As President of the Zoological Society of London, I am pleased to introduce the Institute of Zoology Annual Review.

One of the key successes of 2016 was the successful translocation of hihi to the New Zealand mainland since their disappearance from the area over a century ago. The Institute’s researchers have been working with hihi for over a decade, alongside several conservation partners and the New Zealand Government, and the successful growth of hihi populations represents the project’s strong emphasis on planned research and theoretical frameworks.

Another area I am extremely proud of is our work to understand and mitigate the effects of infectious pathogens on wildlife health. The increased pace of human activity – motorised transport, the encroachment of wildlife habitats and an expanding population – has exposed both wildlife and humans to infections they have not previously contended with. Our major research in this area includes the discovery of snake fungal disease in Europe; providing the scientific evidence demonstrating that culling of badgers increases the risk of bovine tuberculosis spillover to livestock; and a 10-year study into the ecology of pathogens carried by West African fruit bats.

ZSL’s Institute of Zoology remains at the cutting edge of developing conservation technology to address the long-term issues facing wildlife. Genetic diversity is crucial to the future survival of species, and the Institute has developed new software to evaluate genetic diversity based on population size, as well as new methods for estimating individual relationships based on genetic marker data.

This review presents six key impact areas in which our research is making a difference to conservation and increasing our understanding of the natural world. Thank you to those involved, whose tireless diligence makes our work possible.

The Institute of Zoology is at the forefront of tackling the challenges faced by the world’s most seriously threatened wildlife, developing new techniques and a deeper understanding of the issues at hand to help drive conservation action across the globe.

In 2016 our scientists made a step forward in the fight to eradicate fungal pathogens, such as chytrid fungus (*Batrachochytrium dendrobatidis*), a disease that has devastated amphibian populations globally. A new study indicated that microbiome diversity could be a critical trait in predicting host resistance to disease, and research will continue into whether microbiome diversity can weaken pathogens.

Meanwhile, our UK Cetacean Strandings Investigation Programme continues to monitor strandings and put pressure on the UK Government to speed up the destruction of polychlorinated biphenyls (PCBs) through a variety of policy-focused reports. PCBs pose a major global threat to the future of marine apex predators, such as killer whales, and the issue was widely covered in several broadsheet newspapers – bringing the toxic legacy of PCBs to public attention more than ever before.

We are dedicated to educating the scientists of the future, supporting more than 100 PhD and master’s students, and we remain one of the world’s leading institutions for zoological study. We continue to run MSc courses in Wild Animal Biology and Wild Animal Health, in collaboration with the University of London’s Royal Veterinary College, and support capacity building in developing nations through our ‘Interventions in Wildlife Health’ field course. Meanwhile, our Soapbox Science initiative provides a platform for women scientists to encourage greater diversity in the next generation of research scientists.

Finally, as we look back at the past 12 months at the Institute, I must take this opportunity to announce my own retirement after 13 years at the helm of this incredible Society. ZSL’s Institute of Zoology is vital to the future of our wildlife and it has been an honour to be a part of such an important organisation.
The Institute’s global reach

A  Iceland
The light-bellied brent goose (*Branta bernicla hrota*) has one of the longest migratory journeys of any goose species, and spends most of May refuelling in Iceland before breeding in the High Arctic. Institute researchers, in collaboration with the University of Exeter and the University of Iceland, are using long-term ringing data to understand how differences in migratory route and habitat use during the Icelandic staging period can influence individual reproductive success. Understanding how individuals use foraging resources across their entire annual range, and how these patterns drive variation in breeding success, has important implications for the management of threatened populations in the wild.

B  United Kingdom
Previously found in almost every county of England and Wales, the common dormouse (*Muscardinus avellanarius*) has undergone a marked decline over the past century. The Institute’s Disease Risk Analysis and Health Surveillance team carries out essential research on disease management for reintroduction, for example, screening dormice for pathogens that could present a health risk for the dormice themselves or other wildlife at the release site. In 2016, in partnership with the People’s Trust for Endangered Species and Natural England, 38 dormice were released into managed woodland in the Yorkshire Dales National Park.

C  Mauritius
Only 25 years ago, fewer than 20 echo parakeets (*Psittacula eques*) remained in the wild after widespread habitat loss and increasing competition with introduced, exotic species. Through the intense work of the Mauritian Wildlife Foundation, the population has now increased to almost 600 wild birds. Institute research is examining the underlying demography of the population and, in particular, its response to environmental conditions, disease and management actions, to ensure a long-term, viable population.

To find out more about our current research projects, visit zsl.org/science/research
Institute of Zoology research is truly international. Each dot on the map represents at least one project. Here, we highlight six projects that illustrate the breadth of our work.

**Spain**

The Institute has partnered with the Spanish National Research Council for almost 20 years, investigating the geographic distributions and impacts of emergent viral and fungal diseases of amphibians. Our work has identified species and amphibian habitats most at risk of ranavirus and chytridiomycosis, the diseases that most threaten Europe’s amphibian biodiversity. We have been developing strategies to mitigate disease impacts, including characterising skin microbial communities that can help amphibians fend off and clear infections, and applying antifungal and antiviral interventions that have, in some cases, cleared infections from isolated amphibian populations. Our goal is to ensure the survival of the novel and highly endemic Spanish amphibian species community in the face of an ever-expanding repertoire of threatening infectious diseases.

**Namibia**

Ephemeral rivers are fundamental to biodiversity in arid lands. Although dry and sandy for most of the year, their groundwater supports riparian woodlands, which act as a linear oasis, providing food and shelter to a wide variety of desert animals, as well as natural resources to local people. However, these unique ecosystems are under threat. In Namibia, we have been investigating widespread decline among the riparian trees of the Swakop River, one of the country’s most important rivers (and on which our Tsaobis Baboon Project is based). Our results suggest that damming is largely responsible, but that the management of tributary flows may help to alleviate local impacts.

**New Zealand**

The New Zealand fairy tern (*Sternula nereis*) is New Zealand’s rarest bird. Only 39 adult individuals remain and this tiny population is facing a range of threats, including human encroachment on breeding habitat and predation from non-native mammalian species. A recent evaluation of past recovery actions has called for more aggressive strategies that may promote recovery, but that are also risky. This includes translocation to establish breeding colonies in areas protected from predators and away from beachfront development. Institute researchers are working closely with the Department of Conservation in New Zealand to compare alternative recovery strategies, thus allowing an evidence-based choice of management that provides the best chance for population recovery.
Institute news

Over the past year, Institute research has continued to improve our understanding of the natural world and advance a range of important conservation issues.

Hihi highlights ▼
Our conservation efforts with New Zealand hihi (Notiomystis cincta) have continued to reap rewards over the past year. An exceptionally successful breeding season in the reintroduced population on Tiritiri Matangi Island, which ZSL manages via a contract from the New Zealand Department of Conservation, resulted in 40 juvenile birds being translocated to a new site in the Taranaki Region of the North Island – Rotokare Scenic Reserve. This is the first time hihi have been in the region since their local extinction 130 years ago. The efforts of ZSL and the multiple conservation partners we work with in New Zealand have resulted in a growth of hihi populations from one offshore island remnant in the early 1980s to an extra six reintroduced populations spread across northern New Zealand by 2017. The Institute’s John Ewen co-chairs the recovery team for this species and ZSL has recently co-published the project’s first formal annual review.

Making Brexit work for conservation science ▲
In September ZSL held the event ‘Making Brexit work for ecology and conservation science’, in collaboration with the British Ecological Society, the Campaign for Science and Engineering, the Royal Society of Biology, and Wildlife and Countryside Link. Speakers, including Professor Sir John Beddington CMG FRS, Professor Sue Hartley, Dr Elaine King and Professor Graeme Reid, focused on the key role science plays in the UK to help society address current and upcoming environmental challenges, making the point that the UK has a world-class scientific community capable of informing governmental decisions in the face of environmental uncertainty.

Mauritius Partnership Meeting ▶
In June, various partners involved in a wide range of conservation programmes in Mauritius met to review progress and plan future work. The meeting covered endangered species recovery, island restoration and the control of non-native predators. Outcomes from the meeting include a plan for a new conservation breeding and release project to boost numbers of Mauritius kestrel (Falco punctatus), which will be supported by staff from ZSL London Zoo; a network of zoos that are helping breed pink pigeons (Nesoenas mayeri) in captivity for ultimate release into the wild; and an ambitious idea to create a predator-free ‘island’ on the mainland of Mauritius, to protect olive white-eyes (Zosterops chloronothos) and other threatened birds and reptiles.

▼ Below: (left to right) Laura Bellingan, Elaine King, Sir John Beddington CMG FRS, Graeme Reid and Sue Hartley

◀ Left: Hihi (Notiomystis cincta)
▶ Right: Round Island petrel (Pterodroma arminjoniana)
Keep up to date with all the latest Institute news and breakthroughs at zsl.org/science/news

Soapbox Science

The 2017 season of Soapbox Science, our public outreach platform for promoting women scientists, was our biggest year to date, with 19 events across the globe, including new events in Canada, Germany and Ireland. Soapbox Science, founded in 2011 by Seirian Sumner, University College London, and the Institute’s Nathalie Pettorelli, transforms public spaces into arenas for public learning and scientific debate, giving everyone the opportunity to interact with, and be inspired by, leading women scientists.

Royal College of Veterinary Surgeons Fellowship

Congratulations are due to Andrew Cunningham (right, accepting award), who has been elected Fellow of the Royal College of Veterinary Surgeons. This prestigious accolade is awarded in recognition of outstanding contribution to the veterinary profession. Following 28 years of conducting world-class science, Andrew received the Fellowship for his ‘meritorious contributions to knowledge’. In the mid-1990s Andrew led the groundbreaking multidisciplinary team that identified one of the greatest emerging threats to amphibian populations worldwide – the Batrachochytrium dendrobatidis fungus. Andrew’s research includes the identification of vulture declines in South Asia, the discovery of ranavirus disease of amphibians in Europe and the spillover of zoonotic pathogens from bats in West Africa.

