LARGE PELAGICS RESEARCH CENTER
ANNUAL PROGRESS REPORT – DEADLINE 7/30/2007

Report: #2 **Reporting Period: 05/01/2006 – 10/31/2006**

Project Title: Assessment of natal homing and mixing of Atlantic bluefin tuna using $\delta^{13}C$ and $\delta^{18}O$ signatures in otoliths

Principal Investigator(s): Jay R. Rooker, David H. Secor

1. Purpose of the Project:

This project represents the application phase of previous research funded through NOAA. In previous projects/publications, we have evaluated alkaline earth, trace, and heavy metals in otoliths. Discrimination of yearling bluefin tuna from eastern and western natal regions approached 90% but the mixture of discriminating metals varied year to year, which ultimately could limit application. We have recently concentrated on stable isotopes ($\delta^{13}C$, $\delta^{18}O$), which should vary more consistently year to year due to differing physical conditions between Mediterranean and western Atlantic nurseries. Indeed, otolith stable isotopes showed substantially stronger inter-annual stability, and the discriminatory power of stable isotopes in otoliths was high with > 90% cross-validated classification success of yearlings to eastern and western nurseries over 5 year-classes (1999-2003). Our findings clearly indicate that these natural tags can predict the natal origin of Atlantic bluefin tuna. We have also verified that we can effectively mill internal material of adult bluefin tuna otoliths that gives similar isotopic signatures to whole otoliths of yearling bluefin tuna. In preliminary work, we milled otolith core material from 100+ medium and giant category bluefin tuna and observed compelling evidence of mixed stock fisheries. Most notably, a large fraction of the medium and giant category bluefin tuna collected in the western Atlantic (northeastern U.S.) originated from nurseries in the east, while adults in the Mediterranean were largely (>90%) of Mediterranean origin. Here, we take the next logical step and build on previous research to assess natal homing and mixing rate of Atlantic bluefin tuna. Objectives of the current investigation are threefold: 1) quantify stable $\delta^{13}C$ and $\delta^{18}O$ isotopes in whole otoliths of yearling Atlantic bluefin tuna from eastern and western nurseries to complement the current set of reference samples or birth certificates; 2) determine trans-Atlantic mixing and natal homing tendencies of adult bluefin tuna collected from the two known principal spawning regions (Gulf of Mexico and Mediterranean Sea) by comparing $\delta^{13}C$ and $\delta^{18}O$ isotopic signatures in otolith cores of adults to yearling signatures (reference samples); 3) predict the natal origin of adult bluefin tuna sampled from mixed stock fisheries in the central North Atlantic, Canada (Gulf of St. Lawrence), and New England (U.S.).

2. Progress during the first year:

Efforts during the first year of the project centered on the collection of otoliths from yearling and adult bluefin tuna. To date, otoliths from over 400 bluefin tuna have been obtained in 2006 and 2007 for this project (Table 1). In addition, otoliths of giant bluefin tuna from Gulf of St. Lawrence over the past three decades have been obtained from Dr. Neilson. Drs. Rooker and Secor traveled to the Mediterranean in mid October to sample from tuna pens as well as process yearling samples collected by colleagues (Dr. Gregorio DeMetrio, University of Bari) in the region over the past 1-2 years. Samples of yearlings and adults bluefin tuna collected on this trip include 40 medium/giants as well as over 50 yearlings (see Preliminary Data section for details). In addition, Texas A&M University entered into a cooperative agreement with the primary tuna farming operation in the region (Fuentes Group), and the head biologist form the company (Antonio Belmonte) will assisted with collections in 2006 and will do so again in 2007. In the central North Atlantic and Gulf of St. Lawrence, Dr. Neilson has been working with IVY Fisheries and local contractors to procure bluefin tuna heads (otoliths) for the project. Otoliths from the central North Atlantic have been more challenging. An initial batch of heads was provided by IVY Fisheries; however, cuts were too far anterior to obtain otoliths. We are currently work with other entities to obtain fish from this region.

