Nursery origin of yellowfin and bigeye tuna in the Hawaiian Islands

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Local versus equatorial recruitment of YFT and BET to Hawaii

- Effective management requires the understanding of stock structure and the degree of mixing for tuna stocks

- **Questions**-
  
  1. *To what degree are YFT & BET from the Hawaiian Islands supported by local recruitment?*

     YFT may exhibit restricted movement challenging the “highly migratory definition” (Sibert & Hampton 2003; Schaefer et al. 2007); restricted movement around Hawaii Seamounts & FADs (Itano & Holland 2000); more significant movement for BET (Hampton et al. 1998)

  2. *To what degree are YFT & BET from equatorial nursery grounds recruiting to Hawaii-based fisheries?*

     Hampton & Fournier (2001) model estimated a significant portion of large tuna in Hawaiian waters originate from other regions of WCPO
Approaches to assess movement and stock structure of tunas

- Genetics, organochlorine tracers
- Tagging (conventional & electronic)
- Otolith chemistry (stable isotopes & trace elements)

Otolith composition linked to ambient water chemistry and thus material deposited during the first few months of life serves as a natural “birth certificate” that can be used to determine an individual’s place of origin.

Spatial variation in stable isotopic (e.g. C, O) and elemental (e.g. Mg, Mn, Sr) signatures in otoliths reported for tunas in both the Atlantic Ocean (Rooker et al. 2008a, 2008b) and Pacific Ocean (Rooker et al. 2003); global-scale differences in ambient water chemistry also reported (LeGrande and Schmidt 2006).
Objectives

1. Characterize chemical signatures in otoliths of age-0 YFT & BET from putative nurseries in the WCPO

2. Assess inter-annual variability (temporal stability) in chemical signatures of age-0 fish (2008 vs. 2009)

3. Determine the origin of sub-adult (age-1 & 2) YFT & BET collected in Hawaii inshore & Equatorial-based fisheries
Methods: sample collection

- Hook-n-line
- Fish auction & processors
- Students!
- Tagging cruises
**Methods: collection sites**

**YFT & BET nursery areas**

- Philippines (Moro Gulf)
- Marshall Islands
- Line Islands
- Solomon Islands
- Hawaiian Islands & Cross Seamount
Otolith chemistry protocol

Core isolation of age-0 YFT or BET otoliths, corresponding to approximately the first 3 months of life = baseline fingerprint or “birth certificate”

Origin of sub-adults (2009): isolate otolith core using template (~3 mo period) and match to 2008 baseline (age-0 reference samples) → “age-class matching”
Age-0 YFT by Region

Hawaii inshore classification success: 2008 = 80%, 2009 = 100%
**Age-0 YFT by Region**

- **MANOVA:** $p < 0.01$
- **DFA:** jackknifed classification success
  - All regions = 78%
  - Hawaii inshore = 94%

Temporal Stability!
Sub-adult YFT: Hawaii inshore

Collection locations by Hawaiian Island

- Oahu: 12%
- Hawaii: 23%
- Maui: 32%
- Kauai: 33%

N=103

δ¹³C vs. δ¹⁸O graph:
- Hawaii
- Kauai
- Maui
- Oahu
**Sub-adult YFT: contribution estimates from Hawaii**

- **δ¹³C** and **δ¹⁸O** plots showing the percent composition of different areas:
  - **Hawaii inshore**: 95.0 (± 4.0)
  - **Line Is., Hawaii offshore**: 5.0 (± 4.0)
  - **W. Equatorial**: 0

**Mixed stock analysis**
- HISEA (Millar 1990)

- Hawaii inshore sub-adults, n=103
Sub-adult YFT: contribution estimates from Equatorial

Mixed stock analysis
HISEA (Millar 1990)

Marshall Is. 76%
Solomon Is. 15%
Line Is. 6%

Hawaii inshore 0
Hawaii offshore 9.0 (± 12.1)
W. Equatorial 91.0 (± 23.2)

δ¹³C

δ¹⁸O

-12
-11
-10
-9
-8
-4
-3
-2
-1

Percent composition

0 20 40 60 80 100

Hawaii inshore
Line Is., Hawaii offshore
W. Equatorial
W. Equatorial sub-adults, n=50
**Age-0 BET by Region - All elements**

- **MANOVA**: $p < 0.01$
- **DFA**: jackknifed classification success
  - All regions = 58%

**Variables:**
- $\delta^{13}C$
- $\delta^{18}O$
- Ba
- Ca
- Mg
- Mn
- Sr

Legend:
- Red circle: Hawaii inshore
- Cross: Hawaii offshore
- Yellow plus: Line Is.
- Blue triangle: Marshall Is.
- Green inverted triangle: Philippines
Age-0 BET by Region-2008

MANOVA: $p < 0.01$

DFA: jackknifed classification success
All regions = 81%

- Central Pacific
  (Hawaii inshore, Hawaii offshore, Line Is.)
- W. Equatorial
  (Marshall Is., Philippines)
Sub-adult BET: contribution estimates from Equatorial

$\delta^{13}C$ vs $\delta^{18}O$

- C. Pacific (HI in, HI off, LI)
- W. Equatorial (MI, PH)
- W. Equatorial sub-adults, n=50

Mixed stock analysis
HISEA (Millar 1990)

Central Pacific: 0.4 (3.3)
Western Equatorial: 99.6 (± 2.6)
Applications: species-specific or environment?

δ\textsuperscript{18}O

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δ\textsuperscript{13}C

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Otolith $\delta^{13}C$ and $\delta^{18}O$ promising markers to identify age-0 YFT from different nurseries in the WCPO; clear separation of Hawaii inshore from other putative nurseries sampled

Inter-annual variability of age-0 YFT was present in some regions suggesting that age-class matching is required

Origin of sub-adult YFT from Hawaii inshore $\rightarrow$ local recruits (locally spawned fish)

Origin of sub-adult YFT from Equatorial-based fishery $\rightarrow$ local recruits

Discrimination of age-0 BET was moderate among WCPO nursery regions (Western vs. Central Pacific); addition of trace elements for BET (+ YFT) may further improve classification success

Sub-adult BET showed similar trend of local recruitment in W. Equatorial
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