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CONFRONTING CLIMATE CHANGE

*Nazca Booby (*Sula granti*) at Punta Suarez, Espanola Island, Galapagos. © Jonathan R. Green (**www.jonathangreenimages.com**)*

The booby was photographed standing in front of a natural blowhole that shoots sea-water up to 100 ft high. As the early morning sunshine caught the spray a spectacular rainbow formed momentarily. The sky behind was dark with rain clouds brought by the earlier than usual hot season. The Nazca booby is one of the three members of the gannet-like Sulidae family living in Galapagos. They nest on the ground, laying one or two eggs depending on the season and conditions. Dependent on marine species for food, their population varies enormously with climatic fluctuations and events such as the El Nino phenomenon forecast for 2009-10 may drastically cut their numbers.

Jonathan R. Green

Contents

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A change in climate

Over the past several years, there has been a significant shift in the attitudes of the public and governments around the world towards climate change. When it comes to this pressing issue, the political climate has started to warm in parallel with the anthropogenic climate change going on around us. There are, of course, still those who deny the reality of climate change. There are others who argue that if change is occurring it is part of a natural warming cycle that humans have not had a hand in. If only either camp were right.

Unfortunately for Planet Earth and pretty much everything on it, there is now a terrifying burden of scientific evidence that indicates otherwise. In 1988, the United Nations Environment Programme and the World Meteorological Organisation established the Intergovernmental Panel on Climate Change (IPCC) to provide independent advice on this important issue. According to historian Spencer Weart, author of *The Discovery of Global Warming*, the IPCC's Third Assessment Report, published in 2001, was something of a turning point. "They announced that although the climate system was so complex that scientists would never reach complete certainty, it was much more likely than not that our civilization faced severe global warming," he wrote. "At that point the discovery of global warming was essentially completed."

Since then, public perception of the issue has grown at an extraordinary rate, largely as a result of the media's preparedness to report on this unfolding crisis. The message was captured forcefully in 2006, with Al Gore's *An Inconvenient Truth*. Then, in 2007, the IPCC's fourth report concluded that global atmospheric concentrations of carbon dioxide – the main greenhouse gas that contributes to global warming – "exceeds by far the natural range over the last 650,000 years." Both Gore and the IPCC shared the 2007 Nobel Peace Prize. With such coverage bringing much-needed awareness of this problem to the single species that can do anything about it, the voices that continue to speak out against the existence of anthropogenic climate change are now firmly in the minority.

Clearly, Galapagos cannot escape the consequences of global climate change and this issue seeks to explore the impact this phenomenon will have on the biodiversity and human population living in Galapagos and what can be done about it. In April, the Charles Darwin Foundation (CDF), Conservation International and the World Wildlife Fund convened the first international workshop on climate change and Galapagos. The week-long event, held in Puerto Ayora, aimed to summarise existing knowledge of climate change in the Archipelago, identify gaps in this knowledge and come up with a set of measures to help the Islands adapt to future change.

An overarching message, which recurs throughout this issue of *Galapagos News*, is that climate change is likely to slow the cool, nutrient-rich upwelling that underpins the entire Galapagos ecosystem. On pp. 6-7, CDF oceanographer Stuart Banks looks at several aspects of Galapagos life that are likely to be affected by such a change and explores some of the possible solutions.

Climate change is also expected to exaggerate El Nino events, a phenomenon that is known to have a dramatic impact on the archipelago's ecology. On pp. 8-9, University of Colorado biologist Maren Vitousek describes how marine iguanas respond to El Nino, including their surprising ability to shrink in size as they struggle to survive. Patricio Goyes Arroyo, director of the Oceanographic Institute of the Ecuadorian Navy, outlines the contribution the Navy has made and continues to make to environmental monitoring in the region (pp. 10-11). On p. 12, Ulf Torsten Haerdter of WWF-Galapagos describes progress in efforts to reduce the environmental footprint of residents. Conservation International's Emily Pidgeon takes a wide perspective of climate change in this issue's Global Galapagos article (p. 13) and on the back page, we have an interview with CDF's meteorologist Solanda Rea. In addition, there is the usual dose of news, (pp. 4-5), several reviews of Galapagos-related culture (including one of the new Hollywood movie *Creation*, pp. 14-15) and an update of the contributions Friends of Galapagos Organisations are making to the conservation of this natural wonder.

Climate change is a global problem. It will take a global effort to limit the damage it will cause.

Henry Nicholls
Editor

NEWS *from Galapagos*


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Golden celebrations

The Charles Darwin Foundation (CDF) celebrated its 50th anniversary in July with an International Science Symposium in Puerto Ayora. This will act as a turning point for the way CDF operates, according to an official statement issued by the Foundation. By combining research into both natural and social sciences, CDF will promote "a holistic treatment of the particular needs of this Natural World Heritage site."

This broadening of CDF's research to include the human face of Galapagos has been ongoing for several years, but there was repeated emphasis on the importance of this approach throughout the meeting. Robert Constanza, an ecological economist and the keynote speaker at the symposium summed things up. "Achieving interaction between the social and natural sciences is fundamental in Galapagos," he said. Provided that all stakeholders were able to agree on a shared vision of their future, Constanza was optimistic that Galapagos could become a sustainable society. "You might think this is not possible because of tourism pressure on Galapagos, but it is." The global financial crisis presents an opportunity, he said. "This crisis lets us rethink the whole economic model."

There were more than 100 experts from many different fields and from all over the world at the five-day symposium. CDF's executive director Dr J Gabriel Lopez (above left) echoed Constanza's address, stressing the importance of improving integration of the social and biophysical sciences and learning from the applied scientific work being done elsewhere in the world. CDF's president Peter Kramer described the event as one of the most valuable he has been a part of in over 40 years of working with the Foundation.

The Galapagos National Park (GNP) is also 50 years old, and has held several events to celebrate its many achievements since Galapagos became Ecuador's first protected area in July 1959.

Mosquito threat

A systematic search of aircraft landing on Baltra has helped reveal the extent of insect introductions to the Archipelago. There were 74 live insects in the holds of 93 aircraft touching down on Baltra, report researchers in *Proceedings of the Royal Society of London*. Six of these were *Culex quinquefasciatus* mosquitoes, known vectors of West Nile Virus and avian malaria. An accompanying genetic analysis reveals that these stowaways can integrate into the population that has, in recent years, become established in the Islands. "That we haven't already seen serious disease impacts in Galapagos is probably just a matter of luck," says Simon Goodman, a biologist at the University of Leeds in the UK. In another article, published in *Proceedings of the National Academy of Sciences*, Goodman and a different team of researchers have revealed that the black salt marsh mosquito (*Aedes taeniorhynchus*) may have been a resident of Galapagos for some 200,000 years. This has given it plenty of time to adapt to a diet of predominantly reptilian blood, raising concern it could act as a vector of disease should new pathogens reach the Islands. "It is absolutely vital that...control measures are maintained and carried out rigorously, otherwise the consequences could be very serious indeed," says Goodman.