From PhD to Parliament and the Royal Society

PhD student Dani Rabaiotti was lucky enough to undertake two policy placements during the past year: one in the Parliamentary Office of Science and Technology (POST), funded through the British Ecological Society, and one at the Royal Society, funded by the Natural Environment Research Council. While working in Parliament Dani prepared a research summary, known as a POSTnote, on environmental crime and organised an event for MPs to discuss environmental crime with experts. At the Royal Society, Dani helped the policy team with its work on genetic technologies. These placements offer an excellent opportunity for researchers to learn about how Parliament and wider science policy work.
Welcome to the Anthropocene. Human impacts on the natural world are now so huge that we have our own epoch. This is the first time in the Earth’s history that a single species has defined a geological era. The evidence of our impacts is both overwhelming and terrifying, as revealed in our most recent Living Planet Report. The nature conservation challenges we face as a result are global and daunting. But all hope is not lost.

Evidence is emerging that shows conservation action can reduce human impacts. Global analyses have demonstrated that conservation has slowed down the rate of wildlife losses, which would have been more severe had conservationists not intervened. It is often important in human medicine to slow down the progress of a disease sufficiently for a patient to lead a relatively normal life, irrespective of whether a cure is possible. Conservation is no different. Progress is being made.

Director of Science Professor Ken Norris recognises the devastating environmental impact of human activity, but argues that conservation is making a difference.

The Endangered pink pigeon (*Nesoenas mayeri*) from Mauritius has been the subject of an intensive recovery programme for more than 30 years. As a result, the species has been restored from around six birds in one location to 400 birds split between six subpopulations on mainland Mauritius.

In collaboration with the Mauritian Wildlife Foundation, Institute researchers are now undertaking a telemetry study to understand pink pigeon habitat use and identify movement corridors between subpopulations to inform long-term conservation management strategies.

**To learn more about the IoZ’s conservation science, visit zsl.org/science**

**Saving species from extinction**

In a few places, human impacts have been sufficiently reduced to improve the conservation status of threatened species. We are involved in two of these places – Mauritius and New Zealand. Here, intensive conservation work is restoring some of the most threatened wildlife in the world. We are quite literally helping bring back species from the very brink of extinction. You can read about our work on threatened species on page 12 in this report. Mauritius is remarkable in that it is one of only a few countries that improved the status of its wildlife in recent years. Conservation can make a difference – a big difference – and we are beginning to understand the factors that define conservation success, so we can improve. The trajectory is upwards.

Earlier this year, we were part of the Conservation Optimism Summit. This meeting brought people together to understand and celebrate the very real difference conservation has made to wildlife and people around the world. The challenges we face are daunting, but we know how to succeed. Don’t lose hope!
Making an impact

In the pages that follow, we highlight a selection of Impact Areas where our research is making a difference. From the management of small populations to understanding wildlife microbiomes, monitoring the status of the world’s biodiversity to a ‘one health’ approach to wildlife and human health, our work is continually advancing conservation science.
The ‘one health’ approach

Infectious pathogens harboured by wildlife are a threat to both human and animal health – Institute researchers are finding solutions.

Over recent decades, there has been a growing realisation of the importance of infectious agents (or pathogens) harboured by wildlife, and their effects on both wildlife populations and public health (Cunningham et al. 2017).

Although wildlife pathogens have caused disease in wild animals for millennia, human activities are increasingly enabling these to become a conservation threat. This can be through the reduction in size of wild animal populations to a level where disease becomes significant to their survival or, more dramatically, when people (usually inadvertently) transport pathogens to new areas, exposing and infecting populations and species that have not naturally evolved with the infection. As people move wild animals and wild animal products, and therefore wild animal pathogens, in increasing volumes and at greater speeds around the world, disease is occurring – and being recognised as a growing threat to species conservation (Cunningham et al. 2017).

It is not just wild animals that are at risk from wildlife pathogens. These diseases can cross over into other species, including livestock and people (Cunningham et al. 2017). Indeed, as we have learned to combat and control diseases natural to human beings – as well as those such as measles that we acquired from our food and companion animals around the time of domestication – we are faced with the prospect of dealing with new diseases spilling over into people from wildlife. Such spillover has been ever present, but as we encroach further into remaining wildlife habitats, and as we interact with many previously ignored species (for example, turning to bats for bushmeat in the absence of larger animals that have been depleted due to overhunting), our exposure to new wildlife pathogens has increased.

At the same time, motorised transport and increased human population densities provide new opportunities for human-to-human transmission and spread of novel pathogens. Infected people are now able to reach towns, cities and hospitals prior to recovery or death, and the volume and speed of international travel allows pathogens to spread even before the first signs of disease are detected.

Tackling the root of the problem

Clearly, these two issues, of disease threats to wildlife conservation and to public health, are interconnected and require a common mitigation approach that tackles the root of the problem (Cunningham et al. 2017). Such an approach, often termed ‘one health’, ‘ecohalth’ or ‘planetary health’, has been a key focus of Institute research for many years, and it is gaining public and political attention. We have a long and successful history of diagnosing where disease is a conservation threat, identifying the causes and underlying drivers of such diseases, and developing mitigation methods in captivity and in the wild. For example, in the 1990s, the Institute led the international consortium of scientists who discovered the non-hyphal chytrid fungus *Batrachochytrium dendrobatidis* as a cause of amphibian disease, and showed that this disease is causing multi-species amphibian population declines and extinctions globally (Berger et al. 1998). In the UK, our researchers recently discovered finch trichomonosis, caused by the protozoan parasite jumping from pigeons and doves to finches, and showed this is causing sudden and rapid population declines of the greenfinch (*Chloris chloris*) (Lawson et al. 2012).

Minimising the risk of spillover

From a public health perspective, our research aims to understand the host-pathogen-human system, including the ecology of the pathogen in nature. Knowledge of pathogen infection dynamics in the natural host(s) can be used to inform the modification of human behaviours to minimise zoonotic spillover risk. Working collaboratively with social scientists is often essential to understanding human behaviours and motivations and how to implement solutions (Wood et al. 2012).

Our work in this field is exemplified by research to understand the significance of badgers (*Meles meles*) as hosts of bovine tuberculosis and the factors that increase the likelihood of spillover to livestock (and eventually to people). Institute scientists and...
collaborators found that the control measure of proactive culling of badgers actually increases the rate of spread and likelihood of spillover; an important result for informing mitigation measures that will actually work (Bielby et al. 2014).

Public health risks
In collaboration with the University of Cambridge, we have carried out a 10-year study into the ecology of viral pathogens carried by West African fruit bats, such as the straw-coloured fruit bat (Eidolon helvum). Fruit bats are often termed ‘keystone species’ because of their importance for the maintenance of ecosystem structure and function. Without these bats dispersing seeds and pollinating forest and orchard trees, our diet would be depleted of many fruits, and tropical forests would fail to regenerate in their current form.

By understanding the ecology of pathogens such as rabies and Ebola viruses in their natural bat hosts, and the interactions between bats and people that lead to human infection, we hope to find ways of minimising public health risks – allowing bats and humans to coexist (Wood et al. 2012; Wood et al. 2016). Future work in this area will include research to better understand the impacts of viral infections on the bats and how these infections can persist over time in their host populations.

‘One health’ was the subject of a special issue of the journal Philosophical Transactions of the Royal Society B: Biological Sciences, published in June 2017 and edited by the Institute’s Andrew Cunningham along with Ian Scoones (Institute of Development Studies) and James Wood (University of Cambridge). This special issue, entitled One Health for a changing world: zoonoses, ecosystems and human well-being, brought together a wide range of natural and social scientists to examine how well one health is working for conservation, livestock and public health, where it is failing and to identify priorities for further research. All papers in the special issue are available free online at rstb.royalsocietypublishing.org/content/372/1725.

References

Bielby, J, Donnelly, CA, Pope, LC, Burke, T and Woodroffe, R (2014) Badger responses to small-scale culling may compromise targeted control of bovine tuberculosis. Proceedings of the National Academy of Sciences of the United States of America 111: 9193-9198


Saving small populations from extinction

The Institute’s work is safeguarding some of the world’s most vulnerable and threatened small populations.

In the face of unprecedented biodiversity losses, effective strategies for saving small populations from extinction are urgently required. Among conservationists there is almost universal agreement on the need for evidence-based management decisions and for science that supports conservation decision-making. However, management of small populations remains primarily based on the application of experience without careful evaluation of evidence.

For management to be truly evidence-based the science should seek to provide information that will help in choosing management actions. In general, science can support management by firstly predicting the consequences of management actions based on available evidence; secondly, reducing uncertainty around choices between alternative actions; and, finally, providing specialist tools to help select the best action for a given set of objectives.

Institute researchers aim to inform small population recovery in a variety of ways – for example, we have predicted the consequences of supplementary feeding (Ewen et al. 2015) and predator control (Maggs et al. 2018), reduced uncertainties around the effectiveness of disease management (Hudson et al. 2016) and helped select the best management option under risk aversion (Canessa et al. 2016). The evidence support we provide is frequently done in a highly collaborative way, embedding our science directly into management, working alongside local partners.

Hainan gibbon conservation in China

The Hainan gibbon (Nomascus hainanus) is possibly the world’s rarest mammal, with only 25 individuals known in the wild. This level of rarity is important not only for the management of a species on the verge of extinction, but also because we have very limited knowledge of the species’ ecology.

We are working with colleagues in China to provide the scientific information needed for informed conservation decisions. This includes improving estimates of the spatiotemporal requirements of Hainan gibbon social groups, suggesting that habitat availability may not be the current driver of poor population growth (Bryant et al. 2017).

Through field monitoring using acoustic call playback methods, Bryant et al (2016a) discovered an additional small social group of Hainan gibbons. This amazing discovery increased the known number of breeding-age female Hainan gibbons from five to six individuals. Additional breeding individuals are critically important and provide more options for interventions to manage the extremely high rates of inbreeding and reduced genetic diversity also revealed by Bryant et al (2016b).

Hihi conservation in New Zealand

The hihi (Notiomystis cincta) is an endemic and threatened passerine of New Zealand. Institute researchers have been working with hihi for well over a decade, providing a substantial level of science and decision support to their continued recovery. From a low point of a single remaining population on an offshore island, the hihi is now found spread across this remnant island and in six additional reintroduced populations. Some of these reintroduced populations are on the mainland of New Zealand and are thus exposed to population establishment challenges linked to dispersal from protected areas.

