CONTRIBUTION OF GULF OF MEXICO POPULATION TO U.S. ATLANTIC BLUEFIN TUNA FISHERIES, 2010-2011

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SUMMARY

Membership to natal population, Mediterranean Sea or Gulf of Mexico, was assigned for U.S. harvested Atlantic bluefin tuna, sampled 2010-2011. The estimated Gulf of Mexico population contribution was 100% for both the recreational category (~ 70 to160 cm curved fork length; N=247) and the commercial category (> 180 cm; N=74) based on otolith stable isotope composition of $\delta^{18}O$ and $\delta^{13}C$. This level of stock contribution was similar for a previous sample (collected 1996-2002) of Gulf of Maine adults but substantially different than a previous sample from the recreational fishery collected 1996-2000, which showed a substantial contribution (~50%) by the Mediterranean population.

RÉSUMÉ

L'appartenance à une population natale, de la Méditerranée ou du golfe du Mexique, a été assignée à des thons rouges de l'Atlantique capturés par les États-Unis, échantillonnés en 2010 et 2011. L'estimation du taux de contribution des spécimens du golfe du Mexique s'élevait à 100 % tant dans la catégorie récréative (~ 70 à 160 cm de longueur courbée à la fourche; N=247) que dans la catégorie commerciale (> 180 cm; N=74) reposant sur la composition des otolithes en isotopes stables (O et C). Ce niveau de contribution au stock était similaire à celui d'un échantillon antérieur prélevé entre 1996 et 2002 d'adultes du golfe du Maine, mais était radicalement différent à celui d'un échantillon antérieur recueilli entre 1996 et 2000 sur des spécimens capturés dans le cadre de la pêche sportive qui présentait une contribution importante (~50%) de la population méditerranéenne.

RESUMEN

Se asignaron los miembros de población natal, mar Mediterráneo o Golfo de México, para el atún rojo capturado en Estados Unidos y muestreado entre 2010 y 2011. La contribución estimada de la población del golfo de México fue del 100% tanto para la categoría de recreo (~ 70 a 160 cm longitud curva a la horquilla; N=247) como para la categoría comercial (> 180 cm; N=74) basándose en la composición de isotopos estables de otolitos $\delta^{18}O$ y $\delta^{13}C$. Este nivel de contribución de stock fue similar al de una muestra anterior (recogida en el periodo 1996-2002) de adultos del golfo de Maine, pero difería en gran medida de una muestra anterior de la pesquería de recreo recogida en el periodo 1996-2000, que mostraba una contribución importante(~50%) de la población del Mediterráneo.

KEYWORDS

Otolith stable isotopes, stock composition, natal homing, tuna fisheries, Thunnus thynnus

1. Introduction

Natural markers supports two populations of Atlantic bluefin tuna, both exhibiting high levels of natal homing to the two known spawning and nursery regions (Carlsson *et al*. 2007; Rooker *et al*. 2008; Dickhut *et al*. 2009). Evidence from otolith stable isotope analysis indicated that in the 1990s many school and medium size class bluefin tuna (69-183 cm CFL), captured in US angler fisheries originated from the Mediterranean population (Rooker *et al*. 2008; Secor *et al*. 2012). On the other hand, samples of adults larger than 183 cm CFL targeted by US commercial fisheries were predicted to originate exclusively from the Gulf of Mexico population. These results and others (Block *et al*. 2005; Rooker *et al*. 2007; Dickhut *et al*. 2009) led to the view that transoceanic migrations and mixing were more likely during the juvenile/sub-adult period than during the adult period.

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Mixing in US bluefin tuna fisheries depends on (1) the degree of transoceanic migrations by Mediterranean and Gulf of Mexico-origin fish and (2) the relative recruitment (production) between these two stocks (Porch *et al*. 2000; Sissenwine *et al*. 1998; Secor 2002; Taylor *et al*. 2011). Therefore, we might expect the level of mixing in US fisheries to vary over decades in concert with changes in relative production and rates of transoceanic migrations between the two principal stocks. To evaluate recent changes in mixing levels in US fisheries, we estimated stock mixing for recent samples (2010-2011) based on otolith stable isotope stock composition analysis. We also evaluated a unique sample of young-of-the-year juvenile Atlantic bluefin tuna captured in Virginia US waters and made available by J. Graves (Virginia Institute of Marine Science). We predicted this sample would show similar or lower $\delta^{18}O$ than baseline values than Western-origin age-1 year juveniles.

