Investigations of age and growth of yellowfin tun eastern Pacific ocean

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Inter-American Tropical Tuna Commission

Yellowfin tuna stock assessment review, La Jolla, California USA,

Outline

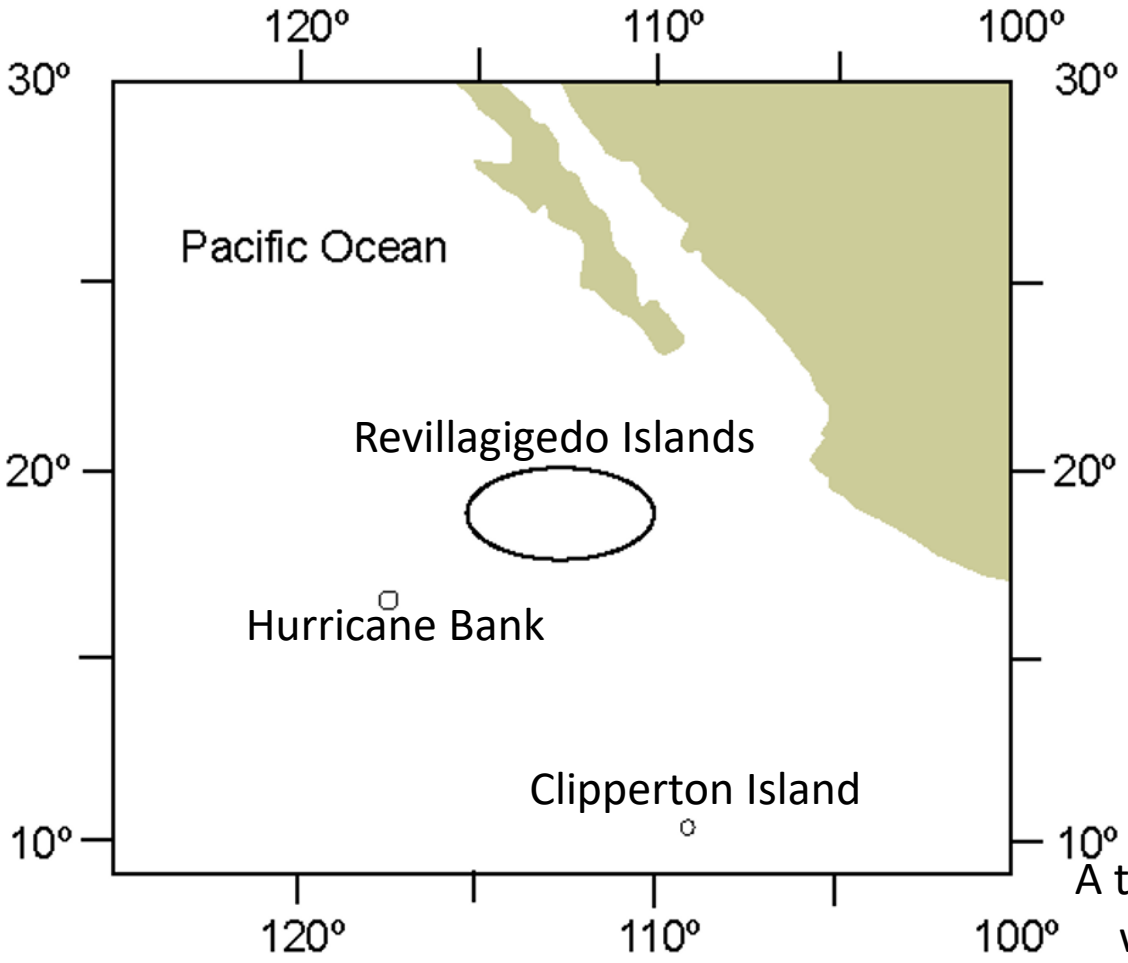
- Describe Oxytetracycline mark – recapture experiments conducte evaluate increment deposition rates in yellowfin tuna otoliths
- Describe the aging methodology and the growth model currently yellowfin tuna stock assessment at IATTC
- Discuss ongoing work and methodologies being utilized at IATTC spatiotemporal variability in growth and maturation of female ye
- Outcome of both the age and growth workshop and technical wo aging methods will be presented
- Results from a comparison of daily and annual aging methods ba of 67 otolith pairs

Introduction

- Tagging experiments conducted during 1976, and 1980 – 81, use
  tetracycline injected into some yellowfin tuna to evaluate depos
  calcified structures (otoliths)

Introduction

Tagging experiments 1976-1981



A total of 10,909 yellowfin were captured and tagge
were injected IM with 27 $mg \cdot kg^{-1}$ body weight of
FL measured to nearest cm
Tagged with a color coded dart tag and released

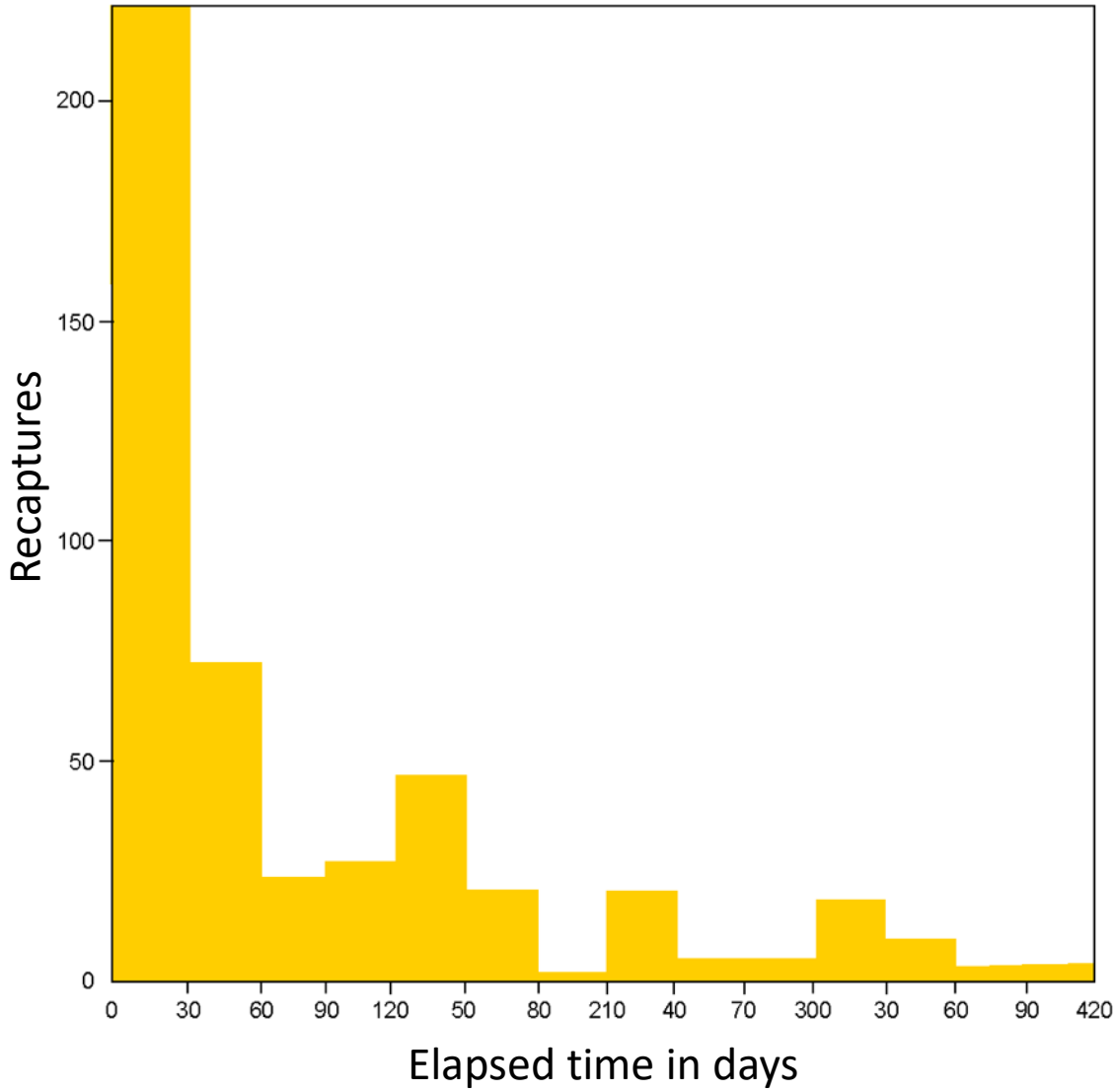
Introduction

Year	Baitboat cruise number		Number Released	Number Returned	Numbers of fish used for validation[1]	Percent recaptured	Return rate (%)	Con Test 5%
1976		Control	2,355	1,327		56.3	36	0
		OTC	978	562	53	57.5	36	
1980-1981	1093	Control	822	147		17.9	15	
		OTC	1,658	377	74 (total from all cruises)	22.7	19	
	1095	Control	3,017	840		27.8	22	6
		OTC	476	30		6.3	6	
	1096	Control	1,277	294		23.0	19	0
		OTC	326	77		23.6	19	

[1] Fish were selected based on the return of both fish and tag, known recapture dates, and a represent
elapsed time since tagging and injection. (after Wild and Foreman, 1980; Wild, Wexler, and Forema

Recaptures by times at liberty of OTC-injected yellowfin tuna fr tagging experiment

Returns by times at liberty for OTC-injected yellowfin tuna from the 1976 tagging experimen



