Atlantic bluefin's comeback reveals an ocean-spanning mix that could upend how this iconic fish is managed

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Researchers Steve Wilson and Robert Schallert tagging an Atlantic bluefin tuna off Nova Scotia. Credit: Brian Skerry

Atlantic bluefin tuna, the largest of all tuna species, declined

precipitously toward commercial collapse in the early 2000s after decades of overfishing. The species has since rebounded across most of its range, a recovery experts credit to tighter international management, including reduced catch limits in the Mediterranean Sea.

A new study of the ocean giant's migratory biology reveals a hidden driver for the comeback: Many bluefin tuna of eastern origin prefer to forage off the coasts of the United States and Canada. Decades of strict catch limits off North America created a partial refuge where bluefin tuna from across the Atlantic came to feed, grow, and in some cases spawn, according to the April 20 study published in the *Proceedings of the National Academy of Sciences*.

Atlantic bluefin spawn in three areas: the Gulf of Mexico/America, the Mediterranean Sea, and the Slope Sea off the U.S. East Coast. The new study, based on tagging and tracking bluefin tuna, indicates they mix from east to west across the Atlantic far more than management models currently reflect.

"It's time to recognize the life cycle of the giant bluefin occurs primarily in the North Atlantic," said lead study author Barbara Block, a professor of biology in the Stanford School of Humanities and Sciences and of oceans in the Stanford Doerr School of Sustainability.

"We must consider in the quota distributions a more equitable way to account for the vast movements of each fish and the shifts in biomass this creates. Tagging reveals the preferred habitats of bluefins spawned in the Mediterranean Sea extend across the entire North Atlantic from Gibraltar to North Carolina and Nova Scotia shores."

'Pinnacle of bony fish evolution'

Atlantic bluefin tuna are warm-bodied predators that can top 1,400

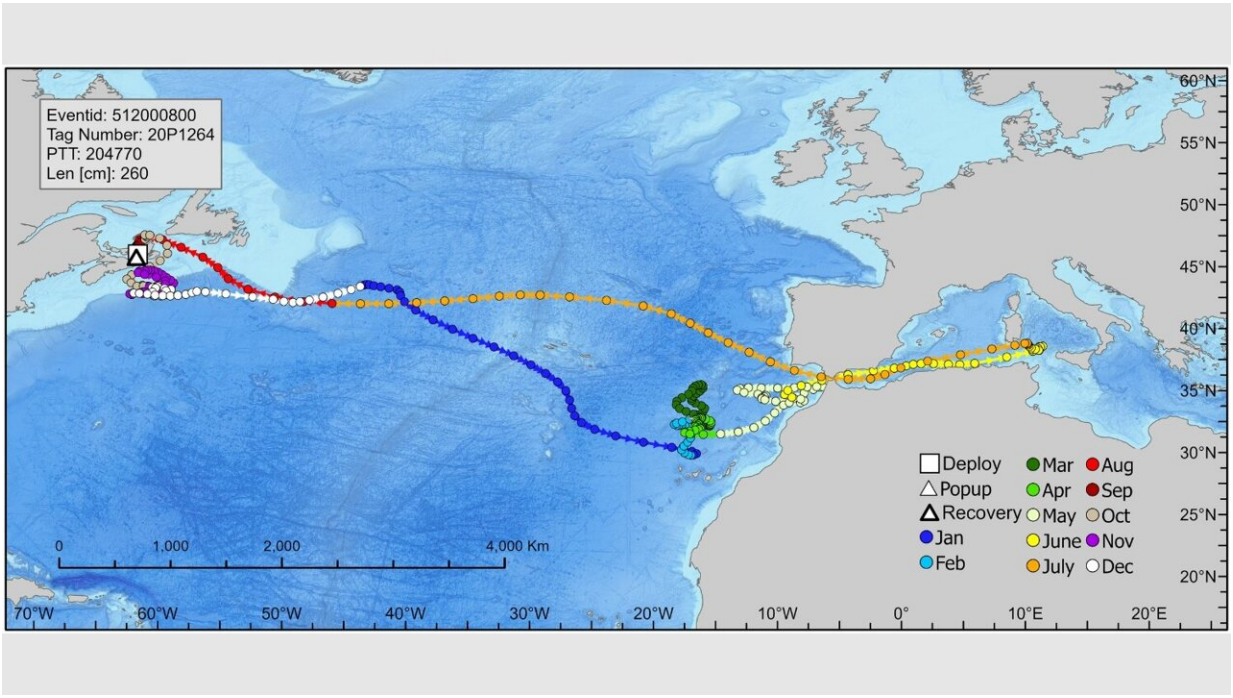
pounds. Their streamlined bodies, muscles powered by internal heat, and efficient stiff-bodied swimming style let them dive deeper than 6,000 feet in search of squid. Bluefin tuna cross the ocean to feed where oily fish like herring are abundant and return home to spawn. To Block, they are "the pinnacle of bony fish evolution."