© GNP.

Satellite system

GNP has recently installed a Satellite Monitoring System to track tourism and fishing activities within the Galapagos Marine Reserve. Within weeks, the new set-up had drawn attention to the *Tatiana II*, an artisanal fishing boat that had repeatedly entered and left the reserve over a three-

day period. A detailed inspection of the vessel subsequently revealed it had been involved in illegal shark fishing. The satellite system, put in place with support from WildAid and Conservation International, will allow GNP to monitor the activity of all vessels greater than 20 tons registered in Ecuador – including fishing boats, tankers and cargo ships – that are within a 60 mile radius of the Islands. Plans are afoot to widen the monitoring to include smaller boats.

Galapagos remains "in danger"

Thirteen natural World Heritage Sites, including Galapagos, will stay on the World Heritage "in danger" list, according to the International Union for the Conservation of Nature (IUCN). "The decision to retain Galapagos on the World Heritage List shows the clear commitment of the government of Ecuador to continue with its conservation efforts and work together with the international community to maintain the outstanding universal value of this unique place on Earth," says Pedro Rosabal of IUCN's Protected Areas Programme.

In the pink

The enigmatic pink iguana on Isabela's Wolf volcano could be more abundant than researchers had feared. An expedition to the volcano in May found 101 individuals with almost equal numbers of males and females. "This gives us time to complete the genetic analyses of the blood samples and evaluate other data to determine if any management measures are necessary for its conservation," says Washington Tapia of the GNP. The extraordinary *rosada* variety came to the world's attention last year, when researchers described its unique genetic makeup *(Galapagos News* No. 28*)*. It has now been formally recognised as a new species *Conolophus marthae*.

Celebrity appearance

His Royal Highness Charles, Prince of Wales (below), visited Galapagos in March, pledging his support for CDF's efforts to encourage sustainable development of the Islands. During the British prince's tour of the Charles Darwin Research Station, Rodolfo Rendón, CDF Executive Council member and ex-Minister of the Environment of Ecuador, suggested that "Galapagos is the optimal place to test the implementation of a truly sustainable model for the world. If we can achieve it here, we can do so in any other parts of the planet." Then, following his re-election in April with over 50% of the popular vote, Ecuador's president Rafael Correa took his family on holiday to Galapagos, taking the opportunity to acknowledge the fruitful partnership between CDF and GNP and emphasising his government's commitment to the conservation and sustainability of the Archipelago.

© CDF.

Baltra joins Park

A large chunk of Baltra Island – the gateway to Galapagos for many tourists – is now officially part of the Galapagos National Park, according to an Executive Decree passed in June. GNP is now responsible for managing almost 75% of the island, with the remainder split between the Ecuadorian Armed Forces and the Office of Civil Aviation.

© Sonia Kleindorfer and Jeremy Robertson.

Finch uplisted

The medium tree finch *(Camarhynchus pauper*), found only in the highlands of Floreana, is now "critically endangered" according to recent updates to the IUCN's Red List of endangered species. The main threat to this species is thought to be the introduced parasitic fly *Philornis downsi*, which can destroy entire broods of chicks.

Visitor reduction

There are signs that visitor numbers could take a dip for the first year since Galapagos tourism began in the 1960s. In the first quarter of 2009, GNP recorded 41,000 visitors, down 7.5% compared to the same period for 2008. It is too early to say why this has occurred.

At it again?

There are fresh hopes that Lonesome George, the last remaining Pinta tortoise, may yet become a father. One of the females (from Wolf volcano on Isabela) that has shared his enclosure at the Charles Darwin Research Station for almost 20 years laid a clutch of five eggs in July. These are being artificially incubated and, if fertile, are expected to hatch out in November. Last year, both females laid clutches for the first time since they have been with George although none of them hatched (*GN* No. 28).

Feeling the heat

Stuart Banks

Stuart Banks is the Charles Darwin Foundation's oceanographic expert.

The Galapagos marine environment is one of the most dynamic in the world and is expected to become more so in the face of global climate change. Here is an overview of some of the species and aspects of Galapagos life that are especially sensitive to rapid fluctuations in the Archipelago's environment.

Green turtle

The green turtle (*Chelonia mydas)* has made Galapagos its principal nesting ground in the Eastern Tropical Pacific. Each year from November to March thousands of turtles forage across the productive coastal zones and seamounts in the reserve and females pull themselves up the sandy beaches at night to lay eggs. However, beaches will warm in the future and sea-level changes could shift nesting beach habitat. Since the gender of hatchlings is determined by the temperature of the sand in the nest, there may be a change in the sex ratio, with an abundance of females and fewer males. This could reduce genetic diversity of the population and cause changes in migration behaviour. Ongoing work with marine reptiles should clarify these long-term impacts of climate change. The creation of shaded zones along nesting beaches, conservation of mangrove areas and increasing protection from egg poaching and coastal development could all help reduce the impact of human-induced climate change on this species.

Photo by Andries3.

© Jack Baldelli.

Penguins

No penguin in the world is found as far north as the charismatic Galapagos penguin *(Spheniscus mendiculus)*. Normally sustained by the rising currents that bring rich food to the west of the Archipelago, Galapagos penguins and flightless cormorants suffered heavy mortalities during the strong El Nino events of 1981-82 and 1997-98. Today, with an increased risk of disease, invasive predation by cats upon nests and netting of baitfish for local fisheries, these species are at particular risk of becoming extinct. Scientists predict that climate change will increase the strength and duration of El Nino events, which will have an immediate impact on these sensitive, cold-water-adapted species. Charles Darwin Foundation (CDF) scientists working with the Galapagos National Park (GNP) and visiting groups continue a long-term monitoring programme, studying pathology of blood parasites linked to avian malaria and investigating possible adaptation measures such as artificial nesting caves and adjustments to the coastal marine protected areas covering their home ranges.

Fisheries

In spite of repeated recommendations for quotas and closures, sea cucumber and lobster fisheries off Galapagos have been overexploited for the last 30 years. Given that the most productive coastal fisheries are located in the cold-water habitats that are particularly sensitive to climate change, fishing will be adversely affected. CDF scientists are exploring several options, including establishing sustainable fisheries in the open water, encouraging hand lining for large pelagic fish such as wahoo, and carrying out tagging studies to examine the site fidelity of keystone predator species like hammerhead and Galapagos sharks. At the same time, we are using mathematical models to work out the best way to restore natural stocks of sea cucumber, lobster and species taken in near-shore fin-fish fisheries. These steps are important, not just for the future livelihoods of artisanal fishers, but also to encourage a shift back to a natural, healthier ecosystem in which currently overfished reef-fish predators can regulate overgrazing, thereby aiding natural recovery after climatic disturbances.

© Chris Hall.