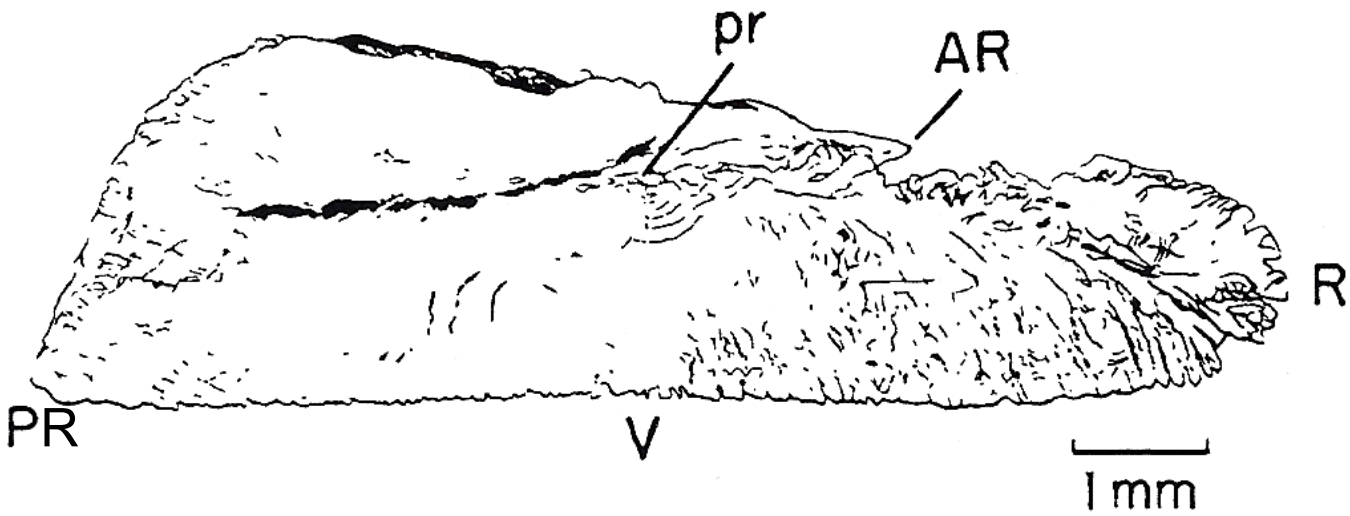
(Wild and Foreman, 1980)

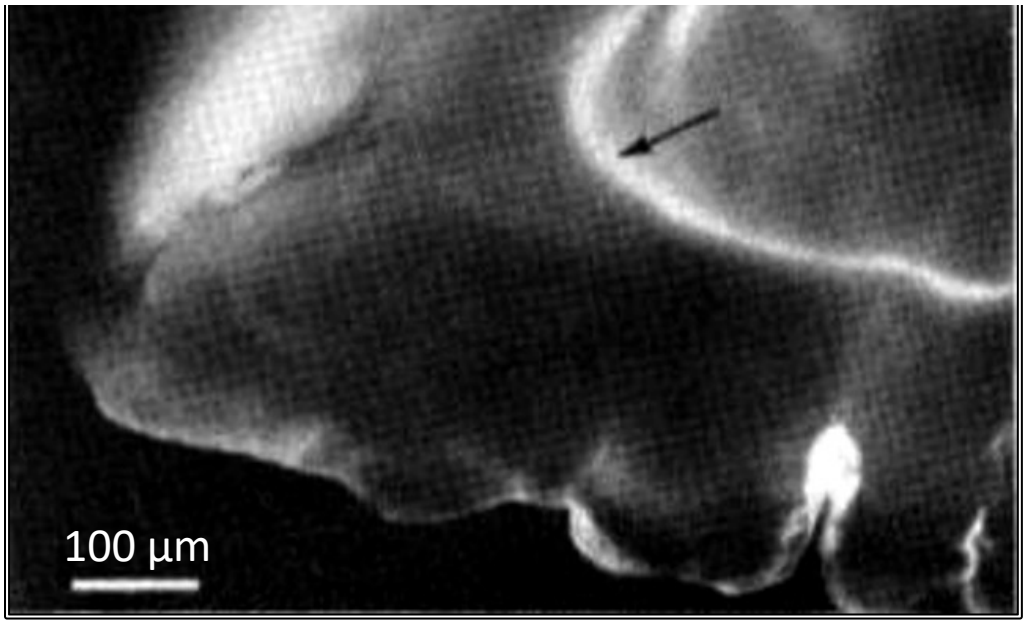
Validation

- Tagging experiments conducted during 1976, and 1980 – 81, use tetracycline injection of some fish for evaluation of deposition ra calcified structures (otoliths)

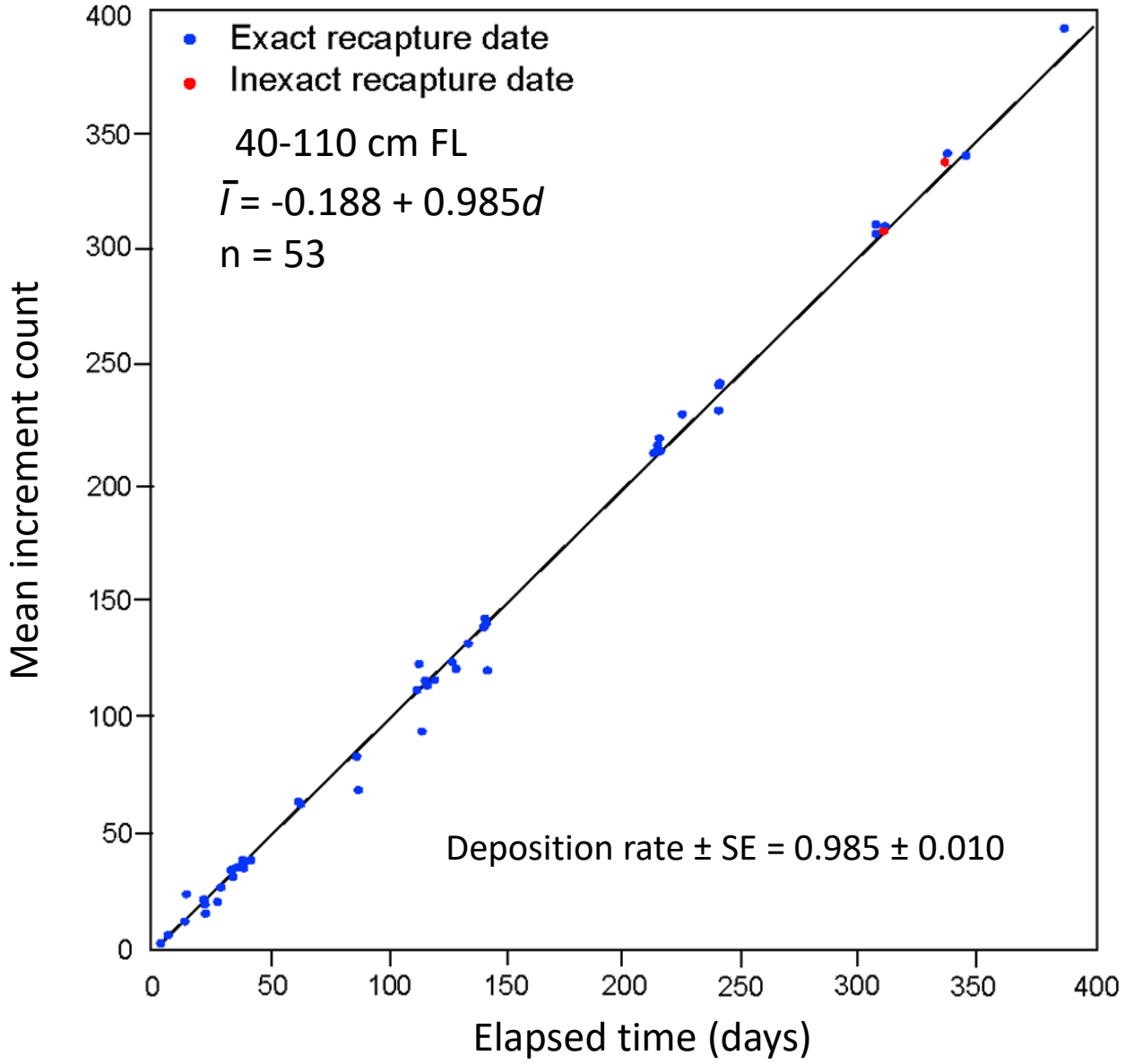
- Methods developed to determine the periodicity of otolith incre

Procedures used for counting increments at the distal su sagittae of OTC-injected yellowfin



