The Bluefin in Peril

The only way to save the bluefin tuna, one of the most marvelous and endangered fish in the ocean, may be to domesticate the species

By Richard Ellis

CHRIS PARK *AP Photo*

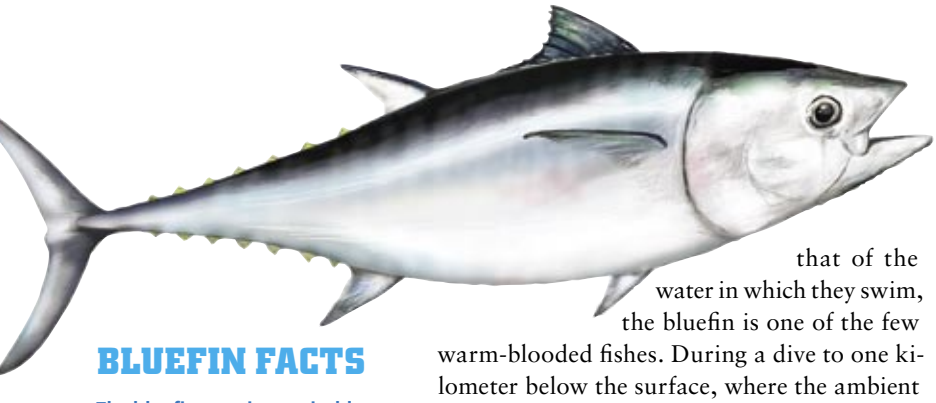
All tuna are not alike. The canned tuna fish in sandwiches and salads comes from either skipjack, a meter-long species that is caught in prodigious quantities around the world and served as "light meat tuna," or albacore, another small fish that is marketed as "white meat tuna." The yellowfin and the bigeye tuna are larger species that are also heavily fished, but neither makes for particularly wonderful sushi, and they are usually served grilled. But the bluefin tuna, a giant among fishes, is the premier choice for sushi and sashimi and has become the most desirable food fish in the world. As such, it has vaulted to the top of another, more insidious list: it is probably the most endangered of all large fish species. Heedless overfishing is steadily pushing the bluefin toward extinction, and the species may soon disappear unless entrepreneurial fish farmers can learn how to breed the tuna in captivity.

Reaching a maximum known weight close to three quarters of a ton and a length of four meters, the bluefin is a massive hunk of superheated muscle that cleaves the water by flicking its scimitar-shaped tail. Whereas most of the approximately 20,000 fish species are cold-blooded, possessing a body temperature the same as

KEY CONCEPTS

- The surging popularity of sushi and sashimi has devastated the bluefin tuna. Overfishing has slashed populations in the Atlantic, Pacific and Indian oceans, pushing the species toward extinction. Regulatory bodies have failed to set sufficiently strict catch quotas, and illegal fishing is rampant.
- Captive breeding of the bluefin could save the species, but the effort will be challenging. Research groups in Japan and Europe have bred the tuna in laboratories, and now an Australian company is attempting to perform the feat on a commercial scale.

—The Editors



that of the water in which they swim, the bluefin is one of the few warm-blooded fishes. During a dive to one kilometer below the surface, where the ambient water temperature can be five degrees Celsius (41 degrees Fahrenheit), the bluefin can maintain a body temperature of 27 degrees C (81 degrees F), close to that of a mammal. The bluefin is also among the fastest of all fishes, capable of speeds up to 80 kilometers per hour and able to migrate across entire oceans. It is such a marvelous swimmer that when scientists in the 1990s endeavored to build a mechanical fish, they used the species as a model, designing a robot with a tapered, bullet-shaped body and a rigid, quarter-moon tail fin [see "An Efficient Swimming Machine," by Michael S. Triantafyllou and George S. Triantafyllou; Scientific American, March 1995]. The researchers found that the tail's efficiency lay in the interaction of the vortices created by its rapid flexing, but the hydrodynamics of their electronic models did not even come close to that of a true bluefin. "The more sophisticated our robotic-tuna designs become," the Triantafyllou brothers wrote, "the more admiration we have for the flesh-and-blood model."

