

New species reveal their secrets

Claire Miller

Nearly two thousand marine, freshwater, and terrestrial species previously unknown to science have been discovered in recent field expeditions that explored remote corners of the globe. In the deepest parts of the Southern Ocean, off the Australian coast, scientists have photographed and sampled hundreds of new creatures, including a curious carnivorous sea squirt, sea spiders, crustaceans, and “glass” sponges so fragile they would fall apart if brought to the surface.

In January 2009, Australian and American scientists returned from a month-long voyage with photos and footage of hundreds of remarkable new deep-sea creatures. The collaborative expedition aboard the American vessel *RV Thomas G Thompson* was led by chief scientists Jess Adkins (California Institute of Technology, Pasadena, CA) and Ron Thresher (Commonwealth Scientific and Industrial Research Organisation’s [CSIRO’s] Climate Adaptation and Wealth from Oceans Flagships, Hobart, Australia).

Using a remote-controlled, deep-diving submarine – the *Jason* – borrowed from the Woods Hole Oceanographic Institution, MA, researchers surveyed the near vertical slice in the Earth’s crust known as the Tasman Fracture Zone, which drops from 2000 m to more than 4000 m within the Huon Commonwealth Marine Reserve. “The Australian Department of Environment manages this huge marine reserve, and we had no idea what was down there”, explains Thresher. “One real possibility was that there would be nothing much but rocks and mud. But when we got below depths of 2000 m, we found vast numbers of an unknown species of anemone – millions of them covering the rocks and packed in as



Laotian rock rat, *Laonastes aenigmamus*.

far as the eye could see. And then, below 2500 m, the anemones disappeared and the bottom was dominated by large white barnacles. Below that, meter-high gorgonian forests and – in between – giant sponges and creatures like spider crabs, walking around in the pitch black.”

As Thresher points out, the abundance of life at these depths is impressive, given the ecosystem’s total reliance on detritus floating down from the surface, 3 to 4 km up. “I think we were all amazed at how pretty it was down there; it was surreal, flying over meter-high corals, some with bizarre corkscrew shapes. As Jess Adkins described it, it was like a Dr Suess landscape – nothing was quite like anything we had seen before.” But the expedition also found sobering evidence that most reef-forming coral deeper than 1400 m was dead, much of it apparently recently. According to Thresher, data were collected to study the causes, including whether changing ocean chemistry and temperatures linked to climate change were playing a role. “These creatures were very long-lived, some up to 2000 years. In some cases, at least, it appears they are not coping well with changes in their environment over the past several centuries.”

The new discoveries built on the knowledge gained from two previous CSIRO Flagship voyages in 2006 and 2007, in which the Tasmanian Seamounts Marine Reserve was mapped and more than 270 new corals, sponges, crustaceans, seastars,

and mollusks were identified. Although these species might prove useful for medicinal or commercial purposes, Thresher believes that their survival (as well as that of their ecosystems) is also important because of their intrinsic value and because many species are likely to be endemic. “We really don’t know what, if any, role such communities play in key oceanic processes”, he comments.

Meanwhile, back at the surface, WWF is collaborating with several research institutions to discover new species in the Mekong region spanning Vietnam, Thailand, Laos, and Cambodia, and identify threats to their survival. A new report, *First contact in the Greater Mekong*, launched by WWF last December, identifies more than 1000 new species found over the past 10 years. The largely unexplored region has yielded such curiosities as a hot-pink, cyanide-producing dragon millipede, the world’s largest huntsman spider (with a foot-wide [~0.3-m] leg span), and the Annamite striped rabbit. Other species were found not so far off the beaten track – researchers spotted the Laotian rock rat, a species thought to have disappeared millions of years ago, for sale in a local food market, while the Siamese pit viper was discovered in the rafters of a restaurant in Thailand’s Khao Yai National Park.

Chavalit Vidthayanon (WWF-Thailand, Bangkok, Thailand) spent 10 years compiling an inventory of aquatic species, turning up eight new types of fish, including an eyeless cave dweller he named the Laotian cave loach (*Schistura kaysonei*). Vidthayanon’s research will contribute to WWF’s work with the greater Mekong governments and local industry to ensure that sustainable habitat management is incorporated into development plans. “We feel glad when we find a new fish species in a pond or a marsh, because it indicates that the habitat is still relatively pristine”, he says. “And new species will become flagships for protecting the wetlands and other habitats, locally and regionally.” ■

Human appetites driving frogs to extinction?