2. Methods

Most otolith samples were collected by samplers under contract to National Marine Fisheries Service's (NMFS) through their Large Pelagic Biological Survey conducted 2010-present. In addition, staff at the University of Maryland sampled recreational category bluefin tuna. Principal landing sites for recreational category samples (N=247) were Maryland (54%) and Massachusetts (31%). The majority (90%) of commercial category fish (N=72) were landed in Massachusetts. Samplers sometimes took incomplete or inconsistent records of fish length. In a majority of instances, curved fork length was estimated from other length measurements (straight fork length, curved pectoral fork length, snout length, etc.) based on accepted or new (Secor *et al*. 2013a) conversion factors.

Otoliths were prepared according to Schloesser *et al*. (2010) and analyzed for $\delta^{18}O$ and $\delta^{13}C$ from core regions. Classification of the unknown sample mixtures to source populations was performed using a maximum likelihood estimation (MLE) method (HISEA: Millar 1990; http://www.stat.auckland.ac.nz/~millar/mixedstock/code.html; aka finite mixture distribution; Prager and Shertzer 2005) using a new juvenile baseline. The baseline is largely a reanalysis of archived juvenile otoliths but also includes recent years' Mediterranean samples made available by GBYP partners. Juvenile otoliths (age =1 year; N=265) were drawn from eastern and western nurseries for the period 1998-2011 and were treated using the same approach (rastering thin sections) and analyzed by a single laboratory.

3. Results

The US recreational and commercial fishery samples comprised fish 60-210 cm CFL and 150-275 cm CFL, respectively (**Figure 1**). A small number of the commercial sample was less than the regulatory size limit (CFL=183 cm), which could in part be explained by imprecision in length conversion factors. Otolith stable isotope stock composition analysis indicated 100% contribution by the Gulf of Mexico population for both samples (**Table 1; Figure 1**).

The 2010 western young-of-the-year juvenile sample (N=26; lower jaw CFL=24.3-37.3 cm) was more depleted in both $\delta^{18}O$ and $\delta^{13}C$ in comparison to the US age-1 juvenile baseline, but $\delta^{18}O$ levels overlapped substantially with both the western juvenile baseline and the US recreational sample (**Figure 1**).

4. Discussion

Results indicate that mixing in US recreational fisheries has been variable during recent decades, likely due to the joint influence of variable migration and production rates between the two principal populations. The higher level of mixing by the Mediterranean population during the 1990s (Rooker *et al*. 2008) was not an artifact of using a new juvenile baseline. In a reanalysis of fish sampled during 1996-2002 (CFL=100-200 cm), 47% were predicted to have originated from the Mediterranean population (**Table 1**). Rather, the shift in mixing level may have resulted from lower recruitment for estimated year-classes 1987-1996 in comparison to recent times. At least one (2003) and perhaps other (2006) recent strong year-classes have appeared in the US recreational fishery, and evidence from otolith stable isotopes indicates that these year-classes are of western-origin (Secor *et al*. 2013b). Stronger recruitments attributable to the western stock have important implications to management reference points and recovery goals.

The US-collected young-of-the-year sample supported the premise of natal differences in otolith stable isotopes between Gulf of Mexico and Mediterranean populations. Depleted values for $\delta^{18}O$ are expected due to persistent regional oceanographic differences where western Atlantic US shelf waters are more depleted in $\delta^{18}O$ than the Mediterranean Sea (Rooker *et al*. 2008). That the young-of-the year values of $\delta^{18}O$ were less than the western age-1 juveniles supports previous speculation that some Western baseline age-1 juveniles were of Mediterranean origin, having already migrated across the Atlantic Ocean. Tagging data indicates that yearling Atlantic and Pacific bluefin tuna are capable of such migrations (Itoh *et al*. 2003; Rooker *et al*. 2007). The migration of a small number of Mediterranean yearling bluefin tuna to US waters could explain (1) the overlap in stable isotopes between eastern and western juveniles; and (2) the wider distribution of western juvenile otolith $\delta^{18}O$ in comparison to Mediterranean samples. The more depleted values of $\delta^{13}C$ in young-of-the-year juvenile otoliths are less easily explained, perhaps influenced by ontogenetic or trophic effects.