Like wolves, bluefins often hunt in packs, forming a high-speed parabola that concentrates the prey, making it easier for the hunters to close in. Tuna are metabolically adapted for high-speed chases, but as opportunistic (and by necessity, compulsive) feeders, they will eat whatever presents itself, whether it is fast-swimming mackerel, bottom-dwelling flounder or sedentary sponge. A study of the stomach contents of New England bluefins by Bradford Chase of the Massachusetts Division of Marine Fisheries revealed that the predominant food item, by weight, was Atlantic herring, followed by sand lance, bluefish and miscellaneous squid. (Other prey included butterfish, silver hake, windowpane flounder, winter flounder, menhaden, sea horses, cod, plaice, pollack, filefish, halfbeak, sculpin, spiny dogfish, skate, octopus, shrimp, lobster, crab, salp and sponges.) Tuna will eat anything they can catch, and they can catch almost anything that swims (or floats, crawls or just sits on the bottom). By and large, they hunt by vision.

BLUEFIN FACTS

The bluefin tuna is a veritable eating machine, superbly adapted to hunting in the cold waters of the temperate oceans.

Size: The largest bluefin ever recorded, caught off Nova Scotia in 1979, weighed **679 kilograms** (1,496 pounds). A typical adult weighs about half as much and measures **two meters** (six feet) long.

Speed: Bluefins can swim as fast as **80 kilometers per hour** in short bursts and can travel across the Atlantic Ocean in less than 60 days.

Reproduction: Females produce up to **10 million eggs a year.** Newborn fish (larvae) are three millimeters long at hatching and grow at a rate of one millimeter a day.

Life span: Bluefin larvae have only a one-in-40-million chance of reaching adulthood, but a mature tuna can live as long as **30 years.**

Price: In 2001 a 200-kilogram bluefin was purchased at a Japanese fish market for **$173,600,** or about $868 per kilogram ($394 per pound).

From Horse Mackerel to Sushi

The bluefin was not always considered a delicacy. In the early 1900s the fish was known as "horse mackerel," and its red, strong-flavored flesh was considered suitable fare only for dogs and cats. Nevertheless, big-game fishers off New Jersey and Nova Scotia targeted the bluefin because these powerful fish were considered worthy opponents. Zane Grey, the popular author of Western novels such as *Riders of the Purple Sage,* invested most of his not inconsiderable royalties (his books sold more than 13 million copies) on fishing gear, boats and travel to exotic locales in search of tuna, swordfish and marlin. Although swordfish were certainly considered edible, tuna and marlin were thought of as strictly objects of the hunt. The bluefin did not become valuable as a food fish until the latter half of the 20th century, when sushi began to appear on menus around the globe.

One might assume that sushi and sashimi have been staples of the Japanese diet for centuries, but in fact the widespread consumption of raw fish is a relatively modern phenomenon. Dependent on the sea to provide the great majority of their protein, the Japanese could not store fish for any length of time before it spoiled, so they preserved it by smoking or pickling. But when refrigerators were introduced to postwar Japan, fish that once were smoked or pickled could now be stored almost indefinitely. As the fishing industry adopted new technologies such as longlining (using extremely long lines with many baited hooks), purse seining (deploying large nets that can enclose an entire school of fish) and onboard freezers, the circumstances became propitious for an unprecedented modification of Japanese eating habits. The bluefin tuna changed from a fish that samurai would not eat because they believed it was unclean, to *maguro,* a delicacy that can be as expensive as truffles or caviar. *Toro,* the best quality *maguro,* comes from the fatty belly meat of the adult bluefin. Truffles or caviar are expensive because they are rare, but bluefin tuna, previously perceived as inedible, could be found in huge offshore schools and soon became an internationally exalted menu item. In 2001 a single bluefin tuna sold at the Tsukiji fish market in Tokyo for $173,600.

In America—where the thought of eating raw fish was anathema 40 years ago—sushi and sashimi have become commonplace, sold in supermarkets, delis and high-end restaurants. Perhaps the grandest temple to sushi in the U.S. is Masa, a New York City restaurant opened in

LUCY READING-IKKANDA

▲ OVERFISHING of the bluefin tuna is particularly severe in the Mediterranean Sea. In southern Spain, a group of tuna fishers raises a net full of bluefins (*above*) and brings the heap of giant fish to shore (*right*).

