Ripple Marks

The Story Behind the Story

BY CHERYL LYN DYBAS

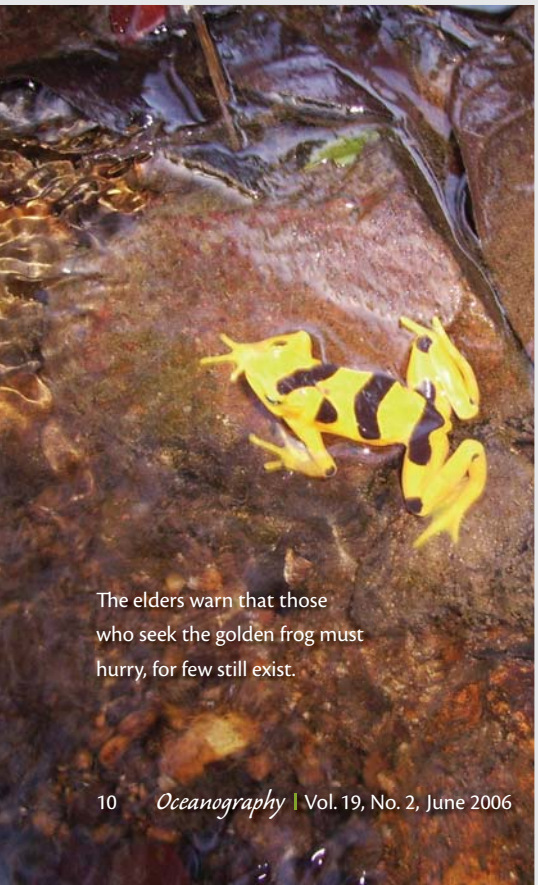
DISAPPEARANCE OF THE MAGICAL GOLDEN FROG

THE DISAPPEARANCE OF THE MAGICAL GOLDEN FROG BODES ILL FOR PANAMA'S STREAM ECOSYSTEMS. The woods are dark and deep here in the mountains of Panama. As night falls, tribal elders speak in hushed tones of a beautiful, miraculous frog that dwells in the green forest.

According to legend, the golden frog is a secretive creature. The only chance of finding it is by determined searches along clear mountain streams and fog-shrouded slopes. But the reward for success is, as tropical biologist Jay Savage of San Diego State University has written, sublime: any man or woman, it's said, lucky enough to discover a golden frog will find true happiness.

But there's a catch: that happiness lasts only as long as the finder can hold the frog.

Once released, the golden frog takes with it the bliss foretold by ancient wise ones.



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The elders warn that those who seek the golden frog must hurry, for few still exist. "Golden frogs are declining precipitously; they and other amphibians are fast disappearing, especially in remote, montane regions of the tropics," said Karen Lips, a biologist at Southern Illinois University Carbondale who has tracked populations of Neotropical amphibians. "At some sites, more than 75 percent of amphibians have vanished, especially those species that breed in streams."

Globally, these declines can be linked to land-use changes and habitat loss. "In the tropics, the emergence of infectious diseases like chytridiomycosis, caused by a chytrid fungus, has caused rapid die-offs in several families of Panamanian amphibians," said James Collins, National Science Foundation assistant director for biological sciences (currently on leave from Arizona State University). Golden frogs are among those affected.

In a paper published in the February 28, 2006, issue of the journal *Proceedings of the National Academy of Sciences (PNAS)*, Collins, Lips, and others show that outbreaks of chytridiomycosis can wipe out entire amphibian species. "It is no longer correct to speak of global amphibian declines, but more appropriately of global amphibian extinctions," they state in *PNAS*. The rockhopper frog, for example, which lived along riverbanks near El Cope, Panama, disappeared completely within one month of a recent outbreak.

What will these losses mean to aquatic ecosystems?

In the February 2006 issue of the journal *Frontiers in Ecology and the Environment*, Lips and colleagues discuss research on freshwater habitats in Central America where the disappearance of stream-breeding frogs like the golden frog is resulting in wide-ranging effects on the aquatic environment. Amphibians may be critical species in stream habitats because they have disproportionately large impacts on ecosystems.

