INSTITUTE OF ZOOLOGY REVIEW 2015/2016

SCIENCE FOR CONSERVATION

ZSL
LET'S WORK FOR WILDLIFE

Welcome

The President and Director General of the Zoological Society of London introduce the Institute of Zoology Review 2015/2016.

As President of the Zoological Society of London, it gives me great pleasure to introduce the Institute of Zoology Annual Review. Our scientists continue to tackle challenges presented by the natural world and are finding new, scientifically robust ways to protect the world's seriously endangered wildlife. This review illustrates the science conducted to directly address these challenges.

Among other activities, scientists in the Institute have developed novel mechanisms to monitor global biodiversity, devised new methods to manage animal diseases and played a global role in reintroducing species. I am particularly proud of the work involved in introducing captive-bred dormice to UK woodlands.

Key targets of biological biodiversity come directly from the Aichi Targets of the Convention on Biological Diversity, agreed in 2010 by more than 190 countries. This agreement is aimed at tackling the huge problem of biodiversity loss. It outlines actions individual countries can take and the Institute has developed new scientific indicators to track progress towards these targets.

It is important that an Institute like ours uses cutting-edge tools to address and understand the problems faced by wildlife and the underlying changes in biological diversity. The Institute uses key methods such as remote sensing from satellites and has been instrumental in understanding the variety of ways that animals use their habitats.

This review highlights six impact areas that show how our research is making a difference to conservation and helping to increase our understanding of the natural world, and I'm proud to present this body of work.

Our scientists at the Institute of Zoology are dedicated to conserving animals and ensuring that scientific research not only underpins our own conservation efforts, but informs the decisions made by governments and businesses to ensure a positive future for the world's wildlife.

The Institute carries out a broad range of research, and in the past year this has included finding new methods of monitoring animals and their habitats we know relatively little about, combating disease in amphibians and identifying a pollutant posing a significant threat to cetacean species.

Without the support of a host of external collaborators and, most notably, our partnership with University College London, this fundamental research would not be possible. A wide range of organisations fund our research and I would like to thank them for their continued generosity.

With its participation in postgraduate education such as the Masters courses, and with more than 50 PhD students studying at the Institute, there is a marked commitment to educating scientists of the future. New ideas and techniques are essential to the innovative environment in which our scientists operate, and the students make an important contribution to this.

The Institute carries out a calendar of scientific events throughout the year which are opportunities for not only peers, but also the public to learn more about our work, and for our scientists to share ideas. This review looks at the past 12 months and illustrates the year's highlights.

Professor Sir John Beddington, FRS
President, Zoological Society of London

Ralph Armond
Director General, Zoological Society of London

IoZ's global reach

Institute of Zoology (IoZ) research is truly international. Each dot on the map represents at least one project. Here, we highlight seven projects that illustrate the breadth of our work.

To find out more about IoZ's current research projects, visit zsl.org/science/research

1 ICELAND

Trawling can have a significant negative impact on the biodiversity of the seabed. In collaboration with Iceland's marine and freshwater research institute, researchers at IoZ are collecting images and video surveys to document the biodiversity of the continental shelf of North and West Iceland. We are examining patterns of diversity in relation to fishing effort, to assess the impact of trawling and to investigate the value of marine protected areas in preserving vulnerable habitats such as sponge fields.

2 BRAZIL

Since 2011 we have been working on research projects using camera traps and the random encounter model method to explore how mammalian abundance and diversity patterns respond to different land-use types in and around protected areas in Brazil. These include the Iguaçu National Park in Paraná State, the Cerrado in Minas Gerais State and the Atlantic forests near Rio de Janeiro.

3 CAMEROON

Across West and Central Africa, a wide variety of terrestrial species are hunted and sold as bushmeat. The Critically Endangered Cross River gorilla (*Gorilla gorilla diehli*), which is endemic to the Cameroon-Nigeria border area, is one of many species threatened by this trade. Yet in rural communities affected by poverty, the bushmeat trade provides an important source of income. Economic alternatives to hunting have been explored, but often the projects implemented are based on simplistic assumptions about local people's livelihoods. IoZ research seeks to better understand the complexity of livelihood strategies in forest-adjacent communities in order to improve future conservation interventions.

4 PHILIPPINES

Mangrove forests are in decline globally due to human activities and climate change, yet are of enormous importance for the goods and ecosystem services they provide at local to global scales. IoZ research is evaluating the climate change mitigation and adaptation ecosystem services (carbon stocks and coastal protection potential) of natural and rehabilitated mangroves in the Philippines. Field and satellite remote sensing-based techniques are used to explore mangrove diversity and community structure. They are also used to assess rehabilitation strategy influences on potential climate change mitigation and adaptation benefits derived from mangrove rehabilitation activities. This research feeds in to mangrove rehabilitation and protection projects implemented by ZSL-Philippines since 2007.

5 INDIA

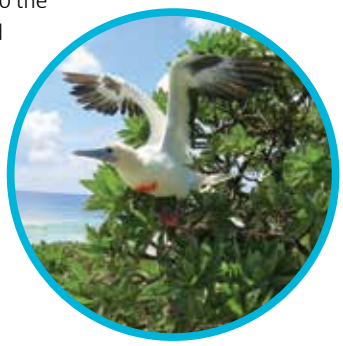
In the northeast corner of India where tropical forests meet the Tibetan plateau, IoZ research is examining the relationship between tigers and one of the most threatened indigenous cultures, to explore how their conservation might be interlinked. The aim is to understand social, cultural and ecological factors that have allowed a recently discovered tiger population to exist under a unique set of conditions. This interdisciplinary research combines cutting-edge techniques, such as camera trapping and genetic analysis, with in-depth anthropological methods, such as ethnography and study of shamanic folklore, to understand how to best conserve tigers in this cultural landscape.

6 MAURITIUS

The olive white-eye (*Zosterops chloronothos*) is the rarest and least known of the nine remaining land bird species of Mauritius, with only around 80 pairs restricted to a 25km^2 area in the Black River Gorges National Park. IoZ research has identified invasive rats as a major threat to the olive white-eye and has developed decision-making tools for local project managers to assist in the creation of long-term management, while accounting for financial, logistical and epistemic uncertainty. This research provides valuable scientific evidence into olive white-eye ecology and conservation that will guide management decisions and build the capacity of the species recovery project.

7 CHAGOS

The Chagos Archipelago supports a diverse and abundant seabird community. In 2010 the world's largest 'no take' marine protected area (MPA) was designated around the archipelago to conserve marine biodiversity, including seabirds. IoZ is examining how effectively the MPA supports resident breeding seabirds and the wider role it plays in supporting non-breeding seabirds from across the western Indian Ocean. The research involves status and distribution surveys and the deployment of tracking technology to establish the year-round use of the MPA by seabirds.



IoZ news

The IoZ continues to promote interest in and understanding of the natural world, and initiate valuable training programmes.

Main image: *IoZ tutors have started wildlife veterinary courses in India*
Left: *Professor Sir John Beddington presents Sarah Durant with the ZSL Medal*
Below: *enthusiastic young scientists at Soapbox Science in London*

IoZ researcher awarded for outstanding achievements

Congratulations to Sarah Durant, who was presented with the ZSL Medal for her contributions to conservation biology. Sarah's research explores the implications of competition and habitat heterogeneity for population persistence, the impact of predator avoidance behaviours on the spatial distribution of populations, and human-wildlife conflict. Sarah runs the Tanzania Cheetah Conservation Programme, the only long-term study of free-living cheetahs. Closer to home, Sarah's letter to the journal *Nature* on the proposed Infrastructure Bill for England and Wales led to a constructive dialogue regarding the definition of non-native species, which resulted in protection for many UK species, including barn owls (*Tyto alba*) and red kites (*Milvus milvus*).

New collaboration with the Royal Veterinary College

Vets at IoZ are responding to the increasing threats of disease to wild animal populations by extending our collaboration with the Royal Veterinary College (RVC) and expanding the range of educational opportunities we offer. The first RVC/ZSL senior clinical training scholar in Wildlife Population Health, Helle Hydeskov, began a three-year training programme in September 2015. The European College of Zoological Medicine (ECZM) was formed in 2009 to provide training and promote excellence in zoological medicine, and offers the highest-level qualifications in the field. The RVC and ZSL are the first institutions to offer an ECZM training scholarship in this discipline in Great Britain.

Royal Society Pairing Scheme

Tom Leveridge, Senior Specialist, the House of Commons Environmental Audit Select Committee, and Nathalie Pettorelli, IoZ Research Fellow, had the opportunity to learn about each other's work by spending time together in Westminster and at IoZ. The Royal Society Pairing Scheme aims to pair scientists with parliamentarians so they can explore how research findings can inform policymaking.

NEW CONSERVATION SCIENCE STAFF

We are delighted to welcome Piero Visconti, University College London/ZSL Research Fellow in Conservation Science. Piero's research focuses on estimating past impacts and predicting future potential impacts of land use and climate change on individual species and ecosystems. He is also involved in the science-policy dialogue and is a member of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services regional assessment for Europe and Central Asia.

IoZ trains wildlife vets in India

IoZ ran a three-week field course in India, entitled Interventions in Wild Animal Health, in collaboration with the Wildlife Institute of India and the University of Edinburgh, in February 2016. The aim was to increase the capacity of wildlife vets in biodiverse developing countries with hotspots of wildlife disease, such as in South Asia. In total, 21 students of 11 nationalities attended, including 14 from developing nations and 11 from South Asia. The tutors provided practical teaching on a range of topics, including animal population monitoring and management, wild animal restraint and anaesthesia, and field disease investigation. The course was carried out in Sariska Tiger Reserve, Ranthambore National Park, Keoladeo National Park and at Wildlife SOS bear and elephant rescue centres in Agra. Following positive student feedback and our experiences, we intend to run the course annually.

Soapbox Science travels to Australia

The popularity of Soapbox Science continues to grow annually. Thirteen events were held in the UK in 2016 and the first international event was held in Brisbane in August. Recent figures show that women make up just over 14% of people working in STEM (science, technology, engineering and mathematics) occupations. Soapbox Science addresses this by creating public events where top women scientists speak about their work. Soapbox Science was founded in 2011 by Seirian Sumner, University of Bristol, and Nathalie Pettorelli, IoZ, who were recently awarded the ZSL Silver Medal for promoting diversity in science. Nathalie and Seirian were recently asked to give evidence on science communication to the House of Commons Science and Technology Select Committee.

Keep up to date with all the latest IoZ news and breakthroughs at **zsl.org/science/news**

Improving the research environment

Science Director Professor Ken Norris reports on the IoZ's determination to give greater support to its staff, and contemplates the effects of the EU referendum.

This reporting year started with my first anniversary at the Zoological Society of London as Director of Science, and ended with the EU referendum and its immediate fallout. A period of mixed emotions – a good start and a very frustrating end.

I reported last year that our science and its conservation impact had been rated highly in the 2014 Research Excellence Framework. However, although our science is in good shape, the research environment in which it is carried out is much less satisfactory. This environment has both social and physical components and, because science is a highly collaborative venture, the social environment in which people interact is critical. It is also important to support the needs and aspirations of individuals to develop their careers and manage the often conflicting demands of work and family life. The Institute has an international reputation for scientific excellence, but we also want to be known for the quality of the research environment we offer our staff throughout their careers.

Promoting diversity

As an institution, we believe that excellence in our science is underpinned by diversity among our scientists, and we want to create a more inclusive, flexible and supportive working environment that promotes and retains this diversity. In so doing, we believe we will be creating a higher-quality working environment for everyone.

With this aim in mind, in 2015 we became a member of the Athena SWAN Charter (which recognises commitment to advancing gender equality among staff and students in higher education and research), and submitted a Bronze Award application in April 2016. Our application consisted of two parts. First, we had to take a long, hard look at ourselves and assess how we supported our staff. Were we being fair and equitable in recruitment, promotion, career development, management of career breaks, and so on? Next, having identified our 'issues', we had to produce an action plan detailing how we proposed to address them. In developing our application, we compiled a great deal of data, involved all our staff in discussions and really got to know ourselves. I'll tell you whether we were successful next year.

The physical component of our working environment – our buildings – is at the top of next year's agenda!

IoZ is researching the life history, morphological and behavioural traits of the Vulnerable New Zealand hihi

The Institute has an international reputation for scientific excellence, but we also want to be known for the quality of the research environment we offer

Supporting the scientific community

Lastly, why was I frustrated by the EU referendum? Whatever your politics, one issue was relatively clear-cut – a large majority of scientists believe that leaving the EU will be bad for UK science. Why? Because science requires us to bring people together with complementary skills and ideas, and provide them with the funding to support their work. Whatever its other faults, the EU is extremely good at this, and UK science has been a major beneficiary of EU funding. It seems so shortsighted to put all this at risk. Let's hope a coherent plan for UK science emerges over the next few months.

A diversity of skills, ideas and perspectives is the lifeblood of science. We need to nurture it within our Institute, within the UK and internationally. We will be working hard to do so.

To find out more about the IoZ's work to improve its working environment, visit **zsl.org/science/about-the-institute-of-zoology/women-in-science-athena-swan**

Making an impact

In the pages that follow, we present a range of case studies – a selection of 'Impact Areas' in which our research is making a difference to conservation. From monitoring the effects of human activity on the environment to studying how the activities of animals themselves can help determine their survival, and from satellite technology to fieldwork, our science is expanding the understanding of conservation around the world.

