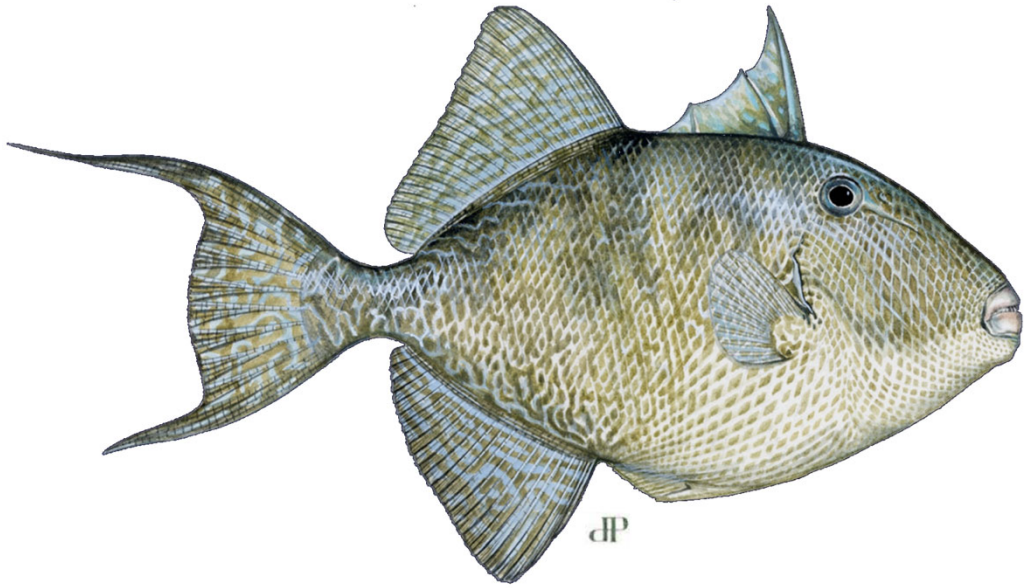
Validating Gray Triggerfish Age Estimates Derived from Otoliths and Spines, and Assessing Effects of Ageing Error on Estimates of Size-at-Age, Growth, and Stock Status Benchmarks



Will Patterson, Derek Chamberlin, Zachary Siders

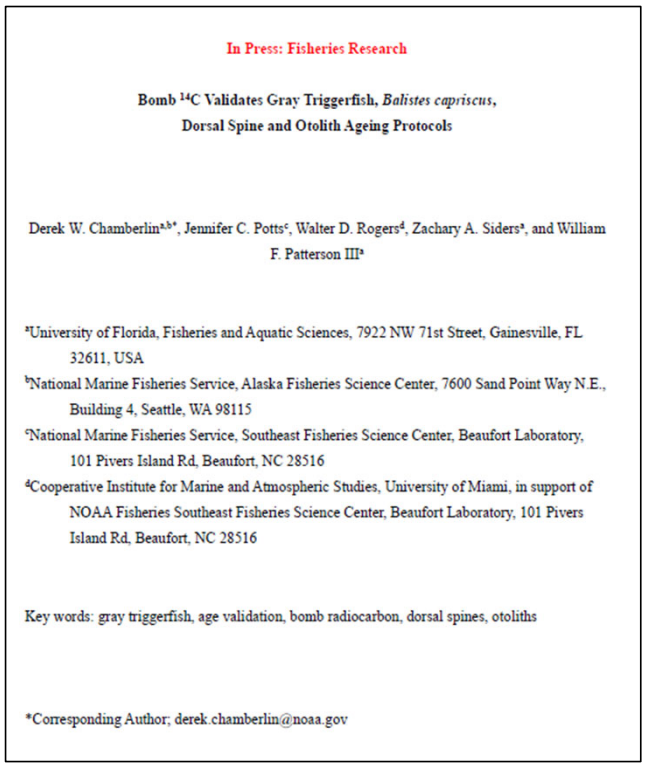
UF IFAS UNIVERSITY of FLORIDA

UNIVERSITY of FLORIDA UF Marine Fisheries Laboratory

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

Report Organization and Study Contributors

Jennifer Potts, Walt Rogers, Miaya Taylor, Nick Fisch, Kelli Johnson, Katie Siegfried, Shannon Cass-Calay



In Press: Fisheries Research

Bomb ^{14}C Validates Gray Triggerfish, *Balistes capriscus*, Dorsal Spine and Otolith Ageing Protocols

Derek W. Chamberlin[a,b*], Jennifer C. Potts[c], Walter D. Rogers[d], Zachary A. Siders[a], and William F. Patterson III[a]

[a]University of Florida, Fisheries and Aquatic Sciences, 7922 NW 71st Street, Gainesville, FL 32611, USA
[b]National Marine Fisheries Service, Alaska Fisheries Science Center, 7600 Sand Point Way N.E., Building 4, Seattle, WA 98115
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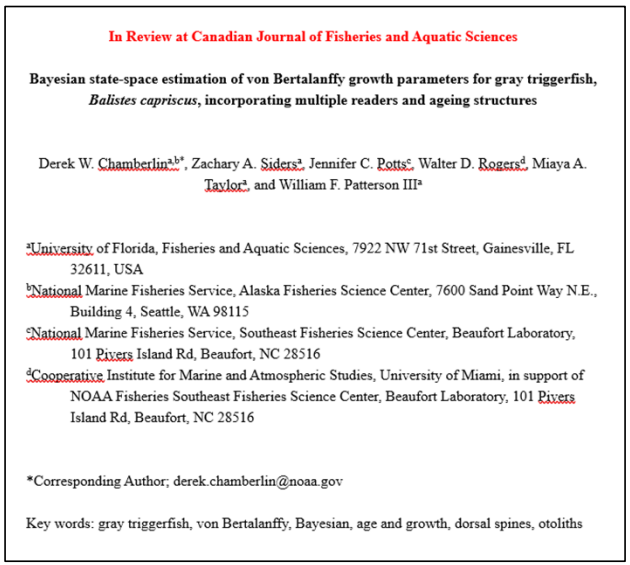
Key words: gray triggerfish, age validation, bomb radiocarbon, dorsal spines, otoliths

*Corresponding Author; derek.chamberlin@noaa.gov



In Review at Canadian Journal of Fisheries and Aquatic Sciences

Bayesian state-space estimation of von Bertalanffy growth parameters for gray triggerfish, *Balistes capriscus*, incorporating multiple readers and ageing structures

Derek W. Chamberlin[a,b*], Zachary A. Siders[a], Jennifer C. Potts[c], Walter D. Rogers[d], Miaya A. Taylor[a], and William F. Patterson III[a]

[a]University of Florida, Fisheries and Aquatic Sciences, 7922 NW 71st Street, Gainesville, FL 32611, USA
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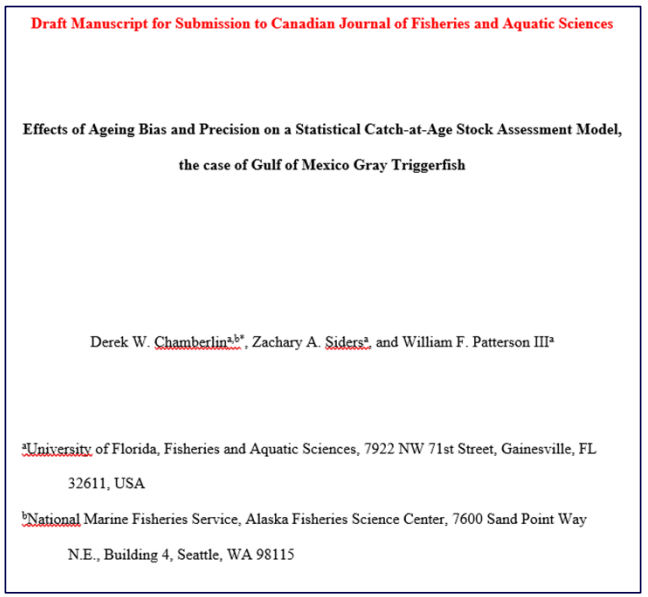
*Corresponding Author; derek.chamberlin@noaa.gov

Key words: gray triggerfish, von Bertalanffy, Bayesian, age and growth, dorsal spines, otoliths



Draft Manuscript for Submission to Canadian Journal of Fisheries and Aquatic Sciences

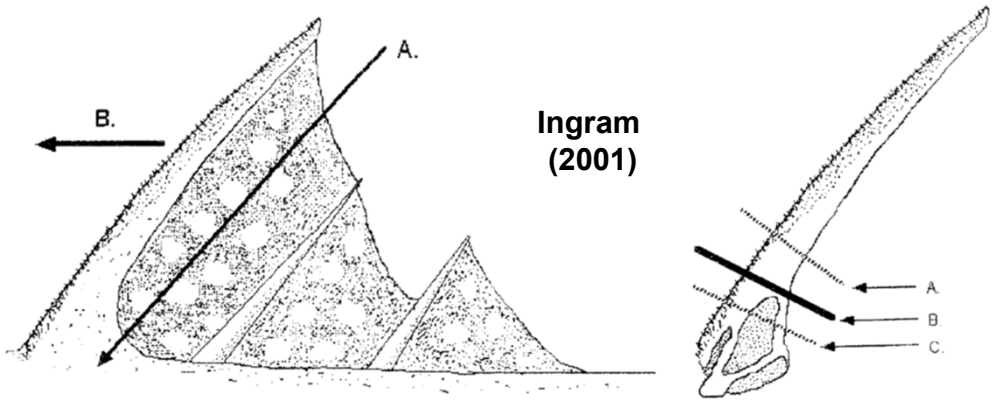
Effects of Ageing Bias and Precision on a Statistical Catch-at-Age Stock Assessment Model, the case of Gulf of Mexico Gray Triggerfish

Derek W. Chamberlin[a,b*], Zachary A. Siders[a], and William F. Patterson III[a]

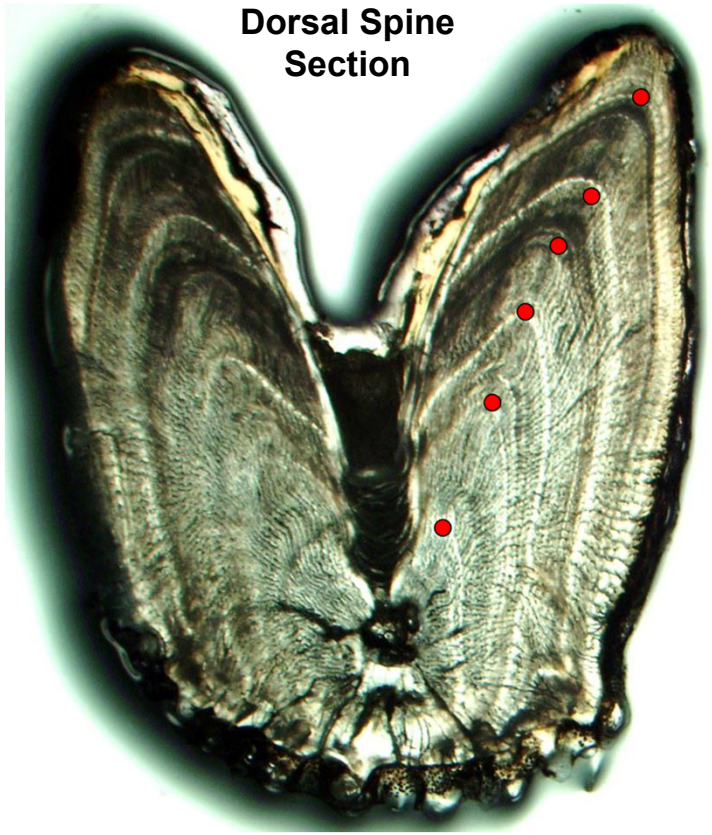
[a]University of Florida, Fisheries and Aquatic Sciences, 7922 NW 71st Street, Gainesville, FL 32611, USA
[b]National Marine Fisheries Service, Alaska Fisheries Science Center, 7600 Sand Point Way N.E., Building 4, Seattle, WA 98115