AMERICAN MUSEUM OF NATURAL HISTORY (*Ellis*); NEIL LUCAS *Nature Picture Library* (*fishing photographs*)

2004 by Japanese chef Masayoshi Takayama. With a prix fixe of $350 (excluding tax, tips and beverages), Masa immediately became the most expensive restaurant in the city; a lunch or dinner for two can easily exceed $1,000.

It stands to reason that a fish that can be sold for hundreds of dollars a slice is going to attract fishing fleets. The pell-mell rush to provide tuna for the Japanese sushi and sashimi markets has—not surprisingly—intensified tuna fishing around the world. The Japanese tried to fill their larders (and freezers and fish markets) with tuna that they could catch off their own shores (this would have been the Pacific bluefin, *Thunnus orientalis*), but they soon observed that the bluefins were larger and more plentiful in the North Atlantic. The buyers for Japanese fish importers became a familiar sight at the docks of American ports such as Gloucester and Barnstable in Massachusetts, ready to test the tuna for fat content and, if they passed, buy the fish on the spot and ship them to Japan.

At one time, researchers believed that there were two separate populations of North Atlantic bluefins (*Thunnus thynnus*), one that bred in the Gulf of Mexico and stayed in the western Atlantic and another that spawned in the Mediterranean and foraged in the eastern part of the ocean. The International Commission for the Conservation of Atlantic Tunas (ICCAT), a regulatory body established in 1969, based its catch quotas for the bluefin on this two-population concept, setting strict limits in the western Atlantic (where bluefin were becoming scarce as early as the 1970s) while allowing much larger catches in the eastern Atlantic. But tagging experiments—pioneered in the 1950s and 1960s by Frank J. Mather and Francis G. Carey of the Woods Hole Oceanographic Institution and refined in recent years by Barbara A. Block of Stanford University's Hopkins Marine Station—showed that the bluefin confounds the conventional wisdom. The Gulf of Mexico and the Mediterranean are indeed the breeding areas of the North Atlantic bluefins, but individual fishes can migrate across the ocean, and the foraging grounds of the two populations overlap. Because ICCAT has failed to stop overfishing in the eastern Atlantic, bluefin stocks have collapsed throughout the ocean.

If possible, things are worse in the Mediterranean. Employing ideas and technology originally developed in South Australia (with the southern bluefin, *Thunnus maccoyii*), fishers corral schools of half-grown tuna and tow them in floating pens to marine ranches where they are fed and fattened until they can be killed and shipped to Japan. There are rules banning fishing fleets from taking undersize tuna out of the Mediterranean, but none that prevent catching immature tuna and fattening them in floating pens. Every country on the Mediterranean (except Israel) takes advantage of this loophole and maintains tuna ranches offshore. The fishers from Spain, France, Italy, Greece, Turkey, Cyprus, Croatia, Egypt, Libya, Tunisia, Algeria,

[THE AUTHOR]

One of America's leading marine conservationists, **Richard Ellis** is generally recognized as the foremost painter of marine natural history subjects in the world. His paintings of whales have appeared in *Audubon, National Wildlife, Australian Geographic, Encyclopedia Britannica* and many other publications. His books include *The Book of Whales, The Book of Sharks, Imagining Atlantis* and *The Empty Ocean.* Ellis is a special adviser to the American Cetacean Society, a member of the Explorers Club and a research associate at the American Museum of Natural History in New York City. From 1980 to 1990 he was a member of the U.S. delegation to the International Whaling Commission. He is currently working on a book about tuna and serving as co-curator of the "Mythic Creatures" exhibit for the American Museum of Natural History.

▲ FISH BUYERS inspect the bluefin carcasses on sale at the Tsukiji wholesale market in Tokyo. This fish market was the site of the record purchase in 2001, when a single bluefin sold for 20.2 million yen, or about $173,600.

SUSHI HISTORY

The insatiable demand for sashimi (sliced raw fish) and sushi (rice topped or rolled with fish or vegetables) is the primary threat to the bluefin tuna.

