



NOAA
FISHERIES

Highly Migratory Species Research Update Southwest Fisheries Science Center

*Presented by
Annie Yau, Fisheries Resources Division Director*

Presentation to Pacific Fishery Management Council Sep 23, 2024

Updates since September 2023



HMS Research Update: Outline



NOAA
FISHERIES

- **Assessments:**
 - 2023-2024 assessment summaries
 - North Pacific albacore
 - Shortfin mako shark
 - Pacific bluefin tuna
 - Other 2023-2024 assessments
 - 2025 assessment schedule
 - Pacific bluefin tuna MSE
- **Genetics:**
 - Albacore genetic sex marker
- **Life History:**
 - Age and growth: Albacore, Bluefin
 - Foraging: Albacore, Bluefin, Swordfish
- **List of publications and presentations**



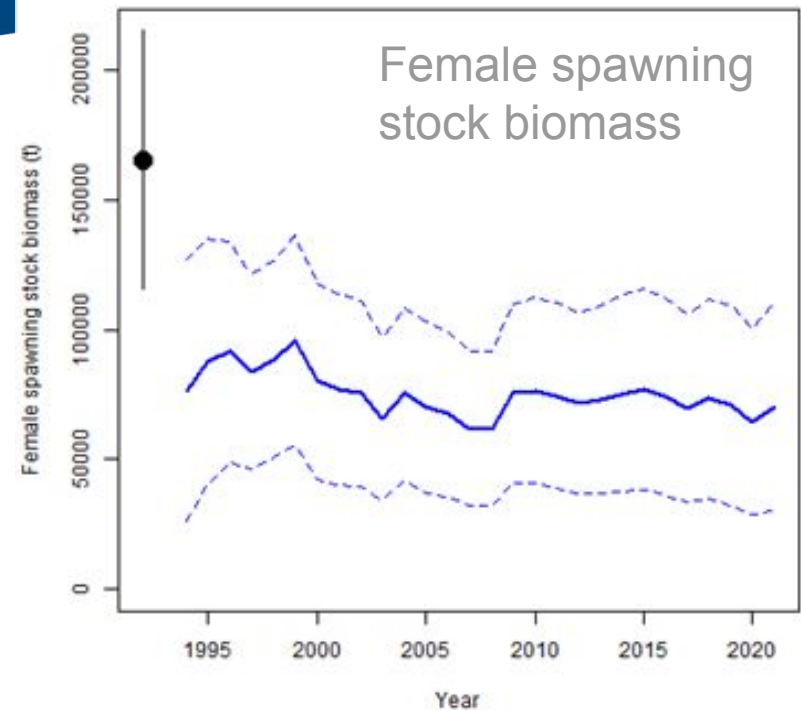
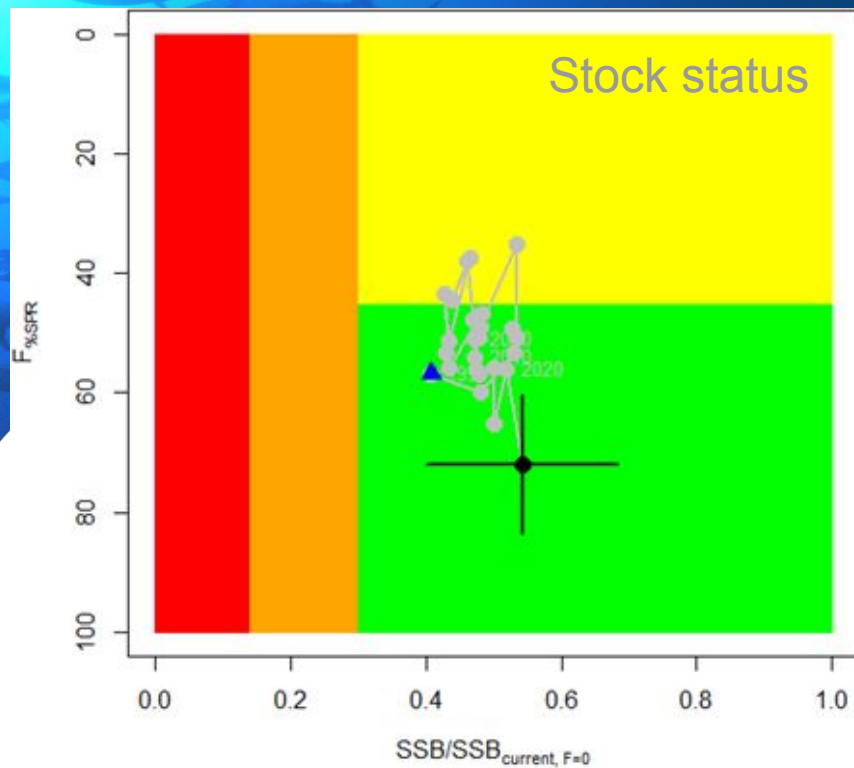


NOAA
FISHERIES

2023 North Pacific Albacore benchmark assessment



- ISC assessment every 3 years, led by SWFSC scientists
- Details can be found in [Assessment Report](#)

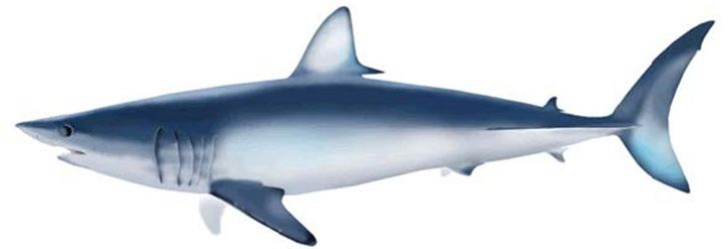


- **North Pacific albacore stock not likely overfished**
relative to the threshold ($30\%SSB_{current, F=0}$) and limit ($14\%SSB_{current, F=0}$) reference points adopted by WCPFC & IATTC, as well as US domestic MSST reference point.
- **Stock not likely experiencing overfishing**
relative to the adopted target ($F_{45\%SPR}$), as well as US domestic MFMT reference points



