaviour of ABFT during aerial surveys in the Gulf of Lions, Northwestern Mediterranean. Our analyses focused on changes in surface presence and absence periods, defined as continuous residence time (crt) and continuous absence time (cat), using survival curve analysis. Preliminary results indicate seasonal changes in ABFT surface presence, likely related to thermal stratification. However, frequent deep and long lasting spike dives (up to 6h) during the twilight periods were also evident from the tagging data, probably related to feeding in the deep scattering layer. The dynamics in the vertical behaviour are further subject to empirical approaches to estimate the abundance of ABFT that underlies the amount of tuna schools detected during the aerial surveys.

Poster # 112

Jasminca Behrmann-Godel, Clara Sandkühler, Martin Wikelski

The implanted carrier plate - a new method for attaching ICARUS pop-up satellite tags on the European eel (Anguilla anguilla)

Limnological Institute of the University of Konstanz • Max Planck Institute for Ornithology
Jasminca.Behrmann@uni-konstanz.de

Information about the endangered species European eel (Anguilla anguilla) is crucially needed because up to today, only a single eel could be tracked on its whole journey until reaching its spawning ground in the Sargasso Sea. This small success rate indicates a problem with the tagging methods used. Here we present a practical new method for tag attachment to European eels, the implanted carrier plate. Previous pop-up satellite tagging methods were compared to the new method, were a carrier plate is implanted under the skin of the eel. To this carrier plate a pop-up satellite ICARUS tag can be easily attached. Tensile force tests using dead eels were made for both, recent methods and the new carrier plate implantation method. The newly developed method turned out to withstand high tensile forces (Ã˜ 136.7 N) and was intermediate between two previous methods from the literature where tags were either fixed via metal wires, thread through the muscle tissue (Ã˜ 196.12 N) or cramped to the skin (Ã˜ 53.93 N). Different locations on the dead eelÂ s body and different shapes of the carrier plate were tested. The new implantation method allowed the dummy tag to be attached very close to the eelÂ s body surface. This will highly reduce conspicuousness of the eel and thus will decrease predation by sharks and mammals which was the major source of mortality of tagged eels in previous studies. First recent results using the new attachment method on living eels are also reported.

Poster # 212

Roxanne S. Beltran, Greg A. Breed, Patrick W. Robinson, Dana K. Briscoe, Elliott L. Hazen, Steven J. Bograd, Daniel P. Costa

Oceanographic drivers of foraging effort and success in the northern elephant seal

RSB, GAB: University of Alaska Fairbanks • PWR, DPC: University of California Santa Cruz • DKB: Stanford University, Hopkins Marine Station • ELH, SJB: National Oceanic and Atmospheric Administration

roxanne.beltran@gmail.com

Recent initiatives have facilitated extensive animal tracking efforts around the globe, resulting in efforts to explain the distributions and behaviors of animals relative to oceanographic variables. State-space models (SSMs) have been developed to estimate foraging effort (by distinguishing foraging time from transiting time) and, likewise, drift rate changes provide a proxy for foraging success. While these metrics are commonly used to study at-sea behavior, they are rarely cross-validated or compared to oceanographic variables. Our objectives were twofold: 1) To determine how drift rate changes and proportion of time spent foraging relate to body condition gains, and 2) To determine which oceanographic metrics are correlated with mass and condition gains. We analyzed ARGOS-linked satellite tag data from 88 northern elephant seals Mirounga angustirostris in the northeast Pacific across ten years (14,600 positions) and weighed the seals before and after tag deployment. For daily latitude and longitude positions, we obtained SSM-derived behavioral states, measured seven-day sums of drift rate, and obtained oceanographic metrics: Chlorophyll a (Chl a, representative of local productivity), sea surface temperature (SST, water masses and fronts) and sea surface height (eddies). Positive drift rate changes and foraging states occurred most often near the boundary of the subtropical and subarctic gyres. Percent time foraging and drift rate changes were positively correlated to body composition changes, however, the correlation varied interannually, with years of more significant mass gain reflected in higher drift rate changes relative to foraging effort. Mean Chl a showed the most pronounced differences between foraging and transiting states and was significantly higher in foraging areas than transit areas for all years (paired t-tests, $p<0.05$ for all). Understanding the oceanographic drivers of animal foraging effort and success will help to highlight ecologically significant ocean areas and provide a baseline for understanding climate impacts on top predators.

Poster # 204

Benjamin Benti, Charlotte Curé, Patrick Miller

Humpback whales (Megaptera novaeangliae) can discriminate between the calls of different killer whale (Orcinus orca) ecotypes

BB: Université de Strasbourg • CC: Cerema Strasbourg • PMUniversity of Saint-Andrews
bb65@st-andrews.ac.uk

Humpback whales feed in high latitude waters during summer, breed in tropical waters during winter and migrate annually between these areas. Agregations of fish-eating killer whales and humpback whales feeding on similar prey have been observed on the feeding grounds. By contrast, the interactions between humpback whales and mammal-eating killer whales are less common and more complex: they range from predation attempts by the killer whale and avoidance by the humpbacks, to attraction and interference of humpback whales towards killer whales attacking on other marine mammal prey. In order to determine if the acoustic channel could mediate the variation in the nature of the interaction between humpback whales and killer whales, we played back sounds from different killer whale ecotypes to the north Atlantic population of humpback whales feeding in Norwegian fjords. In these areas, both humpback whales and fish-eating killer whales feed on overwintering herring. In January 2016 and 2017, we exposed 6 humpback whales to sounds from both familiar fish-eating killer whales recorded in the same area, and unfamilar mammal-eating killer whale sounds recorded in the North Pacific (simulating a potential predator). Humpback whales were equipped with non-invasive tags (DTAGs) which allow the recording of their movements (horizontal and vertical) and behaviour (feeding and vocal behaviours). Humpback whales changed their horizontal course towards the fish-eating killer whale sound source, while they ceased resting, and moved horizontally away from the mammal-eating killer whale sound source and stayed in shallow waters. Those results demonstrate the ability of humpback whales to discriminate between sounds of the two killer whale populations and to adjust their behavior accordingly to the perceived stimulus.

Poster # 6

Amy Bishop, Casey Brown, Leigh Torres, Mike Rehberg, Markus Horning

Risky Business: Developing a habitat use model with inclusion of predation risk

Alaska SeaLife Center, Alaska SeaLife Center, Oregon State University, Alaska Department of Fish and Game, Alaska SeaLife Center
amybi@alaskasealife.org

The spatial distribution and habitat utilization of upper trophic level predators is assumed to be primarily driven by foraging opportunities and predation avoidance, but the latter is rarely included in species distribution models for marine animals due to lack of data. Modern implanted telemetry devices, e.g. Life History Tags (LHX tags), can assist in bridging this data-gap by detecting the occurrence and location of predation events from known age, free-living animals. In our case-study, we have geospatial tracking data from juvenile Steller sea lions (SSLs) tagged between 2000 and 2014 (n=105) in the Prince William Sound (PWS) and Kenai Fjords (KF) regions in Alaska. LHX tags were implanted in a subset of these animals (n=45), of which there have been 20 known mortalities to date. The data from the LHX tags suggests at least fifteen mortalities were classified as predation, in turn demonstrating that predation is the single greatest cause of mortality for juvenile Steller sea lions in the PWS/KF region. By integrating the geospatial satellite tracking information, environmental data, and a spatially explicit predation event probability layer, our habitat use models will be used to address several questions including: (1) Is predation pressure influencing juvenile SSL dive or movement behaviors? (2) Is there evidence to support a specific species is the primary predator of juvenile SSLs? and (3) Under various climate change scenarios, how might predation risk change, and therefore, how might juvenile SSL distributions shift? Here we will present our preliminary results, and provide opportunity to discuss various methods for addressing these questions. Juveniles constitute one of the most vulnerable life history stages for SSLs, therefore understanding the preference and avoidance of specific environmental and predator related factors is vital to management, and for promoting the recovery of the species.

Poster # 186

Asgeir Bjarnason, Andres Gunnarsson, Tomas Arnason, Matthias Oddgeirsson, Asgeir Gunnarsson

Validation of ECG-derived heart rate in cod (Gadus morhua L.) from Icelandic waters recorded with implantable data logging system.

AB, AG: Star-Oddi Ltd, Skeidaras 12, IS-210, Gardabaer, ICELAND • TA, MO: Iceland Marine Research Institute, Grindavik, BOX 1390, IS-240, Reykjavik, ICELAND
asgeir@star-oddi.com

Background Archival tags have been used on fish for number of years measuring temperature, pressure, salinity amongst other parameters. However, heart rate measurements in fish have been difficult to conduct in the wild due lack of commercial availability, large size of the recording systems, restriction in setups with external systems and unreliable measurements or calculations of heart rate. This works presents a validation of a commercial ECG-derived heart rate data logging system on farm raised cod fish (Gadus morhua L.), both its signal processing algorithm and recording quality. Methods Six farm raised cod from Icelandic waters were equipped with Star Oddi DST milli-HRT heart rate and temperature monitor and kept in captivity for 50 days measuring heart rate and temperature every 5 minutes and ECG data used to derive heart rate recorded every 30 minutes. Heart rate calculations were validated for each fish with over 2500 ECG data snippets per fish. Baseline measurements were compared with over 30 days of stable temperature (10°C) and standard feeding from one week after implantation, concluding with a stressor experiment 5 weeks later. Results During the experimental period, all six fish had both individual periodical variation as well as individual baseline variation in the heart rate, the mean heart rate ranged from 30bpm to 48bpm. Heart rate calculations matched the manually validated R-R interval used to derive the heart rate in the recorded data in >95% of instances. During the stressor experiment all fish showed an increase of at least 25% from their individual mean heart rate and a 4h recovery period where the heart rate went back to pre-stressor experiment daily average. Conclusions Data loggers recording ECG-derived heart rate can be used to assess the cardiac response in cod and other types of fish if validated.

Poster # 36

Charles-André Bost, Florian Orgeret, Henri Weimerskirch

Improve or perish? Early diving behaviour in juvenile penguins

Centre d'Etudes Biologiques de Chize UMR 7372 du CNRS-Universite de La Rochelle, 79360 Villiers-en-Bois, France
charly.bost@cebc.cnrs.fr

During the first year of their life, fledged penguins disperse at-sea for periods exceeding several months to a year without any return on land. Information on their at-sea activity and survival during this period is essential because their mortality controls recruitment to reproductive stages, and thus the future of populations. In 2014 and 2015, we instrumented with data archiving tags transmitting via the Argos system a total of 17 and 21 juveniles of the 2 Aptenodytes penguins, the king penguin Aptenodytes patagonicus (from Crozet islands) and the emperor penguin Aptenodytes forsteri (from AdÉlie Land) respectively. Analyses indicate that juvenile emperors firstly disperse away from Antarctica toward the north of the pack-ice edge, in the polar frontal zone. The number of daily dives they performed strongly increased as did dive depths and durations. During austral winter, the individuals generally moved south-westward, close to the extending pack-ice. Juvenile king penguins performed very distant trips, up to 4000 km from their colony. In autumn, they gradually traveled south, off the polar frontal zone. Juveniles behave in a way very different than the breeding adults, exhibiting more exploratory looping trips and navigating against the Antarctic Circumpolar Current. The data on foraging performance of the two species revealed two groups of juveniles. The first group made shallower, shorter dives and increased post-dive duration before the end of transmissions, that strongly suggest an early mortality, while the second group progressively increased their diving skills, but their diving parameters were still lower compared to adults, even after nine months at sea. As such, there is a relationship between improved diving behaviour and survival in young penguins. The juvenile behaviour of the 2 species is discussed in relation to the life history strategies of the Aptenodytes genus and according to the marine habitat used.

Poster # 122

Peter L. Boveng, Shawn P. Dahle, Markus Horning, Paul B. Conn, Josh M. London

Evaluation of archival life history tags surgically implanted in wild harbor seals

PLB, SPD, PBC, JML : Marine Mammal Laboratory, NOAA Alaska Fisheries Science Center, Seattle, WA USA •
MH: Alaska SeaLife Center, Seward, AK USA

peter.boveng@noaa.gov

Harbor seals in the western Aleutian Islands declined dramatically since the early 1980s and have shown little sign of recovery. As part of a research program to understand the ecology and demography of these seals, we deployed life history transmitter (LHX) tags in 10 individuals during September, 2016. Two of these tags were surgically implanted in the abdominal cavity of each seal, where they will log the temperature and light until those values indicate that the tags have been liberated from the body, evidence of the seal"s demise. The buoyant tags then surface and transmit the data through the Argos system, providing evidence for time and location of death. An abrupt transition from internal body temperature to ambient temperature indicates disgorgement of the device by a predator, whereas a gradual transition suggests some other cause of mortality such as disease or starvation. For female seals, the temperature record prior to death also provides inference about the occurrence and timing of parturition. Because this study was the first deployment of LHX tags at sea and in wild harbor seals, our first objective was to determine whether there were any acute or chronic effects on the seals from the implantation surgeries or the tags. We present a treatment-versus-control comparison for a suite of movement and foraging performance parameters obtained from external, Argos-linked location and depth recorders deployed on both the experimental seals and a group of control seals without LHX tags.

Poster # 54

Dr. Franziska Broell

Deep Sleep? Accelerometry reveals how grey seals partition time at sea: resting vs foraging

Dalhousie University, 1355 Oxford Street, Halifax, Canada
franziskabroell@dal.ca

Many pinniped species spend extended periods of time at sea, separated from haul-out locations, and therefore presumably devote a fraction of their time at sea to resting. In grey seals, mean foraging trip duration typically varies from 7-10 days. Given the difficulties associated with identifying behaviours from 2D time-at-depth records, resting and other functions of diving in pinnipeds is still poorly understood. We collected ~ two months of GPS locations, time-at-dept (1 Hz), and head-mounted tri-axial acceleration (32Hz, +/- 6 g) data on n = 18 adult grey seals instrumented on Sable Island, Canada (2014 to 2016). We used these data to classify at-sea behaviour and test hypotheses about grey seals resting behaviour during trips to sea. A signal processing algorithm based on the magnitude of jerk (ms-3) and dive profiles was developed to differentiate among resting, foraging, and transiting dives. Resting while at sea was not observed at the surface, but rather occurred during the bottom of square-shaped dives, and occurred in 40% of dives per day. Resting dives were longer in duration (7.1 min, 15.6% CV) than foraging (4.9 min, 9.0% CV) dives, but occurred at similar depths (107 m, 3.6% CV). Unlike foraging dives, resting dives typically occurred during daylight in ~ 6-hour bouts. The frequency of resting dives increased with distance from the haul-out location on Sable Island. Results are used to test if resting at depth is a strategy to minimise predation risk and energy expenditure while at sea or to optimise time spent near foraging patches by avoiding surface advection. Results indicate that both the spatial and temporal distribution and the proportion of time devoted to foraging may be over-estimated in pinnipeds that spend extended periods of time at sea and exhibit flat-bottomed dives.

Poster # 38

Casey Brown, Amy Bishop, Markus Horning

A quantitative approach for identifying spatially explicit distribution of Steller sea lion predation events

Centre for Applied Ecology "Prof. Baeta Neves" - InBIO, Instituto Superior de Agronomia, Universidade de Lisboa, Portugal
caseyb@alaskasealife.org

There is increasing evidence that marine mammals adjust their behavior under predation threat. However, few data or analyses exist showing how predators affect the movement patterns of tracked marine mammals. This gap in information is largely due to the cryptic nature of pelagic predators and the difficulty associated with directly observing predatory behavior. To overcome these limitations, Life History Tags (LHX) have been developed to determine the approximate location and time of known mortality events from tagged individuals. We used LHX data from juvenile Steller sea lions to spatially characterize the distribution of predation events in two coastal fjord systems in Alaska. Here, we present our modeling approach which includes: 1) developing analytical tools from simulated predation events (n=24) to improve the location accuracy of Argos-based postmortem event location estimates, 2) expanding upon a "reverse" Bayesian state-space model that processes and interpolates the ARGOS locations received post-mortem from LHX tags (n=18), 3) creating a predation presence/absence model that uses the estimated locations from LHX tags and Steller sea lion locations within season utilization distributions, 4) applying machine learning software to create a spatial grid layer that represents areas where predation is more likely to occur. The goal of this effort is to create a predation model to be used in future Steller sea lion distribution and habitat modeling efforts.

Poster # 90

David E. Cade

Determining forward speed from accelerometer jiggle in aquatic environments

Hopkins Marine Station, Stanford University
davecade@stanford.edu

How fast animals move is critical to understanding their energetic requirements, locomotor capacity, and foraging performance, yet a consistently applicable and accurate bio-logging technique to determine speed underwater remains unresolved. Our new method relates forward speed to the stochastic motion of bio-logging devices in a turbulent flow as measured by high sample-rate accelerometers. Accelerometers have increasingly become ubiquitous in aquatic animal tags due to their utility, low-battery requirements, reasonable cost, and ever-increasing data storage capacity. These devices record vibrations of increasing amplitude that correlate exponentially with increasing speed. The amplitude of these vibrations, the tag jiggle, can thus be used to measure speed through water, and tag video clearly demonstrates periods of rapid tag motion coincident with periods of high speed. We confirmed the efficacy of the jiggle method in a flow tank using two types of bio-logging tags and tested the method in situ using data from two types of suction cup attached tag and two types of dart-attached tag deployed on wild cetaceans. Our analyses revealed strong correlations between accelerometer jiggle and the animal"s orientation corrected depth rate (OCDR) at all tag orientations tested, and we found stronger correlations to OCDR than with a frequently used acoustic method. The jiggle method was effective when the accelerometer was sampled at > 40 Hz with improved correlation with OCDR when sampled above 100 Hz. Sampling higher than 180 Hz did not improve results. This method is an improvement over other bio-logging methods for determining speed as it combines multiple metrics (three accelerometer axes) into a single model that relies on data from a nearly universal, low-drag and low battery power device that can be deployed in a variety of orientations. The method can be applied retroactively to archived datasets on various species and could become a standard metric of animal speed.

Poster # 91

Goldbogen, J. A., Cade, D. E., Boersma, A. T., Calambokidis, J., Kahane-Rapport, S., Segre, P. S. , Stimpert, A. K., Friedlaender, A. S.

Using digital tags with integrated video and inertial sensors to study moving morphology and associated behavior in large aquatic vertebrates

Hopkins Marine Stations, Stanford University
jergold@stanford.edu

As a result of the historical whaling industry, the anatomy of large cetaceans has been well documented and studied. In recent decades, gross dissection and medical imaging have provided detailed insights into anatomical structures. However, the difficulty of studying the world"s largest predators in their natural environment means the functions of these structures must be inferred. The study of free swimming cetacean behavior and locomotion has been made possible with the recent use of non-invasive tracking devices that measure body position and orientation and have allowed for the detailed reconstruction of underwater trajectories. The addition of cameras to the whale-borne tags allows the sensor data to be matched with real-time observations of how whales use their morphological structures, such as flukes, flippers, feeding apparatuses, and blowholes for the physiological functions of locomotion, feeding, and breathing. Here we describe a new tag design with integrated video and inertial sensors and how it can be used to provide insights to the function of whale anatomy. This technology has the potential to facilitate a wide range of discoveries and comparative studies, but many challenges remain to increase the resolution and applicability of the data.

Poster # 15

Francesca Cagnacci, Kevin Morelle, Stefano Focardi, Ferdinando Urbano

EUROUNGULATES: Collaborative science for studying ungulates movement ecology at the European scale

FC: Biodiversity and Molecular Ecology Dept., Research and Innovation Centre, Fondazione Edmund Mach. Via Mach 1 San Michele all"Adige, TN, Italy • KM: Freelance Euroboar Database Curator, Stockach, Germany • SF: Istituto dei Sistemi Complessi - CNR via Madonna del Piano 10 50019 Sesto Fiorentino (FI), Italy • FU: Freelance Eurodeer Database Manager, Milan, Italy
morelle.k@gmail.com

EUROUNGULATES (www.euroungulates.org) is a network of projects for data and knowledge sharing on movement ecology of European ungulates. Its aim is to investigate variation in ungulates behavioural ecology along environmental and climatic gradients and to record population responses to specific conditions, such as habitat changes, impact of human activities, different hunting regimes. EUROUNGULATES is an umbrella platform that coordinates 3 species-specific projects on roe deer Capreolus capreolus (EURODEER, www.eurodeer.org), red deer Cervus elaphus (EUREDDEER, www.euredder.org) and wild boar Sus scrofa (EUROBOAR, www.euroboar.org) European populations. At the moment, it promotes collaborative science among 50 research institutes from 24 countries. EUROUNGULATES is supported by an external sponsor and by the voluntary contribution of each partner. Structurally, EUROUNGULATES platform connects the EURODEER, EUREDDEER and EUROBOAR databases that serve as repositories where data coming from the project partners are harmonized, stored and shared to be analysed. The main set of data stored are those generated by biotelemetry sensors to monitor animals movement, i.e. GPS, VHF and accelerometer, but a key role is played by the large set of additional information on individuals, populations, management and the environment standardized among the different research groups. EUROUNGULATES connects a large part of the European community working on deer and wild boar, thus facilitating the definition of protocols and standards for future data collection and storage, improving the effectiveness of data sharing, and joining forces to address large scale ecological and societal challenges. Migration, dispersal, effect of hunting regimes on individual responses, range distribution changes because of climatic variability are some of the topics EUROUNGULATES published about or is working on at the moment. The open, bottom-up and cooperative structure of EUROUNGULATES spurs proactive involvement of partners and assures that they are involved in all stages of research.

Poster # 19

Ana P B Carneiro, Maria Dias

EO4wildlife platform: using earth observation data to protect, conserve and monitor marine wildlife

BirdLife International
ana.carneiro@birdlife.org

In January 2016 a new three-year project, EO4wildlife, funded by the European Horizon 2020 program for research and innovation, was launched. The multi-disciplinary collaboration between ATOS, Argos CLS, Agence FranÇaise pour la BiodiversitÉ, BirdLife International, IT Innovation and the University of Exeter will explore how earth observation data can be better used to protect, conserve and monitor marine wildlife. The project will be guided by an advisory board including additional marine management bodies and scientific organisations. EO4wildlife project aims to design and develop an open service platform and interoperable toolbox that allows management authorities, biologists, ecologists and ornithologists to easily process geospatial environmental simulations using Sentinel Earth Observation data that are intelligently combined with other observation sources. The platform will offer high level services that can be accessed by scientists to perform their respective research. The design of the platform will be informed by four different use case scenarios in the fields of wildlife movements, habitats and behaviour: seabirds, sea turtles, marine mammals, and pelagic fishes. BirdLife international has been working on the seabird scenario to facilitate the linkage between the seabird tracking data and environmental variables. The general objective of this scenario is to be able to predict distribution of species of seabirds using environmental data in order to identify and monitor important bird areas, and to develop effective management frameworks taking into consideration threats and pressure. These could then be used to set up dynamic management tools for authorities (e.g. fisheries, shipping, Marine Protected Areas) to help them make real-time decisions to protect selected seabird species.

Poster # 240

Tegan Carpenter-Kling, Maelle Connan, Ryan Reisinger, Pierre Pistorius, Clive Trueman

Coupling biologgers, stable isotopes and simulation models

TCK, MC, RR, PP: Zoology Department, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa • TCK, MC, PP: DST/NRF Centre of Excellence at the Percy FitzPatrick Institute for African Ornithology, University of Cape Town, Cape Town, South Africa • TCK, CT: Ocean and Earth Science, National Oceanography Centre, Southampton, University of Southampton Waterfront Campus, European Way, Southampton

tegan.carpenterkling@gmail.com

Understanding of the foraging ecology and life history traits of marine predators has been dramatically improved with the development of biologgers, providing high resolution information regarding location, and in some cases, foraging behaviour. At the same time, stable isotope ecology has developed as an additional method to track the spatial origin of assimilated nutrients (and thus infer foraging-related movements). Relatively few studies have combined these two approaches, despite the potential wealth of complimentary information. A major drawback in marine isotope ecology is the lack of reference maps (isoscapes) needed to relate the isotopic composition of an animal's tissues to a location. Recently, Magozzi et al. (2017) developed a carbon isotope model that predicts the spatio-temporal distributions of the $\delta13C$ value of phytoplankton across the global ocean at one degree and monthly resolution. Modelled, spatio-temporally explicit isoscapes provide a framework for in-silico modelling, where an animal can move through the isoscape, assimilating nutrients. Animal movements can either be modelled experimentally, or inferred from biologger measurements, and the isotopic compositions estimated from the model can then be compared to measured values to infer likely combinations of movements and foraging location. Here, we apply this conceptual framework to a dataset of 6 pelagic seabird species nesting on sub-Antarctic Marion Island. Seventy-four individual birds were tracked with GPS loggers and as they returned from the logged foraging trip, a blood sample was taken for stable isotope analyses. We show how the in-silico experiments enhance interpretations both of geolocation and foraging behaviour, particularly improving retrospective geolocation from intrinsic biochemical tags (e.g. $\delta13C$). This method is a powerful tool that can be applied to any mobile marine predator, and we hope that the in-silico modelling approach outlined here will stimulate more studies combining biologger and intrinsic biochemical methods for geolocation.

Poster # 159

Matt ID Carter, W James Grecian, Debbie JF Russell, Kimberley A Bennett, Philip J Hosegood, David Thompson, Clare B Embling

Ontogeny of habitat preference in a naïve marine top predator

Plymouth University
matthew.carter@plymouth.ac.uk

Grey seal (Halichoerus grypus) pups are abandoned on the natal colony after a brief suckling phase, and must learn to find food without maternal guidance. Previous research has indicated regional differences in the early movement patterns of recently-weaned pups as they leave the colony and develop foraging skills during their initial months of independence. However little is known about the habitat requirements of pups during this vulnerable life stage. We tracked 29 pups from two distinct geographic regions of the United Kingdom with GPS-GSM devices. We examined how physical habitat features (substrate type, bathymetry, distance from haulout) associated with pup foraging locations varied with age. Variables were analysed in Generalized Additive Mixed Models (GAMMs) in a use-availability framework. We compare the results between the sexes and regions. Preliminary results suggest that pups develop preference for foraging areas in shallower water, closer to shore in their third month of independence. Identifying important habitat for pups during this critical developmental time is key to mitigating anthropogenic disturbance and designing effective conservation management.

Poster # 205

Philippine Chambault, Fabien Roquet,Simon Benhamou, Alberto Baudena, Etienne Pauthenet, Benoît de Thoisy, Marc Bonola, Virginie Dos Reis, Rodrigue Crasson, Mathieu Brucker, Yvon Le Maho, Damien Chevallier

The Gulf Stream frontal system: A key oceanographic feature in the habitat selection of the leatherback turtle?

Université de Strasbourg, CNRS, IPHC
philippine.chambault@gmail.com

Although some associations between the leatherback turtle Dermochelys coriacea and the Gulf Stream current have been previously suggested, no study has to date demonstrated strong affinities between leatherback movements and this particular frontal system using thorough oceanographic data in both the horizontal and vertical dimensions. The importance of the Gulf Stream frontal system in the selection of high residence time (HRT) areas by the North Atlantic leatherback turtle is assessed here for the first time using ocean reanalysis products. Ten adult females from the Eastern French Guianese rookery were satellite tracked during post-nesting migration to relate (1) their horizontal movements to physical gradients (Sea Surface Temperature (SST), Sea Surface Height (SSH) and filaments) and biological variables (micronekton and chlorophyll a), and (2) their diving behaviour to vertical structures within the water column (mixed layer and thermocline). All the turtles migrated northward towards the Gulf Stream north wall. Although their HRT areas were geographically remote (between 80-30 °W and 28-45 °N), all the turtles targeted similar habitats in terms of physical structures, i.e. strong gradients of SST, SSH and a deep mixed layer. Turtles remained within the enriched mixed layer at depths of 38.5±7.9 m when diving in HRT areas, likely to have an easier access to their prey and maximize therefore the energy gain. These depths were shallow in comparison to those attained within the thermocline (82.4±5.6 m) while crossing the nutrient-poor subtropical gyre, probably to reach cooler temperatures and save energy during the transit. In a context of climate change, anticipating the evolution of such frontal structure under the influence of global warming is crucial to ensure the conservation of this vulnerable species.

Poster # 78

Ching-Tsun Chang, Shian-Jhong Lin, Wei-Chuan Chiang, Michael K. Musyl, Sheng-Ping Wang, Nan-Jay Su, Ching-Ping Lu, Kazuki Tone, Sasaki Akira

Horizontal and vertical movements of dolphinfish, Coryphaena hippurus, in coastal waters of Taiwan and Kagoshima Bay, Japan

CTC, WCC: Eastern Marine Biology Research Center, Fisheries Research Institute, Taiwan • SJL, SPW, NJS, CPL: Department of Environmental Biology and Fishery Science, National Taiwan Ocean University, Taiwan • MKM: Pelagic Research Group LLC, USA • KT: Graduate School of Fisheries and Environmental Science, Nagasaki University, Japan - Masanori Nishino • SA: Kagoshima City Aquarium, Japan
r01241201@ntu.edu.tw

Dolphinfish (Coryphaena hippurus) is an epi-pelagic, widely distributed species found in tropical, subtropical and temperate waters warmer than ~20°C. Though this species is

primarily found near coastal areas, it is also widely distributed off-shore in the pelagic environment. Thus, their wide distribution patterns suggests dolphinfish may adapt to several different eco-regions with varying environmental conditions. To compare their movement patterns, habitat preferences and thermal niche between sub-tropical and temperate waters, we conducted a tagging study using pop-up satellite tags (PSATs) in the southeast coast of Taiwan (n=3) and Kagoshima Bay, Japan (n=3). Fish were tagged during different times of the years and tagged fish were tracked for periods of 7 to 40 days, reaching depths >100 m, and experiencing temperatures ranging from 15-29 °C in Taiwan, and 20-23 °C in Kagoshima Bay. Fish tagged in Taiwan made primarily northward movements during early summer but changed to a southward course in early winter. In Kagoshima Bay, tagged fish undertook southward excursions along the coast and all short-term movements were confined to the bay. Tagged fish exhibited pronounced diel oscillations in their vertical diving behavior. Dolphinfish spent >50% of their time near the surface and made more extensive vertical movements during nighttime than daytime, but vertical movements were largely confined to the mixed layer and did not cross the thermocline. Crepuscular diving periods and transitions were evident in the time series but dolphinfish dove deeper at nighttime than in the daytime. The depth distributions of the tagged fish appeared to be limited by a 6Â°C change relative to sea surface temperature (i.e., 100% of movements were within 6Â°C of the warmest water). Overall, dolphinfish primarily inhabit near-surface habitat and vertical movements are limited to the depth of the mixed layer.

Poster # 70

Yachang Cheng, Rebekka Blessenohl, Wolfgang Fiedler, Martin Wikelski, Andrea Flack

The link between migratory decisions and juvenile survival in White Storks

Department of Migration and Immuno-Ecology, Max-Planck-Institute for Ornithology, D-78315 Radolfzell, Germany and Department of Biology, University of Konstanz, D-78468 Konstanz, Germany
ycheng@orn.mpg.de

In the last few decades, changes in the migration behaviour of many bird species have become apparent (e.g. a shift in timing or a shortening of routes). Such changes may be linked to changes in the global climate, an increase in human activities or habitat degradation. The White Stork (Ciconia ciconia), a well-studied long-distance migrant, is known to mainly breed in Europe and overwinter in Africa, but recently the wintering populations in the South of Europe, like France, or the Iberian peninsula, are growing

rapidly. It is so far unknown which environmental and/or social factors contribute to the decisions of immature individuals to choose a wintering quarter (e.g. Europe or Africa), and what effect this decision has on population dynamics. Here, we estimate the survival probability of GPS tagged stork fledglings to test whether individual properties such as hatching order and different movement parameters affect survival. Further, we investigate the spatial-temporal distribution of the variable causes of death. Our results show that juveniles that migrate later and shorter have a higher survival chance, also wintering region is a curial factor influencing winter survival. Our study will contribute to a better understanding of the relationships between individual behaviour, population responses and the adaptations of migrants in a changing world.

Poster # 210

James Cheshire

Bio-logging with Context: Bespoke Base Maps for Tracking Data

University College London
james.cheshire@ucl.ac.uk

Data collected by bio-logging technologies are being processed with increasingly sophisticated software and algorithms to reveal unprecedented insights into animal behaviour. To date, there is an understandable focus in the bio-logging community on the data collected directly by tags, but this is only part of the story. This presentation seeks to demonstrate the ways in which contextual data of the kind generated from environmental models or national mapping agencies can be extremely valuable in the visualisation and analysis of bio-logging data. Most studies overlay GPS data on free base map layers from commercial providers, such as Google or Microsoft (Bing). Their ease of use and widespread integration with popular software makes them an important resource for data exploration and visualisation. However, they are generic in nature and offer little or no control over what information is shown, or when it was obtained. What"s more there are no guarantees it will continue to be available in the future since terms of use can be changed without notice. This presentation will offer three examples that demonstrate the significant additional insights that can be gained from sourcing alternative base map information. The first is the use of NASA's satellite imagery the study of seasonal behaviours, the second is the addition of modelled wind data for providing context to the migration of birds, finally a number of national and international land use classifications will be explored as alternatives

to straightforward satellite imagery. Whilst it is acknowledged that these data are not without their limitations, it is clear that the benefits of well-sourced base maps are not just cartographic, they augment analysis through providing estimates of other variables, such as temperature and wind speed, not collected directly by the tag on the animal.

Poster # 77

Yuan-Tian Chou, Wei-Chung Chiang, Yun-Hui Wu, Chia Shu Chih, Chin Gchou Chang, Ju Jui Hsien, Yuan-Shing Ho

Swimming temperature of migrating Japanese eels, Anguilla japonica, revealed by pop-up satellite archival tags

Eastern Marine Biology Research Center, Fisheries Research Institute, COA
hope3958@gmail.com

Japanese eels, Anguilla japonica, initiate their lengthy spawning migration from freshwater to open ocean during October to December, but overall spawning migrations and pathways remain largely enigmatic. Pop-up archival transmitting (PAT) tags provide a relatively inexpensive tool for scientists to explore swimming behavior and horizontal movement patterns during spawning migration. Two eels (76 and 90 cm total length) were tagged with mark report PAT (mrPAT) and survivorship PAT (sPAT) tags and released in November 2016 at a location near the Shin Gang river of eastern of Taiwan (23° 05"986N, 121° 23"768E). The tags were scheduled to detach after 30 days and 60 days, after which data downloaded from satellites would provide pop-up position, and water temperature. Location and temperature data from the tags was compared to equivalent spatial and temporal data acquired from conductivity-temperature-depth casts (CTD). The two tags detached and popped-up near 20 and 37 km from the deployment site. The longest tracking period (60 days) showed that the tagged eel experienced maximum temperatures during from 21.5°C to 26°C and minimum temperatures was from 16.5 to 24.5. Compared to the CTD data, the swimming depths of the tagged eels was estimated to be ~50 to 225 m.Overall, eels spent ~80% of their time in water less than 24.5°C. Moreover, the data also indicated eels' movement patterns were confined to an 8.5°C change in water temperature. One eel tracked for three days showed evidence of diel vertical excursions suggesting they might be selecting a preferred minimum temperature rather than depth.

Poster # 79

Jamie Cornelius, Taylor K. Chapple, Tom Hahn, Martin Wikelski

Antenna wobble, radiotelemetry and heart rate as methods to assess activity in free-living red crossbills

JC: Eastern Michigan University • TKC: Stanford University • TH: University of California- Davis • MW: Max Planck Institute of Ornithology
jcornel7@emich.edu

Positional tracking data give important information about habitat use and movement patterns throughout a home range and, in combination with temporal data, limited information regarding activity budgets. However, when animals are stationary it is not typically possible to assess if an animal is resting or foraging from these data if there is little directional movement. We discuss the use of antennae wobble - produced by antenna movement of continuous-tone transmitters - to estimate activity at a finer distinction than positional data allow for. We use data from free-living red crossbills fit with continuous-tone heart rate transmitters to explore relationships between antenna wobble, positional data and heart rate in the context of seasonal activity budgets.

Poster # 43

Ivo Costa, Ana Couto, Nicolas E. Humphries, David W. Sims, Nuno Queiroz

Thermocline influence on vertical behaviour of pelagic predators

CIBIO - Universidade de Porto, Centro de Investigação em Biodiversidade e Recursos Genéticos, Campus Agrário de Vairão, Rua Padre Armando Quintas, 4485-668 Vairão, Portugal
nuno.queiroz@gmail.com

Pelagic predators, such as sharks and tunas, move over large areas and display specific behaviours under distinct environmental characteristics. Oceanic features, such us thermal fronts and the thermocline, are characterised by convergence processes known to constrain the movement patterns of marine predators by aggregating prey. Thus, these regions likely represent areas of forage accumulation. Pelagic fish are also expected to move through the environment in a manner that maximises encounter rates with prey patches. Lévy flights are a special class of random walk that may represent an optimal solution to the biological

search problem in complex landscapes where preys are sparsely and randomly distributed. Nevertheless, the adaptive significance of this strategy in response to specific environmental features in the ocean is unclear. The main goal of this paper was to elucidate how changes in thermocline (intensity, location) impact the movements and foraging patterns of pelagic predators. Results showed that tracked fish displayed LÉvy-like vertical movements and that increases in the Levy exponent were associated with increases in thermocline strength. Furthermore, the turning points distance to the thermocline also decreased with increasing thermocline intensity. Results suggest the thermocline is an important foraging area of increased prey availability.

