IUCN SSC Iguana Specialist Group Annual Meeting
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ORAL PRESENTATION ABSTRACTS
In alphabetical order by author's last name, presenter denoted by *

Introduction to the IUCN SSC Iguana Specialist Group

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International Iguana Foundation, San Diego, California, USA

This presentation is designed to provide an introduction to the history, mission, and activities of the Iguana Specialist Group. General background on the taxonomy, biogeography, ecology, and conservation status of iguanas will be shared. The various activities and contributions of the ISG over the past two decades will be highlighted. For those new to the ISG, this presentation will provide an overview of who we are and what we do. For those who are already ISG members, reflecting on the history and success of the ISG will hopefully foster pride in everything we have accomplished together.

Understanding the Past to Improve the Future: The Story of the Conservation of the Lesser Antillean Iguana, *Iguana delicatissima*

Angin, Baptiste*[1], Jeanelle Brisbane[2], Farah Mukhida[3], Karl Questel[4], and Matthijs van den Burg[5]

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The Lesser Antillean Iguana (*Iguana delicatissima)* has been updated in the IUCN Red List of Threatened Species to Critically Endangered in 2018. Its range extends from Anguilla in the North to Martinique in the south. It only survives on a few islands, where its main threat is the arrival of the Common Green Iguana (*Iguana iguana*) that has increased its range year after year. Today, all the main islands where *Iguana delicatissima* are still living are invaded by Common Green Iguana. Populations that are free of Greens subsists o only five small islets. Since two decades, many islands have set up projects to

ensure the conservation of this endemic species: employing translocation, *in* or *ex situ* reproduction, culling of Common Green Iguana, etc. With very different time and funding scales, these projects were sometimes successes and sometimes failures, but have informed us with keys to improve existing or new projects yet to be launched.

Preliminary Results Concerning the Development of a Photo Identification Protocol for *Iguana delicatissima*

Balandraud, Elodie, Nathalie Duporge*, Morjane Safi, and Benjamin de Montgolfier

Aquasearch, Immeuble Genipa, Zac de Genipa, Martinique

Population monitoring in natural environments is essential for *in-situ* conservation of species. These follow-ups often involve the capture, handling, and marking of animals (CMR method). Photo-identification as a CMR technique has been previously used for monitoring various animal populations, such as cetaceans, salamanders, or sea turtles. It had never been used for the Lesser Antilles Iguana (*Iguana delicatissima*) before. The purpose of this study was to apply photo-identification to *Iguana delicatissima*, by developing a specific protocol, in order to provide an additional tool to managers in charge of the conservation of the species.

First step was to select the best photo-identification software. Then, was to determine the species-dedicated parameters needed by the I3S Pattern algorithm, namely a precise study area on the animals and three specific reference points. For four zones and three reference point models, the success rate and the value of the similarity scores were analyzed. Results led to the selection of a combination of a study area and a reference point model allowing the best matches quality. To understand the limits of the protocol, influence of the quality of a picture on its success of processing was also studied. It was concluded that angle of view, over- or under-exposure, or poor sharpness are parameters that cause high scores for the pictures, indicating low probability of a good match in I3S.

All the compiled results made it possible to write down a protocol dedicated to *Iguana delicatissima* and their analysis showed that photo-identification assisted by the I3S pattern software is suitable for the individual identification of the Lesser Antilles Iguana. The prospects opened up by the photo-identification tool could in the future allow monitoring of populations that would be simpler to implement, more easily repeatable over time, less expensive, more dynamic, and possibly using participative science.

Review of a Long-Term Conservation Program for the Anegada Rock Iguana (*Cyclura pinguis*)

Bradley, Kelly*

Fort Worth Zoo, Fort Worth, Texas, USA

The Critically Endangered Anegada Rock Iguana (*Cyclura pinguis*) comes from the small island of Anegada (39 km^2) in the British Virgin Islands (BVI). The species has suffered a large decline in population numbers since the late 1960s. Human development and over-browsing by free-ranging livestock are major threats. However, the chief risk is the large population of feral cats on the island. Each year this introduced predator kills most hatchling iguanas within months of hatching, drastically reducing recruitment. For the past 20 years, the IUCN SSC Iguana Specialist Group (ISG) and the National Parks Trust of the Virgin Islands (NPT VI) have worked together to spearhead the recovery program for this species centered around headstarting. Other initiatives have included applied ecological research, public education and awareness, local capacity building, monitoring of feral mammals, and the reintroduction of 260 headstarted animals back to the wild. This talk will review information discovered about this species, the program's achievements, challenges, and a vision for future actions that will ensure the long-term survival of this species.

Comparisons of 25-OH-vitamin D3, Calcium, Phosphorous, Ionized Calcium, and Parathyroid Hormone Concentrations between Captive and Wild Anegada Rock Iguanas (*Cyclura pinguis*)

Bradley, Kelly*[1], William Gehrmann[2], and Gary Ferguson[3]

[1]Fort Worth Zoo, Texas, USA; [2]Texas Christian University, Fort Worth, Texas, USA; [3]*In memoriam*

The Critically Endangered Anegada Rock Iguana (*Cyclura pinguis*) from the island of Anegada in the British Virgin Islands is the subject of a long-term conservation program centered on headstarting iguanas to combat high juvenile mortality due to the presence of feral cats. Wild-caught hatchlings are collected each fall, reared in a safe environment, and released back to the wild at a larger, less vulnerable size. Such repatriation strategies require that conservation managers ensure the best possible health of introduced animals, which requires knowledge of baseline physiological values of healthy specimens. Vitamin D3 synthesis and calcium absorption are essential biological processes in all lizards so far studied. Most basking lizards, including iguanas, are thought to require exposure to ultraviolet light in order for these processes to occur naturally. Vitamin D3 promotes the absorption of calcium and regulates calcium and phosphorus homeostasis. This homeostasis is necessary to prevent metabolic bone disease and captive reptiles must be monitored closely for clinical signs of this disease. The goal of this study was to generate a more complete picture of calcium metabolism for the Anegada Rock Iguana in the wild and in captivity. We compared seasonal blood values of 25-OH-vitamin D3, calcium, phosphorous, ionized calcium, and parathyroid hormone concentrations between captive and wild Anegada Rock Iguanas.

