TAG-A-GIANT NEWS: JANUARY 2006

The Tag-A-Giant (TAG) scientific team at the Tuna Research and Conservation Center had another exciting year tagging Atlantic bluefin tuna in 2005. Funding from the Monterey Bay Aquarium Foundation, Stanford University, the National Oceanic and Atmospheric Association (NOAA), Marine Ventures Foundation and individual sponsorship of tags allowed for a significant tagging effort by the TAG bluefin tuna team in the north Atlantic. The TAG program placed a total of 903 electronic tags on bluefin in the Atlantic Ocean in 2005. This past year, over 100 tags were deployed off the coast of North Carolina and Canada with the help of the Morehead City, Beaufort and Nova Scotia fishing communities. In addition, our work continued across the North Atlantic in Ireland. Below is a synopsis of our tuna tagging in 2005.

The TAG Program

The objectives of the TAG program are to gain knowledge required to reduce the uncertainty surrounding the international management of bluefin tuna in the Atlantic Ocean and Mediterranean Sea. We use a variety of electronic tagging technologies to study the movements and behaviors of Atlantic bluefin tuna. TAG is meeting its objectives by deploying electronic tags in the Eastern and Western Atlantic Ocean. Key questions remain regarding the population structure of bluefin tuna. Our research is establishing the location and timing of reproduction, spawning site fidelity, ontogeny of movement patterns, and the influence of climate variability on movements. This knowledge will improve stock assessments and future management. Understanding the level of mixing between eastern and western stocks is very important for the survival of bluefin in the Atlantic Ocean.

Who We Are

The TAG team is a group of scientists from Stanford University, the Monterey Bay Aquarium, and Duke University. Our research is supported primarily by *Private Funds* and periodically by federal grants and contracts from NOAA. A critical component of our team is the bluefin tuna fishers. US fishers, in particular, North Carolina charter and private vessels have been instrumental in placing tags on the bluefin tuna off Morehead City and Hatteras, North Carolina. Over 85% of the 903 electronic tags have been deployed off the coast of North Carolina. In addition, the TAG team has deployed tags fishing from sport fishing boats in Cape Cod, commercial longliners in Louisiana and Texas in the Gulf of Mexico, and fishers from Spain, Ireland, Canada and Corsica.

TAG Program Results

Despite the management and rebuilding efforts of the International Commission for the Conservation of Atlantic Tunas (ICCAT), the western Atlantic bluefin tuna

populations have failed to recover following their significant decline in the 1970's (see www.ICCAT.es). The lack of success in rebuilding the western stock indicates that some assumptions of the ICCAT management plan may be flawed and should be reevaluated. When the plan was established in the early 1980's much of the understanding of bluefin abundance and distribution in the Atlantic was based on conventional tagging studies and fisheries data. Based on the available information, it was concluded that there were two independent stocks with unique spawning grounds and limited mixing across the 45 meridian. The original management boundary was drawn to separate the eastern and western stock. With the recent advent of electronic tagging technologies we are in a position to re-examine these basic assumptions and obtain the data necessary to improve the current plan and rebuild the stocks in the western Atlantic.

To date TAG scientists have placed 903 archival and satellite tags in the ocean. Over 103 archival tags have been recovered (~20%) and pop-up satellite tags (89%) have reported via satellite or been recovered providing incredible information to the TAG research team. The electronic tag data provide significant information on bluefin tuna movements. Tagging data reveal:

1. At least two populations of bluefin occupy the North Atlantic.
2. Bluefin tuna tagged in North Carolina waters most often move into New England or Canadian waters and then back to North Carolina in the first year post tagging.
3. Some bluefin tuna released in North Carolina and Massachusetts show directed movement paths to the Gulf of Mexico spawning grounds.
4. Spawning primarily occurs in April, May and June in 78^{o}F to 80^{o}F water temperatures. Behaviors of the fish captured on the archival tag show periods of preferred "spawning area" residency along the Gulf of Mexico continental shelf.
5. Some bluefin tuna tagged in the west Atlantic off of North Carolina move to the Mediterranean spawning grounds in the eastern spawning season.
6. Bluefin tuna tagged in the west Atlantic that show visitation to the Gulf of Mexico spawning ground, also can move rapidly into the eastern Atlantic and become vulnerable to eastern fisheries.
7. Bluefin tuna that go to the Gulf of Mexico from North Carolina tend to be very large, on average, 94" and above in curved fork length. Bluefin in the warm breeding areas experience higher ambient water and higher body temperatures. They are vulnerable to high mortality on longlines because surface waters in the Gulf are lower in oxygen. Restrictions once captured on longline gear keep the fish from diving deep where oxygen is more plentiful.
8. Most bluefin tagged in North Carolina require one year or more of foraging in the North Atlantic prior to moving into the known Gulf of Mexico or Mediterranean breeding areas.
9. Potential breeding areas also occur in the South Atlantic Bight areas but these require further study.