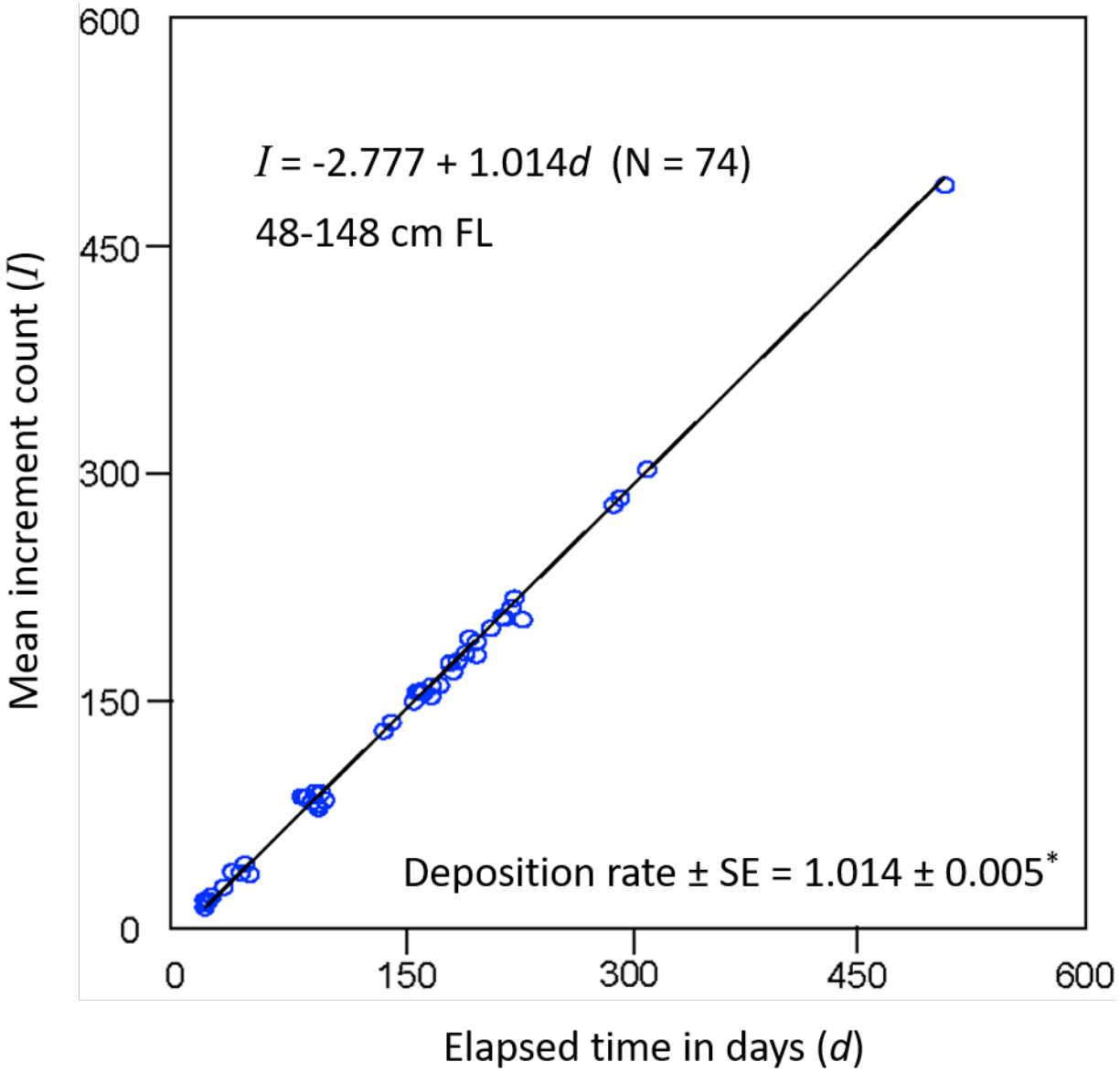


Relationship between mean increment count and elapsed time in sa of OTC-injected yellowfin tuna recovered from the 1976 tagging e



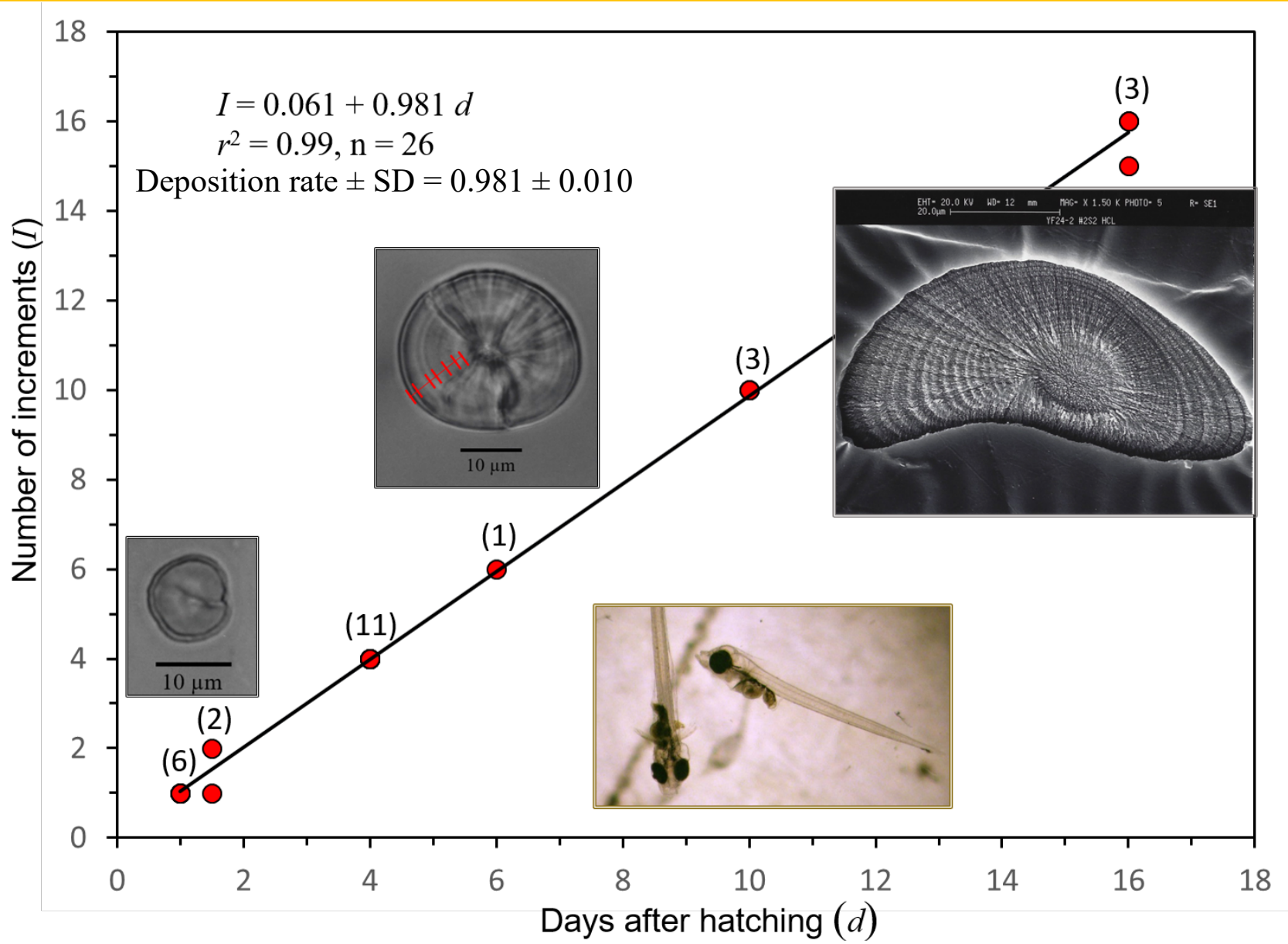
(Wild and Foreman, 1980)

Relationship between mean increment count and elapsed time in sa of OTC-injected yellowfin tuna recovered from the 1980 - 1981 taggi



(Wild et al., 1995)

Increment deposition rate in larval yellowfin tuna (3-7 mm SL) otc western Pacific Ocean (JASFA, IATTC ELH group)



(Wexler, et al. 2001)

Validation

- Tagging experiments conducted during 1976, and 1980 – 81, use tetracycline injection of some fish for evaluation of deposition ra calcified structures (otoliths)

- Techniques developed to determine the periodicity of otolith inc

- Validation of daily increments in sagittal otoliths yellowfin tuna f and other oceans

Daily increment validation studies for yellowfin tuna

OTC tagging/ recapture years	Length range	Range of days at liberty $\triangle t$	Ocean	Number of yellowfin	Relationship between the change in mean increments and elapsed time $\triangle t$	Reference
1976-1981	40-148 cm FL	3-515	EPO	127	1:1	Wild and Foreman, 19 Wild et al., 1995
1979-1983	?	32-132	SE Atlantic	5	1:1	IATTC Annual Repo 1987
1987[1]	25-40 cm FL	21-39	Central Pacific	12	1:1	Yamanaka, 1989
1992[1]	3-7 mm SL	1-16	Western Pacific	26	1:1	Wexler et al., 2001
1992	35-91 cm FL	21-175	South and SW Pacific	3	1:1[2]	Lehodey and Leroy 1999; IATTC Annua Reports 1992-1994

[1] Laboratory validation

[2] Final confirmation needed with transverse section and SEM for largest fish

Key results from the mark-recapture experiments conducted 1976 and 1980-81

- Tag-return rates between OTC injected and non-injected yellowfin were not consistently different

- There is evidence from other ocean areas to suggest daily increme not unique to the EPO, however data is limited, and uncertainties

- Results of mark-recapture experiments conducted during 1976 an provide validation of daily increment formation in otoliths of 40-14 yellowfin tuna in the EPO along primordium – post-rostral axis.

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Yellowfin tuna growth model currently used in the IATTC as