Noreen Parks

Frog populations worldwide are plummeting as a result of habitat loss, climate change, disease, and environmental contamination. However, an upcoming study in *Conservation Biology* highlights yet another peril: relentless harvesting to satisfy the human appetite for frogs' legs. Once harvested seasonally for local consumption, frogs' legs have become a commodity of year-round, global commerce, and a menu item in eateries ranging from street stalls to first-class restaurants across Europe, Asia, and North America. UN trade statistics – compiled by biologist Ian Warkentin of Memorial University (Corner Brook, Canada) in collaboration with colleagues in Singapore and Australia – reveal that the international market currently accounts for at least 200 million frogs annually. But given spotty information on domestic market de-



A bag of frogs' legs from Vietnam.

mand, the actual number could be far higher. Indonesia – the top producer – has exported more than 4000 tons of frogs' legs annually since the 1990s, and its domestic market demands an additional 2–7 times that volume.

The authors contend that the pattern of shifting locations for the wild-frog harvest across the globe resembles the practices in (and sequential collapses of) marine fisheries during recent decades. By the mid-1900s, frog harvesting in Europe and North America drove local stocks to commercial extinction, and improved food-freezing technology enabled the

importation of frogs' legs to these markets from far-away sources, such as India and Bangladesh. When populations declined in those areas, operations moved to southeast Asia, and escalated. “We are now potentially looking at frog exploitation leading to commercial extinctions in countries like Indonesia”, Warkentin says, citing recent export declines as evidence.

“Probably five to ten species comprise over 75% of the international trade, but determining the species of skinned and frozen frogs' legs is difficult”, Warkentin adds, “and no regulatory framework governs the trade”. The researchers propose the establishment of a mandatory certification program that would track the origin, species, and conservation status of the source populations of frogs exported for consumption.

Ecologist James Collins of Arizona State University (Tempe, AZ), comments, “Better data on populations of harvested frogs are urgently needed to inform policy makers”. ■

Anti-androgens feminize fish

Adrian Burton

Environmental estrogens may not be the only molecules causing the feminization of male freshwater fish; anti-androgenic pollutants may also be to blame (*Environ Health Persp* 2009; doi:10.1289/ehp.0800197). “We have some good evidence linking environmental estrogens to feminization”, says Charles Tyler (University of Exeter, Exeter, UK), the senior author of the study. “But the effluent released into our river systems from wastewater treatment plants contains hundreds of other organic chemicals that could also contribute to this phenomenon. Strong candidates would be compounds with anti-androgenic activity; we wanted to test whether this group might also be involved.”

The researchers used data on the types and amounts of estrogenic substances entering river systems

from sewage treatment works, and estimated their concentrations following dilution at 30 fish (roach: *Rutilus rutilus*) sampling sites around the UK. The estrogenic and anti-androgenic properties of the water at these points were also estimated from data provided by screening tests involving recombinant yeasts.

“The male fish we caught were checked for signs of feminization, such as elevated plasma vitellogenin levels, feminized reproductive ducts, and oocytes developing in the testes”, explains Tyler. “Using linear and generalized additive statistical modeling, we determined the relationships between this feminization the modeled concentrations of estrogens, and the modeled activities of estrogens and anti-androgens.”

The feminization effects were indeed related to the presence of estrogens – but the results show that anti-androgen activity also plays an important role. “In essence, male fish were more likely to show stronger

feminization when estrogen concentrations were higher and occurred in combination with greater anti-androgen activity”, says Tyler.

Work to identify the anti-androgen compounds involved – derivatives of certain pesticides and anti-prostate cancer drugs, for instance – is currently underway.

“This eloquent work further demonstrates how complicated the issue really is”, says Karen Kidd (University of New Brunswick, Saint John, Canada). “Reproductive dysfunction in wild fishes is widespread, and it is clear that advances in wastewater treatment should not focus solely on reducing discharges of estrogens. These improvements are needed, but feasible.”