NOAA
FISHERIES

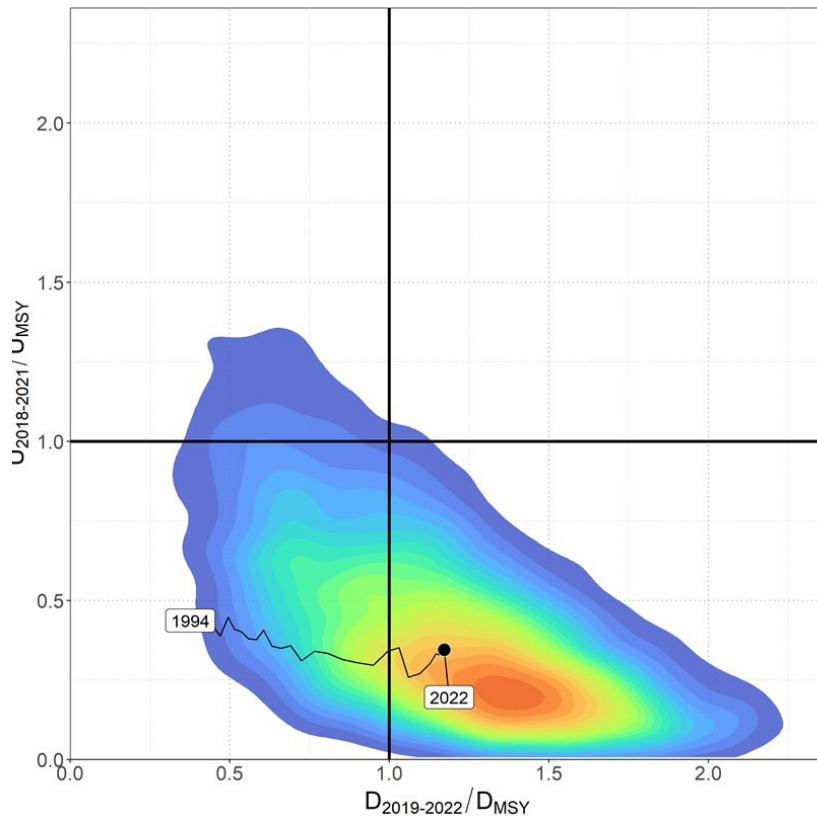
2024 North Pacific shortfin mako benchmark assessment



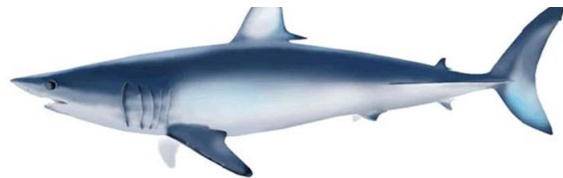
- ISC last assessed in 2018
- 2024 assessment led by NOAA scientists
- Details can be found in [Assessment Report](#)

Probability distribution of utilization and depletion ratios relative to MSY in 2022

Utilization ratio



Depletion ratio



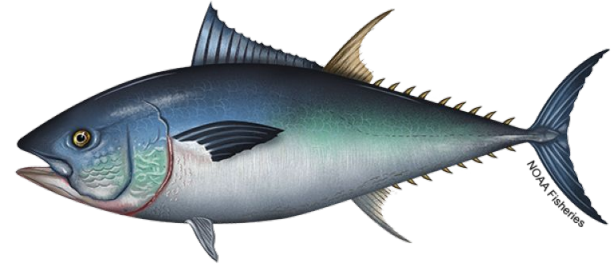
- Uncertain biology and catch data
- Model ensemble of 32 Bayesian surplus production
- Shortfin mako shark stock likely not overfished and likely not experiencing overfishing

65% joint probability relative to MSY-based ref points; no adopted international reference points