Traditional Gray Triggerfish Ageing with Dorsal Spines

Extracting and Sectioning Dorsal Spine

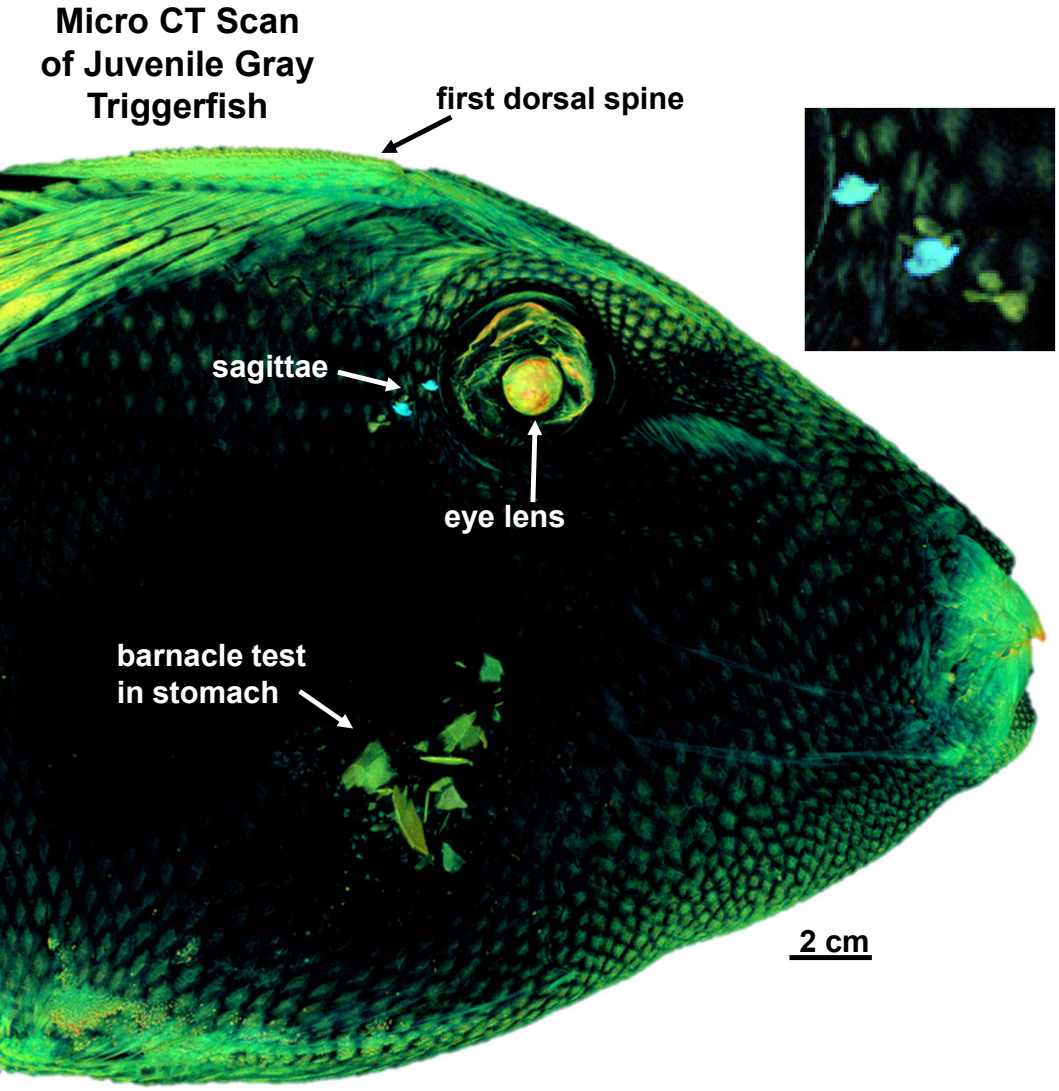


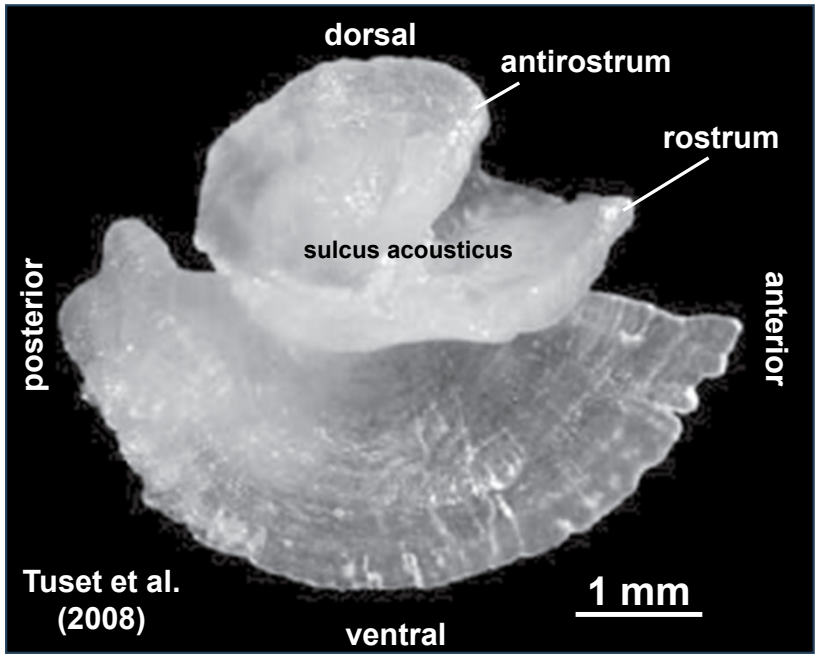
Ingram (2001)

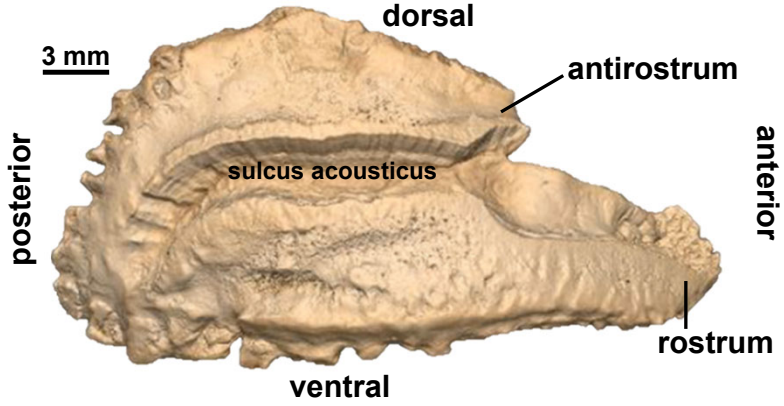


- First dorsal spine = historical ageing structure of choice
- Relatively easy to extract and section
- Concerns raised about ageing error, both imprecision and bias
- Important implications for population ecology and stock assessment

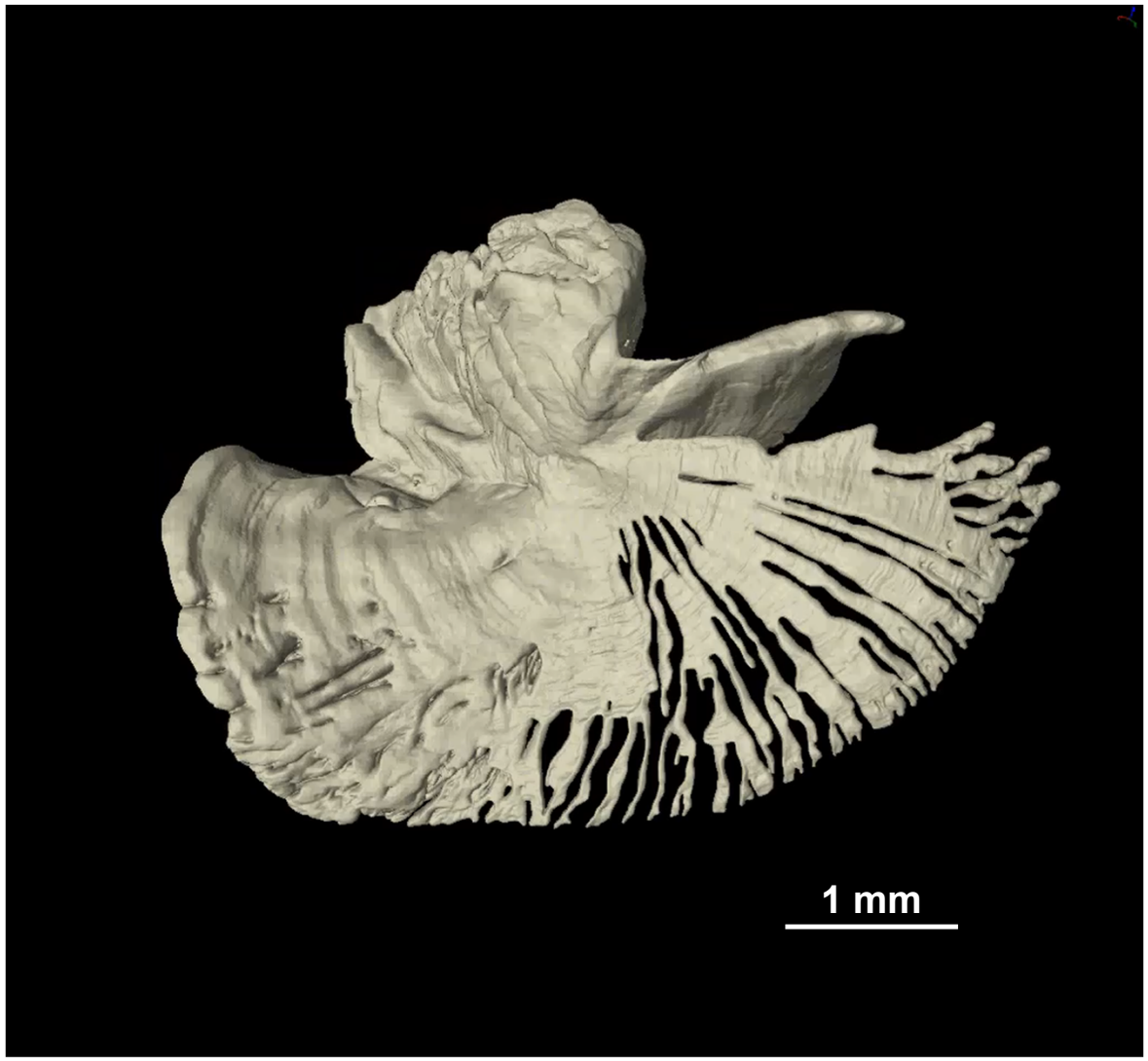
Gray Triggerfish Otoliths: Small, Delicate, Difficult to Extract