Scientists affiliated with the Tropical Amphibian Declines in Streams (TADS) project are comparing pre-amphibian-decline and post-amphibian-decline stream sites in the Panamanian highlands. The goal, said Lips, "is to quantify the consequences of the loss of amphibians to stream and riparian ecosystem structure and function."

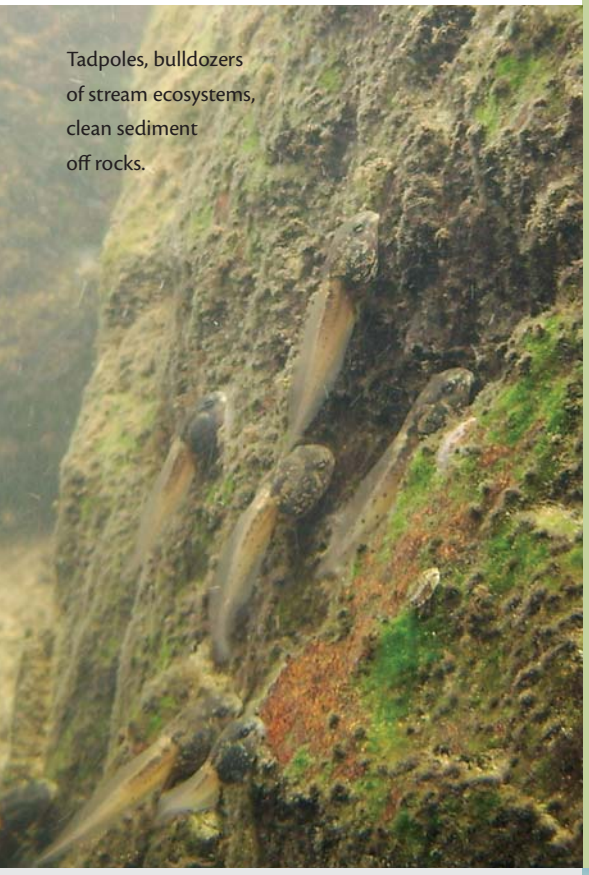
Although usually unseen, "amphibians comprise a surprisingly large proportion of the vertebrate abundance and biomass in temperate and tropical wetlands and forests," said Lips. "Amphibians contribute considerably to energy flow in neotropical streams. Through them, energy is efficiently converted to biomass, which then becomes available to higher trophic levels."

Evidence to date, say Lips and scientists at the University of Georgia, Drexel University in Philadelphia, and the University of Alabama, suggests that amphibian declines have large-scale and lasting effects, including changes in algal community structure and primary production, altered organic-matter dynamics, changes in numbers of consumers like aquatic insects and riparian predators such as snakes, and reduced energy transfer between streams and riparian habitats.

The disappearance of amphibians in stream ecosystems is a double loss: amphibian larvae occupy one niche, adults another, almost as though they were different species. "Because of habitat preference and functional differences between larvae and adults in most amphibians, the loss of a single species is akin to losing two species," said Lips.

Most larval frogs feed on detritus and algae. Tadpoles, bulldozers of stream ecosystems, clean sediment off rocks, exposing diatoms living below. Insects like mayflies depend on this "open access" to diatoms for food. Without tadpoles to function as sediment removers, diatoms are soon buried, leaving mayflies high and dry.

Just as mayflies need tadpoles, many tropical snakes need adult frogs as their main food source. If all the frogs have gone missing, snakes shift their



Tadpoles, bulldozers of stream ecosystems, clean sediment off rocks.

preferred prey to lizards. "Are frog-eating snakes now mostly eating lizards?" asks Lips. "Data we're just beginning to analyze suggest that's the case." Lizard populations, too, are declining.

As goes the frog, so go the mayfly, the snake, the lizard…and, perhaps, us.

Changes rippling through stream ecosystems may affect the abundance of freshwater shrimp and fish like tilapia. Shrimp and tilapia are important to people as both wild-caught and farmed stocks.

The golden frog is the revered symbol of Panama. It graces the country's lottery tickets and adorns its tourist brochures. Schoolchildren are still taught the story of this favored frog.