Poster # 31

Sam L Cox, F Orgeret, M Gesta, C Rodde, I Heizer, H Weimerskirch, C Guinet

Processing of acceleration and dive data on-board satellite relay tags to investigate diving and foraging behaviour in free-ranging marine predators

Centre d'Etudes Biologique de Chizé - CNRS
slcox417@gmail.com

Biologging technologies are changing the way the marine environment is observed and monitored. However, because device retrieval is generally required to access the high resolution data they collect, use is generally restricted to those animals that predictably return to land. Data abstraction and transmission techniques aim to address this, although currently are limited in scope and do not incorporate, for example, acceleration measurements which can quantify animal behaviours and movement patterns over fine-scales. Here, we present a new method for the collection, abstraction and transmission of accelerometer data from free-ranging marine predators via the Argos satellite system. We test run the technique on 20 juvenile southern elephant seals (Mirounga leonina) from the Kerguelen Islands during their first months at sea following weaning. Using retrieved archival data from nine individuals that returned to the colony, we compare and validate abstracted transmissions against outputs from established accelerometer processing procedures. Estimates, across five segments of a dive profile, of time spent in prey catch attempt (PrCA) behaviours, swimming effort and pitch were summarised and compared to archival outputs across three dive phases: descent, bottom and ascent. Correlations between the two datasets were variable but generally good (dependent on dive phase, marginal R^2 values of ~0.45/0.6 to > 0.9) and consistent between individuals. Transmitted estimates of PrCA behaviours and swimming effort were positively biased to those from

archival processing. The data from this study represents some of the first remotely transmitted quantifications from accelerometers. The methods presented and analysed can be used to provide novel insight toward the behaviours and movements of free-ranging marine predators, such as juvenile southern elephant seals, from whom logger retrieval is challenging. Future applications could however benefit from some adaption, particularly to reduce positive bias in transmitted PrCA behaviours and swimming effort, for which this study provides useful insight.

Poster # 32

Sam L Cox, F Orgeret, M Authier, H Weimerskirch, C Guinet

High mortality rates of juvenile free ranging marine predators during their first months at sea and links to dive and foraging performance

SLC, FO, HW, CG: Centre d'Etudes Biologique de Chizé - CNRS (France) • MA: Université de la Rochelle (France)
slcox417@gmail.com

Juvenile and immature individuals play a key role in population dynamics, yet survival rates are typically low compared to adults. For many marine species, this may be related to the dive and foraging abilities of individuals which, to be able to exploit the large heterogeneous environments typically inhabited, need to rapidly develop with little to no parental guidance. Here, we present results from a novel double tagging study aimed at investigating the fine-scale movements and survival rates of juvenile southern elephant seals (Mirounga leonina) during their first months at sea following weaning. We equipped 20 individuals (aged 4-8 weeks) from the Kerguelen Islands with (1) a smart position only transmitting tag, and (2) a state-of-the-art custom designed Argos relay satellite tag, capable of remotely transmitting behavioural summaries of dives from archival logs of depth and, for the first time, acceleration. Using differences in the dates of last transmissions from the two tags, the survival of each juvenile southern elephant seal was estimated. Following this, the departure weights, body conditions, and dive and foraging behavioural metrics (e.g. dive depths and durations, total time spent attempting prey capture and descent/ascent swimming efforts) of each individual that died were examined and compared to those of surviving individuals. We found that, within 120 days of their departure from the field site, 9 individuals had died. The remaining 11 individuals were thought alive on the date of their last double tag transmission (~160-330 days after device deployment). Whilst departure weight had little impact on survival, the dive and foraging performances of around half the individuals that died appeared decreased compared to those of individuals that survived.

128

These results and their implications will be discussed in tandem with those from analyses of other potential drivers of mortality, such as interactions with extreme storm events and predation.

Poster # 118

Corrie Curtice, Daniel C. Dunn, Autumn-Lynn Harrison, Eleanor Heywood, Connie Y. Kot, Guillermo Ortuão Crespo, Patrick N. Halpin

Advancing Area-Based Planning and Network Approaches in Areas Beyond National Jurisdiction: A Global Review of Data on Connectivity for Migratory Marine Animals

CC, DCD, CYK, JOC, PNH: Marine Geospatial Ecology Lab, Duke University • ALH: Smithsonian Conservation Biology Institute, National Zoological Park • EH: Marine Geospatial Ecology Lab, Duke University
corrie.curtice@duke.edu

Due to their large geographic ranges, migratory marine mammals, seabirds, sea turtles and fish experience a variety of anthropogenic pressures over their life histories. Combined with conservation and management strategies that largely fail to consider spatial connectivity over their full life cycles, these threats have contributed to population declines worldwide. Information on connectivity is vital for marine spatial planning initiatives focused on areas beyond national jurisdiction (ABNJ) which encompass 40% of the Earth's surface and have very fragmented governance. Advances in electronic tracking technology over the past 25 years have resulted in the rapid accumulation of information on migratory connectivity in the ocean. However, this information is not widely available nor has it been effectively synthesized as actionable knowledge for planning purposes. The Marine Geospatial Ecology Lab (MGEL) of Duke University is leading a consortium to develop the Migratory Connectivity in the Ocean (MiCO) system to fill this gap. MiCO seeks to compile and synthesize data about connected areas and migratory corridors for species utilizing ABNJ. MiCO will convey knowledge on connectivity among nodes (aggregations of areas used for a particular life cycle activity such as feeding or breeding) and about corridors (aggregations of routes animals travel between nodes). Data from many sources including telemetry, mark and recapture, stable isotope, genetic, and acoustic sampling are being gathered from a systematic literature review and direct contributions by collaborating partners as input to MiCO. The literature review encompasses over 200 species, and the complete system will address nearly 1000 migratory species across the four taxa. Here we present initial results detailing the information available on migratory connectivity in ABNJ, the degree to which

that information has been processed (e.g. kernel utilization distributions and state-space models) and is useful for marine spatial planning initiatives, and regional and thematic gaps in knowledge.

Poster # 126

Pietro D'Amelio, Lisa Gill, Nicolas Adreani, Andries ter Maat, Manfred Gahr

Wireless microphones for small birds overcome bioacoustic challenges

Max Planck Institute for Ornithology
pdamelio@orn.mpg.de

Vocalisations are a fascinating means of communication in animals. But given that most of them occur in social situations, it is not always easy to study vocal communication at the individual level. Remote sensing technology allows us to record the vocal behaviour of individual animals that behave in natural, meaningful settings. Such devices have been available for decades for large animals. Due to technological development and miniaturization, this field has recently opened up to the study of small animals, and is rapidly growing. Here we present microphone backpacks with which it is possible to record the individual vocal behaviour of very light animals, including small songbirds. Our devices are radio-transmitters, meaning they send acoustic data continuously to a receiving base station, in real time. Due to this technical property, the devices are extremely light weight, and allow long-term continuous recordings (up to 2 weeks) of multiple channels in parallel. In an experiment on caged zebra finches, we evaluated the effect that the devices had on naïve individuals, under standardized conditions. We found that 1) birds were able to fly off immediately after the brief tagging procedure, 2) the birds' vocal and locomotor activity showed a habituation period of up to three days, 3) replacing the battery took less than a minute, and affected the studied behaviours for one day. This is important to consider in study design, and highlights the importance of long-lasting recording periods to avoid methodological biases. With our poster, we aim to present and discuss potential areas of application, opened up by the device"s technical properties. For example, the backpacks could deepen our understanding of individual vocal interactions in group settings, or allow long-term studies to follow changes in vocal behaviour during development or in changing environments, even in the field.

Poster # 156

Jan Grimsrud Davidsen, Jo Vegar Arnekleiv, Gaute Kjærstad, Sindre Eldøy, Lars Rønning, Aslak Darre Sjursen

Do European freshwater crayfish alter behavior during rotenone treatment in a small lake

NTNU University Museum
jan.davidsen@ntnu.no

Rotenone treatment is commonly used to eradicate undesirable species in freshwater habitats. Roach (Rutilus rutilus) is a black listed species in parts of Norway, and lakes invaded by the species in these regions are treated with rotenone to eliminate the fish. During such a treatment, 15 European freshwater crayfish were tagged with acoustic tags equipped with a 3-axis accelerometer registering gravity forces and acceleration in the x-, y and z directions with high sensitivity. From these generic measurements, the tag registered the tilt- and roll angle of the fish, as well as motion in the forward- and lateral directions. Registrations from the accelerometer were together with the Unique ID code of the tag transmitted to eight acoustic receivers deployed in the lake. In addition to information about acceleration, data from detected tags were used to triangulate exact positions of the cray fish before, under and after the treatment with rotenone.

Poster # 129

Jacob D. Davidson, Deborah M. Gordon

Spatial organization and interactions of harvester ants during foraging activity

Max Planck Institute for Ornithology • Stanford University
jdavidson@orn.mpg.de

Local interactions, when individuals meet, can regulate collective behavior. In a system without any central control, the rate of interaction may depend simply on how the individuals move around. But interactions could in turn influence movement, individuals might seek out interactions, or their movement in response to interaction could influence further interaction rates. We develop a general framework to address these questions, using

collision theory to establish a baseline expected rate of interaction based on proximity. We test the models using data from harvester ant colonies. A colony uses feedback from interactions inside the nest to regulate foraging activity. Potential foragers leave the nest in response to interactions with returning foragers with food. The time series of interactions and local density of ants show how density hotspots lead to interactions that are clustered in time. A correlated random walk null model describes the mixing of potential and returning foragers. A model from collision theory relates walking speed and spatial proximity with the probability of interaction. The results demonstrate that although ants do not mix homogeneously, trends in interaction patterns can be explained simply by the walking speed and local density of surrounding ants.

Poster # 196

Randall Davis

Seasonal comparison of Weddell seal dives under high and low light conditions based on three-dimensional movements and video-recorded behavior

Texas A&M University, 200 Seawolf Parkway, OCSB, Galveston, Texas 77553, USA
davisr@tamug.edu

The primary challenge to understanding differences in the seasonal diving behavior of marine mammals is observing and tracking them at depth. In this study, we compared free-ranging dives of Weddell seals (Leptonychotes weddellii) under low light conditions during late winter (winter dives, WD) and under high, continuous light conditions during the spring (spring dives, SD). Comparisons were based on 21 descriptors for three-dimensional dive paths computed from data obtained from animal-borne video and data recorders attached to 10 Weddell seals in spring and 6 in late winter in McMurdo Sound, Antarctica. We inferred functions for dive classes based on video-recorded observations of prey capture and other behaviors. Three dive types previously identified for seals during the spring were also observed during late winter. Most prey captures (SD 82%, WD 100%) occurred during Type 1 dives, and the primary prey (SD 98%, WD 88%) was Antarctic silverfish (Pleuragramma antarcticum). Type 1 dives were the deepest (mean maximum depth 316 m), longest in duration (19.7 min), covered the greatest total distance (1,629 m), and had the steepest dive angles (-25 to 24 deg). Type 2 dives were short duration (4.5 min), shallow (mean maximum depth 29 m) and often involved aggressive interactions with other seals for breathing opportunities around ice holes. Type 3 dives were intermediate in duration (10.2

min), shallow (mean maximum depth 70 m) and associated with transiting between holes, exploring and occasionally foraging. There were only minor differences in the characteristics of spring and winter dive types suggesting little seasonal change in behavior including foraging strategies and prey preference. However, SD were 3.2-fold more successful than WD indicating that light level may influence foraging success. This type of detailed dive analysis is only possible with recorders that enable three-dimensional tracking and video recording, something not possible with time-depth recorders.

Poster # 96

Hélène de Pontual, Ewan Hunter, Ronan Le Goff, Victoria Bendall, Loïc Le Ru, Serena Wright, Karine Heerah

Seasonal migrations, site fidelity and population structure of European sea bass: novel insights from large scale electronic tagging

HDP, RLG, LLR, KH: Ifremer, Sciences et Technologies Halieutiques, CS 10070, 29280 Plouzané, France • EH, VB, SW: Cefas, Lowestoft Laboratory, Pakefield Road, Lowestoft NR33 0HT, UK
helene.de.pontual@ifremer.fr

European sea bass, Dicentrarchus labrax, an iconic species in the North East Atlantic targeted both by professional and recreational fishers, has recently shown strong declines due to poor recruitment and overfishing. To better understand bass behavioural ecology and population structure, large-scale DST tagging programs were recently executed in the central part (Southern North Sea, English Channel and Bay of Biscay) of the species home range. Of 1561 deployed DSTs, 399 have been recovered to date, approximately half of which have yielded time-series long enough to cover the spawning migration. Analysis of individual tracks, reconstructed using Hidden Markov Model geolocation models, confirms bass to be a partial migratory species, as individuals exhibited either long distance migrations or localised residency in the vicinities of their tagging locations. Migrants exhibited a strong fidelity to summer feeding areas while fidelity to winter spawning areas was also demonstrated by the majority of recovered tags that covered two successive annual cycles. Our extensive dataset further enriches our knowledge of the biological traits of sea bass, notably the temperature and depth ranges occupied, and vulnerability to predation and fishing. Our results suggest that the sea bass population is spatially structured, the underlying mechanisms for which will require further investigation. In the meantime, however, our data provide an evidence base through which fisheries managers can explore the consequences and implications of considering population substructure

either by EU managers, or by local managers looking to achieve regional conservation outcomes (e.g. marine protected area).

Poster # 34

Karine Delord, Yves Cherel, Christophe Barbraud, Olivier Chastel, Henri Weimerskirch

High variability in migration and wintering strategies of brown skuas (Catharacta antarctica lonnbergi) in the Indian Ocean

Centre d'Études Biologiques de Chizé, UMR 7372 du CNRS-Université de La Rochelle, 79360 Villiers-en-Bois, France

Movements of brown skuas (Catharacta antarctica lonnbergi) originating from two populations in the southern Indian Ocean were studied during the nonbreeding period using geolocation. A total of 33 individuals were equipped resulting in 34 annual tracks recovered from 50 deployments. Brown skuas varied extensively in their post-breeding movements, from true long range migrations to reach distant wintering zones, to short movements in the vicinity of breeding grounds. Overall, brown skuas migrated northward to overwinter in different areas in the southern hemisphere; individuals remained in the Indian Ocean, except two that overwintered in the Benguela Current (Atlantic Ocean). Wintering grounds were generally situated in productive dynamic upwelling waters or frontal systems. Brown skuas avoided the less productive area of the South Subtropical Gyre in the Central Indian Ocean. Individuals clearly differed in migratory strategies, targeting areas in a continuum from the sub-Antarctic to the tropics. Inter-individual differences were not sex-dependent. The migration dates varied between sexes with females leaving the breeding sites earlier and returning later compared to males. The duration of migration depended on wintering area and sex. Males had shorter migrations than females, regardless of the wintering area. Isotopic signatures clearly indicated that birds moulted in the wintering area and during migration. The low $\delta15N$ values of feathers that grew in mixed subtropical-sub-Antarctic waters suggest that skuas fed on low trophic level prey in these areas. The origin and consequences of such strong inter-individual variation in migratory strategies requires further investigation.

Poster # 21

Stacy DeRuiter, Mark Johnson, René Swift, Catriona Harris, Tiago Marques, Ye Joo Oh, David Sweeney

Software Tools for Analysis of Data from High-Resolution Animal-Borne Tags

SDR, YJO, DS: Calvin College • MJ, RS, CH, TM: University of St Andrews

sld33@calvin.edu

Bio-logging studies with high-resolution movement sensors offer opportunities to observe animal behavior in unprecedented detail, but analysis of the resulting data is often complex, and there is a need for freely available, easy-to-use, flexible, well-documented software tools to facilitate analysis and interpretation. We introduce a new open-source tool kit for processing data from tags with high-resolution movement sensors (such as pressure, accelerometer, magnetometer, gyroscope). The tool kit has Matlab, Octave, and R versions, and includes tools to read/write, calibrate, process, visualize, and carry out statistical analysis of data from multiple tag types. Read/write and calibration tools read in data files from multiple tag types, associate the raw tag data with appropriate metadata, and perform calibration and validation (for example, converting to an animal-centric frame of reference, and converting from raw measurements to standard scientific units of measure). Users can save calibrated data with metadata in a well-defined standard file format (netCDF). Data processing functions include computing derived metrics like jerk, overall dynamic body acceleration, and minimum specific acceleration, detecting events, or computing summary statistics for events such as dives or prey captures. Visualization functions facilitate plotting multiple exemplars of detected events, creating multi-panel plots of multivariate time-series, and exploring and annotating tag data interactively. Finally, statistical analysis functions include Mahalanobis-distance-based dimension reduction and change-point detection, three-dimensional track reconstruction, and a rotation test for changes in event rates. All tools, along with complete documentation, will be freely available online, we are developing a website, http://www.animaltags.org, to provide information about the tools, documentation, and links to download tools and sample data. The goal of the tool kit is to enable high-quality, reproducible, sophisticated analyses of tag data, while also facilitating comparison of results between studies, tag-types and computational software.

Poster # 56

Nicole Dykstra, Lisa O'Bryan, Gareth Russell, Malgorzata Wisniewska, Guy Cowlishaw
,Andrew King, Simon Garnier

Follow me: leadership in a domestic ungulate herd

ND, LOB, GR, MW, SG: Department of Biological Sciences, Rutgers University - Newark / New Jersey Institute of Technology, Newark, NJ, USA • GC: Institute of Zoology, Zoological Society of London, London, United Kingdom • AK: Department of Biosciences, College of Science, Swansea University, Wales, United Kingdom
nfd14@scarletmail.rutgers.edu

Group-living is a common strategy across taxa, as individuals living in groups are able to take advantage of social benefits such as a diluted risk of predation and improved resource exploitation. However, in order to receive long-term social benefits, individuals must coordinate their activities. The aim of this study is to determine how leadership decisions influence the foraging efficiency and cohesiveness of a herd of domestic sheep (Ovis aries). The central hypothesis is that agreement among leaders will increase foraging efficiency while disagreement will result in lower efficiency and a less cohesive group. Novel, wearable data-loggers including a GPS and triple-axis accelerometer + magnetometer were used to obtain detailed data on the behavior and social interactions of individuals in a flock of 12 sheep. In addition, high-resolution (~ 3 cm) images of the research site were captured during the study, which will allow us to measure time spent foraging under periods of leader agreement/disagreement. Results from this study will demonstrate how disagreement among leaders influences the behavior of the group, thereby improving models of collective animal behavior and providing insight into the evolution of sociality in group-living species.

Poster # 203

Milene A. A. Eigenheer, Rogerio Cunha de Paula, Milton Cezar Ribeiro, Mauro Galetti, Luca Bürger

Coordinated movements of maned wolves (Chrysocyon brachyurus) in fragmented landscapes

MAAE, MCR, MG: UNESP - Univ. Estadual Paulista, Brazil • RCdP: Instituto Chico Mendes de Conservação da Biodiversidade, Brazil • LB: Swansea University , United Kingdom
mileneaae@gmail.com

Understanding how social species interact and how this impacts their spatial behavior is fundamental for their conservation and management. The maned wolf (Chrysocyon brachyurus) is a species at risk of extinction whose social system is based on solitary individuals forming monogamous pairs during the breeding season. Little is known about their spatial behavior and responses to environmental change, thus here we quantified the movements of maned wolves in fragmented landscapes. Using GPS location data from 13 individuals and satellite-based landscape maps we quantified social interactions (encounters, coordinated movements) of maned wolf dyads, comparing movement statistics of couples, dyads of spatially contiguous neighbors, and of non-neighboring individuals. Pairwise distances of couples, analyzed using GAM models, showed a consistent pattern of close contact during the mating and pupping seasons and larger pairwise distances otherwise. A dynamic interaction index (Di-index) analysis indicated positive values for couples and dyads of neighboring individuals, thus a lack of strong avoidance, and conversely strong avoidance among non-contiguous individuals. Thus, contrary to the general view of maned wolves as strictly solitary animals, we showed that they may have a strong overlap in their home range, avoiding spatial usage at the same time („dynamic interactions"). We discuss implications of our findings for a better comprehension of maned wolf ecology. Similarly we discuss the potential of biologging sensors to further refine our understanding of maned wolf space use and social behaviour.

Poster # 241

Siri Lander Elmegaard, Birgitte Irene McDonald, Mark Johnson, Peter Teglberg Madsen

Cardiac responses of captive harbour porpoises to anthropogenic noise

SLE, PTM: Zoophysiology, Department of Bioscience, Aarhus University, 8000 Aarhus C, Denmark • BIMD: Moss Landing Marine Laboratories, California State University, Moss Landing, CA 95039, USA • MJ: Scottish Oceans Institute, University of St. Andrews, St. Andrews KY16 8LB, Scotland, UK

siri@bios.au.dk

Increasing levels of anthropogenic noise in marine ecosystems may have negative effects on marine mammals, including behavioural or physiological responses impairing individual and population fitness. Mass strandings of beaked whales and porpoises have coincided with naval sonar exercises, and beaked whales display clear avoidance and alteration of diving behaviour caused by mid-frequency naval sonar. Unfavourable cardiovascular responses to such noise sources could impair gas management and recovery time at the surface of breath-hold divers, however, little is known about cetacean heart rate responses to acoustic disturbances. Many terrestrial animals increase heart rate and muscle blood flow when startled, but pinnipeds decrease heart rate to levels resembling their dive response. This decrease enables longer dives by conserving blood oxygen, which is critical if a sudden danger is perceived at depth. In this study we assessed the cetacean heart rate response to sonar and a sound designed to create a startle response in two captive harbour porpoises during noise exposure experiments. We measured heart activity (electrocardiogram) and fine scale behaviour (depth, acceleration, sound) using a small digital datalogger (ecg-dtag3) attached with suction cups. The non-invasive, quick attachment and small size of the tag allows the animals to move freely and conduct their normal or experimentally induced behaviour immediately after deployment. We found that the first sonar exposure (received level 155 dB re 1µPa (rms)) to the naïve animals caused a pronounced drop in heart rate (24 beats min-1 and 38 beats min-1). Neither subsequent sonar exposures nor startling sounds caused acute heart rate changes. Although our sample size is small, these results suggest that porpoises can respond physiologically to noise exposures, but that they may habituate quickly. The initial sonar-induced heart rate reduction suggests that these small odontocetes have adapted their startle response, like pinnipeds, to improve stress handling time when submerged.

Poster # 162

Leonie Enners, Philipp Schwemmer, Christian C. Voigt

Individual movement patterns and foraging ecology of Herring gulls (Larus argentatus) breeding in the German Wadden Sea

LE, PS, SG: Research and Technology Centre (FTZ), University of Kiel • CCV: Leibniz Institute for Zoo and Wildlife Research (IZW), Berlin
enners@ftz-west.uni-kiel.de

As flexible and opportunistic top-predators Herring gulls (Larus argentatus) can be used as an indicator for changes in the food web. They often exploit the food sources closest to their breeding colonies, in order to save energy. Previous studies demonstrated that Herring gulls forage mainly in the intertidal zone, where they feed on bivalves and crustaceans. Individuals from some colonies spend a large amount of time foraging also in terrestrial habitats. The aim of this study was to test how individuals adapt to the food sources in the vicinity of their breeding colonies and whether individual habitat use and prey utilisation depends on the colony's distance to the mainland, tide, time of day or sex. We caught Herring gulls in three different colonies in the German Wadden Sea to equip them with GPS-data loggers and to take blood samples. The colonies "Oland", "Langeness" and "Amrum" are situated in the World Heritage Site of the Wadden Sea and are surrounded by tidal flats. GPS-data loggers recorded date, time, geographical position and speed of the birds. These data were used to assess individual patterns of spatial movement. We analysed the utilisation of the habitat types "land" and "intertidal zone", to assess differences in foraging ecology and food choice between the three colonies. In addition, the diet of breeding Herring gulls was studied by pellets and stable isotope analyses of blood samples.

Poster # 207

Manfred R. Enstipp, Yves Handrich, Charly-A. Bost, Henri Weimerskirch

Foraging behaviour and thermoregulation of juvenile king penguins during their first years at sea

MRE, YH: UniversitÉ de Strasbourg, CNRS, IPHC UMR 7178, F-67000 Strasbourg, France • MRE, YH, CAB, HW: Centre d'Études Biologiques de Chizé, CNRS, UMR 7372, 79360Villiers en Bois, France.
manfred.enstipp@iphc.cnrs.fr

Little is known about the early life at sea of marine top predators, like deep diving king penguins (Aptenodytes patagonicus), although this dispersal phase is likely a critical phase in their life. Apart from finding favourable foraging sites, they have to develop effective prey search patterns as well as physiological capacities that enable them to capture sufficient prey to meet their energetic needs. To investigate the ontogeny of their foraging behaviour and thermoregulatory responses at sea, we implanted 30 juvenile king penguins and 8 adult breeders with a small data logger that recorded pressure and subcutaneous temperature continuously for up to 2.5 years. We found that dive capacity of juveniles was sufficiently developed at first departure to enable birds to conduct dives in excess of 100 m within 4 days. Dive capacity increased over time, facilitating extensive daily foraging bouts, during which birds dived to great depth and for extended periods. We also found important changes in the development of peripheral temperature patterns throughout their first year at sea. Peripheral temperature during foraging bouts fell to increasingly lower levels during the first 6 months at sea, after which it stabilized. Most importantly, these changes re-occurred during their second year at sea, after birds had fasted for ~4 weeks on land during their 2nd molt. Furthermore, similar peripheral temperature patterns were also present in adult birds during foraging trips throughout their breeding cycle. We suggest that rather than being a simple consequence of concurrent changes in dive effort or an indication of a physiological maturation process, these seasonal temperature changes mainly reflect differences in thermal insulation. Heat loss estimates for juveniles at sea were initially high but declined to ~half, after ~6 months at sea, suggesting that juvenile king penguins face a strong energetic challenge during their early oceanic existence.

Poster # 208

Manfred R. Enstipp, Brian L. Bostrom, David R. Jones

Heat loss and the energetic costs of shallow and deep diving in double-crested cormorants (Phalacrocorax auritus)

MRE: Université de Strasbourg, CNRS, IPHC UMR 7178, F-67000 Strasbourg, France. • MRE: Centre d'Études Biologiques de Chizé, CNRS, UMR 7372, 79360Villiers en Bois, France. • BLB, DRJ: Department of Zoology, University of British Columbia, Vancouver, British Columbia, Canada

manfred.enstipp@iphc.cnrs.fr

Avian divers are confronted with a number of physiological challenges when foraging in cold water, especially at depth. Cold water temperatures and a reduction in body insulation provided by their plumage air, due to the increase in pressure with dive depth, will elevate the energetic costs of foraging in these endotherm divers. This could be especially severe in cormorants (Phalacrocorax spec.), where a partially wettable plumage might greatly increase heat loss at depth. Dive costs of double-crested cormorants (P. auritus) diving vertically to 10m were shown to be substantially greater (~22%) than when birds swam within a horizontal tank at 1m depth. This difference was attributed to the supposedly increased heat loss at greater depth, elevating thermoregulatory costs. However, heat flux has not been measured directly in freely diving birds. From temperature recordings during diving, heat conservation mechanisms, such as peripheral vasoconstriction, have been indicated for a number of deep diving seabirds. We used heat flux sensors attached to various sites on the plumage of five double-crested cormorants to measure heat loss during vertical dives to 3 and 10m depth. Our results show that heat loss varied greatly with location, in accordance with plumage thickness, but was considerably less than previous estimates based on a physical model. Heat loss during a dive was greatest before birds reached their final depth. Peak heat loss at all sites was significantly greater during deeper dives but mean heat loss did not differ with dive depth. We suggest that the greater dive costs measured during deep vertical dives, when compared with shallow horizontal dives, is not related to thermoregulatory costs but to the steeper dive angle and, hence, the greater locomotor effort during vertical dives.

Poster # 133

Ethan Estess, Steve Teo, Barbara Block

Using Light Data from Animal-Borne Sensors to Track Deep Scattering Layers

Monterey Bay Aquarium
eestess@mbayaq.org

Recent developments in biologging technologies have enabled the marine science community to utilize in situ oceanographic data measured by animal-borne sensors to advance our knowledge of animal behavior in relationship to environmental parameters. Many models of electronic tags deployed on diving animals rely on highly sensitive measurements of ambient light in order to estimate an animal's location, however, these light recordings may have unforeseen applications beyond their intended function. A previous study demonstrated the use of light attenuation curves from animal-borne sensors to estimate chlorophyll profiles in the euphotic zone, and suggested that the same methodology could also be applied in the deep sea to estimate the depth of mesopelagic deep scattering layers (DSLs). Many pelagic predators utilize DSLs as a food resource, performing diel vertical migrations to target the communities of organisms that create these layers. Here, we detail how light level data from various models of Wildlife Computers geolocating tags can be used to estimate the depth of the deep scattering layer (DSL) and compare these light-based DSL depth estimates with estimates from a ship-borne acoustic Doppler current profiler (ADCP). We deployed various models of electronic tags on an oceanographic carousel and compared the light-based DSL depth estimates with simultaneous measurements of echo intensity. In addition, the ADCP-based DSL depth estimates were compared to estimates from an electronic tag deployed on a white shark, Carcharadon carcharias, in the same area and period. The diving behavior of the white shark was shown to target the tag-estimated depth of the DSL. Our results suggest that under certain conditions, light data from electronic tags can be used to effectively detect the DSL depth when deployed on free-swimming animals, thus providing a new means for examining animal behavior in relationship to this understudied biophysical parameter.

Poster # 84

Andreas Fahlman, Rory Wilson, Mark Holton, Emma Archibald, James Redcliffe, Geraldine Lacave, Amadine Dupret, Julie van der Hoop, Peter Madsen, Mark Johnson, Frants H. Jensen, Alex K.Shorter, Daniel Garcia-Párraga, Stefan Miedler, Randall Wells, Craig Har

Physiology and movement to assess breathing frequency and tidal volume in marine mammals

AF, DGP, SM: Fundacion Oceanografic, Valencia Spain • AF: Woods Hole Oceanographic Institution, Woods Hole, MA, USA • RW: MH, EA JR: Swansea Lab for Animal Movement, Biosciences, College of Science Swansea, Wales, UK • GL: Marine Mammal Veterinary Services, 8310 Brugge, Belgium • AD: Nausicaa, Centre National de la mer, 62203 Boulogne sur mer, France • JVDH, PM: Zoophysiology Department, Aarhus University, 8000 Aarhus C, Denmark • MJ: Scottish Oceans Institute, St Andrews • FHJ: Aarhus Institute of Advanced Studies, Aarhus University, 8000 Aarhus C, Denmark • AKS: Dept of Mechanical Engineering, University of Michigan, Ann Arbor, 48109, Michigan USA • RW: Chicago Zoological Society's Sarasota Dolphin Research Program, c/o Mote Marine Laboratory, 1600 Ken Thompson Parkway, Sarasota, FL 34236 USA • CH: College of Veterinary Medicine and Center for Marine Sciences and Technology, NC State University, Morehead City, NC, USA • PT: School of Biology, University of St. Andrews, St. Andrews, UK, KY16 8LB
afahlman@oceanografic.org

Breathing frequency and tidal volume are potential indicators of respiratory health and metabolic rate, but are difficult to determine in free-ranging marine mammals. Respiratory body acceleration or respiratory sinus arrhythmia (RSA) are two potential proxies that can be used to detect breaths using archival biologging tags. To assess this, we measured heart rate, body movement, and breath-by-breath respiratory flow in trained California sea lions (Zalophus californianus) and bottlenose dolphins (Tursiops truncatus) under managed care. Heart rate was measured using transthoracic echocardiography (ECG), movement assessed using a daily diary tag and a dtag, and respiratory flow measured using a custom made flow meter. Data collected from the dolphins and sea lions indicate that inhalation is coupled with a RSA, making it possible to detect breaths by measuring the ECG. Further analysis is being conducted to determine if the variation of magnitude of the RSA can be used to estimate tidal volume. In the resting bottlenose dolphin, the Vectorial Dynamic Body Acceleration (VeDBA) allowed detection of breaths and correlated with respiratory effort (respiratory flow). These preliminary results indicate that cardiac physiology and movement can be used to assess respiratory physiology.

Poster # 183

Mike Fedak, Helen Mallett, Lars Boehme

Preferred diving locations of elephant and Weddell seals in relation to sea ice cover in the Amundsen Sea.

SMRU Instrumentation Group, University of St Andrews
maf3@st-andrews.ac.uk

Unlike Weddell seals, southern elephant seals are not usually considered true "ice seals", even though they may forage in ice covered waters. The Edwards Islands, near the Pine Island Glacier (PIG) at 74S) provide the most southerly moulting site for southern elephant seals (SES). The iStar-ocean2ice project equipped 7 SES (4 males & 3 females) on snow free beaches on the Islands and 7 Weddell seals (WS) (2 maels & 5 females) caught on nearby sea ice, with SMRU CTD-SRDLs. We monitored their movements and diving behaviour from February through October in relation to bathymetry and ice cover. We used AMSR2 3km2 data* to create a gridded data set of cells of ice cover for each day we had seal diving data. Both species remained over the shelf throughout the Austral Winter, sometimes within the PIG or Thwaites polynyas but also under dense pack ice. They frequently dived to near the bottom, often in the trenches that funnel warm CDW water to the glacier. All seals used grid cells of every class of ice cover. We produced an index of preference for diving within each sea ice class of the two species by calculating the ratio of the number of grid cells chosen by each seal in each class of ice cover on each day in relation to daily overall class availability chosen at random for that day. Both species used areas of high ice cover. The most prominent difference between the species was that the Weddell seals avoided areas with less than 10% ice. The data show a clear overlap in distribution suggesting that SES play an important role deep within ice covered areas even though they are rarely observed there. * G. Spreen, L. Kaleschke and G. Heygster 2008: Sea ice remote sensing using AMSR-E 89 GHz channels. J. Geophys. Res 113, C02S03, doi:10.1029/2005JC003384. http://www.iup.uni-bremen.de:8084/amsr2data/asi_daygrid_swath/s3125/2015/apr/Amundsen/

Poster # 188

Gaelle Fehlmann, Justin O'Riain, Emily Shepard, Adrian Luckman, Andrew King

Understanding baboon behavioural ecology in a human-altered landscape

Swansea University
fehlmanng@gmail.com

As the human population expands, we come into increasing contact with wild animal populations that can result in human-wildlife conflicts. One of the most high-profile human-wildlife conflicts in Africa is the Human-Baboon (Papio ursinus) Conflict (HBC) in the Cape Peninsula, South Africa. To mitigate this conflict, Cape Town municipality employs field rangers with paintball markers that "herd" baboons away from the urban edge. This talk will describe our research programme aimed at developing a complete understanding of HBC dynamics in the Cape Peninsula and development of proactive mitigation methods. To achieve this, we used bespoke animal-attached sensors enabling us to map a range of fine-scale baboon behaviours and relate these to environmental data such as habitat type, management risk and food availability. Overall, we found that exploitation of the human-modified environment is costly, resulting in the baboons spending <2% of their time in urban spaces and conducting short, high-activity raids. We also show that adult males had the highest raiding propensity and left the main troop to venture in urban areas often alone or as a pair, indicating that raiding is largely a non-social foraging strategy. Additionally, we show that the troop, and especially raiders utilise space that is close to the urban edge where inter-individual variation in field ranger management strategy is highest. We communicated these results to the management company, along with specific recommendations, resulting in a clear diminution of raiding frequency and a shift in baboons' space use toward more natural areas. This work provides an interesting framework describing the adaptation of individuals and social units to human altered landscapes, which can be extended to other raiding species. As such, we envisage our approach to become a benchmark for the successful management and conservation of species in conflict with humans.

Poster # 9

Marco Flagg, Klemens Pütz

A solar powered Argos tag for penguin extends tracking endurance for juveniles and small species

MF, KP: Antarctic Research Trust • MF: Desert Star Systems LLC
marco.flagg@desertstar.com

Satellite reporting tags for penguin have traditionally been battery powered, thus creating a trade-off between tag size and transmission endurance. Solar powered tags by contrast provide an opportunity to combine very long endurance with small size, and have long been used for flying birds. However, solar tags for penguin face special demands, including limited light levels in the (sub) Antarctic regions during winter, and the requirement to survive substantial diving exposure. Our work focuses on the development of a practical solar powered tag in a staged effort. In March 2015, a first 26g version of the tag was deployed on five king penguin at Parque Pingüino Rey (TDF), one of which was tracked through a year-long migration of the Pacific and Atlantic. Improvements were made and a further 11 rock hopper penguins and five king penguins were tagged in 2016 with second and third generation tags at sites around the Falkland Islands, TDF and Staten Island. In this presentation, we will review the tracking performance of the tags throughout the seasons, and observed endurance and survival of the tags. We will discuss a method and the accuracy of obtaining position estimates through Argos reported GLS observations in the darkest periods of the year when Argos fixes may no longer be available. These observations are transmitted by the tag in occasional 'heart beat' messages that can be sustained with minimal light exposure. We find that solar powered satellite reporting tags for penguin do offer an ability to track juveniles and smaller species for long durations and that tracking gaps in winter can be limited through methods such as Argos reported GLS positions. Our presentation concludes with a discussion of anticipated next steps to further exploit opportunities provided by solar power in penguin tag design.

Poster # 72

Marco Flagg

Capabilities, Opportunities and Limitations of a Pop-Up Satellite Tag (PSAT) for Tracking Animals in the Bathypelagic and Abyssopelagic Zones

Desert Star Systems LLC
marco.flagg@desertstar.com

While PSAT tags are providing detailed migratory tracks, vertical habitat utilization profiles and other data returns for marine species, their depth limitations of typically 2000m or 2500m have excluded research at greater depths. In recent years, diving behavior beyond this limit have been documented in species including Cuvier's beaked whale, sperm whale and whale sharks. In support of tagging research in the bathypelagic and abyssopelagic zones, we have developed and tested SeaTag-6K, a PSAT capable of operation at depths up to 6000m and incorporating depth, temperature, magnetic, acceleration and light sensors. This presentation reviews the tag's capabilities and redundancy mechanisms for deep exposure survival and reporting, as well as limitations. Results of the estimation of a drifter and a one- year tiger shark track produced with geomagnetic measurements introduce a method for reconstructing animal migration patterns beyond the reach of light or SST observations. Drawing on lessons learned from the project, we conclude by proposing strategies for successful tagging and reporting at extreme depths and provide an initial baseline performance reference for pioneering researchers seeking to study animal behavior at the extreme depths of the oceans.

Poster # 116

Jorge Fontes

New non-invasive methods for short-term electronic tagging of pelagic sharks and rays

MARE/IMAR/University of the Azores
jorge.mr.fontes@uac.pt

Biologging technology has provided scientists with unprecedented tools to investigate the ecology and behavior of marine animals, but tag deployment and attachment methods have

lagged behind. Electronic tagging of elasmobranchs still essentially involves implanting anchors or drilling the fins of restrained animals. Here we present two new non-invasive methods for deploying satellite and biologging tags on pelagic sharks and rays that don't require restraining or manipulation of the animals, neither the attachment of intramuscular anchors. The attachment of a modified fin clamp and a harness systems were tested on 12 blue sharks and four devil rays in the Azores, mid-north Atlantic. Clamps and harnesses were fitted with galvanic timed releases and deployed manually by a free-diver or from the boat using a harness tagging pool. The tags remained on the animals over the entire short term duration of the trials. Focal observations and deployment data suggest that both methods produce little or no adverse behavioural reaction of the animals, offering a valid alternative for short term tagging of pelagic sharks and rays. Deployment length can be substantially increased by selecting longer duration galvanic timed releases.