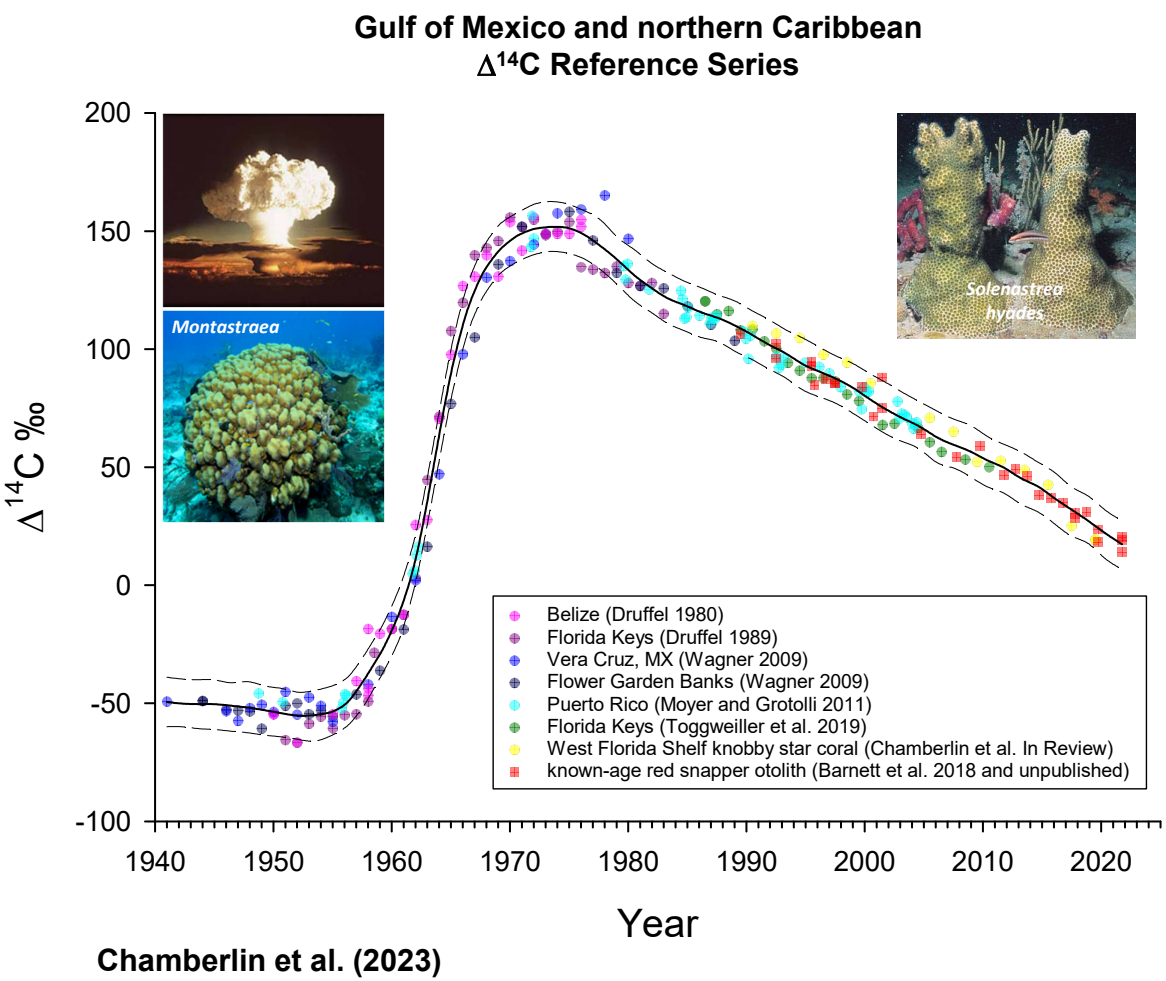




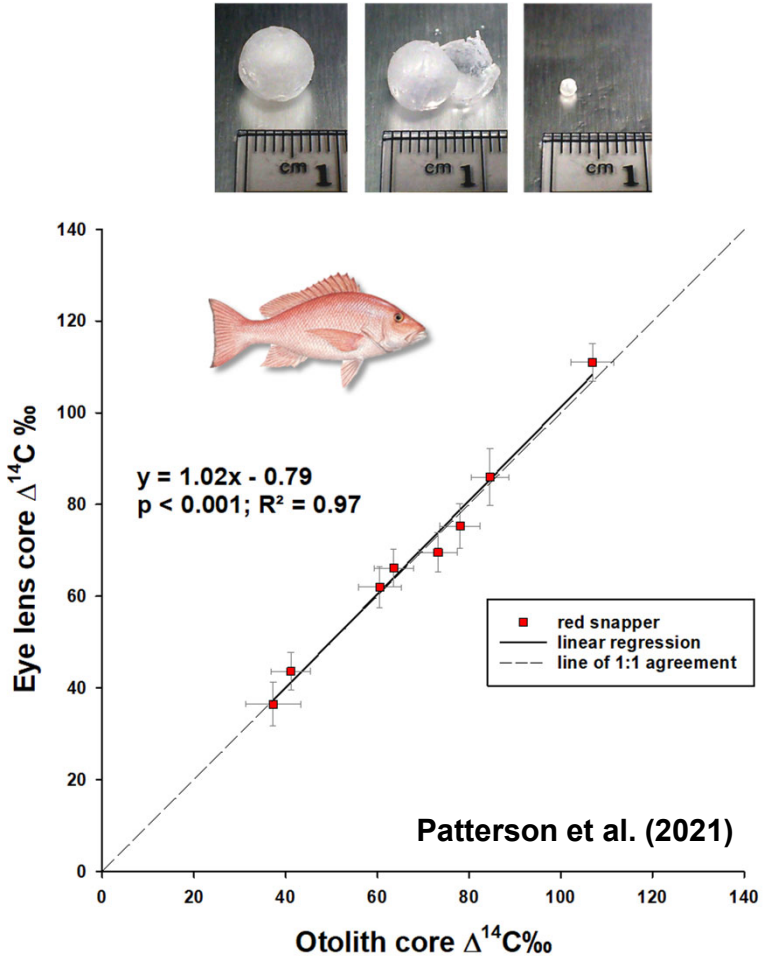
Gray Triggerfish Otoliths: Small, Delicate, Difficult to Extract



Eye Lens-Based Bomb ^{14}C Fish Age Validation



Chamberlin et al. (2023)



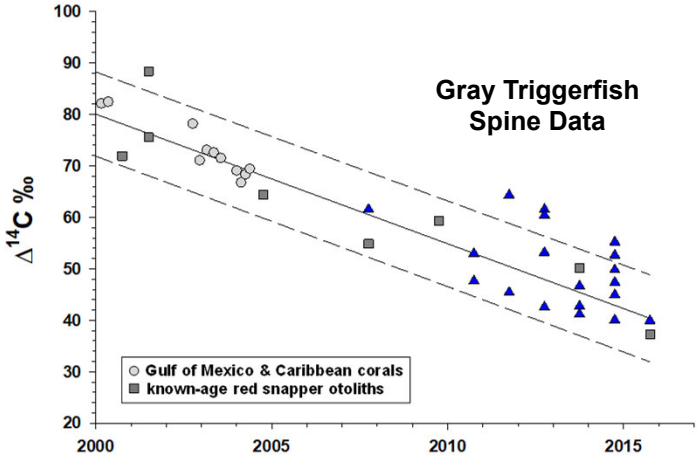
Preliminary Validation of Gray Triggerfish Spine- Versus Otolith-Derived Ages

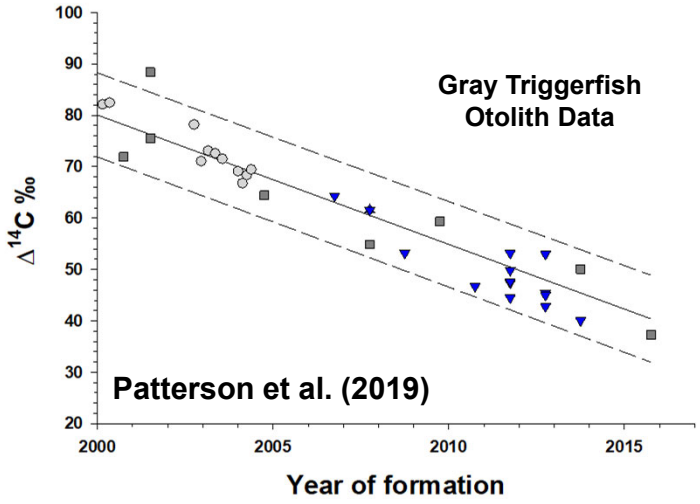
Do Sagittal Otoliths Provide More Reliable Age Estimates Than Dorsal Spines for Gray Triggerfish?

William F. Patterson III, Virginia R. Shervette, and Beverly K. Barnett, and Robert J. Allman[3]

SEDAR62-WP-17

21 May 2019
Updated: 23 May 2019





Advocating for Otolith-Derived Age Estimation in Gray Triggerfish

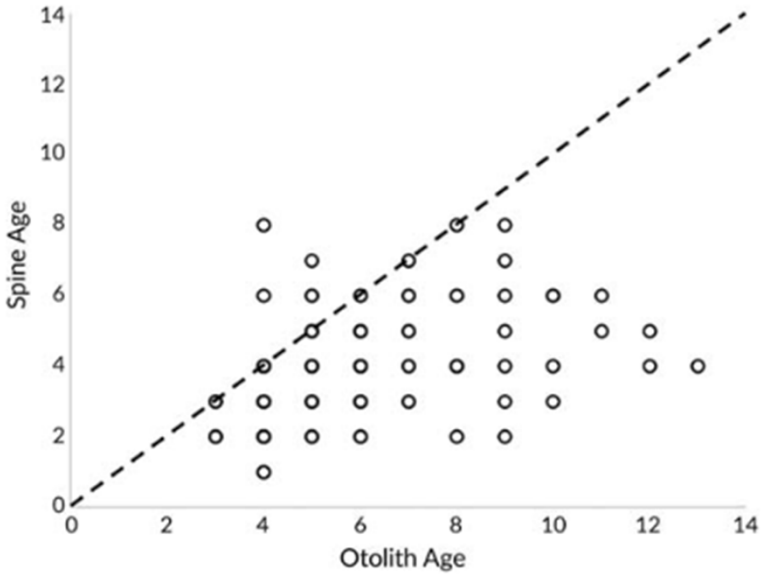
Received: 8 August 2020 | Accepted: 9 December 2020
DOI: 10.1111/jfb.14644

REGULAR PAPER

JOURNAL OF FISH BIOLOGY fsbi

Age and growth of grey triggerfish *Balistes capriscus* from trans-Atlantic populations

Virginia R. Shervette[1,2] | Jesús M. Rivera Hernández[1,2] | Francis Kofi Ewusie Nunoo[3]