Cold-water oases

Without a doubt the most productive environments in the Archipelago are associated with the nutrient-rich water that rises around Fernandina and western Isabela. Like a hose spraying against a wall, the submarine Cromwell current collides from the west with the Galapagos platform, deflecting cold water up into the shallows where it generates astounding blooms of phytoplankton. These sustain a rich and cold-water-adapted marine fauna with high levels of endemism and generate an environment suitable for productive macro-algae beds, rare pockets of threatened solitary corals and macro-invertebrates along the coastal fringe. Not surprisingly, these regions are also focal points for intensive local fisheries. We are using ecological monitoring data to model these complex interactions, which is crucial if we are to protect the vulnerable populations and marine communities in this region from the consequences of climate change.

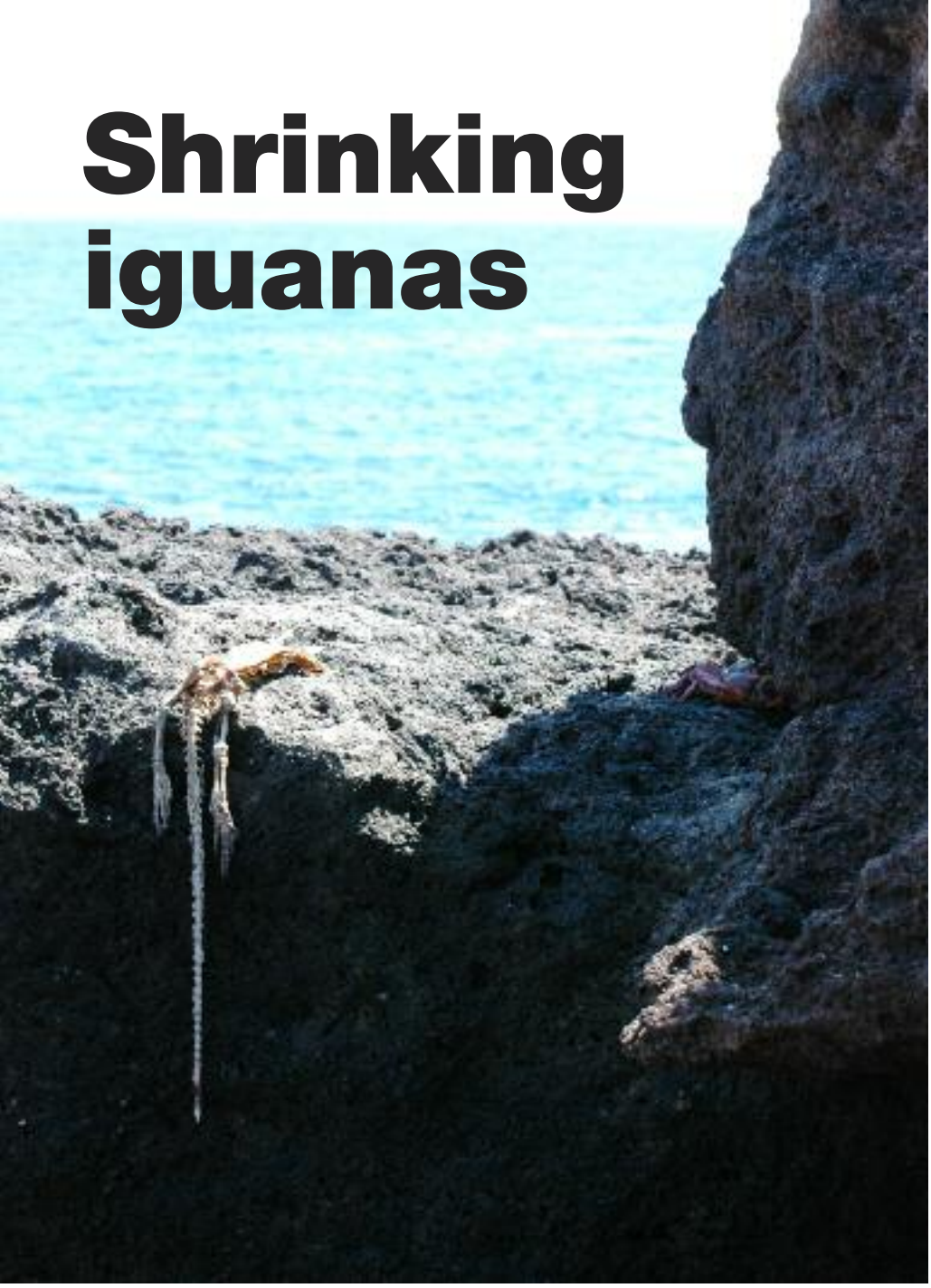
Marine aliens

As climate shifts, new species and pathogens are likely to reach Galapagos and out-compete stressed native and endemic species. Although the marine realm is in a continual state of flux, new transoceanic pathways have opened in the last 40 years that greatly facilitate the transport of non-native species, developments that are unprecedented in the ecological history of the Islands. As the tourism industry expands at an alarming 14% per year, other marine organisms will reach the Islands on the hulls and anchors of the increasing number of regional and transoceanic vessels. There are several notable potential threats, including the North Pacific sea star (*Asterias amurensis,* above) and a barnacle (*Chthamalus proteus).* Their successful establishment elsewhere has resulted in a complete restructuring of marine communities, requiring millions of dollars for their removal. A proactive, preventative approach is imperative in Galapagos and CDF will conduct diver surveys of hull epifauna and epiflora and of marine species associated with local Galapagos and Guayaquil ports. This will allow us to assess the risk associated with particular itineraries, develop methods to control such invasive species and communicate the problem to schoolchildren, shipping operators and authorities.

Corals

With global warming, the ocean is becoming more acidic. This makes it likely that entire groups of coral will become extinct over the next 50-100 years, an extremely alarming prognosis given the rich marine communities they support. The case for protecting Galapagos corals is particularly strong. In spite of severe bleaching of corals in recent years, there are still fragmented coral reefs in the Archipelago, notably off the northerly Islands of Wolf and Darwin, suggesting that Galapagos corals may be better able to adapt to climate change than corals elsewhere. Working with international coral and taxonomic experts, CDF scientists recently produced an extensive overview of the condition of those last reef communities. Whilst we are developing links with paleoclimatologists in the hope that past climate change can inform the future, we are also improving our understanding of coral health and disease, working out the best way to assist the recovery of bleached reef, and studying the impact that shark removal, dive tourism, anchor damage and pollution have on coral communities.

Shrinking iguanas



© Nathan Gregory.

The remains of a dead iguana.

© Nathan Gregory.

Maren Vitousek

Maren Vitousek is an ecologist and evolutionary biologist at the University of Colorado, Boulder. She has been studying the marine iguanas of Galapagos since 2002.

The dead iguana lay in the hot, black sand about fifty metres from the ocean. It was a large male and appeared to have died fairly recently. After a brief look I continued walking along the shoreline, but managed only a few steps before coming across another. A few metres further along lay another, and another.