IoZ has assisted in the recovery of the Mauritius kestrel

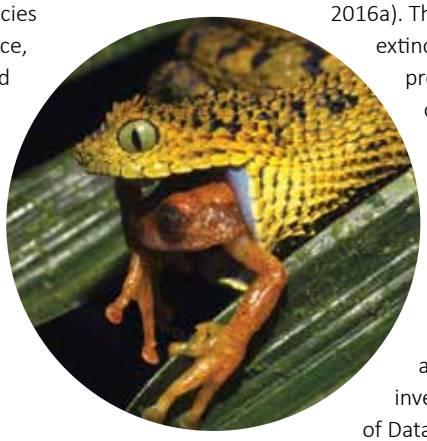
Monitoring lesser-known biodiversity

IMPACT AREA

Determining the status of the world's species is important to track progress towards global environmental targets – and IoZ leads the way.

IoZ is at the forefront of monitoring global biodiversity and developing scientifically robust indicators to track progress towards targets such as the Aichi Targets of the Convention on Biological Diversity, assessing conservation actions and measuring human impact on biodiversity.

Monitoring species with very few data, such as less well-studied reptiles, invertebrates and plants, is a challenge for science. Over recent years, IoZ has increased our knowledge of the extinction risk of reptiles, freshwater molluscs, dung beetles and crayfish, among others. Reptiles provide us with an excellent group for testing how to assess and monitor species trends when data are scarce, data deficiency is high, and species groups are highly species-rich, making complete assessments of the whole group time- and resource-consuming.



Extinction risk in reptiles

In partnership with the International Union for Conservation of Nature (IUCN), IoZ researchers are developing and refining the Sampled Red List Index. This indicator relies on repeated assessments of the extinction risk for a random sample of 1,500 species, to assess status and trends in the extinction risk of megadiverse species groups. Previous work using this sampled approach, led by IoZ researchers with help from more than 200 reptile experts, estimated that one in five reptile species is threatened with extinction. This research has been instrumental in putting reptile conservation in the international spotlight.

Our recent work focused on predicting extinction risk by investigating species-specific factors that correlate with extinction risk, and by employing novel machine-learning techniques to determine the true extinction risk of species currently listed as Data Deficient. In addition to reptile species with a smaller range size having a higher risk of extinction, our research found that at smaller range sizes, habitat specialisation and accessibility of a species range to humans became important predictors of extinction risk (Böhm et al. 2016a). This suggests that extinction risk may be predicted by models based on range size, coupled with other key factors, so as to discriminate between threatened and non-threatened range-restricted species.

IoZ researchers and collaborators also investigated the true status of Data Deficient species using more complex models, specifically machine-learning techniques. Essentially, we trained a computer to discriminate between threatened and non-threatened species by deriving decisions based on species-specific data (for example, biological traits such as size and longevity, and environmental factors such as climate and human impact). We found that 19% of Data Deficient reptiles are likely to be threatened with extinction (Bland and Böhm, 2016). Therefore, our models may provide a timely and efficient way to dramatically increase our knowledge of the extinction risk of previously under-studied species groups. We are now refining and testing these models on other species groups, so we can estimate extinction risk not only for Data Deficient species, but also for previously unassessed ones.

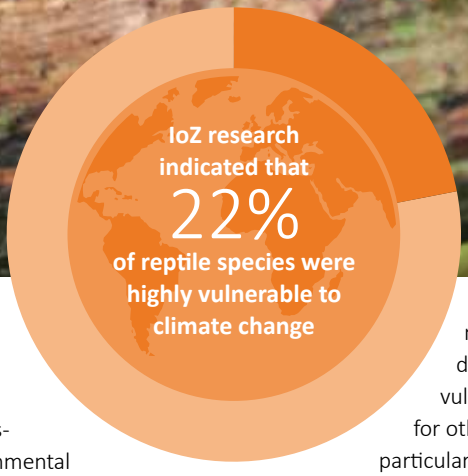
Main image: *reptiles in the conservation spotlight: lyre head lizard (*Lyriocephalus scutatus*)*

Inset left: *Usambara eyelash viper (*Atheris ceratophora*), Vulnerable on the IUCN Red List due to restricted range in the montane rainforests of Tanzania, an area affected by high rates of deforestation; the species is also assessed to be highly sensitive to climate change*

Measuring range for extinction risk assessments

For many lesser-known species, for which we lack estimates of population trends over time, range size becomes an important criterion for assessing extinction risk under the IUCN Red List Categories and Criteria. These criteria arguably provide the most comprehensive and scientifically robust system for assessing species extinction risk. IoZ has been involved in the development of the current IUCN Red List criteria since their inception in 2001. In the past year, work primarily focused on the effects of inconsistently estimating extent of occurrence (EOO), which is a key measure of extinction risk. This work highlighted that,

Learn more about the Red List at **iucnredlist.org**



while a one-time downlisting of hundreds of species may be required (as extinction risk may be lower for these species than previously estimated), estimating EOO as a strict minimum convex polygon – as in IUCN Red List guidance – ultimately ensures consistency across assessments and realigns the calculation of EOO with the theoretical basis on which the metric was founded (Joppa et al. 2015).

Emerging threats from climate change

Climate change represents an often slow-acting threat, potentially affecting species over longer time periods than those considered in IUCN Red List assessments. Climate change may therefore not feature as prominently on the Red List as other threats, such as habitat loss, invasive species and pollution. IoZ researchers are working with the IUCN Climate Change Unit to refine climate change vulnerability assessments. These assessments use species-specific trait and environmental data relating to climate change to assess the vulnerability of species to climate change. While such assessments have been carried out globally for better-known species groups, IoZ researchers published a first assessment of climate change vulnerability for a sampled assessment of nearly 1,500 reptile species. Our results indicate that 22% of reptile species were highly vulnerable to climate change (Böhm et al. 2016b). Overlap between climate change-vulnerable species and species threatened on the IUCN Red List is very limited, suggesting that climate change will present new and additional conservation priorities. Work is ongoing to make the assessment process more robust, and deliver climate change vulnerability assessments for other species groups, particularly invertebrates.

References

Bland, LM and Böhm, M (2016) Overcoming data deficiency in reptiles. *Biological Conservation.* DOI: 10.1016/j.biocon.2016.05.018

Böhm, M, Williams, R, Bramhall, HR, McMillan, KM, Davidson, AD, Garcia, A, Bland, LM, Bielby, J and Collen, B (2016a) Correlates of extinction risk in squamate reptiles: the relative importance of biology, geography, threat and range size. *Global Ecology and Biogeography.* DOI: 10.1111/geb.12419

Böhm, M, Cook, D, Ma, H, Davidson, AD, García, A, Tapley, B, Pearce-Kelly, P and Carr, J (2016b) Hot and bothered: using trait-based approaches to assess climate change vulnerability in reptiles. *Biological Conservation.* DOI:10.1016/j.biocon.2016.06.002

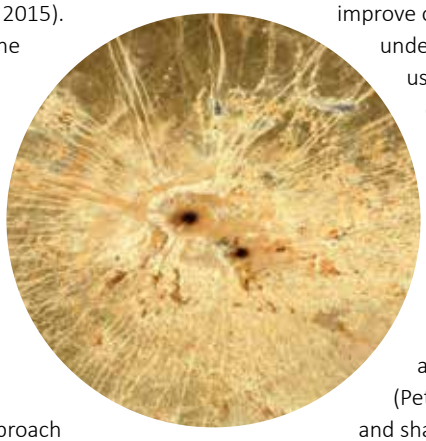
Joppa, LN, Butchart, SHM, Hoffmann, M, Bachman, SP, Akçakaya, HR, Moat, JF, Böhm, M, Holland, RA, Newton, A, Polidoro, B and Hughes, A (2015) Impact of alternative metrics on estimates of extent of occurrence for extinction risk assessment. *Conservation Biology* **30(2)**: 362-370. DOI: 10.1111/cobi.12591

Remote sensing for conservation science

IMPACT AREA

Satellite remote sensing is changing the way we look at Earth's biodiversity, as well as how we monitor, assess and protect wildlife and habitats – and IoZ is at the forefront of these developments.

Societal, economic and scientific interests in knowing where biodiversity is, how biodiversity is faring and what can be done to efficiently mitigate further biodiversity loss are at an all-time high. Among the variety of methodologies likely to deliver global monitoring options for capturing and understanding change in biological diversity, satellite remote sensing has been highlighted as displaying considerable potential (Skidmore et al. 2015). Reasons for this include the fact that remote sensing can (1) provide global coverage that spans multiple decades; (2) inform on the loss of biological diversity at a wide range of scales in a consistent, borderless, repeatable and rapid manner; and (3) support a dynamic approach to environmental and wildlife management (Pettorelli et al. 2015).

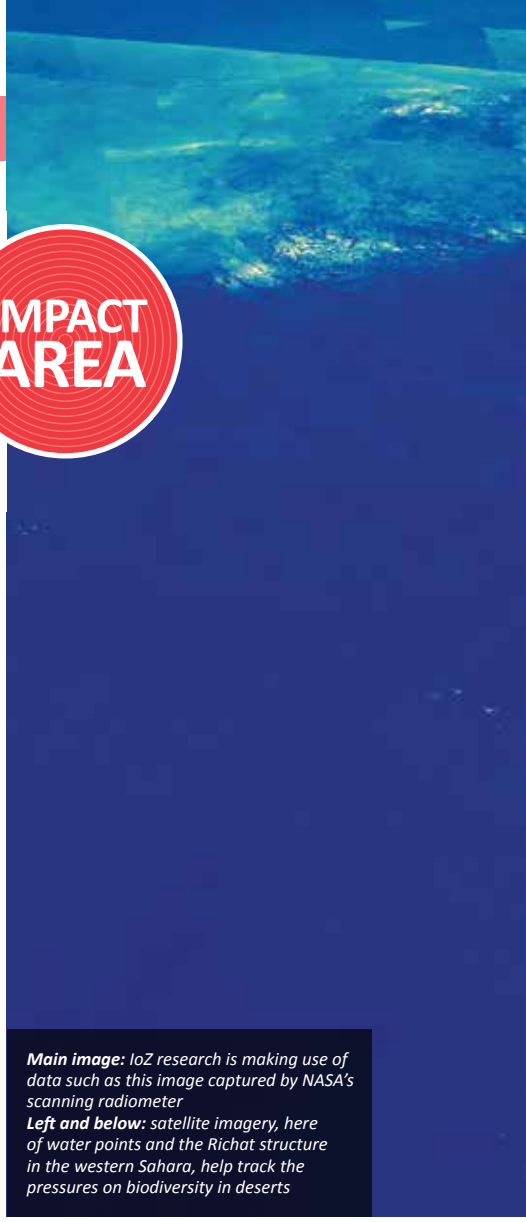


Integrating research to map biodiversity

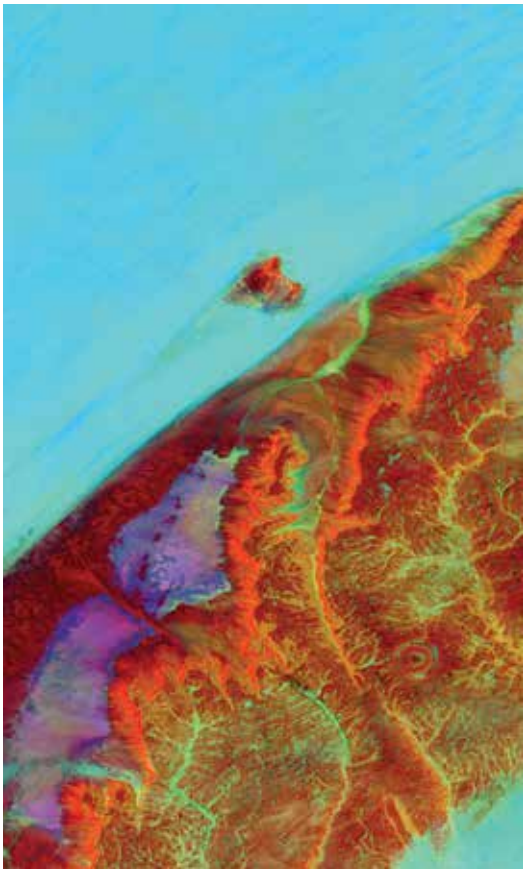
Researchers at IoZ have been at the forefront of developments in using satellite remote sensing technology for ecological analysis and biodiversity monitoring across spatial scales, and have made major inroads at integrating approaches to provide new insights into the status of biodiversity and the causes and consequences of future change. High-resolution images have been used to map problems associated with oil exploration and exploitation; the response of animals to shifts in resource availability have been analysed and predicted from satellite-based information; and land degradation and fragmentation of ecosystems have been successfully monitored using the unique viewpoint of satellites. Examples of research conducted by our staff and students in this arena include developing a new, highly accurate framework to remotely map artificial water points from space using freely available data and open-source software (Owen et al. 2015), and demonstrating how satellite-derived information on resource dynamics can improve our macroecological understanding of habitat use by species (Duncan et al. 2015). Recently, we also demonstrated the potential for satellite remote sensing-based methodologies to support conservation in data-deficient areas, such as the Sahara (Pettorelli et al. 2016), and shape the next generation of species distribution models (He et al. 2015).