An Update on Iguana Conservation Actions in Dominica

Brisbane, Jeanelle*[1], Thijs van den Burg[2], and Chuck Knapp[3]

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Iguana delicatissima (Lesser Antillean Iguana) is a regionally endemic species of the northern Lesser Antillean island chain. The introduction of *Iguana iguana* (Common Green Iguana) into the species' range has resulted in rapid, region-wide displacement through hybridization and out-competition, causing *I. delicatissima* to be present in only 2 km^2 without the presence of *I. iguana*. However, following Hurricane Maria (a Category 5 hurricane which impacted the island in September 2017), observations of *I. iguana* were made on island, which led to the removal of 283 pure and hybrid *I. iguana* x *I. delicatissima* individuals. Through field and outreach efforts, an observed decrease in the number of invasive iguanas seen on Dominica was made. Such findings have allowed for national planning to further prevent the introduction of non-native species. Continued eradication efforts are needed to ensure the health of *Iguana delicatissima* populations in its last stronghold.

Piloting Wildlife Camera Traps for *Cyclura lewisi* Population, Distribution and Threats

Burton, Frederic*[1], Luke Harding[2], and Christine Proctor[3]

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The Blue Iguana Recovery Programme (BIRP) has bred, headstarted and released over 1,000 sub-adult Grand Cayman Blue Rock Iguanas to the wild in protected areas on Grand Cayman over the last two decades. With the Department of Environment (DoE) and international partners, BIRP has relied on distance sampling with repeat counts to monitor the population in the release areas. As the released population has been observed to breed, these surveys have revealed a failure to recruit young to the population in the release areas, and evidence has emerged of wide dispersal out of the protected areas. In 2019–2020, BIRP, DoE and University of Harrisburg began collaborating in the use of camera trap stations to test their effectiveness in detecting identifiable Blue Iguanas within and outside the release area, at the same time as assessing threats. Preliminary data suggests this technique will be effective in quantitative population density estimation for both Blue Iguanas and feral cats. The data also revealed an extremely active, breeding feral cat presence in the Salina Reserve release area, a high frequency of detection of Black Rats, and captured the breeding behavior of Caribbean Doves.

Galápagos Land Iguana (*Conolophus subcristatus*) Reintroduction to Santiago Island, Galápagos: A Strategy to Support the Ecological Restoration of the Island and Mitigate Non-target Risk from Rodent Eradication on Seymour Norte Island

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Invasive species continue to be the largest threat to island biodiversity, resulting in more than 86% of island extinctions. Invasive species eradication, especially invasive mammals from islands, has become an increasingly common and powerful conservation tool with demonstrable biodiversity benefits worldwide, including the Galápagos Archipelago. Often these efforts require the use of toxicants that may result in unintended non-target mortality. Where these risks are unacceptable, mitigation actions can be implemented. This was the case for the invasive rat (*Rattus rattus, R. norvegicus*) eradication on North Seymour Island conducted by the Galápagos National Park Directorate (GNPD) with support from Island Conservation in 2019. Risk of Galápagos Land Iguana (*Conolophus subcristatus*) mortality was mitigated by translocating more than 25% (>2,000 individuals from an estimated population of ~6,000–8,000) of the North Seymour population to Santiago Island. Land Iguanas went extinct on Santiago at the end of the 1800s due to predation by feral pigs. Feral pigs were eradicated from Santiago in 2006, and feral goats and donkeys in 2005 and 2004, respectively. Vegetation recovered significantly and the extinction driver had been removed, establishing the conditions for Land Iguana reintroduction. Translocating >2,000 iguanas was completed in two efforts (~1,400 initially, followed by 700) over a three-month period in 2019. Each translocation consisted of three steps: 1) capture and translocation to Santa Cruz Island, 2) one-month quarantine in custom-built enclosures, and 3) translocation and release on Santiago Island. One-month post-release monitoring was conducted to evaluate the health and adaptation of the translocated population. Monitoring showed promising results, with iguanas adapting well (e.g., increased weight) and some dispersing more than 2 km from the release site. To our knowledge, this translocation involves the largest number of iguanas reintroduced in a short time span and has demonstrated that with adequate planning and support, large-scale reintroductions are possible.

Cyclura carinata: the Legacy and Future of a Successful Conservation Program in the Turks and Caicos Islands

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The conservation endeavors to protect Turks and Caicos Rock Iguanas, *Cyclura carinata*, and their habitat have been going on for over 25 years. Multiple local and international partners have contributed to what can be considered a successful conservation story. Now, with more than 3,000 sampled individuals, 570 meters of tail measured, and about two tons of iguanas weighed, the conservation of *C. carinata* is moving forward to ensure this species persists undisturbed in its habitat in the future. The species has recently been down-listed from Critically Endangered to Endangered in the IUCN Red List of Threatened Species. A massive effort to eradicate invasive alien species (IAS) from multiple islands has been conducted between 2017 and 2020. After the eradication of rats and cats, a biosecurity project is currently ongoing to make sure IAS do not re-colonize the islands they have been extirpated from. Contextually, remnant natural populations of iguanas are monitored to document the positive effect of the accomplished eradication. A plan is currently under development for the translocation of individuals to islands that formerly were part of the species habitat. At the same time, populations that are more intensely impacted by tourists and other human activities are closely monitored to guarantee appropriate mitigation actions. Among the ingredients that are contributing to make the work on *C. carinata* a successful recipe, is the organization of all the data on this species in a relational database that can be easily referred to and/or distributed. Moreover, the conservation of this species has been fostered by a multidisciplinary approach that capitalizes on the contribution of different disciplines such as molecular and field ecology, and evolutionary genetics.

Is there Risk in Describing Endemic Iguanas from Fiji due to the Continued Threat of Illicit Trade?