This was my fourth season studying Galapagos marine iguanas on the island of Santa Fe, one of the long-term study sites established by researchers Andrew Laurie and Fritz and Krisztina Trillmich in the 1980s. Dr Laurie had set out to study the basic reproductive biology of this unusual species, but early in his research career the enormously strong 1982-83 El Nino hit, causing the deaths of many marine iguanas. Instead, his research proved to be a fascinating account of the struggle for survival. Inspired by this research, I was in Galapagos to investigate the effect of these climate cycles on reproductive behaviour. Still, I was completely unprepared for the sight of so many of these amazing animals lying dead on the shore.

By most standards the El Nino that I witnessed in 2006 was fairly minor. Strong El Nino events, like those of 1982-83 and 1997-98, can kill up to 90% of marine iguanas on some Islands. With death rates this high, there is a very real risk that an increase in the frequency or magnitude of these events could result in the extinction of marine iguanas on some Islands. Although all marine iguanas are members of the same species, animals from different islands vary widely in their size, colour and behaviour, and recent research shows that these island populations are genetically distinct. The disappearance of any of these unique groups would represent a major loss of biodiversity in Galapagos.

Marine iguanas are so sensitive to El Nino events because of the way they feed. Intrigued by their talent for swimming, Charles Darwin dissected a few animals and found their stomachs "largely distended with minced seaweed... I do not recollect having observed this seaweed in any quantity on the tidal rocks," he wrote in his *Journal of Researches*. "I have reason to believe it grows at the bottom of the sea". Darwin correctly concluded that it's this "seaweed" (technically, algae) that entices these cold-blooded creatures into the sea.

This algal diversity on which the iguanas depend is sustained by the cold, nutrient-rich upwelling that normally characterises the marine environment in Galapagos. But during El Nino events, the upwelling moves away and the surface temperature of the sea rises dramatically throughout the Archipelago. The red and brown algae consumed by marine iguanas are not able

© Nathan Gregory

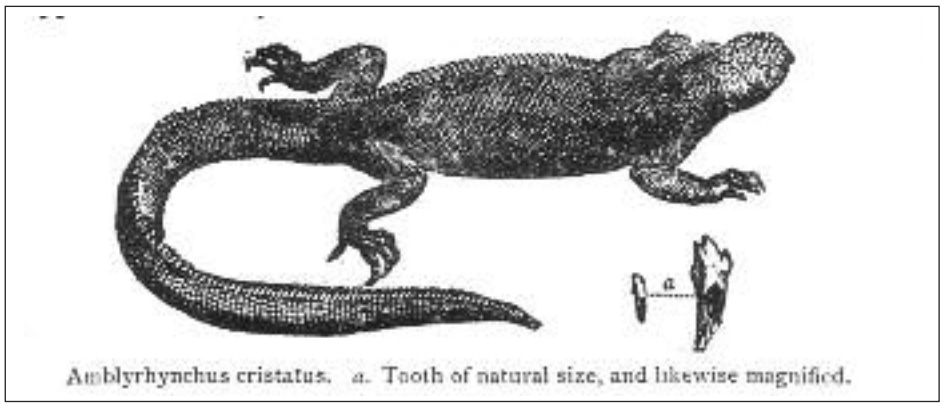
Jim Adelman of Princeton University prepares to measure the length of a marine iguana.

to survive these changes, and the intertidal zone instead becomes colonised by tough brown algae of a different species. Starving iguanas fill their hungry stomachs with this new algal form, but in a cruel twist of fate they are unable to digest it.

"Strong El Nino events can kill up to 90% of marine iguanas on some islands"

The largest iguanas die first. Their higher energetic demands mean they have to go foraging more frequently, but once the algae disappear they can no longer find enough food to survive. Some iguanas show the astonishing ability to shrink in length by as much as 20% during food shortages. Animals that shrink, by absorbing bone mass, have a significant survival advantage over those that do not; however, if the edible algae fail to return, even the smaller animals begin to die. Interestingly, despite the high death rates overall, some iguanas are able to survive extensive periods with little or no food. Researchers Martin Wikelski and Michael Romero are currently trying to find out why some iguanas live while others succumb during these famines.

Fortunately, extremely strong El Nino events are rare, though weaker El Ninos can still have a significant impact on Galapagos marine iguanas. Many individuals forego reproduction in the year following an El Nino. In normal years females are extraordinarily picky, mating with only the largest and most active males. The strength of these preferences determines what characteristics get passed down to the next generation. My research has shown that during even weak El Ninos, females are less choosy about their partners. If El Ninos do increase in strength or frequency, this is likely to cause a change in the body size of iguanas in future generations. Incredibly, the marine iguanas at our study sites today are, on average, around half the size they were a decade ago. This striking trend, too large to be explained by individual shrinkage alone, may result from higher death rates in larger animals during El Nino events, as well as the weakening of female preferences for large mates.



A woodcut of the Galapagos marine iguana from Charles Darwin's Journal of Researches. *© GCT.*

Long-term research projects like this one initiated more than two decades ago provide vital clues about the impact of El Nino on these vulnerable populations. Our research shows that although marine iguanas appear to be quite sensitive to changes in climate, they have also developed a surprising variety of unique adaptations to increase their survival. The evolving response of marine iguanas to these temporary climate shifts also enables us to begin to predict how longer-term changes in climate will affect this unique and fascinating species.

