



## MARINE BIOLOGY

# Persevering Researchers Make a Splash With Farm-Bred Tuna

A 30-year effort has paid off in raising bluefin tuna in captivity, but the benefit for wild stocks of the embattled predator may be years more away

**OHSHIMA, JAPAN**—With a snap of its jaws, a meter-long bluefin tuna grabs a fish tossed into its circular enclosure and darts away in murky Kushimoto Bay. “They’re excellent swimmers,” says Yoshifumi Sawada, a fisheries biologist at Kinki University’s Ohshima Experiment Station, as he shovels fish into the water. The note of pride in his voice is understandable: The bluefins in the pen are the product of a 30-year effort to rear second-generation captive tuna—something no other group in the world has accomplished. It’s “a magnificent achievement,” says Daniel Pauly, a fisheries biologist at the University of British Columbia, Vancouver.

The feat could hold vital significance for one of the ocean’s keystone predators. In recent decades, the bluefin tuna’s succulent belly meat has become the favorite of sushi and sashimi aficionados, driving the price sky high. Tunas auctioned at Tokyo’s Tsukiji fish market routinely fetch tens of thousands of dollars; in 2001, a prize 202-kilogram specimen sold for an astounding ¥20.2 million, or roughly \$1000 per kilogram.

To satiate rising demand, dozens of tuna farms have sprung up off Japan’s coasts. Each year, Japanese fishers capture 300,000 to 400,000 young bluefins from the open ocean and fatten them in pens before shipping them off to wholesalers. But removing juveniles from the wild has only increased pressure on the heavily fished species, leav-

ing some populations on the brink of collapse (see sidebar).

The bluefin’s eccentricities have contributed to its downfall. “The bluefin tuna has habits that are completely wrong for species survival,” says Gary Sakagawa, a fisheries biologist at the U.S. National Oceanic and Atmospheric Administration’s Southwest Fisheries Science Center in San Diego, California. For instance, young tuna congregate in coastal areas in spring and summer as they feed on schooling fish, making them easy prey for fishers, Sakagawa says.

The researchers at Kindai, as the university is known locally, hope their breakthrough will give wild tuna a reprieve. “We want to supply all of the farmed bluefin tuna harvested in Japan,” says Sawada. They have a long way to go. This year, Sawada says they hope to sell up to 20,000

juveniles to fish farms, a small fraction of what’s needed. “This technology will take a while to have a positive impact on the conservation of tuna,” says Pauly.

Kindai’s tuna program started in 1970, when “it seemed Japanese were eating up all the world’s tuna,” says university trustee Hidemi Kumai, a fisheries biologist who led

◀ **“Magnificent achievement.”** Japan has broken through a key bluefin tuna breeding barrier.

the Kindai research for years. Concerned that the country would be blamed for depleting wild tuna stocks, Japan’s Fisheries Agency funded three groups, including one at Kindai, to try raising bluefin tuna from eggs.

As a private university with campuses scattered across a rugged peninsula that juts into the Pacific Ocean southeast of Osaka, Kindai emphasizes “practical studies” attuned to the needs of local agricultural and fishing communities, Kumai says. Kindai had already succeeded in raising yellowtail, sea bream, sole, and other fish from eggs. The university sells fry to farmers and harvests mature fish for the market, then sinks the proceeds into research.

The know-how gleaned from farming other fish, however, didn’t readily transfer to bluefins. “Tuna have many unique characteristics that make culturing them difficult,” says Sawada. For starters, bluefin tuna, one of the larger oceanic predators, are simply much bigger than other farmed fish. A half-century ago, before overfishing started to take its toll, 4-meter-long tuna tipping the scales at half a ton were common. These days, mature bluefins can exceed 2 meters in length and weigh 250 kilograms.

When it comes to captive breeding, more than size matters. Tuna, unlike most pelagic fish, are warm-blooded. And like some sharks, they must move continuously to force water over their gills; otherwise, they suffocate. “They swim all day, all through their lives,” Sawada says. Bluefins are built for both speed and endurance: They can accelerate as quickly as a sports car, and they crisscross the Atlantic several times a year. For these reasons, tunas require pens much bigger than those used for other captive fish.

It took the Kindai group 4 years to learn how to keep penned tuna alive longer than a few months. Then it took another 5 years, until 1979, to get them to spawn. That was a world first, Kumai says, but his team couldn’t keep the spawned fish alive. Then, for more than a decade, they couldn’t get captive tuna to spawn at all.

Facing similar difficulties, the two competing research groups gave up, and Kumai worried that Kindai’s program would get the ax. At one point, he confessed to Kindai’s



**Tuna kahuna.** Fisheries biologist Yoshifumi Sawada.

president that his team had “no results despite spending a lot of money.” “The president said to me, ‘You have to take the long view when considering living creatures,’” Kumai recalls. With such encouragement, he says, the group resolved to “succeed in this project at any cost.” (The price of success is hard to quantify, he says, as the Fisheries Laboratory, with an annual budget of about \$25 million, doesn’t itemize expenses by project.) Finally, in 1994 their captive tunas spawned again.

Through sheer persistence, the team has gained a trove of information about tuna biology. Postmortems on dead juveniles revealed that many fish were snapping their necks by swimming into the walls of the square enclosures. Such injuries tapered off after fish passed their 80th day. In juvenile tuna, the tail fin, used for propulsion, develops more quickly than the pectoral and abdominal fins, which adults use to steer and brake, Kumai says. “The only thing [juvenile] tuna can do is dash straight ahead,” he says. To reduce the number of deadly collisions, the researchers switched to circular enclosures.