We may soon know how feasible. A report on the efficacy of different systems for removing estrogens and potential anti-androgens from wastewater is to be published in the near future by the UK firm, Water Industry Research Ltd. ■

Glossy crops combat global change

Virginia Gewin

The search is on for technological fixes to reduce the impacts of global warming. Some current projects being explored – such as space-based solar shields or injection of sulfate aerosols high into the atmosphere – are risky, billion-dollar engineering efforts to cool Earth by altering its albedo, or reflectiveness.

Scientists at the University of Bristol (Bristol, UK) have come up with a novel crop-cooling technique to reduce summertime temperatures – planting crop varieties with glossier leaves to better reflect incoming sunlight. Reporting in the January issue of *Current Biology*, researchers say the 1°C summertime temperature drop throughout much of central North

America and mid-latitude Eurasia may not seem like much, but it would seasonally offset about 20% of the warming expected by the end of this century in these regions.

Lead author Andrew Ridgwell, an environmental scientist, had been working with colleagues on computer models to assess the ability of sun shields in space to restore global climate to pre-industrial levels when he was surprised to discover that the albedo of different crops can vary considerably. “I realized that substituting crop varieties might be a low-budget, easy way to reflect radiation without disrupting agriculture”, he explains.

Ridgwell then altered canopy albedo in his computer models to determine the change needed to have an effect on temperature. He found that a modest 20% increase in canopy albedo resulted in a 0.11°C decrease

in global annual average surface air temperature. “One degree is substantial – equal to the amount of warming expected over a 20–30 year period – so this is definitely worth exploring, because it is feasible and the cooling occurs in some of the food-producing areas we expect to be hardest hit by warming”, points out David Lobell, environmental scientist at Stanford University (Palo Alto, CA).

The real question, suggests Lobell, is whether crops can be made glossier without compromising their productivity. Ridgwell admits it is a valid concern. The researchers’ next step is to characterize variability in leaf albedo and performance over a wide range of commercial and non-commercial plant varieties. Assuming it works, Ridgwell says plant waxes could be genetically modified to achieve greater cooling effects. ■

Climate-cooling algae

Janet Pelley

Scientists on board the *Polarstern*, a research ship owned by the Alfred Wegener Institute (Bremerhaven, Germany), began spreading 6 metric tons of iron sulfate over 300 km² of the Southern Ocean on 27 January. The controversial experiment, which is expected to trigger an algal bloom, will investigate whether ocean fertilization can provide relief from global warming.

Despite an abundance of nitrogen and phosphorus, algal growth is minimal in roughly one-third of the ocean because of a lack of iron, explains Ken Buesseler, an oceanographer at Woods Hole Oceanographic Institution (WHOI; Woods Hole, MA). In theory, fertilizing these waters with iron will boost algal growth, converting atmospheric CO₂ into organic matter, so it eventually sinks into deeper water and stays put for several decades or even centuries, says WHOI oceanographer Scott Doney.

According to Buesseler, between 1993 and 2005, scientists conducted 12 open-ocean experiments that increased algal biomass by 10–20 times. But in those cases, only 2–50%



Marine biologist Philipp Assmy analyzes a plankton sample under the microscope.

of the carbon was lost to the deep sea. “The *Polarstern* voyage is an important next step toward understanding the consequences of ocean iron fertilization, and is sorely needed to answer remaining questions about efficacy and impacts”, continues Buesseler. However, the experiment was put on hold amid a storm of controversy, until recently approved by Germany’s Research Minister, Annette Schavan.

“Critics hinted that the *Polarstern* expedition was a prelude to a large-scale mitigation strategy”, Doney explains. Over the past several years, a handful of private companies have talked about running commercial-scale ocean fertilization operations, financed by selling carbon offset credits. Some members of the scientific community are concerned that large-

scale iron fertilization could have unintended consequences, such as impairing fisheries, unleashing harmful algal blooms, and producing greenhouse gases such as methane, admits Buesseler, but not at the scale of individual experiments.

In May 2008, the UN Convention for Biodiversity declared a moratorium on commercial iron fertilization activities. An October meeting of the signatories to the London Convention and Protocol, a marine pollution agreement, adopted a resolution proclaiming that, “Ocean fertilization activities, other than [for the purpose of] legitimate scientific research, should not be allowed”. But Doney isn’t convinced that such a step was necessary. “I’m worried that in the process of trying to stop commercialization, we’re going to stop the research.”