A marine iguana goes in search of a meal. © www.jonathangreenimages.com

Naval attack

Patricio Goyes Arroyo

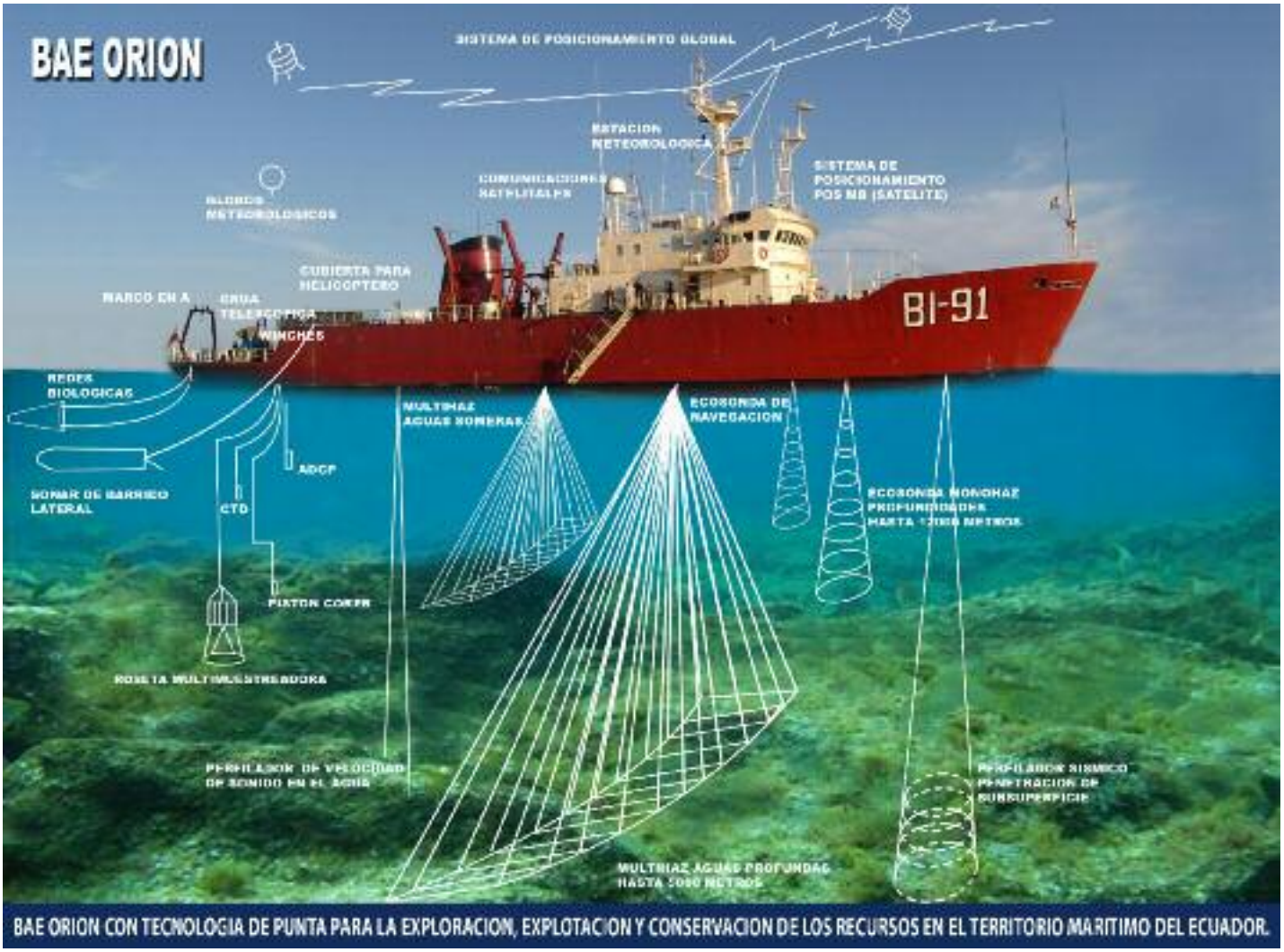
Patricio Goyes Arroyo is director of Ecuador's Instituto Oceanográfico de la Armada (INOCAR), the Oceanographic Institute of the Ecuadorian Navy.

This autumn, a 70-metre-long, bright red vessel will leave Guayaquil on the Ecuadorian coast and set sail for Galapagos. It is a journey the *Orion*, the research vessel of Ecuador's Instituto Oceanográfico de la Armada (INOCAR), has been making every year for more than a quarter of a century.

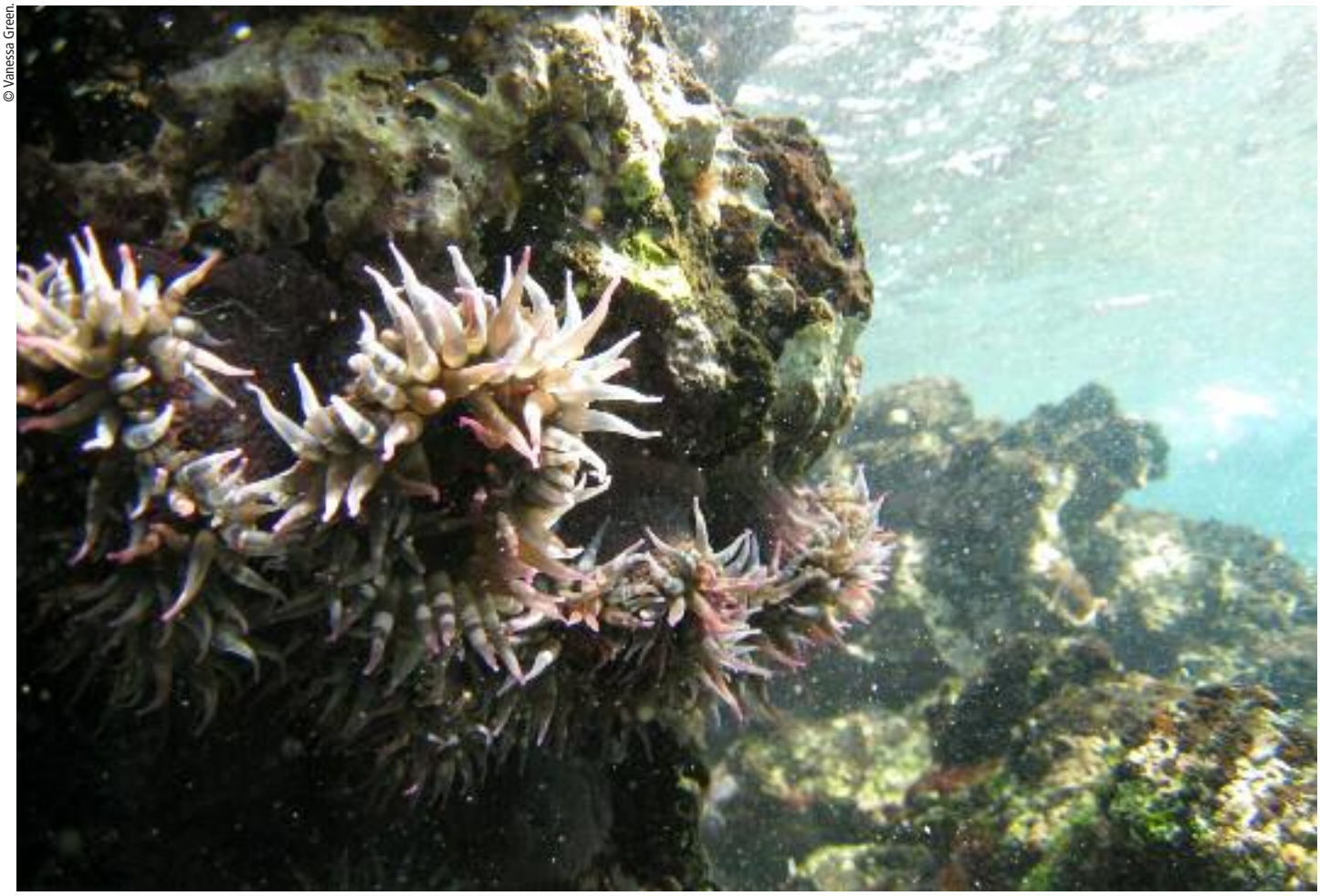
One of INOCAR's missions is to provide permanent monitoring of the oceanic and atmospheric conditions of Ecuadorian waters. A coastal network of weather stations and tide gauges (including a weather station in San Cristobal and a tide gauge off Baltra) transmits a continual stream of data via satellite to the INOCAR headquarters in Guayaquil in almost real time.