They are also among the most sought-after fish in the sea, prized for ruby-red flesh that commands top prices in sushi markets.

There are three species of bluefin tuna, each living in a different part of the world: Atlantic bluefin tuna (Thunnus thynnus), Pacific bluefin tuna (Thunnus orientalis), and Southern bluefin tuna (Thunnus maccoyii).

Teams deployed 1,720 tags on bluefin tuna in the waters off the United States, Canada, Ireland, Spain, and Norway over 30 years. Fish were caught one at a time, brought aboard, irrigated to keep them calm, tagged, and released.

Using computational modeling of tag data captured via satellite transmissions and recovered tags, the researchers mapped the movements, behaviors, and environmental preferences of each fish to determine the spawning stock and to understand how the populations mix.



Researchers mapped the movements, behaviors, and environmental preferences of each fish to determine the spawning stock and to understand how the populations mix. Credit: Adapted from *Proceedings of the National Academy of Sciences* (2026). DOI: 10.1073/pnas.2535185123

Ripple effects from trans-oceanic travels

The International Commission for the Conservation of Atlantic Tunas, or ICCAT, is responsible for sustainable management of the Atlantic bluefin tuna fishery.

Made up of 55 contracting parties, the commission divides the Atlantic into two regions along the 45° west longitude near the mid-Atlantic ridge. Bluefin tuna are treated as independent stocks east and west of this line.

Because bluefin tuna have historically been thought to be far more abundant east of the 45°W dividing line, quotas and thus biomass removals have generally been 10–15 times higher than those in the west. On the western side of the basin, targeted fishing for bluefin tuna is prohibited in the U.S. portion of the Gulf of Mexico/America to protect fish on their spawning ground.

Lower western quotas were designed to protect the relatively small Gulf-spawning population. Tagging data suggests those limits also created what the study authors call "a de facto protected area" for tuna from the eastern stock. This has allowed the fish to proliferate and return to areas where they have not been seen in decades, such as off the coasts of Norway, England, and Ireland.

Fish tagged as juveniles and adults in U.S. and Canadian waters crossed the Atlantic to the Mediterranean Sea to spawn, indicating some had migrated as juveniles from the Mediterranean to forage near North America. Tracks of adult bluefin tuna tagged off the coasts of Canada and North Carolina showed they returned after spawning in the Mediterranean, demonstrating "foraging fidelity." In contrast, bluefin tuna tagged as adults in the western Atlantic frequently remain there.

As for the population that originates in the Gulf of Mexico/America, Block said learning about the extent of their Atlantic-wide movements will require tagging younger Gulf bluefin tuna, which can be hard to find. "The fish we tag have been very big adults—many closing in on 500 to 1,200 pounds," she said.

Atlantic bluefin tuna inside a purse seine net off the Atlantic coast of Spain. Credit: Brian Skerry

'Foraging at the best restaurants'

Tunas from both sides of the Atlantic seek prey such as mackerel, herring, and menhaden, which are relatively abundant in U.S. and Canadian waters due to U.S. policy protecting these fish. "Everyone is foraging at the best restaurants," said Block.

The 30-year tagging effort demonstrates foraging in these North Atlantic waters is more vital for bluefin tuna's recovery and sustainable management than previously understood.

"If you let the fish out of the Mediterranean spawning area, it has a chance to exploit food resources across the entire productivity of the Atlantic Ocean, which means when it comes back to spawn in the Med, it's essentially older and bigger. Thus, it has the potential to make more offspring," Block said.