Poster # 206

Marie-Amélie Forin-Wiart, Yves Handrich

Generalities and specifics of locomotion behaviour patterns in quadrupedal terrestrial mammals

Université de Strasbourg, CNRS, IPHC UMR 7178 F-67000 Strasbourg, France
marie-amelie.forin-wiart@iphc.cnrs.fr

The ability to distinguish locomotion from other behaviours and specify its function, e.g. displacement versus foraging, has broad ecological applications. Global positioning approaches are very useful but they can suffer from a trade-off between fix accuracy and fix interval, which induce a loss of information. A different approach using tri-axial accelerometers or inertial measurement units (tri-axial accelerometers, tri-axial magnetometers and tri-axial gyroscopes, IMUs), could be a solution to overcome such shortcomings. Furthermore, such a tool allows detection of general locomotion patterns among quadrupedal terrestrial mammals and study possible subtle differences between species linked to their morphology. We hypothesise that (1) within a given gait, differences in acceleration patterns between species are linked with specific differences in morphology at the level of family groups, e.g. mustelids versus felids, (2) changes of acceleration patterns between gaits (walking, trotting and galloping) are similar in all species. To study these questions, we equipped individuals belonging to three different quadrupedal species with 3D accelerometers or IMUs (collar): the Eurasian badger (Meles meles) with a bouncing gait, the domestic cat (Felis silvestris catus) with a supple gait, and the domestic dog (Canis

familiaris), with a gait between these species. We recorded tri-axial acceleration while animals were walking, trotting and galloping. From this, we derived (1) the amplitude of dynamic body acceleration along the three axes, (2) amplitude and frequency of stride, (3) pitch and roll angles, (4) angular velocity along the three axes and yaw angle when deploying IMUs. To characterise the dynamic body acceleration oscillations for each axis, we computed frequencies using power spectrum densities (PSDs), wavelet and shape analysis. We discuss (1) the benefits of including additional parameters and (2) different frequency methods to analyse the locomotion patterns of these three different quadrupedal animals.

Poster # 219

Aldina MA Franco, Kate Rogerson, Phil Atkinson, Jenny Gill

Influence of junk food on the annual movement and behaviour of the partially migratory white stork

AMAF, KR, JG: University of East Anglia • PA: British Trust for Ornithology
a.franco@uea.ac.uk

The migratory behaviour of animals is highly flexible and is changing in response to global environmental change and variation in resource availability. Understanding the causes and mechanisms underlying changes in recent migratory behaviour will enable better understanding of the evolution and maintenance of the migratory behaviour of animals. White stork (Ciconia ciconia) a previously wholly migratory species in Europe has established resident populations in Iberia and is now a partially migratory species that takes advantage of year-round food resources resulting from human activities, invasive crayfish in rice fields and organic material from landfill sites. Over half of the breeding population remains in Portugal in the winter. The effect of anthropogenic food sources on movement and behaviour of adult and post-fledging juveniles was investigated. This study is taking advantage of high temporal and spatial resolution data collected from 40 juvenile white storks tracked with GPS/GSM transmitters in 2016/17. The movement of fledglings, while they are still using the nest, is influenced by the distance between the nest and landfill site. Juveniles from nests far from landfill sites fly significantly less per day, spend a greater time on the nest and less time on landfill sites than those that are from nests located close to landfill sites. The movement of fledglings is influenced by the proportion of time birds spent on landfill sites. The individuals that spend less time on landfill sites move greater distances per day and displace more per day than those that spend more time on landfill. Birds that forage in natural habitats are more mobile probably due to the need to search for prey in

diverse locations. White storks are social birds, migrate in groups, and juveniles from nests located close and far from landfill sites are likely following non-naïve individuals to foraging areas and to landfill sites.

Poster # 238

Johannes Fritz, Markus Unsöld, Christian Sperger, Ines Aster, Daniela Trobe

Whole release population bio-logging in Northern Bald Ibises as a mean of population monitoring and illegal-hunting avoidance

Waldrappteam, LIFE+ Northern Bald Ibis
jfritz@waldrapp.eu

The European LIFE+ project aims to reintroduce the continentally extinct, critically endangered Northern Bald Ibis (Geronticus eremita) in Central and Southern Europe (www.waldrapp.eu). It is the first project, which aims to establish a completely new migration tradition with a migratory bird species. The whole release population, which currently consists of more than 70 individuals, is equipped with GPS-tags. The dataset provides detailed information about the establishment and transmission of a human-initiated migration tradition between Southern Germany and Southern Tuscany. Aside of this, the rather complex and expensive whole-population bio-logging also provides an essential dataset for the implementation of a campaign against illegal bird hunting in Italy. Hunting during the autumn migration period is the major mortality cause for the release population. Bio-logging allows to quantify this threat, in terms of the total amount of individuals but also the proportion of the whole population. Such hard-facts are rather exclusive, with a high value to alert the public as well as relevant stakeholders and to apply pressure on the hunting associations. After mid-term of the six-year LIFE project, there are indications that the campaign causes a decrease of hunting as a mortality cause. However, classical bio-logging in this context has one major limitation. In most cases, the awareness of a hunting incident is delayed, for hours or even days. This makes it difficult to identify the perpetrator. We now aim to develop a data-logging technology with the major target to recognize the death of a body as soon as possible and to transmit the position of the dead body. The project is implemented with 50 % contribution of the LIFE financial instrument of the European Union (LIFE+12-BIO_AT_000143, LIFE Northern Bald Ibis).

Poster # 66

Boris Fuchs, Théo Marchand, Alina Evans, Jon M. Arnemo, Navinder Singh, Benjamin Rey,
Cindy Canale, Sylvia Pardonnet, Aurélie Cohas, Walter Arnold

Drivers of Hibernation in Marmots and Bears

BF, AE, JMA: Department of Forestry and Wildlife Management, Hedmark University of Applied Sciences,
Campus Evenstad, NO-2418 Elverum, Norway • TM: ENS de Lyon, Departement of biology, Université Lyon 1,
Lyon 69000, France • NS: Department of Wildlife, Fish and Environmental Studies, Swedish University of
Agricultural Sciences, SE- 90183 Umeå, Sweden • BR, CC, SP, AC: Laboratoire Biométrie et Biologie Evolutive,
Université de Lyon, CNRS, UMR 5558, Université Lyon 1, 69622, Villeurbanne, Lyon 69000, France • WA:
Research Institute of Wildlife Ecology, University of Veterinary Medicine, Savoyenstrasse 1, 1160 Vienna,
Austria.
theo.marchand@ens-lyon.fr / boris.fuchs@hihm.no

Hibernation occurs as a strategy to overcome harsh environmental conditions. This period is
defined as pronounced multiday reduction of metabolic rate associated with a decrease in
body temperature in mammals. Although many studies have described the effect of
ambient temperature on hibernation patterns, little is known about the role of
environmental factors as drivers of the start and end of hibernation. Nevertheless, a recent
study investigated the environmental drivers of hibernation in the brown bear. The goal of
this work was twofold. First, we investigated the drivers of hibernation in the Alpine
marmot. Second we compared the results to the brown bear study. For marmots, we
identified ambient temperature as a driver of entry into hibernation. We also noted a close
relationship between photoperiod and body temperature and suggest that snow melting
triggers the end of hibernation. We used 33 hibernation patterns of body temperature
recorded during two years from free-living Alpine marmots (Marmota marmota). We
applied the same method as the brown bear study to have comparable results. New
knowledge on this topic will help to predict the effects of climate change on the denning
phenology of hibernators.

Poster # 195

Lee A. Fuiman, Randall W. Davis, Terrie M. Williams

Consistent Bearing During Terrestrial Movement Suggests Guided Navigation by Antarctic Seals

University of Texas at Austin • RWD: Texas A&M University • TMW: University of California - Santa Cruz
lee.fuiman@utexas.edu

Weddell seals live in the fast-ice environment of Antarctica where they undertake long-range migrations on a seasonal basis, as well as medium-and short-range movements between sparse breathing holes. Little is known about how they navigate underwater, and even less is known about their terrestrial (including on-ice) movements. During an ongoing biologging study of their underwater navigation, we examined on-ice movements. Six seals were captured along the coast of Ross Island and transported to a camp on the sea ice of McMurdo Sound, Antarctica, approximately 10 km west of the coastline. They were instrumented with an archival data recorder, GPS receiver, and ARGOS satellite tag and transported 5 km to one of three isolated breathing holes covered by a hut and released into the hole. After at least 2 days in the water, a secondary hole was opened to allow the seal to haul out. Seals were allowed to travel freely on top of the sea ice until they were 2.1 to 7.5 km from the haul-out location after which the instruments and seal were recovered. Three of the seals were transported and redeployed two or three times at different locations. Positions during on-ice travel were obtained from GPS and Argos fixes, and bearings were computed using only those fixes having an error radius < 240 m. All seals traveled along remarkably straight paths, tortuosity (gross displacement/net displacement) was 1.4 + 0.28 (mean + s.d., n = 9 paths). Not all seals moved on the same bearing, but each seal that was released more than once moved along a consistent bearing, regardless of location. Cues used for navigating these consistent bearings are not known, but seals continued to move along their preferred bearing during periods when weather obscured visual landmarks and auditory cues, suggesting that vision and hearing are not necessary.

Poster # 71

Joaquin Gabaldon, Ding Zhang, Kira Barton, Matthew Johnson-Roberson, Julie Rocho-Levine,
Julie van der Hoop, Michael Moore

Enhanced localization of marine mammals in controlled experimental settings

JG: Department of Robotics, University of Michigan • DZ, KB: Department of Mechanical Engineering,
University of Michigan • MJR: Department of Naval Architecture & Marine Engineering, University of Michigan
• JRL: Dolphin Quest, Dolphin Quest Oahu • JVDH: Department of Biosciences, Aarhus University • MM:
Department of Biology, Woods Hole Oceanographic Institution
kshorter@umich.edu

Accurate localization is an important part of understanding behavior, social interactions, and environmental utilization of marine mammals. Currently, animal tracks tend to be estimated from some combination of GPS, inertial measurement unit (IMU), and pressure data collected from biologging tags. GPS measurements provide only sparse updates when the animal is at the surface, and assumptions made about the animal"s speed between GPS locations, to fill in the track, can misrepresent the actual dynamics of the animal. Furthermore, it is difficult to accurately assess the quality of the estimated tracks in the wild, because animal observations that are independent of tag data are difficult to obtain. Our work seeks to address this by developing a controlled experimental environment where new tracking algorithms can be developed, tested and evaluated. Furthermore, we will present a method for an optimized localization technique that combines measured animal dynamics from biologging tags with position and speed estimates derived from overhead video data. However, this method can be generalized by using any set of direct speed/velocity measurements and GPS detections of the animal. For this work, animal odometry was estimated from tag and camera data. Odometry data were used to create discrete nodes corresponding to the animal"s estimated locations. Direct measurements of the animal"s locations were also obtained from the camera data, and served as observations that were used in animal location error estimations. Node positions were then modified to minimize the error function, using a least squares optimization approach. Data from bottlenose dolphins (Tursiops truncatus) in a professionally managed setting at Dolphin Quest Oahu during prescribed swimming tasks were used to demonstrate this method. In addition to quantifying the accuracy of the tracking algorithms, we will present detailed swimming biomechanics derived from the estimates of kinematic and kinetic data during the prescribed swimming tasks.

Poster # 33

Richard Gaëtan, Julien Bonnel, Christophe Guinet

How to assess depredation by cetaceans on demersal longlines with accelerometers?

RG, CG: Centre d'Études Biologiques de Chizé, UMR 7273 - CNRS & Université de La Rochelle & Lab-STICC UMR 6285, ENSTA Bretagne • JB: Lab-STICC UMR 6285, ENSTA Bretagne

gaetan.richard@cebc.cnrs.fr

Depredation in longline fisheries by odontocetes is a worldwide growing issue. An example of this is the demersal longline fishery operating around the Crozet Archipelago and Kerguelen Island, where killer whales and sperm whales remove hooked Patagonian toothfish. Until now, interactions with cetaceans have only been assessed from surface observation from vessels. The purpose is now to assess the underwater dimension of depredation. Indeed, questions such as when and at which depth cetaceans removed the fish are essential to understand the phenomenon and then find appropriate solutions to avoid this issue. Our purpose was to assess longlines' "behaviour" using accelerometers paired with pressure sensors, to better understand the fishing process and cetaceans' depredation. Loggers were attached on gangions connecting hooks to the line. Using acceleration we expected first to assess catching time of fish and how far from an equipped hook a catch can be observed. Secondly we aimed at assessing when depredation events happen. In particular, a critical question is to know if the cetaceans remove toothfish within the water column (during hauling) or if they can depredate when the longline is on the bottom. We used the vectorial acceleration's norm to describe movements' amplitudes of the loggers and we assessed the standard deviation of acceleration to determine sharp movements of the logger. During bottom phases, we observed high values of the vectorial acceleration's norm on hooks with fish, and a decrease of this value among following hooks without fish, suggesting a propagation of the catch signal. Besides, through the dispersion of acceleration we revealed sharp movements of loggers, during both bottom and ascent phases. These events were obtained on bent and snatched hooks, commonly considered as depredation clue, and in presence of sperm whales. Thus, we may observe depredation events, and for the first time at the bottom.

Poster # 64

Gabriella Gall, Tim Clutton-Brock, Marta Manser

Spatial structure of foraging meerkat groups reflects social competition among group members

GG, MM: Department of Evolutionary Biology and Environmental Studies, University of Zurich • TCB: Department of Zoology, Cambridge University
gabriella.gall@yahoo.de

Group living animals need to trade-off the benefits and the costs of close proximity to many conspecifics. Benefits can be increased, and costs reduced by preferentially choosing specific locations within a group, best adjusted to an individual's needs or by associating with specific group members and/or avoiding others. Here we investigated the spatial structure of meerkat (Suricata suricatta) groups during afternoon foraging session and examined whether the spatial structure was shaped by predation risk, foraging success, social factors such as affiliation or aggression among group members, or a mix of these different factors. Using social network analyses, we found no correlation between specific within-group spatial locations and an individual's dominance status, sex or age. However, we found evidence of avoidance among individuals of different dominance status or the same litter, suggesting that competition between individuals plays an important role. Young individuals were more strongly connected at close proximity than older individuals and this relative connectedness remained stable over the period of the foraging session. We conclude that predation risk and foraging success were of minor importance during the period of data collection and that social affiliation and competition appeared the main driver of the spatial structure of foraging meerkat groups.

Gabriella Gall*, Charlotte Christensen*, Danai Papageorgiou*, Damien Farine*

Fission and fusion of stable groups of wild vulturine guineafowl (Acryllium vulturinum)

GG, CC: Department of Evolutionary Biology and Environmental Studies, University of Zurich, Winterthurerstrasse 190, 8057 Zurich, Switzerland • DP, DF: Department of Collective Behaviour, Max Planck Institute for Ornithology, 78464 Konstanz, Germany
dpapageorgiou@orn.mpg.de

The Fission-fusion dynamics of animal societies are shaped by ecological and social constraints. The sub-units that constitute these societies can vary in their composition, size and stability. "Molecular fission-fusion", where stable social units aggregate into larger super-groups, has to date only been shown in large-brained mammal species living in fluctuating environments. Daily and seasonal changes in climate conditions can influence food abundance, energy expenditure, predation risk and roosting patterns. This can determine the movement patterns within and between groups. Here we provide first evidence of molecular fission-fusion in vulturine guineafowl (Acryllium vulturinum) and test whether this fission-fusion dynamic is influenced by climatic constraints. Using observations on one group and high-resolution GPS data (e-obs Digital Telemetry) on 9 groups we show that vulturine guineafowl live in stable groups of 15 to 60 individuals and roost communally with conspecifics of other social groups. Groups were more likely to travel together after roosting together than expected by chance. In addition, these groups were more likely to encounter each other throughout the day than groups that did not roost together. While daily ranges got smaller with increasing amounts of rain, rainfall did not influence the overlap between daily ranges of different groups. To conclude, our findings show that guineafowl have a molecular fission-fusion pattern similar to some large brained mammals and suggest that at least smaller changes in climate might not influence the fission-fusion dynamics of these groups. * NOTE: All authors contributed equally

Poster # 4

Susan Gallon

EO4wildlife platform case study: Assessing marine mammal habitat preferences to inform conservation and management

Agence Française de la Biodiversité
susan.gallon@afbiodiversite.fr

Decision-making in today's contentious world requires high quality data and tools that are trusted by a wide range of stakeholders. New and evolving technologies provide managers/scientists with the potential to bring such data and decision tools into Marine Protected Area (MPA) discussions, hopefully reducing the cycle of disagreement and stalemate that characterize many forums. The easy-to-use EO4wildlife platform will allow querying, searching, mining and extracting information from different databanks (i.e. owner database, archive database and online database). Scientists and MPAs managers will be able to fusion and cross correlate heterogeneous data via advanced data analytics tools in order to discover patterns, validate or invalidate hypothesis, detect potential similar or reproducible behaviour or favourable conditions associated to the movement of animals (i.e. GPS and Argos data) or any kind of geo localized data (i.e. transects surveys). This platform will facilitate obtaining, visualizing and sharing extracted Earth Observation data that will be used to better understand the environmental factors that may influence the distribution and habitat preferences of tracked/surveyed species in order to better identify and predict important marine mamals areas (IMMAs).

Poster # 232

Samantha A Gordine, Michael A Fedak, Lars Boehme

Current-correction of southern elephant seal movement trajectories

University of St Andrews
sg494@st-andrews.ac.uk

During two annual 3-8 month long migrations, southern elephant seals (SES) are exposed to the world"s strongest oceanic current system: the Antarctic Circumpolar Current.

Consequently, their ground-based trajectories are shaped as a function of their own water-related movements and that of the ambient current"s flow which can either promote or impede travel. Current-correcting the ground-based trajectories thus allows for a better assessment of where and how marine top predators such as SES migrate. A modified vector analysis was applied to 45 SES trajectories from South Georgia collected between 2008 and 2009, which revealed that the supposedly intended heading direction significantly differed from the resultant direction of travel described by a seal. The water-based paths displayed that currents deflected the trajectories of fast-moving SES even when SES were only exposed to strong currents at the surface, and that the differences between ground and water-based paths became more pronounced the longer a trajectory. Localised changes in the current"s flow led to large inter-individual differences in how strongly trajectories were deflected. The difference between ground- and water-based trajectories was largest for benthic diving individuals seeking out fixed bathymetric features around which currents were strong. These individuals counter-acted the deflections and compensated for drift to stay localised. The analyses elucidated that during a migration SES are flexible in using several different movement strategies such as compensation, drift and upstream orientation in response to a spatio-temporally varying flow of the ambient current. Applying track-based behavioural metrics to the water-based paths revealed that these metrics fail to reflect body condition improvements, but rather display different foraging strategies. This large behavioural plasticity could indicate resilience against environmental changes. Further long-term monitoring is necessary to fully gauge the reliance of SES on currents, which is particularly important regarding the imminent alterations in the ocean due to climate change.

Poster # 233

Samantha A Gordine, Michael A Fedak, Lars Boehme

Long-term importance of frontal systems for the improvement of body condition in southern elephant seals

University of St Andrews
sg494@st-andrews.ac.uk

Southern elephant seals (SES) undertake two migrations each year for 2-3 and 7-8 months after fasting on land during the breeding and moulting season. For replenishing resources SES rely on macroscale latitudinal fronts, which provide favourable foraging conditions through aggregating prey and enhancing productivity. However, it is largely unknown how

flexible the reliance on certain frontal systems is within populations over the long-term. Here, we examine the relationship between frontal systems and the (un-)successful resource acquisition of 50 South Georgia SES during 3 post-moult and 3 post-breeding migrations between 2005 and 2010. Conductivity-Temperature-Depth Satellite Relay Data Loggers provided in-situ measurements concurrent with >24,000 dive profiles to define fronts and inter-frontal zones between the Subtropical Frontal Zone and the Southern Boundary of the Antarctic Circumpolar Current. For >390,000 individual measurements the water masses could be identified. Generally, SES associate more frequently with higher latitude fronts/zones. Body condition improvements related to a given frontal system or water mass vary strongly according to year, season, month and sex. The variability in body condition improvements is higher in some frontal systems than in others, likely due to shifts in the Subantarctic and Polar Front. During a migration, some individuals stay within ≤3 frontal systems, whilst others change between several frontal systems and primarily improve their body condition in upper ocean waters. SES do not trace particular water masses across different frontal systems, and both surface and deep foraging strategies are used. This suggests that SES do not target particular water masses, but adjust foraging and movement strategies to exploit boundary areas at which mixing and prey aggregation is high. The large behaviour plasticity towards spatio-temporal variability in the different oceanographic regions they encounter could indicate resilience against environmental changes.

Poster # 171

Christopher A. Griffiths

Testing power laws: how movement scales with body size in free-roaming marine fish.

School of Mathematics and Statistics, University of Sheffield & Institute for Marine and Antarctic Studies, University of Tasmania.
cagriffiths1@sheffield.ac.uk

An organism's physical capabilities are governed by its body size. Power laws are a useful means of describing allometric movement rates, metabolism and predator-prey interactions. Nonetheless, the generality of how body size scales with movement has only recently been investigated in marine fish. Here we analyse in situ movement data from over 750 individuals across 30 different species and over 4 orders of magnitude (body lengths

ranging from 0.005m to 3.0m). We show that three-dimensional movement rates scale with body length according to an exponent of approximately 0.75, irrespective of taxa. Investigations further explore such findings, illustrating that developmental stage, differing life history traits, species identity and habitat all impact the scaling relationship between movement and body size in marine fish. Understanding how scaling relationships stand up to empirical tests is essential for the development of robust and biologically realistic individual, population and community models.

Poster # 172

Christopher A. Griffiths

Making the most out of tagging data: estimating population-level patterns in marine fish from individual movement paths.

School of Mathematics and Statistics, University of Sheffield & Institute for Marine and Antarctic Studies, University of Tasmania.
cagriffiths1@sheffield.ac.uk

An increasingly popular way of gaining meaningful inference from an animal"s recorded movements is the application of hidden Markov models (HMMs) and hierarchical HMMs (HHMMs), which allow for the identification of latent behavioural states in the movement paths of individuals. The advent of these models has been instrumental in advancing our understanding of foraging decisions, species interactions and space use patterns. However, the use of such methods to explore the population level consequences of movement across multiple animals is often limited by model complexity and insufficient sample sizes. Here we introduce an alternative approach to current practices and provide evidence of how the inclusion of prior information in model structure can not only simplify the running of HHMMs across multiple movement paths by ensuring coherent state classification, but also maximize the effective sample size of a tagging dataset. To demonstrate the utility of our approach we apply HMMs and adapted HHMMs to over 100 individual movement paths consisting of daily horizontal and vertical movement rates in two species of demersal fish, Atlantic cod (Gadus morhua, n=46) and European plaice (Pleuronectes platessa, n=61). Our models predict two distinct behavioural states, one less active state (resident) and one more active state (migrating), with time spent in either state varying through space and time. Since our analysis considers an unprecedented number of movement paths and ensures coherent state classification across multiple individuals, we use collective model output to investigate spatio-temporal trends within and across differing sub-stocks of Atlantic cod and

European plaice. Specifically, we show an asynchrony in the seasonal transition to a resident state that is earlier in European plaice compared to Atlantic cod. Furthermore, by plotting space-use patterns by behavioural state, we highlight areas of habitat use that are critical for fisheries management in the North Sea and English Channel.

Poster # 146

Traisnel Gwendoline, Pichegru Lorien

Do African penguins use their colony as information centre?

Nelson Mandela University
traisnel.gwendoline@gmail.com

To minimize energy expenditure at sea, seabirds need to rapidly locate profitable feeding sites in an extremely variable environment. The Information Centre Hypothesis stipulates that birds may use their colony to obtain information on foraging locations during the breeding season. The potential use of personal (e.g. memory) or social (e.g. pair communication) information to locate food at sea is still unexplored in the endangered African penguin (Spheniscus demersus). In this study, we explored whether bird"s consistency in foraging behaviour varied with environmental conditions (i.e. possibly using their memory when food conditions are less profitable) and whether couples use social information to communicate profitable areas (i.e. similar foraging areas between the two partners). Over four years, we measured foraging effort of 69 African penguins (including 15 couples over two years: where partners were tracked simultaneously) with GPS-loggers for 2-6 consecutive foraging trips during the chick-rearing period on Bird Island, Algoa Bay (South Africa). When food availability was low, birds were more consistent (higher repeatability index, R) in their foraging area (e.g. bearing to the maximum distance, R = 0.68), compared to years of higher food availability. No clear consistency in foraging area exploited was apparent within nests (e.g. bearing to the maximum distance, R = 0.27) although partners were highly repeatable regarding their trip duration (R = 0.76) indicating a certain level of coordination. Inter-individual variation was high, though, with some birds and even some couples showing higher consistency compared to others when foraging, suggesting the possible use of personal and social information. As productive areas are scarce during food shortage, birds may also rely more on individual memory. The consequences of inter-individual differences in foraging strategies may be exacerbated with the current context of climate change, which may favour birds that can use both social and personal information.

Poster # 88

Luke Halpin, Ingrid L. Pollet, Harry Carter, Ken Morgan

Geolocators reveal foraging movements of sympatric fork-tailed (Oceanodroma furcata) and Leach's (O. leucorhoa) storm-petrels from Gillam islands, British Columbia, Canada

LH: Halpin Wildlife Research • ILP: Dalhousie University • HC: Carter Biological Consulting • KM: Canadian Wildlife Service •
ipollet@yahoo.com

Information about foraging movements and diet of sympatric species during the breeding season is important for targeted conservation actions. Over the last decade, miniaturization of geolocation logging devices has greatly improved our ability to track movements of the smallest of seabird species. Geolocation is now an important tool for revealing seabird movements and identifying important foraging areas. Combining geolocation data, with stable isotope analysis allows us to make inferences about trophic level interactions and diet, which may help to improve our knowledge of how sympatric species compete for resources, as well as the at-sea threats they may encounter. In 2016, we used geolocators to track movements of breeding fork-tailed (Oceanodroma furcata) and Leach's (O. leucorhoa) storm-petrels that breed on the Gillam Islands, off the northwest coast of Vancouver Island, British Columbia, Canada. We collected blood and feather samples for stable isotopes analysis (C, N, and S) and DNA sexing. We are still in the process of gathering data, but preliminary results suggest long-range foraging behavior in storm-petrels in the Pacific Ocean. All fork-tailed storm-petrels utilized a core area west of Vancouver Island beyond the continental shelf break, an area known to be used by many other seabird species. Importantly, this region has elevated marine vessel traffic and associated threats, which underlines the importance of further efforts to understand the spatial ecology of these species.

Poster # 73

Fumiya Hamai, Emyo Fujioka, Dai Fukui, Shizuko Hiryu

A study on the adaptive foraging strategy of wild echolocating bats: microphone-array measurement of three-dimensional acoustic navigation behavior

Doshisha University
ctub1009@mail4.doshisha.ac.jp

The purpose of this study is to investigate the aerial foraging behavior of echolocating bats in the field. We measured ultrasound emissions and three-dimensional flight paths of Myotis macrodactylus using a 16-ch microphone-array system during foraging over a pond approximately 20 meters square in area last June and September. By surrounding the entire pond with the arrays, we could acoustically determine the foraging duration of individual bats as well as the number, the timing and the 3D position of prey captures by the bats. As a result, we found that the bats gained profits corresponding to the foraging duration in the patch, and there were more prey captures in June than in September. In addition, the trigger that one bat left the feeding patch was the appearance of another bat, suggesting a strategy for avoiding unnecessary acoustic interference over the water surface. Next, we compared three flight paths of foraging bats, low (6 times during 128 s), medium (11 times during 90 s) and high capture rates (12 times during 45 s). In the medium case, the bat repeatedly flew 10-12 m away from and back to the almost same point over the pond (foray search pattern). On the other hand, in the case of low capture rate, bats flew in the circular pattern with interpulse interval of approximately 120 ms, which was longer than in the case of high and medium capture rates (70 ms and 50 ms, respectively). These results suggest that the echolocating bats use adaptive foraging strategies, changing the foraging flight pattern and acoustic surveillance distance according to the prey density in the patch [This research was supported by a Grant-in-Aid for Young Scientists (B), Scientific Research (A) and Scientific Research on Innovative Areas of JSPS, and the JST PRESTO program.]

Poster # 200

Miriam Handler, Gil Bohrer, Anna Gagliardo, Martin Wikelski

Olfactory Navigation of Pigeons Represented by Aerosol Dispersion

The Ohio State University
handler.29@osu.edu

Navigation by olfactory cues is widely used amongst animals. For homing pigeons, and other diurnally-active land birds, olfactory cues may play a role, but gradient-guided navigation tends to be hindered by atmospheric turbulence and strong mixing of the atmospheric surface layer, causing weak odor gradients. After training by free-range flying around a home-based loft, pigeons develop the ability to associate odors with their particular direction of origin as a means to homing. Due to the unique mixture of volatile compounds carried by associated wind directions, pigeons develop the ability to generate an intricate smellscape as a means to identifying these odors. Just how they create this smellscape is dependent upon meteorological conditions that are characteristic of their area of migration, and their perception of these conditions. To determine how smellscapes are perceived, we provide a reference smellscape by mapping the geographic regions of origin for hypothetic smell plumes that the pigeons would be most exposed to under characteristic wind directions during their training period in the lodge. This is accomplished by backward-trajectory modeling of neutral scalar flumes during characteristic days in the training period using NOAA's HYSPLIT model. These modeled smellscapes can identify the most characteristic regions that should be easy to orient toward using smellscape, and can also identify "gaps", i.e. regions where smells are unlikely to have a distinct representation in the perceived smellscape by the training pigeons. Experiments involving release of trained pigeons in different regions will be used to test the hypotheses identified by the modeled smellscapes. Finding the link between pigeon navigation by olfactory cues and the dispersion of smells in the atmosphere as characterized by a specific smellscape is a novel, interdisciplinary study, and assuming that the smellscape hypothesis will by supported by our results, will establish a unique mechanism for animal orientation navigation.

Poster # 145

Jonathan Handley, Norman Ratcliffe, Alistair Baylis, Pierre Pistorius

Habitat use by a generalist and the challenge of prediction to unsampled locations

JH, PP: Nelson Mandela Metropolitan University • NR: British Antarctic Survey • AB: Icelandic Seal Centre (Formerly: Falklands Conservation) - Falklands Conservation
jonorow@gmail.com

Marine systems impose dynamic boundaries upon top predators, that can inhabit multiple locations, which may not always be feasible to study. Therefore, a prerequisite towards conserving these top predators is determining how they utilise their surrounding environment, so that habitat distribution models might be extended to unsampled areas. Ideally, model development will involve cross validation through data collected independently at multiple locations. This study aimed to investigate the at-sea use and develop habitat distribution models for a generalist diving species, the northern gentoo penguin (Pygoscelis papua papua), during its breeding period over two seasons at the Falkland Islands. Utilising GPS and TDR devices, it was shown that these birds are inshore foragers but utilised different foraging strategies across three different colonies in terms of diving behaviour and horizontal space use. Distribution models developed via boosted regression trees showed good cross validation through time but were poor across space. Foraging strategies are likely driven by local prey availability and access to the surrounding seabed. Poor transferability acros space for distribution models is likely driven by data paucity. Nonetheless, results show that even its northern range, gentoo penguins utilise a broad array of foraging strategies which may be facilitating the current population growth. However, in a region undergoing anthropogenic change, this data should be utilised in multispecies to inform management decisions that can support marine spatial planning.

Poster # 222

Hawkes LA, Parr N

Do bar headed geese train for high altitude flights?

University of Exeter, Centre for Ecology and Conservation, Penryn TR10 9FE, UK
l.hawkes@exeter.ac.uk

Exercise at high altitude is extremely challenging, largely due to hypobaric hypoxia (low oxygen levels brought about by low air pressure). In humans, the maximal rate of oxygen consumption decreases with increasing altitude, supporting progressively poorer performance. Bar-headed geese (Anser indicus) are renowned high altitude migrants and, although they appear to minimise altitude during migration where possible, they must fly over the Tibetan Plateau (mean altitude 4,800 metres) for much of their annual migration. This requires considerable cardiovascular effort, but no study has assessed the extent to which bar-headed geese may train prior to migration for long distances, or for high altitudes. Using implanted loggers that recorded heart rate, acceleration, pressure and temperature: we found no evidence of training for migration in bar-headed geese. Geese showed no significant change in summed activity per day or maximal activity per day. There was also no significant change in maximum heart rate per day or minimum resting heart rate, which may be evidence of an increase in cardiac stroke volume if all other variables were to remain the same. We discuss the strategies used by bar-headed geese in the context of training undertaken by human mountaineers when preparing for high altitude, noting the differences between their respective cardiovascular physiology.

Poster # 95

Karine Heerah, Mathieu Woillez, Ronan Fablet, Hélène De Pontual

Coupling spectral analysis and Hidden Markov Models for the segmentation of behavioural patterns

KH, MW, HDP: Ifremer, Brest, France • RF: Institut telecom Bretagne
karine.heerah@hotmail.fr

Detecting animal's behavioural switches and periodicities can provide rich information on the underlying processes driving these movement patterns. However, extracting these

signals from movement time-series requires tools that objectively describe and quantify these behaviours. Behavioural mode inferences from movement patterns has been mainly addressed through Hidden Markov Models. However, until now, the metrics implemented in these models did not allow characterization of cyclic patterns. To address these challenges, we developed a robust but flexible approach to i) extract new metrics of cyclic behaviours and activity levels from a time-frequency analysis of movement time series, ii) implement spectral signatures into a HMM framework to identify and classify latent behavioural states. Applying this to 40 high-resolution European sea bass depth time series (collected with Data Storage Tags), we demonstrated that the fishes occupied different parts of the water column and had different activity levels according to environmental cycles and thermal experience. The presence of different behaviours were well defined and appeared at similar times throughout the annual cycle amongst individuals, suggesting these behaviours are likely related to seasonal functional behaviours (e.g. feeding, migrating and spawning). The innovative aspects of our method lie within the combined use of powerful, but generic, mathematical tools (spectral analysis and Hidden Markov Models) to identify and classify behavioural states. It relies on objective criterion and is fully automated which makes it suitable for analyzing large datasets. In addition, HMMs offer the flexibility to include any variables in the segmentation process. Thus, our method could be widely applied in the bio-logging community and contribute to prime issues in movement ecology (e.g. habitat requirements and selection, interactions with human activities, site fidelity and dispersal) that are crucial to inform mitigation, management and conservation strategies.

Poster # 113

Arne Hegemann

Immune function as a mediator of trade-offs

Lund University, Sweden
arne.hegemann@biol.lu.se

The immune system protects the body against harmful pathogens. It is fundamentally important for self-maintenance and promotes survival by reducing the probability of disease-related mortality. However, it simultaneously incurs costs in terms of its production, maintenance and activation. Therefore, it has been hypothesised that trade-offs with other behavioural and physiological activities make immune function a powerful driver of individual differences in many evolutionary and ecological processes. So far much research has focussed on trade-offs between immune function and reproduction. Only recently

evolutionary biologists and ecologist started to investigate the role of immune function in shaping other annual-cycle stages and in particular animal migration. It has been hypothesised that migrants need to reduce immune function during the physiologically demanding migration seasons. A contrasting hypothesis proposes that migrants need to boost immune function because they encounter more and/or different pathogens during their journey. For residents trade-offs between immune function and thermoregulation might be crucial. In this talk, I will summaries results from my recent work on birds and fish that evaluates these hypotheses and sheds light on how immune function influences key trade-offs in migrants and residents. We applied a number of different tracking techniques (e.g. radio-telemetry, PIT-tags, GPS-loggers) as well as implanted temperature-loggers to link physiological data with ecological and behavioural data in free-living animals. I will show how immune function differs between migrants and residents, how migrants adjust immune function during migration and present first evidence for a trade-off between immune function and other physiological systems, that only becomes apparent during the physiological demanding migration seasons. The presented data will enhance our understanding of the physiological mechanisms that drive trade-offs and ultimately help us to better understand the ecology and evolution of free-living animals.

Poster # 224

Olivia Hicks, Sarah Burthe, Francis Daunt, Jon Green

Linking parasitism and life-history: an energetics approach

University of Liverpool
och@liverpool.ac.uk

Many species exhibit reproductive skew with some individuals consistently more successful than others. The mechanisms underpinning this skew are often poorly understood yet can help us understand how individual variation can have consequences for population level changes. Recent work has illustrated that parasitism may play a crucial role in driving reproductive skew but may have differential impacts in different environmental conditions. We suggest that our understanding of how parasitism interacts with both intrinsic drivers and environmental conditions to determine breeding performance can be greatly improved by considering energetics, since many life-history processes can be quantified through their impacts on rates of energy use and gain. Using a novel endoscope technique to quantify parasite load and tri-axial accelerometers to estimate behaviour-specific energy expenditure we are able to determine the energetic cost of parasitism and understand how individual

responses may vary with changing environmental conditions. Here we present analyses on a population of European shags that suggest that the cost of different behaviours varies with parasite load and environmental conditions. This work provides a potential mechanism linking the energetic cost of parasitism to its role in driving reproductive skew, which may ultimately be influencing population success.