Fourth Century B.C. Sushi originates in Southeast Asia as a method for preserving fish. Fermentation of the rice prevents the fish from rotting. The cuisine arrives in Japan in the eighth century A.D.

1800s Nigiri sushi, in which the fish is eaten raw rather than preserved, is popular in the market stalls of Edo, now known as Tokyo. But raw fish does not become a Japanese staple until the widespread adoption of refrigeration after World War II.

1970s to the Present Sushi consumption explodes in the U.S., but only high-end restaurants serve bluefin; most tuna sushi in America comes from the yellowfin or bigeye species (which are also threatened). The vast majority of bluefin is still consumed in Japan.

Morocco and Malta are capturing half-grown tuna by the hundreds of thousands. If you had to design a way to guarantee the decimation of a breeding population, this would be it: catch the fish before they are old enough to breed and keep them penned up until they are killed. The tuna ranches, once seen as a solution to the problem, are only making it worse. In 2006 the World Wildlife Fund called for the cessation of all tuna fishing in the Mediterranean, but given the tremendous financial rewards of the status quo, you can imagine how effective this plea was. At its meeting last November, ICCAT ignored the arguments of conservationists and set the 2008 quotas at approximately the same levels as 2007. The organization adopted a plan to scale back Mediterranean tuna fishing by 20 percent by 2010, with further reductions to follow, but the head of the U.S. delegation decried this half-measure, saying that ICCAT had "failed to live up to its founding mission."

Even if lower quotas were in place, however, the bluefin would still be imperiled. The tuna fishery is rife with illegal, unregulated fleets that ignore quotas, restrictions, boundaries, and any other rules and regulations that might threaten their catch. Furthermore, the Japanese market—which devours about 60,000 tons of bluefin every year, or more than three quarters of the global catch—is only too eager to buy the tuna, regardless of where or how it is caught. Japanese fishers have contrived to circumvent even their own country's restrictions, bringing in thousands of tons of illegal tuna every year and then falsifying their records. It would be good for the tuna and, in the end, good for the consumer if tuna fishing was not practiced in such a remorseless manner, but such change would entail nothing less than a modification of the fundamentals of human nature. As the tuna populations continue to fall, the Japanese demand for *toro* is increasing; fewer tuna will mean higher prices, and higher prices will mean intensified fishing. Intensified fishing will, of course, result in fewer tuna. (All bets would be off if the Japanese somehow relaxed their demand for *maguro,* but that seems as likely as Americans giving up hamburgers.) It appears that the only hope for the bluefin is captive breeding.

Cattle of the Sea

In an article entitled "When Will We Tame the Oceans?" that appeared in *Nature* in 2005, John Marra, a biological oceanographer at Columbia University's Lamont-Doherty Earth Observatory, observed that "fishing in the ocean is no longer sustainable. Worldwide, we have failed to manage the ocean's fisheries—in a few decades, there may be no fisheries left to manage." His recommendation? A large-scale domestication of the ocean—with fish farmers breeding, raising and harvesting commercially valuable species. Marra acknowledged that existing fish farms have harmed the environ-

COURTESY OF RICHARD ELLIS (*fish market*); DEX IMAGE/CORBIS (*sashimi*)

ment, polluting coastal ecosystems and putting additional pressure on wild fish populations by spreading disease and toxic chemicals. His solution is to move these so-called mariculture operations farther offshore, to the waters of the outer continental shelves, and to deploy much larger fish pens (closed net structures containing as much as 100,000 cubic meters of water) that could be floated below the surface and towed from one destination to another. This strategy would at least disperse the pollutants generated by fish farming, mitigating the environmental damage.

Marra also suggested taking advantage of the inclination of certain tunas to aggregate under an object that is significantly different from their surroundings. This propensity has already been exploited by fishers in the design and implementation of fish-aggregating devices, which are towed behind boats to attract schools of tuna. Instead of netting all the fish at once, though, fish farmers could create a sustainable business by feeding, maintaining and periodically harvesting some of the tuna in the school, handling the fish in much the same way that ranchers on land manage herds of cattle.