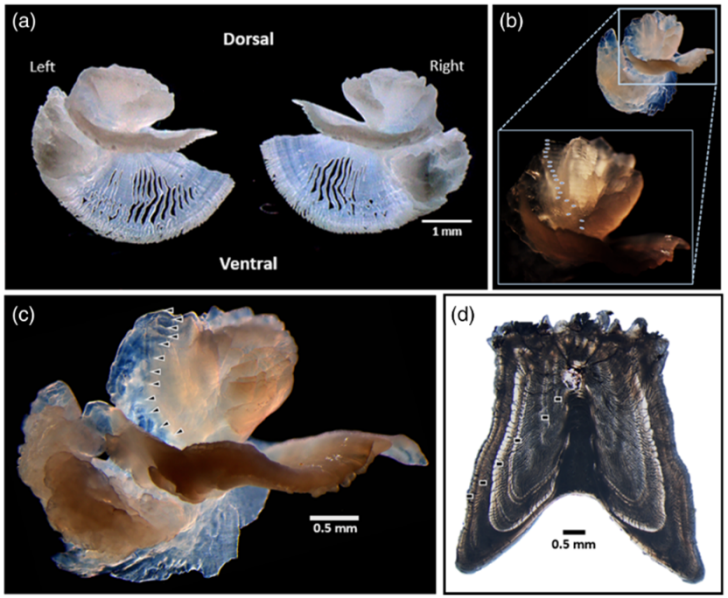
JOURNAL OF FISH BIOLOGY fsbi

REGULAR PAPER | Open Access

Illuminating otoliths: New insights for life history of *Balistes* triggerfishes

Virginia R. Shervette | Jesús M. Rivera Hernández

First published: 01 October 2022 | https://doi.org/10.1111/jfb.15233



Gulf of Mexico Gray Triggerfish 2025-26 Stock Assessment

- **Significant issues to address:**
  - **population structure**
  - **model spatial structure**
  - **stock-recruit relationship**
  - **release mortality**
  - **ageing error**

Examining Aspects of Gray Triggerfish Ageing Error and Their Implications

- **Three-year study funded by the GMFMC ahead of the 2025 GOM gray triggerfish stock assessment to address ageing error issues**

- **Original study objectives:**

  1) sample gray triggerfish from landings in the southeastern, northeastern, and western GOM

  2) estimate fish age via opaque zone counts in sagittal otoliths and translucent zone counts in dorsal spines

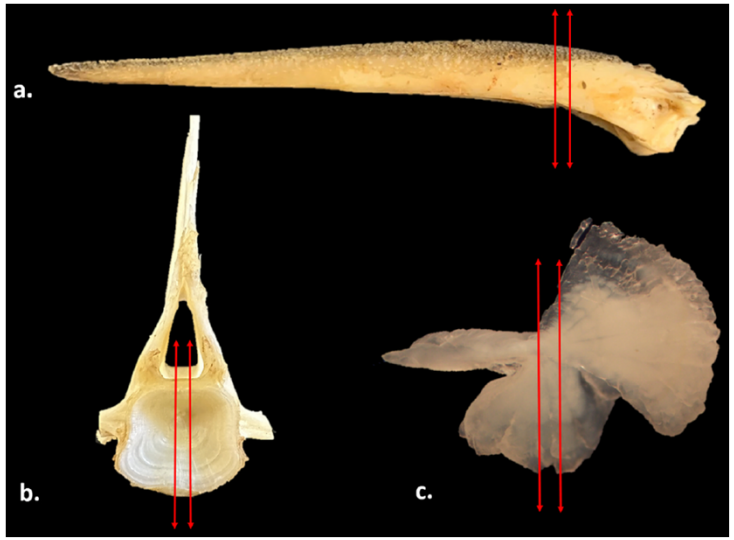
  3) validate age estimates for a subset of samples via application of the bomb ^{14}C chronometer to eye lens core (age-0 portion) $\Delta^{14}C$ values;

  4) test for differences in sex-specific size-at-age and growth estimates among regions and between commercial and recreationally harvested fish

  5) compute age-length keys (ALKs) by sex, and potentially by region and fishery sector, pending results under objective 4.

A Modified Spine-Based Method to Estimate Gray Triggerfish Age

- **Potts et al. (2023): modified spine-based GT ageing protocol produced similar age estimates as sectioned otoliths.**



Fisheries Research 267 (2023) 106809

Contents lists available at ScienceDirect

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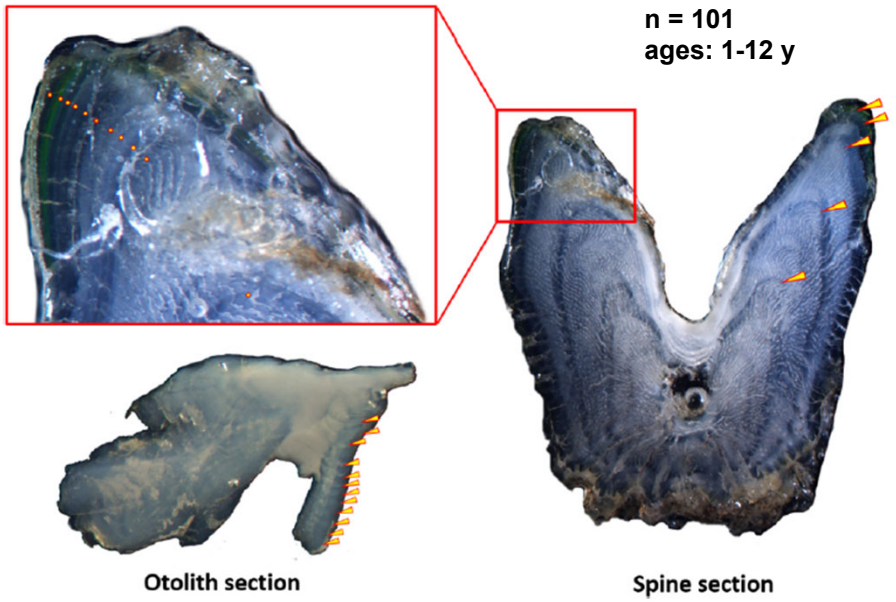
journal homepage: www.elsevier.com/locate/fishres

Full length article

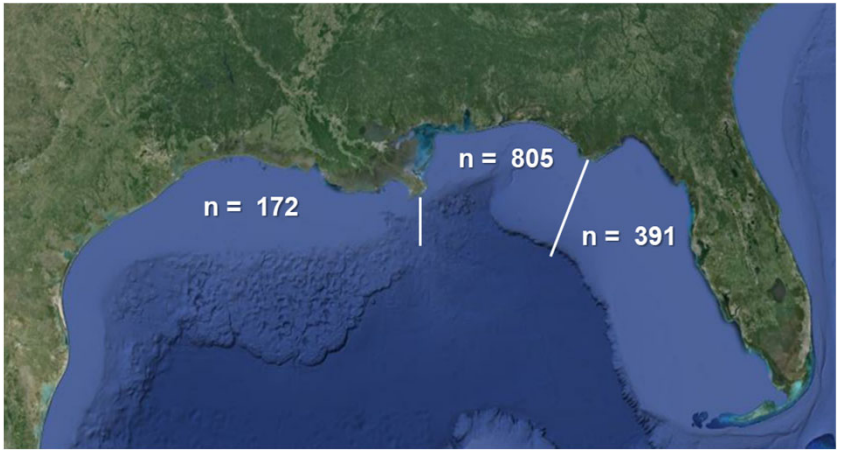
Validation of annual growth zone formation in gray triggerfish *Balistes capriscus* dorsal spines, vertebrae, and otoliths

Jennifer C. Potts [a,1], Walter D. Rogers [b,*,2], Troy C. Rezek [c], Amanda R. Rezek [d]

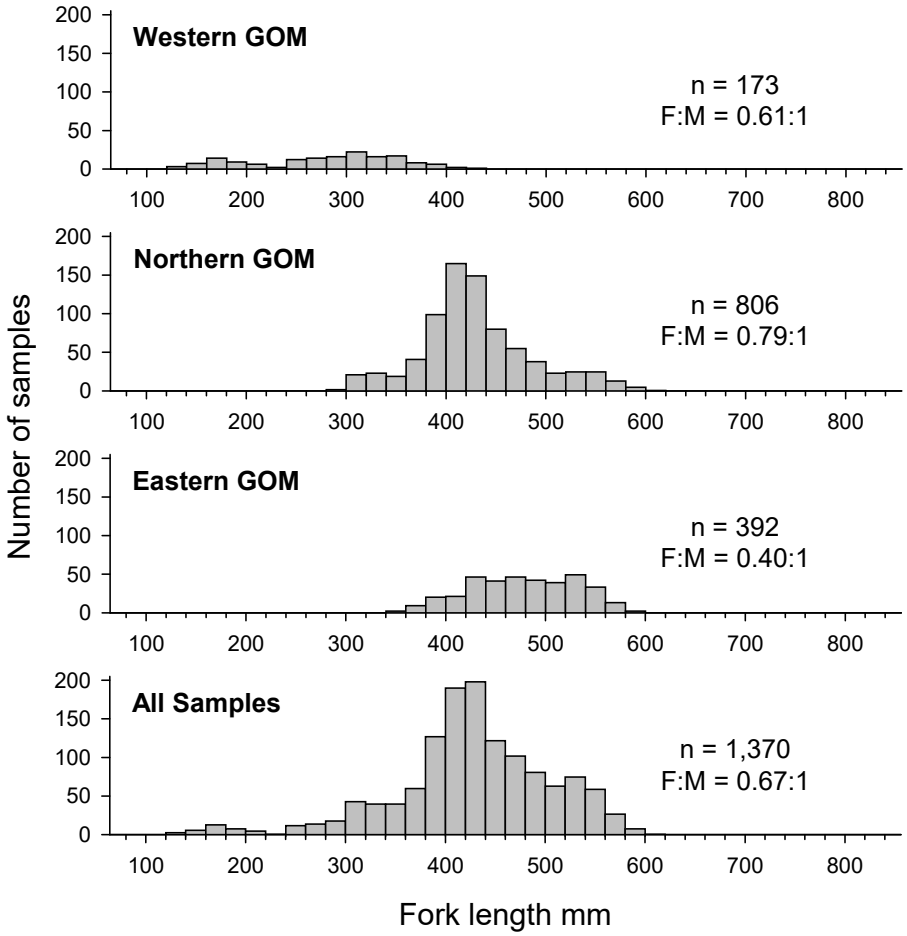


Gray Triggerfish Sample Distributions

- **Total samples: 1,370 samples among commercial handline and longline, recreational landings, and spearfishing and trawl fishery-independent sampling**