Fisher, Robert*[1], Kim Gray[2], Stacie Hathaway[1], Jone Niukula[3], Nunia Thomas-Moko[4], and Peter Harlow[5]

[1]U.S. Geological Survey, San Diego, California, USA; [2]San Diego Zoo Global, California, USA; [3]National Trust of Fiji, Suva, Fiji; [4]NatureFiji-MareqetiViti; [5]Taronga Conservation Society, Australia

Species diversity of endemic iguanas in Fiji is under-represented in the literature based on our recent research. Multiple new species of iguanas await publication, but we have halted the submission of the manuscript naming these species based on the literature

and conversations within the Iguana Specialist Group about the potential eminent threat of poaching and illicit trade in these species once named. We review the literature to assess what has been published about the real-world threat to these species from targeted "traders". We will discuss the potential counter-measures being considered by Fiji to mitigate this risk before we submit the new species descriptions.

Introducing the Iguana Genome Project

Gentile, Gabriele*[1], Mohd Firdaus Bin Mohd Raih[2], Simon Goodman[3], and Mohd Noor Mat Isa[4]

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The Iguana Genome Project is currently conducted in the frame of the Consortium for Iguana Genome (CIG). The CIG is coordinated and led by the University Tor Vergata (Rome, Italy) and at present is in partnership with the Malaysia Genome Institute, the Universiti Kebangsaan Malaysia (UKM), and the University of Leeds (UK). The project aims to provide a genomic perspective on the origins, evolution, and adaptation of Galápagos Iguanas, taking advantage of latest advances in genomics and transcriptomics. Several questions will be tackled such as the adaptation to diving, the origin and implications of depigmentation, the genetic base of ecological requirements, and physiological and behavioral responses to the environment.

Additionally, the project uses a genomic approach to reconstruct the most recent demographic history of specific populations and address the role of hybridization in guiding the evolutionary processes in Galápagos species. Finally, the project also aims to provide reference genomes for the conservation of threatened species.

The CIG has already produced genome data of *Conolophus marthae* (93X coverage), *Conolophus pallidus* (10X coverage), and *Amblyrhynchus cristatus* (40 X coverage). *Conolophus subcristatus'* genome is currently being sequenced. RNAs have been processed for transcriptome analysis for all Galápagos species.

The project aims to carry out the investigations within a phylogenetic framework, and so the sequencing of the genomes of other genera of Iguanidae (*Cyclura* and *Ctenosaura*) is currently programmed. The long term objective is to extend the investigation to the whole family Iguanidae. For this reason, the participation of other partners is envisioned and welcome.

The Sub-regional Species Action Plan for *Iguana delicatissima* on Anguilla, Statia, and St Barts — Update and Outlook

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Disease, genetic bottlenecks, but especially the non-native Common Green Iguana (*Iguana iguana*) which have invaded all Lesser Antillean main islands occupied by *Iguana delicatissima*, currently present the greatest threats for the survival of *Iguana delicatissima* in the Northern Lesser Antilles. We will give an overview of the 2018 Sub-regional Species Action Plan for the three islands with updates on current work, an outlook of challenges and pending work, and how this sub-regional plan fits in with existing and future species conservation/action plans in the Eastern Caribbean.

Updates on *Ctenosaura oedirhina*: Conservation Action Plan Published

Goode, Ashley*[1], Stesha Pasachnik[2], and Tandora Grant[3]

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The Roatán Spiny-tailed Iguana is an Endangered species that is faced with multiple anthropogenic threats, including overharvesting for human consumption and predation by domestic animals. Its population has been monitored for the past decade. This long-term monitoring program has documented population fluctuations, and studies on diet, habitat usage, home range, and reproductive physiology have also been conducted. During the 2019 ISG annual meeting, a two-day workshop was held for local stakeholders, government officials, and international scientists to develop a five-year conservation action plan for this species. The overall goal of this conservation and management plan is "To ensure the long-term survival of Roatán Spiny-tailed Iguanas as a flagship for biodiversity conservation on Roatán, and to perpetuate them as an iconic symbol of the island and Honduras in general." This plan incorporates previous research, local input, and expert opinions to outline management actions considered essential to ensuring the long-term survival of *Ctenosaura oedirhina* in the wild. Using the plan as a guideline, in the coming years' resources and funding can focus on the most serious threats, target outreach specific to tourists and locals, and implement best management practices identified for this species.

Be My Rock: Using Existing Knowledge to Support the Recovery of the Sister Islands Rock Iguana Population Structure

Haakonsson, Jane* and Tanja Laaser

Department of Environment, Grand Cayman, Cayman Islands Government

The Sister Islands Rock Iguana (*Cyclura nubila caymanensis*) is a Critically Endangered species, endemic to two small islands in the Caribbean Sea: Cayman Brac and Little

Cayman. Although all life stages of the Sister Islands Rock Iguana (SIRI) are threatened by habitat loss and road mortalities, growing feral cat (*Felis catus*) predation is driving an increasing decline in recruitment for both sub-populations. While the Brac population will be surveyed during November 2020 using distance sampling, the Department of Environment (DoE) conducted a population survey on Little Cayman in 2015, estimating the population size to be 2,915 iguanas (95% CI: 1,966–4,135). The effort was repeated in 2019, showing an estimated 1,786 (95% CI: 1,274–2,576) iguanas. The loss of approximately 39% of the population between November 2015 and November 2019 is heightened by results revealing the youngest age class (hatchlings) to be nearly absent in 2019 (~4% of the sample) when compared to 2015 (19.4%). These results highlight the importance of focusing conservation efforts on ensuring future recruitment. Due to unprecedented legal complications concerning feral cat control, the DoE began a headstart programme for SIRI as part of the Department's annual tagging efforts. Drawing on the acquired knowledge from the last thirty years of safeguarding the Blue Iguana (*Cyclura lewisi*) on Grand Cayman, parallels between husbandry and dietary requirements, as well as disease management were established. Data on morphometric measurements, together with comparisons of growth rates, both between these two closely related species but also between life stages and management strategies within species, were used to inform adaptive resource management.