Unless tuna can be raised as if they were domesticated animals, their world populations will continue to crash. Breeding the bluefin in captivity, however, is a major challenge. One company that is attempting this feat is Clean Seas Aquaculture Growout, owned by the Stehr Group in Port Lincoln, South Australia. The Australian government has provided Clean Seas with a grant of 4.1 million Australian dollars ($3.4 million) to assist in the commercialization of southern bluefin breeding. The company has already raised captive-bred yellowtail kingfish (*Seriola lalandi*) and mulloway (*Argyrosomus hololepidotus*), which are now in significant commercial production. In October 2006 Clean Seas airlifted southern bluefin broodstock (sexually mature males and females) from their pens to a three-million-liter (790,000-gallon) tank that had been designed to replicate the optimum conditions for spawning. Hagen Stehr, founder of the company, said in a 2006 interview in *The Australian*, "We've got it all on computer, we can make [the tank] lighter or darker, we can leave the fish in a state of well-being, we've got the sun going up, the sun going down.... This is a world first, the Japanese won't try it at all, the Americans have tried it and failed and the Europeans have failed too."

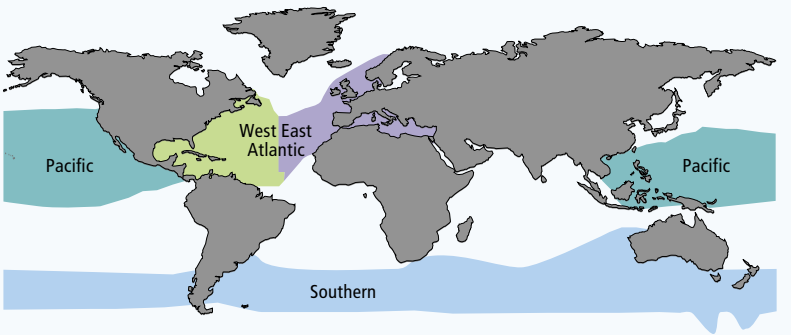
During my February 2007 visit to Port Lincoln, Rob Staunton, the farm manager for the Stehr Group, drove me to Arno Bay, 120 kilometers north of Port Lincoln, on the western shore of Spencer Gulf. I was granted limited entrée into the holy grail of the tuna business, the giant enclosed tuna tank at the Arno Bay hatchery. I say "limited" because my visit, personally sanctioned by Stehr himself, came with severe restrictions,

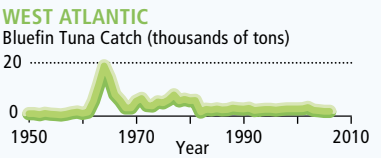
[THE BIG PICTURE]

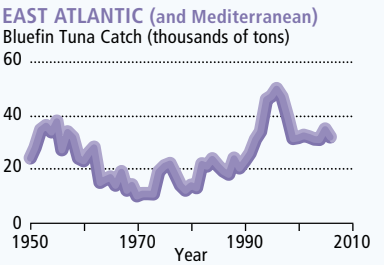
A WORLDWIDE DEPREDATION

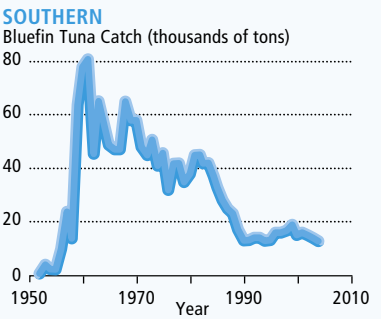
Fishing fleets have extracted so many thousands of tons of bluefin tuna from the world's oceans that the species now faces extinction. The bluefin appears to be in the greatest peril in the West Atlantic. Despite the fact that the International Commission for the Conservation of Atlantic Tunas has imposed strict catch quotas in the West Atlantic since 1981, researchers estimate that the amount of sexually mature fish in that region (measured by their total mass) is less than 20 percent of what it was in the mid-1970s. Part of the problem is that bluefins from the West Atlantic migrate to the eastern part of the ocean, where the catch quotas are about 10 times higher. What is more, the reported catch figures (*graphs below*) do not include illegal fishing; some scientists believe the actual bluefin harvest in the East Atlantic and the Mediterranean Sea may be nearly twice as great as the reported data. Similar trends are shrinking the populations of the Pacific bluefin tuna and the Southern bluefins, which spawn in the Indian Ocean.