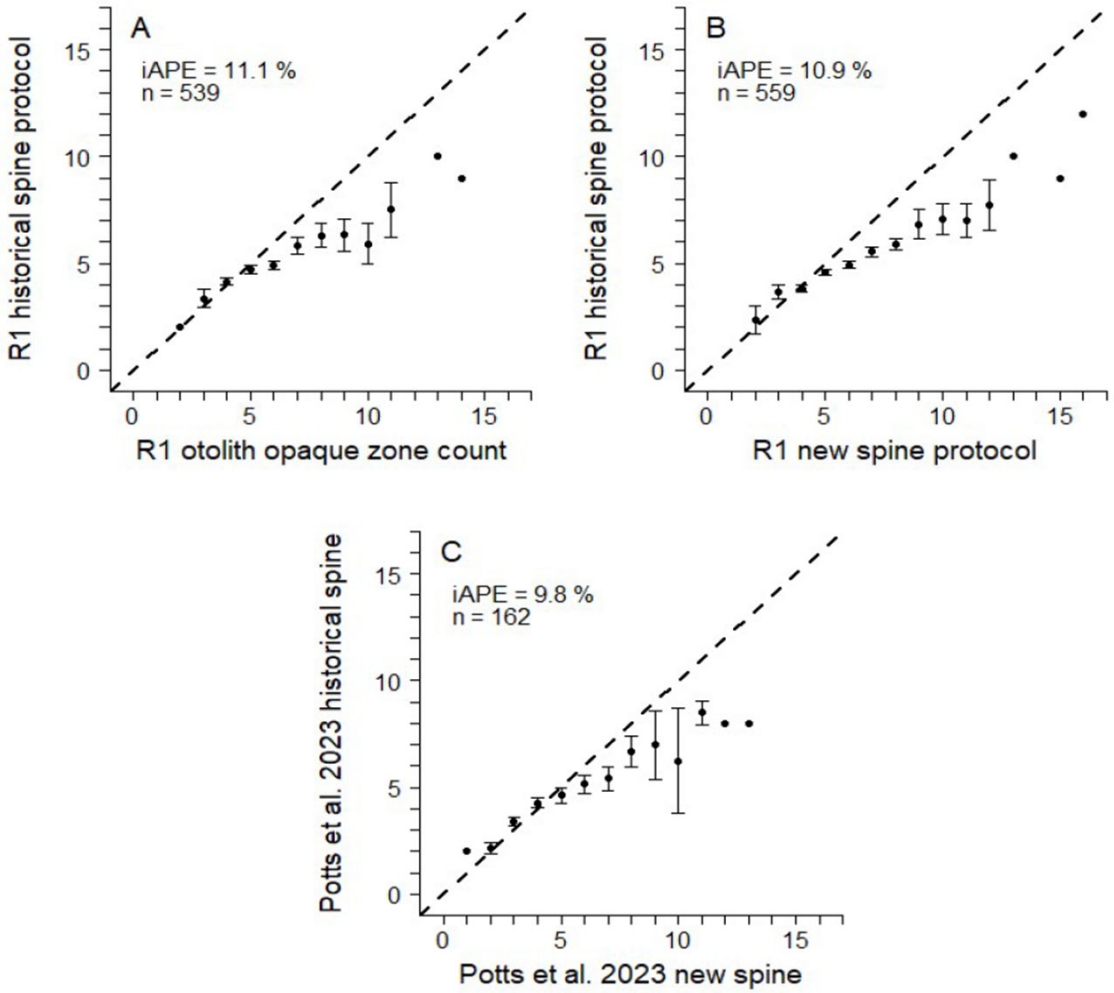


- **First 100 samples treated as a training set among three readers:**
  R1: Derek Chamberlin
  R2: Jennifer Potts
  R3: Walt Rogers



Reader Agreement among Ageing Structures

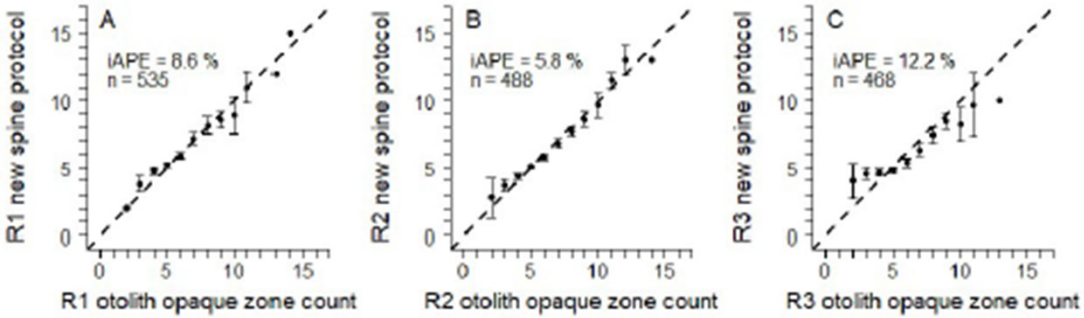
- **Total sample size for reader and protocol comparison: n = 573**
- **Age ranges:**
  - **0–14 for otoliths**
  - **0–16 for new spine protocol**
  - **0–12 for old spine protocol**
- **Historical spine method age estimates lower than otolith or new spine protocol estimates after age-5**
- **R1: Derek Chamberlin**
- **Index of average percent error relatively high for all ageing approaches**



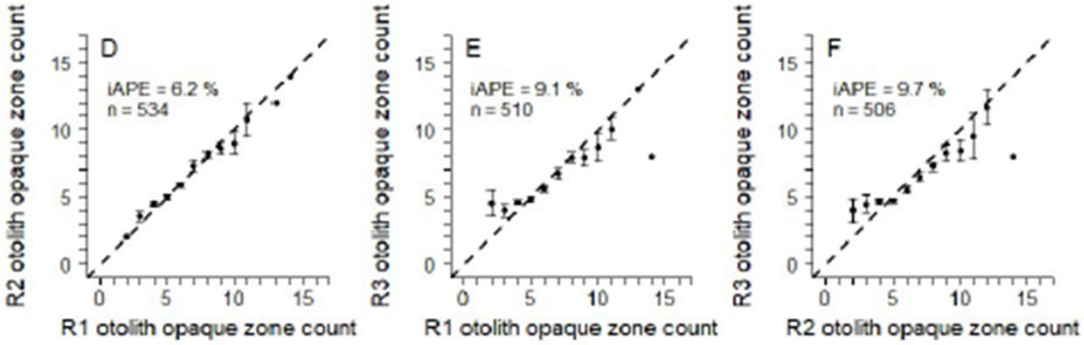
Reader Agreement among Ageing Structures

- **Reader 1: Derek Chamberlin**
  Reader 2: Jennifer Potts
  Reader 3: Walt Rogers

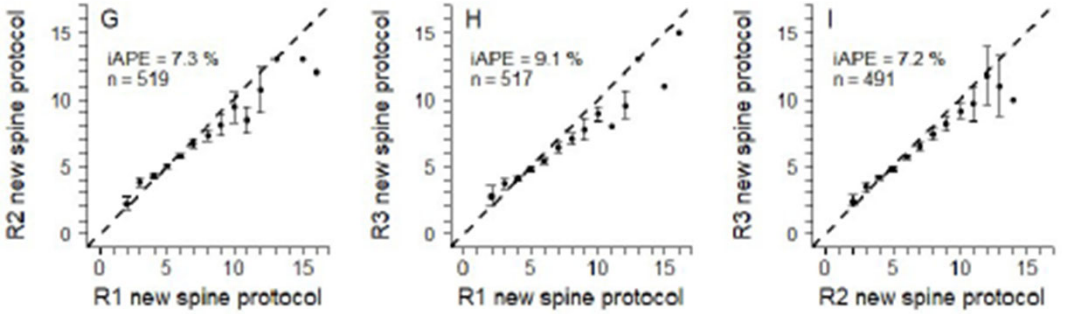
Within reader: otolith versus new spine



Among readers: otolith ages

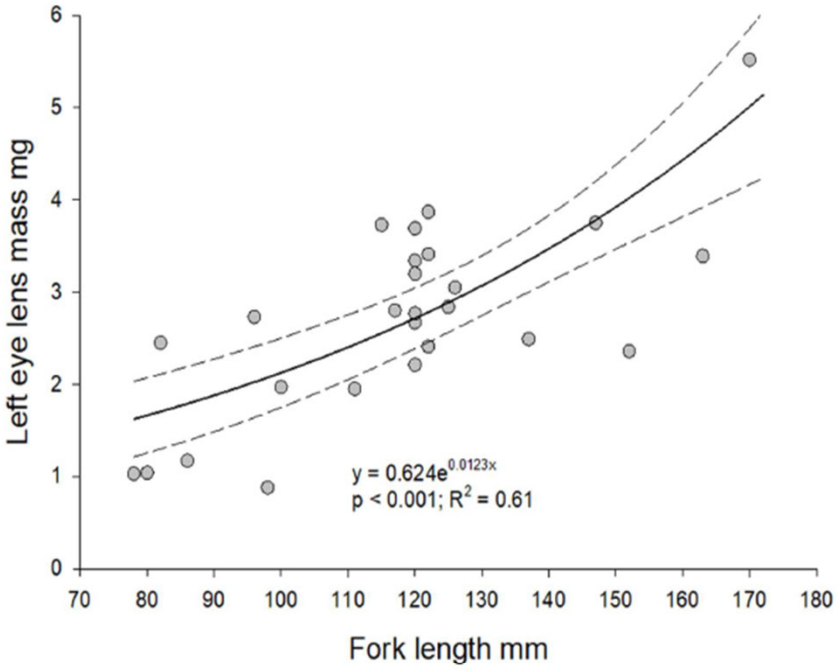


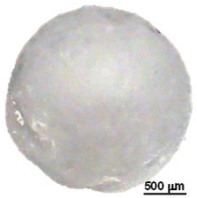
Among readers: new spine ages

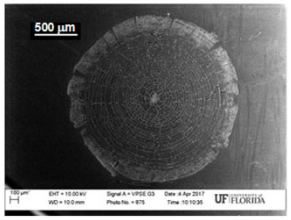


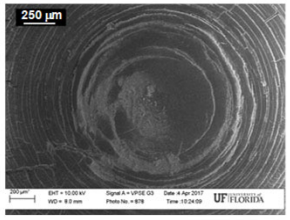
Gray Triggerfish Eye Lens-Based Bomb ^{14}C Age Validation

