duration and course of their migratory routes. No one knows their population size, although the International Union for the Conservation of Nature (IUCN) lists them as vulnerable. Even their maximum size is unknown, although their average length is thought to be between 5 to 8 meters.

What is known is that their spectacular size and gentle nature make them popular with divers and their long, graceful, gray bodies—peppered by thousands of white spots—make them particularly photogenic. Norman took that into account when, as part of his master's research, he developed a technique for identifying individual sharks using the pattern of lines and spots on their skin. He created a library that enabled him to confirm resightings of sharks at Ningaloo Marine Park. Although it was effective, the technique was incredibly time-consuming because he had to match every photo by eye.

Looking at whale sharks, Holmberg realized, was not unlike looking at the pattern of stars in the sky. So he contacted his friend Arzoumanian, an astrophysicist with the Universities Space Research Association at the National Aeronautics and Space Administration's Goddard Space Flight Center in Maryland.

"My initial reaction was that the pattern matching would be very hard. Even with flat images, automated pattern-matching techniques struggle with differences in orientation, contrast, and magnification between the two images," Arzoumanian said. "And I felt that the complication of curved surfaces would make things too difficult."

But another colleague, optical astronomer Gijs Nelemans, told Arzou-manian that star-pattern matching algorithms did exist. Holmberg and Arzoumanian eventually tracked down an algorithm written for the Hubble Space Telescope that fit their needs.

The algorithm doesn't directly match images. Instead, the positions of stars are defined with *x,y* coordinates which are then combined in triplets to form a series of triangles. Geometrically similar pairs of triangles, one from each image, are then identified and compared in an iterative process that recognizes the points found in multiple triangle pairs, indicating that they are common to both images. After a year of tinkering, the scientists had an algorithm that was able to match whale shark photograph pairs accurately in more than 90 percent of cases.

When the trio published their results in the British Ecological Society's *Journal of Applied Ecology* (1), they learned that whale sharks are not the only animals that might benefit from the pattern-matching algorithm. Spotted manta rays would be obvious candidates, but the technique could also work for others. Lions have a distinctly spotted muzzle, with each dot corresponding to the base of each whisker. And fishers, of the mustelid family, can be identified based on the pattern of dots on their paw prints.

But before Arzoumanian tinkers with the algorithm for other species, he has another assignment. For all the whale shark spots he's seen in photos, he's never seen the real thing. He and Holmberg have planned a trip to Honduras, to an area where whale sharks tend to be found. "This will be my first glimpse of a whale shark," he said. ❧

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BUSINESS

Live Rock

A NEW CASH CROP FOR THE AQUARIUM TRADE PROTECTS FIJI'S REEFS

MANY VILLAGERS IN THE ISLAND nation of Fiji earn cash by planting sugar cane. But residents of Tagaqe are growing something different: live rock. Not the loud music variety, but a critical component in saltwater aquaria. When villagers suspend porous rocks in the rich waters of the Fijian reef, the rocks are colonized by living invertebrates and coralline algae. After just eight months, the rocks can be harvested and sold as cultured live rock to aquarium markets around the globe.

The Fijian rock farmers are part of a new effort to develop an alternative to the traditional method of prying live rock from the delicate reef using crowbars. Fiji is the world's largest supplier of live rock. In 2001, the International Coral Reef Action Network estimated that Fiji-based aquarium suppliers

Photo by Make Liku Movono, courtesy University of the South Pacific

Researchers from the University of the South Pacific in Suva, Fiji, and the Georgia Institute of Technology in Atlanta have been working with villagers in Tagaqe, Fiji, to develop the cultured live rock project. The crop of synthetic coral reef substrate becomes naturally covered by desirable algal species. The first crop was harvested in 2005.

airfreighted 1.9 million kilograms of live rock—enough to fill the equivalent of 48 Boeing 747-400 jumbo jets. At the same time, the Fijian government warned that 3 percent of the reefs around the country's largest island, Viti Levu, had already been damaged or removed as a result of the explosive growth in the country's coral and live rock trade.

But Fijian villagers need cash to supplement their partly subsistence lifestyle. In response, researchers from the University of the South Pacific and the Georgia Institute of Technology began working with villagers in Tagaqe to develop the cultured live rock project. The process itself isn't new; porous limestone rubble has been cultured for several years in the reefs off Florida after a live rock-harvest ban was enacted in the 1990s. What's special about the Fiji project is that it provides a workable cash crop for villagers while providing them with incentives to conserve the reef itself.

"This is economic development, coastal management, conservation, and aquaculture all mixed together," said Terry Snell, a biologist at the Georgia Institute of Technology who is working with the project.