Poster # 123

Sandra Hochscheid, Marco Girardello, Fulvio Maffucci, Monica Blasi

The 007 of the oceans - CTD scans conducted by marine turtles

SH, MG, FM: Marine Turtle Research Center, Stazione Zoologica Anton Dohrn • MB: Filicudi Wildlife Conservation
sandra.hochscheid@szn.it

Biologging instruments are not only being used to study cryptic aspects of the life history of marine megafauna but the animals themselves have been employed to sample the marine habitats they live in. Such studies provided novel oceanographic data of even remote and difficult to access areas and while the sampling trajectories cannot be programmed, animal movement is often associated with oceanographic features that are important to be investigated. Here we hand-captured five large juvenile loggerhead turtles and equipped them for the first time with Fluoro-CTD-SRDL's to obtain detailed depth profiles of temperature, salinity and chlorophyll concentrations of the Tyrrhenian Sea, Western Mediterranean. Two tags stopped transmitting after 175 days while three tags continue to work after >200 days. Behavioural data from a total of 1206 dives (135-345 per individual) were collected and the average depth range was 16-24 m with maximum daily depths between 100 and 150 m. CTD scans over a depth range of 11 to 170 m delivered a total of 233, 216 and 212 profiles for temperature, salinity and chlorophyll, respectively. The majority of these data were recorded in the south and central Tyrrhenian Sea, albeit two turtles eventually left this basin and moved into the Eastern Mediterranean. These data have a twofold applicability: first, they were compared to the ARGO data from the Global Ocean Observing System to evaluate the usefulness of marine turtles as oceanographic sampling platforms, second, they were used to identify those features of oceanic habitats to which loggerhead turtles are attracted and which can be used to explain and predict distribution patterns for various climate change scenarios. In summary, our work employs alternative and relatively cheap sampling pathways to deliver oceanographic data which are important to understand and to model current and future ocean processes.

Poster # 180

Sascha K. Hooker, Heather Vance, Jonas Teilmann, Lonnie Mikkelsen, Ursula Siebert, Abbo van Neer, Pauline Goulet, Mark Johnson

Reconstructing behaviour: using posture to resolve modes of foraging in diving harbour seals

SKH, HV, PG, MJ: Sea Mammal Research Unit, University of St Andrews, Scotland • JT: Department of Bioscience, Aarhus University, Denmark • LM, PM: Department of Bioscience, Aarhus University, Denmark • US, AVN: University of Veterinary Medicine Hannover, Germany • AVN:
s.hooker@st-andrews.ac.uk

Behaviour of aquatic animals is often inferred from dive shape using long-lasting time-depth tags. However, dive shape may be misleading for shallow-water species that rest, travel and forage on various prey at similar depths. Here we explore whether parallel sensors can help resolve modes of behaviour. 40 days of data (DTAG-4) were collected from 3 harbour seals in the shallow North Sea in 2016. These record 3-axis acceleration (200 Hz sampling rate) and sound (64kHz) in addition to magnetometer, depth (50 Hz), and GPS positions (every surfacing). During 8-day foraging trips, tagged seals showed both straight line and highly tortuous surface movements. Diving was almost continuous with about 250 dives/day, approximately 80% of which were flat-bottomed, likely to the sea floor, with duration 2-4 minutes. Long sequences of highly stereotyped dives suggested continual foraging. However, mean posture at the bottom of these dives was less monotypic. In 10% of flat-bottomed dives, animals rolled onto one side, or rolled continuously from side to side. These contained no transient accelerations (jerks) and so were presumably not foraging. The remaining flat-bottomed dives usually contained at least one jerk, which sometimes coincided with a vertical nose-down posture, presumably indicating seafloor prey capture. Nose-down encounters near the end of dives were associated with impact sounds, followed at the surface by sounds consistent with prey handling. This suggests that seals can acquire multiple prey per dive, switching opportunistically between small prey consumed underwater and larger prey brought to the surface. Diurnal behavioural cycles were not evident from depth records, but were clear from dive posture, with steeper mean pitch angles at night possibly indicating increased reliance on tactile sensing at the seabed. Simultaneous analysis of posture and jerk from acceleration data thus provides rich material to help interpret the sensory and ecological constraints on foraging.

Poster # 5

Markus Horning, Martin Haulena, Pamela Tuomi, Jo-Ann Mellish, Caroline Goertz, Kathleen Woodie, Rachel Berngartt, Shawn Johnson, Courtney Shuert, Kristen Walker, John Skinner, Peter Boveng

Best practice recommendations for the use of fully implanted biologging devices in pinnipeds.

MH, PT, JAM, CG, KW, RB, JS: Alaska SeaLife Center • MH: Vancouver Aquarium • SJ: The Marine Mammal Center • CS: Durham University • KW: University of British Columbia • PB: National Marine Fisheries Service
markush@alaskasealife.org

Electronic biologging devices have enabled innovative and important studies on difficult to observe animals. However, externally carried devices often have limited attachment durations. Furthermore, devices and attachments may affect thermoregulation, energetics, social and reproductive behavior, visibility, as well as an animal's wellbeing, and may increase the risk of predation and entanglement. Surgically implanted devices may reduce some of these effects and may lead to additional experimental opportunities. However, improper implementation can significantly affect data quality and the welfare of individual animals. We reviewed findings from recent studies in aquatic vertebrates that used fully implanted devices (those that do not break the integument after insertion). From this, combined with our own applications in California sea lions, Steller sea lions and harbor seals, we present 15 specific best practice recommendations for the use of such tags in pinnipeds. These recommendations address issues including device size, coating and sterilization, implantation surgery, and effect assessment, within the framework of the Three R's: Reduction, Refinement, Replacement. We developed these 15 recommendations specifically for pinnipeds, but similar considerations could apply to other aquatic vertebrates, and also to partially implanted or external tags.

Poster # 8

Markus Horning, Amanda Bishop, Casey Brown

A decade of vital rate telemetry: summarizing results, challenges and opportunities.

Alaska SeaLife Center, Seward, Alaska, USA
markush@alaskasealife.org

The Life History Transmitter (LHX tag) is an implantable satellite-linked archival transmitter developed with Wildlife Computers, Inc. LHX tags are surgically implanted into homeotherm hosts, and record data throughout their life. Summarized data is transmitted via the Argos satellite system post-mortem, after tags are extruded from decomposing, dismembered or digested carcasses. LHX tags provide known-fate data on the location and causes of mortality. They can also be programmed to detect reproductive events that may yield age at primiparity and lifetime births in females. For non-traumatic mortalities, measured cooling rates allow estimating body mass at time of death. Two tags are used per animal to increase and quantify data return probability. Since 2004, 118 LHX tags have been deployed in four rehabilitated subadult California sea lions, 45 juvenile Steller sea lions, four rehabilitated harbor seal pups, and 10 subadult and adult harbor seals. 20 LHX tags have been tested via 10 carcass deployments, and LHX tags have been tested on four captive sea otters. 37 data returns have been received from 42 tags deployed in 21 mortalities detected in sea lions and harbor seals. Data were received from 18 of 20 tags deployed in carcasses. From these 55 returns, data return probability for dual tag deployments was estimated at >98%. 18 of 20 mortalities detected in Steller sea lions were classified as predation events. Five of these were attributed to Pacific sleeper sharks, the predator in the remaining events could not be determined. Vital rates are likely biased towards individuals with lower survival rates. Opportunistic data recovery from live animals via shore-based automated data relay systems is being developed and may reduce this bias and provide electronic mark re-sight data. The unique combination of post-mortem known-fate data, opportunistic resights, and reproductive data will allow novel experimental designs.

Poster # 216

Luis Huckstadt

Estimating pregnancy rates from diving behavior: A comparison across the range of Southern elephant seals

University of California Santa Cruz
lahuckst@gmail.com

Female southern elephant seals (Mirounga leonina, SES) display a characteristic life cycle, returning to land only twice a year to breed during the austral spring (September-November) and to molt in the austral summer (January-February), spending >80% of their annual cycle at sea. Successful (i.e. full-term and gave birth) and unsuccessful (i.e. did not give birth) pregnancy rates are critical information to understand basic population dynamics, however the cryptic lifestyle of elephant seals makes acquiring those rates difficult. Northern elephant seals (M. angustirostris, NES) have an analogous annual cycle in the northern hemisphere, and the striking similarities in their diving behaviour and physiology makes it possible to conduct comparisons across species. Using long-term data on diving behavior from 223 NES that returned to land to breed (i.e. pregnancy status confirmed), we developed a robust method to predict at-sea pregnancy status by relating day of the trip and daily mean dive duration using a General Additive Mixed Model (GAMM). The dive duration of pregnant females increased until week 19 of pregnancy, when the dive duration reaches a plateau and later decreases sharply. The dive duration of non-pregnant NES, on the other hand, increases more rapidly throughout their trip, does not plateau until around week 30, and reaches a higher duration compared to their pregnant counterparts. These models allow us to predict the pregnancy status of female NES for whom only diving data was collected. We will compare the rate of successful pregnancies between SES colonies (Macquarie, Kerguelen, South Georgia, and South Shetland Islands). This study will provide important demographic information for these populations, and will help explain differences in observed trends.

Poster # 177

Saana Isojunno, Kagari Aoki, Patrick J.O. Miller

Breathing patterns indicate recovery time and exercise modulated diving costs in long-finned pilot whales

Sea Mammal Research Unit, University of St Andrews
si66@st-andrews.ac.uk

Air-breathing marine predators that target sub-surface prey have to balance the energetic benefit of foraging against the time, energetic and physiological costs of diving to depth. However, physiological data such as metabolic rate are challenging to measure in free-ranging animals. Here we assess whether breathing rates and the timing of breaths can be used to indicate time and energy costs of diving in 17 tagged long-finned pilot whales. Breath times and fluke strokes were detected using dive depth, pitch and roll derived from onboard sensors (pressure, 3-axis acceleration). The number and timing of breaths before and after dives to 31m or greater were quantified in non-linear mixed models that incorporated serial correlation and individual as a random effect. We found that pilot whales increased their respiration rate (RR) in the 5-10 min period prior to, and immediately following, dives that exceeded 31m depth. While pre-dive RRs did not vary with dive duration, the initial post-dive RR was linearly correlated with dive duration, and showed an exponential decline following >5min dives. The lowest AIC model for post-dive number of breaths included an interaction term between dive duration and number of fluke strokes. Stroke rate was linearly related to swimming speed. Every fluke stroke was estimated to cost 0.0077 (SE 5x10-4) breaths per diving minute, after accounting for individual variation in respiration rate. Diving was estimated to cost 1.74 (SE 0.19) breaths per diving minute, which increased to 2.3 for individuals associated with a calf due to their greater overall stroking effort. Our results indicate that with careful analysis to account for the timing and detection of breaths, breathing rates immediately following dives can be useful to proxy the energy cost of diving, but potential variation in oxygen uptake per breath remains a challenge to convert breathing rates to field metabolic rates.

Poster # 179

Takashi Iwata, Kagari Aoki, Joanna Kershaw, Martin Biuw, Christian Ramp, Katsufumi Sato, Patrick J. O. Miller

How do whales decide the depth of foraging dives?

TI, JK, PJOM: Sea Mammal Research Unit, University of St Andrews • KA, KS: Atmosphere and Ocean Research Institute, University of Tokyo • MB: Institute of Marine Research • CR: Mingan Island Cetacean Study
iwatatakashi@gmail.com

Prey-searching behaviour of breath-hold diving animals is constrained by the requirement to return to the surface at regular intervals to breathe, which means animals cannot remain within prey patches at depth. Therefore the foraging decision of marine mammal is considered more complicated than for terrestrial animals. In the foraging dives, humpback whales Megaptera novaeangliae dive directly to the depth of the prey patch. However it remains unclear how whales decide the diving depth of subsequent foraging dives. This study examined whether humpback whales decide diving depth of subsequent foraging dives based on past experiences. We investigated humpback whales in Tromsø, Norway and the Gulf of Saint Lawrence, Canada using behavioural data loggers recording depth, speed, and tri-axial acceleration. Lunges as feeding events of whales were detected by the coefficient of variation of speed and acceleration. Inter-lunge dive intervals (ILDIs) were calculated based on the duration from the end of an immediately foraging dive to the begging of a subsequent foraging dive. Each foraging dive was categorized according to length of its pre-ILDI as <15 min, 15-30 min, 30-45 min, 45-60 min, and >60 min. We tested the effect of the maximum diving depth of an immediately foraging dive on the maximum diving depth of subsequent foraging dive using a generalized linear model for each ILDI category. A total of 3189 dives with 1149 foraging dives were obtained from 16 animals. Statistical results showed that the maximum diving depth of an immediately-previous foraging dive with that of the subsequent foraging dive were positively correlated for ILDI categories <15 min, 15-30 min, and 30-45 min, but not for 45-60 min or >60 min. This study indicates that humpback whales changed dive depth when they did not encounter any prey at similar diving depth of an immediately foraging dive within 45 min.

Poster # 201

Sahar Izadi, Craig Radford, Mark Johnson, Natacha Aguilar de Soto, Rochelle Constantine

All work with no relaxation? Bryde's whale activity budget suggests otherwise.

SI, CR, RC: The University of Auckland • MJ, NADS: University of St Andrews

siza778@aucklanduni.ac.nz

The application of bio-logging tools has been critical for uncovering the behaviour of baleen whales that perform most of their vital functions below the water. Despite their wide distribution, Bryde"s whales are one of the least known of the baleen whales and many questions about their behaviour remain unanswered, answering these questions provides us with crucial information to guide their conservation management and risk mitigation. We deployed sound and movement archival tags (DTAGs) on five Bryde"s whales in Hauraki Gulf, New Zealand, to assess their daily activity budget and to study how these large predators" interact with their environment throughout the day. We used RMS jerk and mean flow noise (as proxies for activity and speed, respectively), as well as changes in dive patterns (dive depth and shape), roll, fluke stroke and respiration rates to identify different behavioural states (feeding, resting, traveling). The five tags remained attached to the whales for a total of 60 hours including both day, dusk and night data. All whales were active during the day in combination of travelling and foraging. We detected 315 surface lunges (mean=7/hour) possibly targeting different prey items. Whales also performed some deep lunges during the day, but foraging was mostly focused near the surface (<5m). Whales showed strong diurnal behavioural patterns: resting more at night (94% of rest happened at night and a further 5% during dusk). While whales travelled occasionally at night, but there were no indications of foraging. This pattern suggests either that Bryde"s whales rely on senses that are less effective in the dark to locate prey, or that prey aggregate less densely at night, making foraging less efficient. Thus, Bryde's whales conserve energy through rest during times when the net benefit of foraging effort is low.

M Johnson, N Aguilar de Soto, P Madsen, L Mikkelsen, J Teilmann

Why predict when you can measure? Monitoring noise exposure and its effects on animals

MJ: University of St Andrews, UK • NADS: University of La Laguna, Spain • PM, LM, JT: Aarhus University, Denmark
mj26@st-andrews.ac.uk

Marine animals, especially in coastal areas, are regularly exposed to noise from boat traffic and construction but we have little idea of how much anthropogenic noise animals experience and what impact this has on behaviour and fitness. One way to address this is to combine animal tracks from GPS tags with information on temporally and spatially overlapping noise sources. This allows prediction of exposure and measurement of response (change in movement pattern). Methods to predict vessel noise using AIS records have been proposed but the accuracy of these has not been verified and many small vessels without AIS are excluded from predictions. A more direct approach is to measure sound with a biologging tag which may have the added benefit of giving richer contemporaneous information about behaviour. However measuring ambient noise using tags is complex because of interference from vocalizations and flow noise as well as varying transmission due to body shading and Lloyd's mirror effects. Moreover, sound recording tags typically offer short durations due to memory and battery limitations. This problem has been alleviated by new long-term sound and movement tags (DTAG-4) that enable continuous monitoring for several weeks. We use data from DTAGs on harbour seals, manatees, porpoises and beaked whales to show that animal vocalizations can be readily excluded by spectral processing while intervals and frequency bands with strong flow noise can be identified by harnessing accelerometer data and removed from background noise estimates. Resulting ambient noise measurements from coastal animals show frequent fluctuations due to boat traffic. Some high exposures correspond with vessels listed in AIS logs allowing the accuracy of predictive algorithms to be tested. However many noise events do not correspond to logged vessels verifying that in situ measurements are more reliable for monitoring total noise exposure and its behavioural consequences on marine fauna.

Poster # 42

Esther L. Jones, Haakon C. Bakka, Janine B. Illian, Theoni Photopoulou, Geert Aarts, Sophie Brasseur

Characterising species distributions from individual tracking data

ELJ: Centre for Research into Environmental and Ecological Modelling, School of Mathematics and Statistics, University of St Andrews • HCB: Department of Mathematical Sciences, Norwegian University of Science and Technology • JBI: Centre for Research into Environmental and Ecological Modelling, School of Mathematics and Statistics, University of St Andrews • TP: Institute for Coastal and Marine Research, Nelson Mandela Metropolitan University & Statistics in Ecology, Environment and Conservation, University of Cape Town • GA: Wageningen Marine Research, Wageningen University and Research

el298@st-andrews.ac.uk

Characterising species distributions is a fundamental challenge in ecology. Challenges arise in particular for species such as grey (Halichoerus grypus) and harbour (Phoca vitulina) seals that reside in inaccessible terrain of the marine environment. Telemetry data used to model habitat selection of these species are information-rich but present analytical problems such as spatial and temporal autocorrelation, large volumes of data, biased sampling, and complex boundary structures in the terrain that can lead to edge effects in spatial model predictions. We present two methodologies for characterising species distributions with telemetry data: a first approach using two-stage density estimation and regression modelling that has yielded widely applicable results (1-3 below), and a second integrated Bayesian approach, which aims to provide a framework for reproducible analysis (item 4 below). Results are demonstrated with examples based on data collected in the UK and Europe. (1) Long-term telemetry and terrestrial count data from harbour and grey seals were combined to produce robust maps of seal usage with confidence intervals. Comparing maps between species revealed scales of spatial partitioning. (2) To improve predictions of seal distribution in data-poor regions, environmental covariates were included. The fine-scale maps were used to inform spatial planning of marine renewable tidal turbine developments. (3) Usage maps were used to develop a framework to allow shipping noise, an important marine anthropogenic stressor, to be explicitly incorporated into spatial planning. Potentially sensitive areas were identified through quantifying risk to seals of exposure to shipping traffic. (4) An integrated framework was developed using a 2D spatial random field to implement flexible and computationally efficient Bayesian spatial models. The approach addresses the issues with telemetry data outlined above by using an INLA-SPDE approach to fit location data as spatial point process models.

Poster # 114

Ian Jonsen, Sophie Bestley, Mark Hindell, Rob Harcourt

Fast inference of behavioural processes underlying marine predator movement and habitat use

IJ, RH: Macquarie University • SB, MH: University of Tasmania

ian.jonsen@mq.edu.au

Habitat modelling approaches have been used for decades to understand where animals are found, why they are found there and to predict where else they may be located. This approach, however, cannot provide insight into the behavioural processes that underlie species' habitat use and distributions. We present a maximum likelihood-based approach for inferring behavioural processes from satellite-based telemetry data as a function of environmental attributes. Unlike similar Bayesian methods, our approach is computationally fast and allows straightforward model selection. We illustrate our method by inferring the changes in the autocorrelation of movements by southern elephant seals (Mirounga leonina) as a function of environmental variables such as distance to sea ice, distance to polynya and temperature at dive bottom. Used in combination with habitat models, our approach can provide essential but often missing behavioural context for understanding species' habitat preferences and distribution.

Poster # 136

Salvador J. Jorgensen, Scot D. Anderson,Taylor K. Chapple, Francesco Ferretti, Paul E. Kanive, Jim Tietz, Barbara A. Block

Cryptic ecology of top ocean predators revealed: tracking rare interactions between white sharks and killer whales

SJJ, SDA: Monterey Bay Aquarium • TKC, FF, BAB: Stanford University • PEK: Montana State University • JT: Point Blue Conservation Science

sjorgensen@mbayaq.org

Key animal behaviors or interspecific interactions may have disproportionately far-ranging ecosystem consequences. Yet if these processes are rare, they may be undetectable in biologging studies where data are collected over relatively short time scales. Here we

analyzed data of a unique decade-long passive acoustic tagging program studying white sharks (Carcharodon carcharias) in Central California, and revealed the consequences of rare interactions between white sharks and killer whales (Orcinus orca) at the Southeast Farallon Islands (SEFI). The arrival of killer whale pods at SEFI elicited synchronous flight responses in tagged white sharks. Data for 17 concurrently tagged white sharks provided details regarding not only their flight response, but also their destination and the duration of their displacement from this key foraging site. Though Killer whales remained only for a few hours, their presence stimulated long-lasting avoidance behaviors, or risk-effects, which lead to the loss of white sharks" access to prey. As a result, annual predation by white sharks on local pinnipeds was negatively correlated with close encounters with killer whales.

Poster # 94

Kahane-Rapport, S. R., Cade., D. E., Segre. P. S., Goldbogen, J. A.

First in vivo measurements of dilation and contraction of cetacean nares during respiration

Hopkins Marine Stations, Stanford University
skahaner@stanford.edu

Air-breathing divers incur oxygen debt as they perform critical life functions at depth. These behaviors are dependent on body oxygen stores that are replenished through a sequence of breaths after a dive. Although the duration and frequency of breaths at the sea surface may reflect subsurface behavior and activity level, how respiratory behavior changes with diving performance remains poorly understood. We deployed tags equipped with inertial sensors and cameras directly behind the blowhole to observe respiratory behavior while simultaneously quantifying diving performance in gray whales (Eschrichtius robustus), humpback whales (Megaptera novaeangliae), and blue whales (Balaenoptera musculus). The unique placement of a camera tag near the blowhole allows for a focus on precise changes to the nares during inhalation and exhalation. First, we compared the duration of inhalation to diving and foraging behavior in each species. Second, we measured the duration and frequency of breaths against the duration of the previous dive. Most of the behavior examined in this study consisted of relatively shallow and short dives compared to the known diving capacities of these species. This may indicate that respiratory frequency during a surface series of breaths may not be a reliable proxy for estimating the energetic costs of dives below a certain duration threshold. Nevertheless, our study extends the known uses of suction-cup attached, multi-sensor tags to the direct observation of

respiratory behavior in wild cetaceans, and hints at the potential for future generations of these devices to continue to quantify physiological parameters that previously have been difficult to obtain.

Poster # 193

Jens C. Koblitz, Stefan Greif, Peter Stilz, Antonio Guillén Servent, Yossi Yovel

Foraging behavior of black mastiff bats (Molossus rufus) revealed through GPS telemetry and microphone array recordings

JCK, SG, YY: Tel Aviv University • PS: BioAcoustics Network • AGS: Instituto de Ecología
Jens.Koblitz@bioacousticsnetwork.org

The black mastiff bat (Molossus rufus) is a fast flying hunter of hard-shelled flying insects with extremely short foraging bouts. The bats broadcast alternating lower and higher frequency echolocation calls that include slowly modulated narrowband and steep broadband sections. Little is known about how the flight aerodynamics and the echolocation behavior contribute to the efficient foraging strategy. We used miniature GPS devices with ultrasonic microphones and accelerometers to study the movements and vocalizations of this species in the field near Veracruz, Mexico. The GPS positions allow tracking the foraging routes and identifying important foraging habitats. The ultrasonic recordings reveal presence of conspecifics and detailed insight into the echolocation behavior of the tagged individual, and accelerometer data allows linking body movements to call emission. Large microphone arrays allow tracking of bats exiting and entering the roost on a fine scale and measuring additional echolocation parameters such as call intensity and directionality. Combining the two technologies, miniature tags and microphone arrays, allow novel insight into the echolocation and foraging behavior of bats.

Poster # 127

Andrea Kölzsch, Benjamin Leutner, Kamran Safi, Martin Wegmann, Stefan Dech, Martin Wikelski

Habitat use during spring migration: Remote sensing meets movement ecology

AK, KS, MW: Max Planck Institute for Ornithology – Radolfzell • BL, MW, SD: University of Würzburg

akoelzsch@orn.mpg.de

Forage availability during spring migration is crucial for the survival and successful reproduction of many migratory species. With careful timing in relation to spring growth and small-scale selection of suitable food sites, large avian herbivory migrants are known to maximise foraging rate during spring. However, especially for Arctic breeders, the recent levels of climate and habitat change alter the conditions that they meet at their spring stopover and breeding sites. In the EO-MOVE project we examine the habitat use of greater white-fronted geese (Anser albifrons) along their spring migration route between central Europe and northern Russia. This species is known to be sensitive to land-use intensity, phenology and landscape configuration, which calls for the exploitation of high resolution tracking and remote sensing technologies. To characterise the movement of geese within their spring stopovers, we use over 150 highly resolved GPS tracks of individual adult geese from the years 2006-2017. Since 2014 we have additionally collected acceleration data to classify the animals' behaviour and energy expenditure. We select within-stopover GPS positions that are classified as flight or feeding and overlay the movements connecting different small-scale feeding sites with optical and SAR time series data (20Ã—20m) from the Sentinel 1 and 2 satellite missions using step selection functions. Habitat preference outcomes are then set into context with vegetation indices and compared between individuals, years and stopover sites. First results indicate that white-fronted geese generally select for highly green, low and young vegetation, but also that there are large differences between stopovers. We expect to reveal in detail how the birds select for suitable feeding sites in relation to availability and recent levels of habitat change, potentially allowing for site selection prediction, an important prerequisite for spatially or temporally targeted conservation schemes.

Poster # 121

Carey Kuhn, Jeremy Sterling, Alex De Robertis, Mike Levine, Calvin W. Mordy, Heather Tabisola, Noah Lawrence-Slavas

Fish, fur seals, and Saildrones: using unmanned surface vehicles to understand how prey abundance and distribution influence northern fur seal behavior

CK, JS: Marine Mammal Laboratory, Alaska Fisheries Science Center/NOAA • ADR, ML: Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center/NOAA • JWM, HT: Joint Institute for the Study of the Atmosphere and Ocean, University of Washington • JWM, HT, NLS: Pacific Marine Environmental Laboratory/NOAA

Carey.Kuhn@noaa.gov

Understanding predator-prey relationships for the depleted northern fur seal (Callorhinus ursinus) is critical to help identify potential causes for the recent unexplained population decline, which has resulted in the largest US colony reaching a historic low. However, for wide-ranging marine predators, measuring prey landscapes can be a large undertaking, which is costly in terms of time and resources. Here, we integrate standard biologging techniques (satellite transmitters and dive recorders) with a novel survey method to examine predator-prey relationships between northern fur seals and walleye pollock (Gadus chalcogrammus). The at-sea behavior of 29 fur seals from St. Paul Island (Alaska, USA) was measured using dive recorders and GPS/satellite instruments from July to October 2016. During the same period (July-August), two solar- and wind-powered unmanned surface vehicles, Saildrones, equipped with low-power echosounders, were used to measure pollock abundance and depth distribution within the fur seal foraging area. The Saildrones sampled the fur seal foraging area by conducting survey grids, resulting in over 3700km of survey effort in 62 sampling days. Echosounder backscatter was classified into two categories: widespread aggregations of age-0 pollock in the upper 30m and adult pollock in deeper water, based on observed aggregation characteristics and trawl sampling conducted in July. Fur seal foraging metrics and habitat selection were examined in relation to multiple prey factors (e.g., overall backscatter, backscatter by age class, and depth distribution). We also tested the feasibility of using Saildrones to conduct remote focal-follow studies of tracked northern fur seals. Using transmitted GPS locations, two fur seals were followed in near-real time for approximately 2 days each. The results from this study will fill significant gaps in our understanding of how northern fur seals respond to variation in prey resources, which is essential to develop ecosystem-based approaches for northern fur seal conservation and fisheries management.

Poster # 124

Olga Kulikova, Ivan Pokrovsky

Patterns of landscape use of the rough-legged buzzard connected to the variation of food resourses

Max Pank Institute for Ornithology
gaerlach@gmail.com

Rough-legged Buzzard, being a mostly rodent-eating predator in a major part of its' range, shows a surprising diet variation in the areas where small rodents are naturally scarce. An extreme of this tendency - entire switch to avian prey, is present on the Kolguev Island (Barents Sea, Russia), which is not inhabited by rodents at all. By means of using GPS/gsm tracking we examined how a breeding female uses the territory within its' home range during the summer season on three study sites in the Western part of Russian Arctic: with mostly rodent, mixed and avian diets. It appeared that the shape and configuration of the most visited parts of the home range calculated using dynamic Brownian Bridge Movement Model correlate strongly with the diet type. These parts are logically connected to the specific landscape and vegetation types preferred by the dominant prey species. The mentioned tendency allows us to assume the diet type of the tracked bird when it changes the breeding site for whatever reason. This possibility can be very useful when analysing the migration strategies of the individuals in various weather conditions and food availability. We describe some of the individual rough-legged buzzard life histories that can serve a proof to the species niche broadness.

Poster # 120

Michelle E. Lander, Brian S. Fadely, Thomas S. Gelatt, Devin S. Johnson, Jeremy T. Sterling, Noel A. Pelland

Habitat use of adult female Steller sea lions: the glimmer of information gained from gigantic GAMs

Marine Mammal Laboratory, Alaska Fisheries Science Center, National Oceanographic and Atmospheric Administration
michelle.lander@noaa.gov

From 2011-2015, satellite transmitters were deployed on 13 adult female Steller sea lion (AFSSL, Eumetopias jubatus) from western Alaska because populations have failed to recover in this area and there is limited information regarding the habitat use of this age class. Two approaches were used to assess the importance of environmental variables (i.e. distance to shore and shelf, bathymetry, bathymetric slope, chlorophyll-a, sea surface temperature, sea surface height, eddy kinetic energy, season, proportion of daylight, and lunar illumination) to AFSSLs after location data were processed with a continuous-time correlated random walk model, diving behaviors were interpolated to location data, and kernel density estimates of predicted model locations were used to compute individual-based monthly utilization distributions (UDs). A multimodel inference approach was first used to examine diving behaviors (mean and maximum dive depths, frequency of dives) with respect to environmental variables using linear mixed-effects models. In contrast, single model inference was used to examine density and presence/absence data (i.e. in/out of home range and core areas) of individual UDs (n=74) with respect to environmental variables using a series of Gaussian and binomial generalized additive models (GAMs) with a smooth function applied to the location coordinates. Additionally, the weighted population means of all environmental variable coefficients from individual-based GAMs were examined for the population as a whole and across individual, seasonal, and regional scales. Overall, diving behaviors and distribution patterns of AFSSLs varied with respect to environmental data, likely reflecting specific prey behaviors encountered in different areas. Response variables of most models were significantly related to various combinations of environmental variables (P≤0.05), but distance to shore was the most influential variable across models. Our results not only improved our understanding of the habitat use of AFSSLs, but demonstrated the utility of individual-based models for analyzing animal-habitat relationships with large, heterogeneous telemetry datasets.

Poster # 138

Karissa Lear

Accelerometers reveal thermal performance regimes in free-ranging elasmobranchs

Murdoch University
k.lear@murdoch.edu.au

Temperature is one of the most influential drivers of physiology and behaviour in ectotherms, and therefore understanding how temperature influences physiological performance is important to understanding an animal's ecology. Most previous studies of thermal performance in fish have been conducted under controlled laboratory settings, but measuring physiological performance in wild systems has historically been a difficult task, creating uncertainty in how these laboratory measurements are realized in natural environments. Recent advances in technology have allowed performance of free-ranging fish to be quantified, producing a more cohesive and ecologically relevant picture of thermal performance. We used accelerometers to collect body movement data from eight species of free-ranging sharks and sawfish at a range of temperatures, determining how these fish change their activity in response to temperature. We compare the sensitivity of this response between species and energetic strategies, and fit thermal performance curves to the activity data, allowing for the estimation of optimum and critical temperatures. The temperature sensitivity and thermal performance regimes of each species are examined in the context of climate change and biogeography.

Poster # 149

K.J. Lees, A.C. Mill, P.A. Robertson, D.J. Skerritt, C. Fitzsimmons

Fine-scale movements, activity patterns, and catchability of European lobsters within a north-east fishery

Newcastle University
k.lees1@ncl.ac.uk

A major limitation in using fishery-dependent data for stock assessment is that the accuracy of the catch rate, as a proxy for abundance, depends on how well other external factors that

affect catch rate are understood (Maunder & Punt 2004). Movement patterns of the European lobster (H. gammarus) can be highly variable (Moland et al. 2011, Skerritt et al. 2015) and knowledge gaps still exist regarding its spatial ecology. A VEMCO Positioning System (VPS) (area ca. 1.5 km) was used to gather high-resolution spatially-explicit data on 58 tagged European lobsters off the Northumberland coast, England (n = 44, 2013 and n = 14, 2016). During spring 2016 parlour traps were baited and placed within the VPS to investigate lobster activity rates, visitation rates, and movement patterns around a bait source. Entrances to traps were blocked to prevent the recapture of tagged animals. A change in speed (Skajaa et al. 1998), direction (Watson et al. 2009) and proximity to the trap were used to identify potential approaches. Six of the tagged individuals (n = 14, 2016) were detected within 20 m of a baited trap. A total of ten potential trap approaches were made across the three trap deployments, eight of these occurred between 2000h and 0800h. The minimum distance a lobster was detected from a trap ranged from 1.03 m to 15.62 m, and the time spent within the vicinity of a trap ranged from 3 min to 16 h. Individual behaviour was highly variable, underlining the importance of using multiple metrics to assess potential behavioural change. Results from this work will begin to address the knowledge gaps surrounding the spatial ecology and behavioural interactions of European lobsters, and are of direct relevance to stock-assessments and marine protected areas, contributing to the further development of successful, sustainable, evidence-based fisheries.

Poster # 23

Robert Lennox, Erika Eliason, Torgeir Havn, Eva Thorstad, Steven Cooke, Tony Farrell, Frederick Whoriskey

Limited behavioural thermoregulation of Atlantic salmon Salmo salar reveals potential bioenergetic failure in a warming world

RL, SC: Carleton University • EE: University of California Santa Barbara • TH ET: Norwegian Institute for Nature Research • TF: University of British Columbia • FW Ocean Tracking Network
robertlennox9@gmail.com

Climate change poses a challenge to wild fishes, yet little is known about the behavioural use and metabolic consequences of thermally heterogeneous water encountered by wild Atlantic salmon (Salmo salar) during their energetically stressful upstream spawning migration. Archival temperature loggers revealed the thermal habitat of adult migrating salmon, which we used to apply bioenergetics models that estimated temperature driven metabolic expenditures as part of the costs of the migration. We revealed that between July

16 and August 19, the mean water temperature experienced by these salmon (tFISH) ranged from 11.5 - 18.0 °C (14.5 ± 1.2 SD°C) and closely followed the ambient surface water temperature (tRIVER) of the river (11.5 ° - 18.5 °C, 14.8 ± 1.4 °C) such that the regression equation tFISH = 1.62 + 0.88 (tRIVER) provided an accurate index (t = 260.83, p < 0.01) of fish thermal experience. Using this thermal experience and oxygen consumption data generated in the laboratory, we modeled somatic energetic depletion while the fish held in the river from July 13 - December 16, a period encompassing the migration, spawning, and post-spawn periods. Models were generated for three climate warming scenarios and three size classes of salmon at four hypothetical swimming speeds. Temperature increases were projected to elevate energetic costs, albeit more drastically for small (63.5 cm TL) salmon (51% to 65%) than large (119 cm TL) salmon (20% to 26%). Our findings suggest that with limited behavioural thermoregulation during the freshwater stage of migration, global warming will affect Atlantic salmon life history phenotypes in the Arctic. We conclude that this problem could drive the evolution of different life history phenotypes in the system, e.g., delayed river entry to avoid excessive energy depletion at warmer temperatures, or reduced probability of iteroparity, with more dire consequences for smaller individuals.

Poster # 165

Miriam Lerma, José Alfredo Castillo-Guerrero, Salvador Hernández-Vázquez, Stefan Garthe

Foraging behaviour of Masked Booby Sula dactylatra breeding in the Revillagigedo Archipelago, Mexico, eastern tropical Pacific.

ML, SG: Research Technology Center (FTZ), University of Kiel, Hafentörn 1, 25761 Büsum, Germany • JACG: CONACYT-Universidad de Guadalajara, Centro Universitario de la Costa Sur, Gómez Farías 82, CP. 48980 Melaque, Jalisco, Mexico • SHV: Departamento de Estudios para el Desarrollo Sustentable de la Zona Costera. Universidad de Guadalajara, Gómez Farías 82, CP. 48980 Melaque, Jalisco, Mexico
lerma@ftz-west.uni-kiel.de

In the eastern tropical Pacific, the Revillagigedo Archipelago was declared a Natural Protected Area in 1994 and recently designated as a world heritage site by UNESCO. The criteria for designation included its importance for breeding seabirds. Though the marine protected area extends 22.2 km around each of its four islands, it presumably excludes important feeding areas for seabirds. Furthermore, Revillagigedo is affected by El Niño Southern Oscillation events, which are known to reduce prey predictability, causing seabirds to forage further from their colonies. To identify foraging areas used by seabirds during the

breeding seasons 2016 (El Niño) and 2017 (El Niño-neutral), we attached GPS loggers on incubating Masked boobies Sula dactylatra in Isla Clarion. We obtained data from 7 individuals (22 foraging trips) in January 2016 and 15 individuals (53 foraging trips) in March 2017. We found that during the 2016 season the maximum distance from the colony was 105.1 km, maximum total distance travelled on a trip was 193.2 km, and maximum trip duration was 12 h, whereas during the 2017 season, the maximum distance from the colony was 180.1 km, maximum total distance was 378.1 and the maximum trip duration was 24 h. This is the first time that information of foraging trips of seabirds in Revillagigedo has been studied. As expected, we found that the marine protected areas exclude extensive areas that seabirds used at sea, especially during the 2017 breeding season. In addition, we found that Masked boobies foraged closer to the colony in 2016, the opposite to predictions for El Niño events. A delay in energy transfer from primary productivity to pelagic fish can occur, causing a temporal mismatch of El Niño effects on foraging seabirds. A deeper analysis will be taken to explore the foraging parameters found during El Niño event in Clarion.