A technical working group of the London Convention and Protocol, scheduled to meet as this issue goes to press, aims to develop guidelines for both research and commercialization of ocean iron fertilization. “I would like to see them allow experiments, so we can better weigh the consequences against other geoengineering options”, Buesseler concludes. ■

Not exactly ashes to ashes

Kathryn Senior

Disposing of the recently deceased in a sensitive, yet environmentally conscious, way is becoming a major issue globally. In January, the Philippines announced regulations that will force crematoria to limit their carbon emissions, a policy adopted by many other countries. The UK is currently concerned about the impact of amalgam dental fillings, which contain minute quantities of mercury; by 2020, British crematoria will be the country's single largest source of mercury emissions, accounting for 25% of the national total. Some reduction is expected after 2035, as more modern dental materials work their way through the generations, but in the meantime, new UK regulations insist that crematoria reduce their individual contributions by 50% by 2012.

"Many crematoria have inefficient, ancient burners that have a



Ecofriendly coffins can be made of willow, bamboo, or seagrass.

large carbon footprint", says Rosie Inman-Cook of the Natural Death Centre (London, UK). Roger Short (University of Melbourne, Australia) reports that research on carbon emissions and cremation – commissioned by an Adelaide-based funeral director – showed that "a single cremation releases 160 kg of CO₂ into the atmosphere". He cited these data during a meeting with a senior Chinese diplomat, explaining that, "She was unaware that the recent Chinese government deci-

sion to cremate every deceased person in the future would mean an extra annual contribution of about 1.5 billion kg of CO₂".

Traditional burial is hardly better. "Chemicals such as formaldehyde, used for embalming, can leach out into the land and nearby groundwater", says Inman-Cook, who provides more ecologically friendly burials through the use of biodegradable coffins and the planting of trees to mark final resting places. "A tree will sequester a metric ton of CO₂ from the atmosphere every 100 years, so you can do more good to the environment after death than you did during life", explains Short. Inman-Cook told *Frontiers* that public demand for this type of burial has increased in Britain by 30% each year, but space is unlikely to be a limiting factor. "If all the set-aside land in the UK was used for ecologically sound burial of the half-million people who die each year, it would take 2000 years to fill up", she says. ■

Biofuels crop growth often overestimated

Chris Emery

The ability of countries to grow crops for producing biofuels such as ethanol and biodiesel is often overestimated, according to a recent study (*Environ Res Lett* 2009; **4**: 019801). Researchers found that, in both developed and developing countries, the potential for biofuels production is based on overly optimistic crop yield estimates and, consequently, is often exaggerated. For some crops, the predictions overestimated yield by more than double what is realistic.

The poor estimates stem from using the crop output of farms in one region to predict the output of farms in other regions, which may exist in markedly different physical climates and political environments, and use different farming techniques, according to lead author Matt Johnston (University of Wisconsin-Madison, Madison, WI).

In some cases, says Johnston, yields for one crop have been used to make predictions for another crop. "The more I looked into it, the more I realized that the yields being quoted didn't make sense", explains Johnston. "I wanted to reset expectations with existing yields."

To provide more accurate country-by-country predictions of crop yield, Johnston and his colleagues analyzed a global agricultural database compiled by the Center for Sustainability and the Global Environment at the University of Wisconsin-Madison. The database provided actual crop yields of 175 crops – from across the globe – at a resolution of roughly 10 square km, data that were subsequently used to calculate the amount of biofuels that could be produced per hectare for every country, using 20 different crops. Johnston found major differences between his estimates and commonly cited estimates, and that some predictions were between

100–150% off, especially for those in developing countries. The datasets produced in this study are available online, at www.sage.wisc.edu/energy/index.html.

The erroneous estimates are commonly found on "yield tables", which make predictions of biofuel production per unit of land planted with crops such as wheat, corn, soybeans, and sugarcane. The tables are often used as guidelines in policy debates over energy production and the use of biofuels as an energy source. But as interest in biofuels as an alternative energy source has grown, Johnston has become concerned that the debate over their use isn't always based on solid facts. "Often these [yield tables] contain very optimistic numbers, because they are used to promote biofuels", says Johnston. But the industry has grown quite large, and I think we need to move beyond back-of-the-envelope calculations." ■

Can microbes save the world?