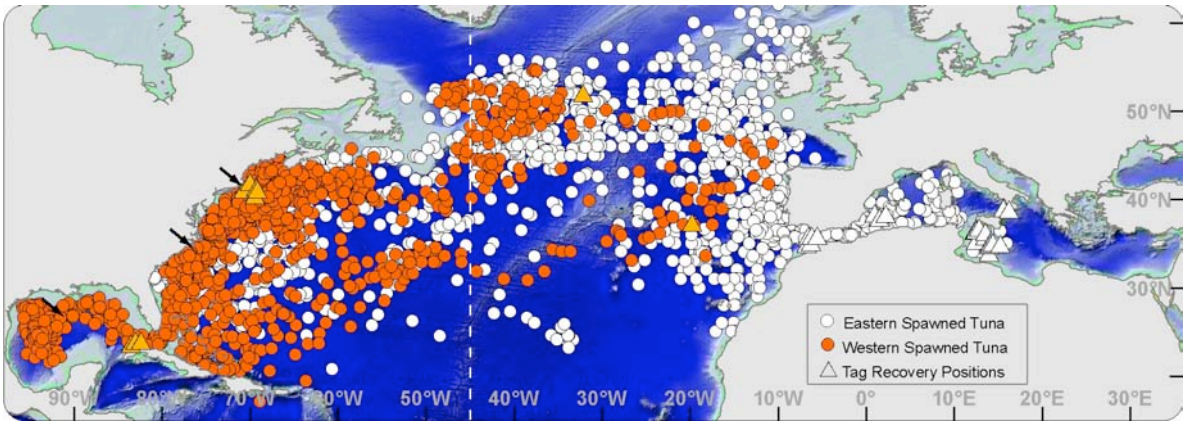
The electronic data collected from Tag-A-Giant project have been presented to the International Commission for the Conservation of Atlantic Tunas (ICCAT), the

managing authority for Atlantic bluefin. In April 2005 the journal *Nature* published an internationally peer reviewed paper of the TAG data sets (n= 772 fish). This paper provided our data regarding the movements and stock dynamics of the bluefin to the scientific community, fisheries managers and the public. The data indicate that the stocks are separated geographically and discretely during this spawning period but mixing significantly during foraging activities. Our results support the existence of two spawning stocks of giant bluefin tuna. Our data also indicate that mixing of both eastern and western stocks occurs when the fish are adolescents and adults on feeding grounds in North Carolina, New England and in the central and eastern Atlantic. The extent of the mixing is more significant than had previously been realized. Thus, tunas of all sizes tend to move to productive North Atlantic feeding grounds and sort potentially to separate breeding grounds. Management is complicated by this problem because eastern and western fisheries are impacting one another. The separation of fish toward independent breeding grounds indicates that stocks could be managed on the spawning grounds. Our major goal is to provide the knowledge to build a sustainable western stock that shows a preferential use of the western portion of the North Atlantic.

Importantly, we have advised ICCAT that to ensure the maximum diversity of bluefin tuna in the North Atlantic, it is important to keep the western Atlantic bluefin tuna stock viable (the Gulf of Mexico breeding stock). Overfishing in the east Atlantic is so intense, and conducted by so many Nations that to keep the western stock viable, it is of high importance to learn as much as we can and then adapt new strategies for management.

