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CONTRIBUTION OF THE GULF OF MEXICO POPULATION TO US ATLANTIC BLUEFIN TUNA FISHERIES IN 2015

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SUMMARY

US harvested Atlantic bluefin tuna sampled in 2015 were assigned membership to natal origin, East (Mediterranean Sea) or West (Gulf of Mexico), using otolith stable isotopes $\delta^{18}O$ and $\delta^{13}C$. Stock contribution estimates for all 2015 samples combined showed a substantial contribution from the East (71.6%) compared to the West (28.4%). Maximum likelihood estimates (MLE) indicated decreased mixing with size: Eastern contribution was 78.7%, 64.2%, 50%, and 36.5% respectively for school, large school, medium, and giant size bluefin tuna. Stock contribution estimates by size categories support previous studies that have shown transoceanic migration at younger sizes but deviate substantially from other recent estimates showing stronger dominance by western origin bluefin.

RÉSUMÉ

On a assigné au thon rouge de l'Atlantique capturé par les États-Unis et échantillonné en 2015 l'appartenance à une origine natale, à l'Est (mer Méditerranée) ou à l'Ouest (Golfe du Mexique), en utilisant des isotopes stables d'otolithes δ18O et δ13C. Les estimations de la contribution de chaque stock à tous les échantillons de 2015 combinés ont montré une contribution importante de l'Est (71,6%) par rapport à l'Ouest (28,4%). Les estimations de la vraisemblance maximale (MLE) ont indiqué une diminution du mélange avec la taille : la contribution de l'Est a été de 78,7%, 64,2%, 50% et 36,5% respectivement pour le thon rouge en bancs, en grands bancs, de taille moyenne et de taille géante. Les estimations de la contribution de chaque stock par catégories de taille soutiennent les études antérieures qui ont montré une migration transocéanique à des tailles plus jeunes mais s'écartent sensiblement d'autres estimations récentes montrant une prédominance plus forte du thon rouge d'origine occidentale.

RESUMEN

El atún rojo del Atlántico capturado por Estados Unidos y muestreado en 2015 fue asignado a su origen natal, este (Mediterráneo) u oeste (golfo de México) utilizando isótopos estables de otolitos δ18O y δ13C. Las estimaciones de la contribución de cada stock a todas las muestras de 2015 combinadas mostraban una sustancial contribución del este (71,6%) en comparación con la del oeste (28,4%). Las estimaciones de verosimilitud máxima (MLE) indicaban una mezcla decreciente con la talla: la contribución del este era de 78,7%, 64,2%, 50% y 36,5% respectivamente para los atunes rojos de talla de cardumen, de cardumen grande, medios y gigantes. Las estimaciones de la contribución de cada stock por categorías de talla respaldan estudios previos que han demostrado migraciones transoceánicas en tallas más jóvenes, pero se apartan sustancialmente de otras estimaciones recientes que muestran un dominio más fuerte del atún rojo originario del oeste.

KEYWORDS

Bluefin Tuna, Thunnus thynnus, Stock Mixing, Otolith Stable Isotopes, Natal Homing

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1. Introduction

Stable isotopes recorded as natural markers in otoliths have been shown to discriminate nursery origins of bluefin tuna thus supporting two Atlantic bluefin tuna populations (Rooker *et al.* 2008b; Rooker *et al.* 2014). Results from these and other natural tracer studies have supported separation of bluefin tuna homing areas (Gulf of Mexico and Mediterranean Sea) associated with the Western and Eastern stocks (Carlsson *et al.* 2007; Rooker *et al.* 2008b; Rooker *et al.* 2014; Dickhut *et al.* 2009).

In this study, we provide estimates of stock contribution based on otolith stable isotope composition for samples collected during 2015 from US recreational and commercial fisheries.