After numerous other tweaks to rearing techniques, the Kindai team eventually bred mature fish. Six fish spawned in 1995, and 16 from the class of 1996 survived to adulthood. Those fish spawned in 2002, and Kindai is now rearing the third generation. “We’ve completed the life cycle,” Kumai says. That, says Sakagawa, “gives us some idea what may be going on in nature.” The Kindai group has identified behavioral triggers for spawning and clarified that the time of first spawn is more closely related to size than age. The group acknowledges that they still have a lot to learn. Kumai figures they get mature fish from only about 1% of eggs, compared with 60% for sea bream.

The Kindai group now hopes to develop an attractive product. They are selectively breeding tuna for fast growth, disease resistance, and higher-quality meat, Sawada says. The group does not plan to genetically engineer tuna out of concerns about unforeseen consequences if fish were to escape into the wild. But they are introducing the use of molecular markers, small DNA fragments that identify desirable traits, says Yasuo Agawa, a molecular biologist who cut his teeth on *Drosophila* and recently joined the Kindai team. Pauly, however, worries that the feed requirements of scaled-up tuna farming could harm wild stocks of feed fish, many of which are a staple for people in developing countries.

That might be avoided if the Kindai group’s most ambitious plan succeeds: to

## Scientists Get No Respect From Fishery Managers

Last June, when a scientific panel met to review the health of the bluefin stock in the East Atlantic and Mediterranean, they were miffed to find they had so little to go on. Only three of 48 member countries and regions of the International Commission for the Conservation of Atlantic Tunas (ICCAT) had reported 2007 catch data. Despite that handicap, the ICCAT advisory panel gleaned that the situation was grave: The 2007 bluefin catch, they estimated, was roughly 61,000 tons—more than double ICCAT’s limit.

In its report,\* the Standing Committee on Research and Statistics warned that overfishing “will most probably lead to further reduction in spawning stock biomass with high risk of fisheries and stock collapse.” To forestall that disaster, the scientists recommended that ICCAT set a quota of 15,000 tons starting in 2009. ICCAT’s response: quotas of 22,000 tons in 2010, 19,950 tons in 2011, and 18,500 tons in 2012. “Even in 3 years, the quotas will be higher than what scientists recommended the quotas be immediately,” fumes Rebecca Lent, an economist in charge of international affairs for the U.S. National Oceanic and Atmospheric Administration’s National Marine Fisheries Service.

ICCAT’s problems run deeper than quota

\*[www.iccat.int/Documents/Meetings/Docs/2008\\_SCRS\\_ENG.pdf](http://www.iccat.int/Documents/Meetings/Docs/2008_SCRS_ENG.pdf)

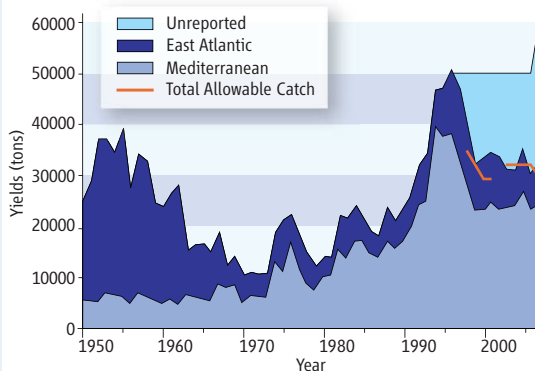
transform their captives into vegetarians. Sawada says they intend to gradually substitute plant protein for fish feed, in part to improve the program’s sustainability. Pauly, for one, is skeptical. “This is where these plans veer off into science fiction,” he says. He notes that despite decades of trying, the Norwegian salmon industry has not weaned farmed salmon off a fish diet.

It is unclear what impact the landmark breeding success might have on wild tuna stocks. Sakagawa worries that replacing fish caught for farms with juveniles raised from eggs might simply expand the market, as happened when Australian fisheries started pen-rearing captured Southern Pacific

setting. In a September 2008 report, an independent review panel chaired by Glenn Hurry, CEO of the Australian Fisheries Management Authority in Canberra, concluded that ICCAT’s management of bluefin tuna fisheries for sustainable fishing “is widely regarded as an international disgrace.”

In response to an e-mail asking for comment on the catch quotas, ICCAT Assistant Executive Secretary Victor Restrepo wrote, “We abstain from interpreting how or why the

### Reported Catch



**Under the radar.** By official numbers, East Atlantic and Mediterranean bluefin tuna catches have declined, but unreported catches have soared.

Commission makes decisions.” He added that a meeting on ICCAT’s future planned for next August will address questions raised by the review panel.

Stock mismanagement hasn’t yet dealt a crippling blow to bluefin stocks in the Western Atlantic and the Pacific. Although stock assessments are clouded by gaps in the data, scientists recommended there be no increase in Pacific bluefin catches above the current 23,000 tons a year. This covers taking mature tuna but not capturing juveniles for pen-fattening. **—D.N.**

bluefins. He says he appreciates Kindai’s contributions to understanding tuna reproductive biology. However, Sakagawa says, “I don’t think it’s a solution for conservation of wild stocks.”

Toward that end, Japan’s Fisheries Research Agency is working to raise tuna from eggs for release. To have an impact on natural populations, a restocking effort would have to be massive—and “many issues need to be solved before [we can] start to release tuna,” says agency official Kazumasa Ikuta. But as the Kindai team has demonstrated in their decades-long effort to breed tuna, patience is a virtue.

**—DENNIS NORMILE**