To date, our western fishers have sacrificed greatly to conserve the fishery. Our data indicate that mortality has continued to be high. One problem is that western breeders are targeted not only on the western fishing grounds, but also on the central and eastern feeding grounds. Importantly, we have also shown that mortality on the breeding grounds of the Gulf of Mexico is high. Mortality on spawning adults combined with increasing adolescent mortality in the west on adolescent bluefin has most likely led to further declines of the western Atlantic bluefin tuna stock. It is urgent that we use the tagging data we are obtaining to increase protection for our fish in the central and eastern Atlantic. Your help in placing tags and retrieving tags is vital for the future of the fishery. More information and downloads of the scientific papers can be accessed at the publications portion of the tuna research website at www.tunaresearch.org

Figure 1. Two populations of bluefin tuna are revealed with the TAG recoveries from implantable archival and pop-up satellite data sets combined (N=311 individuals). All fish were released in the west Atlantic. The orange points are bluefin tuna that were identified as breeders in the Gulf of Mexico. White points are bluefin that returned to the Mediterranean during the breeding season indicative of spawning site fidelity. Triangles are locations for archival tag recovery reported by commercial fisheries.



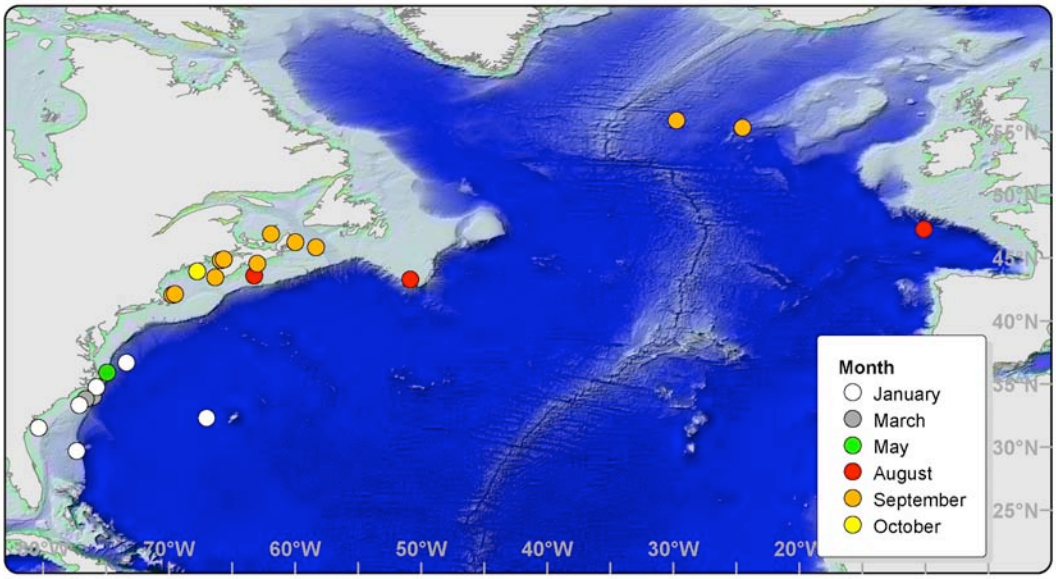
Our tagging efforts in 2005 began in January with a 21 day TAG event that took place in very cold and rough seas off the coast of Morehead City, North Carolina. Duke University Marine Lab provided the headquarters for TAG 2005. A team of a dozen scientists (Stanford, Duke and Monterey Bay Aquarium) worked together and fished approximately 16 days. We had some spectacular weather at times, mixed in with a few storms. We had significant interactions early on with the commercial fleet that luckily caught their quota of Carolina fish early in January.

With determination and the support of the Carolina fishers, the TAG crew and scientists placed 90 electronic tags in or on bluefin tuna. TAG 2005 was once again a year with big fish. Over 70 fish were measured and the mean size of a fish handled by the TAG team was the largest ever at TAG (220-230 cm curved length).

Sixty five of the tags deployed were the LTD 2310 archival tag, built by Lotek Inc. of Canada, which has the potential to record over five years of continuous data from bluefin tuna. Twenty-five fish carried the Wildlife Computer pop-up satellite archival tag. The archival tags are implanted in the body cavity of a fish where they log internal and external temperature, depth and light intensity. The tags are programmed to calculate local noon from measurements of sunrise and sunset events and converts these times to longitude estimates. An algorithm developed in the Block lab (Teo et al. 2004) takes the known longitude and observed sea surface temperatures and estimates latitude by comparing tag measured sea surface temperatures to those obtained from satellites. We have calibrated this technique by comparing positions returned by light-based geolocation tags to those returned through continuously transmitting satellite tags.