NOAA
FISHERIES

2024 Pacific bluefin tuna benchmark assessment

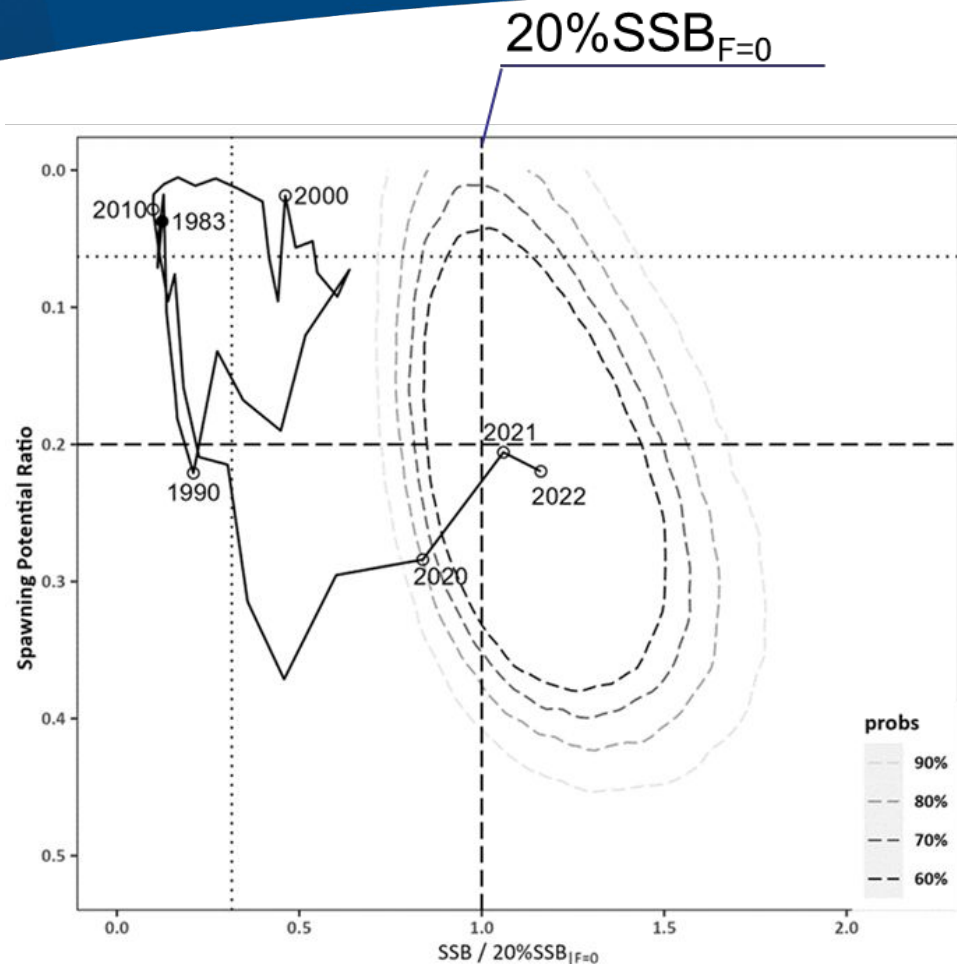
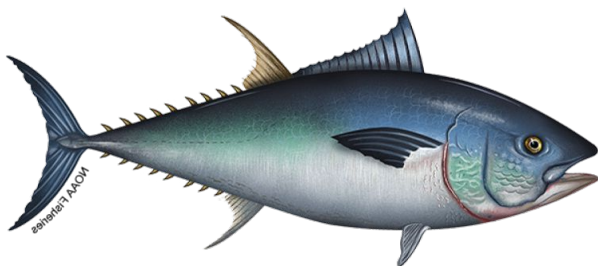


- ISC assessment every 2 years, led by SWFSC scientists
- Details in the [assessment report](#)



NOAA
FISHERIES

Reduced mortality
of age 0-3 fish has
resulted in more of
them!



- Pacific bluefin tuna stock not likely overfished and not likely experiencing overfishing relative to reference points of 20% of unfished biomass. No adopted international reference points.
- Stock reached initial rebuilding target in 2017 and second rebuilding target in 2021, a decade ahead of schedule



**NOAA
FISHERIES**

Pacific Bluefin tuna are rebuilt!

NMFS story on rebuilding



From Overfished to Sustainable Harvests: Pacific Bluefin Tuna Rebound to New Highs

June 25, 2024

New stock assessment reveals largest recorded biomass since assessments began.



Pacific bluefin tuna swim underwater. Credit: Adobe Stock

The recovery of Pacific bluefin tuna has achieved a major milestone—the species exceeded international targets a decade ahead of schedule. The rebuilding of Pacific bluefin tuna reflects a fisheries management success. International organizations cooperated across the Pacific to reverse decades of overfishing for the prized species.

The [International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean](#) (ISC), including NOAA Fisheries researchers, provided scientific expertise to inform conservation measures. The [Inter-American Tropical Tuna Commission](#) (IATTC) and [Western and Central Pacific Fisheries Commission](#) (WCPFC) adopted these measures.

The ISC recently finalized the new stock assessment at the annual meeting in Victoria, Canada. The assessment confirmed that the stock reached the second rebuilding target in 2021. If the current management measures persist, the population growth is expected to continue growing.

"This is an amazingly resilient fish and the new assessment is showing us that. While the population is thriving, ongoing monitoring of data quality is essential to ensure the continued accuracy of the assessment," said Dr. Huihua Lee, a research mathematical statistician at NOAA Fisheries' Southwest Fisheries Science Center who led the work on the stock assessment in the



Other 2023-2024 HMS assessments

ISC

- 2023 NPO Swordfish (PIFSC-led)
- 2023 WCNPO Striped marlin (PIFSC-led)

WCPFC

- 2023 WCPO Bigeye tuna
- 2023 WCPO Yellowfin tuna
- 2024 South Pacific Albacore
- 2024 Southwest Pacific Striped marlin
- 2024 WCPO Silky shark
- 2024 WCPO Skipjack tuna indicator analysis

IATTC

- 2024 EPO Bigeye tuna
- 2024 EPO Skipjack tuna



2025 Assessment Schedule

ISC

- Pacific Bluefin tuna Management Strategy Evaluation (MSE) - SWFSC lead

WCPFC

- Western and Central Pacific Oceanic Whitetip Shark
- Southwest Pacific swordfish

IATTC

- EPO Bigeye tuna (MSE)
- EPO Yellowfin tuna (may be delayed)

Pacific Bluefin Tuna MSE Process



**NOAA
FISHERIES**

1st ISC PBF MSE Workshop (May 2018), Yokohama, JAPAN

- ✓ ~70 participants
- ✓ **Purpose:** review the requirements to implement an MSE, define stakeholder roles, review recent progress made by tuna RFMOs towards implementing the MSE process

7th Meeting of the IATTC_WCPFC NC JWG on PBF (July 2022), Virtual

- ✓ Workplan for development of long-term harvest strategy (including MSE) adopted
- ✓ Candidate **operational management objectives** and **harvest control rules (HCRs)** for MSE discussed