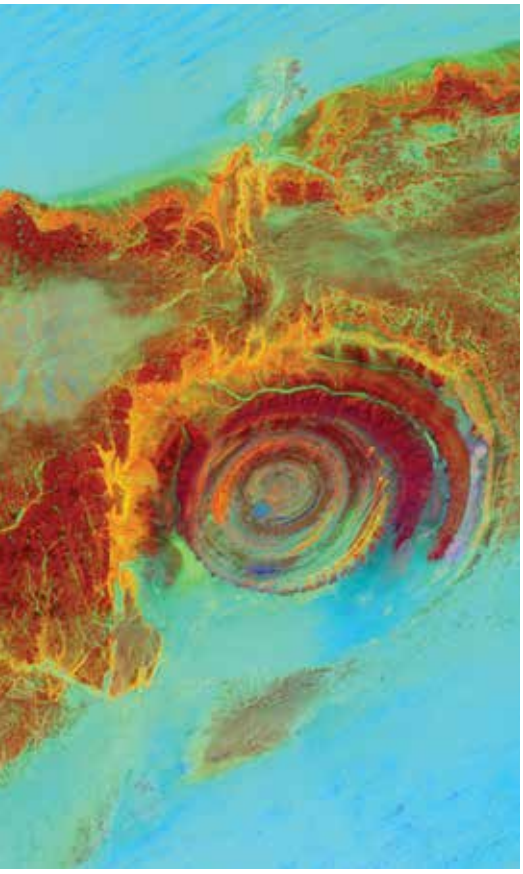
The global impact of IoZ's remote monitoring

The research carried out at the IoZ on the use of Earth observations to inform biodiversity monitoring has clear global impact. Over the past 12 months this work has been featured in *Scientific American*, Mongabay and *WIRED*, and our work has played a key role in the development of the Remotely Sensed Essential Biodiversity Variable Framework for the Group on Earth Observations Biodiversity Observation Network. A recent IoZ-led publication (Pettorelli et al. 2016a) has become the reference paper for the 2016 European Space Agency (ESA) funding call on Essential Biodiversity Variables. In 2015 ZSL launched a new open-access journal, *Remote Sensing*



Main image: *IoZ research is making use of data such as this image captured by NASA's scanning radiometer*
Left and below: *satellite imagery, here of water points and the Richat structure in the western Sahara, help track the pressures on biodiversity in deserts*





in Ecology and Conservation, in order to provide a platform for innovative research at the interface of ecology, conservation and remote sensing science.

As satellite data become more accessible, there's little doubt that space technology will play an increasing role in helping track biodiversity change across the planet. Essential Biodiversity Variable, Natural Capital, Biodiversity Indicator and Ecosystem Service are four concepts that underpin the most popular frameworks currently considered for helping coordinate and structure biodiversity monitoring efforts worldwide, and IoZ is leading the way in terms of understanding how satellite remote sensing can inform these initiatives (Pettorelli et al. 2016b).

The next steps

Priorities for future research include (1) capitalising on the new data made available by NASA and ESA to develop tools and processes that better track anthropogenic pressures to biodiversity, particularly in desert ecosystems; (2) demonstrating how satellite data can be used to inform the Red List of ecosystems; and (3) exploring how satellite data can help interpret and predict changes in the Living Planet Index.

References

Duncan, C, Nilsen, EB, Linnell, JDC and Pettorelli, N (2015) Life-history attributes and resource dynamics determine intraspecific home-range sizes in Carnivora. *Remote Sensing in Ecology and Conservation* **1**: 39-50. DOI: 10.1002/rse2.6

He, KS, Bradley, BA, Cord, AF, Rocchini, D, Tuanmu, M-N, Schmidtlein, S, Turner, W, Wegmann, M and Pettorelli, N (2015) Will remote sensing shape the next generation of species distribution models? *Remote Sensing in Ecology and Conservation* **1**: 4-18. DOI: 10.1002/rse2.7

Owen, HJF, Duncan, C and Pettorelli, N (2015) Testing the water: detecting artificial water points using freely available satellite data and open-source software. *Remote Sensing in Ecology and Conservation* **1**: 61-72. DOI: 10.1002/rse2.5

Pettorelli, N, Nagendra, H, Williams, R, Rocchini, D and Fleishman, E (2015) A new platform to support research at the interface of remote sensing, ecology and conservation. *Remote Sensing in Ecology and Conservation* **1**: 1-3. DOI: 10.1002/rse2.1

Pettorelli, N, Wegmann, M, Skidmore, A, et al. (2016a) Framing the concept of satellite remote sensing essential biodiversity variables: challenges and future directions. *Remote Sensing in Ecology and Conservation*. DOI:10.1002/rse2.15

Pettorelli, N, Owen, HJF, Duncan, C and Freckleton, R (2016b) How do we want satellite remote sensing to support biodiversity conservation globally? *Methods in Ecology and Evolution* **7(6)**: 656-665. DOI: 10.1111/2041-210X.12545

Skidmore, AK, Pettorelli, N, Coops, NC, Geller, GN, Hansen, M, et al. (2015) Environmental science: Agree on biodiversity metrics to track from space. *Nature* **523** (7561): 403-405. DOI: 10.1038/523403a

Disease and risky reintroduction decisions

IMPACT AREA

Researchers at IoZ have advanced methods of disease risk analysis and developed a decision analytic toolkit to support practitioners along the conservation translocation pathway.

Reintroductions and all forms of conservation translocation present a risk of disease to the translocated populations and the recipient ecosystems. At their worst, disease outbreaks can result in failure of the translocation, declines in other species and even potential extinction. So when undertaking reintroductions, we need to take care. Two decades ago, an understanding of these risks led to the development of rudimentary forms of disease risk analysis, based on import risk analysis for domestic animals. Clear differences exist for conducting risk analysis for wild animal reintroductions, and IoZ researchers have developed a novel method that recognises the need to assess hazards throughout the translocation pathway, assumes parasites are hazards based on novelty at the destination alone, considers the effects of stress on hazard impact and assesses non-infectious hazards such as toxins (Sainsbury and Vaughan-Higgins 2012). Our method has been developed during a period of keen interest in how best to assess the risks of translocations to wildlife, and we recently examined three different disease risk analysis methods to compare and contrast their relative attributes (Dalziel et al. 2016), subsequently reviewing all currently available methods used in reintroduction (Hartley and Sainsbury 2016).

The risks of translocating herptiles

We continue to apply and hone our method through application to reintroductions conducted in England in collaboration with Natural England and non-governmental organisations. In a recent assessment of risk in four herptile conservation translocations, we were able to show that translocation crossing ecological or geographical barriers increases the probability that the translocated hosts would contact novel parasites (Bobadilla Suarez et al. 2015). For example, the reintroduction of pool frogs (*Pelophylax lessonae*) from Sweden, crossing the geographic barrier of the North Sea, and the reintroduction of adders (*Vipera berus*) from a zoological collection that housed non-native vipers of other species, allowing contact across an ecological barrier, represented high-risk translocations. We have also described our biosecurity methods used for reintroduction, one of the means to mitigate the risks from disease that we have identified (Vaughan-Higgins et al. 2016).

The disease risk analysis process can be time-consuming and expensive, and the number of hazards that need to be analysed can be large. For example, the risk from 27 infectious agents were analysed for the reintroduction of the short-haired bumblebee (*Bombus subterraneus*) and the risk analysis took six months to complete (Brown et al. 2016). Current work aims to hone our risk analysis process in order to grasp the highest risk hazards at an early stage. To this end we conducted a review of infectious hazards to provide clear advice on which parasites are most likely to be dangerous in undertaking conservation translocations (Rideout et al. 2016).

Main image: *translocated pool frogs are found to be at risk of parasitical infection.* ***Left:*** *ZSL has reintroduced about 300 captive-bred common dormice to UK woodlands. In a quarantine period, they are screened for parasites, microchipped and their condition monitored before they are fully released.* ***Right:*** *ZSL works with Natural England to test translocation methods*

The importance of post-release surveillance

Post-release health surveillance offers an opportunity to gather crucial evidence on the prior disease risk analysis. For example, if a hazard considered low risk causes disease in the destination environment, mitigation measures can be re-evaluated and the disease risk analysis rewritten to account for the new information and, at the same time, reasons for the original mistaken analysis clearly described, to increase certainty in this and other analyses. Only through prolonged and costly post-release surveillance can we gather substantial evidence to improve the value of our disease risk analyses. At IoZ we have continued to monitor all translocations we

of disease risk analysis for conservation translocations. With each refinement we have been able to test the method in real translocations, which, through investment by ZSL and Natural England, are intensively monitored. This allows us to provide clear guidance on analyses to conservation groups in different translocation scenarios, and our method contributed to the development of Guidelines for Disease Risk Analysis by the International Union for Conservation of Nature and the World Organisation for Animal Health (OIE) (Jakob-Hoff et al. 2014).

ZSL has carried out
20 years
of post-release monitoring on red kites

Stochastic dominance in decision-making

Reintroductions require us to make risky decisions. Our attitudes toward risk shape the decisions we make and yet risk attitude is rarely openly addressed in real-world conservation decision-making. Risk arises because of uncertainty, and this is certainly the case when trying to make decisions around disease management. In a most recent development, IoZ researchers are developing a decision analytic toolkit that will use information generated in our disease risk analysis methods to make rational decisions on what disease management action to undertake in reintroductions (Ewen et al. 2015). One particularly useful method is stochastic dominance, a method that can be used to rank alternative disease management actions by comparing the probability distributions of their outcomes, making progressive simplified assumptions about the preferences of decision makers. We recently showcased this method for conservation decision-making in an endangered Australian frog species (Canessa et al. 2015). Our work on rational decision-making in reintroduction is assisting management of threatened species in multiple countries, including hihi (*Notiomystis cincta*) and short-tailed bats (*Mystacina tuberculata*) in New Zealand, regent honeyeaters (*Anthochaera phrygia*) in Australia, Mauritius olive white-eye (*Zosterops chloronothos*) in Mauritius and yellow-bellied toads (*Bombina pachypus*) in Italy.

have undertaken. The health of red kites (*Milvus milvus*) has been monitored since the start of reintroduction over 20 years ago, cirl buntings (*Emberiza cirlus*) have been monitored for eight years and pool frogs for over 12 years. Our work on pool frogs has shown the difficulties of carrying out effective health surveillance on animals of small body weight that might be predated when sick and quickly disappear when they die due to scavenging (Sainsbury et al. 2016), while post-release surveillance on cirl buntings showed that the month of release was critical to the survival chances of these birds (Fountain et al. 2016).

In carrying out these studies we have been able to provide an evidence-based approach to developing a robust method

References

Bobadilla Suarez, M, Ewen, JG, Groombridge, JJ, Beckmann, K, Shotton, J, Masters, N, Hopkins, T and Sainsbury, AW (2015) Using qualitative disease risk analysis for herpetofauna conservation translocations transgressing ecological and geographical barriers. *EcoHealth*. DOI: 10.1007/s10393-015-1086-4

Brown, MJF, Sainsbury, AW, Vaughan-Higgins, RJ, Measures, GH, Jones, CM and Gammans, N (2016) Bringing back a healthy buzz? Invertebrate parasites and reintroductions: a case study in bumblebees. *EcoHealth*. DOI: 10.1007/s10393-015-1093-5

Canessa, S, Ewen, JG, West, M, McCarthy, MA and Walshe, TV (2015) Stochastic dominance to account for uncertainty and risk in conservation decisions. *Conservation Letters* **12**: DOI:10.1111/conl.12218

Dalziel, AE, Sainsbury, AW, McInnes, K, Jakob-Hoff, R, Ewen, JG in press. DRAs to DRATs: a comparison of disease risk analysis tools for animal translocations. *EcoHealth*

Ewen, JG, Sainsbury, AW, Jackson, B and Canessa, S (2015) Disease Risk Management in Reintroduction. *Advances in Reintroduction Biology of Australian and New Zealand Fauna*. Armstrong, DP, Hayward, MW, Moro, D and Seddon, PJ (Eds), Collingwood, Australia: CSIRO Publishing

Fountain, K, Jeffs, C, Croft, S, Gregson, J, Lister, J, Evans, A, Carter, I, Chang, YM and Sainsbury, AW (2016) The influence of risk factors associated with captive rearing on post-release survival in translocated cirl buntings (*Emberiza cirlus*) in the UK. *Oryx*. DOI: 10.1017/S0030605315001313

Hartley, M and Sainsbury, A (2016) Methods of disease risk analysis in wildlife translocations for conservation purposes. *EcoHealth*. DOI: 10.1007/s10393-016-1134-8

Jakob-Hoff, RM, MacDiarmid, SC, Lees, C, Miller, PS, Travis, D and Kock, R (2014) Manual of procedures for wildlife disease risk analysis. World Organisation for Animal Health, Paris, 160pp. Published in association with the International Union for Conservation of Nature and the Species Survival Commission (available online)

Rideout, BA, Sainsbury, AW and Hudson, PJ (2016) Which parasites should we be most concerned about in wildlife translocations? *EcoHealth*. DOI: 10.1007/s10393-016-1132-x

Sainsbury, AW and Vaughan-Higgins, RJ (2012) Analyzing disease risks associated with translocations. *Conservation Biology* **26**: 442-452

Sainsbury, AW, Yu-Mei, R, Ågren, E, McGill, IS, Molenaar, F, Peniche, G, Vaughan-Higgins, RJ, Foster, J (2016) Disease risk analysis and post-release health surveillance for a reintroduction programme: the pool frog (*Pelophylax lessonae*). *Transboundary and Emerging Diseases.* DOI:10.1111/tbed.12545

Vaughan-Higgins, RJ, Masters, N, Sainsbury, AW (2016). Biosecurity for translocations: cirl bunting (*Emberiza cirlus*), Fisher's estuarine moth (*Gortyna borelii lunata*), short-haired bumblebee (*Bombus subterraneus*) and pool frog (*Pelophylax lessonae*) translocations as case studies. *EcoHealth.* DOI: 10.1007/s10393-016-1150-8

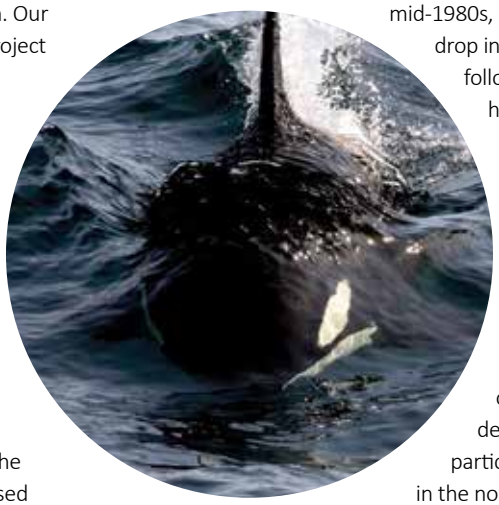
The threats of persistent chemical pollutants

IMPACT AREA

Banned chemicals pose a significant threat to marine top predators, according to new research led by IoZ. These findings highlight the critical need for policymakers to act quickly to tackle the lingering toxic legacy of PCBs.