The pop-up satellite archival tags (PAT tags) are similar to archival tags. They ride externally on the fish and record data every minute from light, temperature and pressure sensors. At a pre-determined date, these tags release from the fish, float to the surface and transmit summaries of stored data to satellites. The data are summarized prior to transmission in the form of depth and temperature histograms, temperature vs. depth profiles and light data for subsequent longitude and latitude estimation. The advantage of these tags is that the fish does not need to be recaptured in order for data to be retrieved from the tags. Positions are calculated in much the same way as archival tags, using both light level and sea surface temperatures.

For attachment of the PAT tags, we succeeded in obtaining significantly longer external tag deployments (274 days is our current long-distance record on an Atlantic bluefin external attachment). To date we have received a remarkable 95% of the endpoints from the 25 tags deployed (figure below). While data sets are shorter using the satellite pop-up tags than with implantable archival tags, we get many more individual data sets using these tags. Although some of the PAT tags came off at the very early stages of the experiment, for reasons that to date remain unknown, the typical pattern of fish moving to the New England and Nova Scotia fisheries emerged. The linkages between Carolina and Canada came to the forefront this past year. This may in part be related to the fact we kept the tags on for longer durations. We also had 3 of the 25 tagged fish pop up in the east Atlantic. One fish that popped up in Canada had a track that showed rapid movements from the west to the east followed by a migration back to Nova Scotia. Thus a pop up endpoint- is a moment in time- just one location that give a fish a few days- and it might be back on the other side of the ocean.



Results of Pop-Up Satellite Tags released in 2005. Most fish popped up in the typical places we had seen in years before, however one fish recorded a rapid movement from Carolina to the Bay of Biscay. More fish were in Canada than we had recorded before but overall the positions are very similar to prior years.

In October of 2005 a team of scientists from TAG were in Canada for the first time off Prince Edward Island and for the fourth year in a row we attempted to deploy PAT tags on the large fish in Ireland. We were successful under the leadership of my former student, now Dr. Mike Stokesbury. Mike successfully tagged three large fish, one measuring approximately 950 lbs. The other two fish were too large to bring on the boat. The 2003 Irish deployments provided some exciting results; a fish recaptured near Libya logged a full archival record of the movements of a fish from Ireland into the Mediterranean during the breeding season. We're still analyzing this tag. This represents the first archival data collected by TAG for bluefin tuna from this poorly understood Tunisian breeding region and we anxiously await the results on the tag.

Implantable Archival TAG Recoveries

Once again this year we recovered implantable archival tags from fishers of several nations in the Atlantic and Mediterranean Sea. Below are two tracks: one from a fish that demonstrated a west Atlantic track and the second figure is an image of the longest track ever, a 4.8 year record of a fish released in January 1999. This fish spent its first year post-tagging like many of our fish going from Carolina to New England demonstrating the tight linkage between the fisheries. This fish traveled across the eastern Atlantic to the coast of Ireland-where TAG scientists have also been working the past two seasons. This bluefin tuna then moved from the North Atlantic into the Mediterranean Sea over three consecutive years, presumably returning to the Mediterranean to spawn each year.

The longer tracks are showing that some tunas older than 8 years of age tagged in the west Atlantic move to the east Atlantic and into the Mediterranean Sea during breeding season. Of the archival returns from 1997 and 1999 releases, 30% have been recaptured in the Mediterranean or East Atlantic. Two patterns are apparent in these

eastern recaptures: some fish travel into the eastern management zone to feed before returning to the west, while others are moving into the Mediterranean to spawn. What remains unclear is whether bluefin that move to the Mediterranean are natal eastern spawners returning home or whether these are "western bluefin" crossing to the east to feed or breed. We hypothesize that juvenile eastern bluefin tuna may cross to Carolina to feed at the best restaurant in town (North Carolina Outer Banks), and return home to breed many years later.