3rd ISC PBF MSE Workshop (2025), TBD

2nd ISC PBF MSE Workshop (May 2019), San Diego, USA

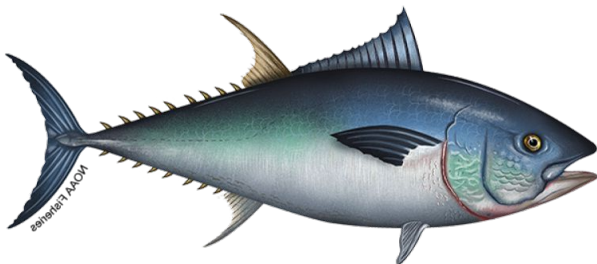
- ✓ ~70 participants
- ✓ **Purpose:** promote understanding of MSE among stakeholders and continue discussion on required elements for PBF MSE

8th Meeting of the IATTC_WCPFC NC JWG on PBF (July 2023), Fukuoka, JAPAN

- ✓ Candidate **operational management objectives** and **harvest control rules** for MSE finalized
- ✓ Reviewed and adopted by WCPFC NC

10th Meeting of the IATTC_WCPFC NC JWG on PBF (July 2025), TBD

ISC presents **final results** from the MSE
JWG recommends a final HS to WCPFC and IATTC for adoption





HMS Science Requires Collaboration

Who we work with

- Sportfishing Association of CA
- CPFVs and Fish Processors
- Albacore Research Foundation
- American Albacore Fishing Association
- Hawaiian Longline Fishery
- Pacific Northwest Troll Fishery
- Deep set buoy and Drift Gill Net Fishery
- West Coast Region Observer Program
- Pacific Islands Region Observer Program
- Pacific States Marine Fisheries Commission
- (many scientists from other universities)

What they help us collect

- Length and weight data
- Otoliths
- DNA samples
- Stomachs
- Ovaries

HMS Genetics Research

FRD Genetics, Physiology, and Aquaculture Group



NOAA
FISHERIES

Genetic Sex Marker for Albacore



What is it?

- A genetic assay allowing for individual sex assignment

Why pursue?

- Previous research has indicated skewed sex ratios and sex-specific growth rates in Albacore
- Faster sampling time, can sample from any part of fish (not just gonad)
- With enough data on sex ratios and sex-specific growth rates, could incorporate into assessments

Methods

- Currently completing assay on ~1,500 Albacore samples from the different fisheries in the Pacific
- Checks for DNA cross contamination

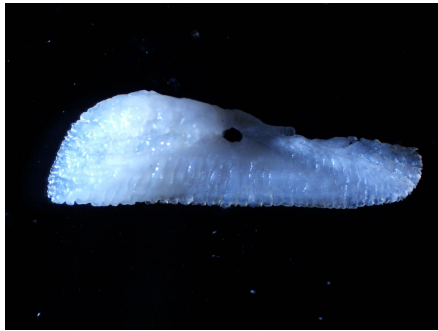
North Pacific albacore: age and growth

(ARF/ AAFA/ OSU)

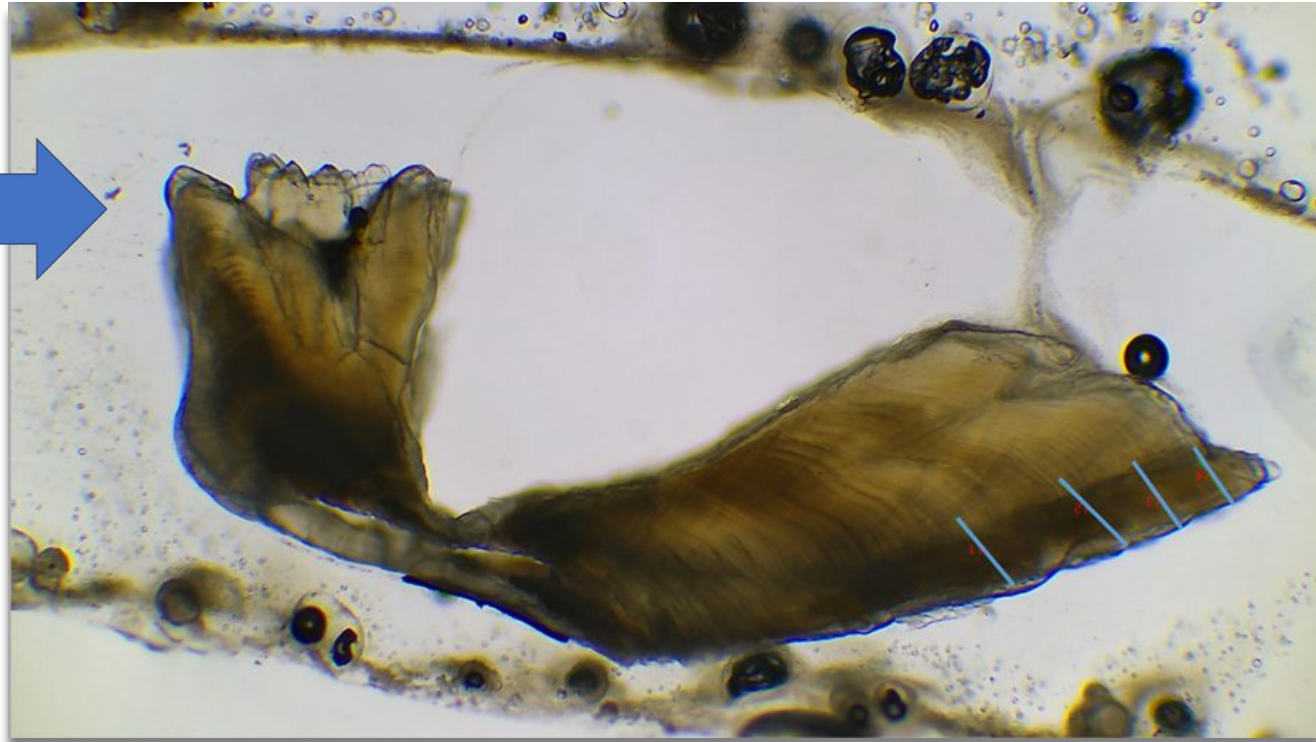
Goal: Generate sex-specific growth curves