As for the magical golden frog itself, its luck appears to have vanished into the tropical mountain mists.

LETHAL MARINE SNOW

PATHOGEN HITCHES RIDE TO QUAHOGS ON MARINE SNOW. Could marine snow be a conduit for transporting pathogens from the sea's surface to bottom-dwelling shellfish like northern quahogs (also called hard clams)?

If scientists Evan Ward and Maille Lyons of the University of Connecticut at Groton are right, marine aggregate or snow is serving as a reservoir for the pathogen QPX (Quahog Parasite Unknown). Ward and Lyons, along with Roxanna Smolowitz and Kevin Uhlinger of the Marine Biological Laboratory in Woods Hole, Massachusetts, and Rebecca Gast of the Woods Hole Oceanographic Institution, published results of their research in the November 2005 issue of the journal *Limnology & Oceanography*.

"Marine aggregate or snow ranging in size from a few microns to more than a centimeter is common in coastal environments where large populations of benthic, suspension-feeding invertebrates thrive," said Ward. "Marine snow serves as an important mechanism for the transport of carbon, nutrients and other materials to benthic ecosystems. But to our knowledge, no studies had addressed the role of marine snow in the transmission of diseases to marine animals."

Ward and colleagues uncovered evidence that marine snow is a major factor in disease transmission of QPX.

Since the 1950s, northern quahogs (*Mercenaria mercenaria*) have suffered severe mortality from QPX. "The presence of QPX-laden marine snow in areas where disease outbreaks have occurred suggests this is a way in which pathogens have survived and spread," said Lyons.

Marine snow is ubiquitous in the ocean environment, but is often overlooked because it's destroyed by traditional sampling equipment like plankton nets, said Ward. "Aggregates turned out to be an unexplored link between waterborne pathogens and their benthic hosts. This result is the first documentation of QPX in the environment outside of the quahogs themselves, as well as the first report of a protistan (thraustochytrid) pathogen embedded in marine snow."

Ward and Lyons focused on QPX, "but the idea of pathogens persisting in and being transported by marine snow applies to other disease-causing organisms, including those that infect humans and those entering the marine ecosystem from land," said Ward.

"Marine snow would provide a means of pathogen survival and transport between epidemics by serving as an environmental reservoir."

As reports of marine disease epidemics continue to increase, he said, "the need for comprehensive surveillance programs will also increase."

The scientists used the northern quahog as their model organism because the shellfish are ecologically and economically important. "But the concepts also apply to other marine animals, and demonstrate the need to evaluate the role of marine aggregates as reservoirs and vectors of disease," said Ward.

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Meltwater accumulating in Greenland's "super-blue lakes" drains through the ice sheet to the bedrock below, forming a layer of liquid water that makes the ice melt faster.

BLUER THAN BLUE

BLUE LAKES ATOP GREENLAND ICE SHEET INDICATE RAPID MELTING. Beautiful they are, but their beauty is only skin deep. Saucer-shaped lakes that have formed like blue pockmarks on snow-white glaciers in Greenland betray an accelerating melting of the ice cap there, according to climatologist Jason Box of Ohio State University.

Greenland's ice cap is the largest in the Northern Hemisphere and second largest in the world after the Antarctic ice sheet. Box has found that meltwater accumulating in Greenland's "super-blue lakes," as he calls them, drains through the ice sheet to the bedrock below, forming a layer of liquid water that makes the ice melt faster.

"We've known that this phenomenon is important in the downhill acceleration of mountain glaciers," said Box, "but it's only recently been discovered in polar ice." The meltwater builds up heat as it drains through moulins—vertical shafts or cavities in a glacier.

Moulins in the Greenland ice cap are being carved into its glaciers by the blue meltwater lakes. Box estimates that 1,200 of these bluest-of-blue lakes exist in southwest Greenland alone. "If we were counting them at the level of mere puddles, that number would likely be in the millions."

Last summer, Box joined a Greenpeace expedition called Project Thin Ice, which took place in southwest Greenland. There he studied these "incredibly light-saturated lakes, whose color ranges from a sky-blue to a blue-deeper-than-cobalt," he said. The information Box returned with is a first look at the extent of lake formation on the Greenland ice sheet, an up-close-and-personal view that almost cost Box his life.