3. Preliminary Data:

Table 1. Collected material for the current project (note: O = otoliths, T = tissue, T* = Frozen)

Region	Year	Size Class	No. Samples	Type
Mediterranean	06	Giant	20	O, T
E. Atlantic	06	Medium	20	O, T
Ionian Sea	06*	Yearling	56	O,T
Gulf of Mexico	05	Giant	12	O
W. Atlantic	06	Yearling	12	O, T
C. N. Atlantic	06	Giant	9	O
Gulf of St. Lawrence	06**	Giant	300+	O
Gulf of St. Lawrence	06	Giant	29	O
Gulf of St. Lawrence	07	Giant	22	O, T*

**Collections were obtained in 06 but include samples of yearling from 04 and 05 being saved by colleagues in Italy. **Samples obtained in 2006 are from Canada Fisheries and Oceans archive and span three decades.*

Overview of work completed in first year of project:

1) Expanded library of $\delta^{13}C$ and $\delta^{18}O$ values in otoliths of yearling bluefin tuna by analyzing new year classes of bluefin tuna collected last fall as well as otoliths from the bluefin tuna otolith archive in J. Rooker's Lab. We now have yearling values from both the eastern and western Atlantic over a 6 year period (Fig 1.).

Note: Information provided will be included in the Center's reports to NMFS-NOAA and made public through the center's website. Clearly indicate any confidential information that you do not wish to make public at this time.

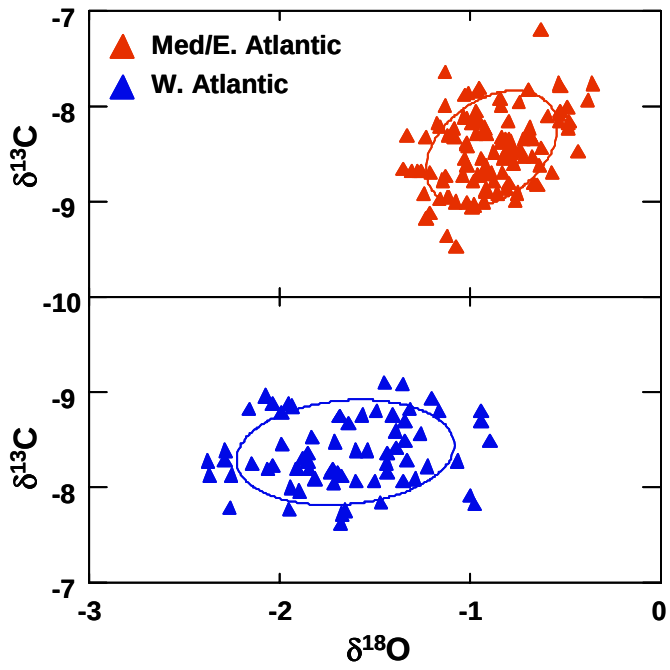


Figure 1. $\delta^{13}C$ and $\delta^{18}O$ values of yearling Atlantic bluefin tuna collected in the eastern Atlantic/Mediterranean Sea and the western Atlantic over a 6 year period.

2) Assessed variability between stable isotope facilities at the University of Arizona and the University of Maryland by running otolith powder from the same individual bluefin tuna at each lab (Table 1). Paired t-tests indicated that $\delta^{13}C$ values did not differ significantly between labs ($P > 0.05$); however, $\delta^{18}O$ values were significantly more enriched (0.28 per mil at the University of Arizona lab (Table 1). Since in-house standards were used at both facilities, we will use these results to standardize stable isotopes values between labs. We are in the process of running additional paired samples to further develop our correction factor.

Table 1. Comparison of stable isotope values for paired samples (powder from the same individual) processed at different labs.

U MD $\delta^{13}C$	U AZ $\delta^{13}C$	U MD $\delta^{18}O$	U AZ $\delta^{18}O$
-8.61	-8.69	-0.53	-0.19
-8.75	-8.80	-0.83	-0.42
-8.28	-8.34	-0.75	-0.10
-7.90	-8.70	-0.53	-0.56
-7.93	-9.04	-0.48	-0.60
-8.63	-8.80	-1.27	-1.11
-7.62	-7.62	-1.61	-1.30
-8.39	-8.58	-1.26	-0.84
-8.78	-8.93	-1.21	-0.82
-8.32	**-8.61**	**-0.94**	**-0.66**

Note: Information provided will be included in the Center's reports to NMFS-NOAA and made public through the center's website. Clearly indicate any confidential information that you do not wish to make public at this time.