Yellowfin tuna age estimation – Wild 1986

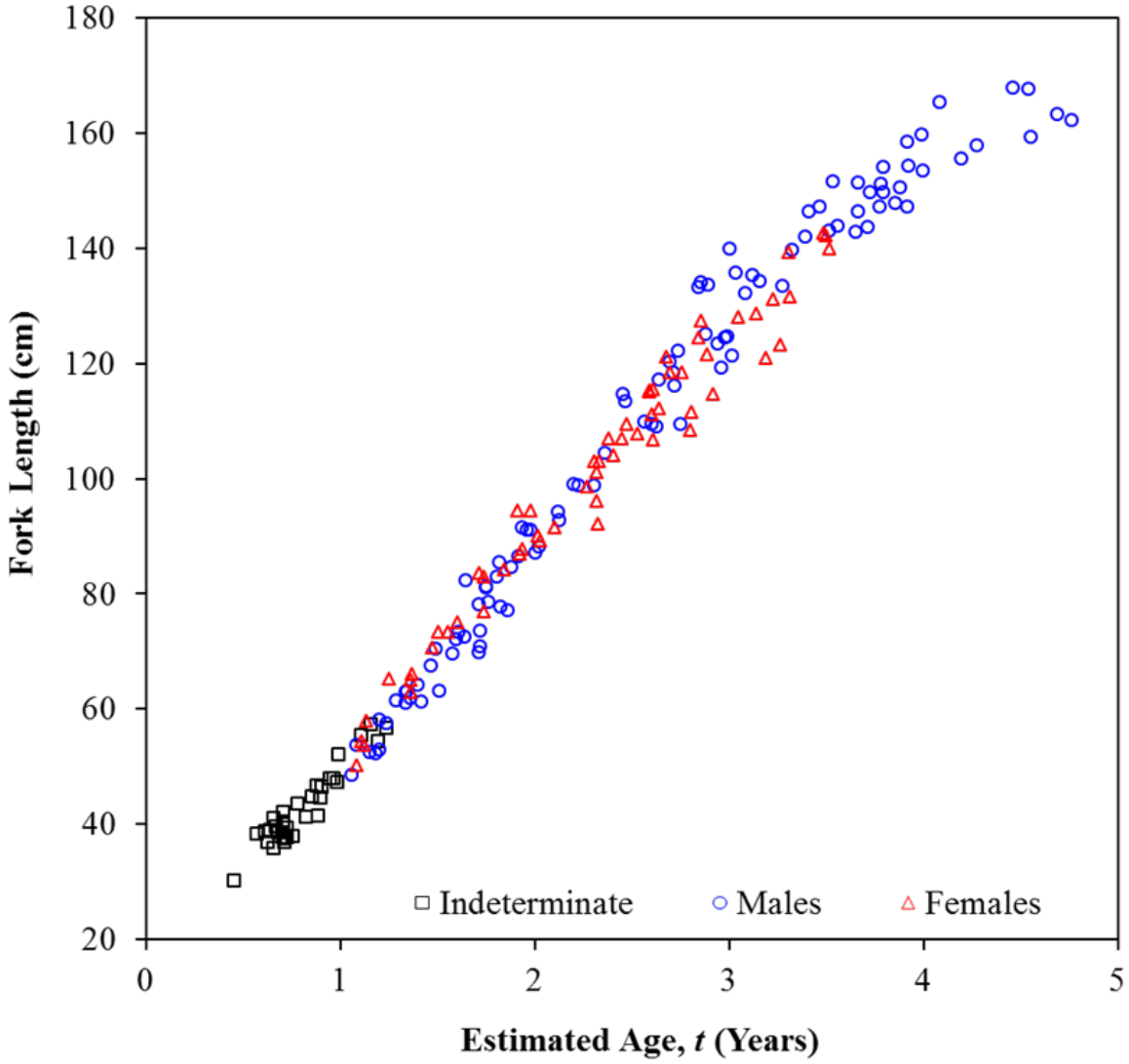
- Deposition rate experiments for yellowfin tuna conducted by Wild and Forema
  Wild et al. (1995) indicate the relationship between increment count and time f
  fluorescent mark to the PR tip was 1:1. There is anecdotal evidence to suggest
  increments are readable out to ~170 cm.

- Age and growth of yellowfin tuna by Wild (1986) was described from a sampl
  30-170 cm FL, collected during 1977 through 1979 from purse seiners fishing
  equator and east of 137°W.

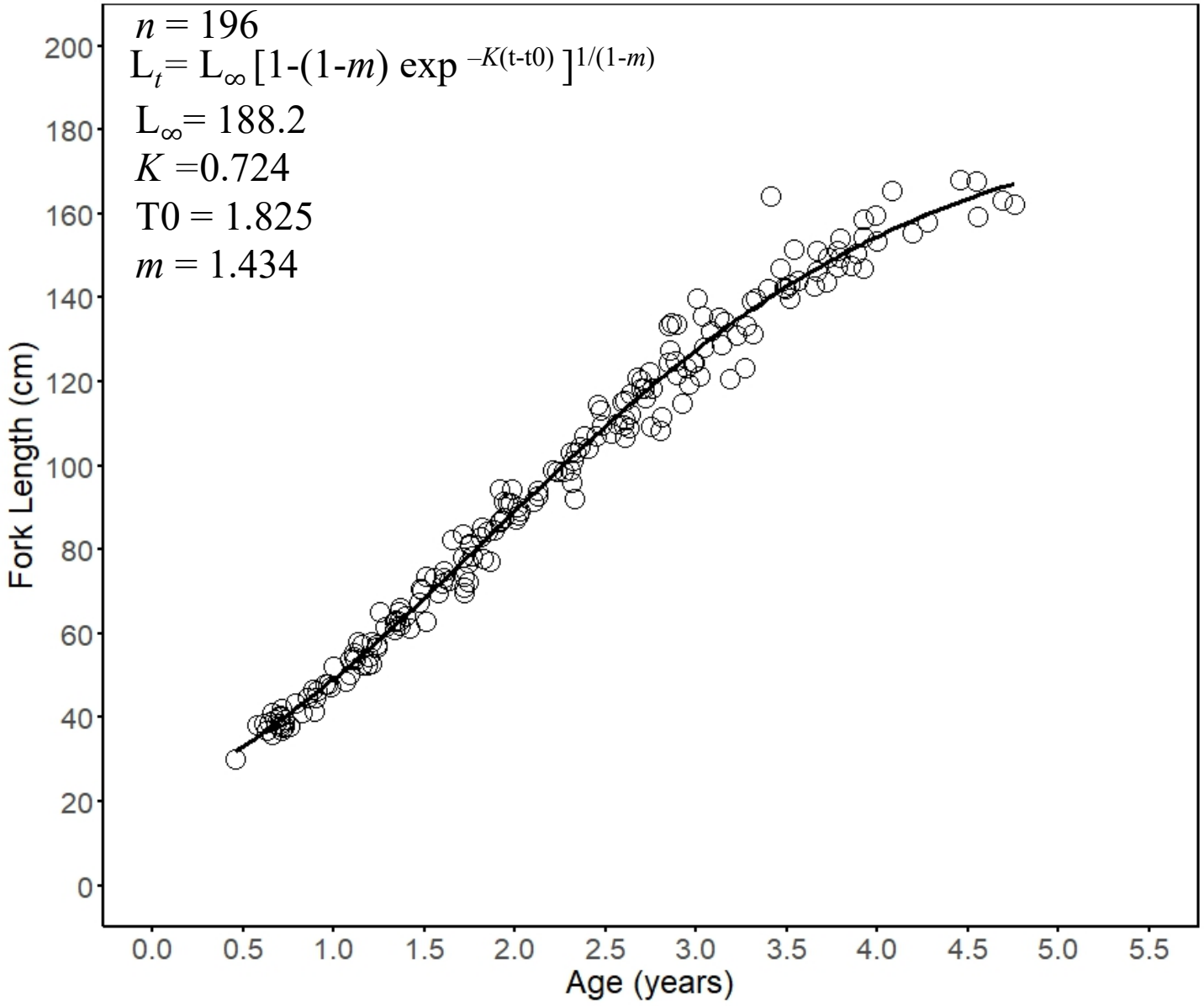
- A replica was created using a cellulose acetate film after an extensive acid etch
  From the replica, the number of increments on a sagittal of each fish was used
  estimate of its age in days

Yellowfin tuna age estimation – Wild 1986

Estimated age at length from daily increment counts by Wild (1986)



Yellowfin tuna age estimation – Wild 1986



Investigations of age and growth of yellowfin tun eastern Pacific ocean

Spatiotemporal variability in growth and maturation of femal ye in the EPO

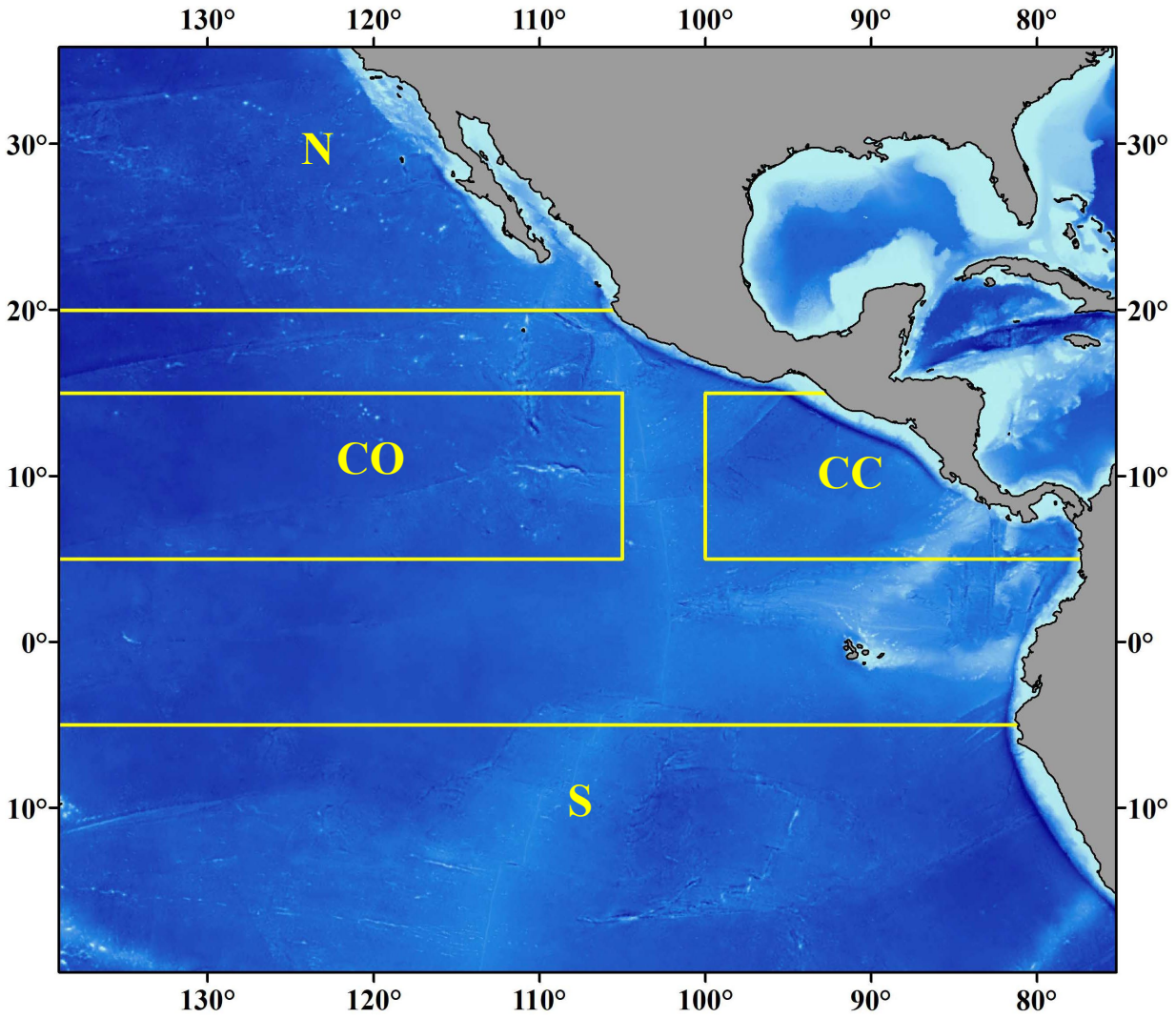
Yellowfin tuna stock assessment review, La Jolla, California USA,