INOCAR's research vessel *Orion* also carries out frequent oceanographic cruises, mostly though by no means exclusively in Ecuador's national waters. The *Orion* has been to the Antarctic on three occasions, in 1988, 1990 and 1998, and since it was built in 1981, has performed more than 100 scientific cruises, travelling hundreds of thousands of miles. These expeditions are highly multidisciplinary, involving dozens of researchers working on different projects in different Ecuadorian institutions. They are also international, involving collaboration with organisations outside Ecuador, such as the US National Oceanic and Atmospheric Administration.

The importance of Galapagos, both to Ecuador and to the international community, warrants a dedicated annual expedition to the Archipelago. This has



The BAE Orion with its state-of-the-art technology for exploration, exploitation and conservation of marine resources in the waters around Ecuador. © INOCAR.



A submarine view into the the Galapagos Marine Reserve.

given us a rare and valuable long-term set of data on the productivity of Galapagos waters, the strength and direction of currents from the surface down to a depth of 350 metres, surface and subsurface water temperature, salinity, nutrient content, acidity and other key oceanographic and atmospheric measures. This year, INOCAR has installed the *Orion* with state-of-the art multibeam echo sounders. This new equipment, which will be tested in Galapagos waters in September, will allow us to map the ocean floor around the Islands in unprecedented detail.

In October, INOCAR will begin construction of a small laboratory in Puerto Ayora to carry out oceanographic measurements and water-quality monitoring of the main visited bays. Later this year or early next year, construction will also start on the Centro de Investigaciones Marítimas de Galapagos (CIMAG) on San Cristobal, a research centre that will give INOCAR a permanent presence in the Islands. This will allow us greater opportunity to collaborate on projects with the Galapagos National Park, Charles Darwin Foundation and other partners around the world.

INOCAR is currently involved in many projects that should help in the conservation of Galapagos' unique marine environment. We are studying changes in

"A coastal network of weather stations and tide gauges transmits a continual stream of data in almost real time"

the acidity of seawater and the bleaching effect this can have on coral reefs. Based on the recommendations of organisations like the Intergovernmental Oceanographic Commission (IOC), the Permanent Commission for the South Pacific (CPPS) and others, we have started new projects investigating carbon dioxide, algal blooms and fertilisation of the oceans. We are also defining a draft of the Oceanographic and Coastal Research Programme of Ecuador and the Galapagos, which is due to be discussed at a forthcoming workshop.

In years to come, global climate change is expected to bring about several significant changes to Galapagos. It is likely to exacerbate the impact of El Nino and El Nina events, alter rain patterns, affect coastlines through erosion or accretion, increase salinity, elevate sea level, cause ocean acidification and possibly influence the pattern of currents. All these changes will have serious effects upon the biodiversity of these unique Islands. We hope that our investment now will pay off in the future as we attempt to minimise the impact of this damage.

Erratum

In the last issue of *Galapagos News*, it was stated that David Lack's influential *Darwin's Finches* was published in 1961 (p. 9). In fact, it first appeared in 1947.

Changing attitudes

Ulf Torsten Haerdter

Ulf Torsten Haerdter is the programme officer for WWF-Galapagos' Programme for Energy and Recycling.

Tortuga Bay and Playa de la Estacion are two beaches that are synonymous with Galapagos. Unfortunately they have also become rather symbolic of a little-known danger to the Archipelago's wildlife. Anyone who has had a close look at the fine line of organic flotsam on the edge of the waterline will have noticed it. Besides the plastic bags, bottles and caps that you occasionally find, there are a lot of tiny, almost invisible plastic chips and pieces of synthetic fishing line. Sadly, there is more, far more, floating in the waters of the Galapagos Marine Reserve. Part of this problem stems from litter discarded on land and subsequently blown into the sea.

(Above) Plastic flotsam. © WWF-Galapagos. (Top) Employees sorting waste at the recycling plant on Santa Cruz. © WWF-Galapagos.

But this is by no means a merely a matter of aesthetics. According to the United Nations Environment Programme "worldwide, plastic is killing a million seabirds a year, and 100,000 marine mammals and turtles". We do not know how much wildlife in the Galapagos is affected by marine pollution simply because there are no studies made so far. But it's an alarming problem, and one that gets worse with every passing year.

The management of solid waste in Galapagos is complex and has not evolved at the same pace as the Islands' recent population growth. The expanding human presence has led to an increase in the generation of waste of all kinds and the general lack of environmental awareness has brought with it improper waste management practices such as fly-tipping, littering and open-sky dumpsites.

Since 2006, the World Wildlife Fund has been working with the Municipality of Santa Cruz to implement a sustainable waste-management and recycling programme to tackle this problem at its roots and to start improving the environmental management on the most populated island. These efforts are the first of their kind to involve the local population, stakeholders, politicians and decision makers, asking them to care for and be aware of the unique environment that they are living in. Today, some 40% of household waste is separated, recycled, composted or sent back to the mainland. Santa Cruz is therefore by far the most efficient recycling initiative in Ecuador.

"Santa Cruz is by far the most efficient recycling initiative in Ecuador"

This has also led to a 25% reduction in the amount of waste produced per person and a significant decrease in the incidence of littering and fly-tipping.

Perhaps the most important lesson is that according to regular surveys, most people in Santa Cruz do not participate in the recycling programme because they are concerned about marine pollution. Rather, most people recycle, reduce littering and start caring about their environment little by little for selfish reasons: they are concerned about their health, their reputation among colleagues and neighbours, or they just consider it "the right thing" to do or even "cool". The local decision-makers are taking over the initiative and show commitment to environmental issues because they realise that this is bringing them votes.

There is still progress to be made but the success to date shows that it is possible to change apparently entrenched attitudes.

A pile of plastic separated for recycling. © WWF-Galapagos.

Emily Pidgeon

is director of Conservation International's (CI) Marine Climate Change Programme, working with partners around the world to develop and implement the best new conservation approaches that will ensure that life in the Earth's oceans can adapt to the threat of climate change. She is based at CI's head office in Arlington, Virginia but has spent much of the last year in Galapagos.

Observations from around the world make clear that every component of the Earth's climate system has warmed over the last 50 years. Globally, the eight warmest years on record have all occurred since 2001, with the warmest being 2005. In 2007, the Intergovernmental Panel on Climate Change (IPCC) concluded that warming of the Earth's climate is now "unequivocal", as seen in increasing air and ocean temperatures, widespread melting of snow and ice, and rising sea levels.

We now know the main cause of this warming is an increase in levels of carbon dioxide and other heat-trapping gases in the Earth's atmosphere. By analysing tiny bubbles of air caught in the ice buried deep below the Antarctic, scientists have reconstructed a long history of the Earth's changing atmosphere. From this record, it is clear that that current carbon dioxide concentrations in the atmosphere are higher than at any time in the last 650,000 years.