Poster # 150

Josh M. London, Devin S. Johnson, Kenady Wilson, Tomo Eguchi, Brett T. McClintock, Henry R. Scharf, Frances E. Buderman

Keeping Track of Track Uncertainty: Process Imputation in Animal Movement Models

JML, DSJ, TE, BTMC: NOAA Fisheries, Alaska Fisheries Science Center • KW: Wildlife Computers • HRS, FEB: Colorado State University
josh.london@noaa.gov

Movement models are now a common tool for inferring animal space use and behavior from satellite telemetry data. An important benefit of these models is the ability to properly account for and incorporate uncertainty (both measurement and process error) into the resulting ecological interpretation. Process imputation is one of the more accessible methods for addressing uncertainty in movement models. Inferences can be made at any time interval and are based on multiple realizations of the (unobserved) position process underlying the (observed) individual track. We present four real-world examples that combine movement models with process imputation to produce movement inference that more accurately reflects the true level of uncertainty in the data. We use Argos derived locations from tags deployed on Arctic seals (ribbon and spotted seals) to develop seasonal

utilization distributions that incorporate and accurately display model uncertainty. We contrast this approach with more widely used kernel density techniques for deriving utilization distributions. Argos and GPS locations of Steller sea lions will demonstrate an expanded approach that also incorporates multiple habitat covariates. We will explore a process imputation version of a continuous-time Markov chain to estimate the effect of landscape covariates on the speed and directionality of northern fur seal movement. Lastly, using examples from Argos locations of sea turtles (green and leatherback) we demonstrate applications of a hidden Markov model to estimate behavioral states while accounting for location uncertainty and ocean surface currents. Each of these examples are based on established R packages and the techniques are readily available for movement ecologists to use in most analyses.

Poster # 157

Stephanie Loredo, Rachael A. Orben, Robert M. Suryan, Donald E. Lyons, Josh Adams

Three-dimensional habitat-use of Common Murres (Uria aalge) in the Northern California Current

SL, RAO, RMS, DEL: Oregon State University • JA: U.S. Geological Survey
stephanie.loredo@oregonstate.edu

The Common Murre (Uria aalge) is the most abundant colonial nesting seabird in the California Current Ecosystem (CCE), with at least half the population along the Oregon coast. Individual foraging strategies, at-sea movement patterns, and habitat associations are not well studied for either the breeding or non-breeding periods. To plan for renewable energy (i.e. wave and wind energy) development off Oregon, a comprehensive understanding of year-round movement patterns is needed. Obtaining such information requires small, waterproof, and high-pressure tolerant devices, as these prolific diving birds are sensitive to handling and tagging techniques. In this study, we used state of the art micro satellite transmitters coupled with saltwater sensors to study the large-scale movement patterns, habitat-use, and diving activity of murres associated with a large breeding colony on the central Oregon coast (Yaquina Head, 44.6°N), and a prominent foraging area, the largest river plume on the U.S. West Coast (the Columbia River plume, 46.2°N), during 2012, 2013, and 2015-2017. Murres in this study were not constrained to a colony (i.e. were apparently failed or non-breeders, or tagged outside the breeding period) and subsequently used a large portion of the northern CCE. Colony-wide reproductive failure and effects of tag size

were likely causes of non-central-place trips during the breeding season. Murres used nearshore habitats during both the breeding and non-breeding season and displayed the greatest diving activity during crepuscular periods. Future analysis will determine relationships between movement and environmental and habitat indicators. Diel and frequency patterns will be examined between sexes and compared between years of warm water anomalies and neutral ENSO conditions. This study is among one of the first murre tracking studies off Oregon and results will emphasize the importance of commonly used habitats and provide a better understanding of the environmental factors driving movement patterns in the northern CCE.

Poster # 63

Matthias-Claudio Loretto, Kristina B. Beck, Richard Schuster, Thomas Bugnyar

From large scale movements to local food caches - the spatial behaviour of non-breeding ravens

MCL, TB: Department of Cognitive Biology, University of Vienna, Austria • KBB: Department of Behavioural Ecology and Evolutionary Genetics, Max Planck Institute for Ornithology, Germany • RS: Department of Biology, Carleton University, Canada
mail@m-loretto.com

Non-breeders of a species can strongly influence population dynamics, however their behaviour often remains unstudied. Common ravens (Corvus corax) start breeding with three years at the earliest. In saturated populations it may take them up to 10 years or more, resulting in a large proportion of non-breeders. While raven breeders defend a territory year round, non-breeders are described as vagrant, and they are often observed in groups to forage and roost. As group they easier overcome food monopolizations of territorial breeders, but group members have to deal with high competition, high aggression rates and a higher chance that food caches get pilfered by conspecifics. We investigated on different spatial scales which behavioural strategies non-breeders follow, i.e. non-breeders could opportunistically move between different areas, or they focus on a small area with a relatively predictable physical and social environment. We combine data from GPS-tracking, VHF-tracking and behavioural observations. All non-breeding ravens relied on anthropogenic food sources such as landfills, compost station or zoos. However, we found large individual differences in the use of these food sources: Some non-breeders roamed through thousands of square kilometres (km²) and visited many food sources leading to

nomadic-like movement patterns, others moved between several food sources covering around 100 km² , and a third group were residents, i.e. they focused on a single food source and were found in an area of only a few km² over months to years. The residents of the same food source mostly shared the same space, but they developed individual site preferences on a small scale (e.g. group of trees). For a subset of resident non-breeders these areas overlapped with their preferred locations for caching food. Our results uncover different behavioural strategies in non-breeding ravens, however, on the long term the costs and benefits of each strategy still remain unclear.

Poster # 220

Emmanuel Lourie, João Paulo Silva

How can we go beyond GPS data to achieve a better understanding of species habitat selection?

University of East Anglia, UK
emm.lourie@gmail.com

GPS tracking provides highly detailed information on the location of individual animals, and by inference, the habitats they rely on. However, due to their purely spatiotemporal nature, these data fail to capture the behavioural mechanisms that drive habitat choice. Here, we tested a novel approach integrating behavioural information and space use in the study of habitat selection using data from 12 GPS tracked Little Bustards (Tetrax tetrax) in the Iberian Peninsula. To this end, we employed GPS tags equipped with an accelerometer sensor, enabling the remote identification of distinct behaviours (e.g. feeding, lying, alert) along with their corresponding spatial locations. Subsequently, behaviour-specific habitat selection models were created and compared against a conventional habitat selection model, based on locations alone. We found that habitat selection models which take account of specific behaviours identified relative habitat preferences that went undetected by the conventional location-based approach. Most evidently, the behaviour-specific models revealed that (1) frequently visited habitats are not used uniformly for all behaviours, and (2) less frequently used habitats nonetheless host important behavioural functions. This study demonstrates that by incorporating behaviours into habitat selection models, via the joint application of GPS and accelerometer technologies, a deeper understanding of habitat selection can be achieved. By disclosing the links between habitats and the key ecological functions they support, conservation managers can obtain a more comprehensive

understanding of different habitat functional roles and devise more accurate conservation intervention prescriptions.

Poster # 154

Andy Lowther, Charmain Hamilton, Jade Vacquie-Garcia, Christian Lydersen, Kit Kovacs

Gone with the wind: biologging, lies, truths and the evil realities of scale

Norwegian Polar Institute
andrew.lowther@npolar.no

Advances in biologging technology in recent years have been exponential. We now have electronic devices that are a fraction of the size that they were only a few years ago, which can collect multiple data streams at resolutions that would have defied belief at the turn of the millennia. Matching this technical evolution, there has been a growing symbiosis between ecologists and statisticians, leading to development of user-friendly advanced statistical data treatments. Both advances have in turn increased inertia within the field of biologging and inspired new animal-borne technologies. However, given that animal behaviour is modulated by their environment, this leads us to a well understood but often ignored conundrum - false positive (Type I) and false negative (Type II) relationships. We now know in incredible detail what some animals do, but the resolution of the data needed to explain why has not kept pace. If fine-scale explanatory data is not available we run the risk of i) identifying behaviours that cannot be attributed to environmental variability and ii) making predictions about animal behaviour without knowing what really drives them. We illustrate these issues with three examples of interpreting high-resolution animal movement data both with and without sufficiently resolved explanatory environmental information. Firstly, we illustrate/show profound inter-annual changes in movement patterns of GPS-instrumented chinstrap penguins in the Antarctic, with behavioural interpretation varying wildly contingent on the different qualities of environmental data incorporated. The other two examples focus on detecting and correctly assigning glacier-front habitat exploitation by (II) ringed seals and (III) white whales based on location data in the rapidly changing Svalbard Archipelago. These examples in combination highlight the pitfalls one can encounter if studies concentrate on only half the story.

Poster # 105

Warrick S Lyon, Peter De Joux, Malcolm P Francis, John Montgomery

What has GPS tracking of New Zealand smooth hound sharks taught us about these small coastal sharks?

WSL, JM: Institute of Marine Science, University of Auckland, New Zealand • PDJ, MPF,: National Institute of Water and Atmospheric Research, Wellington, New Zealand

warrick.lyon@niwa.co.nz

Smooth hound sharks (Mustelus spp.) are found throughout the world"s oceans, most are small with maximum sizes < 1.5 m. Many of these sharks migrate between shallow coastal habitats and the deeper waters of the outer continental shelf and slope. The New Zealand smooth hound shark (Mustelus lenticulatus) is distributed throughout mainland New Zealand with commercial catches reaching 1000 tonnes annually. Catches peak during the spring and summer when the sharks migrate to and congregate in shallow sheltered harbours and estuaries that are used as spawning and nursery areas. With rapid urbanization taking place around many harbours and estuaries, it is important to understand how the sharks use these coastal areas. Using a bespoke GPS tracking system that obtains location fixes every 1 - 2 minutes, we monitored 61 sharks (26 females 35 males), between October and May (Spring to Autumn) over 3 years in one estuary, for a total of 1000 hours and 500 km of tracks. We found seasonal differences, with sharks moving straighter and faster at the start of the mating season compared to highly tortuous and slower tracks after the mating season. There were also distributional differences based on the size of the shark, with medium sized sharks preferring steep sided fast flowing channels, and larger sharks being more prominent in the central basin of the estuary. A number of environmental variables have been recorded to understand and predict the distributional patterns.

Poster # 3

Chloe Malinka, Mark Johnson, Peter Teglberg Madsen

How to find your keys with a laser pointer: Using acoustic recording tags to examine spatial filtering of target information in echolocators

CM, PTM: Aarhus University, Denmark • MJ: Sea Mammal Research Unit, University of St Andrews, UK
chloe.e.malinka@bios.au.dk

Biologging technologies incorporating acoustic sensors have allowed researchers to study how echolocating animals sample their environment actively. Although toothed whales produce narrow forward-directed biosonar beams, they appear to be able to dynamically adjust beamwidth as they home in on a target. High beam directionality during search-phase echolocation reduces acoustic clutter, and the widening of the beam during final phases of prey capture allows for keeping fast-moving, evasive prey within the field of view. Biosonar beamwidths are conventionally quantified by their half-power width but this arbitrary bound may not be biologically relevant: Toothed whales steer their acoustic gaze to include and exclude information, but it is unknown what the functional beamwidth is, i.e., how far off-axis can information still be collected. Additionally, we do not know if echolocators modify their beamwidth when multiple targets are present. This study sought to understand how echolocators spatially filter their echoic scene to modulate information flow. Harbour porpoises (Phocoena phocoena) at the Fjord&Bælt centre, Denmark, were trained to close in on simultaneously presented spherical targets while performing a two-alternative forced choice task. Distances between the targets ranged from 13.5-108 cm, and were presented at varying orientation orders from one another. The free-swimming porpoises wore eyecups and were tagged with a sound and movement tag (dtag4) to record the echoic scene as experienced by the porpoises. The known ranges between targets and the porpoise, combined with the sound levels received on the target-mounted hydrophones revealed how the porpoises controlled their acoustic field of view. Porpoises exited the buzz phase when switching attention to the other target, even at close spatial separation. Here we show that the animals need to be closer to targets to discriminate between them when the targets are spaced closely together, revealing that the narrow beam of echolocators serve as a spatial filter.

Poster # 1

Shiiwua Manu, Sam Ivande, Soladoye Iwajomo, Onoja Joseph

Observations of intra-African migratory movements of some Afrotropical birds

A.P.Leventis Ornithological Research Institute (APLORI), Jos, Nigeria
shiiwua.manu@aplori.org

Advances in satellite tracking technology have led to increased study of animal movements. While this has improved our understanding of especially intra-continental migration, similar information on the intra-tropical movements of Afrotropical birds still remains scare. Using geolocator and satellite telemetry, we tracked year round movement of three Afrotropical birds: Abdim's Stork Ciconia abdimii (n=2), African Cuckoo Cuculus gularis (n=3) and Black Coucal Centropus grillii (n=1). Preliminary results from our ongoing studies indicate that after breeding in north central Nigeria, both tagged Abdim's Storks migrated north to a stop-over site around Lake Chad, before migrating southeast to a non-breeding site south of Lake Victoria. African Cuckoos however migrated to more forested sites in the Adamawa region of Cameroon (n=2) and western Central African Republic (n=1). The Storks covered a distance of about 3,500 km in three months and 22 days during the post-breeding migration but covered a similar distance on the return journey within two months with a brief stop-over north of Lake Victoria. This pattern was similar for both Storks, although there was considerable individual variation and with more stopover sites used during post-breeding migration for African Cuckoos. The Black Coucal migrated from its breeding ground in central southern Nigeria to the rainforest of the Niger Delta region of Nigeria (n=1), covering a total distance of 225 km in 30 days during the post-breeding migration and 184 km in 2 days during the return journey. Overall, the observed migratory movements of these intra-African migrants are similar to those of other inter-continental migrants with directed movement at specific times of the year, but also highlight the importance of certain habitats as stop-over and non-breeding habitats for these species.

Poster # 169

Chimienti Marianna, Cornulier Thomas, Owen Ellie, Bolton Mark, Davies Ian, Travis Justin, Scott Beth

Should I stay or should I go? Hierarchical movement decisions in foraging seabirds

School of Biological Sciences, University of Aberdeen, Tillydrone Ave, Aberdeen, AB24 2TZ, UK, RSPB Centre for Conservation Science, North Scotland Office, Etive House, Beechwood Park, Inverness, IV2 6AL, UK, RSPB Centre for Conservation Science, The Lod
mariannachimienti@gmail.com

Movements of foraging animals in heterogeneous environments vary according to forager information about resource distributions, internal state and motion capabilities. Animals adopt scale-dependent movement patterns aiming to exploit hierarchically distributed resources efficiently. The information rich data collected with combined tracking technology has not been yet fully explored and exploited in order to gain insights into how movement effort and past experiences affect animal decision making and movement modes at several temporal scales. We use data collected with combination of GPS, TDRs and accelerometers on two species of foraging diving seabirds, Razorbills (Alca torda) and Common guillemots (Uria aalge). By using the number of prey and catching events performed over time spent underwater (PCE/s) and the partial Overall Body Dynamic Acceleration as perceived patch profitability and effort, we explore how these variables lead to dynamic behavioural switching and, specifically, scale dependent movement patterns. Type of resource encountered, foraging tactics and different evolutionary trade-offs between pursuit-diving and flight in the two species shaped differences in foraging decisions. Within a foraging patch, intense foraging activities, long and deep dives, effort accumulated and prey availability reduced the probability of staying in the foraging state. When moving between patches, both species preferred to rest on the water surface rather than flying. After short rests, specific thresholds of patch profitability stimulated foraging activity. The probability of getting back to foraging peaked for values of patch profitability of 5-10 (PCE/s) in razorbills and 2.5 (PCE/s) in guillemots. Differences in foraging decisions indicated preferences for different perceived optimal patch profitability, prey aggregations and different abilities to respond to temporal changes. Understanding animal decision making in environments where resources highly vary in space and time has the potential to better predict the effects of anthropogenic developments and climate change and inform conservation and management plans.

Poster # 119

Bruce Mate, Ladd Irvine, Tomas Follett

Sperm Whales as Indicators of Benthic Oil Impacts Associated with the Deepwater Horizon Oil Spill

Marine Mammal Institute, Fisheries and Wildlife, Hatfield Marine Science Center, Oregon State University
bruce.mate@oregonstate.edu

Gulf of Mexico (GOM) sperm whales were tagged with Argos Advanced Dive Behavior (ADB) tags (Wildlife Computers PATF) during 2011 and 2013 as part of a larger study to assess impacts of the 2010 Deepwater Horizon (DWH) oil spill. ADB tags recorded GPS positions at the surface and 1 Hz depth and acceleration data to describe underwater behavior up to 45 days. Tags released from the whales, floated and were recovered to download full datasets. No diel pattern was detected in dives. "Jerks", a proxy for foraging effort, occurred at midwater, but most commonly near-bottom depths. Highly variable jerk rates from dive to dive suggested whales searched over large areas for sparsely distributed high-density prey patches. A low-use habitat (LUH) area of ~4,000 sq.km, including the DWH site, was identified from 2011 tagged whale movements and was also apparent from 2013 movements. The LUH was a SW-NE-oriented oblong area, between whales moving along the continental slope and those using deeper water, coinciding with the modeled distribution of spilled oil. In 2013, one tagged whale circumnavigated the deepwater side of the LUH in 3 days, with a 95% reduction in foraging effort compared to dives outside the LUH. We don"t know if whales foraged on demersal squid or fish, but hypothesize that benthic oil contamination has reduced LUH prey density, and thus also the distribution of whales. Monitoring benthic communities directly is exceedingly difficult. Our study suggests the distribution and foraging of wide-ranging GOM sperm whales is a unique opportunity to evaluate the duration and extent of oil impact on the benthic food web and habitat recovery. If the observed effects are long-term, then subsequent spills may have cumulative impacts, which are typically hard to measure, resulting in population consequences at multiple trophic levels.

Poster # 137

Birgitte I. McDonald, Siri L. Elmegaard, Mark Johnson, Danuta M. Wisniewska, Jonas Teilmann, Peter T. Madsen

Wild harbor porpoises exhibit exercise modulated surface heart rate response

BIMD: Moss Landing Marine Labs, California State University • SLE, DMW, JT, PTM: Department of Bioscience, Aarhus University • MJ: Scottish Oceans Institute, University of St. Andrews • DMW: Hopkins Marine Station, Stanford University
gmcdonald@mlml.calstate.edu

Cetaceans have evolved an impressive capability to undertake long, deep breath-hold dives. If we are to understand the limits of dive performance, the foraging ecology, and the ability of cetaceans to adapt to environmental change, it is essential to understand the physiological responses to diving. Decreased heart rate is central to the ability of marine mammals to perform extended dives, and has been documented in captive dolphins. Based on these captive studies, it has been hypothesized that cetaceans exhibit an exercise modulated dive response, with higher dive heart rates associated with increased activity, however, we know essentially nothing about cardiovascular regulation in wild foraging cetaceans. In 2016 we deployed a suction cup ECG Dtag3 on two porpoises allowing us to investigate the heart rate response in relation to diving, exercise, and foraging behavior for the first time in a wild cetacean. The dataloggers remained on the porpoises until programed release, collecting 12 and 38 hours of data. Both porpoises exhibited several hours of foraging behavior. Bottom heart rates were similar in both foraging and non-foraging dives and typically ranged between 55-75 beats/min, despite an increase in activity associated with foraging behavior. Conversely, surface heart rates were significantly different. After non-foraging dives, surface heart rates ranged between 160-180 beats/min and heart rate decreased between respirations. After foraging dives, heart rate ranged between 190-210 beats/min and remained elevated between respirations. In contrast to studies that report an exercise modulated dive response, we found that, while porpoises exhibited a similar dive response in most dives, they increased heart rate at the surface after active foraging dives, likely to offload CO_2. This new technology offers a promising window into the complex relationship between foraging, exercise, and oxygen management in wild cetaceans facing increased human encroachment that may have physiological consequences.

Poster # 175

J. Chris McKnight

Shedding new light on diving physiology: using non-invasive near-infrared light spectroscopy to measure haemodynamics and oxygenation in the brain of free-swimming seals

Sea Mammal Research Unit
jcm20@st-andrews.ac.uk

Knowledge of oxygen store management during diving underpins our understanding of energetics and foraging decisions in marine mammals. Minimally invasive measurement of real-time tissue-specific blood flow and oxygenation in diving mammals remains challenging. We developed the first aquatic, non-implanted, near-infrared spectroscopy (NIRS) sensor measuring regional blood flow (total haemoglobin [tHb]) and oxygenation (oxy-deoxyhaemoglobin [HbO2 - HHb]) in the brain of four freely-diving harbour seals. Optical properties (μa, μs, g, $\mu s1$) were generated for seal tissues using optical-coherence-tomography and spectrophotometry. Optical propagation and Differential-Pathlength-Factor (DPF) were modelled using 3D Monte Carlo radiation transfer codes to develop seal-specific optical algorithms extracting tHb, HbO2 and HHb concentrations from optical signal. Instrumented seals performed voluntary dives (n =194) swimming underwater to a feeding station 60m from a respirometry chamber. Oxygen consumption (VO2) was measured for each post-dive surfacing. Blood flow to the brain decreased rapidly over the first 60s of a dive, after which it steadily increased to above pre-diving levels. Oxygen depletion rate was constant throughout the dive independent of locomotor activity, suggesting locomotor muscle blood flow decouples from core flow. Brain blood flow increased rapidly 10-15s before surfacing, reaching oxygen concentration minima (O2min), suggesting reperfusion in anticipation of surfacing. O2min of brain tissue for each dive were compared with VO2. Generalized additive mixed models showed a robust relationship between O2min and VO2 in brain, showing utility of the method to estimate tissue specific dive-by dive oxygen consumption. Seals do not fully reoxygenate blood oxygen between dives resulting in declining blood oxygen concentrations across consecutive post-dive-surface-intervals. As oxygen concentration falls across consecutive surface-intervals there is an increase in haemoglobin suggesting utilisation of venous oxygen stores to maintain a diffusion gradient in cerebral tissue. Physiological tolerance to falling blood oxygen concentration allows seals to maximise foraging efficiency by reducing post-dive-surface-interval duration.

Poster # 225

Rhiannon Meier, Federico De Pascalis, Gina Ebanks-Petrie, Tim Austin, Jonathan Green, Greg Morgan, Jane Haakonsson, Stephen Votier, John Arnould

Male frigatebirds are less magnificent than you think: linking foraging behaviour to parental roles in a pantropical seabird

University of Liverpool
fededepa@primolivello.it

Intra-population differences in movement behaviour based on factors such as sex, age, life stage and social status are observed in a wide range of taxa, and are often attributed to competition, nutritional requirement, physiological constraints and/or levels of parental investment. Magnificent frigatebirds (Fregata magnificens) are pantropical seabirds known to use a range of feeding techniques, and exhibit dramatically differing parental roles between the sexes (males reduce rates of chick-provisioning, and cease parental care, months before females). Despite the intriguing life history traits of frigatebirds, our understanding of their movement behaviour and links to breeding strategies remains poorly studied. Using a combination of archival GPS, GPS-GSM loggers, bird-borne cameras and tri-axial accelerometers, we investigated the fine-scale foraging movements of chick-rearing adult magnificent frigatebirds from a breeding population in the Cayman Islands. Opportunistic regurgitate samples were also collected to provide information on dietary behavior. Our results indicate that this population engages in two markedly different foraging strategies: i) short, coastal trips over the continental shelf during which individuals target reef species, and are known to engage in both kleptoparasitic interactions and other modes of scavenging, and ii) long, offshore trips during which birds feed on schooling pelagic prey. These differences were partially explained by sex, with males roaming further from nests than females, and showing a higher propensity to forage offshore. Preliminary video data indicate that coastal foraging birds feed in groups while conspecific interactions were not observed offshore. We examine changes in movement behaviour based on the stage of chick rearing, and discuss our results with respect to differing levels of parent investment between the sexes.

Loriane Mendez Aurélien Prudor, Henri Weimerskirch

Ontogeny of foraging flights in juvenile red-footed boobies (Sula sula)

Centre d'Etudes Biologiques de Chizé (CEBC-CNRS)
loriane.mendez@cebc.cnrs.fr

Juvenile stage represents a crucial period in the life of an individual and can strongly influence population dynamics. We studied the development of the foraging behaviour of the red-footed booby, a tropical seabird with an extensive post-fledging care period. Juveniles and adults from Europa Island (Mozambique Channel) were observed from shore during visual surveys and tracked at sea using GPS loggers over 3 consecutive 12-days periods. Juveniles made first a majority of inland flights and some short trips at sea probably to practice flying. On land, they often formed groups of several juveniles leaving later and returning to the island earlier than the adults in order to be fed on their nest. Juveniles left the colony progressively more often alone over time. The total distance travelled and the maximum range from the colony of their trips increased over time, while remaining significantly shorter than those of adults. Juveniles associated frequently with congeners at-sea but foraged independently of their parents. Their intensive foraging activity could reflect practicing with attempts to catch preys. These results are briefly compared with juveniles of 2 islands located at distant latitudes: Genovesa Island (Galapagos archipelago) and Surprise Island (New Caledonia). The extensive post-fledging care period observed in the red-footed booby may be explained by the need to develop proper foraging skills adapted to tropical waters, where resources are particularly scarce and unpredictable.

Poster # 155

Benjamin Merkel, Sébastien Descamps, Nigel G Yoccoz, Francis Daunt, Kjell-Einar Erikstad, Aleksei V Ezhov, Mike P Harris, Maria Gavrilo, David Grémillet, Svein-Håkon Lorentsen, Erlend Lorentzen, Tone K Reiertsen, Harald Steen, Geir H Systad, Þorkell Lindb

Migration in geographic and environmental space by two sympatric seabird species on an ocean basin scale

BM, SD, EL, HSte, HStr: Norwegian Polar Institute, Fram Centre, P.O. Box 6606 Langnes, 9296 Tromsø, Norway • BM: Department of Arctic and Marine Biology, The Arctic University of Norway, 9037 Tromsø, Norway • NGY, FD, MPH, SW: Centre for Ecology and Hydrology, Natural Environment Research Council, Bush Estate, Penicuik, Midlothian EH26 0QB, UKKEE, TKR: Norwegian Institute for Nature Research, Fram Centre, P.O. Box 6606 Langnes, 9296 Tromsø, Norway • AVE: Murmansk Marine Biological Institute, 17 str. Vladimirskaya, Murmansk 183010, Russia • MG: National Park Russian Arctic, 57 Sovetskikh Kosmonavtove ave., Archangelsk, Russia • DG: Centre d'Ecologie Fonctionnelle et Evolutive, UMR 5175 du CNRS, Montpellier, France • DG. Percy FitzPatrick Institute, DST/NRF Centre of Excellence, University of Cape Town, Rondebosch, South Africa SHL: Norwegian Institute for Nature Research, P.O. Box 5685 Sluppen, 7485 Trondheim, Norway • GHS: Norwegian Institute for Nature Research, Thormøhlensgate 55, 5006 Bergen, Norway • ÞLÞ: Northeast Iceland Nature Research Center, Hafnarstett 3, 640 Husavik, Iceland

benjamin.merkel@npolar.no

Taking advantage of spatially distributed, but temporary resources, is one major benefit of migration. Seabird migration, however, is often seen as geographical movements, despite the highly variable association between resources and space in dynamic marine ecosystems. Here, specific environmental conditions might be often more strongly associated with seabird prey resources (i.e. plankton and fish) than geographical locations. Using more than 1000 light level logger tracks of more than 600 common and BrÜnnich"s guillemots from 11 colonies in the Barents, Norwegian and North Seas during nine years, we analysed the inter- and intra-specific geographical and environmental space use and their overlap during the non-breeding season. These sympatric species represent the deepest diving seabird species in the northern hemisphere. They have high flight costs and display contrasting population dynamics. Preliminary results indicate that both species use distinct, sometimes colony-specific, geographical areas throughout the North Atlantic during different seasons that overlap to varying degrees. A suite of environmental parameters were chosen, in order to describe the energetic costs (e.g. air temperature) and possible prey availability (e.g. bathymetry, sea surface temperature, and distance to marginal sea ice zone) for the two species. Here, first results indicate rather distinct environmental conditions for each species, with Brünnich"s guillemots mostly associated with colder water masses near frontal systems and common guillemots mainly associated with Atlantic water masses in shelf seas.

Poster # 211

Gregory B Merrill Jr, J. Ward Testa, Jennifer M Burns

Foraging Trip and Shore Stay Durations: potential indices of prey availability and reproductive success in a depleted marine mammal - the northern fur seal (Callorhinus ursinus).

University of Alaska Anchorage
gbmerrilljr@alaska.edu

Lactating northern fur seals (NFS) make repeated foraging trips from Pribilof Island colonies to predictable regions in the Eastern Bering Sea to support milk production, which in turn influences pup growth and survival. Female NFS show a high degree of philopatry to both rookeries and foraging domains, which facilitates an investigation into whether rookery-averaged Maternal Foraging Trip and Onshore Stay Durations (MFTD/OSD) can be used to track prey availability through its effect on average pup mass in late fall. Specifically, we expected MFTD/OSD (1) to vary by rookery within and among seasons in response to factors that influence prey availability, and (2) to correlate spatially and temporally with the average pup mass at each rookery. VHF transmitters recorded MFTD/OSD for fourteen females at Polovina Cliffs (PC), St. Paul Island (SP) in 2015 and on eighteen females in 2016. In 2016, 117 additional females were tagged at Zapadni Reef, SP and four rookeries on St. George Island (SG: South, North, East, and Zapadni). Pup mass was measured at three rookeries. In 2016, MFTD and OSD were longer on SP than SG ($p < 0.05$), and females from rookeries that were in close proximity had similar MFTDs, which differed from females from rookeries further afield (North|East=7.1|6.6days vs. South|Zapadni =5.9|5.4days). Yet, OSD did not differ between SG rookeries (x =1.48days) suggesting that females from the northern side of SG had to travel further, or forage longer in order to obtain similar amounts of energy for milk production. An interannual comparison at PC revealed that MFTD and OSD were ~1d longer in 2016 than in 2015 ($p < 0.01$), and that mean pup mass fell from 11.2 to 10.0kg. General trends of lower average pup mass and longer average MFTD/OSDs during the unusually warm 2016 summer suggest MFTD/OSD may be a good index of local prey availability.

Poster # 51

Katherine Mertes, Jared Stabach, Tim Wacher, Melissa Songer, John Newby, Peter Leimgruber,

Reintroduction in motion: movement timing by released Scimitar-horned oryx in a heterogeneous, seasonal environment

KM, MS, PL: Conservation Ecology Center, Smithsonian Conservation Biology Institute • JS: Smithsonian Conservation Biology Institute, USA • TW: Zoological Society of London, London, UK • JN: Sahara Conservation Fund, L'Isle, Switzerland

MertesK@si.edu

The scimitar-horned oryx (Oryx dammah) has been considered Extinct in the Wild since the mid-1980s. Beginning in August 2016, approximately 100 oryx - including 75 carrying GPS collars - have been released into the Ouadi-Rimé Ouadi Achim Game Reserve (OROAGR), a large protected area in central Chad. We used generalized linear mixed models to evaluate the drivers of movements by these captive-reared oryx released into a novel, seasonally variable environment. In general, the optimal movement trajectory of an herbivore moving through a heterogeneous landscape is expected to maximize its exposure to nutritious forage (i.e., early stages of plant phenology). Such optimal resource exploitation may be achieved by (1) perception of current environmental conditions or (2) spatially explicit memories of past environmental conditions. We used the instantaneous rate of green-up (IRG), a rate of change in the normalized difference vegetation index (NDVI), to assess forage quality at different temporal lags (up to a maximum of 4 months, the median annual duration of precipitation-elevated IRG across OROAGR since 2000). We constructed generalized linear mixed models relating observed and available oryx locations to (i) median IRG within a mean weekly displacement distance at different lags, and (ii) cumulative measurements of recursion density. Models included random effects to account for locations grouped within both individuals and release groups. We assessed model fit using the Akaike information criterion (AIC), and generated gridded predictions of oryx occurrence across OROAGR. The most accurate model predictions arose from IRG from eight months prior to the observed location and cumulative recursion density. Our results suggest that reintroduced oryx employ a hybrid strategy of anticipating forage quality (i.e., "jumping" the green wave), and returning to known areas to optimize their exposure to nutritious vegetation - with additional variation explained by the management regime at their captive institution of origin.

Poster # 18

Bernd Meyburg, Wouter M.G. Vansteelant

Survival and migratory development of Lesser Spotted Eagles (Clanga pomarina): insights from translocation and lifelong tracking

BM: BirdLife Germany • WMGV: Inst. for Biodiversity and Ecosystem Dynamics, Univ. of Amsterdam
BUMeyburg@aol.com

The mechanisms driving ontogeny of migration routines and survival of migrant birds are still largely unresolved. We studied migratory development and concomitant survival of a social soaring migrant: the Lesser Spotted Eagle (Aquila pomarina). Between 2004 and 2015, 79 second-hatched eaglets (Abels) that would normally be killed by their elder siblings (Cains), were removed from wild nests, reared in captivity, then released to supplement the declining German population, including 50 birds that were translocated 940 km from Latvia. In 2009, 12 of these translocated juveniles, as well as 8 juveniles and 9 adults from German nests, were tracked by satellite telemetry to determine how translocation affected the ability of birds to learn strategic migratory detours, and how migratory behaviour affected survival. Most native German juveniles (6/8) departed along the eastern Mediterranean flyway around the same time as native adults. Five translocated eagles travelled southward, following a different innate migratory direction than native juveniles, and died in the Mediterranean region. Consequently, a smaller proportion of translocated LSEs (4/12) than native LSEs (7/8) reached Africa. Those translocated individuals that successfully migrated around the Mediterranean had departed at approximately the same time and in the same direction as native birds, suggesting they learned the route by following experienced older birds. In the future, juveniles used in such a supplementation effort will be sourced from a nearby population in Poland to ensure they can follow adults after translocation. Unfortunately, many eagles are shot on migration, and so few eagles survived their first year, whether they were translocated (2/12) or not (2/8). However, survivors improved migratory performance in years following their first, and had a high chance of reaching adulthood and establishing territories in or near Germany. Removing and translocating Abels helps reinforce the declining German population, however illegal hunting must be stopped.

Poster # 215

Megan M. Meyers, Mark Erdmann, Malcolm Francis, Abraham Sianipar, Rochelle Constantine

Whale shark spatio-temporal distribution in Cenderawasih Bay, West Papua, Indonesia

MMM, RC: University of Auckland • ME, AS: Conservation International • MF: The National Institute for Water and Atmospheric Research
r.constantine@auckland.ac.nz

The whale shark (Rhincodon typus) is a cosmopolitan species found in tropical and subtropical oceans that exhibits a range of residency and movement patterns. From 2010 to 2016 we photographically identified 108 individuals in Cenderawasih Bay, Indonesia, a population dominated by juvenile males (93%). To determine spatio-temporal habitat use and distribution, from June 2015- May 2016 we deployed 16 SPLASH10 fin-mount satellite tags on male sharks. Ten tags were recovered after 88 to 499 days of deployment, with mean transmission of 271 days (± 30 S.E.). Five sharks remained within the bay during the study and ten sharks traveled outside the bay from late March to early May. Their paths covered both coastal and offshore waters, with individuals traveling up to 5,154 km away from the initial tagging position. These movements may be in response to environmental factors, including sea surface temperature and local current changes. A switching state space model showed that sharks spent an average of 81% of their time foraging, mostly in shallow waters (median=35m), while the majority of traveling was observed over deeper waters (median=1,284m). Sharks spent the majority of their time in the upper 25 m of the water column (66%). Reverse diurnal vertical movement was observed, with more time spent at the surface (<10m) during the day than at night. The majority (84%) of deep diving activity (>200m) took place during the day, with an observed maximum depth of 1,860 m. The movement patterns show variable periods of residency in the bay during the sharks" juvenile years, with individual patterns of horizontal and vertical movement most likely in response to different abiotic and biotic factors, which may trigger seasonal dispersal and affect diving behaviour.

Poster # 230

Théo Michelot

Can animals do MCMC? Integrating resource selection and step selection

University of Sheffield
tmichelot1@sheffield.ac.uk

Linking animal movement to environmental conditions is a crucial step to understand how animals might be affected by a changing environment. Resource selection functions aim to model the spatial distribution of an animal's locations in terms of the distribution of spatial covariates (or resources). Step selection approaches extend the framework to incorporate movement, by modelling the animals' displacements in terms of the distribution of resources. However, step selection methods do not generally make it possible to estimate the resource selection function, such that the two approaches are usually incompatible. We will describe a new model for step selection, for which the distribution of the animal's locations (i.e. its utilisation distribution) coincides with the resource selection function. Our method uses an analogy between the movements of an animal in the plane and the movements of an MCMC sampler in 2D parameter space, to guarantee convergence to the utilisation distribution. This defines a very vast and flexible class of movement models, within which parameters of resource selection can be estimated. We will compare our model to other resource selection and step selection approaches, on simulated data with known distributions and, if time permits, on real data.

Poster # 153

Børge Moe

Persistent post-breeding hotspots in the cold - large-scale tracking of kittiwakes in the north-east Atlantic

Norwegian Institute for Nature Research
borge.moe@nina.no

After the breeding season, seabirds are presumed to aggregate in areas of high resource abundance, so-called hotspots, to replenish energy reserves and replace worn feathers. Few studies, however, have investigated inter-annual variation in such movements among

multiple populations and whether hotspots might persist over years. We performed a large-scale study on black-legged kittiwakes Rissa tridactyla in the north-east Atlantic, comprising data from twenty colonies in six countries during 2007- 2016. Kittiwakes, from each of the colonies, were tracked with geolocators for 1-8 years, and we used data from the post-breeding period August to November. Kittiwakes aggregated in hotspots located in the seasonal ice zone in the Barents Sea and the Greenland Sea/Denmark Strait. Birds from Norway and Russia were more likely to target the Barents Sea, while birds from UK, Denmark, Faroe Islands and Iceland were more likely to target the Greenland Sea/Denmark Strait, demonstrating spatial patterns in the movements and in the composition of the post-breeding aggregations. These hotspots, thus, attracted birds from colonies located far away, migrating > 1500 km north to reach these areas before heading southwest to the wintering area. The alternative strategies used by kittiwakes were to stay close to their breeding colony or migrate directly towards the wintering area. Furthermore, the results show both inter-annual variation and that hotspots persisted over many years with high and predictable concentrations of birds. Large-scale tracking studies can effectively monitor seabirds on ocean scale. Our results seem to reflect both dynamic and predictable features of the north-east Atlantic, including waters close to the breeding colonies and distant waters, and their importance for kittiwakes. Given concerns about ocean warming, melting sea-ice and increased human activities in the north, identification of persistent hotspots may assist marine spatial planning and the conservation of declining seabird species.