The Successes and Challenges of Invasive Predator Management to Save the Iguana Islands of the Turks & Caicos

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Endangered Turks & Caicos Rock Iguanas, *Cyclura carinata*, are found only on the small surrounding cays of the Turks & Caicos Islands, a UK Overseas Territory in the Caribbean, and on Booby Cay in The Bahamas. These iguanas now occupy less than 10% of their historic range, largely due to the impact of invasive mammalian predators such as feral cats and dogs. Conservation efforts have stabilized the population, resulting in the recent down-listing of this species from Critically Endangered to Endangered on the IUCN Red List of Threatened Species in 2020, in part through the removal of invasive predators from iguana islands. Despite recent successes, threats persist and further management efforts are needed.

Here we present the recent successes and challenges of 1) efforts to completely remove invasive feral cats and rats from 10 islands in the Turks & Caicos, 2) efforts to prevent further arrivals of invasive species through biosecurity measures on two critical islands

supporting significant *C. carinata* populations, and 3) demonstrate a recent response to the arrival of invasive Common Green Iguanas in the Turks & Caicos Islands.

We will demonstrate how cross-sector collaborative partnership work is leading to holistic approaches in the Turks & Caicos Islands, including government departments, local and international NGOs, and the private sector. We will outline upcoming conservation efforts through a recently funded project entitled "Strengthening Biosecurity to Protect Turks & Caicos' Iguana Islands", awarded in 2020 through the UK Government's Darwin Plus Initiative, aiming to ensure a legacy for the recent conservation achievements. Focusing on protecting the Turks & Caicos Rock Iguana, the project aims to mitigate impact from invasive vertebrates and uncontrolled tourism across 11 islands, spanning three national parks and three privately-owned islands.

Long-term Studies of the Allen Cays Rock Iguana (*Cyclura cychlura inornata*) in the Exuma Islands

Iverson, John B.*

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The Allen Cays Iguana (Endangered by the IUCN Red List of Threatened Species) has been under study in The Bahamas since 1980. We have now marked over 2,148 individuals and made over 6,610 recaptures of them on the two islands with natural populations (Leaf and U Cays), and another 180 individuals on seven other islands (with waif or translocated populations). In addition to quantifying natural history (including reproductive) parameters, over the last 40 years we have documented 1) a transition from male-dominated to female-dominated sex ratios on Leaf and U Cays; 2) population increases to carrying capacity on Leaf and U Cays (from a total population of *ca* 300 in the early 1980s to over 1,500 today); 3) significant genetic divergence between Leaf and U Cay iguanas (now eroding due to unauthorized introductions); 4) significant effects of supplemental feeding by tourists on behavior, growth, body size, parasite loads, and blood chemistry; 5) a decrease in maximum body size (particularly in males) due at least in part to removals by humans; and 6) the probable basis of iguana gigantism on Allen Cay (allochthonous nitrogen supplementation of the terrestrial food chain by Shearwaters). Future work will focus on 1) finishing our study on the effects of density on life history traits (with Kirsten Hines); 2) further monitoring of the effects of supplemental feeding of these iguanas by people (with Susannah French and Chuck Knapp); and 3) the morphological and genetic distinctions between *C. c. inornata* and *C. c. figginsi* (with Chuck Knapp and Mark Welch).

Overview of Long-term Research and Conservation Efforts with *Cyclura cychlura* in The Bahamas

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[1]Daniel P. Haerther Center for Conservation and Research, John G. Shedd Aquarium, Chicago, Illinois, USA; [2]Independent, Nassau, The Bahamas; [3]International Iguana Foundation, Arizona, USA

The Northern Bahamian Rock Iguana (*Cyclura cychlura*) is restricted to two island groups on the Great Bahama Bank that differ in size and anthropogenic disturbance. Two currently recognized subspecies (*C. c. inornata* and *C. c. figginsi*) inhabit a handful of small, uninhabited cays in the Exuma Island chain, while *C. c. cychlura* inhabits Andros Island, which is the largest, yet fragmented island in The Bahamas and inhabited with ~8,000 people. All subspecies face similar threats including poaching or smuggling for the pet trade, mammalian predators, and vulnerability to stochastic perturbations. Additional specific threats include anthropogenic habitat loss on Andros Island and the effects of supplemental feeding by tourists in the Exuma Islands. Since 1994, our team has been conducting population surveys, targeted ecological studies, and sentinel monitoring to understand the ecology of the species and inform conservation measures. We will provide a broad overview of research and outreach activities along with conservation outcomes over the last two decades.

Monitoring Physiology and Gut Microbiota of the Northern Bahamian Rock Iguana

Lewis, Erin*[1], Karen Kapheim[1], Susannah French[1], John Iverson[2], and Charles Knapp[3]

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Humans have significantly impacted wildlife populations in a variety of different ways for many years. Yet, we continue to allow and even sometimes encourage human behavior that could be detrimental to wildlife in the long-term. Moving forward it is important to look more closely at the human impacts on wildlife health both at the individual and population-levels. Recent scientific findings, in both human and animal research, have emphasized the importance of gut microbiota and physiological health. The importance of such findings could be particularly important in addressing human-induced diet changes for different species. One particularly important model for studying the anthropogenic diet modifications of wildlife is in the Caribbean. The Northern Bahamian Rock Iguana (*Cyclura cychlura)* of the Exumas, The Bahamas has been fed human food by tourists for many years. We have been documenting health impacts from this tourist behavior on the iguanas. These findings could be incredibly important for the conservation of species affected by anthropogenic disturbances.