Our research is showing how individual temperament predicts dispersal distances and can shape the probability that individuals recruit into establishing populations (Richardson et al. 2016). Importantly, all reintroduced hihi populations require substantial support, including supplementary feeding. Our most recent work shows that the benefits of supplementary food are equally strong even when hihi are released into mature and pristine forest (Doerr et al. 2017), a finding that continues to improve our understanding of their habitat needs and the beneficial roles supportive management can provide.

Wolf conservation in Europe

The science support we provide to management decisions is often closer to home. Carbon reduction is of growing environmental importance and Europe is addressing this by considering changes in how energy is produced. Wind farming can be damaging to small and threatened populations, including wide-ranging carnivores, such as wolves (Canis lupus). Institute research has provided a decision support framework offering an optimal trade-off between energy capacity and overlap with critical wolf reproduction habitat in Croatia (Passoni et al. 2017).
This work shows how science tools can help resolve complicated and often conflicted conservation objectives.

Science support for recovering small populations
Conservationists recognise the absolute need for evidence-based conservation action; however, the scientific support that provides this often fails to truly influence decisions. It is important we understand why this happens, and our work is providing leading insights on this issue. For example, Taylor et al (2017) investigated how well science supported management within reintroduction biology an effective applied science?

References


The Hainan gibbon is possibly the world’s rarest mammal, with only 25 individuals known in the wild.
Wildlife microbiomes

Institute research is advancing our understanding of the complex microbial communities essential to the health of species and ecosystems.

Microscopic organisms are found everywhere on Earth: in soils, oceans and living in association with animal and plant hosts. Complex microbial communities, known as the ‘microbiome’, play an essential role in maintaining the health of both individual species and entire ecosystems.

In animals, the microbiome underpins a myriad of physiological processes critical to host health, including metabolism, digestion, optimal immune system function and protection from pathogens. Understanding the links between the microbiome and animal health can help us to tackle a broad range of global conservation challenges. Institute scientists are conducting groundbreaking research into the fundamental science of host-microbiome interactions, how these principles can be applied to issues such as global population declines caused by wildlife disease, and how best to manage threatened populations.

Interaction between microbiome and wildlife pathogens

Infectious diseases are responsible for the decline of amphibian biodiversity around the globe. These declines have largely been caused by fungal pathogens such as Batrachochytrium dendrobatidis (Bd) and Batrachochytrium salamandrivorans, and the virus ranavirus. The amphibian skin microbiome can defend the host against these pathogens, and so it is vital that we understand what drives variation among individuals in their microbiome, and what consequences this variation has for disease resistance.

New research led by the Institute has revealed that common frogs (Rana temporaria) living in habitats with greater bacterial diversity in turn had more diverse skin microbiomes. More importantly, frogs with more diverse microbiomes were less susceptible to the lethal pathogen ranavirus. In a separate study, we have shown that midwife toads (Alytes obstetricians) in populations suffering more severe outbreaks of Bd, characterised by rapid population declines, exhibited lower microbiome diversity compared to populations suffering milder Bd infection dynamics. Thus, microbiome diversity appears to be a critical trait in predicting host resistance to disease and disease dynamics, and colonisation of the host by bacteria living in the environment may be a crucial process determining that diversity. Future research will probe the mechanistic basis of these links between microbiome diversity and disease resistance. For example, we will use both shotgun metagenomics and metabolomics to understand whether increased microbiome diversity also results in a greater diversity of bacterially derived metabolites that may directly attenuate the pathogen.

Bacterial probiotics to mitigate wildlife disease

A novel tool for the mitigation of wildlife disease involves the augmentation of the host microbiome with bacteria known to inhibit the growth of the pathogen. The Institute plays a leading role in the development of probiotic treatments for wildlife disease. Previous work has demonstrated the ability of a single probiotic bacterium to inhibit Bd is not consistent across multiple variants of chyrid isolated from separate geographic locations.

By adopting a community-level approach to probiotic development, we have demonstrated that using a combination of multiple bacterial isolates as a single ‘consortium probiotic’ yields broader-spectrum inhibition of Bd compared to single bacteria. This research highlights the possibility that bacterial consortia may offer a more robust tool for the probiotic inhibition of wildlife diseases, such as chytridiomycosis, in the wild.
Linking gut microbiome to nutrition and physiology

Bacteria living in animal digestive tracts have enormous potential to impact host health and physiology by controlling the efficiency of energy metabolism from food. There is now growing interest in the idea that differences among individuals in their gut microbiomes may underpin the differences we observe in the wild in animal body condition and health, and the extent to which individuals are able to specialise on different food resources.

The Institute is leading a novel research programme to understand the links between gut microbiome and nutritional health, using the light-bellied brent goose (Branta bernicla hrota) as a model system. Migratory brent geese use fat reserves stored during the spring staging period in Iceland to finance the energetic cost of reproduction in the Canadian Arctic. Thus, geese able to liberate more energy from food can store more fat and lay more eggs. This study will probe the mechanistic link between gut microbiome composition and ability to maximise energy metabolism, and how differences in microbiome may allow individuals to specialise on different food sources by providing a pre-adapted metabolic toolkit digestion of specific nutrients. Results from this study will have marked implications for our management of wildlife populations. For example, we may be able to improve the health of animals translocated to new areas by administering probiotics that will optimise their ability to digest local food/prey items.
Monitoring species through telemetry

Tracking technologies are revolutionising how we monitor populations, allowing us to record high-resolution data on the behaviour and movements of animals. Institute researchers lead the way in combining telemetry and novel analyses for conservation.

Understanding the long-term behaviour of animals in their natural habitat is crucial for effective conservation. The development of smaller, cheaper and more powerful tracking equipment is enhancing the scale and variety of species that can be monitored across the globe.

This increasing sophistication of tag design is transforming species conservation from determining simply where and when species are present to understanding and predicting how changes in the environment and ecology of species drive patterns of distribution. The volume and richness of data available from animal-borne data devices require increasingly versatile and powerful tools to extract and interpret this vital information; Institute research continues to play a leading role in advancing both tagging and analytics for improved species conservation.

Inferring behaviour through machine learning approaches
The Institute currently monitors a host of populations using a broad range of tracking technologies. These include, but are not limited to, acoustic transmitters on sharks in Palmyra (Central Pacific Ocean), the Chagos Archipelago (Central Indian Ocean) and the Bahamas; light-based geolocation tags on seabirds in the UK, Chagos and Mauritius; and our own open-source, low-cost GPS trackers (Mataki tags) deployed on tigers (Panthera t. tigris) in India, pygmy three-toed sloths (Bradypus pygmaeus) in Panama, Manx shearwaters (Puffinus puffinus) in the UK, and a variety of large carnivores in Africa.

Typically, researchers and conservationists wishing to employ telemetry to monitor species have faced a trade-off; with limited budget, should one favour a small number of sophisticated, often satellite-linked and expensive electronic tags that give high spatial and temporal resolution, or a larger number of less precise, but cheaper, devices such as geolocation or acoustic tags? In recent years, research at the Institute has demonstrated how more information can be extracted from both high- and low-resolution devices using novel machine learning methods – the automated recognition of patterns in big data by computers – as an important tool for conservation.

A priority for developing these machine learning tools is to better measure the interaction of wide-ranging animals with one another and their local environments in order to understand the broad and complex drivers of population dynamics. Our recent work in this area revealed that patterns of global wind speed and direction obtained via remote sensing can be used to predict the behaviour and movement energetics in a wide-ranging seabird, the Manx shearwater (Gibb et al. 2017).

Machine learning methods in the marine environment can play a significant role in species conservation. For fish species that rarely surface and for which it is therefore difficult to obtain frequent satellite positions, acoustic transmitters and receivers provide coarse residency and space-use patterns. Recently, we developed a widely applicable method for inferring social interactions from acoustic telemetry data, enabling us to establish patterns of social leadership behaviour in a population of grey reef sharks (Carcharhinus amblyrhynchos) at a remote atoll in the Pacific Ocean (Jacoby et al. 2016). It is hoped that behavioural inference at the population level will ensure that characteristics, such as a species’ tendency to aggregate or move in a specific way, can be built into future vulnerability assessments.

Applied telemetry
Remote refuges can provide wilderness areas where we might expect animal populations to thrive, but these are also some of the hardest places to monitor species. This challenge is epitomised through our research on species that occupy the marine realm, particularly as the remote nature of some of these locations makes them susceptible to unregulated activity, such as illegal fishing.

Spatial network analyses that quantify how animals link different habitats, in combination with electronic monitoring, offer a broad set of analytical tools that help us to assess the efficacy of protected areas for highly mobile species such as sharks and seabirds. Developments in these tools, and how they are likely to contribute to improved conservation strategies, were recently assembled in a comprehensive review (Jacoby and Freeman 2016).

From tags to targets
Alongside their application for conservation management, these sophisticated monitoring tools can have broader use in assessments of species extinction risk and in feeding into global biodiversity indicators (e.g. estimating changes in population size, range size or the impact of specific threats). Indicator development for the Sampled Red List Index and Living Planet Index relies on monitoring data but often lacks information for difficult-to-monitor species in remote locations. Improvements in telemetry to monitor populations could help fill gaps in our knowledge of biodiversity trends worldwide.

Our research is at the forefront of communicating global biodiversity trends (e.g. McRae et al. 2016), developing indicators for policy used to measure progress towards international biodiversity targets. These advances in biodiversity monitoring therefore contribute not only to single-species management, but to the conservation of biodiversity more broadly.
The Institute has developed a method for inferring social interactions between grey reef sharks in the Pacific Ocean, using acoustic telemetry data.

Below: data from remote sensing can help predict the behaviour of Manx shearwaters. Below right: a common guillemot with a Mataki tag. Bottom left: the Institute uses acoustic transmitters to study grey reef sharks in the Pacific Ocean. Bottom right: an acoustic receiver used to monitor movement patterns and social networks in sharks.

Learn more about the Living Planet Index at livingplanetindex.org

For further information, contact Robin Freeman: robin.freeman@ioz.ac.uk

References


Fostering coexistence between people and nature

Institute research improves our understanding of the relationships between nature and people, and develops and evaluates mechanisms to support coexistence.

Human development, as explicitly acknowledged in the UN Sustainable Development Goals, can only be sustainable if it does not destroy the ecosystems on which people and wildlife depend. Yet human populations continue to grow and anthropogenic impacts are increasingly affecting every corner of the globe. The global human population is expected to reach nearly 10 billion by 2050, and rising per capita consumption will place unprecedented pressures on the planet’s support systems. Maintaining biodiversity in the face of these pressures is an enormous challenge and depends on knowledge of the complex interdependencies between people and nature.