Poster # 57

Christopher T. Monk, Thomas Klefoth, Robert Arlinghaus

Are individual differences in fish movement related to angling vulnerability? A whole-lake reality mining experiment in the wild using four species

CTM, RA: Department of Biology and Ecology of Fishes, Leibniz-Institute of Freshwater Ecology and Inland Fisheries, MÜggelseedamm 310, 12587 Berlin, Germany • TK: Angler Association of Lower Saxony, Bürgermeister-Stümpel-Weg 1, 30457 Hannover, Germany,
monk@igb-berlin.de

Passive fishing gears, such as hook-and-line angling, are expected to selectively capture fish of certain behavioural types because by definition passive gears exploit fish behaviour. Behaviours increasing angler encounters (e.g., activity or activity space size) and behaviours promoting bites (e.g., boldness or aggression) are good candidates for angling induced behavioural selection, but the importance of specific behaviours is likely a function of a

given species' foraging mode in light of the lures and baits by which it is targeted. Further, fishing induced behavioural selection is expected to be modified by the searching strategies and techniques of fishers. Our aim was to comprehensively tease apart the role of fish and fisher behaviour as it relates to fish vulnerability in the wild by analyzing long-term high-resolution acoustic tracking data at a whole lake-scale collected from both piscivorous and omnivorous fishes, viz.: perch (Perca fluviatilis), carp (Cyprinus carpio), tench (Tinca tinca) and pike (Esox lucius). All species were experimentally angled. Direct encounters with anglers and related behaviours including activity, activity space size, or distance to the shore were unrelated to angling vulnerability in carp, tench and perch. Perch preferring a certain habitat (north lake shore) were, however, preferentially captured independent of angler encounters. By contrast, activity and activity space size were significant drivers of vulnerability in pike, supporting the idea that the relationship between fish behaviour and vulnerability is species specific. All behaviours we assessed were repeatable in the wild, such that ultimately our data suggest angling-induced selection targets different behaviours in different species.

Poster # 135

Jerry H. Moxley, Connor F. White, Adrian C. Gleiss, Taylor K. Chapple, Paul E. Kanive, Scot D. Anderson, Salvador J. Jorgensen

Development and assessment of a generalizable correction method and R package gRumble for orienting unfixed biologging devices in the stomach of white sharks

JHM, CFW, SJJ: Monterey Bay Aquarium • ACG: Murdoch University • TKC: Stanford University • PEK: Montana State University • SDA: Point Reyes National Seashore
jmoxley@mbayaq.org

Advances in movement and behavioral observation by biologging devices are complicated by difficulties in deployment and retrieval that necessitate animal capture causing handling stress and introduce potential behavioral effects from carrying a tag. With proper post-processing, data loggers ingested by animals can similarly monitor overall body movements, negating invasive capture and deployment and mitigating possible behavioral changes. To address these needs for unfixed logging devices, we developed a correction method and software package capable of estimating correction angles dynamically that continuously re-align the tag's orientation with animal body posture. We fed data loggers to free-swimming white sharks (Carcharodon carcharias) that monitored behavior via tri-axial accelerometer,

magnetometer, and gyrometer sensors that were unfixed in relation to the animal's posture and re-positioned intermittently through stomach movement. Using a dynamic approach to identify optimal averaging of tag positions over sufficiently long periods of time, the software package gRumble calculates rotation angles between animal posture and tag orientation. Using estimated correction angles, raw acceleration data is transformed to align with the tagged animal's posture producing a data series equivalent to a fixed tag attachment. Simulation exercises assessed the accuracy of this method by rotating fin-mounted (i.e., fixed) data through random walks, applying the gRumble methodology, and evaluating the method's ability to recover the original data. Recovery of locomotion signals (tail beat amplitude and frequency) was robust even at high rotation rates. Instantaneous measures of body pitch were more sensitive to the effect of increasing rotation rates, suggesting the method is more capable at characterizing organismal movement patterns than body posture. This generalizable method thus allows researchers to capitalize on high-resolution movement sensors while minimizing tagging influence.

Poster # 141

Yasuhiko Naito

Towards sophistication of foraging behavior study, development of new observation systems for investigation of prey sensing system of marine mammals

National Institute of Polar Research
yasuhiko@dream.ocn.ne.jp

Feeding is critical event for animals to survive, and animals should have developed adaptive and skillful foraging manner to fit to their own environments. Therefore "foraging" has been main theme in ecology and physiology. However, our understanding on animal foraging have remained less clear, because observation is often difficult particularly in marine mammals and thus studies have been depending on experimental approach in captive condition, indirect approach using behavioral proxy of foraging, e.g. dive profile analysis in diving mammals and theoretical approach. For improvement of foraging study method, we recently developed long-term feeding event recorder and movement recorder, which enabled us to assess foraging success of northern elephant seal based on gain-cost efficiency. While our advanced system may contribute to study of animal foraging in ecology, nothing has been developed in physiology to study how animals locate their prey, which is a first key to our understanding animal foraging. To contribute foraging study in

physiology development of new observation system is strongly expected. For this purpose, we developed (1) very small video to record whisker movement and (2) light level recorder for detection of bioluminescence in ambient environment. Simultaneous data from those and the feeding recorder may allow us to examine how those were synchronized, and may provide us idea if animals use these as tools for locating prey. To gain new insight into foraging system of deep diving mammals we successfully used these systems on northern elephant seals indicating a new developed system may support our understandings of animal foraging in deep sea.

Poster # 213

J.K. Nielsen, F. Broell, T. Loher, C. Rose, P. Drobny, C.T. Taggart, A.C. Seitz

Characterizing activity patterns of Pacific halibut with accelerometer data from Pop-up Satellite Archival Tags

JKN, ACS: University of Alaska Fairbanks College of Fisheries and Ocean Sciences • FB, CTT: Dalhousie University Department of Oceanography • TL: International Pacific Halibut Commission • CR: FishNext Research LLC • PD: Spearfish Research
julie.nielsen@gmail.com

Pacific halibut is one of the largest flatfish species and is the basis of high-value commercial and sport fisheries in the north Pacific Ocean. Halibut are ambush predators that may remain motionless on the seafloor for extended periods of time. Although halibut activity patterns in heterogeneous study areas can be characterized based on change in depth alone, it is difficult to distinguish movement along the seafloor from periods of inactivity in areas with homogeneous bathymetry. We present a method for detecting and characterizing activity of halibut based on accelerometer data from Pop-up Satellite Archival Tags (PSATs). PSATs are attached to halibut with a dart and tether and float freely above the fish in a vertical orientation when the fish is sedentary. When halibut switch from sedentary to swimming behavior, the PSAT changes to a horizontal orientation as it is pulled behind the swimming fish. These changes in orientation are recorded in the tilt measurements on board the PSAT. We provide examples of daily and seasonal activity patterns based on PSAT accelerometer data from lab studies, physically recovered PSATs with detailed data, and summarized accelerometer data transmitted via the Argos satellite network. The method has been successfully used to assess survival of Pacific halibut caught as bycatch in bottom trawl fisheries.

Poster # 197

Takuji Noda, Takuya Koizumi, Nobuaki Arai, Yoshinori Miyamoto, Takashi Kitagawa, Hiromichi Mitamura, Kazushi Miyashita

A cloud-based data management system for extracting, archiving and querying important features of bio-logging dataset

The Institute of Statistical Mathematics • Biologging Solutions Inc. • Field Science Education and Research Center of Kyoto University • Graduate School of Marine Science of Tokyo • University of Marine Science and Technology (et al.)
noda.takuji@ism.ac.jp

In Japan, there is a national project (CREST) ongoing to develop efficient but reduced-cost data loggers to increase the volume and rate of data recovery in open water, and the number of researchers using bio-logging technology have been expanding. However, it is not generally an easy task for newly-joined researchers to analyze bio-logging data. With the advance of electronics of bio-logging devices, data volume even tends to be increased, which makes it more difficult to deal with the data. Therefore, to promote the usage of bio-logging technologies, we have been developing a cloud-based solution which allows users to analyze bio-logging data easily on web while managing their dataset. Although there have been already many data management/analysis/sharing system hosted on web for bio-logging in the world, these conventional system are not tuned for accepting, processing and analyzing dataset of bio-logging devices composed of a variety of sensors (e.g. acceleration, depth, acoustic, image data etc.). In addition, with the increase of data volume in the database system, it is difficult to grasp the feature of data at hand. Thus, it is beneficial for the system to store statistics and important features of data by applying signal processing functions, machine learning and artificial intelligence, at the same time with storing raw dataset. From the viewpoint of data-sharing, although not all researchers are willing to transfer their data for sharing, it may be more easily accepted to publish extracted statistics and features from the raw data (e.g. trained models for accelerometer metrics in relation to foraging behavior). Thus, our cloud-based data management system can allow users for extracting, archiving, and querying important features of bio-logging dataset. Our system is scalable so that it is easy to maintain and develop additional functions for processing and analyzing dataset, with thanks to the recent PaaS vendors' technologies.

Poster # 198

Tenaya Norris, Deborah Fauquier, Cara Field, Sophie Whoriskey, Casandra Gálvez, Teresa Rowles, Justin Viezbicke

At-sea distribution and habitat use of free-ranging and rehabilitated Guadalupe fur seals

TN, CF, SW: The Marine Mammal Center, USA • DF, TR: Marine Mammal Health and Stranding Response Program, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, USA • CG: Centro Interdisciplinario de Ciencias Marinas, Instituto Politécnico Nacional (CICIMAR-IPN), Departamento de Pesquerías y Biología Marina, Mexico • JV: West Coast Region, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, USA
norrist@tmmc.org

Tracking rehabilitated animals post-release provides greater access to study the distribution and habitat use of poorly understood species, such as the Guadalupe fur seal (GFS, Arctocephalus townsendi). It is, however, often difficult to assess if post-release movements of rehabilitated animals represent normal species distribution and habitat use patterns. In 2015-2017, 29 rehabilitated and 43 free-ranging GFS were tracked using location transmitting satellite tags (pups and yearlings, n=46) or satellite-linked dive recorders (juveniles and adult females, n=26). Overall, GFS broadly used the California Current System (CCS), but primarily remained offshore of the continental shelf with mostly shallow (<100 m) nocturnal diving by animals >2 yr old. Twenty-eight GFS were rehabilitated as part of an Unusual Mortality Event (UME), released at 11-15 months of age in central California, USA (37.99ºN, 122.97ºW), and tracked for 64±28 d. These animals primarily traveled north post-release, and those tracked in 2015 had less variable movements, traveled farther north, and remained closer to shore than animals tracked in 2016-2017. Although most of the 18 free-ranging GFS tagged at 8-9 months of age on Guadalupe Island, Mexico (29.05ºN, 118.28ºW) also traveled north, their tags stopped transmitting after 35±16 d, before these animals reached the more northerly areas used by rehabilitated GFS. Telemetry data collected to date from juvenile and adult GFS indicate that older animals may primarily use the southern CCS. Thus, rehabilitated GFS dispersed farther north than free-ranging animals, which may be related to differences in release location, age, and/or oceanographic conditions among tracking periods. Although tracking rehabilitated GFS allowed us to study young animals >2 months post-weaning, more free-ranging animals need to be satellite tagged across years, seasons, and demographic groups to better understand GFS distribution and habitat use and assess the impact of the UME and other threats, including oil exposure, on this recovering population.

Poster # 148

Lisa R O'Bryan, Nicole Abaid, Shinnosuke Nakayama, Tanujit Dey, Daniel Rubenstein, Andrew King, Guy Cowlishaw, Simon Garnier

The Role of Contact Calls in Facilitating the Reunion of Separated Group Members

New Jersey Institute of Technology
lisa.r.obryan@njit.edu

Individuals from many social animal species produce vocalizations when they become separated from their group. These "contact calls" are assumed to play a role in facilitating the recovery of contact between group members. However, the effect these vocalizations have on the behavior of others and whether, or how, these behavioral changes facilitate the recovery of contact remains unclear for many species. We examined this question with data on a semi-free ranging group of 16 domesticated goats (Capra aegagrus hircus) inhabiting Tsaobis Nature Park, Namibia. For 5-6 hours per day during a 10-day period during September 2015, the goats wore dataloggers consisting of a GPS device, accelerometer and audio recorder, enabling us to collect continuous data on their location, behavior and vocal communication. We are analyzing data from 118 events in which one individual became separated from the group to test the hypotheses that contact calls 1) slow or stop the trajectory of the other group members, increasing the likelihood that the separated individual will find the group, 2) pull the group members towards the separated individual or 3) elicit counter calling by group members, enabling the separated individual to move towards the group. Preliminary analyses indicate that both the separated individual and the group are capable of closing the gap between themselves and that which of these closes the gap does not differ between events in which the separated individual produces contact calls and events in which it remains silent. We are in the final stages of processing all vocal data from the dataloggers which will enable us to explore the role of counter calling by group members in the reunion process. We expect results from this study to clarify the mechanisms through which social animals can regain group cohesion and the specific role that vocalizations play in this process.

Poster # 37

Florian Orgeret, Sam L Cox, Henri Weimerskirch, Christophe Guinet

Ontogeny of juvenile southern elephant seal diving behaviour

Centre d'Etudes Biologiques de Chize UMR 7372 du CNRS-Universite de La Rochelle, 79360 Villiers-en-Bois, France
florianorgeret@gmail.com

During the first year of their life, young elephant seals disperse for time periods often exceeding several months. Information on their at-sea activity and survival during this period of their life cycle is essential, because their mortality controls recruitment to reproductive stages alongside future population dynamics. Moreover, it is young individuals that disperse most, and thus have the potential to emigrate. In 2015, 20 juvenile (4-8 weeks) elephant seals Mirounga leonina were equipped at Kerguelen Island , Southern Indian Ocean, for the first time with satellite data relay tags, capable of collecting and transmitting summaries of dive and foraging behavior recorded from time-depth recorders and accelerometers. Juveniles showed the same at-sea range as 13 adult females during post-moult trips, and foraged mainly at the edge of the Kerguelen Plateau. Juveniles made shallower dives than adults, although the swimming effort required to reach comparative depths was similar as was the time to attain these depths. However, the bottom times of juvenile dives were much shorter. Moreover, juveniles performed globally 5 times less prey catch attempts. Ascent swimming efforts and swimming speeds were near constant through time, and were comparable to adults, suggesting individuals restrained their speed, possibly to avoid decompression sickness. At the beginning of the austral winter, juvenile diving skills increased, which reflects lower food availability alongside increases in performance. Thus, juveniles were able to respond to food scarcity and the winter migration of prey. However, their diving capabilities and foraging efficiencies were still lower than those of adults despite having spent nine months at sea. The long period of the juvenile life stage where diving and foraging performances is being improved upon is potentially a critical period for the survival of deep divers, and may have implications for their ability to adapt to environmental change.

Poster # 14

Federico Ossi, Davide Molteni, Gian Pietro Picco, Amy Murphy, Stefano Avenia, Nicola Svaizer, Tobia Sforna

Biologging in service of wildlife management: a system for bear dissuasion and reeducation

FO: Biodiversity and Molecular Ecology Department, IASMA Research and Innovation Centre, Fondazione Edmund Mach, San Michele all'Adige, Italy • DM: Department of Information Engineering and Computer Science (DISI), University of Trento, via Sommarive 9, I-38123 Povo (TN), Italy • GPP: Department of Information Engineering and Computer Science (DISI), University of Trento, via Sommarive 9, I-38123 Povo (TN), Italy • AM: Center for Scientific and Technological Research, Bruno Kessler Foundation, via Sommarive 18, I-38123 Povo (TN), Italy • SA: Nuzoo Robotics srl, via Asiago 20 Milano, Italy • NS: L.B. Books sas, via Solteri 74, Trento, Italy • TS: Biodiversity and Molecular Ecology Department, IASMA Research and Innovation Centre, Fondazione Edmund Mach and AND Life Science Department, University of Trieste, Piazzale Europa 1, Trieste, Italy
federico.ossi@fmach.it

Brown bear (Ursus arctos) has been successfully reintroduced in Central Alps (Trentino, Italy) in 2000, where the population currently expanded to 50 individuals. Bear presence in a highly anthropized landscape poses significant management challenges to promote coexistence between this species and local stakeholders, such as farmers and beekeepers, as bears may approach and use anthropic resources. Prevention measures represent a crucial element to significantly reduce damages caused by bears. To address these issues, we developed BEARFENCE, an innovative prevention system that aims both at deterring bears and at reeducating confident individuals. BEARFENCE consists of i) a base station emitting 125 Khz radio signals, ii) a bear tag mounted on a collar that wakes up once the bear falls within the transmission range of the base station, communicating back with the base station in case of wake-up, iii) a wireless sensor network (WSN) composed of the base station that coordinates several sensors, which in turn trigger the proper deterrents in case of bear attack. The triggering sequence, duration and intensity of the deterrents are randomly coordinated by the base station, with the ultimate goal to minimize the risk of habituation of the bear to the prevention system. Prior to final deployment on bears (ongoing), we extensively evaluated Bearfence performance in the field, under different environmental conditions and application scenarios. We combined „in vitro" tests (i.e., performed by operators that carried tags) and „in vivo" tests (fitting the tags to donkeys). The tests demonstrated the effective functionality of the Bearfence system, with the rate of missed detection of the bear tag close to zero. We encourage wildlife managers to consider Bearfence as a complementary system to prevent bear attacks. We foresee future applications of this system for other mammals of management concern.

Poster # 130

Adam Parlin

Monitoring cardiovascular function and microclimate selection during thermoregulation in free-living Eastern Box Turtles (Terrapene carolina carolina)

Miami University
parlinaf@miamioh.edu

Monitoring free-living animals provides insight into the microclimates and microhabitats selected by individuals as well as their effects on physiological processes. Reptiles exploit microclimates for thermoregulation that can be difficult to monitor with stationary models or macro-environmental data. Additionally, cardiovascular function plays an important role in regulation of internal body temperature via retaining or dumping of excess heat. We monitored the physiological adjustments of cardiovascular function during thermoregulation and habitat use in free-living ectotherms. Eastern box turtles (Terrapene carolina carolina) were monitored in Southwest Ohio, USA during 2014 and 2015, from May until October each year. Biologging devices were used to monitor internal body temperature, microclimate temperature, heart rate, and movement in the field to observe physiological processes during daily activity. We hypothesized that field metabolism and movement would be correlated with ambient conditions because box turtles are thermoconformers. Field metabolic rate was calibrated with heart rate and body temperature using closed-system respirometry in the laboratory measured at 15, 20, 25, and 30 °C. GPS coordinates and accelerometry measurements were also recorded for box turtles in 2015. We found that field metabolism was positively correlated with ambient conditions, and followed patterns similar to internal body temperature. Additionally, we found that movement, recorded as overall dynamic body acceleration (ODBA) or as distance between GPS coordinates, was independent of body temperature indicating that field activity does not depend on body or microclimate temperature. Our findings show that thermal conditions influence field metabolism but do not impact movement of free-living box turtles.

Poster # 221

Nicole Parr, S Bearhop, DC Douglas, JY Takekawa, DJ Prosser, SH Newman, WM Pery, S Balachandran, MJ Witt, Y Hou, Z Luo

High altitude flights by ruddy shelduck (Tadorna ferruginea) during Trans-Himalayan migrations

NP, SB: University of Exeter • DCD, JYT, DJP, WMP: USGS • SHN: FAO • SB: Bombay Natural History Society, Mumbai, India • MJW: Environment and Sustainability Institute, University of Exeter, UK • YH: Qinghai Lake National Nature Reserve, Xining, China • ZL: Computer Network Information Center (CNIC), China
n.parr@exeter.ac.uk

Birds that migrate across high altitude mountain ranges are faced with the challenge of maintaining vigorous exercise in environments with limited oxygen. Ruddy shelducks are known to use wintering grounds south of the Tibetan Plateau at sea level and breeding grounds north of Himalayan mountain range. Therefore, it is likely these shelducks are preforming high altitude migrations. In this study we analyse satellite telemetry data collected from 15 ruddy shelduck from two populations wintering south of the Tibetan Plateau from 2007 to 2011. During north and south migrations ruddy shelduck travelled 1,481 km (range 548 - 2,671 km) and 1,238 km (range 548-2,689 km) respectively. We find mean maximum altitudes of birds in flight reached 5,590 m (range of means 4,755 - 6,800 m) and mean maximum climb rates of 0.45 m s-1 (range 0.23 - 0.74 m s-1). The ruddy shelduck is therefore an extreme high altitude migrant that has likely evolved a range of physiological adaptations in order to complete their migration. Further work aims to identify if the ruddy shelduck have a unique physiology at the muscular level that is distinct from a low altitude comparative species, the European shelduck. This work is currently underway, and hopes to clarify how the ruddy shelduck complete their migrations across the Himalayas.

Poster # 68

Etienne Pauthenet, Fabien Roquet, Gurvan Madec, Christophe Guinet, Mark Hindell, Clive McMahon, Robert Harcourt

Instrumented seals help refining the frontal mapping of the Southern Indian Ocean

EP, FR: Department of Meteorology (MISU), Stockholm University, Sweden • GM: OCEAN Sorbonne Universitées (UPMC, Univ Paris 6) / CNRS / IRD / MNHN, 75252 Paris, France • CG: Centre d'Études Biologiques de Chizé, CNRS, Villiers en Bois, France • MH: Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, Tasmania 7001 Australia • CMM: Sydney Institute of Marine Science, 19 Chowder Bay Road, Mosman, New South Wales 2088, Australia • RH: Department of Biological Sciences, Macquarie University, Sydney, New South Wales 2109 Australia
etienne.pauthenet@misu.su.se

The Kerguelen Plateau obstructs the eastward flowing Antarctic Circumpolar Current (ACC) in the Indian sector of the Southern Ocean strongly interacting with the frontal structure. While the Subantarctic Front (SAF) lies north of the plateau and the Southern ACC Front (SACCF) is deflected southward by the Fawn Trough, the position and structure of the Polar Front (PF) in the Kerguelen region remains ambiguous given the intense current-topography interaction and the paucity of oceanographic observations. Since 2004 southern elephant seals, instrumented with CTD data loggers, have provided new temperature-salinity profiles, especially over the Kerguelen Plateau at unprecedented spatial and temporal resolution (MEOP database, 261 tags and >76000 profiles in the Indian sector). These observations are used here to resolve the uncertainty around the PF definition. We propose to define objectively the ocean zonation by analyzing the shape of temperature and salinity profiles up to 300m using a functional Principal Component Analysis (PCA). This statistical method decomposes the thermohaline structure and describes 95% of the variance with two modes only. These two modes present circumpolar patterns that can be closely related with standard frontal definitions. The method is applied on the MEOP database combined with profiles of the World Ocean Database and model outputs (e.g. SOSE, GLORYS) adding more insight on the spatio-temporal variations of the fronts over and near the Kerguelen Plateau. It is found that the PF tends to meander seasonally by up to 5° of latitude west of the Kerguelen Plateau, before it becomes steered by the southeastern edge of the Kerguelen Islands.

Poster # 163

Verena Peschko, Sabine Müller, Philipp Schwemmer, Bettina Mendel, Tanja Rosenberger, Peter Lienau, Janne Sundermeyer

Dispersal and foraging areas of juvenile Grey Seals in the southern North Sea

VP, SM, PS, BM: Research and Technology Centre (FTZ), University of Kiel • TR, JS: Seal Centre Friedrichskoog • PL: Seal Centre Norden-Norddeich
peschko@ftz-west.uni-kiel.de

The Grey Seal population in the German North Sea has been steadily growing during the last decades. So far little is known on the at-sea distribution, behaviour and habitat use of juvenile Grey Seals in the southern North Sea. As a marine top predator the Grey Seal plays an important role in the marine ecosystem and is confronted with different anthropogenic pressures, such as offshore wind farms (OWF). To better understand their ecologic role and to assess possible anthropogenic impacts it is of great importance to increase the knowledge on Grey Seals in German waters. Eleven wild juvenile Grey Seals were tagged with GPS/Argos data loggers on the island of Helgoland (the largest Grey Seal colony in Germany) for the first time in German waters from 2015 to 2017. The devices were glued to the fur on the upper back of the animals and recorded GPS positions for up to ten months. All tagged animals showed individual space use patterns, some conducted long foraging trips for up to several weeks into different offshore areas, others repeatedly used the same areas closer to shore. An area to the northwest of Helgoland was intensively used by different individuals both in 2015 and 2016, hence indicating a potentially important foraging site. In 2015 and 2017, most individuals travelled far from Helgoland, in 2016 all animals stayed closer to the island. Several individuals crossed the newly established OWF north of Helgoland while travelling to other foraging areas. Some juvenile seals even stayed in the wind farms for several hours, in contrast to others that did not exhibit any spatial overlap with the OWF. Our data suggest a high degree of individual variability in space use. Currently, there is no indication of an adverse effect of OWF on the habitat use of juvenile Grey Seals.

Poster # 98

Zuzanna Pestka, Sebastian Menderski, Adam Zbyryt, Dariusz Jakubas

Breeders vs. Non-breeders - movements of White Storks during the breeding season based on GPS-positioning

ZP, DJ: University of Gdansk, Faculty of Biology, Department of Vertebrate Ecology and Zoology • SM, AZ: Polish Society for Bird Protection
zuz.pestka@gmail.com

Foraging strategies of animals may be affected by multitude of factors including age, sex, environmental conditions, weather, stage of annual life cycle or reproductive status. Movement patterns of failed breeders may differ significantly from those of successfully breeding birds.   The aim of the current research was to gain knowledge about the breeding season activity of adult White Storks Ciconia ciconia differing in breeding status (successful breeder vs. failed breeder). We investigated area and type of habitats explored by tagged individuals and daily and seasonal variation in feeding activity of this birds.   We analysed GPS-tracking data from two adults, i.e. successful breeder and failed breeder (hereafter SB and FB, respectively) caught in 2014 in Natura 2000 Special Protection Area â€˜WarmiÅ„ska Refugeâ€™ (one of the main breeding areas of White Stork in Poland). As predicted, area used by SB was about three times smaller than in FB. Also the median distance (from deployment site to recorded GPS position) of flight differed between compared individuals: 127.5 m for SB (range 4.4-14870.4 m) and 466.0 m for FB (range 4.7-19961.5 m, Mann-Whitney U test, $Z = 35.53$, $p < 0.05$). What is interesting, foraging flights of SB were directed to the Kaliningrad Oblast area (northern direction), including local rubbish dump, while the FB almost exclusively explored areas located within â€˜WarmiÅ„ska Refugeâ€™ (southern direction). Our study indicates a significant difference in use of space between SB and FB White Storks. This is a preliminary study, based on just two individuals, but filled evident gap in knowledge about activity of FB and SB. Further studies, based on higher sample size are needed to comprehend foraging strategies of birds with different reproductive status.

Poster # 41

Wibke Peters, Julius Bright Ross, Federico Ossi, Paul Moorcroft, Emanuele Eccel, Emanuele Cordano, Maurizio Ramanzin

Old yet useful: VHF and GPS datasets to evaluate climate- and human-driven space use shifts in a large herbivore over decades

WP: Centre for Ecological and Evolutionary Synthesis, Dept. of Biosciences, University of Oslo, Norway • WP, FO, EE, EC: Fondazione Edmund Mach, Research Innovation Centre, Department of Biodiversity and Molecular Ecology • JBR: Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, MA, USA • PM: Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, MA, USA • MR: Department of Agronomy, Food, Natural Resources, Animals and Environment, University of Padova, Padova, Italy
wibke.peters@lwf.bayern.de

Early radio-telemetry methodologies have been surpassed by the more efficient and precise GPS technology in tracking animal movement. However, "old" datasets may spur renewed interest in scientific analyses addressing middle to long-term questions, such as population distribution shifts. Climate trends can normally be tracked in the time scale of several decades, or centuries. However, evidence of temperature global increase requires urgent assessments of responses at different ecosystem levels. We used a contemporary dataset of GPS locations (2012-2015) and an historical one of VHF locations (1997-2002) of a large herbivore (roe deer Capreolus capreolus) in an Alpine ecosystem to evaluate the effects of winter weather variability on its spatial distribution over decades. We hypothesized that the upwards migration of the snow-line in the Alps and the increased availability of supplemental feeding led to significant shifts in roe deer space use patterns. Our analysis built upon a resource selection function (RSF) predicting habitat selection as a function of snow depth, canopy cover, and supplemental feeding in both periods. We then evaluated changes in roe deer habitat selection between ("inter-period") and within ("intra-period") the two study periods, by means of kappa statistics. We found that changes in habitat selection during the historical intra-period were significantly less than those of the inter-decadal period and of the central months of the contemporary intra-period. Also, contemporary intra-period changes in habitat selection were significantly more than those of the inter-decadal period, but not in December and April. Our results suggest that habitat selection variability by roe deer increased over decades, with more variable snow depth and increased supplemental feeding practice. Animals proximately respond to environmental variability through movement, hence studies across decades may track climatic change and variability.

Poster # 217

Katrina Phillips, Kate Mansfield

Combining satellite tracking and genetics to characterize oceanic juvenile sea turtle habitat use

University of Central Florida, USA
katrina.phillips@knights.ucf.edu

Complex conservation strategies are often required for long-lived marine species that undergo habitat shifts between life stages. In sea turtles, the early oceanic stage and the transition between oceanic and coastal juvenile habitats are poorly understood. From 2011-2016, we tracked 71 oceanic juveniles encountered in the Gulf of Mexico using 9.5-gram solar-powered Microwave Telemetry Argos tags. We also collected a tissue sample from each tracked individual for genetic analysis of the mitochondrial control region to estimate stock of origin likelihoods. We sampled and tracked oceanic juveniles of four species: Kemp's ridley (Lepidochelys kempii), green turtles (Chelonia mydas), loggerheads (Caretta caretta), and hawksbills (Eretmochelys imbricata). Kemp's ridley and green turtles were documented shifting between offshore oceanic and nearshore neritic habitats. Juvenile green turtles that remained offshore were significantly smaller than those that entered nearshore waters. While some loggerheads and green turtles left the Gulf of Mexico for the western Atlantic, all Kemp"s ridleys remained in the Gulf of Mexico. Mitochondrial haplotypes were not well differentiated among Kemp"s ridleys, but green turtle haplotypes suggest genetic drivers of habitat use at the regional scale. By combining movement data with genetic results in a poorly-studied sea turtle life stage, we describe factors influencing habitat use and identify strategies that differ among species.

Poster # 40

Theoni Photopoulou, Alison Kock, Mandy Lombard, Res Altwegg, Justin O'Riain, Théo
Michelot, David Borchers

Modelling movement patterns of great white sharks using acoustic detections

TP, ML: Centre for Coastal and Marine Research, Nelson Mandela Metropolitan University & Statistics in
Ecology Environment and Conservation, University of Cape Town • AK: South African National Parks & South
African Institute for Aquatic Biodiversity • RA: Statistics in Ecology Environment and Conservation, University
of Cape Town • JOR: Institute for Communities and Wildlife in Africa, University of Cape Town • TM: School of
Mathematics and Statistics, The University of Sheffield • DB: Centre for Research in Ecological and
Environmental Modelling, University of St Andrews
theoni.photopoulou@gmail.com

Acoustic monitoring is used regularly to gather information on marine species' occurrence
and density. An array of acoustic receivers was deployed in False Bay, South Africa, in 2005
as part of a tagging programme to monitor great white sharks in the Bay by equipping them
with acoustic transmitters. False Bay is surrounded by the large metropole of the city of
Cape Town, and its beaches and waters are used throughout the year. White sharks are
perceived as a threat to water users and this research aims to improve our understanding of
shark movement patterns to (1) mitigate shark-human conflict, and (2) improve our
knowledge of local white shark movement ecology. Acoustic detection of fish has been used
to study residence patterns, seasonality and association patterns, but has seldom been used
to study individual movement patterns. A sequence of acoustic detections of an individual is
a time series and offers opportunities for analysis using individual-based movement models.
From the raw data, we know when sharks are in the vicinity of receivers, but we have no
information on their movements away from receivers. We processed the data into detection
events using a set of criteria, and modelled them using a hidden process approach, where
the observations are used to do inference on the underlying process of interest: the sharks'
spatial locations through time irrespective of receiver location. We treat this as a gridded
spatial process whereby the underlying states are spatial locations and each grid cell is a
state. The infered state sequence comprises a time series of gridded spatial locations.
Understanding where sharks spend time when away from receivers may also inform future
acoustic monitoring designs to maximise effectiveness of the technique for this population.

Poster # 30

Jérôme Pinti, Antonio Celani, Uffe Høgsbro Thygesen, Patrizio Mariani

Behavioral traits in long distance migrations: combining GPS tags data and modelling

JP, UHT, PM: Center for Ocean Life, National Institute of Aquatic Resources, Technical University of Denmark, Kongens Lyngby, Denmark • AC: International Center for Theoretical Physics, Trieste, Italy • UHT: s151368@student.dtu.dk

The behavioral traits regulating the ability of individuals to migrate are largely unknown but are likely dependent on a balance between individual preferences, energetic costs, risk and advantages in moving and possibly collective decisions processes when moving in large groups. Despite this complexity, migration between widely separated but geographically stable locations is a widespread phenomenon in animal ecology. For example, whales and turtles are iconic marine species travelling thousands of kilometers during their life through seasonal long-distance migrations. Specific adaptation of physiological, morphological and life-history traits are present in those animals, likely shaped by interactions between specific behavioral attitudes and local oceanographic conditions. However, risk-seeking or risk-averse strategies of the single individuals can also affect migratory strategies and can then drive meta-population structures and emergence of different personalities in those groups. We hypothesized that migration routes are shaped by evolutionary constraints on physiological, behavioral and personality traits as well as by the interactions with local environmental conditions during repeated migrations. We investigated risk-averse and risk-seeking migration strategies in long distance migrants making explicit the tradeoff between migration time, migration costs and risk-attitudes in migrations. We present a general mathematical framework based on optimal control theory applied to stochastic differential equations and describe optimal migration routes in realistic oceanographic conditions. Combining available tagging data of long-distance migration routes and high-resolution hydrographic data, we use statistical inference methods to gain insight about personality traits for a range of long-distance migratory marine animals. We show that all organisms are optimizing to save energy rather than time even though the relative importance of both costs can vary by several orders of magnitude between individuals. Risk-attitudes were spread between slightly risk-seeking and risk-averse strategies, sometimes within one population. This can be explained from an evolutionary perspective and may have ecological consequences for the considered populations.

Poster # 12

Jennifer Pohle, Roland Langrock, Floris M. van Beest,

Order Selection in Hidden Markov Models - Pitfalls, Practical Challenges and Pragmatic Solutions

JP, RL: Bielefeld University • FMVB: Aarhus University
jennifer.pohle@uni-bielefeld.de

Over the last couple of years, hidden Markov models (HMMs) have emerged as an increasingly popular statistical tool for the analysis of ecological time series data. As an example, consider the case of animal movement data. In this context, the states of an HMM can intuitively be interpreted as proxies for the behavioral states of an animal, such as resting, foraging or traveling. The primary interest usually focuses on identifying the internal and external drivers of behavioral processes. Therefore, in the ideal case, an HMM applied to an animal's movement data can yield a deeper understanding of the behavior of said animal. We discuss the notorious problem of order selection in HMMs, i.e. of selecting an adequate number of states, highlighting typical pitfalls and practical challenges arising when analyzing real data. In particular, we demonstrate why well-established formal procedures for model selection, such as those based on standard information criteria, tend to favor models with numbers of states that are undesirably large in situations where states shall be meaningful entities. We also offer a pragmatic step-by-step approach together with comprehensive advice for how practitioners can implement order selection. Our proposed strategy is illustrated with a real data case study on muskox (Ovibos moschatus) movement.

Poster # 128

Ivan Pokrovskiy, Olga Kulikova

How do nomadic species know where to go during the spring migration?

IP: Max Planck Institute for Ornithology • OK: Arctic Research Center of the Yamal-Nenets autonomous district
ivanpok@mail.ru

Nomadism defined as a type of bird migration in which birds range from one area to another, residing for a time wherever food is temporarily plentiful, and breeding is possible. In the meantime, despite the growing number of movement studies, many questions

according to nomadism remain unstudied, notably: how do nomadic species know where to go during the spring migration? We studied this question on rough-legged buzzards in 2013-2016 in the Russian Arctic. Rough-legged buzzards breed in tundra habitat and track prey dynamics, translating into a cyclical pattern in nesting density and reproductive performance. We tracked 53 rough-legged buzzards using GPS-GSM tags and found that rough-legged buzzards are not changing their breeding site during the spring migration as it was thought to be the case previously. When breeding is failed (no rodents, inclement weather, etc.), rough-legged buzzards can change their habitat in that year for another one in up to 1000 km from their former nest. They stay in the new breeding area up to the fall migration and on the next year, they will return to this place for breeding during spring migration. Thus, they are not changing nesting habitat during spring migration, but during the failed breeding season. However, if on the way to the breeding site they meet area with a high density of rodents they can stop there for breeding.

Poster # 55

Ingrid L. Pollet, April Hedd, Robert A. Mauck, Chantelle M. Burke, Gregory J. Robertson, Robert A. Ronconi, Sabina I. Wilhelm, Neil Burgess

Foraging areas, colony overlap, and mercury levels of incubating Leach's Storm-Petrels (Oceanodroma leucorhoa) in the Northwest Atlantic

ILP: Dalhousie University, Halifax, NS, Canada • AH, GJR: Wildlife Research Division, Environment and Climate Change Canada, Mount Pearl, NL, Canada • RAM: Biology Department, Kenyon College, Gambier, OH, USA • CMB: Psychology Department, Memorial University, St. John's, NL, Canada • RAR, SIW: Canadian Wildlife Service, Environment and Climate Change Canada, Dartmouth, NS, Canada • NB: Ecotoxicology & Wildlife Health Division Environment and Climate Change Canada, Mount Pearl, NL, Canada

ipollet@yahoo.com

Conspecifics seabirds with different forging areas and diet, could experience different threats and contaminant levels. With the miniaturization of geolocation technology, we are now able to track movements of the smallest of seabirds. In this 2013-2015 study, we used global location sensors to track foraging movements from seven eastern Canadian colonies of incubating Leach"s storm-petrels, Oceanodroma leucorhoa, a species that is declining throughout its Northwest Atlantic breeding range, and has been recently listed as vulnerable on IUCN Red-List. Upon the recapture of birds, we collected a small blood sample for mercury and stable isotopes analysis ($\delta13C$ and $\delta15N$). We determined and compared foraging trip, at-sea habitat characteristics, and analysed overlap among colonies. We

related foraging ranges to mercury and stable isotopes values, and we determined whether they overlapped with offshore oil and gas operations. Individuals made foraging trips of 4.0 ± 1.4 days, travelling to deep, relatively unproductive pelagic waters over and beyond continental slopes which lay, on average, 400 to 830 km from colonies. Mercury levels were lower and foraging distances were shorter for individuals at the southern end of the range. Those individuals also foraged in shallower, warmer waters, and fed at a lower trophic level. Foraging ranges for 4 of 7 colonies overlapped with offshore oil and gas operations. Future work should prioritize modelling efforts to incorporate information on relative predation risk at colonies, spatially explicit risks at-sea on the breeding and wintering grounds, effects of climate and marine ecosystem change, as well as lethal and sub-lethal effects of environmental contaminants, to better understand drivers of Leach's storm-petrel populations trends in Atlantic Canada.