Monitoring Galápagos Marine Iguanas Using Drones and Citizen Science

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[1]University of Leipzig, Saxony, Germany; [2]Universidad San Francisco de Quito, Ecuador

Despite being included in the Red List of Threatened Species since 2004, all conservation work on the Galápagos Marine Iguana (*Amblyrhynchus cristatus*) has been severely hampered by taxonomic issues and a general lack of reliable data on the size and location of most populations. Though a recent taxonomic revision enabled a reassessment at the subspecies level in 2020 — where 10 of the 11 subspecies were listed as Endangered or Critically Endangered — the central problem regarding monitoring data remains, and is likely to persist unless new methods for population surveys are developed. In early 2020, we began a pilot project using Unmanned Aerial Vehicles (also called drones) to collect aerial photos of the coastlines on two focal islands, covering colonies of three subspecies. From these photos, we were able to count iguanas, as well as other wildlife and plastics. We are now analyzing these images in two main ways, by "expert" counters (members of our team) and via counts performed by volunteer "citizen scientists" via an online platform (Zooniverse.org). We will compare the outcome of these methods, and should the volunteer counts be sufficiently close to those of experts, we will calculate the population size using citizen science counts. Our pilot work serves to validate and develop this approach, which we plan to roll out to all islands of the archipelago over the next three years. We hypothesize that not only will this method produce reliable counts in a faster, cheaper and safer way compared with traditional surveys, but also (owing to the fact that UAVs can be launched and landed from small boats) it will enable surveys of remote localities impossible to access by foot. During the presentation, we will report on our experiences and progress thus far, sharing insights that may be of use to researchers interested in employing similar methods for their focal species.

Updates on Útila Spiny-tailed Iguana Project – Saving the Swamper

Maryon, Daisy*[1], Tom Brown[1], and David Lee[2]

[1]Kanahau Wildlife Conservation Organization, Útila, Honduras; [2]University of South Wales, UK

The Útila Spiny-tailed Iguana is a Critically Endangered island endemic, unique in the fact it is mangrove specialist, and restricted to the small island of Útila (41 km2) in the Bay Islands Archipelago off the Caribbean coast of Honduras. The species occupies less than 6.5 km2 of the island, one of the smallest areas of occupancy of any iguana. This habitat is currently under threat due to habitat destruction, mainly for tourism development as well as farmland conversion. Other threats to the species survival include illegal poaching, invasive predators (raccoons), and plastic pollution. This presentation outlines the "Save the Swamper" conservation project, including natural history knowledge and research findings gained since 2016, and gives an update on the IUCN Species Action Plan developed during the 2019 ISG workshop on Roatán, Honduras.

A Genetic Assessment of the Blue Iguana Recovery Program

McKinney, Mallory*

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In this study, we used ostensibly neutral microsatellite markers to study genetic variance and heterozygosity of Endangered *Cyclura lewisi* during captive management in the Blue Iguana Recovery Programme. We assessed the variation present in the founding population and how genetic diversity changed throughout the past 20 years of management. We also studied how heterozygosity may correlate with fitness through morphometric measures and success of recruitment after release into the wild. While we found a reduction in effective population size, standardized heterozygosity, and fixation indices did not significantly change from the founders to later generations. We found no evidence for inbreeding depression in the captive population but a significant difference in heterozygosity of animals released to the Salina Reserve. Lastly, we found little evidence to support heterozygosity-fitness correlations using morphometric measures.

A Genetic Analysis of the Invasive Common Green Iguana (*Iguana iguana*) on Grand Cayman

Mitchell, Blaklie* and Mark Welch

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This project seeks to further evaluate the patterns of genetic variability among invasive Common Green Iguana (*Iguana iguana*) populations in the Cayman Islands of the Caribbean. The Common Green Iguana is a highly invasive species that has been introduced to multiple regions outside of its native range of Central and South America. In its introduced range, the Common Green Iguana has negatively impacted several native species, many of which are endangered endemics such as the Sister Isles Rock Iguana (*Cyclura nubila caymanensis*). In a previous project, the genotypes of Common Green Iguana individuals from both Little Cayman and Cayman Brac (the Sister Isles) were analyzed while assessing the sib-ship and parentage of putative hybrids between the invasive iguana and the endemic species. The analysis revealed a similar lack of nuclear molecular variation across all individuals from both islands yet notable differences in mtDNA haplotype frequencies. Given this finding, we hypothesized that individuals colonizing both islands were of similar genetic stock originating from the island of Grand Cayman, where this species has been firmly established, but only a few females have successfully reproduced on Little Cayman and Cayman Brac.

To further test this hypothesis, the genetic variation of invasive Green Iguanas found on the island of Grand Cayman will be characterized. If far more molecular variation is uncovered on this island, it would be clear that a limited sample of genetically similar individuals is reaching the Sister Isles. These results would provide the opportunity to

assess the effectiveness of current control methods in reducing the number of Common Green Iguanas arriving and propagating on Little Cayman and Cayman Brac from Grand Cayman. Continued analysis of the genetic variation of this invasive species in the Cayman Islands will yield a better understanding of how successful introductions and colonization events occur.

Determinants of Community Structures in the Common Spiny-tailed Iguana, *Ctenosaura similis*

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Research on animal social groups, including non-cooperative Squamata, has demonstrated that most animal association patterns are non-random. When sub-groups associate more strongly with each other than to the rest of the network, so-called community structures within animal aggregations are present. As with non-random interaction preferences among individuals, community structure is also a widespread feature of animal groups, and may emerge from a combination of social behavior, ecological, and anthropogenic factors. However, social structures of reptile species are poorly known, and testing for community structure lags behind work in other animal taxa. Using a stable population of free-ranging Common Spiny-tailed Iguanas (*Ctenosaura similis*) in Costa Rica, community structure, size, and determinants were investigated. Previous work with these lizards determined genetic relatedness, personalities, and preferential association patterns. With data from four seasons, network analysis revealed community structures in the overall group, suggesting potentially biologically relevant differences among smaller sets of connected animals. In Common Spiny-tailed Iguanas, these community structures were stable within, but variable between seasons (two breeding, two non-breeding). Statistical models revealed seasonal and individual network attributes as significantly explanatory for group size. This work demonstrates observed community structures may develop from an active choice of individual sociality and not from attributes and resources such as body size, retreat co-location, or spatial distribution. Individual preferences and adaptation to local conditions may explain the social variability of sub-structures. Detecting community structure in a network has practical applications in conservation and invasive species management, as group size and structure may be receptive to manipulation to increase fitness or undermine network cohesion.