"Two of us were out in a small rowboat on one of the lakes," he remembers, "when we were literally sucked into a melt-river rushing into a moulin. I started paddling like crazy. It took everything we had not to get swept along with the fast-running water and end up at the bottom of the world's second largest glacier.

"The water running through Greenland's moulins is incredibly powerful, which tells you something about how fast the melting is happening: it's a torrent."

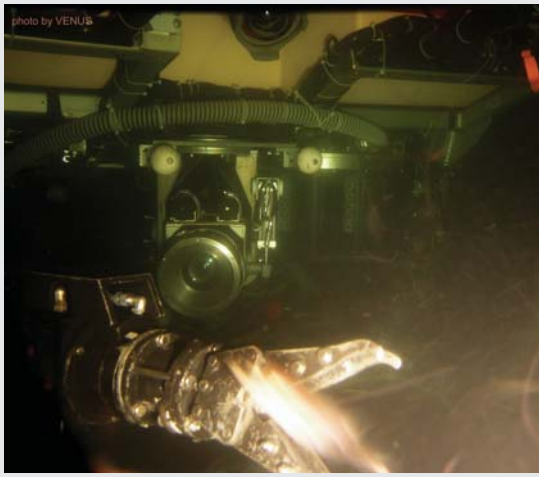
Having survived the ordeal, Box is working on correlating the intensity of the blue color of Greenland's ice sheet lakes with accurate measurements of the lakes' depth. He's using satellite imagery to determine the depth of the lakes by knowing the intensity of their color. NASA MODIS (Moderate Resolution Imaging Spectroradiometer) "true color" imagery is giving Box a new view of what's called the ablation (melt) region of Greenland's ice sheet.

"With MODIS, we should be able to figure out the total volume of water in these lakes," said Box, who thinks there's more than one cubic kilometer of liquid water sitting atop southwest Greenland alone. "That's more water than the city of Los Angeles consumes in two years," he said.

"Ice is melting in Greenland faster than we ever thought possible, fast enough that it's alarming," Box believes. "What controls the speed of a glacier's advance toward the sea is what's going on down at its bed. Adding liquid water to the bases of glaciers via meltwater lakes that flow into moulins is making these glaciers race along.

"What we have in Greenland is nothing short of galloping glaciers."

SMILE, YOU'RE ON VENUS CAMERA!



"Smile, you're on VENUS camera!" said Verena Tunnicliffe of the University of Victoria, British Columbia, Canada. Tunnicliffe is project director of VENUS, the Victoria Experimental Network Under the Sea. She's celebrating the February 25, 2006, birth of the network: on that date, she said, "all the final pieces were brought into place, and we started receiving data from ten instruments deployed in Canada's Saanich Inlet."

Measurements, images, and sound are being delivered to scientists, managers, and the public via seafloor fiber-optic cables laid along two Canadian seafloor sites: Saanich Inlet and the Strait of Georgia.

"VENUS is a marine research station, a public attraction in the ocean, and a classroom in the sea," said Tunnicliffe. "This pioneering approach to studying the oceans is delivering real-time information via the Internet to researchers and others across the country and around the world."

Multidisciplinary observations from the seafloor and water column are available continuously in real-time anywhere someone can access the Internet. Scientists can change or start measurements from their laboratories day and night, said Tunnicliffe, in response to events in the sea.