Investigation of spatiotemporal variability in growth and maturat

- Sample across 12 length classes, each of 10 cm range, between 40 and 160 cm
- At-sea sampling aboard purse-seine vessels was conducted by IATTC observe cooperation of specific fleets in Mexico and Ecuador. IATTC observers sample shortly after capture, so subsamples could be placed in a fixative within a few capture so as to be suitable for detailed microscopic examination
- Sample only when sea-surface temperatures are > 25°C, when mature yellowfi to be reproductively active
- 20 yellowfin were selected from a single set and their lengths and sexes were r
- 40 females sampled for their ovaries and 15 of those for their otoliths, from ea within each strata. No more than 5 specimens of each length class sampled fro same month within a spatial strata
- Fish from which ovaries were sampled were tagged and placed in well racks, t locating them during the unloading process, for remeasuring, weighing, and c heads for later extraction of otoliths by IATTC field office staff.

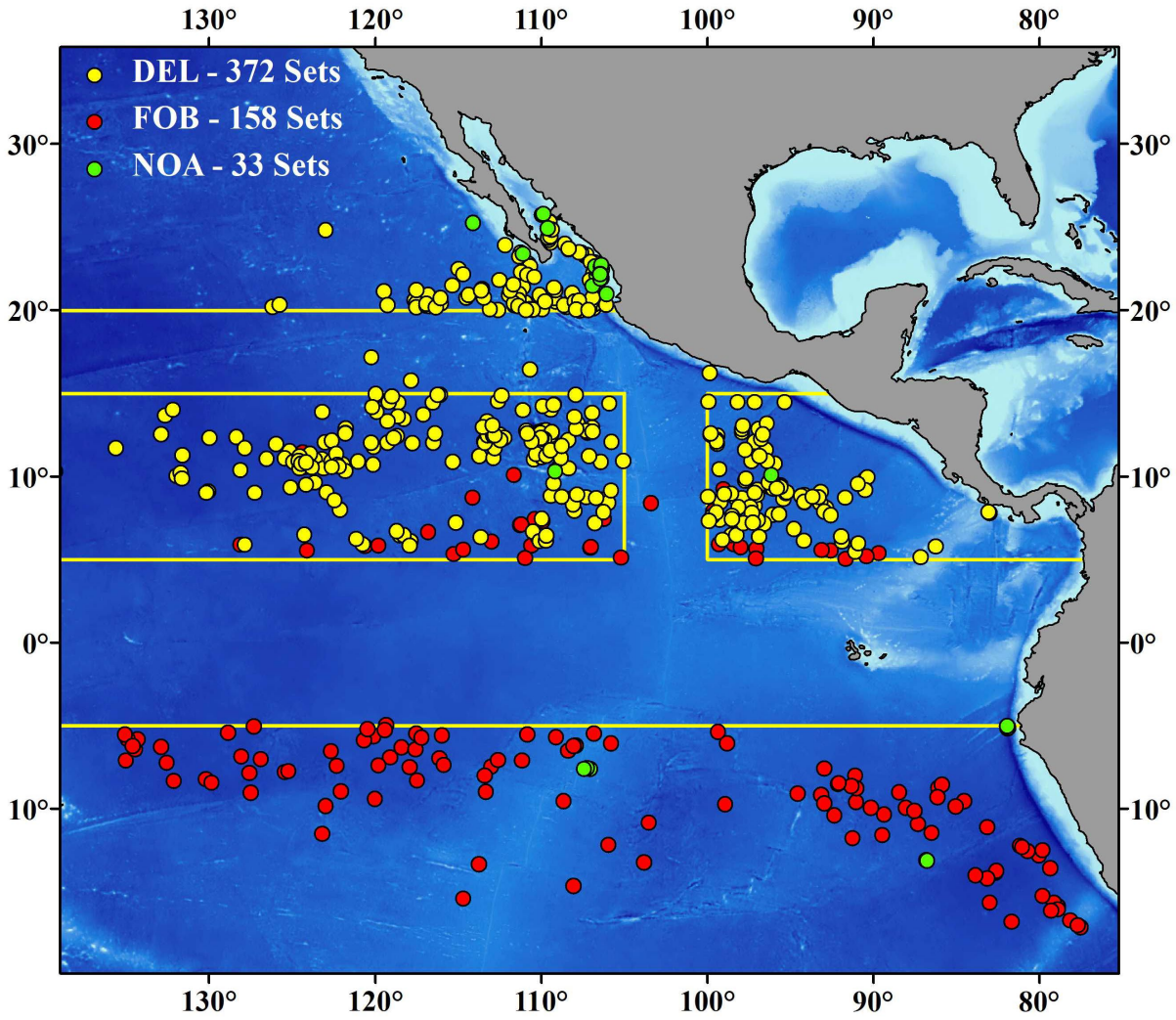
Materials and Methods

Yellowfin tuna otolith sample locations



Materials and Methods

Yellowfin were collected from 563 sets for ovaries and otoliths

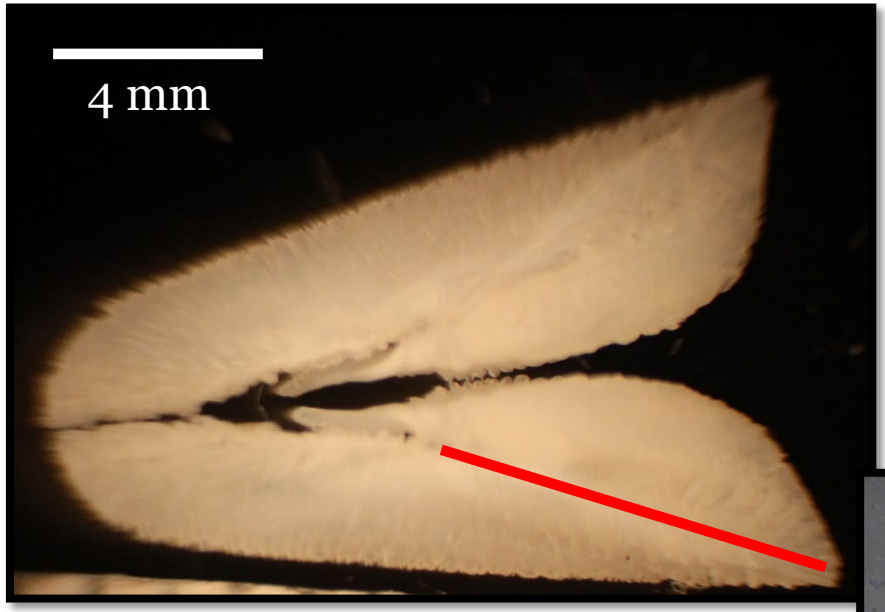


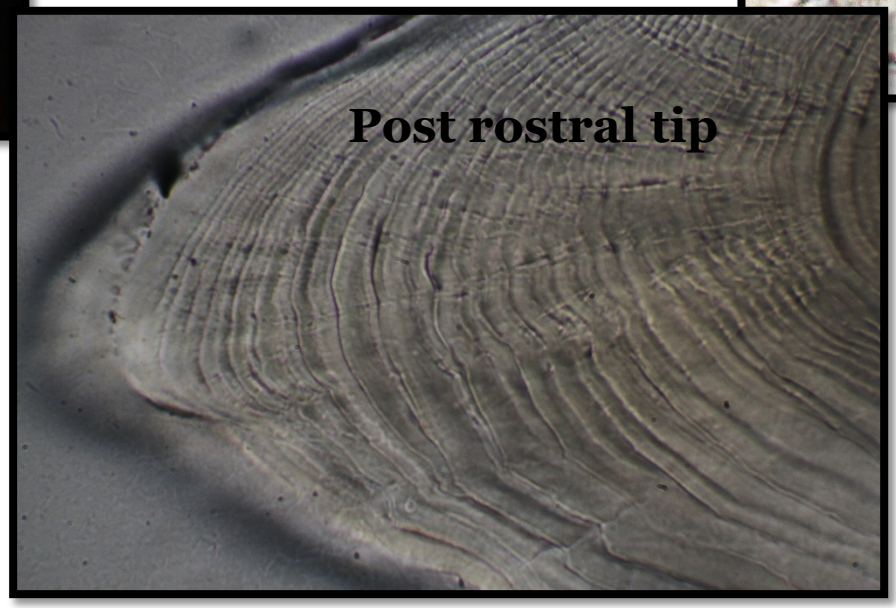
Materials and Methods

- Selected otoliths were mounted in epoxy resin and allowed to cure
- Sections were cut in the primordium – postrostral axis and hand polished
- Sections were viewed and increments counted at 600 -1000x (oil immersion)
- All otoliths are counted blind, with no knowledge of the fork length of the sam
- Only the discontinuous zone was counted
- Each otolith is counted twice, and those counts averaged to obtain a final age e
  However, if the sample coefficient of variation (CV) is larger than 5%, the oto
  third time, or more if necessary, until the CV is within the 5% threshold, so a
  of precision is maintained