Diet Analysis of Northern Bahamian Rock Iguanas Through DNA Metabarcoding

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Northern Bahamian Rock Iguanas (*Cyclura cychlura*) are a threatened species facing numerous anthropogenic threats including hunting, habitat destruction and introduction of invasive species. An emerging threat includes increased visitation and subsequent food provisioning by tourists in the Exuma Islands, The Bahamas. This activity been documented to affect rock iguana physiology, health, and behavior. In addition to individual effects, Rock Iguanas are the largest native herbivores and are important seed dispersers on the remote islands they inhabit. Food provisioning with non-native foods could potentially have negative impacts on native plant dispersal and recruitment. Accurate and objective identification of plant species found in the diet of these animals is essential to determine the relative contribution of provisioned and natural food items. DNA metabarcoding is a promising method for diet analysis, especially when morphological identification of consumed material is hampered by lack of characteristic features in stomach contents or feces. This limitation can be particularly pronounced in Rock Iguanas that have been fed extensively by humans, because the lack of identifiable leaves or seeds in fecal samples would automatically be discarded from visual analysis. By ignoring samples that cannot by visually examined, the full scope of Rock Iguana diet cannot be holistically characterized. To address these issues, we initiated a proof-of-concept study to compare morphological descriptions of Rock Iguana fecal samples with metabarcoding data. Here we present the methodological framework and preliminary DNA metabarcoding results of fecal samples collected from iguanas inhabiting islands in the Exumas where they are heavily visited and frequently food-provisioned by tourists.

How to Improve Your Species Recovery Planning Process with Minimal Effort: Principles and Practicals

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Species recovery plans are all the rage. You want in on this latest trend, but you're not sure where to start. You're worried that planning can only be done by people with a social science degree. You think that a plan will solve your funding problems. There are many misconceptions about species recovery planning. We'll cover them all, share some best practices, and get you ready to coordinate a planning process in only 20 minutes! No agile project management experience required. Challenges and opportunities that come with planning in a virtual environment will also be explored.

Lesser Antillean Iguana National Action Plan Implementation in Guadeloupe and Martinique, French West Indies

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The Lesser Antillean Iguana (*Iguana delicatissima*) is listed as Critically Endangered on the global IUCN Red List of Threatened Species (2018) and equally on the local Martinique IUCN Red List (2020). This species occurs in French territories where they have been protected since 1989. The species is a special focus of attention since 2011, when a first National Actions Plan was implemented. The first National Actions Plan ended in 2016 and improved the knowledge on the species; however, it insufficiently enabled conservationists to cope with the main threat to Lesser Antillean Iguana conservation, i.e., the spread of Common Green Iguanas (*Iguana iguana*). Consequently, the French government requested a second National Actions Plan to establish the organization and actions to be implemented between 2018 and 2022, considering the main conservation requirements and challenges for this iguana species. Three specific objectives and 13 actions have been defined and prioritized to ensure Lesser Antillean Iguana conservation. They are implemented by a network of partners including NGOs, governmental bodies, local authorities, scientists, and citizens. The regulation of Common Green Iguanas, fine-scale population monitoring, and citizen outreach are priority actions we plan to develop.

Jamaican Rock Iguana Recovery Program

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The endemic Jamaican Rock Iguana (*Cyclura collei*) was considered extinct by the 1940s, due to habitat conversion and Invasive Alien Species (IAS). Its rediscovery in 1990 galvanized the zoo and conservation community to develop an extensive recovery effort. The first 20 years of work focused on building IAS control, iguana headstart programs, and nest site protection. These efforts were led by the University of the West Indies until 2013 when the Jamaican government's National Environmental Planning Agency (NEPA) took over leadership of the program. Since 2016, we have been working closely with NEPA and the Hope Zoo to improve the program and support a more sustainable and rapidly growing population. Previous to 2017, a maximum of 40 hatchlings were brought into the headstart program each year and the turnover rate averaged 5–8 years. Since then, we have built 60 new cages and brought in between 70 and 100 hatchlings annually. We also revamped the captive diet and expect the turnover rate to be three years in the near future. We are also now releasing iguanas

twice per year to reduce their time spent in captivity. In Hellshire Hills, we conducted intensive radio-tracking of both iguanas and invasive cats and mongoose. Tracking iguanas has allowed us to better understand iguana post-release behavior, optimized iguana release size, and elucidated novel nesting areas. Invasive mongoose and cat tracking has provided us with the information needed to design a robust plan for increasing the IAS control program. To date, the control program focuses on the iguana core area where IAS incursions are common, and natural recruitment is virtually zero. Advanced methods that incorporate a buffer zone with varied trap and bait types will ensure the level of protection needed for recruitment and population growth.

Eating Well Will Prevent Iguanas from Dying Out Because of Global Warming, as We Evaluated in *Ctenosaura pectinata*

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Climate change may increase nest temperatures, thereby increasing embryo development rate, but reducing hatchling size and growth. Larger individuals generally perform better and have higher reproductive output, hence growth is an important fitness trait. In iguanas, growth could also be affected by feeding. We evaluated the effect of incubation temperature and feeding on the growth of the Guerreran Spiny-tailed Iguana, *Ctenosaura pectinata*. We incubated eggs at 29 and 32°C, and maintained hatchlings at 30°C, feeding them for one year with either high- or low-quality food. We measured and weighed the iguanas every two weeks. We found that iguanas grew faster when they were incubated at 29°C compared to those incubated at 32°C. However, iguanas fed with high-quality food reached larger body sizes, independent of incubation temperature. Growth models revealed that these growth differences caused by incubation temperatures and food types persist throughout their entire lives. In conclusion, incubation temperature has long-lasting effects on this iguana and higher incubation temperatures may result in reduced growth and maturation at later age. However, high-quality food may favor growth and compensate for higher incubation temperature. Hence, good feeding may alleviate the negative effects of climate change on growth.