2. Methods

Otolith samples were collected by vendors under contract to National Marine Fisheries Service (NMFS) through the Large Pelagics Survey or NMFS Southeast Fisheries Science Center Pelagic Observer Program in 2015. A total of 181 fish were sampled; 175 of these provided otoliths for stable isotope analysis. The majority of all samples were landed in Maryland (50%) and New York (18%). In many instances, curved fork length (CFL) was estimated using other length measurements (straight fork length, snout length, otolith mass) based on conversion factors described in Secor *et al.* (2013).

Otoliths were processed at the NMFS Panama City Laboratory, according to methods described by Schloesser *et al.* (2010). Otolith core regions were rastered using a micromill and analyzed for stable isotopes ($\delta^{18}O$ and $\delta^{13}C$). Unknown sample mixtures were classified to source populations (West=Gulf of Mexico; East=Mediterranean) using a maximum likelihood estimation (MLE) method (HISEA; Millar 1990; http://www.stat.auckland.ac.nz/~millar/mixedstock/code.html). Classification depended on juvenile baseline (age =1 year; N=265) of samples from both eastern and western nurseries for the period 1998-2011 (Rooker *et al.* 2014).

Maximum likelihood stock composition mixtures were estimated for the entire 2015 US fishery dataset and separately for three regional-seasonal groups: 1) North Carolina and Virginia – winter fishery; 2) Mid-Atlantic and New England – excluding North Carolina and Virginia; and 3) Mid-Atlantic, New England, North Carolina and Virginia (**Table 1**). Additional analyses were run based on size categories: 1) School; 2) Large School; 3) Small Medium/Large Medium; and 4) Giant (**Table 2**). Mid-Atlantic states included Delaware, Maryland, New Jersey and New York. New England states included Connecticut, Massachusetts and Rhode Island.

3. Results

The US fishery sample was comprised of fish 79 to 287 cm CFL (**Figure 1**). Stock composition analysis from otolith stable isotope values indicated the East (Mediterranean population) contributed a larger percentage for all regions (**Table 1**). Samples landed in North Carolina and Virginia, winter fishery samples, showed nearly equal stock contribution estimates from the East (53%) and West (47%) (**Table 1**). Estimates of stock composition when based on size categories showed that a higher percentage of the East population contributed to school sizes and approximately 50% contribution for both East and West for medium size categories (**Table 2**). However, for the giant size category, stock composition estimates showed majority contribution from the West (64%) (**Table 2**).

4. Discussion

Stock contribution estimates from this study showed a lower Western contribution than estimates provided in more recent years (Secor *et al.* 2014; Siskey *et al.* 2016). Stock contribution estimates for all 2015 samples combined showed a substantial contribution from the East (71.6%) compared to the West (28.4%). Winter fishery bluefin tuna landed in North Carolina and Virginia had contribution estimates in nearly equal proportions for the East and West. Bluefin tuna landed in these states tended to be larger, consisting of large medium size category, as well as six of the nine giant bluefin tuna. A recent study on this same fishery (collection years 2011-2014) estimated a level of 24% Eastern contribution (Secor *et al.* 2014). Similarly, Siskey *et al.* (2016) reported low Eastern contribution levels (<10%) for US recreational fisheries for samples collected 2009-2014. Estimates from samples collected in 2015 based on size categories showed the East population contributing a higher percentage for school and large school sizes, supporting previous studies that have shown transoceanic migrations occur at younger sizes (Block *et al.* 2005; Rooker *et al.* 2008a). Previous studies using otolith stable isotope analysis showed east to west movement for adolescent bluefin tuna (Rooker *et al.* 2008a), and tagging data indicated that eastern and western bluefin tuna intermix in the US North Atlantic Ocean (Block *et al.* 2005). The majority of samples (~87%) collected in 2015 were school and large school size categories, which may have contributed to the higher percentage of the Eastern population; whereas, Eastern contribution estimates decreased for larger bluefin tuna (e.g., giants). Previous studies for US school and medium size bluefin tuna showed similar amplitudes of Eastern contribution levels (Rooker *et al.* 2008b; Dickhut *et al.* 2009; Secor *et al.* 2012), as well as decreased Eastern contribution as size increased (Siskey *et al.* 2016).