Juvenile GOM Gray Triggerfish Eye Lens Mass Versus Fork Length Relationship

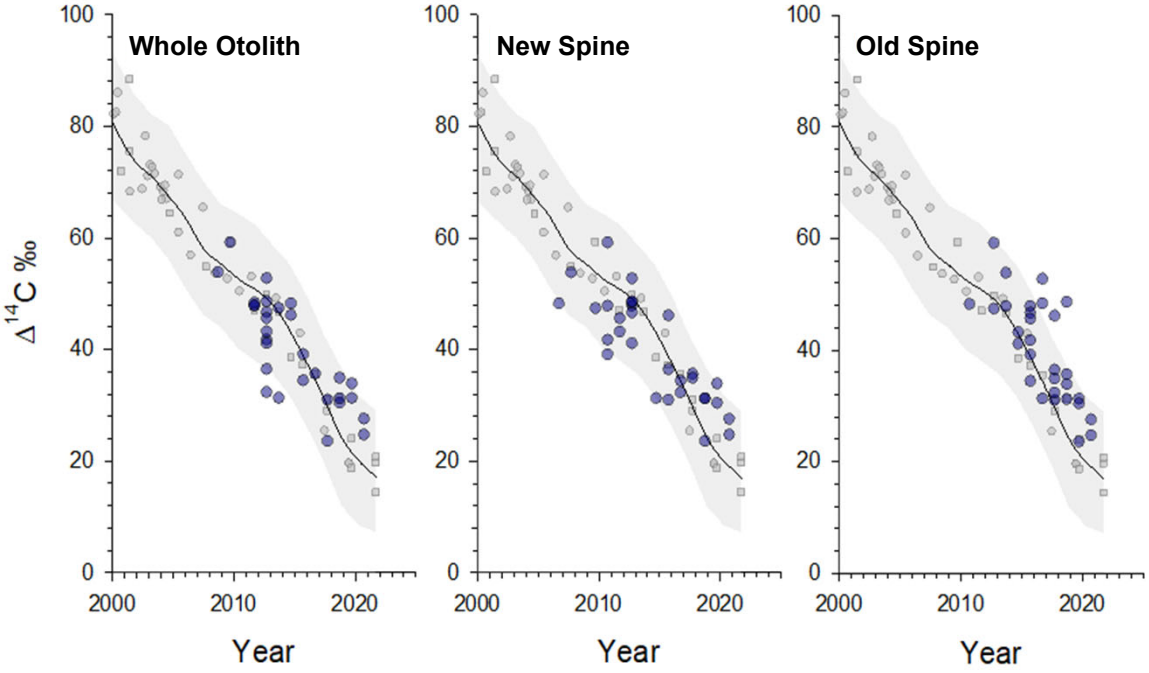








Bayesian Spline-Based Test of Ageing Accuracy



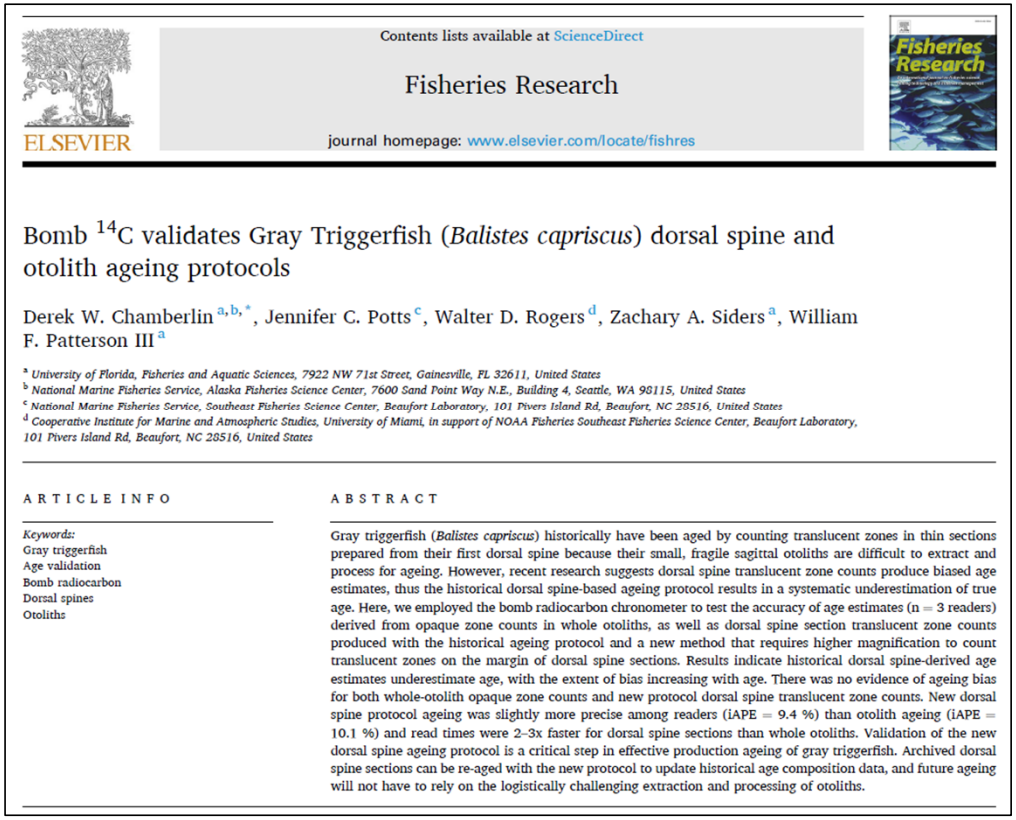
- **Age estimates significantly biased for old spine method; median bias: -1.72 y**
- **No significant ageing bias for new spine method or whole otolith method**

Chapter 1 Conclusions

- **Age estimates derived from whole otoliths or the new spine ageing protocol are unbiased, but precision issues persist with both methods.**

- **New dorsal spine protocol ageing was slightly more precise among readers (iAPE = 9.4%) than otolith ageing (iAPE = 10.1%) and read times were 2-3x faster for dorsal spine sections than whole otoliths.**

- **For 2025 assessment, re-ageing archived spine sections for fish >age-5 is an appropriate solution to produce unbiased age composition estimates.**



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Bomb ^{14}C validates Gray Triggerfish (*Balistes capriscus*) dorsal spine and otolith ageing protocols

Derek W. Chamberlin [a,b,*], Jennifer C. Potts [c], Walter D. Rogers [d], Zachary A. Siders [a], William F. Patterson III [a]

[a] University of Florida, Fisheries and Aquatic Sciences, 7922 NW 71st Street, Gainesville, FL 32611, United States
[b] National Marine Fisheries Service, Alaska Fisheries Science Center, 7600 Sand Point Way N.E., Building 4, Seattle, WA 98115, United States
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ARTICLE INFO

Keywords:
Gray triggerfish
Age validation
Bomb radiocarbon
Dorsal spines
Otoliths

ABSTRACT

Gray triggerfish (*Balistes capriscus*) historically have been aged by counting translucent zones in thin sections prepared from their first dorsal spine because their small, fragile sagittal otoliths are difficult to extract and process for ageing. However, recent research suggests dorsal spine translucent zone counts produce biased age estimates, thus the historical dorsal spine-based ageing protocol results in a systematic underestimation of true age. Here, we employed the bomb radiocarbon chronometer to test the accuracy of age estimates (n = 3 readers) derived from opaque zone counts in whole otoliths, as well as dorsal spine section translucent zone counts produced with the historical ageing protocol and a new method that requires higher magnification to count translucent zones on the margin of dorsal spine sections. Results indicate historical dorsal spine-derived age estimates underestimate age, with the extent of bias increasing with age. There was no evidence of ageing bias for both whole-otolith opaque zone counts and new protocol dorsal spine translucent zone counts. New dorsal spine protocol ageing was slightly more precise among readers (iAPE = 9.4 %) than otolith ageing (iAPE = 10.1 %) and read times were 2–3x faster for dorsal spine sections than whole otoliths. Validation of the new dorsal spine ageing protocol is a critical step in effective production ageing of gray triggerfish. Archived dorsal spine sections can be re-aged with the new protocol to update historical age composition data, and future ageing will not have to rely on the logistically challenging extraction and processing of otoliths.

Chapter 2: Gray Triggerfish Growth Estimation

In Review at Canadian Journal of Fisheries and Aquatic Sciences

Bayesian state-space estimation of von Bertalanffy growth parameters for gray triggerfish, *Balistes capriscus*, incorporating multiple readers and ageing structures

Derek W. Chamberlin[a,b*], Zachary A. Siders[a], Jennifer C. Potts[c], Walter D. Rogers[d], Miaya A. Taylor[a], and William F. Patterson III[a]

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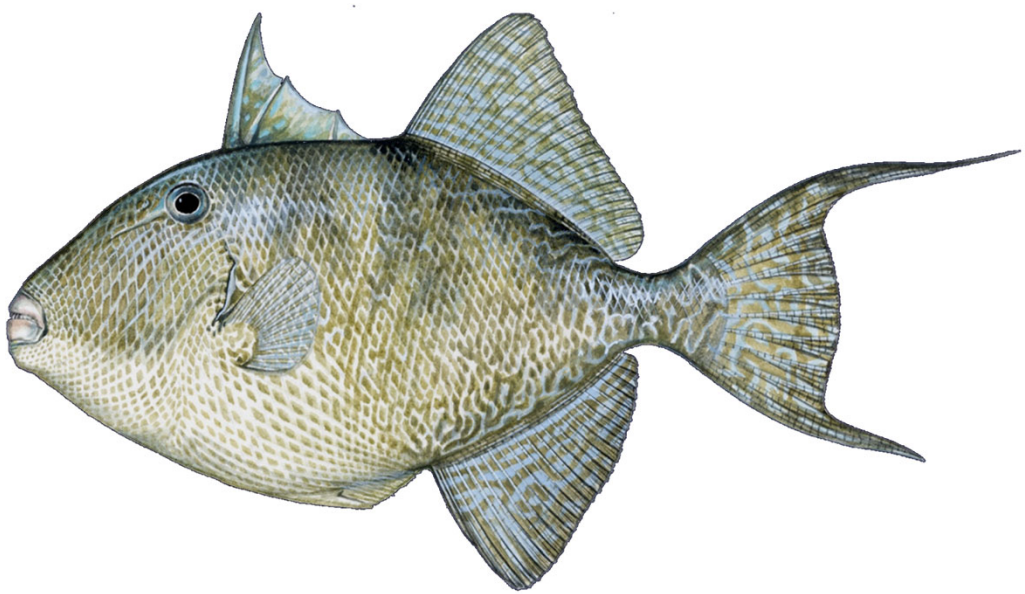
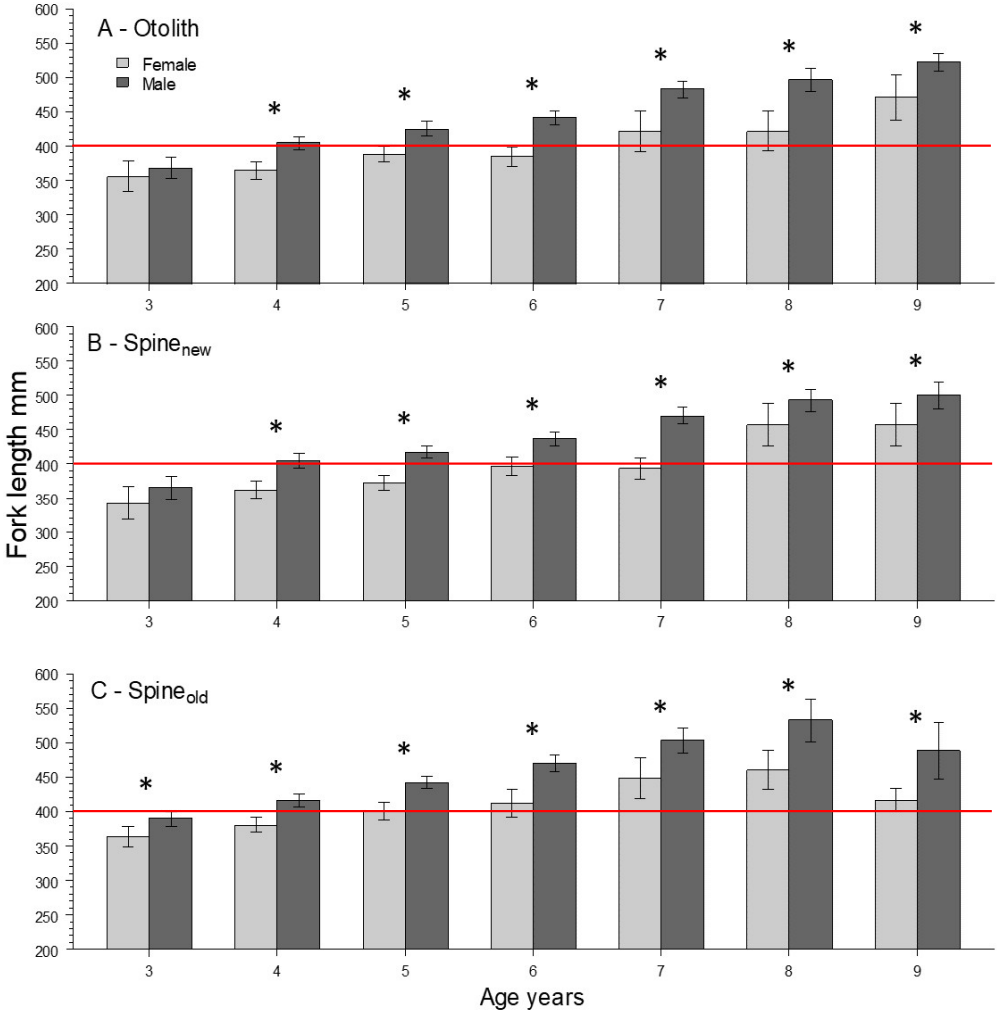
*Corresponding Author; derek.chamberlin@noaa.gov