Kathryn Senior

As the biofuel debate rages on, the new hope is that as-yet-untried microbial biofuel production systems could offer a realistic solution to the growing energy problem. In a review published earlier this year (*J Ind Microbiol Biotechnol* 2009; doi:10.1007/s10295-008-0521-8), Arnold Demain (Drew University, Madison, NY) says that much of the basic microbiological work done on a variety of microorganisms will now allow us to “scale up these process in a cost-effective way, to use microbes to ferment lignocellulosic biomass, producing bioethanol, biobutanol, biodiesel, and biohydrocarbons”.

Microbial systems that use agricultural and human waste will contribute

energy without exploiting valuable land that could be used for growing food. “We should definitely not be using food crops to produce fuels. Not only does it cause so many social and environmental problems, but it cannot come close to meeting the need [for biofuels]”, comments Bruce Rittmann, Director of the Center for Environmental Biotechnology at Arizona State University (Tempe, AZ). Although deriving methane from natural and agricultural residual biomass should not be overlooked, this by itself would not provide nearly enough energy capacity.

“The biggest breakthrough in solving the energy crisis will come from using photosynthetic microorganisms (cyanobacteria or algae) to produce a very large amount of ‘new biomass’ that does not compete with agriculture, and has much higher value as an

energy feedstock than most plant biomass”, says Rittmann. Demain agrees, pointing out that the high lipid content found in some species of algae and cyanobacteria means that, under proper conditions, “these photosynthetic microorganisms can produce lipids for biodiesel, with yields per unit area of 100 times or more than is possible with any plant system, and do not use valuable arable land resources.”

Progress on microbial fuels has been delayed by a lack of investment, but Rittmann is hopeful that the increasing social need and our greater research and bioengineering capability are changing attitudes sufficiently to acquire the necessary funding to make rapid advances. “I am optimistic that a combination of several microbe-based bioenergy approaches can break our dependency on fossil fuels”, he concludes. ■

Australian expansion of dengue projected

Jane Bradbury

Researchers predict that human-induced climate change will increase the range of *Aedes aegypti*, the mosquito that transmits the human disease dengue fever, in Australia. The mechanistic approach taken by zoologist Michael Kearney (University of Melbourne, Victoria, Australia) and colleagues also suggests that changes in water storage practices in response to drought may have a greater effect on the distribution of *A. aegypti* than climate change itself. Genetic adaptations triggered by climate change may also influence the mosquito's future distribution (*Funct Ecol* 2009; doi:10.1111/j.1365-2435.2008.01538.x).

Although found in many parts of the world, in Australia *A. aegypti* is currently confined to the northeastern part of the country. However, climate change could trigger an expansion in its Australian distribution and, therefore, the area affected by dengue. Efforts to predict the effects of climate change on the distribution of a species usually take the form of a “top-down” correlative model, where



Backyard water tanks are ideal breeding grounds for mosquitoes.

the prevailing climatic conditions at sites where the species currently exists are used to infer its future distribution. By contrast, Kearney and colleagues start with the mosquito's biology and combine that with a biophysical model that relates macroclimatic data to the sorts of environments – standing water – where mosquitoes lay their eggs.

The advantage of this “bottom-up approach”, explains Kearney, is that it can predict both direct and indirect effects – such as the influence of human behavior and genetic adaptations – on the mosquito's response to climate change. “We found, for example, that the installation of backyard water tanks to deal with

drought could make a huge difference to the distribution of *A. aegypti*.” Even in the absence of climate change, Kearney believes this alteration in human behavior could make most of Australia suitable for *A. aegypti*. The model also predicts that an evolutionary response to climate change, such as increased resistance to egg desiccation, could allow the mosquito to expand into highly populated regions of the country.