Methods:

- 385 fish sampled from Eastern and Central Pacific
- Length range: 48 to 124 cm FL
- Age range: 1 to 13 years old (sectioned otoliths)
- Results will be presented at ISC Albacore Working Group meeting in 2025



Sectioned otolith
from a 4 year old
individual (80 cm FL)

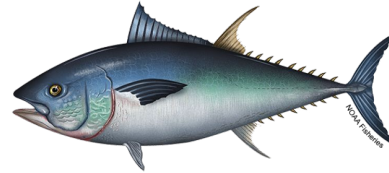


Pacific bluefin tuna: age and growth

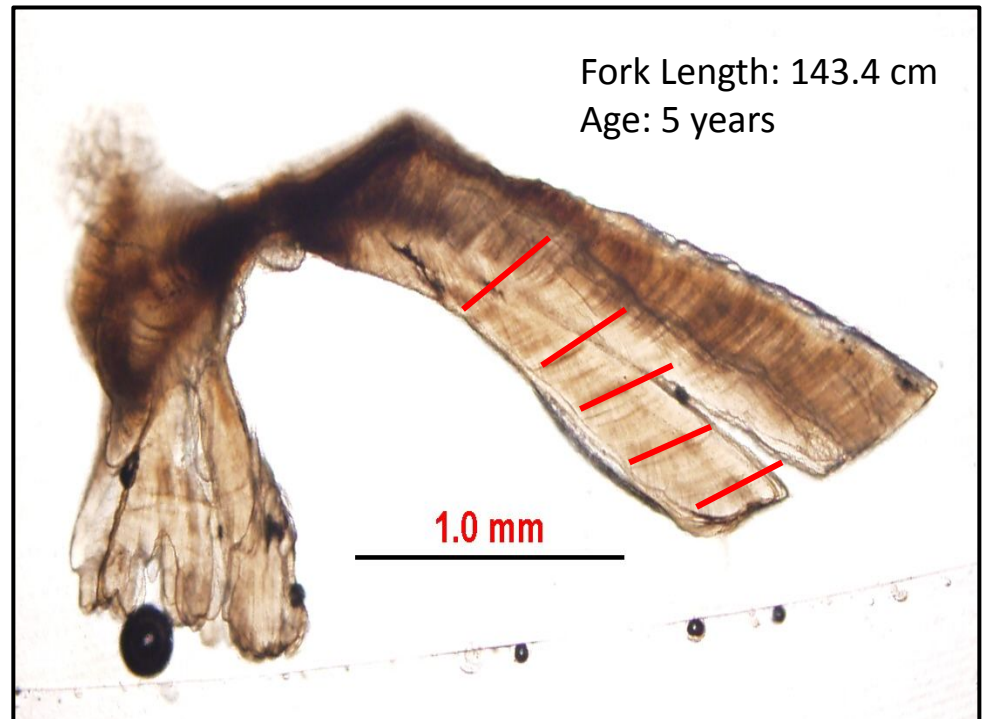
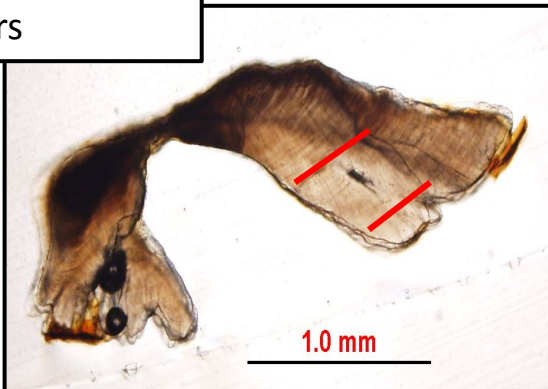
(Fishers, Processors, Texas A&M, UCSC, SAC)

Goal: Generate an EPO-specific growth curve, potentially for stock assessments

- 300 fish sampled from Southern California Bight (CPFVs)
- 102 fish aged (two readers)
- Length range: 65 to 169 cm FL
- Age range: 1 to 7 years old (sectioned otoliths)



Fork Length: 91.6 cm
Age: 2 years



Fork Length: 143.4 cm
Age: 5 years

1.0 mm

1.0 mm

North Pacific albacore: foraging ecology

(ARF/ AAFA/ OSU)

Goal: Understand foraging ecology to support EBFM

- Dr. Antonella Preti analyzed stomachs from 2023
- Draft manuscript on fish condition in prep.
- Tissues sent for mercury and microplastic analysis