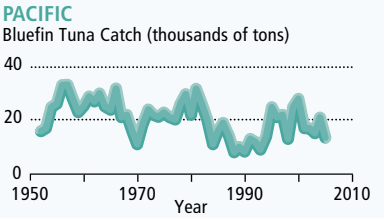
BLUEFIN TUNA GEOGRAPHIC DISTRIBUTION











LUCY READING-IKKANDA; SOURCE: FISHERIES AND AQUACULTURE DEPARTMENT, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

▲ TUNA PENS, which are accelerating the demise of the bluefin, are towed across the Mediterranean Sea to tuna ranches near Sicily (*top*). Each pen contains about 250 bluefins. Off the coast of Ensenada, Mexico, tuna ranchers feed schools of Pacific bluefins until they are fat enough to be sold (*middle*). The slabs of fresh tuna are sent to Los Angeles International Airport, where they embark on non-stop flights to Japan. Inside a tuna pen in the Adriatic Sea off Croatia, a diver swims with the doomed bluefins before they, too, are shipped to Japan (*bottom*).

all of which are perfectly understandable. No photography is allowed in the facility itself, because the engineering, water processing, climate control and every other element in the design of this potential miracle must be carefully safeguarded to prevent corporate theft of the ideas. Along with the grant from the Australian government, the Stehr Group has invested millions in the innovative design of this facility, and it would be a disaster if someone borrowed or modified their designs and somehow beat them to the punch. It is hard to imagine anybody replicating this massive operation without all of Australia knowing about it, but of course, entrepreneurs in other countries—Japan, for instance—are also very interested in the business of captive-breeding bluefin tuna. Indeed, Japanese scientists at Kinki University have already hatched bluefin tuna from eggs and raised them to breeding age in the laboratory but not on the commercial scale being attempted by Clean Seas.

To begin our tour, Staunton and I had to change into special white rubber boots, sterilized to prevent the introduction of alien microbes into the tanks where the bluefin tuna are nurtured. Chaperoned by Thomas Marguritte, the Frenchman-turned-Australian who manages the facility, we exchanged our white boots for blue ones as we entered the sanctum sanctorum of the Arno Bay hatchery, the tuna-breeding tank. In a cavernous room illuminated by a battery of fluorescent lights, with the quiet hum of air-conditioning as the only background noise (the temperature outside was near 38 degrees C, or 100 degrees F), we climbed up to the concrete rim of the vast tank and looked down.

The tank is about 25 meters in diameter and six meters deep, and because the light level was fairly low, we could see very little until Marguritte tossed in a couple of small fish. Suddenly the surface broke with an ultramarine and chrome flash as one of the tuna charged at the baitfish. The tank came alive with froth, pierced by the sicklelike dorsal and tail fins of the tuna, which were anticipating a meal even though, as our docent explained, they had been fed only an hour before. As they circled excitedly underneath us, we could see that these were breeding-size bluefins: 300 kilograms of sleek, polished torpedo, pointed at both ends, with a dotted line of yellow finlets just before the tail, and the startling parentheses that mark the species' horizontal keels, chrome yellow in the southern bluefin and black in the northern varieties. No one can tell a live male from a live female except another tuna.

GAVIN NEWMAN *AFP/Getty Images (top)*; CHRIS PARK *AP Photo (middle)*; AFP/GETTY IMAGES (*bottom*)

Poised on the rim of the tank, we talked about the breeding program. "We can replicate the exact conditions in Indonesian waters where they are known to spawn naturally," Marguritte said. "If they usually spawn in the Southern Hemisphere summer when the days are longest and the water temperature is highest, we can make this tank conform to—pick a date, say, November 20—and set the length of daylight hours, air temperature, water temperature and even currents to conform to that moment in the Indian Ocean, south of the Indonesian archipelago." The only variable they cannot duplicate is the depth of the water, and they are praying that it is not a critical factor in the breeding of the southern bluefin. Just south of the Indonesian arc of islands—Java, Bali, Flores, Sumba, Komodo, Timor—is the Java Trench, which descends to one of the deepest points in the Indian Ocean, nearly eight kilometers down. If depth is a factor, the Clean Seas project is doomed. The broodstock at Clean Seas did not produce offspring in 2007, but they will try again this spring.