Kearney's approach is “a beautiful example of clever science reducing the uncertainty associated with climate change forecasts”, says Steven Chown, director of the Centre of Excellence for Invasion Biology (Matieland, South Africa). Marine ecologist Brian Helmuth (University of South Carolina, Columbia, SC) agrees that accurate predictions of the effect of climate change on non-human organisms are essential. Importantly, he notes, “this research shows that not only can we combine physiological, ecological, and biophysical approaches to predict future patterns in the spread of disease vectors, but that we can also incorporate aspects of evolutionary adaptation into our predictions.” ■

WWF seeks inventions to curb bycatch

Jen Schoenburg

In late January, WWF International (Gland, Switzerland) announced the kickoff of the Fourth International Smart Gear Competition, a worldwide contest for designing fishing devices that will reduce bycatch – the unintended capture of non-targeted fish, turtles, and other marine species. In total, US\$57 500 in cash prizes will be awarded to the inventors of the winning designs, which WWF hopes will lead to more efficient commercial fishing.

WWF calls bycatch “one of the greatest and most pervasive threats to life in the oceans”, which could be “the final nail in the coffin for many endangered marine species”. Each year, millions of tons of fish and billions of invertebrates, such as corals, sponges, and starfish, are caught as bycatch, and are often dead or dying when they are thrown back into the



Leatherback turtle (*Dermochelys coriacea*) caught in a fishing net.

sea. According to WWF, more than 300 000 small whales, dolphins, and porpoises die from entanglement in fishing nets each year. Bycatch has driven several marine species to the verge of extinction, including 26 species of seabirds.

As Michael Osmond, Senior Program Officer of the WWF Fisheries Program, says, “Bycatch is an even more dire problem when the species being affected are endangered;

these are species where every individual in the population counts, and for these populations to be reduced even further as a result of bycatch is simply unacceptable. This is something that WWF is working with the international fishing industry to address. The Smart Gear Competition seeks to identify creative and innovative ideas that enable fishermen to fish more sustainably and rewards those ideas with a cash prize. The global concept is particularly appealing, since an idea that works well in one place may have potential application to a variety of fisheries all over the world.”

Entries can address bycatch issues anywhere in the world, with this year’s regional prize specifically focusing on bycatch issues in coastal East Africa, and the competition is open to eligible teams or individuals from all backgrounds. The deadline for entry is 30 June 2009. Further information, rules, and entry forms are available online, at www.smartgear.org. ■

California’s cash crunch derails conservation

Robin Meadows

California has lost funding for more than 4000 environmental projects, ranging from restoring salmon runs along the coast and streams in the Sierra Nevada to purchasing and conserving open space statewide. The projects are the latest victims of the state’s financial crisis. Citing their inability to sell bonds since June 2007, state financial officials have frozen spending that depends on borrowed money – including voter-approved environmental bonds totaling billions of dollars.

At best, the funding freeze will delay projects indefinitely, running up costs and forcing layoffs; already, 30 people have been forced to leave a project to restore about 6100 ha of former industrial salt ponds around San Francisco Bay, the largest tidal

wetland restoration project on the west coast. The timing could hardly be worse: after years of planning, the project only recently was granted a federal permit to begin restoring habitat islands in the ponds.

“The current bond freeze has put all work on hold, causing us to lose valuable momentum”, says Steven Ritchie, Executive Project Manager of the South Bay Salt Pond Restoration Project (Oakland, CA). “We are in a race to re-establish habitat for endangered species.” The South Bay wetlands are home to four at-risk species: the California clapper rail, the snowy plover, the least tern, and the salt marsh harvest mouse. The delay will also be expensive, adds Ritchie, as inflation will increase both design and construction costs.

At worst, the funding freeze could halt projects entirely. Land deals for conservation purposes could be lost for good in California,

where the already high demand for real estate will only intensify as the population jumps to more than 42 million by 2020. Oceanfront land is particularly desirable, and the bond freeze could nix a deal to buy and preserve the Jenner Headlands, some 2266 ha along the Sonoma County coast. The Sonoma Land Trust (Santa Rosa, CA) spent 4 years negotiating with landowners, who had initially considered developing their property, and was recently granted \$16 million in bond funds to apply toward the \$36 million purchase.

“The alternative to conservation would be more than 40 home sites along the coast, carving up the grasslands and forest”, explains Ralph Benson, who was the Trust’s Executive Director when the purchase agreement was signed last year. Now that the deal is in limbo, the Jenner Headlands may be developed after all. ■