Poster # 58

Tanya Prystay, Michael J. Lawrence, Aaron Zolderdo, Jake W. Brownscombe, Robert de Bruijn, Erika J. Eliason, Steven J. Cooke

Relating heart rate to parental care behaviour and individual fitness in nesting smallmouth bass

TP, MJL, AZ, JWB, RDB, SJC: Department of Biology and Institute of Environmental Science, Carleton University, Ottawa • EJE: Fish Ecology and Evolutionary Physiology Laboratory, Department of Ecology, Evolution, and Marine Biology, University of California Santa Barbara, California
tanya.prystay@carleton.ca

Physiological diversity is the interindividual variation in physiological tolerances, which may yield behavioural differences. For all species, successful reproductive performance is important for individual fitness and population persistence. Previous research has related fitness with diversity in behaviour, morphology, and life history traits, however limited research has investigated the relationship between physiological performance and fitness. Using smallmouth bass (Micropterus dolomieu) as a model species, the objective of this study was to relate individual physiological performance to behaviour during parental care and ultimately, fitness. This study also aimed to determine whether physiological performance can be used to predict fitness. In this case, physiological performance was determined by implanting heart rate loggers (DST milli HRT, Star-Oddi, Iceland) into 29 wild nesting male smallmouth bass (Rideau River, Canada). Parental care behaviour was

monitored using real-time video footage, and fitness was established by recording whether offspring successfully matured to free-swimming fry. Results from this study will provide insight into the relationship between physiological performance and fitness. Furthermore, although reproduction requires a significant portion of energy for spawning and parental care, reproductive energetics is often omitted in centrachids bioenergetics models. By relating heart rate to fitness, results from this study will provide insight on the metabolic costs related to reproduction and fitness that can be further applied to current bioenergetic models.

Poster # 227

Rita Pucci

Advanced Biologging by Machine Learning

University of Pisa
pucci@di.unipi.it

The biologging research field has become in recent decades an important research field to support the animal behavioural study. The biologging took advantage from the technology innovation offered by devices equipped with electronic sensors. Sensors have the ability to sense nearly all the aspects of an animal life allowing us to remotely observe and study the behaviour. If on one hand the technology combined with the field observations spurred great leaps forward in understanding, on the other hand the mole of data recorded by sensors introduced two challenges. The former concerns the storage of the mole of data. Since a device has to stay on the animal logging data for a long period (sometimes it could be months) the storage managing is an important issue. The latter challenge concerns the analysis of data aimed to identify important information about the behaviour. In this context, we investigate autonomous solutions based on Machine Learning (ML) approaches. ML models can classify the data in real time: the model analyses all the data in the interval of interest and provides a single output of classification pertinent to the animal behaviour under analysis. Hence, ML models allow to reduce the stored data to only the ML classification outcome at each interval of interest. In this way, the issue on the mole of data can be radically reduced focusing on the behaviour classification. The ML models are also customizable in order to fit with a solution on board. We developed solutions on this trend for activity recognition of humans (daily activities), tortoises (digging activities), penguins, and seals (in both cases, prey handling activities). These ad hoc ML solutions allow on board

classification of the data that provide a high compression of data with accuracy in classification of 85-96\% for each case of study.

Poster # 52

Verena Puehringer-Sturmayr, Josef Hemetsberger, Kurt Kotrschal, Didone Frigerio

With whom to associate? - Seasonal grouping in the Northern Bald Ibis (Geronticus eremita)

Core Facility KLF for Behaviour and Cognition, University of Vienna, 4645 Grünau, Austria, Department of Behavioural Biology, University of Vienna, 1090 Vienna, Austria
verena.puehringer-sturmayr@univie.ac.at

By foraging in a group individuals may benefit from the experience of others and at the same time avoid predators. In the present study, we investigated whether Northern Bald Ibises (NBI, Geronticus eremita), a critically endangered avian species, associate with specific colony members during the reproductive and post-reproductive season. Focal individuals (n=16, 9 males and 7 females) were breeders of the individually marked and free-roaming colony of the Konrad Lorenz Research Station in GrÜnau im Almtal (Austria). Their grouping was monitored via GPS-transmitters (GPS-UHF or GPS-GSM). Within groups, attraction and avoidance relationships (distance threshold of 1 m) between all tagged individuals were calculated. By using a Beta Regression with an information theoretic approach we assessed different possible factors (i.e. season, sex, same sex associations, age, kinship, nearest neighbour) influencing intraspecific attraction. We found that individuals selectively chose with whom to associate during the reproductive season and in autumn, whereas in summer we found no preferred associations during foraging. Generally, same sex associations were observed more often than opposite-sex ones and females seemed to be more attracted to each other than males. This may suggest that during the reproductive season females use habitat quality cues from other females, probably increasing foraging success. In summer, when the energetically costly breeding season is over, the entire colony members generally forage together. In autumn, however, specific individuals seem to be preferred again, probably in the context of the formation of future breeding pairs for the next reproductive season. In conclusion, we found evidence for adaptive grouping in NBI.

Poster # 61

Eldar Rakhimberdiev

FLightR: an r package for reconstructing animal paths from solar geolocation loggers

Department of Coastal Systems, NIOZ Royal Netherlands Institute for Sea Research & Utrecht University, The Netherlands
eldar@nioz.nl

Solar geolocators are relatively cheap and simple tools which are widely used to study the migration of animals, especially birds. The methods to estimate the geographic positions from the light-intensity patterns collected by these loggers, however, are still under development. The accurate reconstruction of the annual schedules and movement patterns of individual animals requires analytical methods which provide estimates of daily locations, distances between the locations and the directions of movement, with measures of their uncertainty. The new r package FLightR meets all these requirements. It enables refined and statistically validated estimations of movement patterns of birds. Here, we present main features of this advanced package.

Poster # 62

Eldar Rakhimberdiev, Theunis Piersma

Arctic amplification amplifies intra- and interspecific competition on shorebird spring refuelling sites

ER, TP: Department of Coastal Systems, NIOZ Royal Netherlands Institute for Sea Research & Utrecht University, The Netherlands • ER: Department of Vertebrate Zoology, Lomonosov Moscow State University, Russia • TP: Utrecht University, The Netherlands, Conservation Ecology Group, Groningen Institute for Evolutionary Life Sciences (GELIFES), University of Groningen, The Netherlands
eldar@nioz.nl

Spring starts later poleward, creating latitudinal gradient in breeding time for migratory birds, which utilize short peak of food resources availability for reproduction. Difference in time of breeding allows northerly breeding birds to pass refuelling sites later than southerly breeding. This pattern is now being shaped by the global warming that (1) globally advances

onset of spring and (2) is stronger at the higher latitudes, phenomenon called Arctic amplification. Global spring advancement is shown to force birds reproduce earlier to avoid mismatch with the food peak, while effects of Arctic amplification on migratory birds are unknown. We show that Arctic amplification decreases latitudinal gradient in the optimal timing of reproduction between northern and southern populations of migrants, subsequently increases synchrony in their migration timing, and thus densities at the refuelling sites. We demonstrate effect of Arctic amplification on bar-tailed godwits (Limosa lapponica), Arctic breeding long-distant migratory shorebirds. In the breeding ranges of five populations from two flyways synchrony in dates of snowmelt increased 5% over the last twenty years. Together with the fact that godwits followed spring advancement, having current arrivals of four populations marked with the satellite transmitters still in sync with dates of snowmelt, this implies 5% increase in density and thus increase in competition for food at the refuelling sites. Our results suggests that in order to adjust to the global warming amplified by breeding latitude, godwits need to sustain effective fuelling at refuelling sites under ever increasing densities and thus require higher food supplies. Arctic amplification, increasing competition at the refuelling sites, is illustrated by but not limited to bar-tailed godwits - synchrony in the breeding dates and thus overlap during migration are expected to increase for all migratory species that utilize spring peak of resources for reproduction and will reduce many populations of avian migrants.

Poster # 170

Leena Riekkola, Alex Zerbini, Virginia Andrews-Goff, Ari Friedlaender, Mike Double, Rochelle Constantine

The Great Humpback Whale Trail: Oceania to Antarctica

LR, RC: School of Biological Sciences, University of Auckland, Auckland, New Zealand • AZ: National Marine Mammal Laboratory, NOAA, Seattle, Washington, USA • AZ: Cascadia Research Collective, Olympia, Washington, USA • VAG, MD: Australian Marine Mammal Centre, Australian Antarctic Division, Hobart, Australia, AF: Marine Mammal Institute, Oregon State University, Corvallis, Oregon • USA, RC: Institute of Marine Science, University of Auckland, Auckland, New Zealand
lrie003@aucklanduni.ac.nz

Attaining observational data on large oceanic animals, such as whales, that migrate long distances is challenging. The large-scale migration paths between tropical breeding grounds and Antarctic feeding grounds, and the fine-scale movements within the feeding grounds of the Oceania humpback whale (Megaptera novaeangliae) population have so far remained poorly understood. We deployed 25 Wildlife Computers SPOT5 satellite tags on Oceania

humpback whales at the Kermadec Islands, New Zealand, in 2015 to determine the population demographics and connectivity between breeding and feeding grounds. Nineteen whales were tracked for an average of 100 days (range=5-254) across the Pacific Ocean to their Antarctic feeding-grounds, straight-line distances of up to 7,000 kilometers. The whales completed their migration to the Southern Ocean (south of 60°S) in an average of 51 days (range=35-67). All fully tracked mother-calf pairs (n=4) migrated to the Ross Sea, while 70% of adults without calves (n=7) migrated further east to the Amundsen and Bellingshausen Seas. The Antarctic feeding ground destinations may therefore be linked to the whales" life history stage. The mean travel speed of mother-calf pairs was significantly slower than that of adults without calves both during migration (30-60°S) and non-migration (<30°S, >60°S). We applied a hierarchical state-space model to the satellite tracking data which revealed a change towards a more „area-restricted search" based behaviour at 60°S. Satellite tagging was found to be an informative method for studying these „hard to reach" animals as the tags provided a continuous time series of whale movements on their southern migration and at the Antarctic feeding grounds, revealing the large- and fine-scale movements of this population. To understand the drivers behind the movements and habitat choice of these whales within the Antarctic feeding grounds, future work will use these data to link the whales' behaviour to their dynamic environment using remotely sensed data.

Poster # 139

Simon Ripperger

BATS: Broadly applicable tracking sensors enable high resolution positioning and encounter logging in small vertebrates

Museum für Naturkunde Berlin
simon.ripperger@mfn-berlin.de

Recent technological advances allow for automatized recording of animal behavior in free ranging species. However, most fully automated tracking systems cannot be used to monitor small vertebrates due to the considerable weight of sophisticated tags in combination with the small body size of the majority of mammalian or avian species. To overcome this issue we developed a wireless sensor network (WSN) based monitoring system. The system allows for localization of small animals at high spatial and temporal resolution and the simultaneous documentation of associations among tagged animals by direct encounter logging. We use light-weight sensor tags (1-2g) to gain new perspectives on

sociobiology and animal behavior. WSN technology fully automates data collection including remote data download. We present the BATS (Broadly applicable tracking sensors) system architecture and functionality. We report on field deployments for the observation of free ranging bats, a taxon that is particularly difficult to observe. First insights in their nocturnal (social) behavior showcase the high performance of the BATS tracking system.

Poster # 125

David A. Rodríguez

Life Track Oilbirds Costa Rica

Monteverde Institute • Max Planck Institute for Ornithology
chiroxiphia@hotmail.com

The Oilbird (Steatornis caripensis) is one of the 918 species of birds that have been registered in Costa Rica (Garrigues et al, 2017). A nocturnal, fructivorous bird which apparently subsists on lipid rich fruits from trees like palms, lauráceas (Stiles y Skutch, 1989) and burseráceas (Bosque et al. 1995). It is suggested that thanks to its feeding behavior the Oilbird has evolved very unique characteristics such as echolocation, which less than 20 species of birds in the world possess (Brinkløv et al, 2013). This is the only flying fruit eating bird in the world with echolocation (Snow, 1979).

This project started with the support of the Max Planck Institute and the Monteverde Institute. It consists in finding out where the individual Oilbirds found in Monteverde come from and go to. For this purpose the Max Planck Institute donated 2 satellite transmitters. Two birds were caught. The first one was tagged with the transmitter number 4402. It caught flight and there were no visible problems. The second bird was tagged but refused to take flight, and the bird had to be released without the harness. The reasons why there is not data collected with the first bird, and why the second one did not fly still unclear, but there is already a new technology with smaller tags that will be used in the future to continue researching the Oilbirds tracks. This is the first time that a research with this species is done in Costa Rica. It is important to know Monteverde is considered one of the most important Tropical Cloud Forests in the world (Nadkarni & Wheelwright, 2000), and a lot of changes due to Climate Change have been reported in the area (Pounds et al, 1999). Hopefully, in the future this project will contribute new information about the natural history of the Oilbird, and continue collecting data in this endangered and changing habitat.

Poster # 242

Laia Rojano-Doñate, Danuta M. Wisniewska, Birgitte I. McDonald, Mark Johnson, Jonas Teilmann, Magnus Wahlberg, Jakob Højer-Kristensen, Peter T. Madsen

Small bodies in cold water: do porpoises have elevated field metabolic rates?

LRD, PTM: Zoophysiology, Department of Bioscience, Aarhus University, C.F. Møllers Allé 3, 8000 Aarhus C, Denmark • DMW: Hopkins Marine Station, Stanford University, 120 Ocean View Blvd, Pacific Grove, CA 93950, USA • BIMD: Moss Landing Marine Laboratories, California State University, Moss Landing, CA 95039-9647, USA • MJ: Scottish Oceans Institute, East Sands, University of St Andrews, St Andrews KY16 8LB, Scotland • JT: Marine Mammal Research, Department of Bioscience, Aarhus University, Frederiksborgvej 399, 4000 Roskilde, Denmark • MW: Marine Biological Research Center, Department of Biology, University of Southern Denmark, Hindsholmvej 11, 5300 Kerteminde, Denmark • JHK: Fjord & Bælt, Margrethes Plads 1, 5300 Kerteminde, Denmark
laiard@bios.au.dk

Reliable estimates of field metabolic rates (FMR) in wild animals are essential to understand their ecological role, as well as to evaluate fitness consequences of anthropogenic disturbances. Standard methods for measuring FMR are difficult to use on aquatic animals, particularly free-ranging cetaceans. However, biologging tags can provide relevant albeit indirect information about FMR. Harbour porpoises live in the fast lane, with a short life span, early maturity, and high reproductive rates. Such characteristics, together with the potential high costs of thermoregulation in cold water, suggest that porpoises have high FMRs. Yet, the literature is inconsistent. Some studies support the notion of high FMRs, while others conclude that the energetic requirements of porpoises resemble those of similar-sized terrestrial mammals. Here, we addressed this controversy using the novel approach of combining data from captive and wild porpoises. We calculated the average energetic value of a respiration from the relationship between ventilation rate and metabolic rate (using doubly labelled water and food intake) in captive porpoises. After adjusting for the size of each individual, we combined the energetic value of a respiration with ventilations recorded by DTAGs deployed on wild porpoises to estimate their FMR. We conclude that FMRs of wild porpoises are around 2 times higher than similar-sized terrestrial mammals, indicating that porpoises, like other small marine mammals, indeed have elevated FMRs, likely to cope with the extra cost of keeping small bodies warm in cold water. These high FMRs match the recently uncovered high feeding rates of porpoises and highlight concerns about the potential impacts of human activities on the fitness of both individual porpoises and porpoise populations. Their high energy requirements and choice of small prey suggest that they must spend a large part of their time feeding and hence, have little room for compensation to anthropogenic disturbances.

Poster # 187

Fabien Roquet and the MEOP consortium

Ocean Observations Using Tagged Animals

Stockholm University
roquet@misu.su.se

Biologging, i.e. the use of miniaturized data loggers to track marine animals while they are at sea, is revolutionizing the science of marine ecology. It also offers new capabilities to observe the ocean"s physical and biogeochemical environment. In the last decade, ocean observation relying on instrumented animals has developed into an integral component of the global ocean observing system, particularly in the highly productive Polar and continental shelf regions. Taking advantage of the remarkable diving abilities of some marine animals, large numbers of vertical profiles of temperature and salinity have been gathered in a wide variety of locations, many particularly hard to reach by any other more conventional means. A large fraction of these data is now distributed as a unified quality-controlled database by the international consortium MEOP (Marine mammals Exploring the Ocean Pole-to-pole, meop.net). The data are used to study the foraging behaviour of marine animals in relation to their physical environment as well as to improve our knowledge of the oceanic state and its variability. Continuous progress in miniaturization and telemetry are opening new possibilities that will enhance further the scientific value of this approach. In this presentation, I will review important advances in physical oceanography made possible with biologging and I will discuss the future of ocean observations using tagged animals.

Poster # 168

Sonia Sánchez, Akiko Kato, Richard Reina, Yan Ropert-Coudert, Catherine Cavallo, Graeme Hays, Andre Chiaradia

Does location matter? Consequences of colonial breeding in a seabird

SS, RR, CC: School of Biological Sciences, Monash University, Clayton, Victoria 3800, Australia • AK, YRC: Centre d'Études Biologiques de Chizé, Station d'Écologie de Chizé-La Rochelle CNRS UMR 7372, 79360 Villiers-en-Bois, France • GH: Centre for Integrative Ecology, School of Life and Environmental Sciences, Deakin University, Warrnambool, Victoria 3280, Australia • AC: Research Department, Phillip Island Nature Parks, PO Box 97, Cowes, Victoria 3922, Australia
sonia.sanchez@monash.edu

Seabirds have evolved different foraging strategies to successfully exploit patchily distributed prey. According to optimal foraging theory, such strategies should maximise net energy gain, to increase survival and reproductive success. During breeding seasons, the foraging range of seabirds is constrained by the necessity to return frequently to the colony to incubate their eggs or provision their chicks. Thus, intra-specific competition for food resources can be strong and lead to spatial segregation of foraging areas. If the oceanographic conditions influencing prey distribution (e.g. bathymetry, sea-surface temperature, chlorophyll a) differ between foraging areas, there may be area specific differences in the foraging behaviour and success of conspecific individuals. Here, we use a bio-logging approach combining GPS, diving depth and acceleration data to investigate the consequences of sympatric breeding on conspecific diving seabirds. We use little penguins (Eudyptula minor) from Phillip Island (Australia) as a model to address this question. We monitored the foraging trips, diving behaviour and breeding performance of birds from neighbouring (2 km apart) sites during incubation, guard and post-guard stages. GPS tracks revealed strong spatial segregation between these two sites over the breeding season, and differences in the bathymetry of the two feeding areas. Furthermore, integrating horizontal tracking and diving behaviour data revealed differences in the three-dimensional use of the habitat between sites. Birds from one site foraged in shallower water, encountered prey at shallower depths and had a higher number of prey encounter events in relation to their diving effort (i.e. total diving time) than birds from the other site. These differences in foraging behaviour were more pronounced during chick-provisioning stages, although chick mass was similar between sites. We concluded that bathymetry is a very important local oceanographic condition influencing diving behaviour and effort on seabirds, however different foraging strategies within species can achieve similar breeding outputs.

Poster # 131

Paul Schaeffer

Field Metabolic Rate: Best Practices?

Miami University
schaefpj@miamioh.edu

As our capacity to monitor animals in the wild continues to grow, longstanding interest in the energetic demands of both normal life and of exceptional events in life history is attracting greater attention. Older approaches using time-activity budgets or doubly labelled water have begun to fall out of favor with the development of heart rate loggers, 3-dimensional acceleration loggers or other methods, yet there remains some uncertainty about the strengths and weaknesses of biologging approaches to the measurement of field metabolic rate (FMR). In particular, the ability to calibrate data to the range of behaviors exhibited by free-living animals or an assessment of the confidence of analyzed data are parameters in need of careful attention to avoid over-interpretation. I will present an overview of the historical approaches to measurement of FMR, a discussion of the potential contribution of FMR estimates to studies in which detailed life history measurements are made, and consider how approaches to calibration of field data influence the extent of error and confidence in collected data. Finally, I will argue for best practices and identify approaches needed to improve these data.

Poster # 69

Anne K. Scharf, Jerrold L. Belant, Dean E. Beyer Jr, Martin Wikelski, Kamran Safi

Animal defined corridors are not shaped by habitat suitability

AS, MW, KS: Department of Migration and Immuno-Ecology, Max Planck Institute for Ornithology, Radolfzell, Germany • JLB: Carnivore Ecology Laboratory, Forest and Wildlife Research Center, Mississippi State University, Mississippi State, USA • DEB: Michigan Department of Natural Resources, Marquette, Michigan, USA
ascharf@orn.mpg.de

Wildlife corridors increase landscape connectivity and thus a species" ability to cope with habitat fragmentation and loss, and are important to identify and maintain. Under the assumption that corridors represent swaths of suitable habitats connecting larger habitat

patches amid an otherwise unsuitable environment, currently, corridors are mostly identified using methods that rely on habitat suitability measures. Based on high-resolution GPS data of four large carnivore species, we identified corridors within each individual's home range. We investigated whether corridors in fact are representable by suitable habitats surrounded by unsuitable habitat, and if they could be indeed predicted by their environmental composition. We found that most individuals used corridors within their home ranges and that several corridors were used simultaneously by individuals of the same species, but also some were shared by individuals of different species. When we compared the predicted habitat suitability of corridors and their immediate surrounding area we found, however, no differences. We could not establish a direct link between corridors and habitat suitability, or defining environmental characteristics identifying actual corridors. This leads us to speculate that identifying corridors relying on the habitat suitability methods only, may place corridors in the wrong places, at least at the level of space use with an individual's home range.

Poster # 161

Philipp Schwemmer , Leonie Enners, Stefan Garthe

Migration patterns of a threatened and declining shorebird, the Eurasian Curlew (Numenius arquata), along the East Atlantic Flyway

Research and Technology Centre (FTZ), University of Kiel
schwemmer@ftz-west.uni-kiel.de

The East Atlantic Flyway is one of the most important migration routes in the world with the Wadden Sea, the worldÂ s largest system of unbroken intertidal flats, in its centre. Like millions of other individuals of birds Eurasian Curlews (Numenius arquata) use this site as a staging area with about 50 % of their biogeographic population. So far, the temporal and spatial patterns of Curlew migration along the East Atlantic Flyway are only insufficiently known. Since 2014, we have caught 16 Eurasian Curlews at their roost sites within the Wadden Sea and equipped them with GPS-GSM data loggers by a harness system. The devices recorded geographical position, flight speed, date and time of day. This enabled us to unravel the temporal and spatial components of their migration. All equipped individuals left the Wadden Sea during April towards Russia where they spent the breeding period in bog systems. The furthest aerial distance covered was about 3,000 km. During their migration Curlews either followed coastlines or crossed the open Baltic Sea. Virtually all

individuals staged for a few days in coastal areas of the Baltic. The mean flight speed was impressively high with about 85 km/h, with some individuals exceeding 100 km/h. Same individuals tracked in consecutive years showed surprisingly high site fidelity and same timing of migration. All individuals left the Wadden Sea only for a few weeks during breeding. The rest of the years (even the winters) were spent at roost sites in the Wadden Sea by commuting only a few hundred meters between the roost and the intertidal mudflats. The study revealed essential aspects of the migration of a threatened and declining species at the East Atlantic Flyway. The results are critical in our understanding of its ecology and may thus serve as an important basis for management decisions.

Poster # 92

Paolo S. Segre, Dave E. Cade, Frank E. Fish, Ari S. Friedlander, Jean Potvin, Jeremy A. Goldbogen

The role of flippers, flukes, and body flexibility in blue whale maneuvering performance

Stanford University
psegre@stanford.edu

Maneuverability is one of the most important but least understood aspects of locomotion. Maneuvering performance is predicted to decrease at large body sizes because of the scaling differences between control surfaces and body volume. As the world"s largest animals, blue whales (Balaenoptera musculus) are often characterized as highly stable, open-ocean swimmers who exchange maneuverability for long-distance cruising performance. However, recent bio-logging studies have revealed that blue whales use surprisingly acrobatic maneuvers for catching their prey. Yet, because of their enormous size and their deep underwater activities, little is known about how blue whales use their control surfaces to perform maneuvers. Using suction-cup attached multi-sensor tags equipped with cameras we report the timing and movement of the flippers, flukes, and body axis, used by feeding blue whales (n=7) to perform a suite of simple and complex maneuvers. To perform longitudinal axis rolls, blue whales use asymmetric lift generated by the extended flippers, the flukes are not used, and the body does not flex or extend. Blue whales perform pitch changes by using their extended flippers to generate lift in conjunction with asymmetric fluke strokes and a flexed or extended body. Most yaw changes are performed by rolling the body into the direction of the turn and using a laterally directed, upward pitch

change with a dorsally extended body. In contrast, while turning at the surface, blue whales use lower performance, non-banked turns performed by flexing their body laterally. To maneuver along complex trajectories, such as those used to perform a series of breaths or to approach and engulf their prey, blue whales combine sequences of simple maneuvers around the roll, pitch, and yaw axes.

Poster # 151

Michael W. Shafer, Paul Flikkema, Amir Torabi, Carol Chambers, Gabriel Vega, Kellan Rothfus, Matthew Robertson

Wildlife radio telemetry from an unmanned aerial vehicle

Northern Arizona University
michael.shafer@nau.edu

The low cost, low mass, and reliability of very high frequency (VHF) radio tags contributes the technology"s ubiquity in the field of wildlife telemetry despite significant drawbacks. Limited reception range increases tracking labor, which in turn constrains data fidelity. Although the size and power requirements of satellite enabled tags have decreased, they are unlikely to ever match VHF in terms of mass, size, and lifetime due to fundamental power requirements for radio transmission. As such, VHF tags will likely remain a primary means of tracking small animals into the foreseeable future. Given these facts, improvements in data fidelity will likely come from receiver side changes where engineering constraints are significantly reduced. The reception of VHF signals is greatly improved by moving the antenna off of the ground wherein signal attenuation and multipath effects are limited. Manned aerial flights using VHF equipment drastically increases the ability of researchers to detect and localize tags, but cost typically precludes such endeavors. Unmanned aerial vehicles have emerged to improve data collection for a number of fields. This presentation will introduce an open-source unmanned aerial vehicle radio telemetry system (UAV-RT) which integrates VHF radio telemetry equipment with an unmanned aerial system. The system is able to acquire, record (for post-process), and transmit standard audio output from a UAV-mounted handheld receiver to a ground station where the user is able to listen and process the received signals. Automated flight allows for movement across predetermined waypoints and antenna orientations, thus allowing for triangulation or direction of arrival localization methods. In addition to presenting this system, we will discuss the future direction of the project wherein novel software defined radio (SDR)

systems will be implemented to reduced radio system size and mass. Differences between the standard VHF receivers and SDR systems will be discussed.

Poster # 152

Michael W. Shafer, Paul Flikkema, Dan Costa, Lauren Adoram-Kershner, Rachel Holser, Gregory Hahn, Taylor Bruce

Assessing solar power for marine wildlife bio-logging systems

MWS, PF, LAK, GH, TB: Northern Arizona University • DC, RH: University of California Santa Cruz
michael.shafer@nau.edu

The capabilities of bio-logging devices are inherently constrained by battery capacity. Limitations on energy usage manifest as reduced temporal or spatial data fidelity, transmission frequency, and/or system lifetime. The deployment of photovoltaic cells on terrestrial and avian bio-logging tags helps to mitigate these limitations, while marine species still rely solely on primary cell batteries. While solar power is inherently variable, it can be reliably predicted for terrestrial systems over the long term using a variety of models and databases. The marine environment presents a number of additional variables that make reliable power modeling more challenging. Uncertainty and perceptions about low power at depth likely contribute to the dearth of photovoltaic power harvesting in marine wildlife telemetry systems despite potential benefits. This presentation will highlight a model developed to assess solar power for telemetry systems in the marine environment. Power at depth is based on historical global solar irradiance data provided by the NASA CERES database. Daily average irradiance values are used to scale a standard spectrum which acts as an input to the air-water interface. Losses due to surface reflection and spectral absorption as a function of depth are used to determine a downwelling spectrum at a given depth. The resulting spectrum is then used in conjunction with established solar cell models to predict a current-voltage relationship from which power can be calculated. In addition to the model, we present results from assessments conducted on various example species. These assessments use previously collected telemetry data as inputs to the model. The predictions made by the model show variations between species and how seasonal variations in movement states can affect power. We also present initial testing results from a silicon solar cell mounted to a Northern elephant seal (Mirounga angustirostris) and compare results to model predictions.

Poster # 60

Courtney Shuert, Paddy Pomeroy, Sean Twiss

Behavioural trade-offs in a capital breeder: Quantifying individual differences in lactating grey seals (Halichoerus grypus) using accelerometry

Department of Biosciences, Durham University • Sea Mammal Research Unit, University of St. Andrews
courtney.r.shuert@durham.ac.uk

Telemetered pinniped research often targets diving and at-sea behaviour, while the consequences of behaviour in the terrestrial phase of their life history are often ignored. We investigated the fine-scale behavioural trade-offs associated with a capital breeder, the grey seal, through the lens of tri-axial accelerometry. Head-mounted accelerometers were deployed on 31 mothers (including 7 recaptures) in the 2015 and 2016 autumn breeding seasons on the Isle of May, Scotland. Tags were applied early in lactation, sampled at a constant rate of 25 Hz for 11±2 days, and removed prior to weaning, encompassing the core period of lactation. Gross mass transfer efficiency (MT) was also obtained for each mother-pup pair over lactation by repeated massing. Tagged mothers were observed using focal video sampling for at least three dedicated sessions totalling a minimum of 6 hours. Behaviour in videos was later analysed using a pre-existing ethogram and sampled to the nearest second in real time. Accelerometry data were processed by a weighted k-Nearest Neighbor algorithm developed from training data taken from the decoded focal videos, generating a continuous activity budget for each female. This algorithm yielded classification accuracy of around 75% for most core behavioural categories. Acceleration-derived activity budgets are continuous in nature, including periods of darkness, and lack observer biases, enabling an investigation of behavioural trade-offs during lactation previously unattainable by traditional behavioural observation methods. For the first time, we used these data to characterize individual differences in behaviour within the lactation period, but also with respect to their stability between seasons, day versus night, environmental conditions, and to determine individual behavioural type ("personality"). Individual variability and plasticity in balancing time spent resting, alert, nursing, engaging in aggression, and other behavioural states impact fitness outcomes (MT 48.3±9.08%, ranging 27.3-63.4%) for both female and pup during this critical period of development.

Poster # 178

Eilidh Siegal, Sascha Hooker, Patrick Miller

Using acoustics to ground-truth accelerometry: predicting prey capture attempts from motion sensors in a beaked whale

Sea Mammal Research Unit, University of St Andrews
es250@st-andrews.ac.uk

Knowledge of foraging behaviour is key to understanding food-web topology and ultimately ecosystem structure and functioning. Yet identifying prey capture attempts remains challenging, particularly for marine top predators. Here we used terminal acoustic buzzes to ground-truth magnetometer and accelerometer-based methods of detecting beaked whale prey capture attempts. Fifteen DTags were deployed on northern bottlenose whales in Jan Mayen. Receiver operator characteristic (ROC) analysis determined which signals (and thresholds) most efficiently predicted buzzes. Signals were calculated across each axis independently and as a triaxial value, transformed as: 1) squared raw sensor values, 2) jerk, 3) Hilbert transformed jerk, or 4) specific acceleration. ROC statistics, "sensitivity" (true positive rate) and "specificity" (true negative rate), indicated that accelerometer jerk, Hilbert transformed jerk and specific acceleration from Y-axis and triaxial signals were roughly equivalently the best predictors of buzzes. Integrating magnetometer signals added little to the detectability of buzzes, indicating motions peaks were caused by dynamic acceleration rather than rapid orientation changes. Optimal thresholds (identified from the sum of sensitivity and specificity) gave an 81-85% probability (SE=.004) that no jerk peak would be identified when no buzz occurred and an 80-85% probability (SE=.004) that a jerk peak would be identified when a buzz occurred. Using these thresholds to identify jerk peaks, statistical analysis showed the number of buzzes was predicted by the number of jerk peaks per dive, with 1.85±0.1 (95% CI) jerk peaks occurring per buzz on average (GLMM: |z|=34.99, p<.001). This study revealed that analyses of signals from low-power accelerometers (particularly triaxial and Y-axis jerk) efficiently predicted buzzes and are therefore promising methods to estimate prey capture attempts of beaked whales in longer duration tags. Sudden accelerations along the Y-axis appear to be an important component of the prey capture movements of this species.

Poster # 24

João P. Silva, Rita Ramos, João Paulo Silva, Carlos Carrapato, Paulo Marques, Jorge Palmeirim

Spatial behaviour of Iberian-imperial-eagle juveniles during the dependence period revealed by high resolution tracking devices

cE3c - Centre for Ecology, Evolution and Environmental Changes, Faculdade de Ciências da Universidade de Lisboa, Portugal • Centre for Applied Ecology "Prof. Baeta Neves" - InBIO, Instituto Superior de Agronomia, Universidade de Lisboa, Portugal • REN Biodiversity Chair, CIBIO - InBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos - Rede de Investigação em Biodiversidade e Biologia Evolutiva, Universidade do Porto, Portugal • Instituto da Conservação da Natureza e das Florestas, Lisboa, Portugal • Liga para a Protecção da Natureza, Lisboa, Portugal
rita.af.ramos@gmail.com

In long-lived vertebrates, juveniles depend exclusively on their progenitors during the first stage of their life. This dependence stage can play a critical role on their development and fitness. The Iberian-imperial-eagle (Aquila adalberti) is a highly threatened long-lived raptor that only breeds in the Iberian Peninsula. With this work, we aimed to understand the spatial behaviour of juveniles during this dependence period, particularly looking at how home range varied over time and climatic factors influencing exploratory movements. Between 2014 and 2016, we tagged 10 juveniles using high resolution tracking devices. The birds were tagged in four different nests located in Southern Portugal. Juveniles showed a gradual increase of their home range with time, being highly dependent of the nest location during the dependence stage. For the majority of the juveniles, the direction of the exploratory flights were not random, and there was a clear tendency for the juveniles to fly NW from the nest, mainly against the predominant winds. Females travelled longer and to further distances than males. Still, juveniles from the same nest showed a similar exploratory flight patterns. These results may play an important role in assessing key conservation issues such as electrocution risk in the electric grid network.

Poster # 160

João Paulo Silva, Francisco Moreira, Jorge Palmeirim

Spatial and temporal dynamics of male lekking behaviour revealed by high resolution GPS tracking

JPS, FM: REN Biodiversity Chair, CIBIO/InBIO, Research Centre in Biodiversity and Genetic Resources, University of Porto • JPS, FM: Centre for Applied Ecology "Prof. Baeta Neves" InBIO, Institute of Agronomy, University of Lisbon • JPS, JP: Centre for Ecology, Evolution and Environment
silvaj@sapo.pt

Even though leks have been widely used by biologists as a model to study sexual selection, the understanding of how individuals use space, interact and socially progress over time is still lacking. Our work aims to provide new insights into lekking breeding dynamics using a high temporal and spatial resolution dataset derived from the GPS tracking of adult male little bustards Tetrax tetrax, collected over a four-year period. Results show the lekking system as being dynamic at both intra and inter-seasonal scales. Smaller ranges were consistent with territorial behaviour. Using Bayesian Latent Cluster Analysis, based on the movements of each individual, we were able to distinguish the breeding behaviour modes, territorial and floating, within the breeding season. Surprisingly only 27% of the males were found to be constantly territorial within the same year. The remaining birds showed predominant floating behaviour or shifted between the two behavioural modes, floating and territorial, possibly indicating male turnover. Between years birds were found highly philopatric with floating males reducing their ranges within the same area and becoming territorial, indicating a trend for rank progression with increasing adult age. The combination of territorial site fidelity and male rank ascent based on age can explain lek temporal persistence within stable habitats.

Poster # 17

Robert A. Sparks, Jason P. Beason, Luke T. George

Black Swift Movement Ecology

Bird Conservancy of the Rockies
rob.sparks@birdconservancy.org

The Black Swift (Cypseloides niger borealis) is one of the least understood bird species in North America due to remote nest site locations and aerial behavior. This Continental species of Concern, has declined by 94% over the past 60 years. A better understanding of the movement patterns of this species are important to identify potential threats during its full annual cycle. Basic movement data are unavailable during the breeding season for the Black Swift. To address this knowledge gap we will attach GPS nano tags on 5 individuals in Colorado. Recent advances in technology have allowed production of lightweight GPS tags with solar capabilities for extending battery life. We will quantify home range and foraging patterns using hidden markov models and kernel density estimates. Hidden Markov models are a relatively new approach for modeling animal movement patterns and are well suited for analyzing high frequency GPS locations collected at regular time intervals. The Hidden Markov model has two components 1) observable time series (sequence of GPS locations) and 2) latent state sequence (behavioral state). In our application of the hidden Markov model, we will explore 2 behavioral states during the breeding season, a stationary state at the nest site location and a foraging state. Our findings will identify priority areas based on quantifying movement patterns and inform management and conservation actions for this declining species.

Poster # 16

Anouk Spelt, Cara Williamson, Shane Windsor, Emily Shepard, Judy Shamoun-Baranes, Peter Rock

Where do urban-nesting gulls get their food?