Pollution in the marine environment is a major global problem. However, monitoring the effects of such pollution is challenging because samples from wild animals are very hard to obtain. Our cetaceans stranding project provides a window into this world. New IoZ research has shown that several cetacean species have very high mean blubber polychlorinated biphenyl (PCB) concentrations likely to cause population declines and suppress population recovery. The pan-European study used samples from more than 1,000 cetaceans from 1990 to 2012 and has produced very worrying findings, particularly in relation to PCBs (Jepson et al. 2016).

Cetacean blubber samples were obtained from the west of Ireland to the Canary Islands, and from the Iberian Peninsula/Strait of Gibraltar to the western and central Mediterranean Sea. PCB concentrations were shown to persist at excessively high concentrations in the blubber of several marine apex predator species across Europe, including killer whales (*Orcinus orca*), bottlenose dolphins (*Tursiops truncatus*) and striped dolphins (*Stenella coeruleoalba*).



PCBs were banned in the EU in the mid-1980s, but after an initial drop in concentrations following the ban, levels have now stabilised across Europe in humans, fish and wildlife. The high PCB concentrations in European cetaceans are associated with long-term and ongoing population declines across Europe, particularly in killer whales in the northeast Atlantic region and several dolphin species in the Mediterranean Sea. The few remaining killer whale populations in industrialised parts of Europe are now very close to extinction and have very low or zero rates of reproduction. Marked suppression or complete cessation of reproduction is a known effect of very high PCB exposure in mammals.

In February 2016, ZSL held a packed public meeting on PCBs in killer whales and other dolphins in Europe with three speakers including Robin Law (Cefas/ZSL), Paul Jepson (ZSL) and Richard Moxon (Head of Marine Contaminants in Defra). The meeting was chaired by Rob Deaville (CSIP Project Manager, ZSL) and closed by Professor Ian Boyd (Chief Scientist to Defra). The PCB issue was featured in a large number of national and international news outlets in early 2016, including the BBC's *Newsnight* and *The Washington Post*.

The ASCOBANS PCB resolution itself can be found at **ascobans.org/en/document/impacts-polychlorinated-biphenyls-pcbs**

Main image: *numbers of European killer whales are rapidly declining* ***Left:*** *killer whales are particularly at risk in the northeast Atlantic* ***Below right:*** *examining a stranded bottlenose dolphin at Hell's Mouth, North Wales in 2014*

Global reach

In a second paper we showed that PCBs pose a threat to many marine apex predators globally – not just in Europe (Jepson and Law 2016). The killer whale remains the most highly PCB-contaminated species on Earth, with very high PCB concentrations found throughout its range. Other marine apex predator species potentially impacted by PCBs include false killer whales (*Pseudorca crassidens*); coastal bottlenose dolphins (northern hemisphere); several threatened cetacean species in South East Asia; all marine mammals in the Mediterranean and Black Seas; ringed seals (*Pusa hispida*) and harbour porpoises in the Baltic Sea; polar bears (*Ursus maritimus*) in the Arctic and several apex predator shark species, including great whites (*Carcharodon carcharias*) and tiger sharks (*Galeocerdo cuvier*). More work is urgently needed to mitigate PCB contamination of the marine environment, in order to comply with the Stockholm Convention that requires the reduction and eventual elimination of large sources of PCBs and other persistent organic pollutants – both in Europe and in other parts of the world (Jepson and Law 2016).

Our research on cetacean PCB data in Europe has already fed into international scientific/policy fora, including several working

The killer whale remains the most highly PCB-contaminated species on Earth

Investigating strandings around the UK coastline

ZSL is the lead partner in the UK Cetacean Strandings Investigation Programme (CSIP), which was established in 1990 to coordinate the investigation of all whales, dolphins and porpoises that strand around the UK coastline, as well as any marine turtles and basking sharks. Chemical analyses were conducted by the Centre for Environment, Fisheries and Aquaculture Science (Cefas) in the UK and Barcelona University in Spain. The research was mainly funded by Defra and the Devolved Administrations of Scotland and Wales, and forms a major contribution to the UK government's commitment to a number of international conservation agreements.

groups of the International Council for the Exploration of the Sea (ICES). For example, the 2016 ICES Working Group for Marine Mammal Ecology cited Jepson et al. 2016 in concluding that PCBs still pose a major threat to bottlenose dolphins in European waters and are probably the single greatest threat to killer whales throughout the northeast Atlantic region (ICES 2016). The ICES and the ICES Working Groups provide rigorous, peer-reviewed scientific advice to the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) – including EU member compliance with the Stockholm Convention. At the triennial Meeting of Parties in 2016 in Helsinki, Finland, the Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) recently adopted a new resolution on PCBs based on our European PCB-related cetacean research.

References

ICES (2016) Report of the Working Group on Marine Mammal Ecology (WGMME), 8-11 February 2016, Madrid, Spain. ICES CM 2016/ACOM: 26. 117 pp

Jepson, PD and Law, RJ (2016) Persistent pollutants, persistent threats: Polychlorinated biphenyls remain a major threat to marine apex predators. *Science* **352**: 1388-1389. DOI:10.1126/science.aaf9075

Jepson, PD, Deaville, R, Barber, JL, Aguilar À, Borrell A, et al. (2016) PCB pollution still impacts populations of orca and other dolphins in European waters. *Scientific Reports* **6**: 18573. DOI:10.1038/srep18573

Conservation of social animals

IMPACT AREA

IoZ researchers study the complex social processes that underpin survival and reproduction in animal social groups. A better understanding of these processes will help to improve the conservation and management of these species. One important focus of this work is social information use.

Social animals include species such as ants and bees, shoaling fish, flocking birds and herding ungulates. Group-living animals play an important role in the provision of ecosystem services and the maintenance of global biodiversity. Social taxa are also among the most charismatic and popular animals, including elephants, most primates and cetaceans, and many carnivores. Unfortunately, the fascinating societies in which these animals live may also make them more vulnerable to extinction because their survival and reproduction is dependent upon their groupmates.

In order to survive and reproduce, animals must acquire information about their environment. They can do so either by directly sampling it, thereby generating personal information, or by watching others, thus generating social information. While personal information is usually more accurate, it is also time-consuming and dangerous to collect (for example, when it involves exposure to predators). Social information provides a faster and less costly alternative.

Because social information is a vital means through which animals learn about their environment, disruption to its flow can have dire consequences. This is perhaps most famously illustrated by the passenger pigeon (*Ectopistes migratorius*). This species suffered a massive decline due to hunting and habitat loss, but ultimately became extinct because remaining populations were too small to collect and share the necessary social information to track the oak and beech mast crops upon which the species depended.

Despite the importance of social information, we have a poor understanding of how it flows through social networks, and the individual opportunities and constraints on utilising this information. Over the past year, we have made significant progress in elucidating these processes.

Who watches whom? Information flow through social networks

Once social information has been generated, how does it diffuse across a social group? The answer depends at least partially upon patterns of attentiveness between individuals. One possibility is that animals primarily watch those who are closest to them, irrespective of their relationship to one another, but another possibility is that animals are more attentive towards their friends.

We investigated these two potential mechanisms in Tsaobis baboons (*Papio ursinus*), a desert baboon population in Namibia that has been the subject of an individual-based long-term study by IoZ since 2000. In a series of field experiments (Carter et al. 2016), we presented the baboons with small, ephemeral patches of one of their favourite foods, corn kernels. We recorded which baboons learnt about the location of the patch from their groupmates and then assessed which social network best predicted the pattern of learning. Was it the network based on spatial proximity (the time individuals spent in each other's company), or social interaction (the time individuals spent in affiliative interactions)? The answer was the spatial proximity network; individuals appeared to acquire social information from their neighbours rather than their friends.

Who benefits? Personal traits and the information use sequence

It has generally been assumed that all animals in a social group will use social information equally. However, this is unlikely to be true: some may use social information more than others. In order to elucidate this, we defined information use as a sequential process that involves three distinct stages: the acquisition of information, its application and the exploitation of its benefits. We then asked whether there are personal traits that might make some animals better or worse at each step of the sequence.

Main image and below right: *IoZ research has revealed how social information is shared among primates* ***Below:*** *the passenger pigeon became extinct in 1914 (artwork: Les pigeons par Madame Knip, née Pauline de Courcelles, Paris, 1808-43)*

In our experimental food patches (Carter et al. 2016), we assessed who managed to acquire information about the food patch (observe others foraging in it), apply that information (enter the patch), and exploit it (eat in the patch); and then related an individual's performance at each step to its personal traits. We found that the acquisition of information was relatively easy and solely dependent upon how much time was spent in the company of others. However, the application and exploitation of information was more challenging. High-ranking males, especially those who were bolder and better socially connected, were most likely to exploit the information. As a result of these sequential constraints, the average individual acquired social information on fewer than 25% of occasions, and only benefited from that information on fewer than 5% of occasions.

Better to be dominant? The role of resource ecology

Our findings suggest that high-ranking animals gain more benefits from social information use than low-ranking animals. But is this always likely to be the case? In a parallel study (Lee et al. 2016), we used mathematical modelling to ask how a forager's decision to use social information (that is, 'scrounge' at a patch discovered by others) might depend upon the resource ecology (the scarcity, depletion rate and monopolisability of resources).

Surprisingly, we found that the scrounging-related rewards of high rank were not only dependent upon the monopolisability of resources, but also their scarcity and depletion rates. For instance, if monopolisable resources are so scarce that only one patch is available for scrounging at any one time, then scrounging will only be effective for the dominant animal, and other high-ranking animals should switch to using personal information to find food patches.

These processes also have important implications for demography and conservation. Previous researchers have noted that, because scroungers do not find food patches, a large proportion of scroungers in the population will reduce the number of known food resources, potentially leading to population declines. Our model indicates that, counterintuitively, when resources are difficult to find it is better for them to be monopolisable, because then more foragers will switch to using personal information, leading to the discovery of more food patches. Insights such as these enhance our understanding of how social animals exploit their environment, and will help to inform future decisions about the conservation management of social species.

References

Carter, AJ, Ticó, MT and Cowlishaw, G (2016) Sequential phenotypic constraints on social information use in wild baboons. *eLife* **5**: e13125. DOI: 10.7554/eLife.13125

Lee, AEG, Ounsley, JP, Coulson, T, Rowcliffe, JM and Cowlishaw, G (2016) Information use and resource competition: an integrative framework. *Proceedings of the Royal Society of London B – Biological Sciences* **283**: 20152550. DOI: 10.1098/rspb.2015.2550

Mitigating amphibian disease

IMPACT AREA

Declines in amphibian populations represent one of the largest biodiversity crises in modern history. IoZ scientists conduct world-leading research on mitigation strategies to conserve amphibian populations at risk of the infectious disease chytridiomycosis.

Infectious disease is a leading cause of global amphibian declines, contributing to an extinction crisis in which more than 40% of all amphibian species are threatened with extinction and hundreds of species are thought to have become extinct within the past decade. One such disease, chytridiomycosis, caused by two pathogenic fungi, *Batrachochytrium dendrobatidis* (Bd) and *B. salamandrivorans* (Bsal), has been described as the worst vertebrate disease ever recorded in terms of the number of species impacted and the propensity to drive extinctions. IoZ was key to the discovery of chytridiomycosis (Berger et al. 1998) and our research continues to explore the impact of the disease, as well as factors that increase the probability of infection. Although chytridiomycosis is recognised as a major threat, there is currently little work on mitigating the disease. To this aim, IoZ scientists are conducting groundbreaking research into the development of viable amphibian disease mitigation strategies, both in the field and in captivity.

Mountain Chicken Recovery Programme

IoZ is a partner in the Mountain Chicken Recovery Programme, established in 2002 with the aim of saving the Critically Endangered mountain chicken frog (*Leptodactylus fallax*) from extinction. IoZ research has recently provided one of the first species-wide impact assessments for chytridiomycosis (Hudson et al. 2016a), in what is believed to be one of the fastest range-wide declines ever recorded for any animal. The study revealed a loss of over 85% of mountain chicken frogs in 18 months on Dominica and near-extinction in the same period of time on Montserrat. The decline of the species on Montserrat was highlighted as preventable as Bd likely arrived with infected tree frogs that were inadvertently imported with produce. However, prevention of such routes of disease invasion requires international trade controls and collaboration, which are currently lacking. If such support is to be generated, sources of infection in trade need to be identified. To this end, our research illustrated how Bd incursion into the UK is through the amphibian pet trade (Wombwell et al. 2016). An estimated 20,000 live amphibians enter the UK annually through Heathrow Airport, one of four major entry ports for the live amphibian trade. Dozens of genera of amphibians arrive from Asian, North and South American, European and African countries, and our researchers detected infection in multiple shipments. Tracking the true source of infection, though, is not a simple task, as amphibians are not always shipped directly from their collection point to the country of final destination. Further work, again with engagement by the amphibian trading community, will hopefully determine whether infections in the trade can be managed at point of collection or whether infection is acquired during the process of reshipping.