Key words: gray triggerfish, von Bertalanffy, Bayesian, age and growth, dorsal spines, otoliths



Sex-specific Gray Triggerfish Size-at-Age

- Three-factor ANOVA run to test for differences in size-at-age for R1 ages
- Factors: ageing structure, age, and sex
- structure*age*sex interaction sliced by structure and age to test for sex-specific differences in size-at-age



Bayesian State-Space Gray Triggerfish Growth Estimation

- **Bayesian state-space model developed to estimate of gray triggerfish von Bertalanffy growth model (VBGM) parameters and test for differences between sexes and ageing protocols**

- **Size-at-birth formulation of the VBGM (von Bertalanffy 1934)**

- **State-space approach allows for more effective separation of process error (σ_{VB}) from observation error (σ_{obs}) by including multiple readers**

$$L_{i,t} = L_\infty (L_\infty - L_0) e^{-k t_i}$$

where:

$L_{i,t}$ = length at age t

L_∞ = asymptotic length

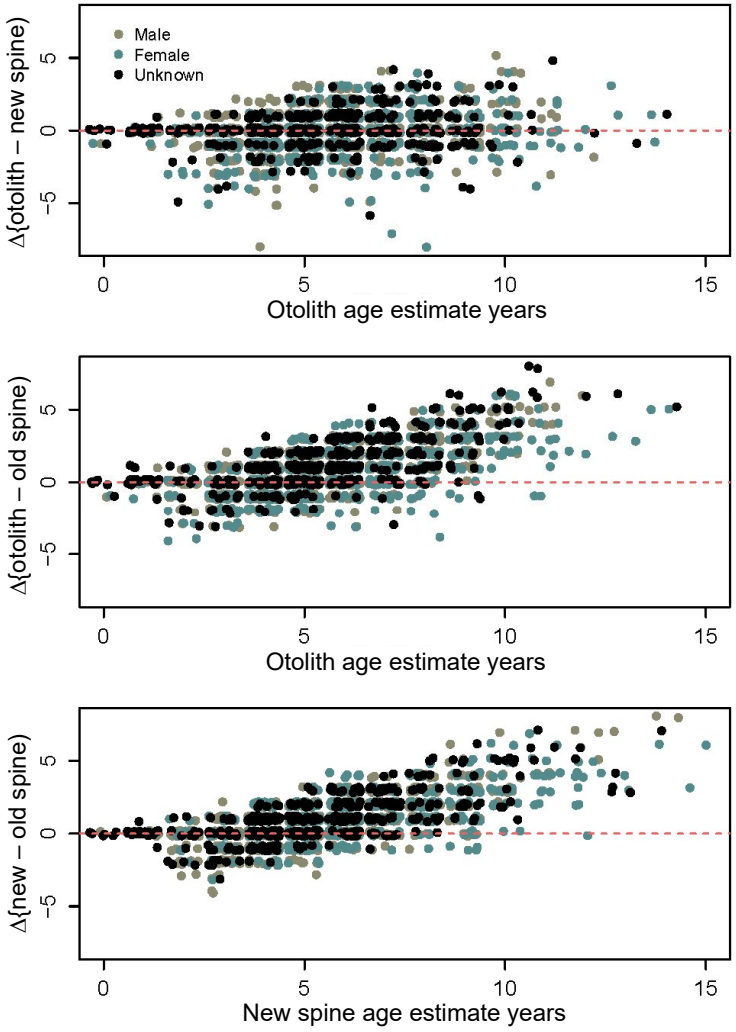
L_0 = size at birth

k = Brody's growth coefficient

t_i = age

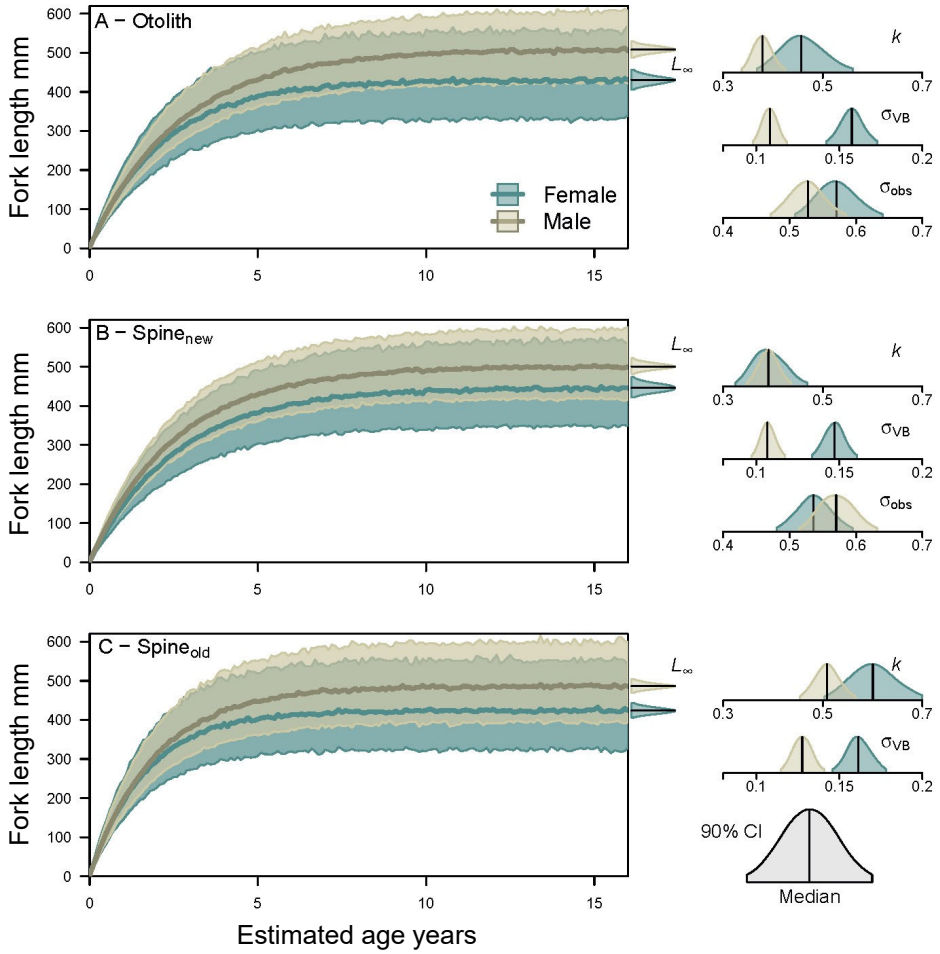
Bayesian State-Space Gray Triggerfish Growth Estimation

- **Clear differences in estimated age between otolith or new spine estimates versus the old spine method regardless of sex**



Bayesian State-Space Gray Triggerfish Growth Estimation

- **Significant differences in VBGMs among ageing protocols and between sexes**
- **No significant differences in VBGM parameters between otolith and new spine ageing protocols**
- **Significant differences in t_0 and k between otolith or new spine versus old spine age estimates, but very small absolute differences in t_0 (<0.01 y)**

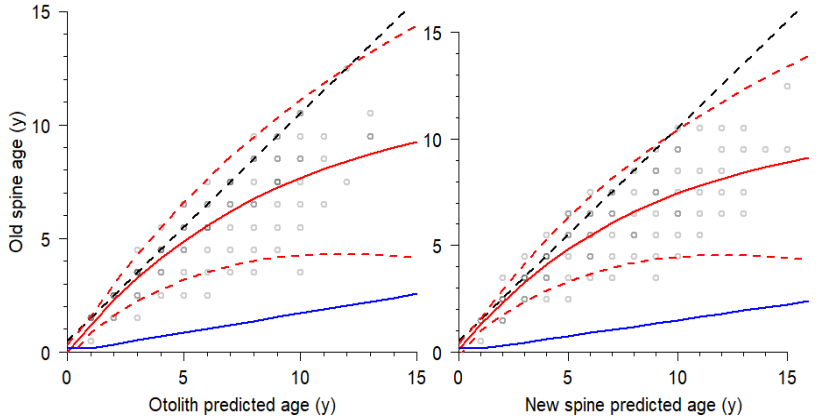


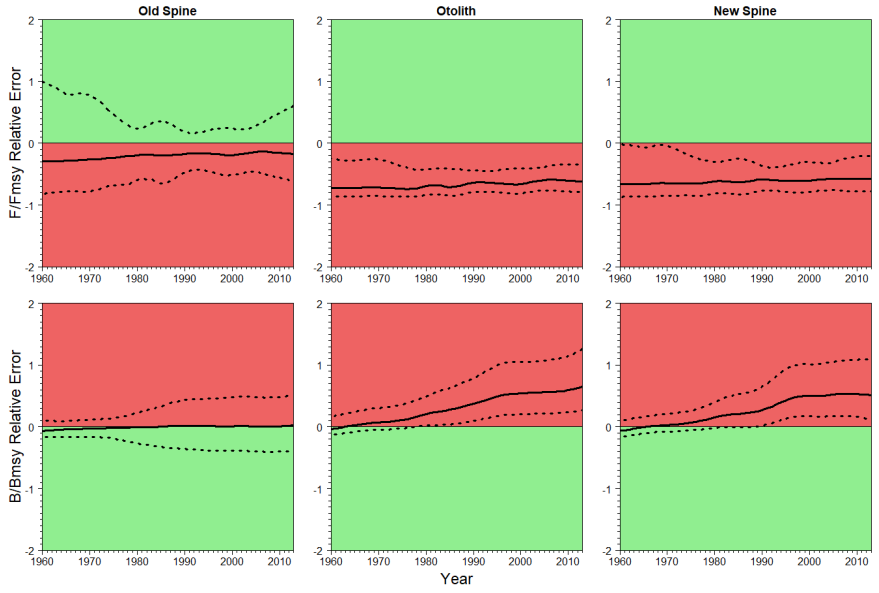
Chapter 3: Stock Assessment Simulations

- **Ageing bias imparted from old spine ageing protocol age comps had a substantial effect on stock assessment results.**

- **It is unclear to what extent, but ageing error likely contributed to the lack of recovery observed in gray triggerfish during the 2000s and 2010s.**