The apparent rapid change in mixing levels between 2009-2014 and 2015 US samples is not easily explained. The same otolith processing laboratory (NMFS Panama City) and analytical laboratory conducted analyses for both periods. Such a result could be explained by an episodic pulse of school and large school fish emigrating from the eastern Atlantic, but that this would suddenly occur across multiple age-classes seems unlikely. A large-scale western range expansion by the Eastern stock could be due to increases in abundance of forage fishes in the western North Atlantic (Overholtz and Friedland 2002) and in waters off Iceland and Greenland (MacKenzie *et al.* 2014). Additional years' samples will hopefully shed light on this sudden apparent shift in 2015 to a more mixed US fishery.

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References

Block, B.A., S.L.H. Teo, A. Walli, A. Boustany, M.J.W. Stokesbury, C.J. Farwell, K.C. Weng, H. Dewar, and T.D. Williams. 2005. Electronic tagging and population structure of Atlantic Bluefin tuna. Nature 434: 1121-1127.

Carlsson, J., J. R. McDowell, J. E. L. Carlsson, and J. E. Graves. 2007. Genetic identity of YOY bluefin tuna from the eastern and Western Atlantic spawning areas. Journal of Heredity 98(1):23-28.

Dickhut, R.M., A.D. Deshpande, A. Cincinelli, M.A. Cochran, S. Corsolini, R.W. Brill, D.H. Secor, and J.E. Graves. 2009. North Atlantic bluefin tuna population dynamics delineated by organochlorine tracers. Environmental Science and Technology 43:8522-8527.

MacKenzie, B.R., M.R. Payne, J. Boje, J.L. Hoyer, and H. Siegstad. 2014. A cascade of warming impacts brings bluefin tuna to Greenland waters. Global Change Biology 20: 2484-2491.

Millar, R.B. 1990. Stock composition program HISEA. http://www.stat.auckland.ac.nz/~millar/mixedstock/code.html

Overholtz, W.J. and K.D. Friedland. 2002. Recovery of the Gulf of Maine-Georges Bank Atlantic herring (*Clupea harengus*) complex: perspectives based on bottom trawl survey data. Fishery Bulletin 100: 593-608.

Rooker, J.R., D.H. Secor, G. DeMetrio, A.J. Kaufman, A. Belmonte Rios, V. Ticina. 2008a. Evidence of trans-Atlantic movement and natal homing of bluefin tuna from stable isotopes in otoliths. Marine Ecology Progress Series 368: 231-239.

Rooker, J.R., D.H. Secor, G.D. DeMetrio, R. Schloesser, B.A. Block, and J.D. Neilson. 2008b. Natal homing and connectivity in Atlantic bluefin tuna populations. Science 322: 742-744.

Rooker, J.R., H. Arrizabalaga, I. Fraile, D.H. Secor, D.L. Dettman, N. Abid, P. Addis, S. Deguara, F. Saadet Karakulak, A. Kimoto, O. Sakai, D. Macas, and M. Neves Santos. 2014. Crossing the line: migratory and homing behaviors of Atlantic Bluefin tuna. Marine Ecology Progress Series 504:265-276.

Schloesser, R.W., J.D. Neilson, D.H. Secor, and J.R. Rooker. 2010. Natal origin of Atlantic bluefin tuna (*Thunnus thynnus*) from the Gulf of St. Lawrence based on otolith $\delta^{13}C$ and $\delta^{18}O$. Canadian Journal of Fisheries and Aquatic Sciences 67: 563-569.

Secor, D.H., J.R. Rooker, J.D. Neilson, D. Bursawon, B. Gahagan, and R. Allman. 2013. Historical Atlantic bluefin tuna stock mixing within fisheries off the U.S., 1976-2012. Collect. Vol. Sci. Pap. ICCAT. 69(2): 938-946.