Materials and Methods

Sagittal Otolith of Yellowfin tuna



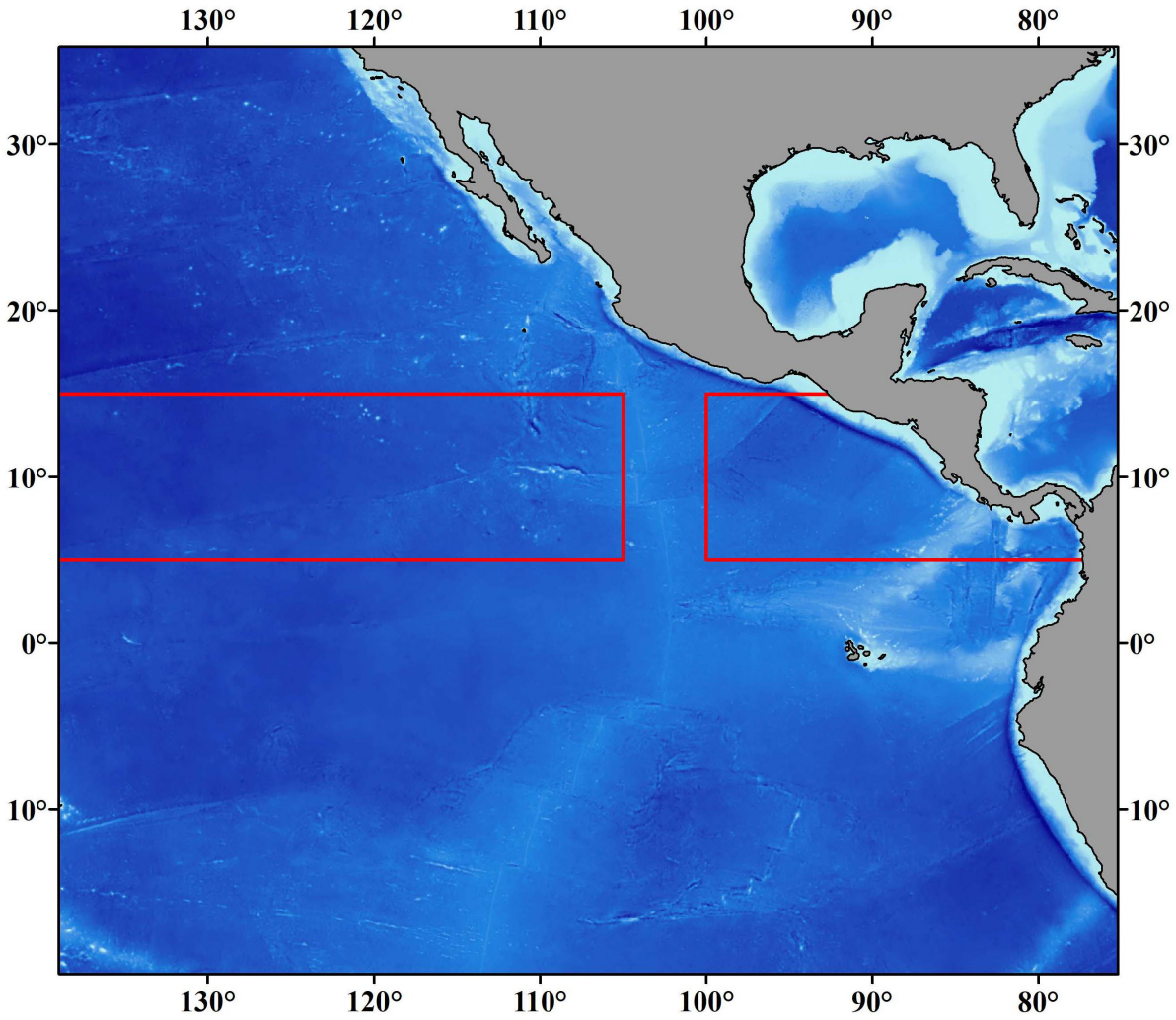


Results

- So far 106 fish from the central coastal area and 128 from the central offshore been aged

Results

234 Otoliths Read: 128 Central Offshore and 106 Central Coastal

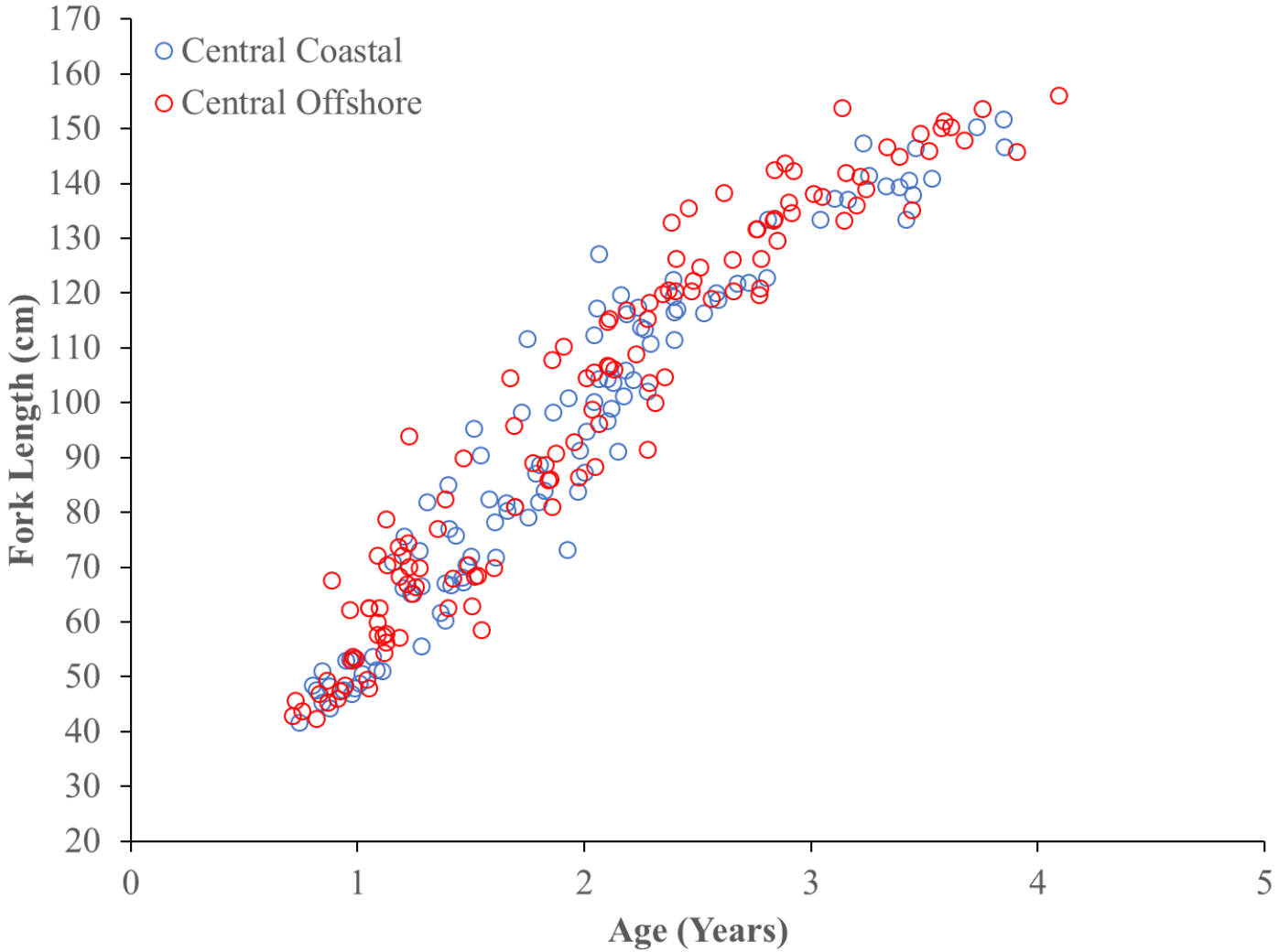


Results

- So far 106 fish from the central coastal area and 128 from the central offshore been aged
- Estimated ages for fish from 41.7 to 156.1 cm have ranged from 0.71 to 4.1 y 1493 d)