Main image: *IoZ scientists have conducted the first eradication of Bd from an isolated pond system, home of the Mallorcan midwife toad*
Left: *IoZ is working with partners to protect the mountain chicken frog*

World first in antifungal treatment

Where it is not possible to prevent the introduction of pathogens, mitigation must focus on pathogen eradication or facilitating pathogen-host co-existence. IoZ researchers have been involved in attempts to achieve both of these outcomes. Firstly, as part of the Mountain Chicken Recovery Programme – where Bd reservoirs, such as tree frogs, prevent the eradication of Bd – in situ mitigation of chytridiomycosis was attempted through the world's first field-based individual-animal antifungal treatment regime conducted during an epidemic (Hudson et al. 2016b). This study was successful in increasing survival and recovery rates in the short-term and has important ramifications for countries which have yet to experience epidemics of this disease.

Secondly, IoZ scientists have carried out research into direct mitigation of Bd infection in the wild on Mallorca, conducting the world's first eradication of Bd from an isolated pond system, home to the Vulnerable Mallorcan midwife toad (*Alytes muletensis*) (Bosch et al. 2015). Our initial efforts to eliminate infection in the larval reservoir using a direct application of an antifungal were successful ex situ, but infection returned when tadpoles with cleared infections were returned to their natal sites. Subsequently, antifungal treatment of tadpoles was combined with environmental chemical disinfection. Infection at four of the five pools where Bd had previously been recorded was eradicated, and remained so for two years post-application. Although the development of disinfection strategies alone cannot eliminate the threat of chytridiomycosis, this research provides proof of principle that in some circumstances the threat of disease can be neutralised.

Working with partners in the Mountain Chicken Recovery Programme, IoZ scientists have discovered that the near-extinction of the species in Dominica and Montserrat may have been caused by the introduction of infected amphibians accidentally brought in with produce

Bio-augmentation with probiotic bacteria

While short-term measures, such as individual-level treatment (Hudson et al. 2016b), are vital in preventing imminent extinctions, and eradications can be effective where conditions permit (Bosch et al. 2015), research is required into methods for longer-term persistence mechanisms for species threatened with chytridiomycosis. IoZ researchers have carried out laboratory-based studies with the aim of identifying novel future mitigation techniques for chytridiomycosis, which could promote long-term amphibian persistence. Bio-augmentation of amphibian skin with probiotic bacteria that inhibit the growth of Bd has been hailed as a promising management strategy; however, to date it has shown mixed results (Rebollar et al. 2016). This research highlights the possibility of selecting probiotic species that are likely to have the greatest protective effect against Bd infection through cutting-edge 'omics' research using genetic and molecular data.

Research into the mitigation of Bd in ex situ amphibians has also been a central component of IoZ's work. This is essential in order to maintain captive 'safety net' populations of amphibian species that may be extinct in the wild. IoZ researchers recently helped develop the first treatment regime for caecilians alongside collection managers and veterinarians from ZSL London Zoo (Rendle et al. 2015).

Research continues to lag behind the conservation need and IoZ continues to play a leading role in trying to bridge this gap, employing cutting-edge methods with a strong track record of dissemination in the scientific literature, and the wider press, to ensure maximum coverage and engagement with conservation practitioners.

References

Berger, L, Speare, R, Dazak, P, Green, DE, Cunningham, AA, Goggin, L, Slocombe, R, Ragani, MA, Hyatt, AD, McDonald, KR, Hines, HB, Lips, KR, Marantelli, G and Parkes, H (1998) Chytridiomycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America. *PNAS* **95**: 9031-9036

Bosch, J, Sanchez-Tome, E, Fernandez-Loras, A, Oliver, JA, Fisher, MC and Garner, TWJ (2015) Successful elimination of a lethal wildlife infectious disease in nature. *Biology Letters* **11**: DOI: 10.1098/rsbl.2015.0874

Hudson, MA, Young, RP, D'Urban Jackson, J, Orozco-terWengel, P, Martin, L, James, A, Sulton, M, Garcia, G, Griffiths, RA, Thomas, R, Magin, C, Bruford, MW and Cunningham, AA (2016a) Dynamics and genetics of a disease-driven species decline to near extinction: lessons for conservation. *Scientific Reports* **6**: 30772 DOI:10.1038/srep30772

Hudson, MA, Young, RP, Lopez, J, Martin, L, Fenton, C, McCrea, R, Griffiths, RA, Adams, S-L, Gray, G, Garcia, G & Cunningham, AA (2016b) In-situ itraconazole treatment improves survival rate during an amphibian chytridiomycosis epidemic. *Biological Conservation* **195**: 37-45

Rebollar, EA, Antwis, RE, Becker, MH, Belden, LK, Bletz, MC, Brucker, RM, Harrison, XA, Hughey, MC, Kueneman, JG, Loudon, AH, McKenzie, V, Medina, D, Minbiole, KPC, Rollins-Smith, LA, Walke, JB, Weiss, S, Woodhams, DC and Harris, RN (2016) Using 'omics' and integrated multi-omics approaches to guide probiotic selection to mitigate chytridiomycosis and other emerging infectious diseases. *Frontiers in Microbiology* **7**: art no 68. DOI: 10.3389/fmicb.2016.00068

Rendle, M, Tapley, B, Perkins, M, Bittencourt-Silva, G, Gower, DJ and Wilkinson, M (2015) Itraconazole treatment of *Batrachochytrium dendrobatidis* (Bd) infection in captive caecilians (Amphibia: Gymnophiona) and the first case of Bd in a wild neotropical caecilian. *Journal of Zoo and Aquarium Research* **3(4)**: 137-140

Wombwell E, Garner TWJ, Cunningham AA, Quest R, Pritchard S, Rowcliffe JM and Griffiths RA (2016) Detection of *Batrachochytrium dendrobatidis* in amphibians imported into the UK for the pet trade. *EcoHealth* 10.1007/s10393-016-1138-4

Research highlights

IoZ researchers continue to enrich our understanding of the natural world. In the following section you will find snapshots of this exciting work, which investigates subjects as diverse as zooarchaeology and population genetics. Also in this section, two of our scientists describe what their work entails, we explain how we share our knowledge, and we celebrate the winners of our annual awards and the work of our students.

Research projects include the social mechanisms in groups of Tsaobis baboons in Namibia

Research highlights

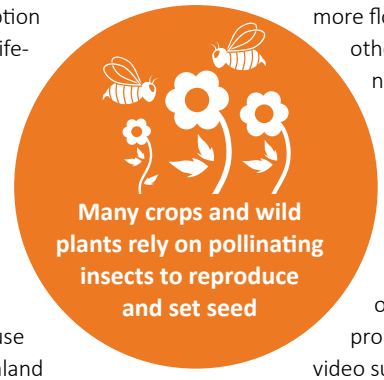
Through their published research, IoZ staff and students continue to widen our knowledge and understanding of the natural world. Here, we present just a few of the papers that have been making an impact over the past year.

Creating flower-rich habitats on otherwise intensive farms supports wildlife

IoZ research has revealed that leopards occupy only 25-37% of their former range

Wildlife-friendly farm management schemes benefit biodiversity

Modern, intensive farming methods are hard on the environment, resulting in widespread loss of habitats and the wildlife they support. How can this issue be addressed? One option is for farmers to adopt wildlife-friendly management measures, which most often involve the creation of habitats that support wildlife. Although wildlife-friendly farming has been practised widely in Europe for several decades, it remains controversial because wildlife populations on farmland have continued to decline. So, do wildlife-friendly farming schemes actually benefit wildlife? We compared the impact of three wildlife-friendly farming schemes in England on wildlife and pollination services provided by insects such as bees and butterflies. The latter is important because many crops and wild plants rely on pollinating insects to reproduce and set seed. The three schemes were organic farming and two non-organic schemes: one prescriptive (Conservation Grade, CG) and one flexible (Entry Level Stewardship, ELS). The research shows that organic and CG farms supported a greater diversity of wildlife habitats and wildlife than ELS farms. Organic farms had more flower-rich habitats than other farms, provided nectar resources for bees throughout spring and summer, and had the highest levels of plant pollination. Wildlife-friendly farming schemes can benefit wildlife, but only if habitat creation is properly targeted. For a short video summarising the research, visit bit.ly/friendly_farming



References

Hardman, CJ, Harrison, DP, Shaw, PJ, Nevard, TD, Hughes, B, Potts, SG and Norris, K (2015) Supporting local diversity of habitats and species on farmland: a comparison of three wildlife-friendly schemes. *Journal of Applied Ecology* **53**(1): 171-180. DOI: 10.1111/1365-2664.12557

Hardman, CJ, Norris, K, Nevard, TD, Hughes, B and Potts, SG (2016) Delivery of floral resources and pollination services on farmland under three different wildlife-friendly schemes. *Agriculture, Ecosystems and Environment* **220**: 142-151. DOI: 10.1016/j.agee.2016.01.015

New study on the distribution and status of leopards

One of the most iconic species on the planet, the leopard is a symbol of the fierce, untamed wild. With remarkable adaptability and a secretive, solitary nature, the leopard's biology may have contributed to the misconception that the species is not severely threatened across its range. In the most detailed assessment ever for the species, we reviewed more than 1,300 sources to delineate the historic (post-1750) and current range of the species. We found that the leopard only occupies 25-37% of its historic range and that several subspecies and regional populations are critically endangered. Of the nine recognised subspecies, three (African *Panthera pardus pardus*, Indian *P. p. fusca* and Persian *P. p. saxicolor*) account for 97% of the leopard's extant range, while another three (Amur *P. p. orientalis*, Arabian *P. p. nimr*, and north Chinese *P. p. japonensis*) have each lost as much as 98% of their historic range. Isolation, small patch size and few remaining patches further threaten six subspecies each with less than 100,000 km^2 of extant range. Approximately 17% of extant leopard range

is protected, although some subspecies have far less. Finally, we found that while research on leopards is increasing, research effort is primarily on the subspecies with the most remaining range, whereas subspecies that are most in need of urgent attention are neglected. The demarcation of historic and current distributions provides important conservation baselines. We believe these results will catalyse enhanced protection for the leopard, elevate its recognition as a threatened species, and increase research and conservation effort for threatened subspecies.

Reference

Jacobson, AP, Gerngross, P, Lemeris Jr, JR, Schoonover, RF, Anco, C, Breitenmoser-Wursten, C, Durant, SM, Farhadinia, MS, Henschel, P, Kamler, JF, Laguardia, A, Rostro-Garcia, S, Stein, AB and Dollar, L (2016) Leopard (*Panthera pardus*) status, distribution, and the research efforts across its range. *PeerJ* **5**: e1974. DOI: 10.7717/peerj.1974

New methods for identifying individuals from genetic marker data

Capture-Mark-Recapture (CMR) is a valuable tool, widely used to study animal population densities, migrations and home ranges. However, it is expensive and difficult to capture, mark and recapture animals that are gigantic (eg large marine mammals), minute (eg insects), shy (eg okapis), or highly mobile (eg some birds). Genetic marker-based identification of individuals can be used as an analogue CMR without actually capturing, marking, and even without seeing animals, because DNA can be acquired non-invasively from sources such as faeces. A recent study has shown that the widely applied genotype mismatch method to identify individuals is unreliable because it cannot cope with genotyping errors efficiently and often yields self-inconsistent inferences. IoZ Senior Research Fellow Jinliang Wang improved this method and developed three new methods to identify individuals from poor-quality data that may have high and variable rates of allelic dropouts and false alleles at genotyped loci. The accuracy of these methods was compared by analysing an empirical frog dataset (comprising tadpole, juvenile and adult DNA samples) and many simulated datasets generated under different parameter combinations. The results showed that one new method, based on pedigree (sibship) reconstruction, is generally one or two orders more accurate for individual identification than the other methods. Its accuracy is especially superior when the sampled multilocus genotypes have poor quality (are teemed with genotyping errors and missing data) and are highly replicated, a situation typical of non-invasive sampling used in estimating population size.

Reference

Wang, J (2016) Individual identification from genetic marker data: developments and accuracy comparisons of methods. *Molecular Ecology Resources* **16(1)**: 163-175

The aurochs, the wild ancestor of modern cattle, became extinct through hunting, disease and a reduction of habitat caused by farming

Human impacts on European large mammals across the Holocene

Conservation science typically focuses on understanding recent impacts on biodiversity, but human activities have affected species and ecosystems for millennia. Understanding longer-term faunal responses to human pressures can therefore provide a unique new perspective for assessing species vulnerability and extinction risk. Long-term archives, such as the archaeological record, contain many biases and data gaps, but for some geographic regions a detailed record of past biodiversity is now available. Researchers at IoZ compiled an extensive database containing 18,700 records of wild mammals in zooarchaeological deposits across Europe through the Holocene Epoch (the 11,700 years since the end of the last Ice Age glaciation), when species declines are likely to have been caused by human activities. We used this database to reconstruct the spatio-temporal dynamics of geographic range change for 15 European large mammals, and showed that past declines varied between species in timing, duration and magnitude. Some species became extinct in the Holocene, significant declines started in other species such as bison around 3,000 years ago and continued to the present, and still other species show no evidence of past human-caused decline. Herbivores experienced significantly greater declines than carnivores, revealing important insights into species vulnerability that may not be predicted by studying threatened carnivores today. These findings emphasise the importance of large-scale, long-term datasets for understanding complex protracted extinction processes. The dynamic pattern of progressive faunal depletion across the Holocene also shows that 'static' baselines for informing current-day environmental management and restoration may not be easy to identify.