The impacts of the Earth's changing climate are already being felt around the globe. From Sweden to New Zealand changing temperatures are resulting in the upper limits of the forest moving to higher latitudes. Changes in the mountain clouds of the highland forests in Costa Rica have resulted in the disappearance of more than twenty species of frogs and toads. In August 2005, the temperature of the Caribbean Sea reached record-breaking levels for weeks on end, affecting some 90% of corals and killing off around 40% at many sites. Warming ocean temperatures and melting ice are causing rising sea-levels worldwide. Coastal communities and the habitats they depend on like coral reefs and mangroves are already feeling the impact. Small islands are particularly vulnerable to sea-level rise and this year the world's first climate change refugees will evacuate the low-lying Carteret Islands in Papua New Guinea. These seven tiny coral atolls in the South Pacific have progressively become eroded away by rising waters, storm surges and high tides and the islands will likely be totally submerged by 2015.

These changes to our natural world are only a foreshadowing of the impacts of climate change that are to come. By 2020, up to 250 million people in Africa are expected to be affected by drought and lack of access to fresh water. These changes will in turn severely disturb agriculture and food production across the entire African continent. In Asia, reduced access to freshwater could affect more than a billion people by the 2050s.

The only solution to the mounting pressures that climate change is placing on life is to address the root causes of climate change itself – curbing the rise of greenhouse gas levels in the atmosphere. Climate scientists tell us that by 2050 the world must cut its greenhouse emissions by 80% relative to 1990 levels if we are to limit global warming to 2°C. To make this possible the countries of the world must commit together to major cuts in their greenhouse gas emissions. In December this year officials from 192 countries will meet in Copenhagen, Denmark for the United Nations climate conference where they will try to agree on a new climate treaty. Our long-term climate future depends on the success of international commitments like those that will hopefully be made in Copenhagen.

However, even if strong commitments are made to reductions in greenhouse gas emissions, our past emissions guarantee that a certain amount of climate change is now inevitable. The well-being of billions of people and the future of the diversity and abundance of life on Earth now requires that we actively adapt to the changing climate.

Nowhere is this clearer than in the unique and remote Galapagos Islands. Their biodiversity – from penguins and tortoises to sharks and corals – depends on an exceptional combination of climate factors, with cold water rising from the deep to create a nutrient-rich, cool and moist oasis in the otherwise warm, tropical Pacific. Climate change will likely weaken this cool upwelling and Galapagos must act now to minimise the impact this will have on its wondrous biodiversity. This means reducing the pressures of fishing and tourism in and around the cool upwelling areas, protecting against invasive species that may be favoured by changing ocean conditions, and minimising development along the especially vulnerable coastal areas.

That climate change will impact the Galapagos is certain. That its unique biodiversity will survive is up to us.

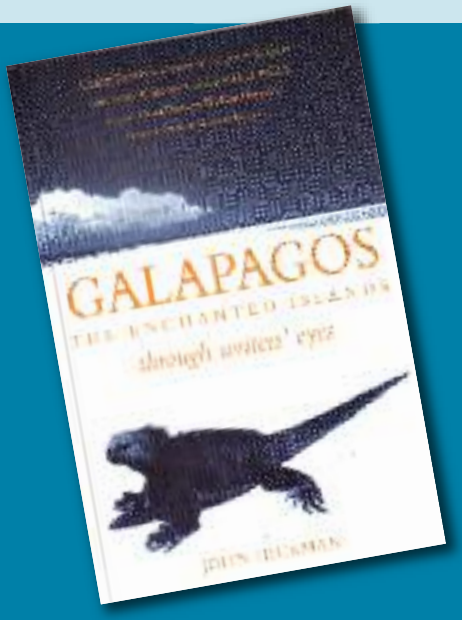
Reviews

FAMILY MAN

Creation
directed by Jon Amiel,
on general release from September 2009

This is a wonderful film adaptation of the book *Annie' s Box* by Randal Keynes. Starring Paul Bettany as Charles Darwin and his real-life partner and Oscar-winner Jennifer Connelly as his wife Emma, *Creation* gives a moving insight into the personal life of the great English naturalist and how he was torn between his work and the views of his devoutly religious wife Emma. Their daughter Annie – brilliantly acted by Martha West – died tragically at an early age and her memory haunts Charles as he struggles with the decision to publish *On the Origin of Species*. Like the book, this film shows the tender and loving side of Charles Darwin, the family man. Whether you are a Darwin fan or not, this emotional and stunning film is a must.

Reviewed by Abigail Rowley
Galapagos Conservation Trust



Reviewed by Julian Fitter
Friends of Galapagos New Zealand

A HUMAN HISTORY

Galapagos: The Enchanted Islands, Through Writers' Eyes
by John Hickman, Eland Publishing Ltd,
$27.95/£12.99
ISBN 9781906011109

Given the number of books written on the natural history of Galapagos, it is surprising there are so few on the human history of these amazing and awesome Islands. John Hickman's fascinating account, first published in 1985, is one of these and it's fitting it should be republished in this year, the bicentenary of Charles Darwin's birth.

As a diplomat Hickman sailed past the Galapagos in 1959 en route to New Zealand, but did not visit the Islands until 1978. Then, as British Ambassador in Quito, he decided to make an official visit to Galapagos and contacted me to charter a very modestly appointed yacht. His daughter Katie's delightful preface to this edition brings back some of the magic of what that visit and visiting Galapagos was like before the global tourism industry really caught on to the attractions of the Islands.

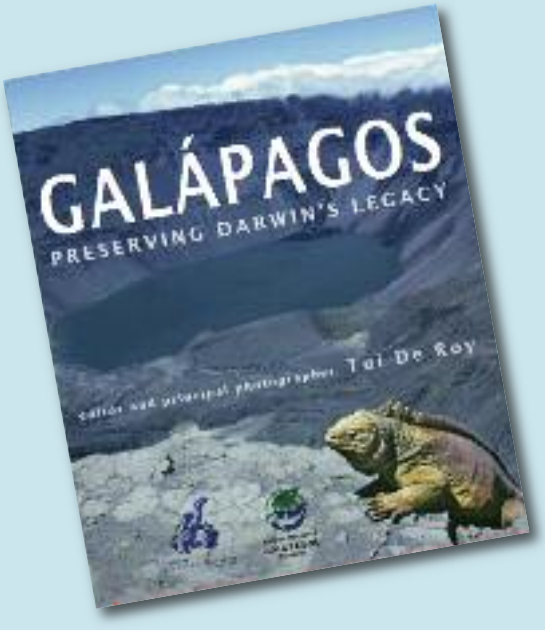
While a serious exercise in historical writing and the result of a great deal of research, the book is not at all academic. Hickman's style displays a slightly wry sense of humour which makes it a delightful, informative and easy book to read. No one should visit the Islands without first reading this book, or taking it along to read on the way, an essential companion to help you appreciate and understand these remarkable, yet threatened Islands.