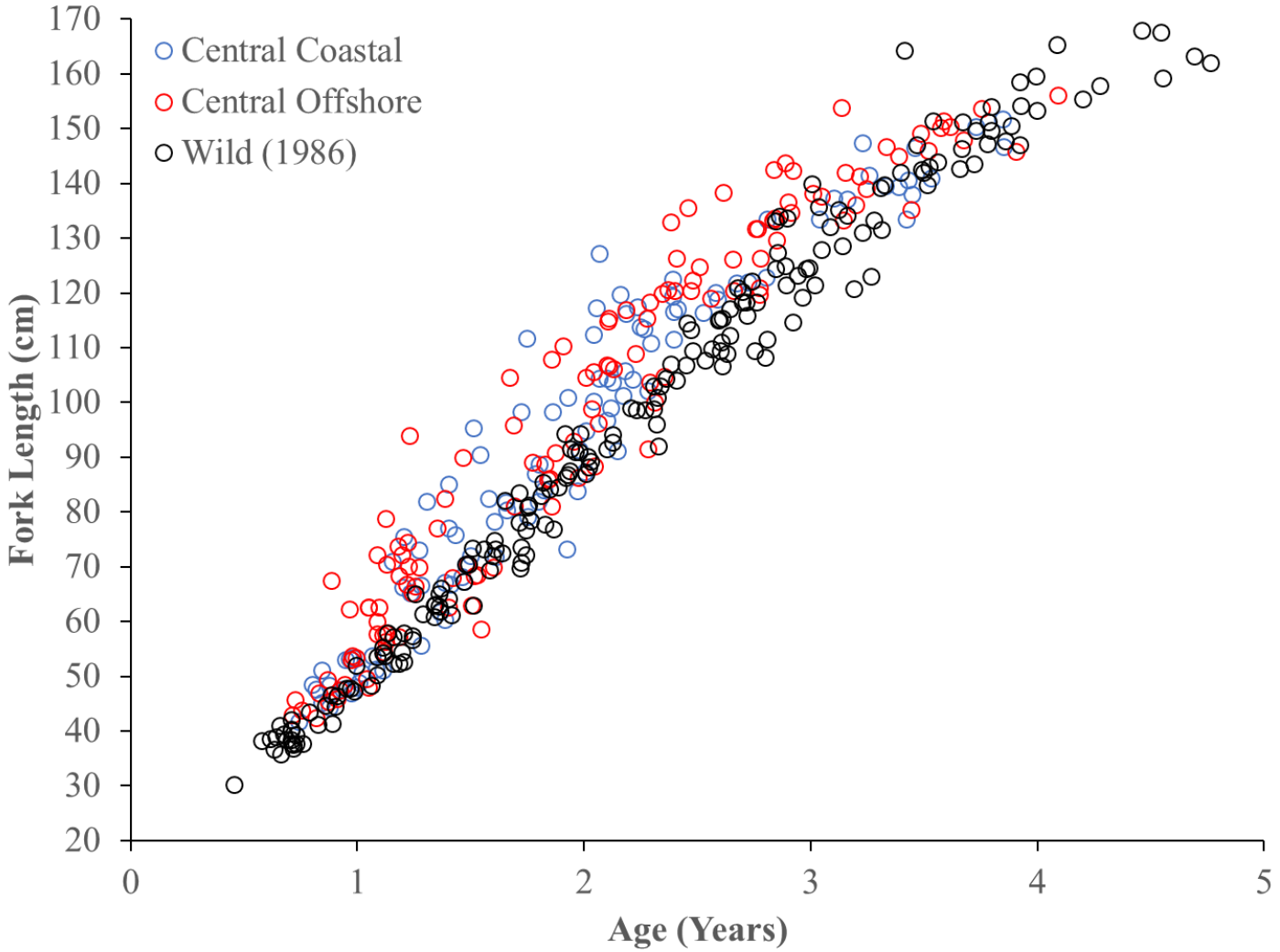
Results

Estimated age at length from daily counts from the CO and CC areas



Results

Estimated age at length from daily counts for the CO and CC areas, and tho (1986)



Results

- So far 106 fish from the central coastal area and 128 from the central offshore been aged
- Estimated ages for fish from 41.7 to 156.1 cm have ranged from 0.71 to 4.1 y 1493 d)
- Although still preliminary, a GAM fit to the age at length data for the CC and indicated a significant difference between the 2 areas (fl~s(ageyear)+area)
- A GAM fit to the age at length data indicated a significant difference between CO and CC data sets and that from Wild (1986)

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Summary of the age and growth workshop, and the age and growth workshops hosted at IATTC during 2019

Yellowfin tuna stock assessment review, La Jolla, California USA,

Overview: WORKSHOP ON AGE AND GROWTH OF BIGEYE AND YE TUNAS IN THE PACIFIC OCEAN

- Hosted in La Jolla, CA during 23-25 January 2019
- 5 Objectives were addressed:
  - Evaluate methodologies
  - Compare daily and annual increment counts from otolith pairs from YFT and BET
  - Compare growth rates from length-at-age data based on otolith increment counts tagging data
  - Evaluate the growth models being used in stock assessments for bigeye and yellow EPO and WCPO
  - Develop a work plan to resolve any scientific and technical issues that exist
- Key points:
  - Collect more data and conduct further validation work to cover a larger spatial are
  - Refine aging protocols and clarify methodologies
  - Evaluate mechanisms for increment formation
  - Improve analytical methods for including age data in assessments
  - Inclusion of high confidence tagging data into integrated models

Overview: WORKSHOP ON METHODOLOGIES FOR ESTIMATING AGE AND YELLOWFIN TUNAS FROM OTOLITHS

- Hosted in La Jolla, CA during 25-26 June 2019
- Topics addressed:
  - Otolith preparation for daily and annual increment counts
  - Validation of daily and annual deposition rated in BET and YFT
  - Counting daily and annual increments in BET and YFT otoliths
- Key points:
  - Otolith preparation for daily aging is time consuming and requires experience
  - Methods employed by FAS for estimating annual age is much more efficient
  - Validation of daily increment deposition rates for BET and YFT in the EPO
    - 70 BET, 38 to 135 cm, 15 to 551d and 127 YFT, 40 – 148 cm, 3 to 515d
    - Examples were viewed by participants defining what a daily increment is
  - Validation of daily increment deposition rates for BET and YFT in the WCPO
    - 2 SrCl marked BET, 94 and 109 cm, and 2 SrCl marked YFT 77 cm and unknown Coral were read using IATTC Prep methods
  - Interpretation of annual increments are subjective, even for experienced readers
  - IATTC staff are adamant that validation of annual increments is required before ur further annual counts, although this was not agreed on by all participants

Investigations of age and growth of yellowfin tun eastern Pacific ocean

Comparison of Daily and Annual aging methods of yellowfin tuna ot

Introduction: Comparison of daily and annual aging

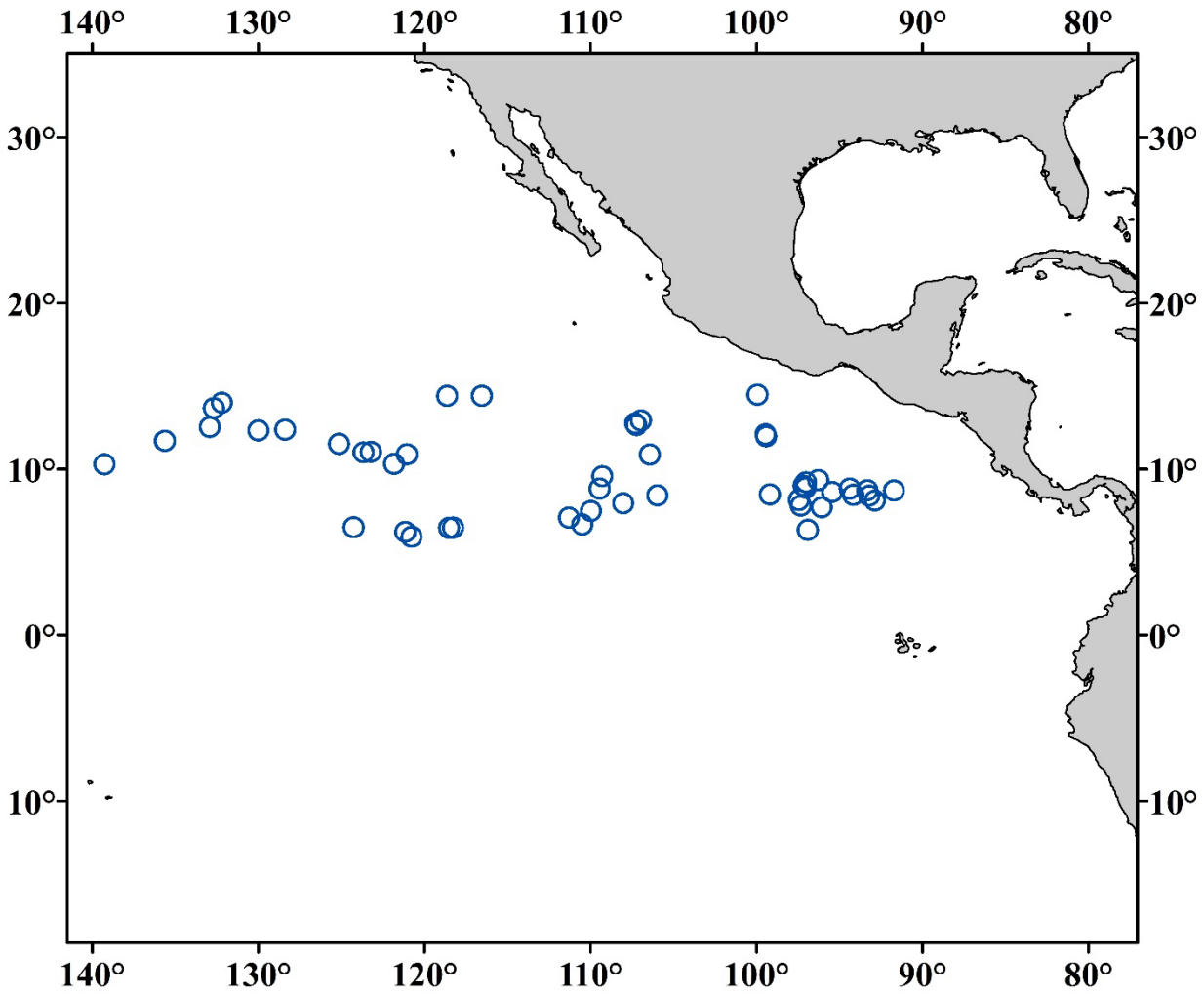
- An investigation of age at length estimates, provided by FAS, from coun zones in otoliths from YFT (80-157 cm) captured in the EPO was under compare to age at length estimates derived from daily increment count otoliths
- Building on the collaborative efforts undertaken to evaluate discrepanc the BET growth models for the EPO and WCPO it seems prudent to con evaluate the age at length estimates, obtained from counts of daily and increments for YFT prior to undertaking a large aging effort using annu increments
- The objectives of this investigation are to evaluate age estimates derive and annual increment counts from 67 otolith pairs

Materials and Methods: Comparison of daily and annual agin

- The methodologies employed for obtaining counts of daily are described abov counts are derived from transverse sections where the first, second, and someti annual increments are estimated using a “measuring stick”, and successive inc band pairs are counted.
- A direct comparison was conducted of the otolith daily versus annual increme adjusted to decimal ages, for 67 YFT (80-157 cm) captured in the EPO primar about 6°N-16°N and 92°W-140°W, during January 2009 to November 2012.
- In the above comparison, where the annual increment zone counts were adjust decimal ages, the algorithm of Farley (2017) was used to account for universal and otolith edge type. While this hasn’t been fully vetted for YFT, especially in considering spawning occurs year round in the area of interest, the assumption birthdate seems reasonable