Reference

Crees, JJ, Carbone, C, Sommer, RS, Benecke, N and Turvey, ST (2016) Millennial-scale faunal record reveals differential resilience of European large mammals to human impacts across the Holocene. *Proceedings of the Royal Society of London B - Biological Sciences* **283**(1827): 201521529. DOI: 10.1098/rspb.2015.2152

Diverse fauna discovered on two deployments from seamounts on the Southwest Indian Ridge

Large organic inputs to the seafloor, such as carcasses, ships, crates or other organic debris that have sunk from the surface layers, are important sources of carbon to the communities of the deep sea. They also constitute a useful experimental approach to studying colonisation processes, community composition and aspects of species distributions in these remote habitats. During an expedition to the Southwest Indian Ocean Ridge large parcels of whalebones and wood were deployed onto the summits of two seamounts of ~750m depth and a few kilometres apart. These were retrieved two years later. Even though they were small 'targets' for larval settlement, a remarkable number and diversity of species had colonised the deployments. Only 11 species were common to both seamounts. Fauna were counted, identified and imaged using a micro-CT scanner. Several new species were found; three have been described so far. This is the first time such faunal assemblages have been observed in the Indian Ocean. The difference in the diversity and composition characterising the two deployments was notable. The Subtropical Front that runs through this region may act as a major biogeographic barrier to larval dispersal, possibly resulting in isolation and eventually speciation. Though this remains speculation until more sampling can be undertaken in the region, it provides interesting insight into potential barriers to genetic and community connectivity.

Reference

Amon, DJ, Copley, JT, Dahlgren, TG, Horton, T, Kemp, KM, Rogers, AD and Glover, AG (2015) Observations of fauna attending wood and bone deployments from two seamounts on the Southwest Indian Ridge. *Deep-Sea Research Part 2: Topical Studies in Oceanography*

Drowning is an unexpected cause of mass mortality of starlings

Mortality incidents that involve multiple wild birds often attract public concern and sometimes media attention. Investigation of infectious disease as a cause, in particular the exclusion of notifiable disease, is a priority in these incidents. However, non-infectious disease can also result in the deaths of multiple wild birds. The Garden Wildlife Health (GWH) project investigates the conditions that affect garden birds across Great Britain in order to identify emerging and novel threats and to evaluate their conservation significance. GWH is a citizen science project and relies

IoZ research into colonisation processes in the Indian Ocean has revealed a number of new species

on members of the public to report observations of sick or dead wildlife in their gardens (gardenwildlifehealth.org). Drowning is infrequently reported as a cause of death of wild birds and such incidents typically involve individual, rather than multiple, birds. Over a 21-year period (1993-2013 inclusive), 12 incidents of mortality of multiple (2-80+) common starlings (*Sturnus vulgaris*) that appeared to be due to drowning were investigated across Great Britain. These incidents occurred during spring and early summer and usually involved juvenile birds. Circumstantial evidence and post-mortem examinations indicated drowning to be the most likely cause of death. A behavioural explanation seems likely, possibly related to the gregarious nature of this species combined with juvenile inexperience in identifying water hazards. While starlings are a Red List species in decline in Great Britain, these findings indicate that drowning events are relatively infrequent and are an animal welfare concern rather than a conservation issue. Provision of a sloping side or ramp in waterbodies, particularly during spring, is recommended to enable wild animals to safely enter and exit.

Reference

Lawson, B, Duff, JP, Beckmann, KM, Chantrey, J, Peck, KM, Irvine, RM, Robinson, RA and Cunningham, AA (2015) Drowning is an apparent and unexpected recurrent cause of mass mortality of Common starlings (*Sturnus vulgaris*). *Scientific Reports* **5**: 17020. DOI: 10.1038/srep17020

Are pedigrees or markers better for estimating relatedness and inbreeding coefficient?

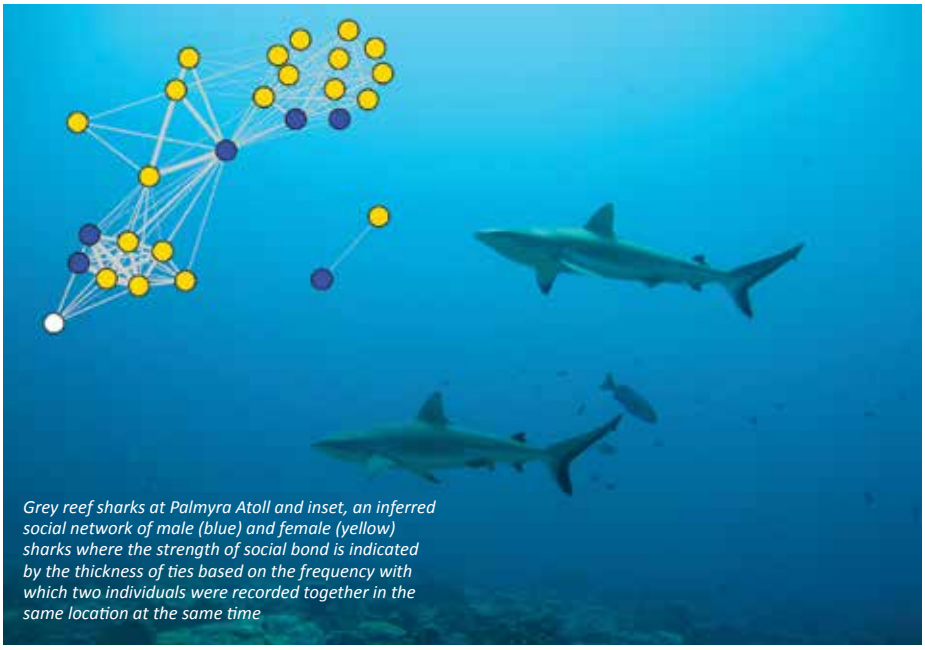
Individual inbreeding coefficient (F) and pairwise relatedness (r) are fundamental parameters in population genetics and have important applications in diverse fields, such as medicine, forensic science, plant and animal breeding, conservation and evolutionary biology. Traditionally, both parameters are calculated from pedigrees, but now are increasingly estimated from genetic marker data, which are easier than pedigree data to collect from natural populations. Conceptually, a pedigree gives the expected F and r values, with the expectations being taken (hypothetically) over an infinite number of individuals with the same pedigree. In contrast, markers give the realised (actual) F and r values at the particular marker loci of individuals. Both pedigree and marker estimates can be used as inferences of genomic inbreeding coefficients (F_G) and genomic relatedness (r_G), which are the underlying quantities relevant to most applications (such as estimating inbreeding depression and heritability) of F and r. In the pre-genomic era, it was widely accepted that pedigrees are much better than markers in delineating F_G and r_G, and markers should be used to validate, amend and construct pedigrees rather than to replace them. Is this still true in the genomic era? This study showed that genomic markers can yield much better estimates of F_G and r_G than pedigrees when they are numerous, under realistic situations. Pedigree estimates are especially poor for species with a small genome, where F_G and r_G are determined largely by Mendelian segregations and may thus deviate substantially from their expectations.

Reference

Wang, J (2015) Pedigrees or markers: which are better in estimating relatedness and inbreeding coefficient? *Theoretical Population Biology* **107**: 4-13

How our science is done

Two IoZ postdoctoral researchers explain the rewards of working in conservation and the value of collaboration.

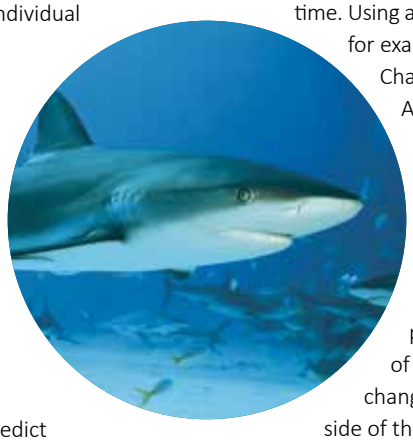


Grey reef sharks at Palmyra Atoll and inset, an inferred social network of male (blue) and female (yellow) sharks where the strength of social bond is indicated by the thickness of ties based on the frequency with which two individuals were recorded together in the same location at the same time

David Jacoby (right) and collaborator Yannis Papastamatiou (Florida International University) installing an acoustic tracking receiver around Mikomoto Island, Japan, to monitor the space use of endangered scalloped hammerhead sharks

David Jacoby explains the rewards of data analysis

For me, science is a love of learning and a love of collaborating with people from different places and different backgrounds, all in the name of better understanding a species or a system and how we can conserve it. I am particularly interested in researching how things are connected in a broader sense. How do individual animals socialise to create population-level patterns? How do species link discrete, seemingly remote habitats, by moving between them, and what does this mean for the spread of information or disease within a population, or how vulnerable species might be to anthropogenic impacts? Finally, can we predict these patterns to give us a head start in managing 'at risk' systems?



These are questions I have been trying to explore in the marine environment, particularly for wide-ranging marine predators such as sharks, where behavioural drivers of population dynamics are particularly difficult to measure. I use a variety of electronic tracking techniques and network analyses of remotely gathered data on movement and social behaviour, to determine how groups of often threatened shark species are structured in space and time. Using arrays of acoustic receivers, for example, in places such as Chagos, Japan and Palmyra Atoll in the central Pacific Ocean, we can monitor the movements and aggregation behaviour of many tagged animals simultaneously over periods of years, providing a detailed picture of systematic population change. While the glamorous side of things can involve diving, tagging sharks in remote locations and developing new tracking technologies, the bulk of the work involves wrangling the large, unwieldy time-series data sets that these technologies produce. Developing bespoke analyses, although challenging at times, can be extremely rewarding. This year, for example, my colleagues and I were able to finalise a set of analyses that provides open-source code for other researchers to infer social behaviour from simple presence-absence data. This allowed us to demonstrate, perhaps unsurprisingly, that female individuals emerge as natural leaders within a social network of grey reef sharks (*Carcharhinus amblyrhynchos*). Now, I am turning my attention to how these tools can be used in the Chagos Marine Reserve to predict where and when sharks are most vulnerable to illegal, unreported and unregulated fishing activities.

Clockwise from top: *the hihi specialist group on Kapiti Island, one of the first hihi reintroduction sites. L-R: John Ewen (ZSL), Nick Fisentzidis (Department of Conservation, Kapiti Ranger), Genevieve Spargo (Department of Conservation, Kapiti Ranger), Patricia Brekke (ZSL), Anna Santure (Auckland University) and Kate Lee (PhD student, ZSL/ Auckland University); hihi male about to land, by John Sibly, winner of the hihi photo competition celebrating the 20-year anniversary since the successful reintroduction of hihi to the island of Tiritiri Matangi in 1995; Patricia Brekke working in the field*

Patricia Brekke on the importance of collaboration

Species at risk of extinction exist in small, isolated populations. One of the biggest uncertainties in conservation biology is whether species under these conditions can adapt to our changing environment in a timescale that is appropriate for their long-term survival. Whether small populations can evolve and adapt is a central theme of my research; in particular, the application of evolutionary thinking and genetic theory to improve the management of threatened species. How do the different evolutionary forces act on small populations? How does this balance change through reintroduction programmes and how can we design management strategies that take this into account?

Most of my research uses data collected as part of ongoing long-term studies of wild and captive-bred populations of the New Zealand hihi (*Notiomystis cincta*) and the UK corncrake (*Crex crex*) breeding programme at ZSL. These datasets provide longitudinal information on a variety of life history, morphological and behavioural traits, from birth to death, in a large number of uniquely identifiable individuals, over many generations. We also collect blood/ tissue samples from every individual hatched during each breeding season. These samples provide the raw material for the genetic and more recently genomic analyses I undertake.

Producing these datasets and maintaining this sampling regime is very labour-intensive, and requires a strong collaboration network between scientists, NGOs, governmental entities and community groups. Some of my time is spent developing these collaborations. In the past year, I visited all my field sites to build and maintain these relationships, update them on the research that is being done and why, and to promote the use of standardised genetic monitoring across all populations. I believe this will prove to be an invaluable resource for understanding the dynamics of single and serial reintroductions and the management of meta-populations of threatened species.

I combine genetic and genomic data with the demographic information to resolve the relatedness among individuals in these populations, to build pedigrees that allow me to quantify inbreeding, effective population size, heritability, and breeding values, among many other genetic parameters. Once these have been established, I can use them to test and predict how different conservation management strategies (eg reintroduction, cropping, supplementary feeding, disease control, captive breeding) can impact their genetic architecture and influence their adaptive potential and long-term viability.

Communicating science

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

Science and conservation events

ZSL's popular science and conservation events are free and open to the public. Held on the second Tuesday of each month throughout the academic year, each meeting provides an overview of the latest developments in conservation and zoological research. This year's programme included lectures on 'What is the future for beavers in Britain?', 'Big-ocean commitments in the UK Overseas Territories', 'The secrets and skills behind conservation breeding' and 'What's killing the killer whales?'.