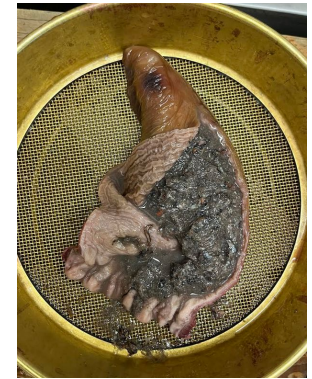


2023 Results:

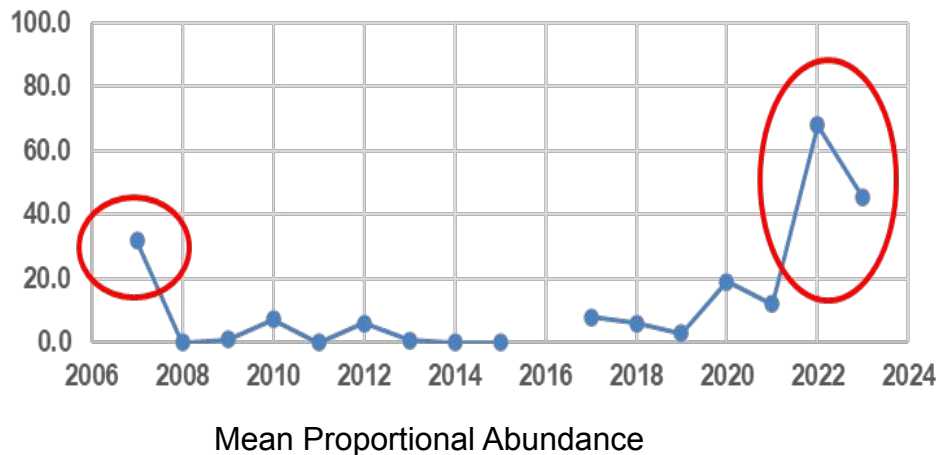
- Pacific sardine YOY continue to be found in significant number of stomachs
- Increased importance of YOY CPS (higher energy density)

Implications:

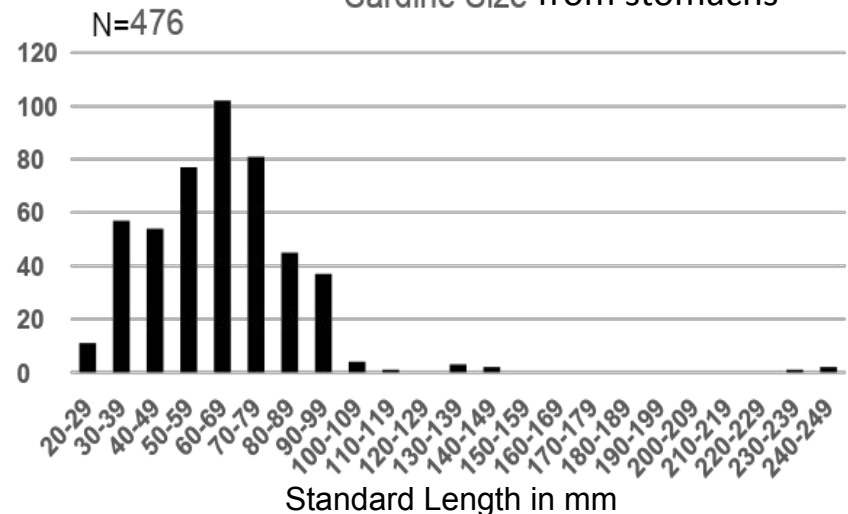
- Continued data collection is helpful given high variability over short time-scales
- How do these diet trends match (or not) CPS biomass trends?



Sardine Trends in Diet Time Series

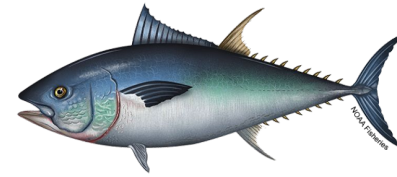


Sardine Size from stomachs



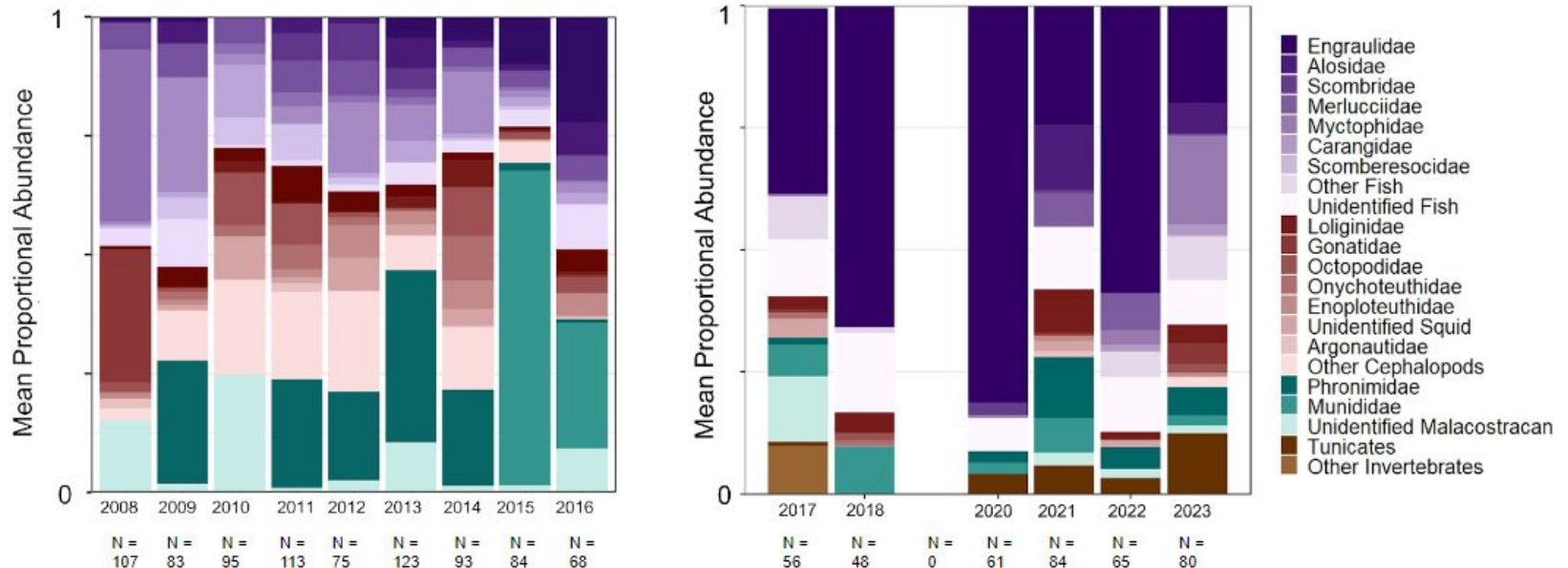
Pacific bluefin tuna: foraging ecology

(Fishers, Processors, Texas A&M, UCSC, SAC)