Assessing natural capital
Evaluating the state of nature in relation to human wellbeing underpins our ability to sustainably manage natural resources while delivering development goals. Recent work at the Institute has focused on the use of satellite remote sensing data in the assessment of natural capital and ecosystem services. This research demonstrates that satellite remote sensing-based methodologies can be used to provide a wide array of metrics that can inform conservation in data-deficient areas, such as the Sahara (Pettorelli et al. 2016). It goes on to make an urgent call for scientists in biodiversity and satellite remote sensing to work together in order to agree on standardised measures that can be used to hold national governments to account on their national and international commitments to biodiversity conservation.

Human-wildlife conflict
The Institute has ongoing research programmes that seek to understand the relationship between wildlife and local communities in order to develop mitigation strategies to reduce human-wildlife conflict. New research in this area has involved an assessment of the socio-economic correlates and management implications of livestock depredation by large carnivores, as well as an analysis of local attitudes to livestock husbandry practices and approaches to reducing livestock loss in the Tarangire-Simanjiro ecosystem, northern Tanzania. These results demonstrate the importance of fortified bomas as a long-term solution to reduce night-time livestock depredations, while adult herders help to prevent losses during daytime grazing at pasture. This research is key to developing effective strategies to foster coexistence with large carnivores (Mkonyi et al. 2017a,b).

Sustainable agricultural development
The need to feed a growing human population means that more food will need to be produced from the limited amount of land available globally that is suitable for agriculture. Finding ways to increase agricultural production, while maintaining biodiversity, is a mounting challenge. We investigated the impacts of different wildlife-friendly production schemes on biodiversity and ecosystem service delivery on farms in the UK. By comparing organic farming with two non-organic wildlife-friendly farming schemes – one prescriptive (Conservation Grade, CG) and one flexible (Entry Level Stewardship, ELS) – and sampling a representative selection of crop and non-crop habitats, we were able to show that pollination services were higher on organic farms overall compared to CG or ELS. These findings support organic farming practices that increase floral resources in crop habitats, such as sowing clover or reduced herbicide usage, as mechanisms to enhance pollination services (Hardman et al. 2016a,b). Understanding how different farming approaches can better foster biodiversity will help improve the sustainability of agricultural development.

Fencing policies for people and wildlife
In dryland ecosystems, mobility is essential for both wildlife and people to access unpredictable and spatially heterogeneous resources. In Africa there have been growing calls to increase fencing to separate wildlife and people as a means to protect wildlife populations from overhunting, poaching, human-wildlife conflict and human encroachment. However, research led by the Institute shows the need to exercise caution in
the use of fencing, as fences can prevent connectivity vital for the mobility of wildlife and people. This research identified six research areas that are key to informing evaluations on fencing initiatives: economics, edge permeability, reserve design, connectivity, ecosystem services and communities. Implementing this research agenda to evaluate fencing interventions will enable better management and policy decisions (Durant et al. 2015). Our research underlies a proposed concerted action to investigate the impact of linear barriers on wildlife movement in Africa, which is under consideration at the 2017 Conference of Parties of the UN Convention for the Conservation of Migratory Species.

Future priorities for our work in this area include developing a better understanding of the social and cultural dimensions of conservation and development interventions. Our ultimate aim is to contribute to the development of effective mechanisms to foster biodiversity and human wellbeing, helping to attain sustainable development goals alongside improved nature conservation.

References


Hardman, CJ, Norris, K, Nevard, TD, Hughes, B and Potts, SG (2016b) Delivery of floral resources and pollination services on farmland under three different wildlife-friendly schemes. *Agriculture, Ecosystems & Environment* 220: 142-151


Conservation genetics

The Institute’s researchers develop methods and tools in conservation genetics, and apply these to inform the conservation of threatened species.

Genetic diversity influences the health and long-term survival of populations, with decreased genetic diversity associated with reduced fitness and adaptability to changing environments. Conservation genetics provides the theory and methods to estimate historical and current genetic diversity and to predict the future distribution of genetic diversity in populations and species. This crucial information informs conservation strategy in order to minimise risk of extinction in threatened species.

**Estimating effective population size**

Threatened species usually have small and declining population sizes, and genetic diversity is lost due to genetic stochasticity. The rate of loss of genetic diversity is determined by the effective population size ($N_e$) of the species, which is affected by factors including the total population size ($N$), variance in reproduction and sex ratio. For wild populations, $N_e$ can be dramatically smaller than $N$, especially for species with extremely unbalanced sex ratio and high reproductive dominance.

Therefore, it is essential to measure the $N_e$ of a population for conservation management. We have developed methods to estimate $N_e$ from genetic marker data (most recently Wang 2016a), and produced user-friendly computer software called Colony, which is available on the Institute website for use by conservation genetics practitioners. Thousands of downloads of the Colony software have been recorded over the past 12 months and new Institute research used these methods to investigate the historical and current effective population size of Hainan gibbons (*Nomascus hainanus*) from microsatellite data (Bryant et al. 2016).

**Inferring population structure**

Individuals of a species may not constitute a genetically homogeneous population. Instead, they are usually clustered into different populations due to patchy geographic distribution and a limited ability to disperse. Inferring population structure by delineating the number and distribution of populations and by measuring the genetic differentiation among populations helps us to understand the current distribution of genetic diversity.

Institute research has shown that the most appropriate statistic for quantifying genetic differentiation is Fst (a measure of genetic differentiation between populations). However, Fst can underestimate differentiation when calculated from highly polymorphic microsatellite data. We have shown for the first time the circumstances when microsatellites give locus-dependent and underestimates of Fst, such as high mutation rate and low migration rate. We have since developed a correlation analysis to detect such circumstances from genotype data (Wang 2015).

We have also used a Bayesian clustering method (Structure) to make individual assignments to populations from multi-locus genotype data, most recently to investigate the population structures of grey squirrels (*Sciurus carolinensis*) (Signorile et al. 2016). A new study showed that Structure is easily misused when sampling is unbalanced, genetic diversity influences the health and long-term survival of populations, with decreased genetic diversity associated with reduced fitness and adaptability to changing environments. Conservation genetics provides the theory and methods to estimate historical and current genetic diversity and to predict the future distribution of genetic diversity in populations and species. This crucial information informs conservation strategy in order to minimise risk of extinction in threatened species.

**Estimating effective population size**

Threatened species usually have small and declining population sizes, and genetic diversity is lost due to genetic stochasticity. The rate of loss of genetic diversity is determined by the effective population size ($N_e$) of the species, which is affected by factors including the total population size ($N$), variance in reproduction and sex ratio. For wild populations, $N_e$ can be dramatically smaller than $N$, especially for species with extremely unbalanced sex ratio and high reproductive dominance.

Therefore, it is essential to measure the $N_e$ of a population for conservation management. We have developed methods to estimate $N_e$ from genetic marker data (most recently Wang 2016a), and produced user-friendly computer software called Colony, which is available on the Institute website for use by conservation genetics practitioners. Thousands of downloads of the Colony software have been recorded over the past 12 months and new Institute research used these methods to investigate the historical and current effective population size of Hainan gibbons (*Nomascus hainanus*) from microsatellite data (Bryant et al. 2016).

**Inferring population structure**

Individuals of a species may not constitute a genetically homogeneous population. Instead, they are usually clustered into different populations due to patchy geographic distribution and a limited ability to disperse. Inferring population structure by delineating the number and distribution of populations and by measuring the genetic differentiation among populations helps us to understand the current distribution of genetic diversity.

Institute research has shown that the most appropriate statistic for quantifying genetic differentiation is Fst (a measure of genetic differentiation between populations). However, Fst can underestimate differentiation when calculated from highly polymorphic microsatellite data. We have shown for the first time the circumstances when microsatellites give locus-dependent and underestimates of Fst, such as high mutation rate and low migration rate. We have since developed a correlation analysis to detect such circumstances from genotype data (Wang 2015).

We have also used a Bayesian clustering method (Structure) to make individual assignments to populations from multi-locus genotype data, most recently to investigate the population structures of grey squirrels (*Sciurus carolinensis*) (Signorile et al. 2016). A new study showed that Structure is easily misused when sampling is unbalanced,
Main image: bumblebee family lineage survival is enhanced in high-quality landscapes. Inset left: microsatellite data are used to investigate the historical and current effective population size of Hainan gibbons.

For further information, contact Jinliang Wang: jinliang.wang@ioz.ac.uk
and could yield biased results when the default parameter values of the software were adopted (Wang 2017). Our research has provided alternative parameter values, which yield more accurate population structure inferences in both simulated and real datasets.

Relatedness and relationship ascertainment

Knowing the genetic relatedness among individuals is essential for investigating breeding behaviour, inbreeding and inbreeding depression, social structure, and population demographics and connectivity. Traditionally, relatedness is calculated from pedigrees (e.g. Brekke et al. 2015). However, pedigree data are rarely available in wild populations.

Non-invasive genotyping alleviates some of these difficulties by obtaining DNA by indirect sampling of a specimen. This does not require handling (or even the presence of) the animal, as DNA can be extracted from small quantities of hair, feathers, scales or scats, which can be genotyped by polymerase chain reaction. We have applied this technique to a range of species, enabling ecological, evolutionary and conservation genetics studies of species that could not have been studied otherwise. However, data quality can be problematic because the quality and quantity of DNA from non-invasive samples is often low and genotyping errors are common. An important application of non-invasive genotyping, estimating population census size by the genetic capture-recapture model, is particularly vulnerable to genotyping errors.

We have proposed advanced likelihood methods for identifying individuals from multi-locus genotypes obtained from non-invasive samples, accounting for genotyping errors and missing data (Wang 2016b). Our methods have recently been used to estimate the density and effective population size of cheetahs using scats detected by trained dogs (Becker et al. 2017).

Disease emergence

Infectious diseases can threaten populations, species and entire communities of wildlife, and the consequences of disease can be exacerbated when genetic diversity of wildlife populations is low. Wildlife hosts of pathogens can respond to the emergence of disease through selection, and we have used population genetics to detect both natural and sexual selection in diseased populations.