As the commodity price for bluefin tuna has increased, so has the demand from each contracting party to get higher quotas from ICCAT, which sets catch limits based on the assumed biomass of each stock in the west and east.

By providing a more complete picture of mixing across these two stocks, the new study can inform assessments of where adult biomass resides and decisions about how to potentially adjust the quotas.

"What happens in the Mediterranean Sea and in the eastern Atlantic close to the Strait of Gibraltar impacts all nations fishing in the North Atlantic," said Block, who is the Charles and Elizabeth Prothro Professor in Marine Sciences in the Doerr School of Sustainability.

Uneven fishing pressure

To understand how fishing pressure has varied across regions, the researchers examined regional catch data from 1950 to 2023, including catches reported to ICCAT and estimates of illegal, unreported, and unregulated fishing.

More than half the total catch was taken in the Mediterranean Sea, with 17% from the nearby eastern Atlantic. Another 17% came from the northeastern Atlantic and just 11% from the entire West Atlantic.

Since 1990, the Mediterranean Sea alone accounted for 72% of the total catch, while the West Atlantic share fell to 6%. This widening gap

coincided with growing global demand for bluefin tuna and rising Mediterranean catches—increasingly through a technology where wild mature tuna are captured in purse seines and transferred to fattening pens.

Over the same period, nations fishing the West Atlantic, including the U.S., Mexico, Japan, and Canada, generally adhered to strict catch limits, the researchers concluded from ICCAT catch data. Currently, ICCAT allows about 15 times more catch in the east than in the west.

"The U.S. and Canadian fishers, along with North Atlantic fishers from Ireland, Norway, Sweden, and Denmark, are the ones doing most of the protecting of the Atlantic bluefin from both stocks," Block said.

If Mediterranean harvests focus on older tuna and allow Atlantic bluefin tuna to complete their full life cycle across the Atlantic, fisheries can improve yields while protecting vulnerable populations, the authors conclude.

Some of this change has already begun. ICCAT tightened enforcement and regulations in 2010 amid global concerns about the bluefin tuna stock.

"Our paper suggests that keeping to that path of not harvesting juvenile individuals and allowing escapement is critical to the current recovery," said study co-author Emilius Aalto, a research scientist in the Block Lab in the Department of Oceans in the Doerr School of Sustainability.

The key to the Atlantic bluefin tuna's rebound may be surprisingly simple, according to the authors: Allow a fish that is restricted to spawn in a narrow environmental niche—but evolved to seek productivity anywhere in the ocean—to do just that.

An Atlantic bluefin tuna is released to the water after researchers tagged it with a data-logging sensor. Credit: Stanford University

Ocean-wide tagging effort

Stanford marine biologist Barbara Block pioneered the use of electronic tags to track large ocean predators such as tunas, billfishes, and sharks.

Together with fishers and scientists from five countries, Block and members of her lab have caught, tagged, and released Atlantic bluefin tuna since 1996 using technology and techniques developed at the Tuna Research and Conservation Center, a collaboration of Stanford's Hopkins Marine Station and the Monterey Bay Aquarium next to Monterey Bay.

Because GPS positioning does not work underwater and fish breathe with gills, researchers use tags that are submerged during the fish's journey. The position of the fish is estimated with geolocation. Tags measure light, pressure, and temperature, and enable estimates of local noon and day length. Some fish are double tagged with acoustic technology that sends pings to seabed receivers, recording location within 1,500 feet of the receiver.

The researchers have used three types of tags to learn how fish move throughout their home range in the North Atlantic:

- Pop-up satellite tags attach externally to the fish and are programmed to detach after a set period, float to the surface, and transmit data to satellites. They record depth, temperature, and light levels that researchers use to estimate the fish's location.
- Acoustic tags with long-lasting batteries are implanted in a fish and emit ultrasonic signals detected by underwater receivers stationed along continental coasts. They provide high-resolution tracking data for multiple years as tagged fish swim past receiver networks.
- Archival tags are surgically implanted in fish and recovered by fishers for $1,000 rewards. They continuously record depth, temperature, and light data at high resolution throughout the fish's life until recapture.

More information: B. A. Block et al, Ensuring the future of Atlantic

bluefin tuna, *Proceedings of the National Academy of Sciences* (2026). DOI: 10.1073/pnas.2535185123