Goal: Understand foraging ecology to support EBFM

- Dr. Travis Richards completed backlog of stomach samples; 2019 is awaiting QA/QC
- 2020-2023: Anchovy ranked highest in mean proportional abundance
 - Marked shift from earlier in the time series
 - Decreased prevalence of cephalopods, hyperiid amphipods, and pelagic red crabs
- 2021 and 2023: Significant number of myctophids, carangids, and tunicates



Implications:

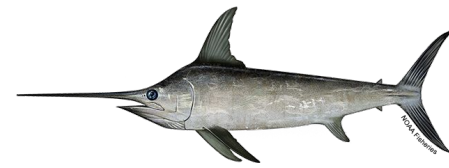
- Large shifts occur over short time-scales
- Continued data collection is helpful given high variability over time
- Implications for growth and condition being explored

2008 to 2016: Portner E.J, Snodgrass O, Dewar H (2022) Pacific bluefin tuna, *Thunnus orientalis*, exhibits a flexible feeding ecology in the Southern California Bight. PLoS ONE 17(8): e0272048. <https://doi.org/10.1371/journal.pone.0272048>

2017 to 2023: unpublished data do not cite

Swordfish: foraging ecology

(Fishers, WCR Observer Program)

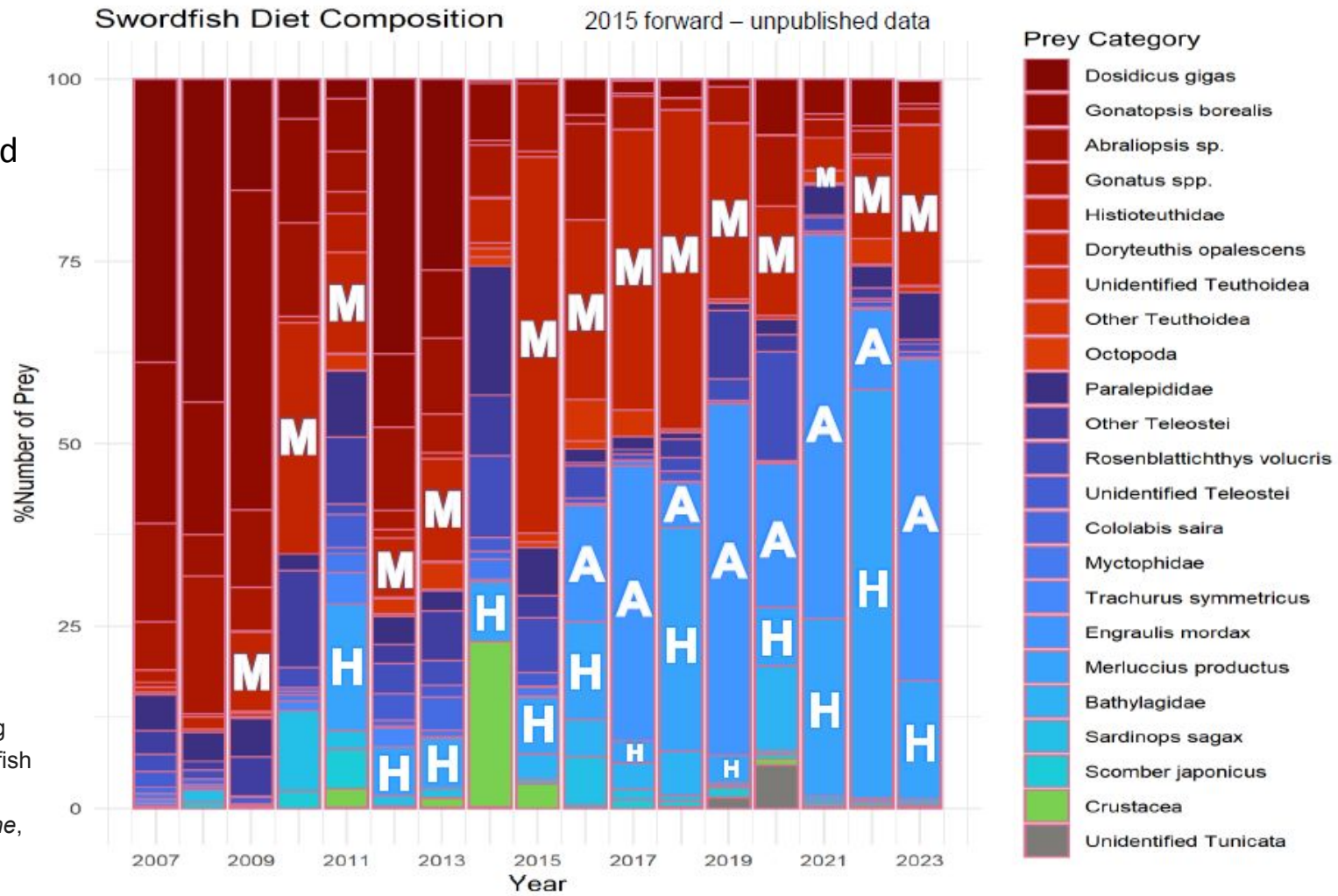


Goal: Understand foraging ecology to support EBFM

- Samples from So Cal Bight
- 2007 - 2023 show fluctuations in % numbers of prey, with a switch over time from cephalopods (like market squid) to fish
- 2011 hake showed up, 2016 anchovy showed up, % numbers fluctuate over time

M = Market Squid
H = Hake
A = Anchovy

Preti et al 2023. Feeding ecology of broadbill swordfish (*Xiphias gladius*) in the California current. *Plos one*, 18(2), p.e0258011.