We have shown how the genetic interactions between host and pathogen are strongly regulated by environmental variation caused by climate change (Clare et al. 2016), and we now need to examine how genes are expressed under these different conditions. Hosts cannot fend off pathogens with a single molecular toolkit, so we will continue to unpick the complexities of host immune gene expression.

To download Colony, visit zsl.org/science/software/colony – and for Coancestry, visit zsl.org/science/software/coancestry

References


Wang, J (2017) The computer program STRUCTURE for assigning individuals to populations: easy to use but easier to misuse. Molecular Ecology Resources. doi:10.1111/1755-0998.12650
Research highlights

Institute researchers continue to advance our understanding of the natural world. In the following pages we highlight new science and report on a diverse range of subjects – from the impact of climate change on African wild dogs to the identification of a new fungal skin disease in snakes. Also in this section, two of our scientists describe what their work entails, we explain how we communicate our knowledge, and we celebrate our students’ work and the outstanding contribution of our award winners.
Research highlights

Through their published research, Institute staff and students continue to widen our knowledge and understanding of the natural world. Here, we present just a few of the papers that have been making an impact over the past year.

Snake fungal disease found in Europe
Snake fungal disease (SFD) is an emerging disease of conservation concern in eastern North America. *Ophidiomyces ophiodiicola*, the causative agent of SFD, has been isolated from more than 30 species of wild snake from six families in North America. While *O. ophiodiicola* has been isolated from captive snakes outside North America, the pathogen has not been reported from wild snakes elsewhere. We screened 33 carcases and 303 moulting skins from wild snakes collected from 2010-2016 in Great Britain and the Czech Republic for the presence of macroscopic skin lesions and *O. ophiodiicola*. The fungus was detected using real-time polymerase chain reaction in 26 (8.6%) specimens across the period of collection. Follow-up culture and histopathologic analyses confirmed that both *O. ophiodiicola* and SFD occur in wild European snakes. Although skin lesions were mild in most cases, in some grass snakes (*Natrix natrix*) they were severe and were likely to have contributed to mortality. Culture characterizations demonstrated that European isolates grew more slowly than those from the United States, and phylogenetic analyses indicated that isolates from European wild snakes reside in a clade distinct from the North American isolates examined. These genetic and phenotypic differences indicate that the European isolates represent novel strains of *O. ophiodiicola*. Further work is required to understand the individual and population-level impact of this pathogen in Europe and which species are affected. Comparing how SFD affects wild snakes on different continents may help us understand the origin of the disease and help managers identify mitigation strategies.

Europe’s inadequate chemical pollution remediation
Polychlorinated biphenyls (PCBs), chemicals once widely used in manufacturing, remain a major global threat to marine apex predators, with killer whales (*Orcinus orca*) still the most PCB-polluted mammalian species globally (ICES 2017; Law and Jepson 2017; Stuart-Smith and Jepson 2017). Europe produced between 299,000 and 585,000 tons of PCBs prior to the ban on their production – but many EU member states are not assessing or decontaminating PCB-contaminated materials, sites or waste stockpiles sufficiently. In Europe, only Norway, Sweden and Switzerland have established procedures for secure disposal or destruction of highly contaminated PCBs in joint sealants. The United States is relatively proactive in terms of PCB mitigation nationally and at state level, including numerous US Environmental Protection Agency Superfund sites. As a direct result, PCB levels in the US have slowly declined in humans and other biota, such as fish, for many years and overall PCB mitigation is generally considered to be successful. We argue in a number of policy-focused reports and papers that Europe should learn the science and policy lessons from the US approach as a matter of urgency. There is also a general lack of compliance – globally – for PCBs under the Stockholm Convention, with approximately 80% of global PCB stockpiles on land still awaiting destruction. Aside from the International Council for the Exploration of the Sea (ICES), reports of the lingering effects of PCBs on marine mammals were also widely covered in the broadsheet newspapers, including an editorial in *The Times* on 3 May 2017.

References
ICES (2017) Working Group on the Biological Effects of Contaminants. ices.dk/community/groups/Pages/WGBEC.aspx

Jepson, PD (2017) Thunderer: Killer whales must be saved from toxic chemicals *The Times*, 3 May 2017


Reference
Remotely sensed wind speed predicts seabird soaring behaviour

Global wind patterns affect flight strategies in many birds, including pelagic seabirds, many of which use wind-powered soaring to reduce energy costs during at-sea foraging trips and migration. Such long-distance movement patterns are underpinned by local interactions between wind conditions and flight behaviour, but these fine-scale relationships are not well understood. Our research has shown for the first time that remotely sensed wind speed and direction can predict soaring behaviour in a migratory pelagic seabird, the Manx shearwater (Puffinus puffinus). High-frequency GPS tracking data and statistical behaviour state classification were used to identify two energetic modes in at-sea flight, corresponding to flap-like and soar-like flight. Importantly, the research found that soaring was significantly more likely to occur in crosswinds and tailwinds faster than eight metres per second. These periods of wind-powered soaring may enable birds to reduce metabolic costs by preferentially soaring over flapping. Our results suggest a behavioural mechanism by which wind conditions may shape foraging and migration ecology in pelagic seabirds, and thus indicate that shifts in wind patterns driven by climate change could impact this and other species. This research also demonstrates the potential of high-frequency GPS biologgers to provide detailed quantitative insights into fine-scale flight behaviour in free-living animals.

Reference

Citizen scientists help reconstruct wildlife disease emergence

Emerging infectious disease can pose a considerable threat to wildlife. Reconstructions of disease emergence can enable action to mitigate against further spread or prevent new emergences. Unfortunately, reconstructions of wildlife diseases are rare, often because wildlife populations are not intensively sampled. Institute researchers combined citizen science data with genetic information to overcome these challenges, and to study how viruses causing a fatal disease in amphibians and reptiles (ranavirus) had spread in the UK. ZSL was a founding partner in the Frog Mortality Project (FMP), a citizen science project initiated 25 years ago to collate information from the British public about incidents of frog mortality. The pattern of mortality incidents derived from the FMP database was used to model disease emergence and test hypothetical drivers, such as climate change, pathogen spread following introduction, and changes in reporting behaviour. We found evidence that ranavirus was independently introduced to the UK at least twice. Following introduction, most new outbreaks were explained through local dispersal of infected amphibians, but additional incidents, likely explained by translocations of infectious materials by people, were important in bringing about a rapid, nationwide spread. Our study supported the reinforcement of guidelines on limiting the movement of potentially infectious materials by people, were important in bringing about a rapid, nationwide spread. Our study supported the reinforcement of guidelines on limiting the movement of potentially infectious materials, but also highlighted how citizen science could help to reconstruct disease emergence in a timescale enabling information to flow into management decisions.

Reference
High temperatures impact reproductive success in African wild dogs

Climate change may be harming the future of African wild dogs, also known as African hunting dogs (*Lycaon pictus*), by impacting the survival rates of pups, according to one of the first studies on how shifting temperatures are affecting tropical species. We explored associations between weather conditions, reproductive costs and reproductive success, drawing on long-term wild dog monitoring data from sites in Botswana, Kenya and Zimbabwe. High ambient temperatures were associated with reduced foraging time, especially during the energetically costly pup-rearing period.

Across all three sites, packs that reared pups at high ambient temperatures produced fewer offspring than did those rearing pups in cooler weather. At the non-seasonal Kenya site such packs also had longer inter-birth intervals. Rising ambient temperatures at the longest-monitored Botswana site coincided with falling wild dog recruitment. Our findings suggest a direct impact of high ambient temperatures on African wild dog demography, indicating that this species, which is already globally Endangered, may be highly vulnerable to climate change.

This vulnerability would have been missed by trait-based assessments. Seasonal reproduction, which is less common at low latitudes than at higher latitudes, might be a useful indicator of climate change vulnerability among tropical species. Ongoing research will focus on identifying conservation actions that might reduce these climate impacts on wild dogs, and working out where they are most needed.

Reference

New species of extinct Late Quaternary giant tortoise

The Caribbean islands have experienced the world’s highest level of mammal extinction during the Holocene Epoch (the past 11,700 years), as a result of pre-modern human exploitation, habitat destruction and introduction of invasive species. However, the extent to which other vertebrate groups have also suffered human-caused extinctions in the Caribbean is much more poorly understood. Giant tortoises are absent from current-day insular Caribbean ecosystems, but tortoise fossils from Late Quaternary deposits indicate the former widespread occurrence of these animals across the northern Caribbean. Interestingly, giant tortoises are extremely rare in Quaternary fossil deposits across most of Hispaniola, a large island that has been studied extensively by palaeontologists over the past century. We recovered and analysed new giant tortoise material from several cave sites in Pedernales Province, southern Dominican Republic, Hispaniola, representing...
Below left: humeri of Chelonoidis marcanoi sp. nov. from Pedernales Province, Dominican Republic. Below right: an Institute study showed that badger vaccination had no discernible risks. Left: climate change may be diminishing African wild dog survival rates.

Badger vaccination against bovine TB offers alternative to culling

Concerns that vaccinating badgers against bovine tuberculosis (TB) might increase transmission rates of the disease to cattle have been diminished by new research showing no discernible behavioural impacts from this treatment. The study, led by the Institute, offers hope of a practical alternative to the UK Government’s controversial cull policy. The behaviour of 54 GPS-collared badgers was studied across four study sites in Cornwall. Scientists found that of these animals, the 15 that had received the TB vaccine during the course of the project had the same ranging behaviour as unvaccinated badgers. Badger vaccination is less risky, more humane and cheaper than culling. We hope that this research will open the door for greater exploration of badger vaccination as a tool to control TB in cattle.

Reference

Fossils indicate the former widespread occurrence of giant tortoises across the northern Caribbean

at least seven individuals, which we describe as a new extinct species, Chelonoidis marcanoi. The surprising abundance of giant tortoise remains in both vertical and horizontal caves in Hispaniola’s semi-arid ecoregion may indicate that this species was adapted to open dry habitats. We hypothesise that the Hispaniolan giant tortoise became restricted to a habitat refugium in southeastern Hispaniola following climate-driven environmental change at the Pleistocene-Holocene boundary, making it more vulnerable to hunting by prehistoric human colonists who arrived in Hispaniola around 6,000 years ago. This research suggests that Hispaniola’s dry forest ecosystem may have been shaped by giant tortoises for much of its evolutionary history.