▲ ACTIVISTS from Greenpeace, the global environmental group, staged a protest at a Mediterranean beach in southern Turkey last November to coincide with the annual conference of the International Commission for the Conservation of Atlantic Tunas, which was held in that country. Ignoring the calls for an immediate cessation of bluefin fishing in the Mediterranean, the regulatory body adopted a plan that called for modest reductions of catch quotas over the next few years.

GREENPEACE/HO *AP Photo*

Taming the Bluefin

At the Clean Seas conference room in the Port Lincoln headquarters, I met with Marcus Stehr, Hagen's 42-year-old son and the managing director of the company. The day before, Marcus had been onboard one of the company's purse seiners in the Great Australian Bight, the huge open bay off the continent's southern coast, as a net cage containing perhaps 100 tons of tuna started on its journey to the pens off Port Lincoln. Like everyone else associated with this venture, Marcus is enthusiastic and optimistic about the potential for success and believes it is imminent. When I asked him if that success would completely change the way bluefin tuna are perceived in Australia, he said, "It's not a question of *if,* mate—it's *when.*"

Although the Aussies appear to be in the lead, it remains to be seen if they, the Japanese, or the Europeans will win the race to breed the bluefin in captivity. In 2005, for example, a research team at the Spanish Institute of Oceanography in Puerto de Mazarrón, Spain, successfully retrieved eggs and sperm from captive Atlantic bluefin broodstock, performed in vitro fertilization and produced larvae. (The hatchlings of bony marine fishes are called larvae because they look so different from the adults.) Somehow or other, it has to happen, because the survival of the species—and the tuna industry—depends on it.

The big-game fisher sees the bluefin tuna as a sleek and powerful opponent; to the harpooner, it is an iridescent shadow below the surface, flicking its scythelike tail to propel it out of range; the purse seiner sees a churning maelstrom of silver and blue bodies to be hauled onboard his boat; the long-liner sees a dead fish, pulled onto the deck along with many other glistening marine creatures; the tuna rancher sees the bluefin as an anonymous creature to be force-fed until it is time to drive a spike into its brain; the auctioneer at the Tsukiji fish market in Tokyo sees row on row of tailless, icy, tuna-shaped blocks; Japanese consumers see it as *toro,* a slice of rich red meat to be eaten with wasabi and soy sauce; to the biologist, the tuna is a marvel of hydrodynamic engineering, its body packed with modifications that enable it to outeat, outgrow, outswim, outdive, and outmigrate any other fish in the sea; and to those who wish to rescue *Thunnus thynnus* from biological oblivion, it has to be seen as a domesticated animal, like a sheep or a cow.

For some, such a shift is almost impossible to contemplate; the bluefin tuna, the quintessential ocean ranger, the wildest, most powerful fish in the sea, cannot be—and probably *should* not be—tamed. But if it remains wild, the future looks bleak for the *maguro* industry—and for the great bluefin tuna. ■

➡ MORE TO EXPLORE

Giant Bluefin. Douglas Whynott. North Point Press, 1995.

Song for the Blue Ocean. Carl Safina. Henry Holt and Company, 1997.

Rapid Worldwide Depletion of Predatory Fish Communities. Ransom A. Myers and Boris Worm in *Nature,* Vol. 423, pages 280–283; May 15, 2003.

Dollars without Sense: The Bait for Big-Money Tuna Ranching around the World. John P. Volpe in *BioScience* Vol. 55, No. 4, pages 301–302; April 2005.

Electronic Tagging and Population Structure of Atlantic Bluefin Tuna. Barbara A. Block et al. in *Nature,* Vol. 434, pages 1121–1127; April 28, 2005.

The Sushi Economy. Sasha Issenberg. Gotham, 2007.