Directed movements across ocean basins to breed would be similar to the results we are now obtaining for the Pacific bluefin. Fish spawned off Japan come to California and Mexico to feed as two year olds where they remain for several years prior to returning home to Japan to spawn. The new archival tags with five years of memory will shed more light on this question of fidelity to breeding grounds.

The TAG team has been working with the American committee that represents US interests at the ICCAT to generate the best knowledge for future management decisions. Importantly, the picture emerging from TAG is one in which western Atlantic released tunas use the western Atlantic to feed and breed, and the eastern Atlantic to feed. Our data suggests that there are at least two breeding populations of Atlantic bluefin that are mixing on feeding grounds. More tagging is required to discern how much mixing is exactly occurring. We ask for your participation either by donating a fish or a tag and supporting our continued efforts.

Figures 2 and 3 directly from Block et al. Nature 2005. The fish on the left goes into the Gulf the first year after breeding while the fish on the right spent a year in the west and a year in the east all in the N. Atlantic prior to three consecutive years of spawning site fidelity

Figure 2

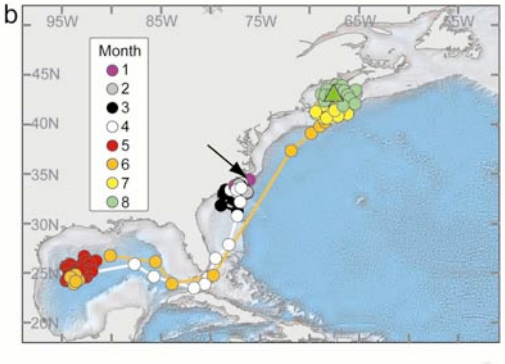
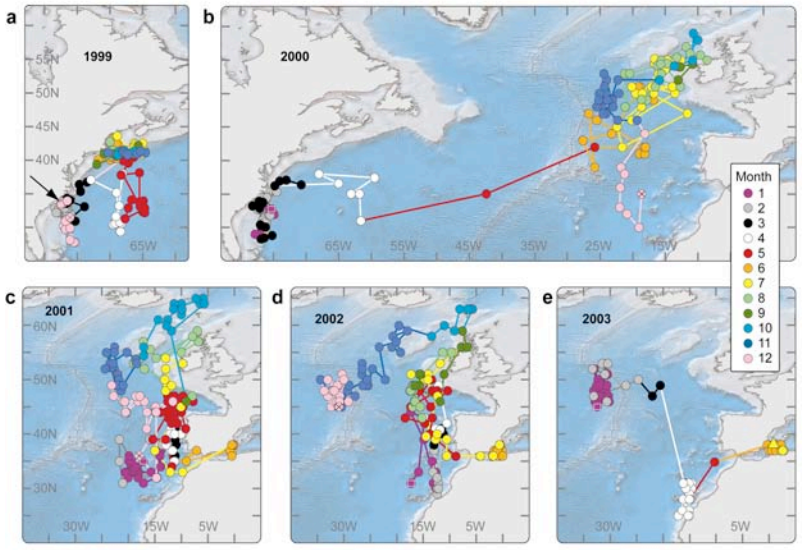


Figure 3



DONATIONS

I want to urge you to support Tag-A-Giant! Please note NOAA cut all the 2006/07 funding to TAG and your donations are vital. Our data is critical for the future management of the US fishery and will help to ensure a healthy bluefin population exists along the US North American Continental Shelf.

SPONSOR AN ELECTRONIC TAG ($1500) WITH A TAX DEDUCTIBLE DONATION

DONATIONS for TAG of any amount are appreciated

Name: _____
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Address: _____
City: _____State:_____Zip: _____

To sponsor an electronic tag Check here: _____$1500.00

To fish for one day in January 2006 with the scientists & tag a bluefin
Check here: _____$1500.00

To support TAG, I am enclosing a check for $_____

Payment Method: _____Check _____Visa _____MasterCard _____

Card Number_____
Expiration Date_____
Signature as it appears
on Credit Card_____

Name _____
Phone _____

Or Please mail your tax deductible donation for an archival tag to:

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www.tunaresearch.org

Or Sign up Online at www.tunaresearch.org
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Make Checks payable only to: Tuna Research and Conservation Center or Stanford University. If you prefer we can accept donations The Ocean Foundation, http://www.oceanfdn.org/pgs/oceanfunds1.html