This image: *anti-poaching measures in Nepal have increased the population of one-horned rhino*
Left: *Jeremy Farrar at the One Health for the Real World symposium*

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 October symposium, 'The future of food – the future of biodiversity?', leading voices from farmers' groups, food suppliers, major retailers, conservationists, scientists and policymakers considered sustainable solutions to the growing challenge of balancing food security and biodiversity conservation.

In February a one-day conference showcased recent conservation successes in Nepal, as part of our Britain-Nepal 200 celebrations.

In March the symposium 'One Health for the Real World: zoonoses, ecosystems and wellbeing' brought together experts from different fields to present new interdisciplinary frameworks for a One Health approach, highlighting evidence from field-based settings in Africa and beyond.

ZSL

ZSL symposia bring together international experts to discuss hot topics in conservation science

In April the symposium 'Space – the final frontier for biodiversity monitoring' focused on the increasing importance of integrating developments in satellite remote sensing technology with biodiversity monitoring initiatives.

A Megophyrus spinata *tadpole – destruction of habitat is contributing to decreasing numbers of this toad*

Stamford Raffles Lecture

The Stamford Raffles Lecture is the foremost event in ZSL's programme of science and conservation events. The 2016 lecture, 'Climate change, habitat loss and biodiversity', given by Jane Hill, University of York, described how species shift their distributions to track climate change.

The fascination of the general public for recording animals and plants in Britain has provided a wealth of detailed information that we can exploit. This information helps us to understand the variety of species' responses, and to explore factors responsible for this variation.

In this talk, Jane described recent patterns of climate-driven range changes among species, focusing particularly on British butterflies and moths for which we have especially good historical information. She explained how this knowledge is being used to inform conservation, for example, improving habitat connectivity to help species reach new areas, and habitat management to prevent climate-driven extinctions, thereby helping to reduce biodiversity losses.

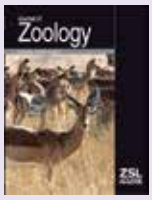
Professor Jane Hill of the University of York delivers the Stamford Raffles Lecture on how climate change affects species of butterflies and moths

Scientific publications

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

Animal Conservation

Animal Conservation provides a forum for the publication of quantitative research on the conservation of species and habitats. Highlights include feature papers and commentaries, and 'Letters from the Conservation Front Line', which highlight questions for scientists from the conservation practitioner community.

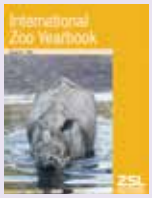


Journal of Zoology

Our monthly journal includes hypothesis-driven studies that advance our understanding of animals and their systems. A special issue and podcast featuring top authors were produced to celebrate the journal's 50th anniversary.

Remote Sensing in Ecology and Conservation

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



International Zoo Yearbook

The *Yearbook* is an invaluable resource for researchers, animal managers and anyone interested in wildlife conservation. The latest volume – Future Perspectives in Conservation Education – presents a range of evidence-based research projects, case studies and reviews on the changing perspective of conservation education.

Conservation Science and Practice book series

The latest title in the *Conservation Science and Practice* books series 'Antelope Conservation', edited by Jakob Bro-Jørgensen and David Mallon, examines the causes of the drastic decline in antelope biodiversity and focuses on management of exploitation, habitat fragmentation, disease transmission, climate change, population genetics and reintroductions.

To see our current programme of events, from public lectures to scientific symposia, visit zsl.org/science/whats-on

Education and training

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

Main image and below right: *ringing Mauritius olive white-eyes to monitor their reintroduction*
Left: *Inez Januszczak is studying the nutrition of tree-runner lizards*
Below left: *David Curnick tagging sharks in the Chagos marine protection area*

MSc courses in Wild Animal Health and Wild Animal Biology

Graduates of our MSc courses in Wild Animal Health (WAH) and Wild Animal Biology (WAB) continue to gain important posts around the world. For example, Ana Gouveia (2006 MSc WAB) is now Post-Doctoral Research Fellow at Xishuangbanna Tropical Botanical Gardens, Chinese Academy of Sciences; Neo Mapitse (1999 WAH MSc) is Deputy Head of World Animal Health Information and Analysis Department, World Organisation for Animal Health; and Alberto Castaños (2012 MSc WAH) is Veterinarian and Operations Manager at Stingray Bay, Dominican Republic. Our 410 graduates originate from 55 countries and form a valuable network of wild-animal health professionals in contact through our alumni association, Wild Animal Alumni. Analysis of graduate careers shows that of 319 graduates surveyed, 83% of WAH and 81% of WAB graduates gained posts in wild animal health and/or conservation.

In 2015, 25 students graduated: Liam Fitzpatrick received the award for the MSc WAB student with the highest aggregate marks and Melisa Unger gained the most marks in MSc WAH. The best research project prizes were awarded to Liam Fitzpatrick for his research on epidemiological tracing of *Batrachochytrium salamandrivorans* infection following its detection in a UK amphibian collection, and Inez Januszczak for her study on the impact of a feeding enrichment device on the behaviour and enclosure use of tree-runner lizards (*Plica plica*), which was recently published in the journal *Applied Animal Behaviour Science*. Over the past 21 years, MSc projects and reports have led to the publication of more than 140 scientific papers, which represents a healthy contribution to the research output of ZSL in conservation science.

Learn more about the postgraduate opportunities at IoZ at **zsl.org/science/postgraduate-study**

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 or action. The 2015 cohort included students from the Philippines, India, South Africa, Uganda, Chile and the USA, as well as the UK and EU. In all, 28 students graduated, with the award of eight Distinctions, 19 Merits and one pass. Brittany Sawrey was awarded the TH Huxley prize for the best student overall, and Paolo Strampelli was awarded the Joseph Hooker prize for the best coursework performance. Lucy Archer was awarded the Durrell prize for the best project, which used scenario-based interviews to evaluate policy options for mitigating the impacts of wildlife crime around Murchison Falls and Queen Elizabeth conservation areas in Uganda.

Access the full Conservation Science thesis archive at **iccs.org.uk/publications/thesis-archive-msc-con-sci**

MSc student prizewinners for 2014-2015 in Wild Animal Biology and Wild Animal Health

Our PhD students

The past year has seen some major changes to the landscape of student support at the IoZ. Our recent Athena SWAN review process resulted in the development of an action plan to help provide an environment that places a strong emphasis on equality and diversity for our staff and students, and provides training support for their careers beyond their stay at the IoZ. We are developing a new workplace that will provide top-of-the-range workspaces and facilities for our students, and we've altered the way we invest the student fees in order to better support them on their PhD journeys. All of these changes have been implemented with a view to meeting our objective of supporting our PhD students to do the best work that they possibly can while at the IoZ.

We also now have two postgraduate tutors. After a year of flying solo in the role, I have been joined by Patricia Brekke, which is great for me, and highlights how seriously the IoZ takes student support, being willing to invest staff time and energy into it.

Something that stands out every year is the quality of our PhD students, their integral role in dictating the dynamics of the IoZ, and the calibre of the research and the applied conservation that occurs as a result of their work. This year has produced a bumper crop of 16 PhD theses from students. These include Mike Hudson ('Conservation management of the mountain chicken frog'); David Curnick ('The role of marine protected areas in conserving highly mobile pelagic species'); Ellie Dyer ('A global study of the distribution and richness of alien bird species'); Gwen Maggs ('The ecology and management of wild and reintroduced populations of the Mauritius olive white-eye *(Zosterops chloronothos)*'); and Simon Dures ('Transfrontier lion conservation: applying genetics across time and space'). These students have not only produced really impactful science that will make an on-the-ground difference to biodiversity conservation, but have also engaged with and contributed to the broader social activities of the IoZ student body. The work of these students, and our other 11 finishers, illustrates very well what the IoZ is about: an engaged, dynamic community that produces top-level research resulting in applied conservation outcomes.

Jon Bielby, postgraduate tutor

ZSL Library

The ZSL Library plays an active role in the activities of the learned society, and manages, develops and facilitates access to a relevant and useful resource of zoological and conservation science.

Main image: *David Lowther, ZSL's Visiting Scholar, shares his knowledge of the Library's Brian Houghton Hodgson material*
Left: *ZSL welcomes visitors at Sunset Safari*
Below left: *Hodgson's adjutant stork*
Below right: *the giraffe from Swiss naturalist Konrad Gessner's* Historiae animalium

Our events

We participated in Open House, an event that promotes public awareness and appreciation of building design and architecture in London, for the first time and visits from external groups included members of the Bartlett Zoo History Society; Information Services Group London and South East; a group of the Chartered Institute of Library and Information Professionals; Camden History Society; the London Appreciation Society; and staff from the library of Anglia Ruskin University and Regent's University. We took the Library to the Reptile House and Aquarium at ZSL London Zoo for two Sunset Safari evenings, where we had an opportunity to show our work to the public.

Talks for ZSL's Fellows were given on a range of topics, including the contributions of women to the development of zoology, and introductory tours were given to Fellows to encourage more effective use of our resources.

For the first time, items from our collections were displayed in the Aquarium at ZSL London Zoo, with an exhibit on the John Reeves drawings of fish collected in China from 1820 to 1840. This wonderful opportunity to exhibit a sample of our historic collections was seen by an estimated 270,300 people.

Members of the public are welcome to visit; our resources are vast and varied, allowing visitors to develop their interest in animals and conservation, and the Library provides an ideal opportunity for informal lifelong learning. Over the past year our special displays included Jumbomania, to celebrate 150 years since the arrival at London Zoo of the iconic African elephant 'Jumbo'; Giraffomania, to celebrate 180 years since the arrival of giraffes; historic books to celebrate National Insect Week; and a presentation on the history and architecture of ZSL London Zoo.

Visit our online catalogue at
library.zsl.org

Our artefacts

Our monthly Artefacts blog on the ZSL website showcases unique items in our collection. Recent posts include Whipsnade during World War II; historic prints of African hunting

dogs; the ZSL Library for National Library Day; Gessner's *Historiae animalium* to celebrate Gessner's 500th birthday; and Indian animals at ZSL and their links with the royal family, to coincide with the royal opening of *Land of the Lions* at ZSL London Zoo.

Items consulted from the archives included Julian Huxley, the architecture of ZSL London Zoo between the wars; 'Jenny', the type specimen of the Andaman macaque; art and nature; the works of John Gould; Cecil Stanley Webb; the Snowdon Aviary; the field journals of William Eustace Poles; Mary Anning's letters; and the unbuilt Tecton Elephant House. As usual, the Daily Occurrences, Council Minutes, correspondence collections and press cuttings were frequently used. We do not normally require visitors to make appointments, but please contact us in advance if you wish to view a specific collection.

Brian Houghton Hodgson manuscripts and Britain Nepal 200 events

ZSL participated in Britain Nepal 200 to commemorate 200 years of diplomatic relations between the two countries. Our celebrations focused on the symposium Britain-Nepal 200: celebrating Nepal's success stories in biodiversity conservation, held in February. Attendees were invited to see Brian Houghton Hodgson manuscripts from 1820 to 1858, in which he described many Nepalese and Indian species that were new to science. A stunning exhibition of drawings of birds and mammals from the Brian Houghton Hodgson manuscripts was held in the Aquarium at ZSL London Zoo, and Volume 2 of Hodgson's Mammals of Nepal and India was made available online via our online catalogue (ID no. ART10000106). This work was funded by the Leche Trust and The Mercers Company. The Charles Hayward Foundation is providing further funding towards the conservation and digitisation of the Hodgson bird manuscripts. Digitisation of such unique items in the collections enables ZSL to offer worldwide access to this primary research material to support conservation and taxonomy across the world, and to allow the public to enjoy these beautiful manuscripts.

ZSL Library Visiting Scholar

David Lowther, PhD student at the University of Newcastle, has continued his honorary role as ZSL Library's Visiting Scholar. David has given talks about the Hodgson material at ZSL. A paper based on his research in the ZSL Library has been published – *Preliminary analysis of the Hodgson Collection at the Zoological Society of London* by D. Lowther, Archives of Natural History, Volume 43, Part 1, pp. 90-94.

Find out more about Brian Houghton Hodgson at **zsl.org/library/an-introduction-to-brian-houghton-hodgson**

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 2016.

Left to right: *Nick Tregenza, Seirian Sumner, Patrick Meyer Higgins, Virpi Lummaa, Sir John Beddington FRS, Paul Thompson, Peter Holland, Jonnie Hughes, David Labonte, Heather Ferguson, Nathalie Pettorelli, Sarah Durant.* ***Below left:*** *Sir John Beddington FRS, Brian Marsh and Ingrid Easton.* ***Below right:*** *Kevin Foster*

ZSL Frink Award

The Society's highest award, presented to professional zoologists for substantial and original contributions to science. Awarded to Peter Holland FRS, Linacre Professor of Zoology, Head of the Department of Zoology, University of Oxford, and Fellow of Merton College, for influential research on the role of homeobox genes and gene duplication in the evolution of animal diversity.

ZSL Scientific Medal

Presented to research scientists with up to 15 years' postdoctoral experience for distinguished work in zoology. Awarded to Heather Ferguson, University of Glasgow, for advancing our understanding of infectious disease ecology and transmission of mosquito-borne diseases; Kevin Foster, University of Oxford, for outstanding theoretical and experimental research on social evolution; and Virpi Lummaa, University of Turku, for influential contributions to our understanding of the ecological causes and evolutionary consequences of variation in reproductive success and longevity.