Fears that the Fijian government might shut down the live rock export business prompted early efforts by Walt Smith International, largest of Fiji's six aquarium supply companies, to culture live rock. The company tested the approach now being used by Tagaqe villagers. Pumice, which is porous and regularly washes up on Fijian beaches, was cemented into plate-sized doughnut shapes that could be strung on a cable anchored to the reef. Tending the rock took little maintenance, other than removing unwanted algae. The real challenge was convincing villagers to try the approach: many were leery of a technique that was being promoted by a commercial industry.

That's when William Aalbersberg, director of the University of the South Pacific's Institute of Applied Science became involved with Snell and his colleagues from the Georgia Institute of Technology. Aalbersberg had been working with Fijian villages for nearly a decade to promote reef conservation. The Georgia Tech group came to Fiji in 2004 to study the reef and its organisms in a search for compounds that might have medicinal or other values. Both groups agreed that finding an alternative to the existing live rock harvest made sense. Culturing live rock seemed like a perfect fit: villagers could make money from their reefs without destroying them.

Together, Aalbersberg and the Georgia Tech scientists began the process of identifying villages and negotiating with local chiefs to implement the aquaculture experiment. Because local villages control the marine resource rights in the waters adjacent to their villages, the only way to bring projects to communities is to speak to individual village chiefs. Tagaqe's Chief Ratu Ti-

moci Batireregu agreed in the summer of 2004 to try out the project. Walt Smith International helped by agreeing to purchase the artificial live rock and market it as a "green" product.

Under the agreement, Tagaqe villagers were given 5,000 pumice blanks, worth about US$2,000. After eight months, the blanks were harvested and sold for about US$4,000, of which half has been reinvested in new blanks to keep the project going. In contrast, a full-time harvester collecting "natural" live rock would be paid US $3,750 a year for 7,500 kilograms of rock. The income from the pilot program clearly isn't enough to supplant the income a full-time harvester makes, but the Georgia Tech group has also signed a bioprospecting agreement with Tagaqe that will eventually bring more income to the village.

Because some communities simply don't have the funding to buy the blanks, Aalbersberg and the Georgia Tech group are planning to provide start-up funds for another five villages.

The Georgia Aquarium, which opened in October 2005 and is the largest aquarium in the U.S., decided to purchase from the Fijian project all 50 metric tons of the live rock needed for its coral tank. Dave Santucci, spokesman for the aquarium, said the cultured live rock was an important part of the aquarium's overall conservation message. "We don't strip live rock from the wild," he said.

Snell, Aalbersberg, and other Georgia Tech scientists visited the aquarium shortly after it opened to see their efforts at work. The live rock covers the bottom of an enormous coral tank exhibit full of brightly colored fish. The 625,000-liter, irregularly shaped tank holds roughly a quarter of the volume of water that would fill an Olympic swimming pool. "Everyone was oohing and aahing over the tropical fish," Snell said. "But we were all just looking at the live rock." ❧

Border Control

WILDLIFE INTERPOL CRACKS DOWN ON ORGANIZED CRIME

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Phoeurk Sar, a 50-year-old Cambodian woman, used a bus ride to the Vietnamese border to ferry her contraband cargo. Her luggage bulged with four endangered Sunda pangolins, curled up big and round as bowling balls, along with 11 Asian soft-shelled turtles, a king cobra, and a rat snake. The acting mayor of Nonthaburi, Thailand, found a different way to transport his illegal catch. He and seven other people were arrested with 410 pangolins hidden in a shipment of coconuts. Then there was the Royal Cambodian Armed Forces soldier whose checked luggage at the Phnom Penh International Airport included a cardboard box with a baby Malaysian sun bear.

Every day, pangolins, turtle eggs, tiger penises, and clouded leopard skins are freighted illegally across borders in Southeast Asia on their way to markets in China or brought to the free port of Singapore, where they can be shipped anywhere on the planet. It's part of an enormous illicit wildlife trade that is valued at US$5-8 billion per year and ranked just behind drugs and arms smuggling in its enormity. Southeast Asia's spectacular biodiversity and long, porous borders make it the globe's hot spot for wildlife trade. But current country-by-country law-enforcement efforts have halted only a fraction of the problem.

The ten countries of the Association of Southeast Asian Nations are hoping they can staunch their losses with the Wildlife Enforcement Network, the brainchild of Thailand's Prime Minister, former policeman Thaksin Shinawatra. Launched in 2005, the Wildlife Enforcement Network is a regional law-enforcement group patterned after Interpol, the international police organization that allows its 184 member countries to