Reference
How our science is done

Two Institute researchers describe the variety of their working days and explain the rewards of a career in conservation science.

Monika Böhm reflects on the benefits of collaboration

Human impact is altering natural environments and pushing species to the brink of extinction. My work looks at the main factors affecting species and what may predispose them to be at an intrinsically higher risk. The majority of my time is spent on groups of species that are little-known in comparison to birds and mammals, such as reptiles and invertebrates. Yet this doesn’t mean I spend all my life in the field, observing animals in their changing environments – in fact, I hardly do any fieldwork!

The science I do relies heavily on extensive collaborations and collating vast data sets to test hypotheses about the causes of high extinction risk and population decline. One of my main collaborations is with the International Union for Conservation of Nature (IUCN), specifically on its Red List of Threatened Species. This is a huge collaboration of organisations and people, which has produced assessments of extinction risk for more than 80,000 species – a vast data repository on the status, distribution, ecology, habitat and threats of species.

Over the past 10 years, we have contributed more than 9,000 assessments to the IUCN Red List, again through extensive collaboration with species experts. This hard work results in huge data sets, which we can now use to study the causes of high extinction risk across a large number of species. Using these data, my research is trialling new ways of carrying out species assessments, by predicting extinction risk from species traits and environmental factors, such as habitat change, and by re-examining sampling regimes to adequately represent extinction risk trends in groups of megadiverse species, such as spiders. In many cases, these activities again rely on collaboration and data sharing, for example, to pull together data sets on species traits.

I see science as sharing knowledge and data widely, fairly and constructively, to address real-world problems. Sometimes we’re the donors, other times the recipients of large data sets. The best thing, in my opinion, is that each of these exchanges helps to shape collaborations, builds research networks and brings people with different expertise together – and more than once, you even make friends for life.
Guy Cowlishaw describes the joys of fieldwork

Understanding animal behaviour and ecology is fundamental to conservation. Without knowing how animals survive and reproduce, and their ability to adapt to changing environments, it is difficult to prioritise scarce resources or to design appropriate management interventions.

The best way of learning about animal behaviour and ecology is to spend time with the animals themselves. Often this is a significant challenge, although exciting new developments in tracking technology now make it possible for Institute scientists to study animals that have previously been out of reach – ranging from oceanic birds, like the Round Island petrels (Pterodroma spp.), to marine predators, such as scalloped hammerhead sharks (Sphyrna lewini). In other cases, our study species are more accessible and can be observed directly. Ideally, we work on foot; for instance, in our research on threatened island birds, but we also use vehicles, especially when observing large carnivores such as cheetahs (Acinonyx jubatus) and African wild dogs (Lycaon pictus).

The most privileged field biologists, and I count myself among them, work with animals that can be habituated to the presence of observers, allowing us to walk among them as if we were a member of their social group. In my case, this perfectly describes our working conditions on the Tsaobis Baboon Project, a long-term, individual-based study of desert baboons (Papio ursinus) in Namibia.

Field days with the baboons are long and tiring, involving 12-hour dawn-to-dusk follows on foot, travelling large distances over hazardous mountain terrain, carrying a heavy backpack in intense heat. Moreover, during this time, observers are continuously collecting data from the baboons (using customised smartphones), and may also be carrying out field experiments, ranging from novel food presentations (to study the transmission of social information) to playbacks of threat vocalisations (to explore male sexual coercion).

Nevertheless, field days with the baboons are also very rewarding. All of the baboons are individually recognisable and are well-known to us; indeed, we’ve followed most of them since they were born. Each individual lives in a complex network of family and friends, and their daily dramas unfold like a soap opera. But, crucially, in addition to the pleasure of sharing their lives with them, the baboons are also teaching us about how complex animal societies work, about how social animals are likely to cope with accelerating environmental change, and about what conservation support is needed to ensure that social animals survive into the future.
Education and training

Educating the next generation of conservation scientists is central to the Institute’s work. Here, we look at student achievements over the past academic year.

Our PhD students

It has been another busy year for our student body. We have a fantastic, dynamic and enthusiastic group that is keen to have an impact on how the Institute evolves. As an institution we have been working hard to improve our student structures, focusing on welfare and developing a nurturing working environment for students and staff. Students have been directly involved in this process by being part of our science development focus groups, having representatives in our Athena Scientific Women’s Academic Network (SWAN) panel and management board, co-managing our speed talk sessions and social committee, and volunteering their time and expertise in a number of events, such as UCL Summer School visits, British Science Week, Soapbox Science and Zoo Nights.

Being a postgraduate tutor over the past year has been immensely rewarding. My co-postgraduate tutor, Jon Bielby, left the Institute in February, but his legacy has had a huge positive impact on our work environment, and me personally – he was incredibly generous with his time and a great sounding board for all the different student policies and programmes we have been implementing. I am also very fortunate that Guy Cowlishaw took on this role upon Jon’s departure, and he has been just as enthusiastic and involved. Recently, we have focused on developing mental health awareness in the student body; our Athena SWAN application; and the development of the student hub, which will open in autumn 2017.

We continue to support programmes such as the Student Lunches, where students meet, share lunch and invite representatives from different ZSL departments. These lunches improve student integration, particularly with our new student cohorts, and give them the opportunity to learn about different non-academic careers in conservation and network with a wider group of conservation professionals. We also awarded four ‘Daisy Balogh’ grants to Cassandra Raby, Sahil Nijhawan, Kirsten McMillan and Sarah Brooke to support travel and subsistence costs associated with their PhDs and not covered by PhD budgets.

This year we have welcomed 12 new PhD students from the SCENARIO NERC Doctoral Training Partnership (DTF), London DTP and Science and Solutions for a Changing Planet DTP, as well as international students based in Chile, China and New Zealand. We have joined two new DTPs – Centre for Doctoral Training in Quantitative and Modelling Skills in Ecology and Evolution, and Environmental Research – and hope these will lead to new collaborations and students in the coming year.

We also bid farewell to 13 students who successfully completed their PhDs, producing impressive theses. They are: Kirsten McMillan (Epidemiology of the amphibian pathogen Batrachochytrium dendrobatidis, across multiple spatial scales); Clare Duncan (Mangrove forest ecosystem services: biodiversity drivers, rehabilitation and resilience to climate change); Andrés Valenzuela-Sánchez (Is chytridiomycosis a threat to the mouth-brooding Darwin’s frog (Rhinoderma darwinii)? A multi-approach disease risk assessment); Dominic Bennett (An appraisal of the ‘living fossil’ concept); Katherine Booth-Jones (Distribution and gene-flow in a hybridising population of Pterodroma petrels); Freya Jephcott (Inefficient responses to unlikely outbreaks: a case study of a supposed monkey-borne virus outbreak in the Brong-Ahafo region of Ghana); Andrew Jacobson (Large carnivores under threat: investigating human impacts on large carnivores in East Africa); Natoya Jourdain (New analytical methods for camera trap data); Elizabeth Moorcroft (Paws for thought: assessing the efficacy of monitoring techniques for rare and elusive species); Leandro Patino (Evolution and community structure of parasites in Galápagos giant tortoises); Silke Riesle-Sbarbaro (The persistence and zoonotic emergence of viral infections in fruit bats in Ghana); as well as Charlotte Clarke and Juliet Wright highlighted right. Time and time again, our students produce high-calibre research that makes a real difference to conservation. We could not be prouder!

Patricia Brekke, postgraduate tutor

Learn more about postgraduate opportunities at zsl.org/science/postgraduate-study
Projects promoting alternative livelihood activities are implemented to reduce reliance on bushmeat hunting, yet evidence that these projects succeed in changing local behaviours is limited. Through my PhD, I sought to gain a better understanding of the complexities of rural people’s lives in Cameroon, and assess how alternative livelihood projects work in practice. I took an interdisciplinary approach and gleaned insights from across the social sciences with the aim of changing the way we think about livelihood projects in conservation and, ultimately, how we might do them better in the future. I have since been involved in designing an impact evaluation of alternative livelihood projects for USAID and have just started a job with the Wildlife Conservation Society to coordinate its bushmeat research activities in the Congo.

Charlotte Clarke
My PhD focused on investigating a novel amphibian-infecting Dermocystid affecting palmate newts on the Isle of Rum in Scotland. Using a multidisciplinary approach, including DNA extraction and sequencing, histological analysis and epidemiological techniques, a pathogen profile was developed to better understand the host-parasite dynamics on the island. The most rewarding part of my PhD was being able to work and collaborate with different people and be exposed to such a vast array of research. I am now living in the Middle East and exploring the possibility of working with the World Wide Fund for Nature in the Gulf or moving towards public health utilising the epidemiology aspects of my work.
Our MSc courses

MSc courses in Wild Animal Biology and Wild Animal Health

Over the past 22 years, more than 400 students, from 57 countries and six continents have graduated from our MSc courses in Wild Animal Biology (WAB) and Wild Animal Health (WAH). In 2016, 17 students took the MSc WAB, of which two were awarded distinctions, seven received a merit, and eight passed. Seven students took the MSc WAH, of which one received a distinction, one a merit and four passed. Phoebe Griffith received the award for the MSc WAB student with the highest aggregate marks, and Victoria Wilkinson gained the most marks for the MSc WAH. The best research project prizes were awarded to Rebecca Lewis (MSc WAB) and Victoria Wilkinson (MSc WAH). Recent analysis of graduate career destinations shows that 84% of WAH and 85% of WAB graduates have gained posts in wild animal health or conservation (of 334 graduates surveyed), forming a valuable global network of wild animal health professionals, contactable through Wild Animal Alumni.

Interventions in Wild Animal Health field course

In February, ZSL ran the second Interventions in Wild Animal Health field course in the beautiful setting of Sariska National Park, Rajasthan, India, in collaboration with the Wildlife Institute of India and the University of Edinburgh. Twenty-six veterinarians attended and received in-depth, practical tuition in population monitoring, surveillance of wild animal disease, and physical and chemical restraint of free-living wild animals. Of the attendees, 23 veterinarians were from biodiverse developing countries where increased capacity of wildlife health professionals is desperately needed.