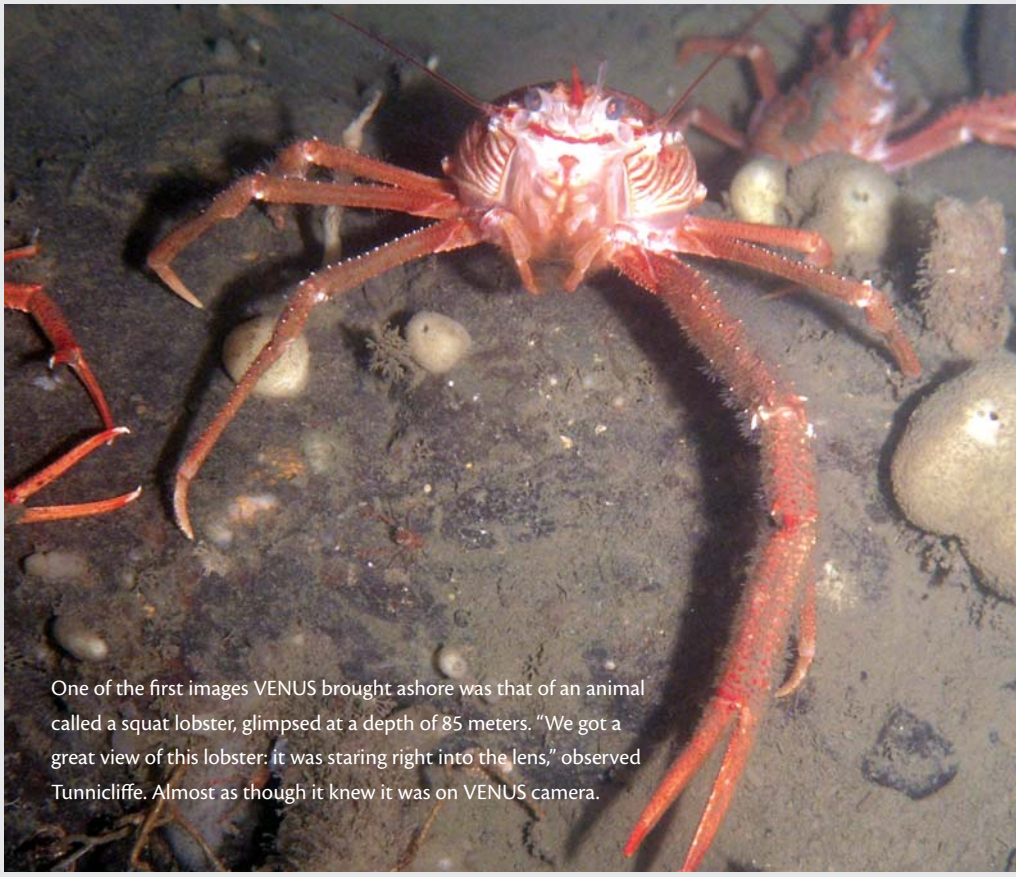
VENUS is composed of five parts, or elements: arrays of scientific instruments; fiber-optic cables on the seafloor; shore station interfaces for power and two-way communication to the instruments; a data management, archive, and distribution center; and an operations center to monitor and control seafloor and shore station interactions.

Two major VENUS instrument arrays continuously monitor the sea. One in Saanich Inlet just off the University of Victoria's Institute of Ocean Sciences is providing data on the physical and biological properties of the inlet. The second extends off Vancouver and supports research on physical and chemical oceanography, animal migrations, and the stability of the Fraser Delta in the Strait of Georgia, a busy Canada waterway.

In addition to advancing the understanding of the oceans, "VENUS is supporting development of marine technology in Canada, and providing viewers with an intimate look at the marine environment," said Tunnicliffe. "Data and images from VENUS are giving us new information about the ocean's response to storms, oil spills, and waste disposal, and helping us track marine mammals and monitor long-term climate change processes."

The concept for VENUS sprang from Canadian involvement with another undersea observatory project: NEPTUNE. "VENUS was set up to answer the need for better information about the ocean between Vancouver Island and the mainland," said Tunnicliffe. "The impetus, however, for a large, regional cabled observatory off North America is growing. VENUS provides a learning base for an effort like NEPTUNE."

Tunnicliffe and colleagues are showcasing VENUS images on the project's web site, www.venus.uvic.ca. "It's not that simple to turn electrons into plots for the web and construct storage files that someone can easily access. But now, no matter where you are on the planet, VENUS can be your eye in the depths of Saanich Inlet."



One of the first images VENUS brought ashore was that of an animal called a squat lobster, glimpsed at a depth of 85 meters. "We got a great view of this lobster: it was staring right into the lens," observed Tunnicliffe. Almost as though it knew it was on VENUS camera.

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