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Table 1. Natal population mixture levels for Atlantic bluefin tuna sampled in US recreational and commercial fisheries during the period 2010-2011. MED=Mediterranean population; GOMEX=Gulf of Mexico population; MLE=maximum likelihood estimate of population composition; SD=standard deviation.

Year(s) sampled	Sample	N	Population	MLE(%)	MLE SD
2010-2011	US Recreational Fishery	247	MED	0.0	~0.0
			GOMEX	100.0	
2010-2011	US Commercial Fishery	74	MED	0.0	~0.0
			GOMEX	100.0	
1996-2002	Mid-Atlantic, New England/ Rooker *et al*. 2008	95	MED	45.7	7.2
			GOMEX	54.3	

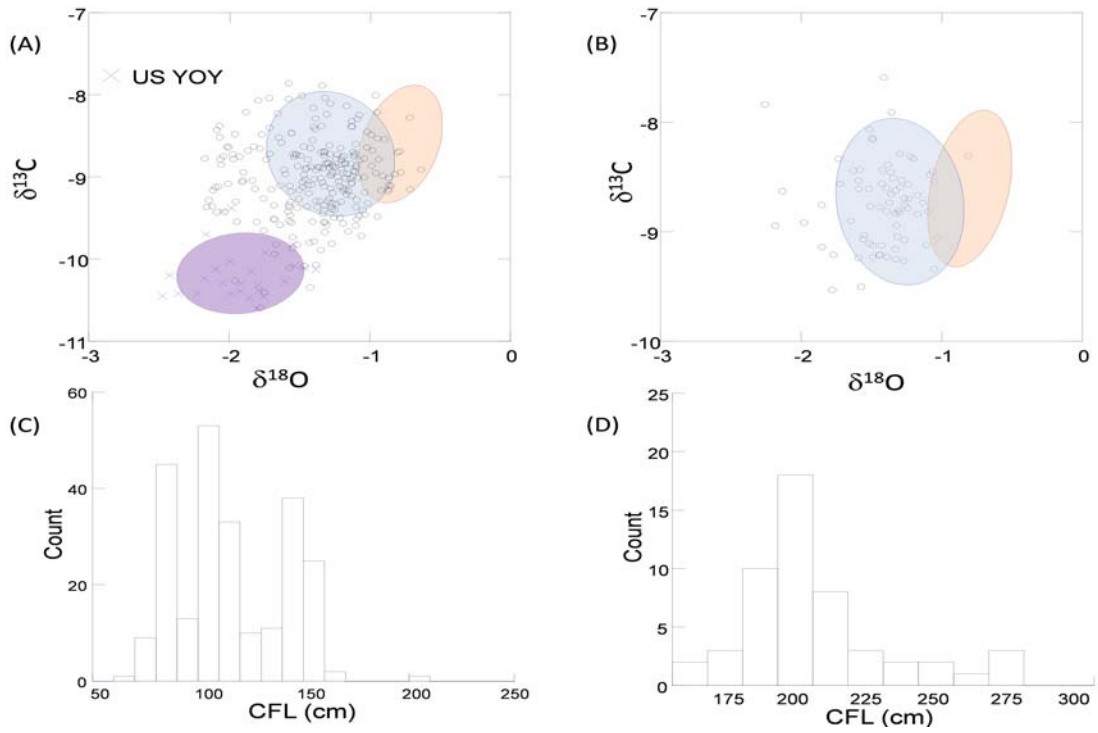

Figure 1. Stable isotope scatter plots for adult Atlantic bluefin tuna sampled from (A) US recreational and (B) commercial (B) fisheries, 2010-2011. Frequency histograms for estimated curved fork length (CFL) are presented for the US recreational (C) and commercial (D) fisheries. Sample ellipses (68%) for the juvenile baseline are shaded blue and orange. A sample of young-of-the-year Atlantic bluefin tuna sampled in US water in 2010 is shown by the purple sample ellipse.