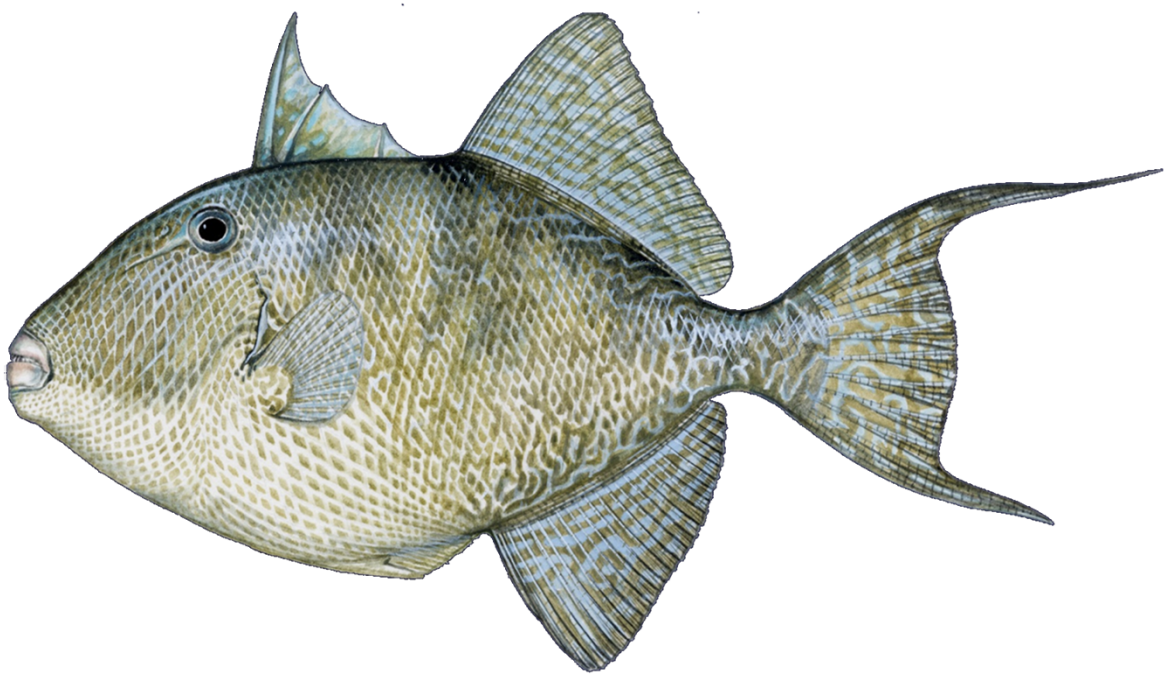
- **There are several issues to address in the next gray triggerfish SEDAR assessment, but re-ageing archived spine samples for fish >age-5 with the Potts et al. (2023) protocol should alleviate ageing error issues revealed during this study.**





Overall Study Conclusions

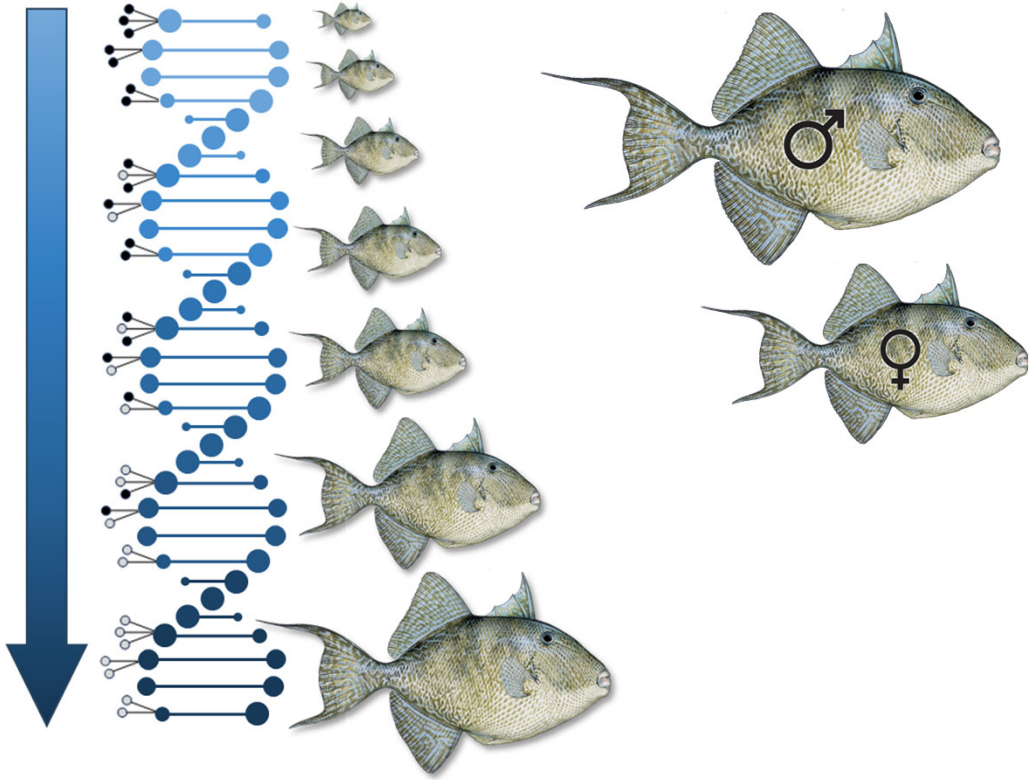
- **Ageing error DOES matter for gray triggerfish stock assessment and management, and quite a bit.**
- **State-of-the-art eye lens-based bomb ^{14}C age validation was used to test for gray triggerfish ageing bias, but a relatively simple solution exists to correct for that bias in future assessments.**
- **Issues related to sexually dimorphic growth in gray triggerfish are likely to persist in the next stock assessment.**

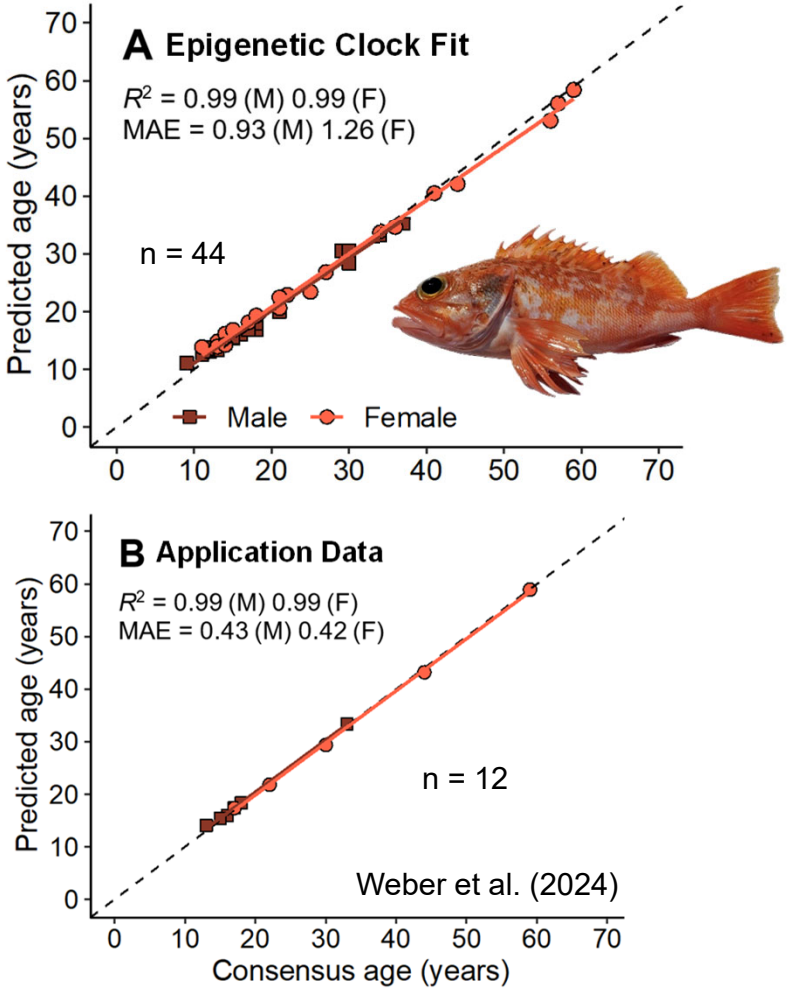


Ongoing Research and Potential Future Directions

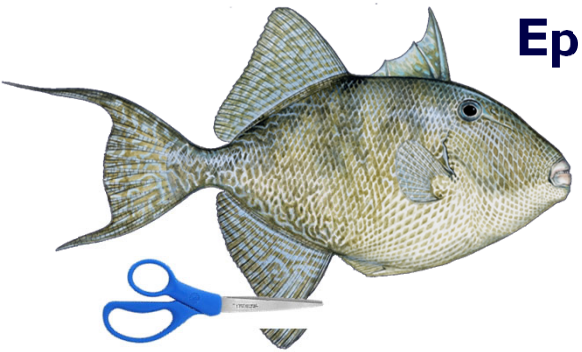
Epigenetic Ageing

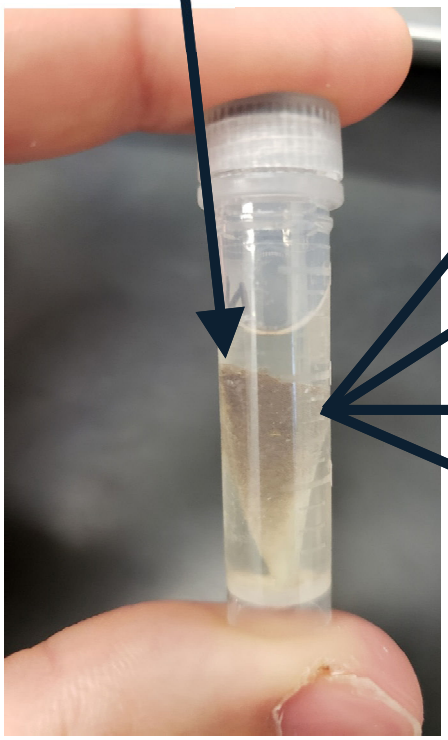
Genetic Sex ID



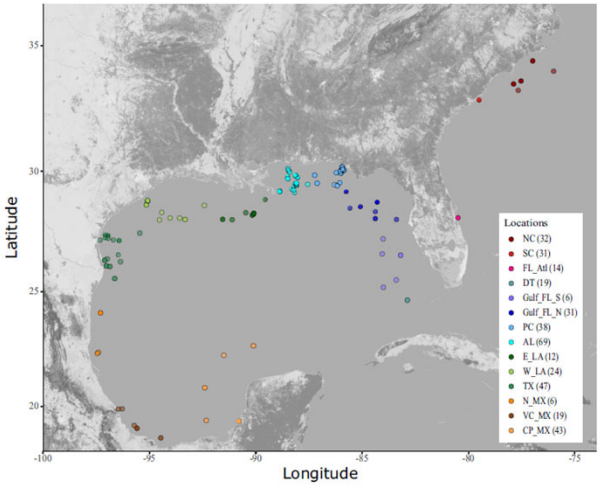


Epigenetic Ageing and Other Genomic Tools

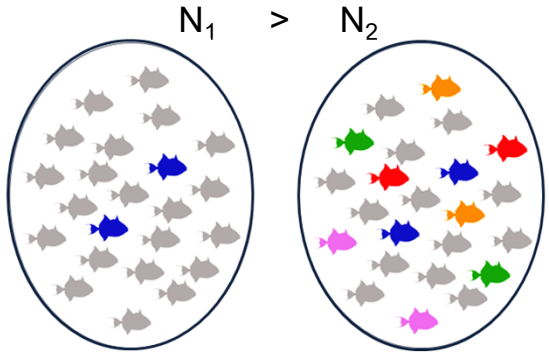




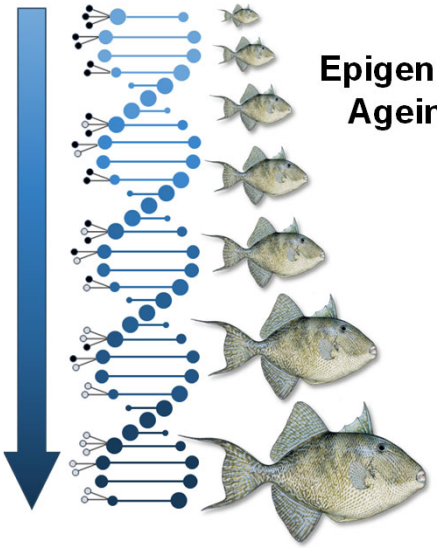
Genetic Population Structure



Close-Kin Mark-Recapture



Genetic Sex ID



Epigenetic Ageing

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Questions???