AS, CW, SW, ES, PR: Bio-Inspired Flight Lab - University of Bristol • JSB: University of Amsterdam
anouk.spelt@bristol.ac.uk

Large gulls traditionally exploit islands or coastal areas for breeding, however, urban gull populations have been increasing since the last century while rural populations have experienced declines. A number of possible explanations have been put forward including access to food resources, nesting sites and lower cost of transport, but studies with fine-scale movement behaviour of urban-nesting gulls are lacking. Such data would provide valuable insight into the resources exploited by these urban birds, and the costs of accessing them, relative to those experienced by their rural counterparts. We analysed the foraging behaviour of urban-nesting gulls in the breeding seasons of 2016 and 2017, using GPS trackers on 11 lesser-black backed gulls Larus fuscus in the city of Bristol. These trackers recorded both GPS location and acceleration (in 3 axes), with the latter being used to determine specific behaviours. By combining the tracking data with extensive land use data, we determined the habitat use and time-activity budgets of these gulls. This demonstrated that urban-nesting gulls only made use of terrestrial environments despite the proximity of marine foraging areas, making particular use of agricultural lands, sport fields, waste centres and urban areas. In addition to nesting and commuting flight in the urban environment, the gulls use this area for other behaviours like washing and foraging, the latter even take place during the night possibly as a result of the street lighting. The foraging behaviour of urban-nesting gulls appears to be different from gulls studied in traditional rural colonies on islands or coastal areas. It is hoped that the continuation of these studies will provide further insight into why and how this group is able to benefit from the urban environment.

Poster # 182

Jared A. Stabach, Matthew Ogburn, Charles Bangley, Thomas B. Ryder, Alex E. Jahn, John McEvoy, Peter P. Marra

Movement of Life: Advancing our Understanding of Animal Movement

JAS, TBR, AWJ, JME, PPM: Smithsonian Conservation Biology Institute, National Zoological Park • MO, CB: Smithsonian Environmental Research Center
stabachj@si.edu

Movement is a critical life process. Upwards of 6,000 species on the planet migrate, often moving thousands of kilometers to breed or locate vital resources like food and water. Understanding animal movement and migration can help us to recognize conservation hotspots, identify human-animal conflict zones, rebuild and sustain productive fisheries, and understand the spread of pandemic diseases. Yet our knowledge of movement, its impacts on ecosystems, and the processes that regulate it are lacking. We know year round ranges for some species like sea turtles, but for many species we know next to nothing about when, why, how, or where animals migrate. How can we conserve these species if we are unable to answer these fundamental questions? I will discuss Smithsonian"s new initiative, the Movement of Life, to advance the understanding of how all animals, from multi-ton elephants to pint-sized ovenbirds, move across varied and rapidly changing land and seascapes. Launched in 2016, we aim to build collaborations between individuals and organizations, to advance quantitative approaches to appropriately account for serial autocorrelation inherent in data series (e.g., continuous time movement modeling), and to understand key habitats/corridors necessary for animal survival. Over the past year, we have fit over 50 individuals with telemetry devices (e.g., acoustic tags, archival tags, horn-mounted GPS collars) across terrestrial, avian, and marine systems. Species tracked include Asian elephant, Przewalski horse, reticulated giraffe, scimitar-horned oryx, white-bearded wildebeest, creamy-bellied/yellow-bellied thrush, blacktip/bull/dusky shark, and smooth dogfish. I will discuss preliminary results from these signature tracking efforts, which reveal interesting aspects of animal life cycles and highlight the need for collaborative global networks to collect fine-scale movement patterns over extended time periods.

Poster # 158

Sheanna Steingass, Markus Horning, Lorrie Rea, Amy Bishop

You are where you eat: correlating spatial habitat use and dietary preference in the Pacific harbor seal

Oregon State University, Oregon State University/Alaska SeaLife Center, University of Alaska Fairbanks, Alaska SeaLife Center
steingas@oregonstate.edu

Pacific harbor seals (Phoca vitulina richardii) are a numerous but understudied marine predator on the Oregon coast, USA. Spatial habitat utilization and ecological niche of Pacific harbor seals were examined through whisker-based carbon and nitrogen stable isotope analyses, and the deployment of Wildlife Computers SPOT5© satellite tags on 24 adult (23M/1F) seals. Seals were tagged in Netarts and Alsea Bays, Oregon in three separate deployments between September 2014-September 2015, and one whisker was collected from each animal. White muscle from 124 potential prey items was analyzed for comparison with whiskers to estimate diet based on established isotopic discrimination ratios. Satellite tracking resulted in over 52,000 locations collected during a period of 606 days. Oregon seals were wide-ranging and demonstrated a high degree of inter-individual variability. Average minimum convex polygon (MCP) habitat area for all animals was 1600.92 ±2072.07 km2. Mean distance from shore was highly variable (5.07±5.73km) and did not vary significantly with body mass, suggesting behavioral dietary preference, not size-related biological factors, drives habitat use. Tracking data was further correlated with carbon and nitrogen stable isotopes from whiskers to contextualize spatial habitat utilization with dietary composition. Whiskers were sampled every 0.5cm for the first ten sections starting at the root, providing a range of values over a multi-month period. Ward's hierarchical cluster analysis categorized seals into three groups based on values of δ13C and δ15N range, mean distance from shore, MCP area, and percent utilization of marine reserves and bays. An emphasis on utilization of sandy substrates, along with results from isotope analyses, strongly suggest a focus on benthic flatfish as a primary dietary source for most animals. This study represents the first comprehensive analysis of at-sea habitat utilization of Pacific harbor seals in Oregon, and provides context for the ecological mechanisms driving spatial behavior.

Poster # 235

Ariana Strandburg-Peshkin, Damien R Farine, Meg Crofoot, Iain D Couzin

Using GPS tracking and UAV imagery to disentangle social and habitat influences on baboon collective movement

ASP: University of Zurich • DRF, IDC: Max Planck Institute for Ornithology • MC: University of California, Davis
arianasp@gmail.com

For animal groups on the move, maintaining cohesion means responding to social influences such as the locations and movements of other group members. However, movement patterns are also driven by the structure of the physical environment through which animals move. Understanding how social and habitat influences interact to drive individual movement decisions - and ultimately the coordinated movements of groups - is key to understanding how the patterns of group movement seen in nature arise. Here, we link simultaneous high-resolution GPS tracking of the majority of baboons in a single troop with a three-dimensional reconstruction of their environment, generated from UAV imagery. Through step selection models, we reveal that a social influence - the previous locations traversed by group members - is the strongest predictor of baboons' movement decisions at the individual level. However, clear habitat influences - such as a propensity to follow roads and to avoid areas of high vegetation density - are also evident. At the group level, habitat features are associated with changes in the spatial structure and movement of the entire group, highlighting the importance of incorporating habitat structure into our understanding of collective animal movement.

Poster # 176

René Swift, Pauline Goulet, Chris McKnight, Peter Teglberg Madsen, Mark Johnson

A blubber thickness logging tag to measure body condition dynamics

RS, PG, CMK, MJ: Sea Mammal Research Unit, Scottish Oceans Institute, University of St. Andrews • PTM: Zoophysiology, Department of Bioscience, Aarhus University
rjs30@st-andrews.ac.uk

Body condition in animals is a measure of an individual"s nutritional health and fitness. Temporal changes in condition occur naturally due to changing energetic demands (e.g.

migration or reproduction), differences in prey quality and availability or human disturbance. Thus repeated, long-term measures of condition can provide valuable information into when and where animals accumulate and expend energy. Non-invasive methods for assessing body condition in terrestrial species include Bio-electrical Impedance Analysis and morphometrics. For marine mammals, blubber depth and/or distribution are strong proxies for condition. These can be measured directly with biopsy cores, and ultrasound or can be inferred from photogrammetry and swimming behaviour. In situ, tag derived estimates of body density analyse changes in buoyancy during underwater resting or glides in active swimming. However, these behaviours are not consistently performed by all species, and can be difficult to detect. Multi-beam medical ultrasound imaging systems are currently too complex to incorporate into a tag, we investigated the feasibility of using a single beam, inward looking ultrasonic sonar to measure backscatter from tissue layers as a function of depth. The low-power prototype sonar uses a 1.5 MHz pulse with a receiving bandwidth of 250 kHz giving a depth resolution of approximately 3mm. To assess if this system could provide reliable measures of blubber depth we used 5 recently expired, bycaught grey seals. Body condition was simultaneously assessed using photogrammetric and empirical measures of body volume, and blubber depths were compared to those from a commercial ultrasound. We show that blubber layers are visible using the sonar tag, and depths correspond to those acquired with the commercial ultrasound, suggesting that autonomous measurements of free swimming marine mammals are possible. A fieldable version of the tag is now being developed and first applications are likely to be on pinnipeds as tag positioning is easier to control.

Poster # 143

Akinori Takahashi, Jean-Baptiste Thiebot, Yuuki Watanabe, Thierry Raclot, Yan Ropert-Coudert

Migratory movements and winter diving behaviour of Adélie penguins from two East Antarctic colonies

AT, JBT, YW: National Institute of Polar Research, Japan • TR: Institut Pluridisciplinaire Hubert Curien, CNRS UMR 7178, France • YRC: Centre d'Etudes Biologiques de Chizé, Univ. La Rochelle, CNRS UMR 7372, France
atak@nipr.ac.jp

Winter generally challenges foraging opportunities of endothermic marine predators due to reduced prey availability in the summer/breeding zones. This is especially the case for Antarctic penguins, as extending sea-ice cover and short daylight hours greatly constrain

their foraging behaviour during winter and may force them to migrate to more favourable feeding grounds. Indeed, successful winter foraging behaviour would be critical for the survival of penguins, though, this has been difficult to study until recently. Here we examined the migratory movements and winter diving behaviour of Adélie penguins by tracking them with geolocation and depth loggers. We compared penguin movement and behaviour between two East Antarctic colonies of different winter sea-ice extent (Syowa and Dumont - Urville - DDU - stations) to better understand the environmental factors influencing penguin behaviours. Migratory movements showed similar patterns between Syowa and DDU birds, despite being separated by 100° in longitude: most penguins migrated toward northwest direction, ranging up to 1500km. The main direction followed suggests a significant role of the west-flowing Antarctic coastal current in shaping the migratory patterns. Mean northward movement from the colony was larger in Syowa birds (7.3° latitude) than DDU birds (4.4° latitude), reflecting larger winter sea-ice extent experienced by Syowa birds. Diving depths were generally deeper in winter than summer, and were highly variable between and within colonies, possibly reflecting the variability in depth distribution of prey. Diving effort (total time spent underwater per day) showed similar seasonal patterns between two colonies: penguin diving effort was low around winter solstice when birds experienced short daylight hours, but was high in pre- and post-moult, and pre-breeding periods when birds are accumulating fat to meet increasing energy demands. Our results suggest that penguin horizontal and vertical movements are driven by extrinsic oceanographic and biological factors linked to changes in energy requirements.

Poster # 142

Jean-Baptiste Thiebot, John P.Y. Arnould, Thomas Mattern, Yan Ropert-Coudert, Juan E. Sala, Akinori Takahashi

Jellyfish and other gelata as food for four penguin species â€" insights from predator-borne videos

JBT: National Institute of Polar Research, 10-3 Midori-cho, Tachikawa, 190-8518 Tokyo, Japan • JPYA: Deakin University, Geelong, Australia, School of Life and Environmental Sciences (Burwood Campus) • TM: Department of Zoology, University of Otago, P.O. Box 56, Dunedin, New Zealand • YRC: Centre d'Études Biologiques de Chizé, UMR 7372 CNRS et Université de La Rochelle, 79360 Villiers-en-Bois, France • JES: Instituto de Biología de Organismos Marinos (IBIOMAR-CONICET), Blvd. Brown 2915 (U9120ACD), Puerto Madryn, Chubut, Argentina • AT: National Institute of Polar Research, 10-3 Midori-cho, Tachikawa, 190-8518 Tokyo, Japan
atak@nipr.ac.jp

Jellyfish and other pelagic gelatinous organisms (â€œgelataâ€) are increasingly perceived as an important, yet poorly-known, component of the marine food webs. Especially, their significance as prey in the oceans is extremely difficult to quantify because of methodological challenges to determining predation on gelatinous structures. Miniaturized animal-borne video data loggers now enable feeding events to be monitored from a predator"s perspective. We gathered a substantial video dataset (over 350 hours of exploitable footage) from 106 individuals spanning four species of non-gelatinous-specialist predators (penguins), across regions of the southern oceans. We found nearly 200 cases of targeted attacks on carnivorous gelata by all four species, at all seven studied localities. Our findings emphasize that gelatinous organisms actually represent a widespread, but currently under-represented trophic link across southern oceans, even for energy-demanding endothermic predators. Modern tools seem key to correctly identifying the niche of gelata.

Poster # 103

Alexandra Thiel, AL Evans, B Fuchs, J Persson, M Aronsson, JM Arnemo

Body temperature patterns in free-ranging wolverines (Gulo gulo)

AT: Institute for Wildlife Biology and Game Management, Department of Integrative Biology and Biodiversity Research, University of Natural Resources and Life Sciences, 1180 Vienna, Austria • AT, ALE, BF, JMA: Department of Forestry and Wildlife Management, Inland Norway University of Applied Sciences, Campus Evenstad, NO-2480 Koppang, Norway • JP, MA: Grimsö Wildlife Research Station, Department of Ecology, Swedish University of Agricultural Sciences, SE-730 91 Riddarhyttan, Sweden • JMA: Department of Wildlife, Fish and Environmental Studies, Swedish University of Agricultural Sciences, SE-901 83, Umeå, Sweden
alexandra.thiel90@gmx.de

We used abdominal body temperature loggers in combination with GPS collars with acceleration sensors on free-ranging wolverine (Gulo gulo) to study diurnal and annual variation in body temperature (Tb) and locomotor activity. In total, we analysed data from 14 wolverines (13 females, 1 male, 0.5 - 11 years old) in northern Sweden 2011-2014. Mean ± SD Tb of all individuals was 38.47 ± 0.58°C. Tb varied between months with highest Tb in July [38.54 ± 0.48 (range: 35.1 - 42.47) °C] and lowest Tb in December [38.37 ± 0.62 (35.88 - 42.27) °C]. Over the day, Tb varied within a mean ± SD range of 2.53 ± 0.25°C. Wolverines have delayed implantation, breeding in spring-summer and giving birth in February-March the next year. All adult females (>3 years old, n=8) showed a pattern of decreasing Tb in the beginning of the year, indicating pregnancy and a sharp increase in Tb at parturition. Mean (range) date of parturition was 22 February (14 February - 4 March). Activity data was

available for four assumed and three confirmed pregnancies and indicated den entry the same day as detected by the drop in Tb. It was possible to determine an approximate date of implantation, which enabled us to calculate a mean (range) gestation period of 28.5 (23 - 33) days. Activity and Tb showed diurnal patterns, which varied between months, according to changes in dusk and dawn periods and ambient temperature. Longer photoperiods in summer increased the probability of wolverines displaying a circadian 24 h rhythm in Tb and activity. Our results demonstrate that wolverine's Tb is stable over the year but display a wide daily variation and a distinct pattern in pregnant females.

Poster # 191

Uffe Høgsbro Thygesen, Toby A. Patterson

Inferring feeding in Southern bluefin tuna from visceral temperature data using a mechanistic model of digestion

UHT: Technical University of Denmark • TAP: CSIRO Oceans and Atmosphere, Hobart, Australia
uhth@dtu.dk

A key question is to quantify the feeding of fish in the wild. For Southern bluefin tuna (Thunnus maccoyii, Castelnau 1872), feeding events are known to be followed by visceral warming, which allows identification of feeding events from visceral temperature data obtained through biologging. Here, we aim to estimate the size of each meal ingested. To this end, we pose a mechanistic model which combines the digestion process, specifically the enzymatic degradation of food items in the stomach, with the thermodynamics of the stomach. The model employs the state space approach and consists of two coupled stochastic differential equations in which the stomach contents is a hidden Markov state. This allows us to estimate the stomach contents at each point in time from the temperature time series using nonlinear filtering. Computations are done in R using Template Model Builder (TMB). We calibrate the model with data obtained from caged tuna and show that the model is able to predict temperature trajectories similar to the empirical ones. We then apply the model to temperature data from wild tuna and obtain estimated feeding signals. Compared to alternative approaches, the method has the advantage of being based on mechanistic model components representing feeding, digestion and thermodynamics, which allows for critical discussions of and possibly future refinements of the processes involved.

Poster # 132

Béla Tokody, Orsolya Kiss

Loop migration in adult European rollers (Coracias garrulus) from the Carpathian Basin

BT: MME BirdLife Hungary • OK: University Of Szeged,Faculty of Agriculture

tokody.bela@mme.hu

European roller is a long-distance migratory species which population has underwent a serious decline in 1980s in the whole breeding range. Besides the shortage of food and suitable breeding sites, the mortality during the migration might have contributed to this decline. The migration of the western population is well-studied, however eastern population"s route has been inferred mostly from ringing recoveries. The aim of this study was to reveal the migration routes and wintering areas of the central-eastern population of rollers by satellite tracking. Altogether, six adults were tagged with solar powered satellite transmitters in Hungary, during the incubation period in 2015 and 2016. Most of the rollers migrated through the Balkan Peninsula, but proceeded on a broad front across the Sahara. Stopover sites in Sahel belt were located in Chad and Sudan, four birds used the same region. Rollers followed a westward and an eastward path to cross the rainforest zone. Botswana, Namibia and Angola were found as wintering area of the rollers. We found counter-clockwise loop migration through the Arabian Peninsula during the spring migration. Our result also showed that crossing rain forest zone and wintering can be challenging for adult rollers and highlight the importance of conservation measures in the countries of the Middle-East.

Poster # 194

Sivan Toledo, Yotam Orchan, Leah Aiach, Yoav Bartan, Motti Charter, Aya Goldshtein, Yosef Kiat, Dana Klein, Oren Kishon, Yael Lehnardt, Ari Lev-Or, Alexandra Pekarsky, Gabriel Rozman, Nir Sapir, Ingo Schiffner, David Shohami, Adi Shohat, Yoni Vortman, Ant

The ATLAS Reverse-GPS System: High-Throughput Regional Wildlife Tracking

ST, AG, OK, ALO, AJW, YY: Tel-Aviv University, Israel • YO, LA, YB, MC, YK, YL, AP, GR, RN: The Hebrew University of Jerusalem, Israel • MC, NS, IS, DS, AS, DZ: University of Haifa, Israel • DK, YV: Tel-Hai College, Israel

stoledo@tau.ac.il ; yotam.orchan@mail.huji.ac.il; ran.nathan@mail.huji.ac.il

The emerging Movement Ecology paradigm has greatly benefited from recent developments in wildlife tracking technologies, enhanced computation abilities and powerful data analysis tools, all of which have helped elucidate movement patterns, the underlying movement processes and their consequences. Yet, some key questions in ecology and behavior remain unresolved due to a lack of movement data from free-ranging wild organisms, including relatively small-bodied species (e.g. most birds and mammals), at the scales and resolution relevant for understanding interactions among organisms and with the environment. To address this challenge we developed ATLAS (Advanced Tracking and Localization of Animals in real-life Systems), a new wildlife localization system that delivers high-throughput GPS-quality localizations using lightweight tags. Tags weighing less than 1g deliver over 100k localizations and heavier tags deliver about 1M localizations per gram. The system uses low-cost tags that transmit unique identification codes, and receivers deliver detection reports to a server that estimates the location of the tags using the reverse-GPS (time-of-arrival) principle. The system can simultaneously track about 200 tags at 0.5Hz (delivering about 100 localizations per second), and localizations are computed and delivered almost at real time (delay of 30s). Due to the low-power tags and to the use of terrestrial receivers that require a line of sight, an ATLAS system can cover tens to hundreds of square kilometers. The prototype system has been established at the Hula Valley in Israel, and operational systems have recently been deployed in the Netherlands (NIOZ) and the UK (U. Exeter), along with a forthcoming system in Germany (BioMove). Thus far, the system has been used to study the movement ecology of more than 30 bird and 4 mammal species including, for example, studies of parent-offspring spatiotemporal relationships among all breeding Barn Owls (400g) in the study region, social interactions among foraging Egyptian Fruit Bats (120g), moult effects on Barn Swallow (20g) and other passerines, space use in Great Reed Warblers (25g) and Red-Backed shrike (30g), and foraging of Kuhl's Pipistrelle (7g).

Kazuki Tone, Itsumi Nakamura, Shian-Jhong Lin, Wei-Chuan Chiang, Sheng-Ping Wang, Kazuyoshi Komeyama, Yoshitaka Sakakura, Ryo Kawabe

The fish is cooled from not only outside but inside

KT, YS: Graduate School of Fisheries and Environmental Sciences, Nagasaki University, Japan • IN, RK: Institute for East China Sea Research, Organization for Marine Science and Technology, Nagasaki University, Japan • SJL, SPW: Department of Environmental Biology and Fisheries Science, National Taiwan Ocean University, Taiwan • WCC: Eastern Marine Biology Research Center, Fisheries Research Institute, Taiwan • KK: Faculty of Fisheries Sciences, Hokkaido University, Japan
kazu.bz.kazu@gmail.com

Since thermal conductivity of water is much higher than that of air, aquatic organisms are greatly affected by ambient water temperature. Heat-transfer between body and ambient water basically occurs on the body surface, therefore, the temperature change near the body surface is considered to be faster than the body core. To investigate difference of temperature changes from the body surface to core, we recorded body temperatures at the multiple body depths of the sailfish. We attached data-loggers with multiple thermometers on two sailfish and released them off the southeastern coast of Taiwan. The probes of thermometers were inserted into muscle with four different depths from the body surface: under skin, 2-cm-deep, 4-cm-deep, and near dorsal aorta. The tags were detached from the fish one day after release, and retrieved. We used heat budget models to estimate a heat-transfer coefficient at each muscle. Additionally, we placed the dead fish alternately in 30°C and 14°C seawater to examine how body temperature changed under deceased conditions. The tagged sailfish mostly stayed just beneath the sea surface, where water temperature was around 30°C, and they sometimes had vertical excursions to a maximum depth of 215 m. The fish experienced lower water temperature (min. 14.6°C) during vertical excursions, subsequently the body temperature decreased faster in the order of under skin, 2-cm-deep, and 4-cm-deep muscles. The temperature change of muscle near dorsal aorta was faster than that of 4-cm-deep muscle. The estimated heat-transfer coefficient of near dorsal aorta was higher than that of 4-cm-deep muscle and similar to that of 2-cm-deep muscle. This phenomenon was not observed in the deceased condition. Our results suggest that fish may be cooled from not only outside but inside possibly, because the blood cooled at the gills passed through the dorsal aorta when the fish experienced lower water temperature.

Poster # 74

Tomohiro Ujino, Dai Fukui, Ken Yoda, Shizuko Hiryu and Emyo Fujioka

Analysis of navigation strategy by echolocating bats across small to large spaces, Measurement of echolocation and flight behavior of bats using GPS data-loggers and microphone-array system

Doshisha University
dmq1048@mail4.doshisha.ac.jp

Animals move in a multi-scale environment in which their behavior should be recorded and analyzed. The purpose of this study is to understand flight and echolocation strategies of wild bats during nightly large-scale navigation by using bio-logging technique and during small-scale navigation by microphone-array system. Here, we first measured large-scale flight paths of the Japanese greater horseshoe bat, Rhinolophus ferrumequinum nippon, using GPS data-loggers. Twelve loggers were successfully retrieved from the total of attached 40 loggers. The results show that the measured flight paths were broadly divided into two patterns, Stay and Travel. In order to examine what the bats do during the Stay, we then attached custom-made GPS-acoustic loggers which can simultaneously log both GPS positions and timing when the bats emit ultrasounds. The only one retrieved prototype of GPS-acoustic logger shows that the bat emitted sounds during the Stay more than the Travel. This suggests that the bats forage during the Stay because they are known to exhibit flycatcher-style, i.e., perch under a tree branch, emitting sonar sounds to search insect-prey. To investigate their detailed foraging behavior in the small-scale space, we reconstructed a microphone-array system at the Stay area to measure echolocation and flight behavior of the bats. As a result, we finally recorded the bat's ultrasounds at the Stay area, and the frequency of the observed emissions was relatively constant at around 68 kHz, suggesting that the stationary bats emit sounds for search of insect-prey. We need further investigation but such hybrid measurement using data-logger for large spatial scale and microphone-array for specific spatial space would reveal the detailed echolocating behavior of bats during daily navigation for foraging. [This research was supported by a Grant-in-Aid for Young Scientists (B), Scientific Research (A) and Scientific Research on Innovative Areas of JSPS, and the JST PRESTO program.]

Poster # 81

David Villalobos-Chaves, Manuel Spínola-Parallada, Katrin Heer, Elisabeth K. V. Kalko, Bernal Rodríguez-Herrera

Implications of a specialized diet for the foraging behavior of the Honduran white bat, Ectophylla alba (Chiroptera: Phyllostomidae)

DVC, BRH: Escuela de Biología, Universidad de Costa Rica, 2060 Montes de Oca, San José, Costa Rica • MSP: Instituto Internacional en Conservación y Manejo de Vida Silvestre, Universidad Nacional, 40101 Heredia, Heredia, Costa Rica • KH: Conservation Biology and Animal Ecology, Faculty of Biology, University of Marburg, Karl-von-Frisch Strasse 8, 35043 Marburg, Germany • EKVK: Smithsonian Tropical Research Institute, P.O. Box 0843-03092, Balboa, Panama
dvillaloboschaves@gmail.com

Specialist species are defined by their restricted range of tolerated environmental conditions and required resources. For example, in the New World leaf-nosed bats (Phyllostomidae), specialization in diet has been linked to morphological and behavioral innovations (i.e., skull form, foraging behaviors) that facilitate the occupation of new ecological niches by these animals. Here, we use the Honduran white bat, Ectophylla alba, as a model to test the behavioral responses of the species to a narrow diet: one based on figs of Ficus colubrinae (Moraceae). Through the use of radiotelemetry and food and roost resource samplings, we demonstrate that the foraging behavior of these bats is highly dependent on their main food resource. In comparison, spatial movements of E. alba are greater than those reported for other, larger-sized frugivorous bats that feed on a high diversity of plant species. Nevertheless, bats compensate these larger movements by selectively foraging on trees with high availability of food resource and preferably at short distances of day roosts. These responses are consequent with behavioral adaptations that have evolved in order to optimize the bats' foraging strategies and - at a broad level - the performance and survival of the species in their habitat. Conservation decisions should consider the tight linkage that exists among some species and their habitat characteristics or food resources (as demonstrated herein), in order to protect highly susceptible and unique species that could potentially go extinct with the disturbance or removal of specific features of their ecological interactions.

Poster # 106

Alexei Vyssotski

Electrophysiological and behavioral monitoring in free-moving animals

Institute of Neuroinformatics, ETH Zurich and University of Zurich

alexei@vyssotski.ch

Cognitive processing in the brain remains one of the main mysteries of modern science. Recording of activity of isolated neuronal cells represents the most direct access to information processing inside the brain. Up to recent time, electrophysiological recording of brain activity was limited to in-house laboratory experiments. To make it applicable to free-moving animals outdoors, we developed a family of data-logging devices called "Neurologgers" (www.vyssotski.ch). Three generations of recording devices have been developed during last decade. The first of them weighing 5.3 g (w/o battery) recorded up to 8 differential EEG, LFP, EMG or ECG channels, or 2 neuronal channels in 32 GB microSD memory card. It was used in junction with a portable GPS logger in flying pigeons to proof the principle, and later - in larger animals like ostriches and walruses. The second generation with the weight 1.7 g was especially adopted to be carried on a head of a small animal like a mouse, a rat, or a homing pigeon. It also has been used with variety of larger wild species. Both generations are able to record 3D acceleration. The latest, the third generation weighing only 2 g and having memory up to 256 GB can record up to 32 neuronal/EEG/LFP channels with the frequency up to 20.8 kHz together with two independent audio channels, 3D compass and 6D inertial tracking subsystem. Recently we added a possibility of indoor high-precision 3D optical tracking, especially useful for studying social interactions in birds and primates. This patent-pending technology is based on several stationary light sources emitting a sequence of infrared flashes and planar laser beams scanning the area of animal location. An animal-attached mobile device receives an angular coordinate relatively to a lighthouse in the form of a time interval between an infrared flash and a planar beam reception.

Poster # 134

Connor F. White, Jerry H. Moxley, Adrian C. Gleiss, Taylor K. Chapple, Paul E. Kanive, Barbara A. Block, Aaron B. Carlisle

Fine-scale variability in stomach temperatures of White Sharks (Carcharodon carcharias) links to digestion and homeothermy

CFW, JHM: Monterey Bay Aquarium • ACG: Murdoch University • TKC, BB, ABC: Stanford University • PEK: Montana State University
connor.white@gmail.com

A variety of marine taxa have evolved the ability to elevate body temperature above ambient conditions (endothermy), a trait that improves the rates of many vital physiological processes and allows animals to operate effectively across a range of thermal conditions, thereby expanding their niche. Understanding of internal stomach and core temperatures and thermoregulatory patterns provides insight into animal behavior, energetics, and digestive processes. White sharks (Carcharodon carcharias) are large-bodied endothermic predators that have been hypothesized to be functionally homeothermic. We fed data loggers that record depth, acceleration and internal stomach temperature to free-swimming adult sharks in order to understand species-specific patterns in internal temperature regulation and digestive behavior. We recorded a total of 1208 hours of depth and temperature data from 9 different individuals, with deployments lasting from 48 to 284 hours. Mean stomach temperatures (25.5 ± 1.4 C) matched internal temperatures reported in the literature. However, we found greater intra- and inter-individual variability than reported in the literature with one individual exhibiting a range of 7.5 C over 90 hours and differences of 2.5 C between individuals' means. This large variability makes identification of heat increments of feeding in the wild problematic, however stomach temperatures in 5 sharks peaked within 24 hours of ingesting the bait-wrapped tag. High frequency variations (<0.5C) in stomach temperatures were correlated with accelerations, indicative of possible digestive movements exposing the tag to thermal heterogeneity in the stomach. Results suggest there is greater variability in stomach temperature than previously acknowledged, yet, further work is necessary to understand the drivers of stomach thermal dynamics in white sharks and other endothermic sharks and fishes.

Poster # 166

Saskia Wischnewski, Derren S. Fox, Aly McCluskie, Lucy J. Wright

Introducing a new device attachment method for tagging sensitive seabird species

SW, DSF, LJW: RSPB Centre for Conservation Science, The Royal Society for the Protection of Birds, UK Headquarters, The Lodge, Sandy, Bedfordshire SG19 2DL, UK • AMC: RSPB Centre for Conservation Science, The Royal Society for the Protection of Birds, Scottish Headquarters, 2 Lochside View, Edinburgh Park, Edinburgh EH12 9DH, UK
Saskia.Wischnewski@rspb.org.uk

Seabird tracking studies using GPS or accelerometers are often limited to short deployments during the breeding season that only provide a snapshot of a species' complex foraging strategies. While long-term attachment methods such as harnesses are available they can have detrimental effects on survival and productivity and are thus not a suitable choice for all species. The achievable deployment length using short-term attachment methods such as Tesa tape are highly dependent on a species' behaviour and can vary from weeks to only a few days. A seabird known to be extremely susceptible to early tag loss is the Black-legged Kittiwake (Rissa tridactyla) because of its ability to rapidly remove devices attached to its body feathers. Consequently, high resolution tracking data covering multiple weeks of the breeding season are not available. Here we test an alternative medium duration approach for the species and other tagging sensitive seabirds. We glued 20 remotely downloadable, solar powered GPS/accelerometer tags (University of Amsterdam) to trimmed back feathers of chick-rearing Kittiwakes, an attachment method often used in wader research but to our knowledge not yet trialled on seabirds. While handling times are longer than in conventional short-term attachment methods and ranged from 9-15 minutes, birds returned to nests on average within 4 minutes after release. The earliest tag loss was noted after 20 days without apparent effect on the birds. Up to date the last data was downloaded after a deployment period of 32 days. Productivity was extremely low across the whole colony but fledging success of tagged and adjacent control nests was similar. The tag/attachment combination provided 2-25 (Mean: 9 ± 6) consecutive trips within a breeding season. Preliminary results suggests that glue mounting is a suitable method to extend deployment periods for tagging sensitive seabird species without the adverse effects of long-term attachment methods.

Poster # 93

Danuta Maria Wisniewska, David Cade, John Calambokidis, Ari Friedlaender, Jeremy Goldbogen

Synchronous behavior of pairs of blue whales on their feeding grounds: insights from multi-sensor tags

DMW, DC, JG: Hopkins Marine Stations, Stanford University, 120 Ocean View Blvd, Pacific Grove, CA 93950, USA • JC: Cascadia Research Collective, 218 1/2 West 4th Avenue, Olympia, WA 98501, USA • AF: Marine Mammal Institute, Hatfield Marine Science Center, Department of Fish and Wildlife, Oregon State University, Newport, OR 97365, USA •

danuta@stanford.edu

Most rorquals migrate seasonally between feeding and breeding grounds, but we know little about migratory behavior of blue whales and how they partition feeding and breeding. Blue whale pairs, where males trail females, have been observed on feeding grounds, with some pairs remaining stable for several weeks, raising further questions about the importance of sociality and coordination of foraging, and potential costs of mate guarding in these animals. However, most inferences regarding fine-scale dynamics of rorqual pairs have come from observations of surface interactions. Here we analysed data from simultaneous deployments of multi-sensor tags (DTAGs, Acousondes, B-probes, Mk10F) on ten blue whale pairs to examine their concurrent diving and foraging behavior. We used vertical proximity and cross-correlation analyses to quantify synchrony between paired whales. Paired individuals were closely associated with median vertical distances <15m. Similarly, dive depths were positively correlated for pairs engaged in shallow- (<100m, correlation coefficient mean=0.78, range=0.41-0.99) and deep-water foraging (120-300m, correlation coefficient mean=0.98, range=0.97-0.99), suggesting the involvement of vision in mediation of the interactions. Dive-by-dive lag time revealed no consistency in who initiated the foraging dives, but the trailing whale always surfaced last. Results from a kinematics-based lunge detector on a shallow- and a deep-diving pair showed the leaders performed approximately twice as many lunges as the trails, suggesting that males may sacrifice feeding opportunities to maintain contact with a potential mate. For the deep-foraging pair, 100% and 93% of the male"s lunges occurred within 25s (median=6s) and 25m (median=10m, max=34m) of the female"s lunges, while for the shallow-foraging pair, 50% and 97% of the male"s lunges were within 25s (median=14s, max=123s) and 25m (median=4m, max=88m) of the female"s lunges. We will expand this analysis to include more pairs and concurrently-collected prey mapping data, allowing us to examine how pairs partition resources under different prey densities.

Poster # 26

Serena Wright, Mathieu Woillez, Victoria Bendall, Karine Heerah, David Righton, Ewan
Hunter Hélène de Pontual

Comparison of geolocation models to reconstruct pelagic fish tracks from temperature and depth data: application to European sea bass (Dicentrarchus labrax)

SW, VB, DR, EH: Cefas • MW, KH, HDP: Ifremer -
mathieu.woillez@ifremer.fr

The deployment of pop-up tag using GPS or ARGOS positioning system is not adapted to all pelagic fish. Thus, recent advances in methods to geolocate pelagic fish from the sole use of depth and temperature recorded by DSTs have provided promising new techniques to reconstruct pelagic fish trajectories. These trajectories provide invaluable information about fish movement patterns, which are key to our understanding of the spatio-temporal structuring of a fish population. However, to capture the full extent of a population, it is necessary to combine DST data from different geographical experiments supported by various countries especially since deployment costs are high and recovery rates are usually low. Movement analyses based on reconstructed tracks from DST tags must use similar geolocation models or at least geolocation models that provide coherent outputs. Here we draw on the results of an extensive DST tagging programme targeting sea bass to explore the abilities of two HMM-based geolocation models to accurately represent movements of tagged pelagic fish. We present the reconstructed tracks from fifteen tagged sea bass released from the southern North Sea to the Bay of Biscay. Despite differences in the source data (temperature and depth reference geophysical fields), in the model structures and in the inference techniques, both models provided consistent outputs which could be jointly used to better understand the sea bass population structure. Our results demonstrate that with sufficient temperature gradients, DST data can accurately geolocate migratory pelagic species without the use of satellite tags, potentially yielding spatial dynamics data from many pelagic species. Results also help to define best practices and future developments required for the successful geolocation of pelagic fish.

Poster # 85

Takashi Yamamoto, Yuichi Mizutani, Mizuho Nagata, Hirokazu Suzuki, Ken Yoda

Post-breeding movement ecology of a coastal seabird, black-tailed gull Larus crassirostris

Graduate School of Environmental Studies, Nagoya University
ytaka@nagoya-u.jp

Tracking studies have revealed the migratory movement of a wide range of avian species especially for highly migratory seabirds, while coastal seabirds have received little attention. Gulls are feeding generalists, preying on plankton, forage fish, demersal fishes, and also scavenging on anthropogenic food resources and dead animals. Migratory movement is often explained by seasonal changes in food availability. In this respect, gulls could find alternative food in almost any habitat and any season. Hence, we may expect that migratory movement of gulls is more flexible, showing a unique migratory strategy compared to most pelagic seabirds that usually exhibit migration to distant fixed wintering destinations sooner after the breeding season. We attached light-based geolocators on black-tailed gulls (Larus crassirostris) breeding on Kabushima Island, Japan in 2010 - 2015, and subsequently obtained 89 post-breeding migration data from 67 individuals. Although gulls stayed along coastal regions of Japan throughout the non-breeding season, some individuals migrated southwards and some northwards from the breeding colony after breeding (August - October). Meanwhile, most individuals became to utilize broadly the same region, west coast of Japan, in winter (November - March). It may indicate that there is a fixed wintering destination in a certain period of time even for coastal seabirds. In addition, individuals showed consistencies in the migratory direction over years, and failed breeders, only in males, appeared to reach further areas. Clutch size in the subsequent year was 2.0 ± 0.6 eggs for successful breeders and 2.4 ± 0.7 eggs for failed breeders. Our results suggest that black-tailed gulls occupy coastal habitats year-round and exhibit the semi-fixed migratory movements, and also the breeding outcome appears to relate to the post-breeding movement and, therefore, likely the subsequent breeding quality.