Secor, D.H., D. Busawon, B. Gahagan, W. Golet, E. Koob, J. Neilson, and M. Siskey. 2014. Conversion factors for Atlantic bluefin tuna fork length from measures of snout length and otolith mass. Collect. Vol. Sci. Pap. ICCAT. 70(2): 364-367.

Secor, D.H. J.R. Rooker, B.I. Gahagan, M.R. Siskey, and R.W. Wingate. 2014. Depressed resilience of Bluefin tuna in the western Atlantic and age truncation. Conservation Biology 29(2): 400-408.

Siskey, M.R., M.J. Wilberg, R.J. Allman, B.K. Barnett, and D.H. Secor. 2016. Forty years of fishing: Changes in age structure and stock mixing in northwestern Atlantic bluefin tuna (*Thunnus thynnus*) associated with size-selective and long-term exploitation. ICES Journal of Marine Science. doi:10.1093/icesjms/fsw115

Table 1. Mixing levels of natal origin using stable isotopes ($\delta^{13}C$, $\delta^{18}O$) for Atlantic bluefin tuna sampled in US recreational and commercial fisheries during 2015. WEST=Gulf of Mexico population; EAST=Mediterranean population; MLE=maximum likelihood estimate of population composition; SD=standard deviation.

Region	N	--------------------MLE--------------------		
		% WEST	% EAST	SD
All samples combined	175	28.4	71.6	0.06
NC, VA (winter fishery)	16	47.3	52.7	0.18
Mid-Atlantic, New England (excluding NC, VA)	157	24.1	75.9	0.06
Mid-Atlantic, New England, NC, VA	173	25.8	74.2	0.05

Table 2. Mixing levels for Atlantic Bluefin tuna sampled in US recreational and commercial fisheries during 2015 based on curved fork length (CFL) size categories. Small Medium and Large Medium combined due to small sample size. WEST=Gulf of Mexico population; EAST=Mediterranean population; MLE=maximum likelihood estimate of population composition; SD=standard deviation.

Size Category	CFL Size Range (cm)	N	--------------------MLE--------------------		
			% WEST	% EAST	SD
School	69 – 117	141	21.3	78.7	0.06
Large School	119 – 147	12	35.8	64.2	0.22
Small Medium, Large Medium	150 - 203	13	50.2	49.8	0.22
Giant	≥ 206	9	63.5	36.5	0.21

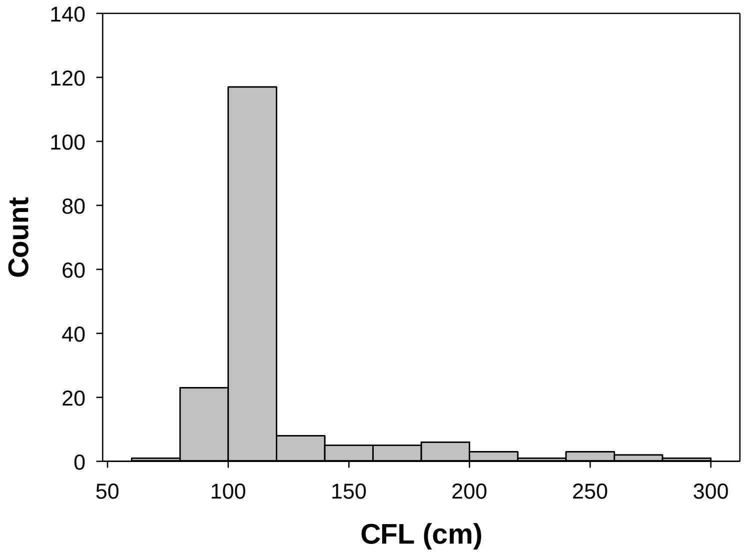

Figure 1. Frequency histogram for estimated curved fork length (CFL) for Atlantic bluefin tuna sampled from US recreational and commercial fisheries in 2015.