3) Compared $\delta^{13}C$ and $\delta^{18}O$ signatures in whole otoliths of yearlings to transverse sections of the other paired otolith. This test was required because cored regions of otoliths from giant category bluefin tuna are being used to represent the yearling signature. Paired t-tests showed no significant difference between cores from transverse sections and whole otoliths in either $\delta^{13}C$ or $\delta^{18}O$ ($P > 0.05$), indicating that our micro-milling protocol did not deplete or enrich the core values. Mean error between core and whole otoliths for $\delta^{13}C$ and $\delta^{18}O$ was similar to the estimated precision of replicated runs. Despite the favorable results, additional tests are being performed to increase the sample size.

4) Isolated core material from giant bluefin tuna collected in the Mediterranean in 2006. Samples have been sent to the University of Arizona lab, and we are awaiting results.

5) Sectioned over 300 otoliths from the Gulf of St. Lawrence. These otoliths are currently being micromilled at Texas A&M University (as of July 1 ~30% of milling completed). J. Rooker and R. Schloesser recently traveled to Prince Edward Island, Canada to collect otoliths from giant bluefin tuna and collections will continue through this summer and next season.

4. Difficulties: In 2006, four brokers or seafood companies agreed to help us obtain bluefin tuna from the Gulf of Mexico (Jensen Tuna Co., Tideland Seafood Co., Tunaco Inc., Dixie Fish Co.). Due to a late start on the funding, most of the bluefin tuna landed in the Gulf in 06 were collected prior to establishing relationships with each group. News is more promising for 2007. NOAA significantly expanded the coverage of observers in the Gulf of Mexico during the primary spawning period of bluefin tuna in this region, and some of this material will be available for this project. Collections from the central North Atlantic are still problematic. Dr. Neilson is currently working with Chubby Tuna to obtain biological samples of bluefin from this region.

5. Plans for the next six months to year:

After all otolith cores are isolated from adult bluefin tuna (in progress) $\delta^{13}C$ and $\delta^{18}O$ will be measured, and values of adults from all areas will be matched to our library of yearling signatures to predict natal origin and mixing rates. Within the next year, we will make prediction related to the natal origin of bluefin tuna collected in both spawning locations (Gulf of Mexico, Mediterranean Sea) as well as at least one presumed mixing ground (Gulf of St. Lawrence). Also, we will continue to collect yearlings and quantify otolith chemistry for these individuals to expand our reference set of signatures from both the east and west. We still have a few minor protocol issues to further test and resolve, and these trials will be conducted over the final year of the project. In particular, we will compare different methods of obtaining core material (prism from drill path versus power from multiple point estimates) to fine tune our core isolation procedure.

Travel: Rooker and Secor will travel to the Spain in October of 2007 to collect bluefin from farming operation in Cartegena, Spain. In addition, we plan to collect more

Note: Information provided will be included in the Center's reports to NMFS-NOAA and made public through the center's website. Clearly indicate any confidential information that you do not wish to make public at this time.

yearling bluefin tuna to complement previous collections and further develop our otolithr reference set of yearling $\delta^{13}C$ and $\delta^{18}O$ values.

6. Dissemination

Publications:

Workshops:

Conferences:

1) Invited talk entitled "Blue travelers: is the sustainability of Atlantic bluefin tuna and blue marlin stocks linked to the Gulf of Mexico." 59th Annual Gulf and Caribbean Fisheries Institute meeting, Belize City, Belize (Nov 2006).

Manuals, Protocols:

Outreach Activities:

Patent, Copyright, Invention Disclosure Activity:

7. Collaborators and Personnel:

John Neilson, Ph.D., Head, Large Pelagics and Pollock Projects Population Ecology Section Department of Fisheries and Oceans, St. Andrews Biological Station, St. Andrews, NB CANADA E5B 2L9

8. Students: (list students receiving funding, degree type, anticipated graduation date, thesis or dissertation title)

Ryan Schloesser, B.S. (M.S. Candidate; expected graduation date 10/08), Department of Wildlife and Fisheries Sciences, Texas A&M University, 5007 Ave U, Galveston, TX 77551

Thesis title: Contribution rates of bluefin tuna recruits from eastern and western spawning grounds to mixed stock fisheries of northwestern Atlantic Ocean

Note: Information provided will be included in the Center's reports to NMFS-NOAA and made public through the center's website. Clearly indicate any confidential information that you do not wish to make public at this time.