Anegada Rock Iguana (*Cyclura pinguis*) Health Assessment Update

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Health assessments have not routinely been performed on headstarted Anegada Rock Iguanas (*Cyclura pinguis*) prior to release, but a disease risk analysis workshop was held in April 2019 during which it was discussed that health assessments be instituted to better

understand health status and disease risk in this species. In July 2019, health assessments were conducted on 32 headstarted iguanas that included physical examinations, morphometric data collection, blood collection, and fecal collection. Blood was processed on Anegada for hematology analytes (packed cell volume, total solids, red blood cell count, white blood cell count, and white blood cell differential) and blood gas analysis (EPOC analyzer: blood gases, electrolytes, ionized calcium, and lactate). Plasma samples were frozen and exported to the USA for chemistry, protein electrophoresis, and 25-hydroxy-vitamin D (25-OH D2 and 25-OH D3) analysis. Direct fecal examinations were performed on Anegada. Additional fecal testing (bacterial culture and quantitative parasite examinations) were performed on samples brought back to the USA. No significant abnormalities were detected on physical examination. All iguanas were considered subadults with snout-vent length (mean ± standard deviation) of 17.3 ± 2.6 cm. No blood analyte reference intervals are available for *C. pinguis*, but compared to other *Cyclura* species, no significant blood parameter abnormalities were found. However, *C. pinguis* does have differences in protein electrophoretogram fractions compared to the Grand Cayman Blue Rock Iguana (*Cyclura lewisi*) and Jamaican Rock Iguana (*Cyclura collei*). Oxyurids were the predominant parasite seen on fecal examinations and no *Salmonella* or *Campylobacter* were detected on fecal cultures. This information and data from future health assessments of headstarted *C. pinguis* may be used evaluate the health status of free-roaming iguanas on Anegada.

Phylogenomics and Historical Biogeography of West Indian Rock Iguanas (Genus *Cyclura*)

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The genus *Cyclura* includes *ca* 15 extant species and subspecies of West Indian Iguanas and is one of the most imperiled genera of squamate reptiles, with habitat loss and historical poaching inducing population extirpation and continuing to threaten extant populations across much of the western Caribbean. An understanding of species diversity, evolutionary relationships, diversification, and historical biogeography in this group is crucial for implementing sound long-term conservation strategies. Despite significant conservation concern (one species has already gone extinct) and limited taxonomic diversity, the only phylogenetic hypothesis for the group based on genetic data examined only a single 900 base pair region of the mitochondrial genome. Here we used a targeted sequence capture approach to construct robust phylogenies for the genus, using genomic sequence data for both complete mitogenomes and for thousands of loci distributed across the nuclear genome for all recognized taxa in the genus, as well

as appropriate outgroups. We then used these data to infer the evolutionary history of the genus, using time-calibrated phylogenetic inference, species delimitation, and reconstruction of historical biogeography. We found support for the recognition of 12 extant species of *Cyclura* and discuss the taxonomic and conservation implications of these data. We thus provide a comprehensive understanding of the evolutionary relationships of these highly imperiled lizards.

To Be or Not to Be *Ctenosaura brachylopha*

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Ctenosaura brachylopha was described in 1928 by Bailey as iguanas inhabiting the states of Sinaloa and Nayarit in Northwestern Mexico. He noticed that some characters of the dorsal and caudal scales were different enough to distinguish between these iguanas and *C. pectinata*. However, later studies lumped these two species together into C*. pectinata* without providing much evidence for this taxonomic change. Recently, we have shown that *C. pectinata* is composed of various lineages with deep genetic and geographic structure and one of these lineages coincides with the distribution of *C. brachylopha* described by Bailey. Here we gather the available evidence to propose the resurrection of *C. brachylopha* and highlight the knowledge gaps that still exist to further support its status as a *C. pectinata* sister species. No basic biology and life history of *C. brachylopha* is known, since all known studies of former *C. pectinata* has been done in the Guerrero, Morelos, and Oaxacan populations, referred to as *C. pectinata*.

Population Dynamics of Common Green Iguana (*Iguana iguana*): Does it Pay for Little Boys to Save their Sisters?

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Altruism via kin selection has been broadly documented in a several vertebrates. Among reptiles, parental care has been documented in a variety of taxa. However, kin selection directed to siblings, which is common among social insects, has not been reported in reptiles; likely because most diploid siblings are better off in maximizing their direct fitness. Previous studies have documented neonate Common Green Iguanas exhibiting risky behaviors in the face of a predator which increase their odds of being preyed upon. These behaviors have the potential to increase the survival of their sisters by attracting the predator towards them. However, since the studies were done in artificial trails, the consequence of the altruistic behavior on the survival of the females

could only be inferred. In this contribution, I present data from a five-year long mark and recapture study of iguana population dynamics analyzing the data in light of the risky behavior exhibited by males. Neonate Common Green Iguanas suffer mortality in excess of 22 times higher than that of neonate females. Mortality seems to even out when females start reproductive maturity, and later becomes stronger again among males as they get larger; likely a consequence of mating combats and their associated injuries. Because of the high mortality in early ages and long time to reproduction, it is likely that very few males reach the size in which they have a good chance of breeding, thus, males helping their sisters survive could very well be the best way to maximize inclusive fitness.

Restoration of Ricord's Rock Iguana Habitat

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Hispaniola is the only island in the Caribbean that has two endemic species of rock iguanas, Hispaniolan Rhinoceros Iguana (*Cyclura cornuta*) and Ricord's Rock Iguana (*C. ricordii*). Both species are ranked as Endangered (EN) according the the IUCN Red List of Threatened Species. *Cyclura cornuta* has a fairly wide distribution on the island, while Ricord's Iguana (*Cyclura ricordii)* is limited to four isolated subpopulations with a total range of occurrence under 100 km^2.

Both species face several threats that vary in degree of severity depending on location. The major threats are habitat destruction related to agricultural activities and charcoal production. Poaching for human consumption and/or commercialization is also quite common. Charcoal production is the greatest threat facing Ricord's Iguana on the southern shore of Lake Enriquillo. In the past, this illegal activity has caused serious habitat destruction with no pristine vegetation remaining.