PRIDE IN GALAPAGOS

Galapagos: Preserving Darwin's Legacy
by Tui De Roy, Christopher Helm
Publishers Ltd, £30
ISBN 9781408108666

Tui De Roy's latest book is a stunning achievement. In *Galapagos: Preserving Darwin' s Legacy,* the self-taught naturalist who grew up in Galapagos has assembled over thirty enthralling personal reflections from Galapagos experts – past and present – to capture the beauty and significance of these Islands like never before. It is chock-full of fascinating and original content, with highly readable essays on every imaginable aspect of Galapagos life – from lichens to molluscs to the recently discovered pink iguanas to all the usual Galapagos suspects – with 600 of De Roy's breathtaking photographs acting as the perfect gel to bind them together. It is a surprising experience to find non-fiction tingling one's spine. This is the perfect Christmas gift for the Galapagos devotee.

Reviewed by Henry Nicholls



THE BIG PICTURE

Galapagos:
Both Sides of the Coin
by Pete Oxford and Graham Watkins,
Imagine Publishing, Inc.
£25
ISBN 9780982293935

This is a unique and important book in the growing world of Galapagos literature. The subtitle will enthrall aficionados of Herman Melville's *Moby Dick*. There are literal, figurative and metaphorical uses of the word "coin" in the subtitle, a reflection of the many complexities of the modern day Galapagos Archipelago. What this book does better than any other to my knowledge is in the section that invites the reader to invert the book and read from the "back" to see the other side of the coin. Here, former director of the Charles Darwin Foundation Watkins and photographer Oxford pull no punches on the modern reality of Galapagos, including over-fishing, prostitution, tourism and resource extraction, as well as conservation efforts. It is a powerful reminder of the fact, frequently ignored by natural history programmes, that approximately 30,000 residents live permanently in the Islands in four towns.

Reviewed by Matthew J. James
Sonoma State University

Not Another Booby ...

A happy face cactus photographed in 1945 during the US Coast and Geodetic Survey's western hemisphere magnetic project in Galapagos. Owing to the careful management of the Galapagos National Park, this is something you just don't see any more.

© C&GC Season's Report Wiles 1945

FOGOS Friends of Galapagos Organisations

A FOGO near you...

Fifty years after its founding, the Charles Darwin Foundation (CDF) remains the leader in Galapagos conservation research and its application. In its jubilee year, CDF has integrated research, community outreach and its role as a policy adviser into three signature initiatives, each examining a different facet of how people and nature can live together in a sustainable way.

Project Floreana, the first holistic project for the restoration of an inhabited island in Galapagos, is underway with support from Friends of Galapagos Organisations (FOGOs) around the world. Thanks to the generosity of several donors, the UK's **Galapagos Conservation Trust** (GCT) has already committed more than £135,000 ($215,000) towards this project. **Friends of Galapagos New Zealand, FOGO Netherlands** and the **Japanese Association for Galapagos** are also making significant contributions. The rich human history of this island from the 1800s has included pirates, fortune hunters, farmers, convicts and, since the 1920s, a small permanent population. Over time, the human presence has resulted in the extinction of plants and animals unique to Floreana and the loss of habitat for many more. Project Floreana links ecosystem restoration with the lives and aspirations of local residents. By involving the community in the efforts to rebuild the native habitat, help restore populations of rare birds and animals and manage invasive species, the local inhabitants' livelihoods are integrated with conservation action, creating a long term model for sustainability.

The **Galapagos Conservancy** is joining other FOGOs in supporting the two other flagship initiatives for this anniversary year and beyond. "Galapagos Climate Change" is an integrated effort that aims to predict the impacts of climate change on the people, plants and animals of Galapagos. "Human Impacts in Galapagos" will measure how human activities affect the Galapagos land and ocean ecosystems.

As the anniversary celebrations reach their finale, **GCT** is joining with other UK organisations to raise awareness for the International Year of Biodiversity (IYB) in 2010. Back in 2002 at the World Summit on Sustainable Development held in Johannesburg, almost 200 countries called for a significant reduction in the rate of loss of biodiversity by 2010 and next year's Convention on Biological Diversity in Japan will assess international progress towards meeting this target.

Finally, the **Swiss Freunde der Galapagos Inseln** is celebrating its 15th anniversary this year. Since 1994, when an enthusiastic group of Galapagos lovers came together to found the association, it has grown slowly but steadily. Today, with more than 1500 members and 200 donors, the Swiss FOGO continues to support the work of CDF and the Galapagos National Park in conserving the unique biodiversity of these enchanted Islands.

Islanders

Solanda Rea ...

... is the meteorologist at the Charles Darwin Research Station in Puerto Ayora, Santa Cruz.

© CDF.

Where were you born?

Guayaquil. I moved to Galapagos when I got married. I remember the date I arrived – 25 June 1983. It was an El Nino year, Puerto Ayora was flooded and the main street was damaged. There were few cars then and no buses and we had to get a truck to take us to our house. It still took hours. Our plane had landed at midday but we were not home until 7pm. The next problem was food. In those days there were few places to eat; we looked for somewhere but in the end we ate a can of tuna and cookies from a cupboard in the house. After this things got better!

What was Galapagos like 25 years ago?

My husband already worked at the Charles Darwin Research Station (CDRS) in herpetology. After being on the Islands for 15 days I got my first job at CDRS, working with the iguanas. It was so peaceful and relaxed here after the noise and pollution of Guayaquil. There were no paved roads when I came. You were walking on earth and lava. There were some street lights but they went out at 11 pm and you had to use a torch. There was no main road to the highlands. Most people walked, some had bicycles and a few had motorcycles. Don Ramos, the driver at CDRS, would pick up people and bring them to work.

How did you get water and food?

In the early days we collected rainwater in tanks on the roofs. You could also collect it from Las Grietas, stunning water-filled crevices not far from Puerto Ayora. You had to boil it to drink it. Later the municipal council introduced a pumping system and you could get water for only one hour a day. Now it's three hours a day. When I came to Santa Cruz, there was very little agriculture on the island, so almost everything had to come from outside.

What does your job involve?

I now work in meteorology, taking readings and gathering information about the climate. It is very important to collect this information, as it has an impact on all the wildlife. I love my work; CDRS has been like a second home to me and my husband.

Describe a normal day

I come to the station at around 7.30 am. I spend most of my time collecting meteorological measurements, entering them into the database and helping run the CDRS shop. I also belong to a Catholic group, which helps people in the Islands facing hardship. We recently collected money to help a woman who had tragically lost her foot and then her leg to gangrene.

How does the future of Galapagos look to you?

I am very concerned about the expanding population. There are so many outsiders coming here, the population is young and they are having large families. It's just not sustainable on a small island. In addition, there are too few opportunities for young people. My daughter is training to be a guide and I hope she will be able to get work here in the future. My son studies gastronomy. He hopes to work in tourism. All institutions in Galapagos need to give young people from the Islands a chance. In the future I would like to see the major institutions managed by people from Galapagos. I have spent most of my adult life here in Galapagos, only leaving for three years when my husband's work took us to Costa Rica. It was beautiful there but we all missed Galapagos.