9. Images and Captions:

Figure 1: (Ryan PEI 1) Credit: J. Rooker

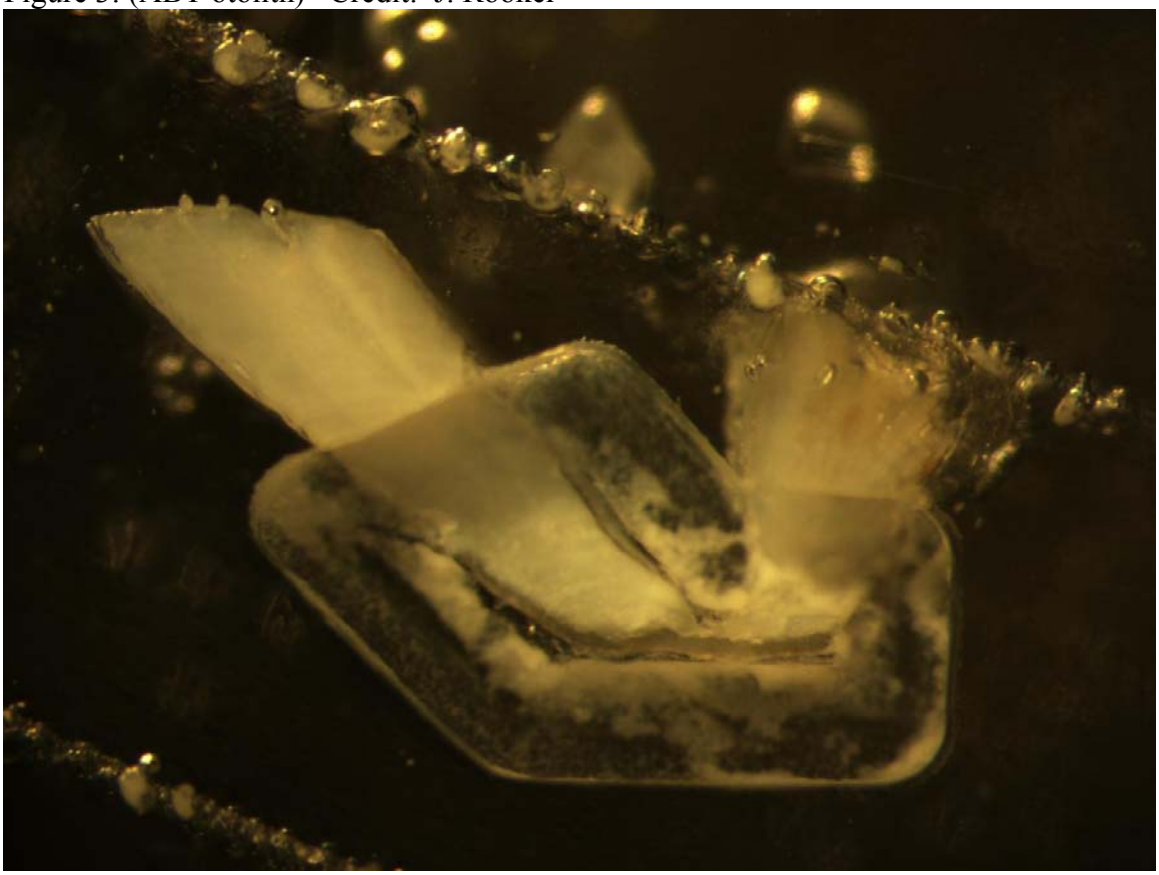
Caption 1: Sampling otoliths from giants in the Gulf of St. Lawrence (Ryan Schloesser—Texas A&M University, graduate student of J. Rooker)

Figure 2: (Ryan PEI 2) Credit: J. Rooker

Note: Information provided will be included in the Center's reports to NMFS-NOAA and made public through the center's website. Clearly indicate any confidential information that you do not wish to make public at this time.

Caption 2: Ryan Schloesser (graduate student) using bone saw to gain access to the otoliths (with Dr. John Neilson).

Figure 3: (ABT otolith) Credit: J. Rooker



Caption 3: Medium category bluefin tuna otolith with core (corresponds to first year of life) milled out. Dashed red line shows the yearling region of the otolith that was removed.

Note: Information provided will be included in the Center's reports to NMFS-NOAA and made public through the center's website. Clearly indicate any confidential information that you do not wish to make public at this time.