School of Nature: A Holistic Approach to Teach Environmental Education in Útila, Honduras

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Kanahau School of Nature is the environmental education program created by Kanahau Wildlife Conservation Organization on March 2019. School of Nature is a holistic educational approach to teach environmental education. It aims to become a learning center without walls, turning the different ecosystems of Útila, Honduras, into the "classrooms" where children learn about ecosystem functions and services, flora and fauna, and general environmental education topics. Through nature walks, expeditions and real biological surveys, Kanahau promotes getting the children in contact with

nature. Most classes are surrounding the Útila Spiny-tail Iguana, using this as a flagship species for biodiversity conservation. It is targeted to local children from 10 to 16 years old, focusing on children from the public school, with a lower- and middle-class background, as they are the most vulnerable group identified. Kanahau believes that by giving the opportunity to children that are interested in the environment, it will help develop their leadership and science skills to make Útila a more sustainable place in the future. By focusing on children, Kanahau targets an entire generation that is still susceptible to positive change. In the long-term, environmental education produces an ecologically literate community who understands and values healthy environments and a rich biodiversity. Educated children will become adults who understand their connection and impact on the environment, and through this understanding they will become motivated to act as environmental agents and live sustainable, healthy lives.

Genomic Insights into Chuckwalla Evolution and Diversification

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In this study, I apply a genomic approach for species delimitation to elucidate the species limits and evolutionary diversification history of Chuckwallas (*Sauromalus*), a conspicuous group of lizards of the arid lands of southwestern North America. Of the five currently recognized species of *Sauromalus*, the species limits of the geographically widespread and morphologically variable Common Chuckwalla (*Sauromalus ater*) are the most uncertain. Given evidence of at least four well-supported mtDNA lineages within *S. ater* that are largely incongruent with any previous taxonomies based on morphology, I explore and test alternative hypotheses that involve multiple species rather than one widespread species. Phylogenetic and multi-species coalescent-based analysis of my genomic ddRADSeq data confirm the presence of at least two major lineages, peninsular and continental groups, within the widespread *S. ater* that likely diverged at the vicinity of the head of the Gulf of California in northeastern Baja California. Population membership and principal component analyses (excluding *S. varius* and *S. hispidus*) demonstrate there is additional phylogeographic structure within the continental and peninsular lineages. Among the four insular endemic species of *Sauromalus* associated with the Baja California peninsula, genomic analyses strongly support the continued recognition of *S. varius, S. hispidus*, and *S. klauberi* as unique species. Weaker phylogenetic signal is provided by the genomic data to support *S. slevini*, as a distinct species. However, due to limited sampling of *S. slevini*, it is advocated to continue recognizing this species until additional data can be analyzed to confirm or disconfirm its distinctiveness. Overall, my results highlight the need for taxonomic revision within *S. ater* and additional studies on the demography and biogeography of *Sauromalus*.

Consequences of Climate Change on Common Chuckwalla Thermoregulation: Maybe Not as Dire as We Thought

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The Common Chuckwalla (*Sauromalus ater*) is a diurnal heliothermic herbivore that requires high body temperatures to forage and digest efficiently. Recently, there has been concern that global warming could lead to extirpations of lizard populations, or extinctions of lizard species, by reducing the time available for lizards to thermoregulate, forage, and mate. We compared the operative temperatures available in the environment at three sites with body temperatures achieved by free-ranging Common Chuckwallas, and we compared activity patterns of lizards to those predicted by the ability of lizards to achieve their optimal body temperatures. Female Chuckwallas were seen to be active above ground much less than were males, but they were still able to thermoregulate as accurately and effectively below ground as lizards active above ground. Furthermore, male Chuckwallas were seen to be active above ground for only a fraction of the time when optimal body temperatures were achievable above ground. Thus, above-ground activity is not always necessary for Chuckwallas to thermoregulate to optimal body temperatures. Therefore, we conclude that Chuckwallas should be able to cope with presumed reductions in activity times that are predicted as a result of global warming because Chuckwallas 1) are only active a fraction of the amount of time available to achieve optimal body temperatures even in the hottest study sites, and 2) can achieve optimal body temperatures equally well below ground. Of course, global climate change includes more than just changes in temperature, and it is very likely that Chuckwallas will be negatively affected by reductions in precipitation, and increases in drought, because those effects will negatively affect availability of food resources.

Towards Understanding the *Iguana iguana* Complex

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The *Iguana iguana* complex is the widest spread taxa among Iguanidae, occurring in the wettest of tropical rainforests as well as a few xeric habitats, and is characterized by high genetic and morphological variation. Notably, and despite recent taxonomic changes, boundaries among the major genetic clades remain unresolved. Additionally, previous biogeographic and ecological studies highlighted the Curaçao population as a

member of an unrecognized, divergent clade. Our study focuses on the *Iguana iguana* complex's phylogeographic history, with an emphasis on the placement and extent of the Curaçao clade within it. We will provide a project update, discussing clade boundaries, morphology, and ecological adaptations.

New Approaches to Combatting the Illegal Wildlife Trade of Iguanas in the Eastern Caribbean

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Illegal wildlife trade has gained great prominence in Africa and Asia, but relatively little attention has been paid to this problem in the Eastern Caribbean. Recent research on Lesser Antillean Iguanas has revealed an alarming upsurge in the trafficking of endangered species and morphs to supply the international pet trade. A new coalition of government and non-governmental agencies from Barbados, Saint Lucia, St. Vincent and the Grenadines, the USA, and the United Kingdom has begun working together to combat illegal wildlife trade. By combining a bottom-up approach with regional collaboration and international policy action, the coalition aims to achieve a significant reduction in the illegal and unsustainable offtake of endangered species from the islands. Actions being tested include: increased field patrols, remote surveillance technology, SMART to streamline data collection and aid strategic responses, building capacity and intelligence sharing between government agencies, public 'pride' campaigns, and listing endangered species on CITES. Even though this initiative is still at an early stage, evidence has already been obtained that increased field presence, strategic use of technology, and improved collaboration among agencies within and between countries can be effective in reducing illegal wildlife trade.