MSc course in Conservation Science

The MSc course in Conservation Science, run in partnership with Imperial College, the Royal Botanic Gardens, Kew and Durrell Wildlife Conservation Trust, remains popular with students focused on starting or enhancing their careers in conservation research and action. The 2016 cohort included students from Indonesia, Trinidad, Palestine, the USA and several European countries, as well as the UK. In all, 29 students graduated, with the award of 15 distinctions and 14 merits. Joss Lyons-White was awarded the TH Huxley prize for the best student overall, and Hollie Booth was awarded the Joseph Hooker prize for the best coursework performance. Ans Vercammen was awarded the Durrell prize for the best project, which evaluated a novel approach to spatial planning for conservation of reefs in the coral triangle by developing a spatially explicit model of coral condition across the region.

Access the full Conservation Science thesis archive at iccs.org.uk/content/thesis-archive-msc-conssci
ZSL Library

The ZSL Library develops and facilitates access to resources in zoology and conservation science. Our unique collections provide an ideal opportunity for lifelong learning.

ZSL Library renamed
In honour of HRH The Duke of Edinburgh’s long-standing support for ZSL, the ZSL Library has been renamed the Prince Philip Zoological Library and Archive.

Events and exhibits
The Wellcome Collection borrowed five items for the Making Nature exhibition, which was visited by more than 130,000 people. An exhibition in the Aquarium at ZSL London Zoo featured drawings of birds and mammals from the manuscripts of Brian Houghton Hodgson as part of our Britain-Nepal 200 celebrations. The exhibit was seen by an estimated 505,000 visitors. This was followed by a display of drawings of fish from the collection of Francis Day. The collection consists of around 690 art originals bound in four volumes. Visits from external groups included City University, the Natural History Museum, Cleveland Museum of Natural History, King’s College London, The Bartlett Zoo History Society, the Buckland Foundation, the Smithsonian and Sparsholt College.

Artefacts
Our monthly Artefacts blog on the ZSL website showcases unique items in our collection. Recent posts include Sir Stamford Raffles, Sir Richard Owen’s involvement with ZSL and his creation of the word ‘dinosaur’, the extinction of the thylacine, and Women, art and zoology: Celebrating International Women’s Day with women artists and illustrators.

Digitisation
The Charles Hayward Foundation kindly donated to the cost of conservation, repair and digitisation of the six volumes of Brian Houghton Hodgson’s manuscript volumes of birds of India and Nepal. Hodgson (1800-1894) is widely recognised for his enormous contribution to the descriptions of the birds and mammals of Nepal. Hodgson wrote more than 140 zoological papers, ranging from descriptions of single species to checklists of the fauna. The mammal volumes have been repaired and digitised, and can be viewed following the link from the online catalogue. Descriptions and illustrations of Indian animal species by Samuel Richard Tickell have also been digitised and can be viewed in the online catalogue. Tickell was related to Hodgson through marriage and both presented their manuscripts to ZSL in 1875. Beryl Leigh kindly funded the digitisation of three volumes of the Daily Occurrences. We aim to offer access to this primary research material worldwide, to support conservation and taxonomy across the world and to provide public appreciation and enjoyment.

Visit our online catalogue at library.zsl.org

Follow us on twitter @ZSLLibrary
Communicating science

Facilitating the communication of science among professional zoologists and researchers, and to the public, is an important part of our work. We achieve this through the publication of scientific journals and a varied programme of events.

Science and conservation events
ZSL’s popular science and conservation events are free and open to the public. Each meeting highlights the latest developments in conservation and zoological research. This year’s programme included lectures on ‘Conserving the mountain chicken frog: the impact of chytridiomycosis under scrutiny’, ‘The state of the Thames’ and ‘Immigrants to the rescue! How can immigration help to save threatened wildlife populations?’.

Symposia
ZSL symposia bring together teams of international experts to discuss important topics in conservation science, providing an opportunity for leaders to exchange ideas and communicate their research. At our symposium ‘The Living Planet Report 2016: threats, pressures and addressing the challenges’, leading experts examined the primary drivers of wildlife population declines, with the aim of exploring how individuals, communities and governments can make better choices in order to preserve biodiversity.

‘CSI of the Sea’ wins BIAZA Gold Education Award
In May, ZSL was awarded a BIAZA Gold Education Award in recognition of our ‘CSI of the Sea’ events, which highlight the work of Institute staff involved with the Cetacean Strandings Investigation Programme. At two sell-out events, audiences had the opportunity to observe a cetacean post-mortem taking place in real time and engage directly with our scientific staff. Broadening public understanding of conservation science is a fundamental part of our remit, and using dissections as an engagement tool has both increased public understanding of our work and acted as a proof of concept for other zoos, aquaria and scientific institutions.
Stamford Raffles Lecture
The Stamford Raffles Lecture is the foremost event in ZSL’s programme of scientific events. The 2017 lecture, ‘How animals shape habitats, ecosystems and the global biosphere’, given by Yadvinder Malhi, University of Oxford, described the ways in which animals can influence ecosystem structure, biomass, fire regimes and even climate. Knowing how animals influence ecosystem function can reveal how even low-disturbance ecosystems carry the legacy of past extinctions. Yadvinder explained that in a world of increasing human pressure and shifting climates, animals can have an important role in maintaining resilient ecosystems. Watch the lecture online at zsl.org/science/whats-on/stamford-raffles-lecture-2017.

Scientific publications
ZSL publishes scientific journals and books that feature the latest research in zoology and conservation science.

Animal Conservation
Animal Conservation publishes quantitative research on the conservation of species and habitats. The journal includes regular feature papers and ‘Letters from the Conservation Front Line’, to highlight research questions that are important to the conservation practitioner community.

Journal of Zoology
Our monthly journal includes hypothesis-driven studies that advance our understanding of animals and their systems. Special features include the annual Huxley review paper, a series of ‘Hidden Gems’ from the archives, and a journal blog and podcast.

Remote Sensing in Ecology and Conservation
Our fully open-access journal provides a new platform for innovative science at the interface between ecology, conservation and remote sensing. Read the latest research at rsecjournal.com.

International Zoo Yearbook
An invaluable resource for researchers, animal managers and anyone interested in ex-situ wildlife conservation, the latest volume presents a range of research projects, case studies and reviews on conservation translocations.

For more information on our publications, visit zslpublications.onlinelibrary.wiley.com/hub
ZSL Scientific Awards

ZSL recognises outstanding achievements in zoological science and conservation through its annual presentation of awards. The following were presented at our most recent awards ceremony in June 2017.

ZSL Frink Award
The Society’s highest award, presented to a professional zoologist for substantial and original contributions to science. Awarded to Sarah Cleaveland FRS, University of Glasgow, for outstanding contributions to the understanding of wildlife disease and the dynamics of infections in natural ecosystems.

ZSL Scientific Medal
Presented to scientists with up to 15 years’ postdoctoral experience for distinguished work in zoology. Awarded to Ashleigh Griffin, University of Oxford, for advancing our understanding of behavioural and evolutionary ecology; Sarah Reece, University of Edinburgh, for outstanding research on the ecology and evolution of malaria parasites; and Claire Spottiswoode, University of Cambridge, for influential contributions to behavioural ecology, and our understanding of parasitic and mutualistic interactions between species.

ZSL Silver Medal
Awarded for contributions to the understanding and appreciation of zoology. Presented to Richard Fortey FRS for major contributions to science communication.

ZSL Stamford Raffles Award
Awarded to an individual for distinguished contributions to zoology outside the scope of their profession. Presented to Malcolm Tait for writing, editing and publishing activities that enhance an appreciation for wildlife.

ZSL Marsh Award for Conservation Biology
For contributions of fundamental science and its application to the conservation of animal species and habitats. Awarded to Richard Griffiths, University of Kent, for significant contributions to amphibian and reptile conservation.

Marsh Award for Marine and Freshwater Conservation
For contributions of fundamental science and its application to conservation in marine and/or freshwater ecosystems. Awarded to Richard Thompson, University of Plymouth, for influential research that informs policy on marine pollutants.

ZSL Prince Philip Award and Marsh Prize
Awarded to an A-Level or Higher student for an outstanding biology project. Awarded to Alexandra Eyles-Owen, Surbiton High School, for her project ‘Dietary turmeric reduces inflammation and improves mood and mobility in horses with fetlock joint inflammation’.

ZSL Charles Darwin Award and Marsh Prize
Presented for the best zoological project by an undergraduate student attending university in the UK. Awarded to Simon Chen, University of Cambridge, for his project ‘Attachment mechanisms in caterpillars’.

ZSL Thomas Henry Huxley Award and Marsh Prize

ZSL Clarivate Analytics Award for Communicating Zoology
Presented for a book or film of a zoological nature that has an outstanding impact on a general audience. Awarded to Tim Birkhead FRS, University of Sheffield, for his book The Most Perfect Thing: Inside (and Outside) a Bird’s Egg.

ZSL Medal
Presented to a member of staff for outstanding achievement and service to ZSL. Awarded to Paul Pearce-Kelly for significant contributions to invertebrate conservation.

ZSL would like to thank the Marsh Christian Trust and Clarivate Analytics for their generous support of our scientific awards programme
Funding

The Institute depends on funding from a wide source of donors, including the Higher Education Funding Council for England, to carry out its research.

Sustainable fishing in the Arctic

Kirsty Kemp and Chris Yesson were awarded £250,000 from the IUCN/European Commission Biodiversity and Ecosystem Services in Territories of European Overseas (BEST) programme for the project ‘Sustainable fishing in the Arctic: Can the harvest of Greenland’s biggest export be compatible with the conservation of benthic ecosystems?’ Greenland’s west coast is home to commercially important cold-water prawn and halibut fisheries. However, entrance of the fisheries into the Marine Stewardship Council sustainability scheme revealed a lack of knowledge of Greenland’s ocean floor. Benthic habitats play vital roles in marine ecosystems, for example, functioning as carbon sinks and nurseries for juvenile fish. Trawl fisheries directly impact the seabed by removing target species and damaging vulnerable, habitat-forming organisms. We are carrying out imaging surveys of the West Greenland benthos to document existing seafloor communities from 200-1,000m depth. Our surveys will revisit the sites of historical photographic surveys to provide a unique perspective of changing habitats in relation to climate change and fishing pressure. A real strength of this project is the breadth of engagement across Greenlandic society, from school children to fishermen to policymakers. The project will help to ensure the long-term sustainability of key Greenlandic fisheries.