Recent HMS Publications

1. 2023-2024 California Current Ecosystem Status Report: A report of the NOAA California Current Integrated Ecosystem Assessment Team (CCIEA) to the Pacific Fishery Management Council.
<https://www.pcouncil.org/documents/2024/02/agenda-item-h-1-a-cciea-team-report-1-2023-2024-california-current-ecosystem-status-report-electronic-only.pdf/>
2. A shallow scattering layer structures the energy seascape of an open ocean predator.
<https://doi.org/10.1126/sciadv.adi8200>
3. Distinct natal origins based on vertebral ring analysis reveal migration pattern of Pacific bluefin tuna in the North Pacific Ocean. <https://doi.org/10.3354/meps14656>
4. Divergent responses of Highly Migratory Species to climate change in the California Current.
<https://doi.org/10.1111/ddi.13800>
5. Dynamic human, oceanographic, and ecological factors mediate transboundary fishery overlap across the Pacific high seas. <https://doi.org/10.1111/faf.12791>
6. 2023 Highly Migratory Species Annual Report. <https://doi.org/10.25923/5fk7-0817>
7. Impacts of marine heatwaves on top predator distributions are variable but predictable.
<https://doi.org/10.1038/s41467-023-40849-y>
8. Insights into vertebral band pair deposition rate in the juvenile common thresher shark (*Alopias vulpinus*) in the northeastern Pacific Ocean. <https://doi.org/10.1111/jfb.15538>
9. Integrating vertical and horizontal movements of shortfin mako sharks (*Isurus oxyrinchus*) in the eastern North Pacific Ocean. <https://doi.org/10.3354/meps14542>
10. Micrometer-scale structure in shark vertebral centra. <https://doi.org/10.1016/j.actbio.2024.01.033>
11. Observations of skin color aberrations in four shark species off the coast of southern California, USA.
<https://doi.org/10.1007/s10641-024-01532-3>
12. State of the California Current Ecosystem report in 2022: a tale of two La Niñas.
<https://doi.org/10.3389/fmars.2024.1294011>
13. Trait-based indicators of resource selection by albacore tuna in the California Current Large Marine Ecosystem.
<https://doi.org/10.1016/j.ecolind.2023.111473>
14. Adaptable foraging ecology of Pacific bluefin tuna (*Thunnus orientalis*) allows for long-term trophic stability in the southern California Current. (in prep)
15. Ocean conditions drive interannual variability in juvenile albacore tuna muscle tissue quality in the California Current System. (in prep for PLOS One)
16. Resource partitioning among pelagic predators in the southern California Current remains stable despite temporal variability in diet composition. (in prep for Journal of Animal Ecology)

Recent HMS Presentations

74th Tuna Conference

- Stomach content analysis of Pacific bluefin tuna (*Thunnus orientalis*) in the southern California Bight from 2020-2023
- Cooperative Fisheries Research on Highly Migratory Species in the Eastern Pacific Ocean
- Over a decade of collaboration between the Sportfishing Association of California (SAC), NOAA Southwest Fisheries Science Center (SWFSC), and California Department of Fish and Wildlife
- Integrating Science and Stakeholder Input: an Example from the North Pacific Albacore Management Strategy Evaluation (MSE) and Harvest Strategy Adoption Process

154th American Fisheries Society

- Flexible Foraging Ecology in Pacific Bluefin Tuna Results in Temporal Trophic Stability

24th Trinational Forum

- Investigating the relative importance of pelagic forage species to the diets of key highly migratory predators in the California Current Large Marine Ecosystem

21st International Institute of Fisheries Economics & Trade (IIFET) Conference

- Fish Auction Markets: A Review

7th International Billfish Symposium (IBS)

- Using Angler Surveys to Observe Changes in the Recreational Billfish Fishery in the Eastern Pacific Ocean

American Fishermen's Research Foundation Board of Directors Meeting

- Albacore Life History Research Update

CIMEAS 5 Year Review

- Life history and management of pelagic fish species

Future Seas Stakeholder Meeting

- Impact of climate and ecosystem change on the California Current forage complex and the fishing communities and predators it sustains

Ocean Foundation Management Procedures in a Changing Climate Harvest Strategies Webinar

- Management Strategy Evaluation and Climate Change

Ocean Sciences Meeting 2024

- Current MPAs Conserve Fish Spawning Aggregations under Climate Change due to Habitat Refugia

PICES, 74th Annual Tuna Conference

- Future changes in habitat suitability, foraging grounds, and energy dynamics of North Pacific albacore
- FUTURE SEAS: an interdisciplinary multi-model approach to assess impacts of climate change on the California Current forage assemblage and the fishing communities it sustains
- Interacting impacts of prey availability and climate warming on indicators of California sea lion reproductive success in the California Current System
- Resource partitioning among pelagic predators in the southern California Current remains stable despite temporal variability in diet composition
- The pelagic species trait database, an open data resource to support trait-based ocean research
- Juvenile Albacore Tuna (*Thunnus alalunga*) diet variability and resilience in the northern California Current Large Marine Ecosystem

UC Davis Sustainable Oceans Workshop

- Climate change and Species Distribution Modeling in the California Current System