ZSL Silver Medal

Awarded for contributions to the understanding and appreciation of science. Presented to Seirian Sumner, Bristol University, and Nathalie Pettorelli, ZSL, for Soapbox Science, a novel science communication outreach platform for promoting women scientists.

ZSL Stamford Raffles Award

Awarded to an individual for distinguished contributions to zoology outside the scope of their profession. Presented to Nick Tregenza for the development of acoustic devices for cetacean research.

ZSL Marsh Award for Conservation Biology

For contributions of fundamental science and its application to the conservation of animal species and habitats. Awarded to Steve Redpath, University of Aberdeen, for important research on human-wildlife conflict and the challenge of coexistence between livelihoods and biodiversity conservation.

ZSL 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 Paul Thompson, University of Aberdeen, for influential research on the impact of environmental change and human disturbance on seabird and marine mammal populations.

ZSL Prince Philip Award and Marsh Prize

Awarded to an A-level or Higher student for an outstanding biology project. Awarded to Ingrid Christina Easton, Queen's Gate School, for her project 'Is the composting worm *Eisenia fetida* repelled by lemon peel in compost?'

ZSL Charles Darwin Award and Marsh Prize

Presented for the best zoological project by an undergraduate student attending university in the UK. Awarded to Patrick Meyer Higgins, University of Oxford, for his project 'A comparative study of Strouhal number in birds: on wing morphology, flight mode, and methodology'.

ZSL Thomas Henry Huxley Award and Marsh Prize

Presented for the best zoological doctoral thesis produced in the UK. Awarded to David Labonte, University of Cambridge, for his thesis 'Biomechanics of controllable attachment in insects'.

ZSL Thomson Reuters 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 Jonnie Hughes on behalf of Silverback Films for the BBC series *The Hunt*.

ZSL Medal

Presented to a member of staff for outstanding achievement and service to ZSL. Awarded to Sarah Durant for significant contributions to conservation science, including research on human-wildlife conflict, population viability analysis, influencing wildlife policy and managing the Tanzania Cheetah Conservation Programme.

ZSL would like to take this opportunity to thank the Marsh Christian Trust and Thomson Reuters for their generous support of our scientific awards programme

Funding

IoZ depends on funding from a wide source of donors, including the Higher Education Funding Council for England, to carry out its research. Here, we look at some funding highlights.

*One of Peñalara's native species, an adult male San Antonio tree frog (*Hyla molleri*)*

Transboundary cheetah conservation

Cheetahs have long been a focus of ZSL's science and conservation activities. ZSL Senior Research Fellow Sarah Durant has led the longest ongoing study of wild cheetahs in the Serengeti National Park, Tanzania, which has generated critical information for the conservation of this threatened big cat. This study led to the establishment of the Range Wide Conservation Programme (RWCP) for Cheetah and African Wild Dog in 2007, which works across the species' African range to conserve these rare large carnivores. To date, the RWCP has established three regional conservation strategies and 17 national conservation action plans for these species. In 2015, there was a significant expansion of ZSL's cheetah activities, with the launch of an ambitious Cheetah Landscapes Project. This initiative, run by ZSL and the Wildlife Conservation Society, is supported by a £1.3m grant from the Howard G Buffett Foundation. The project represents a continuing expansion of the work of the RWCP, and has the challenging aim of establishing three transboundary cheetah landscapes to safeguard critical populations.

Modelling pathogen transmission in multihost amphibian communities

Trent Garner was awarded £275,000 by the Natural Environment Research Council for the research project 'Quantifying host species contributions to pathogen transmission in a multihost community: the case of chytrid fungus in amphibian communities'. Many pathogens of conservation concern infect multiple host species, but not all hosts contribute equally to transmission dynamics. Some species act as reservoir hosts that have a disproportionate responsibility for epidemics. Identifying which species fulfil this role in infectious disease dynamics when host communities are specious is notoriously difficult. To address this, Andy Fenton, University of Liverpool, developed a novel mathematical approach to quantify a host community's ability to maintain a pathogen and to identify 'key hosts' that drive pathogen spread. Garner, Fenton, Andrea Manica of University of Cambridge and Jaime Bosch of the Consejo Superior de Investigaciones Científicas are applying the model to understand transmission dynamics in amphibian communities at 'Ground Zero' for chytridiomycosis in Europe in Peñalara Natural Park, Spain. Once key species and stages have been identified, the team will simulate key host removal and remove key species and stages in Peñalara to test model predictions. This model may prove to be an important management tool for maintaining amphibian communities in the face of persistent chytridiomycosis as well as for managing other infectious diseases that are of conservation concern and circulate in multiple hosts.

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**

Funding organisations

- Animal and Plant Health Agency (APHA)
- ASCOBANS Conservation Fund
- Biotechnology and Biological Science Research Council (BBSRC)
- British Ecological Society
- Crown Estate (Marine Stewardship Fund)
- Department for Environment, Food and Rural Affairs (Defra)
- Edge-Effect
- Higher Education Funding Council for England (HEFCE)
- Howard G Buffett Foundation
- Intertrust Technologies
- King Saud University
- Linnean Society of London
- Micropathology Ltd
- Mohamed bin Zayed Species Conservation Fund
- Natural England
- Natural Environment Research Council (NERC)
- New England Aquarium
- New Zealand Department of Conservation
- Oceanario Lisboa
- Passion Pictures Ltd
- People's Trust for Endangered Species
- Royal Geographical Society
- Royal Society
- Royal Society for the Protection of Birds (RSPB)
- Science and Technology Facilities Council
- Synchronicity Earth
- Taronga Conservation Society
- Taronga Zoo
- Universities Federation for Animal Welfare (UFAW)
- University College London
- Wild Trout Trust
- WWF International
- WWF Namibia
- WWF UK

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

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

ZSL

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

In Attendance

Dan Sinclair (Interim Divisional Manager, Biosciences, UCL)
Elizabeth Francis (Head of Finance, School of Life and Medical Sciences, UCL)
Loren Moyse (Faculty Manager, Life Sciences, UCL)
Fiona Evans (Human Resources Director, ZSL)
Cheryl Buffonge (Science Operations Manager, ZSL)
Professor Ken Norris (Director of Science, IoZ, ZSL)
Amanda Smith (Finance Director, ZSL)
Jo Keogh (Committee Secretary)

IoZ

Professor Ken Norris, Director of Science

Senior Research Staff

Andrew Cunningham, Deputy Director, IoZ; Theme Leader, Wildlife Epidemiology
Chris Carbone, Theme Leader, Biodiversity and Macroecology
Guy Cowlishaw, Theme Leader, Behavioural and Population Ecology
Sarah Durant, Theme Leader, People, Wildlife and Ecosystems
Trenton Garner, Theme Leader, Evolution and Molecular Ecology
Tim Blackburn, Professor of Invasion Biology (UCL/ZSL)
Paul Jepson
Kate Jones, UCL and ZSL Chair of Ecology and Biodiversity
Malcolm Nicoll
Anthony Sainsbury
Samuel Turvey
Jinliang Wang
Rosie Woodroffe

Postdoctoral Research Staff

Jon Bielby, Postgraduate Tutor
Monika Böhm
Patricia Brekke, Postgraduate Tutor
Jessica Bryant
Stefano Canessa
Sam Cartwright
Frances Clare
David Curnick
Ellie Dyer
John Ewen
Robin Freeman
Xavier Harrison
David Jacoby
Kirsty Kemp
Becki Lawson
Tom Letessier
Alexandra Morel
Nathalie Pettorelli
Adam Piper
Marcus Rowcliffe
Hannah Rowland
Alexa Varah
Piero Visconti
Oliver Wearn
Christopher Yesson

Postgraduate Research Students

Judith Ament
Claudia Amphlett
Alice Baniel
Paul Barnes
Kieran Bates
Katie Beckmann
Emily Bell
Dominic Bennett
Anne-Sophie Bertrand
Mariana Bobadilla Suarez
Katherine Booth-Jones
Stephanie Brittain
Adam Britton
Sarah Brooke

Lewis Campbell
Peter Carr
Philip Chapman
Jeremy Cusack
Anthony Dancer
Sérgio da Silva Henriques
David Daversa
Clare Duncan
Simon Dures
Sally Faulkner
Marc Fernandez Morron
Guilherme Ferreira
Deborah Fogell
Victoria Franks
Ben Garrod
Helen Gath
Gianfranco Gliozzo
Cally Ham
James Hansford
Anne Hilborn
Michael Hudson
Andrew Jacobson
Freya Jephcott
Angharad Jones
Samuel Jones
Natoya Jourdain
Gita Kasthala
Alexander Knight
Emmelianna Kumar
Alexander Lee
Kate Lee
Gwendolyn Maggs
Agnese Marino Taussig de Bodonia
Kirsten McMillan
Helen Meredith
Lisa Mogensen
Elizabeth Moorcroft
Sean Morrow
Sahil Nijhawan
Helen O'Neill
David Orchard
Leandro Patino
Daniella Rabaiotti
Cassandra Raby
Rosie Rawlinson
Kate Richardson
Silke Riesle Sbarbaro
Goncalo Rosa
Charlotte Selvey
Su Shan
Rebecca Short
Thomas Smallwood
Fiona Spooner
Richard Suu-Ire
Gemma Taylor
Joseph Taylor
Andrés Valenzuela Sánchez
Charlotte Wood
Juliet Wright
Veronica Zamora-Gutiérrez

ECZM Resident in Wildlife Population Health

Helle Bernstorf Hydeskov

Postgraduate Research Assistants

Stefanie Deinet
Jenny Jaffe
Valentina Marconi
Louise McRae
Harriet Milligan
Kayna Prescott
Julia Rodriguez-Ramos
Naomi Stratton

Project Coordinators and Assistants

Helen Muller
Audrey Ipavec
Rosemary Groom
Heidi Ma
Nicholas Mitchell
Becky Shu Chen
Michelle Wong

Technical Staff

Kelly Astley
Lola Brookes
Robert Deaville, Cetacean Strandings Programme Manager

Patron

Her Majesty The Queen
His Royal Highness The Prince of Wales

ZSL Council Members 2015

President:
Professor Sir John Beddington CMG FRS
Secretary:
Professor Geoff Boxshall FRS
Treasurer: Paul Rutteman CBE
Sheila Anderson MBE
Dr Brian Bertram
Martin Cooke
Ray Heaton*
Dr Andrew Kitchener+
Ken Livingstone (retired March 2016)
Dr Ruth Padel*
Elizabeth Passey
Dr Maggie Redshaw
Sean Rovai+
Martin Rowson
Ken Sims
Paul Wilson
Victoria Wilson+
Robert Wingate*

* to June 2016
\+ from June 2016

ZSL Directors

Director General: Ralph Armond
Conservation Programmes Director: Professor Jonathan Baillie
Human Resources Director: Fiona Evans
Zoological Director: Professor David Field
Director of Science: Professor Ken Norris
Finance Director: Amanda Smith
Commercial and Communications Director: Rich Storton
Development Director: James Wren

Liam Fitzpatrick
Dada Gottelli, Chief Technician
Kevin Hopkins, Senior Technician
Seth Jackson
Shinto John
William Leung
Harry Owen
Matthew Perkins, Senior Technician
Chris Sergeant, Animal Technician
Louise Wong

Administrative Staff
Cheryl Buffonge, Science Operations Manager
Amrit Dehal, Information Systems Administrator
Joanne Keogh, Assistant to Director of Science
Lynne Rushton, Health and Safety Administrator
Alexandra Thomas, MSc WAB WAH Administrator

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

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

Honorary Research Fellows
Andrew Balmford, University of Cambridge
Tim Coulson, University of Oxford
Christl Donnelly, Imperial College London
Matthew Fisher, Imperial College London
Tony Fooks, Animal Health and Veterinary Laboratories Agency
John Gittleman, University of Virginia, USA
Simon Goodman, University of Leeds
Katherine Homewood, University College London
EJ Milner-Gulland, University of Oxford
Ian Owens, Natural History Museum
Andy Purvis, Natural History Museum
James Wood, University of Cambridge

Publication acknowledgements

Design and editorial coordination: Think
Head of Scientific Publications and Meetings: Linda DaVolls
Editorial consultants: Sarah Openshaw, Claire Sargent
Designer: Dom Scott
Senior sub-editor: Marion Thompson

Printed on 100% recycled paper. We extend thanks to all ZSL staff and other colleagues for the use of images, including: Corey Anco, Richard Baxter, Bing Maps 2015, Alecia Carter, CSIP/ZSL, Clare Duncan, Andy Foote, Mike Hudson, Michele Menegon, Malcolm Nicholl, Sahil Nijhawan, Harry Owen (Copernicus Sentinel 1a and Landsat 8 data; NOAA Suomi NPP data), Tre Packard, Jill Pakenham, Yannis Papastamatiou, Rebecca Schoonover, Celia Serrano, John Sibley, Ruchira Somaweera, Ben Tapley, Joseph Taylor, Sam Turvey, Alexandra Thomas, Juliet Wright, Chris Yesson, ZSL

Cover photo: Shutterstock

Contact us

IoZ enquiries 020 7449 6610
The Zoological Society of London, Regent's Park, London NW1 4RY
zsl.org/science
Registered charity in England and Wales: no 208728

ZSL
LET'S WORK FOR WILDLIFE

ZSL
LET'S WORK FOR WILDLIFE

The Zoological Society of London
Registered Charity in England and Wales: no 208728
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 2015
Our annual overview of the year, featuring our Zoos, fieldwork, science and financial statements.

ZSL Conservation Review 2015
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