Garden Wildlife Health

Garden Wildlife Health (GWH) is a citizen science project that investigates diseases affecting amphibians, reptiles, garden birds and hedgehogs in Great Britain, and their conservation significance. Institute veterinary scientists coordinate the GWH project in collaboration with partners at the British Trust for Ornithology, Froglife and the Royal Society for the Protection of Birds. The Animal and Plant Health Agency helps fund the disease investigations, and the Esmée Fairbairn Foundation awarded a second grant of £150,000 over a three-year period (2016-2019) to support GWH’s public outreach and information dissemination activities. We aim to inform the public, and conservation NGOs and their members, about disease threats to wildlife conservation and to offer evidence-based practical solutions to safeguard wildlife health. Online resources include a library of disease fact sheets, e-newsletters, social media, and informative signage within the new Wildlife Garden at ZSL London Zoo, designed to provide visitors with tips on how to enhance their garden habitats for native wildlife species. gardenwildlifehealth.org

Funding organisations

Arcus Foundation
ASCOBANS Conservation Fund
AXA Foundation
Bertarelli Foundation
Biotechnology and Biological Sciences Research Council (BBSRC)
British Ecological Society
Crown Estate (Marine Stewardship Fund)
Darwin Initiative
DEFRA
Environment Agency
Environment Canada
Esmée Fairbairn Foundation
European Commission
Higher Education Funding Council for England (HEFCE)
Honolulu Zoo
Howard Buffett Foundation
IUCN
IUCN/European Commission – Biodiversity and Ecosystem Services in Territories of European Overseas (BEST) Programme
Laurentian University
Marine Institute
Maugatautari Ecological Island Trust
Medical Research Council
National Geographic Society
Natural England
Natural Resources Wales
Natural Environment Research Council (NERC)
Oceanario Lisboa
Pauline Meredith Charitable Trust
Royal Society
Royal Society for the Protection of Birds
Royal Society of New Zealand (Marsden Fund)
Rufford Foundation
Science and Technology Facilities Council
Southoe Consultancy Ltd
St Louis Zoo
Sustainable Fisheries Greenland
Taronga Conservation Society Australia
Thriplow Charitable Trust
Universities Federation for Animal Welfare (UFAW)
University College London
University of Cambridge
University of Edinburgh
Wildlife Conservation Society
WWF International
WWF Namibia
WWF UK

If you are interested in helping to fund ZSL’s vital work, call 0344 225 1826 or find out more at zsl.org/support-us
GOVERNANCE AND STAFF

Governance and staff

ZSL would like to thank its students, interns, volunteers and collaborators, as well as its staff.

ZSL/University College London Joint Committee

University College London

Frances Brodsky (Director, Division of Biosciences); Chair
Helen Chattjee (Professor of Biology, UCL Biosciences, Head of Research and Teaching, UCL Culture)
Andrew Pomiankowski (Head of Department, Research Strategy Director of CoMPLEX)
Geraint Rees (Dean, Faculty of Life Sciences)

ZSL

Ralph Armond (Director General)
Geoff Boxshall FR (ZSL Secretary, Natural History Museum)
Sir Cyril Chantler (Honorary Fellow; former Chairman UCL Partners)
Ian Owens (Natural History Museum)

In Attendance

Edward Hall (Head of Finance, School of Life and Medical Sciences, UCL)
David Meech (Divisional Manager, Biosciences, UCL)
Loren Moyse (Faculty Manager, Life Sciences, UCL)
Cheryl Buffonge (Science Operations Manager, ZSL)
Fiona Evans (Human Resources Director, ZSL)
Ken Norris (Director of Science, Institute of Zoology, ZSL)
Amanda Smith (Finance Director, ZSL)

IoZ

Ken Norris, Director of Science

Senior Research Staff

Andrew Cunningham, Deputy Director, Theme Leader, Wildlife Epidemiology
Chris Carbone, Theme Leader, Biodiversity and Macroeology
Guy Cowlishaw, Theme Leader, Behavioural and Population Ecology, Postgraduate Tutor
Sarah Durant, Theme Leader, People, Wildlife and Ecosystems
Trenton Garner, Theme Leader, Evolution and Molecular Ecology
Tim Blackburn, Professor of Invasion Biology (UCL/ZSL)
John Ewen
Paul Jepson
Malcolm Nicoll
Nathalie Pettorelli
Marcus Rowcliffe
Anthony Sainsbury
Samuel Turvey
Jinliang Wang
Rosie Woodroffe

Postdoctoral Research Staff

Monika Böhm
Patricia Brekke,
Postgraduate Tutor
Jessica Bryant
David Curnick
David Daversa
Ellie Dyer
Robin Freeman
Mona Fuhrmann
Rosemary Groom
Xavier Harrison
Audrey Ipavec
David Jacoby
Kirsty Kemp
Becki Lawson
Tom Letessier
Nicholas Mitchell
Alexandra Morel
Adam Piper
Stephen Price
Alexa Varah
Piero Visconti
Oliver Wearn
Christopher Yesson

Postgraduate Research Staff

Stefanie Deinet
Jenny Jaffe
Valentina Marconi
Louise McRae
Katharina Seilern-Moy
Victoria Wilkinson
Hannah Wood

Postgraduate Research Students

Mario Andres Alvarado Rybak
Judith Ament
Paul Barnes
Kieran Bates
Katie Beckmann
Dominic Bennett
Katherine Booth-Jones
Matilda-Jane Brindle
Stephanie Brittain
Adam Britton
Sarah Brooke
Ella Browning
Lewis Campbell
Peter Carr
Philip Chapman
Charlotte Clarke
Sérgio da Silva Henriques
Anthony Dancer
Clare Duncan
Sally Faulkner
Guilherme Ferreira
Liam Fitzpatrick
Deborah Fogell
Victoria Franks
Helen Gath
Cally Ham
James Hansford
Anne Hillborn
Michael Hudson
Freya Jephcott
Sarah Johnson
Angharad Jones
Samuel Jones
Natoya Jourdain
Alexander Knight
Kate Lee
Stephen Long
Heidi Ma
Gwendolyn Maggs
Agnese Marino Taussig de Bodonia
Claudia Martina Luna
Kirsten McMillan
Thalassa McMurdo Hamilton
Lisa Mogensen
Daniel Nicholson
Helen O’Neill
David Orchard
Diana Alexandra
Penafiel Ricaurte

Interns

Matthew Bennion
Isabel Nicholson Thomas
Holly Pringle

Technical Staff

Kelly Astley
Robert Deaville, Cetacean Strandings Programme Manager
Louise Gibson
Dada Gottelli, Chief Technician

Daniella Rabaiotti
Cassandra Raby
Jonathan Rio
Charlotte Selvey
Rebecca Short
Thomas Smallwood
Donal Smith
Fiona Spooner
Gemma Taylor
Joseph Taylor
Andrés Valenzuela Sánchez
Rosie Williams
Juliet Wright

EZCM Resident in Wildlife Population Health

Helle Bernstorff Hydeskov

Project Coordinator

Becky Shu Chen
Below: a red-footed booby (Sula sula) in the British Indian Ocean Territory – the orange mark on the breast indicates it is carrying a GPS tracking device to record where it forages at sea

Patron
Her Majesty The Queen
His Royal Highness The Prince of Wales (Vice Patron)

ZSL Council Members 2016

President: Sir John Beddington CMG FRS
Secretary: Geoff Boxshall FRS
Treasurer: Paul Rutteman CBE Sheila Anderson MBE
(Vice President)
Brian Bertram
Martin Cooke
Ray Heaton*
Andrew Kitchener+
Ken Livingstone**
Professor Anna Meredith
Ruth Padel*

Elizabeth Passey
Maggie Redshaw
Sean Rova+
Martin Rowson
(First President)
Ken Sims
Paul Wilson
Victoria Wilson+
Robert Wingate*

* to June 2016
** retired March 2016
+ from June 2016

ZSL Directors

Director General: Ralph Armond
Conservation Programmes Director: Jonathan Baillie**
Human Resources Director: Fiona Evans
Zoological Director: David Field
Director of Conservation: Matthew Hatchwell*

Director of Science: Ken Norris
Finance Director: Amanda Smith
Commercial and Communications Director: Rich Storton
Development Director: James Wren

* from June 2017
** to November 2016

Library
Ann Sylph MCLIP, Librarian
Sarah Broadhurst, Archivist and Records Manager
Emma Milnes, Deputy Librarian
James Godwin, Library Assistant

Honorary Research Fellows
Sarah Ball

Tony Fooks, Animal Health and Veterinary Laboratories Agency
Simon Goodman, University of Leeds
Kate Jones, University College London
James Wood, University of Cambridge

Scientific Publications and Meetings
Linda Davolls, Head of Scientific Publications and Meetings
Fiona Fiskin, Managing Editor, International Zoo Yearbook
Jennifer Howes, Scientific Events Coordinator
Elina Rantanen, Journals Manager

Monika Bohm, Patricia Brekke, Jessica Bryant, Charlotte Clarke, Gyu Cowlishaw, Dave Daversa, Ben Dean, Sarah Durant, R Freeman, Helen Gath, Trent Gamer, James Godwin, Rosemary Groom, Lucy Hulmes – Centre for Ecology & Hydrology, Seth Jackson, Bernice Kohl, Ivan Kuzmin/ ZSL, Mhairi McCready, Russ Miles, Royal College of Veterinary Surgeons, Martin Sanders, Scottish Marine Animal Strandings Scheme, Shutterstock, John Sibley, Dan Sprawson, Malcolm Nicoll, Victoria Wilkinson, ZSL

Cover: John Sibley.
Animals and their habitats face increasing threats across the world. Through our scientific research we are helping to build a future where animals are valued and their conservation assured.

ZSL is a registered charity in England and Wales no: 208728

The Zoological Society of London
zsl.org

Regent’s Park
London
NW1 4RY

and at:

ZSL Whipsnade Zoo
Dunstable
Bedfordshire
LU6 2LF

For a closer look at ZSL’s work, look out for our other annual publications at zsl.org/about-us/zsl-annual-reports

ZSL Annual Report and Accounts 2016-17
Our annual overview of the year, featuring our Zoos, fieldwork, science and financial statements.

ZSL Conservation Review 2016-17
An in-depth look at our conservation and research, showing how we are achieving our key targets at home and abroad.

Follow us on Twitter @ZSLScience