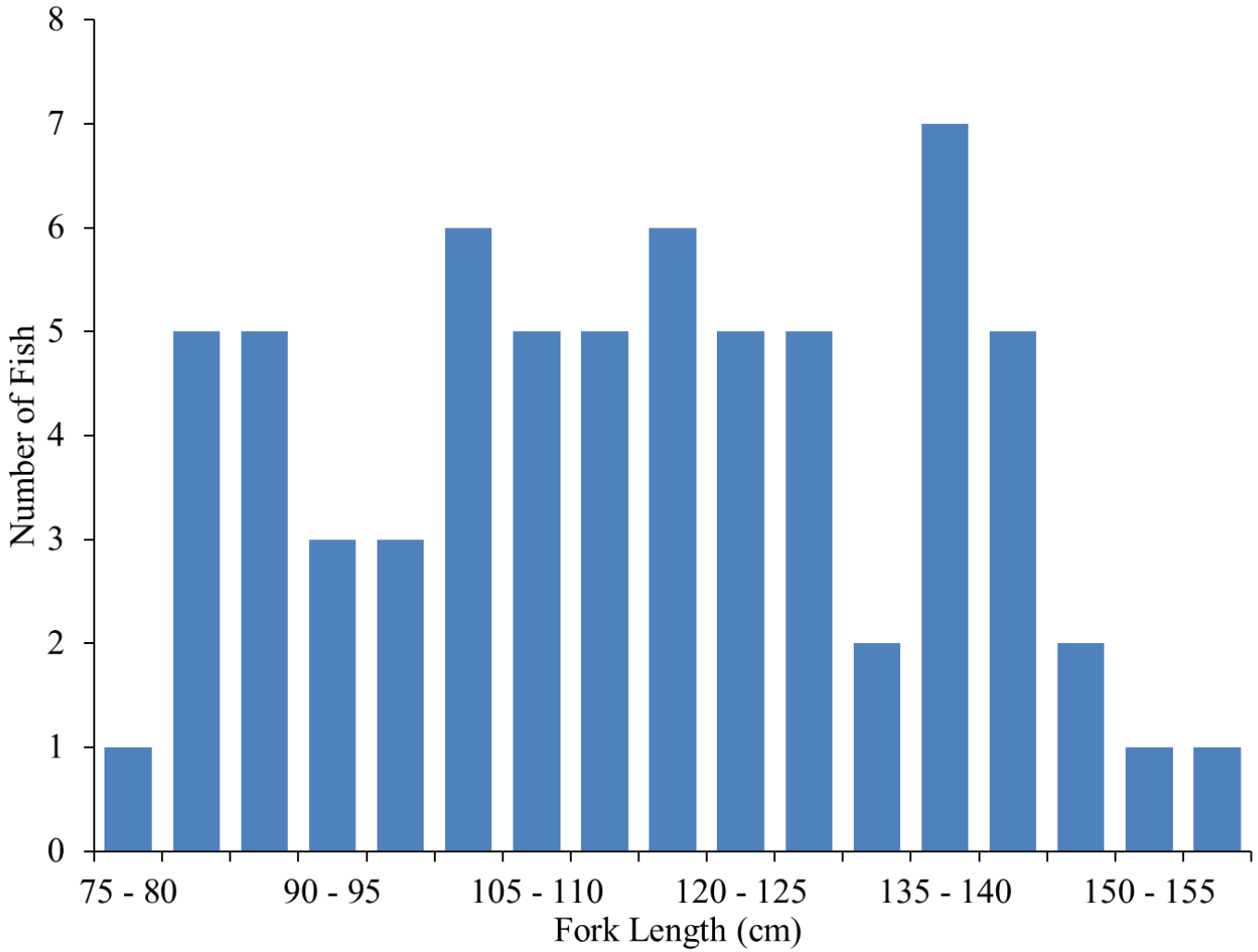
Materials and Methods: Comparison of daily and annual agin

Yellowfin tuna otolith sample locations



Materials and Methods - Sampling

Length Frequency distribution for the 67 otolith pairs read by FAS ar

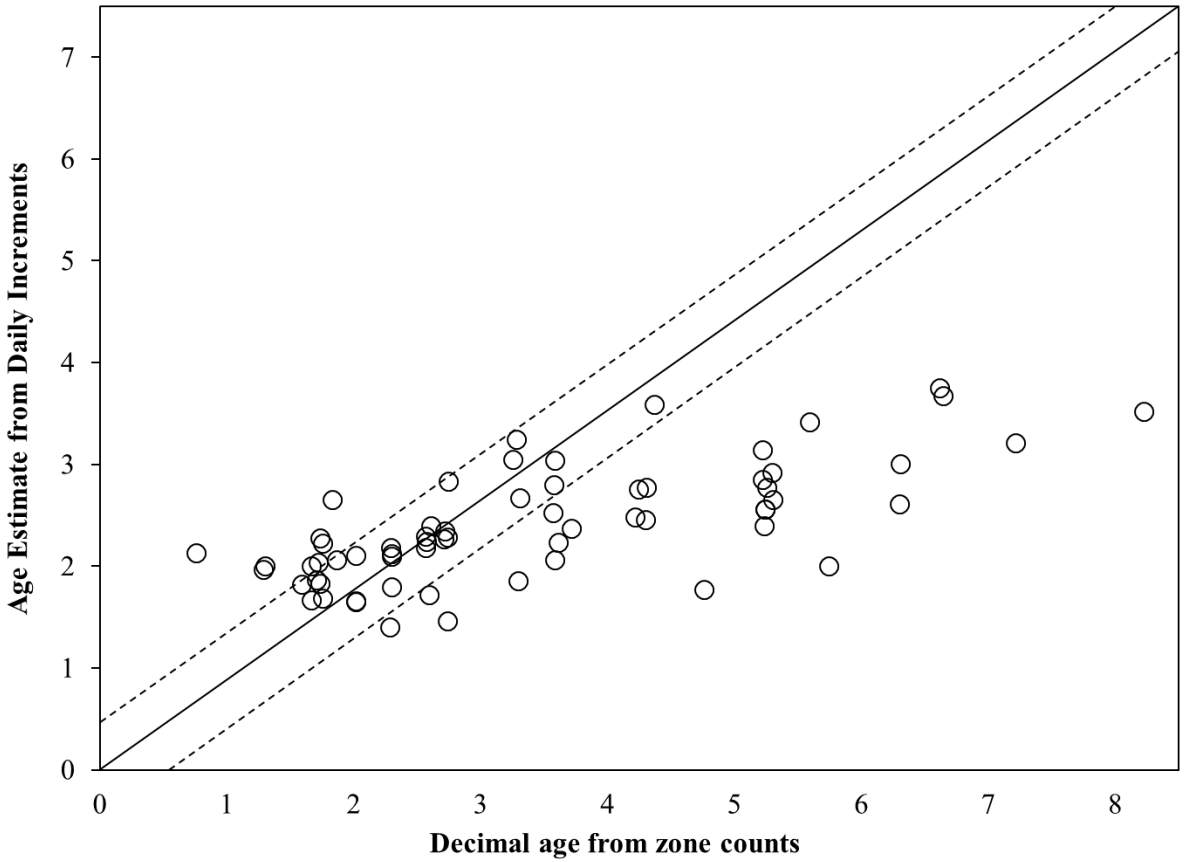


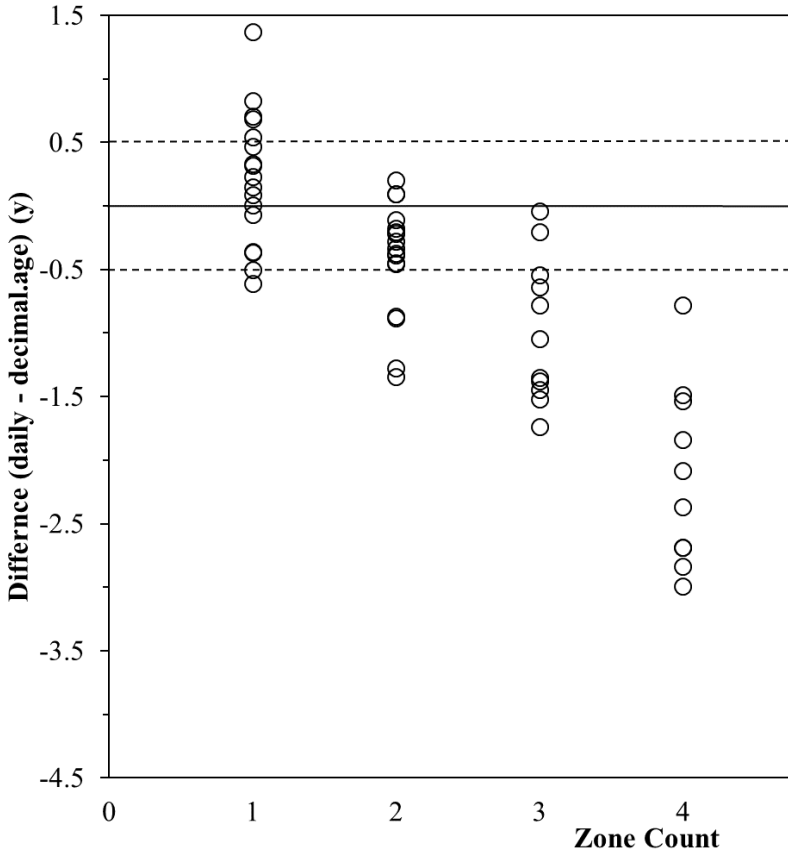
Results

- Comparisons of daily and decimal ages from zone counts for the 67 YFT oto
  shows mostly similar age estimates for fish at about 2 years of age, but there
  under- and overestimation of decimal ages relative to daily ages.
- For fish with daily age estimates between 2.5 and 4 years there is a high prop
  whose ages are overestimated from the decimal ages, derived from annual co

Results

Differences between ages estimated from daily and decimal age from zone c



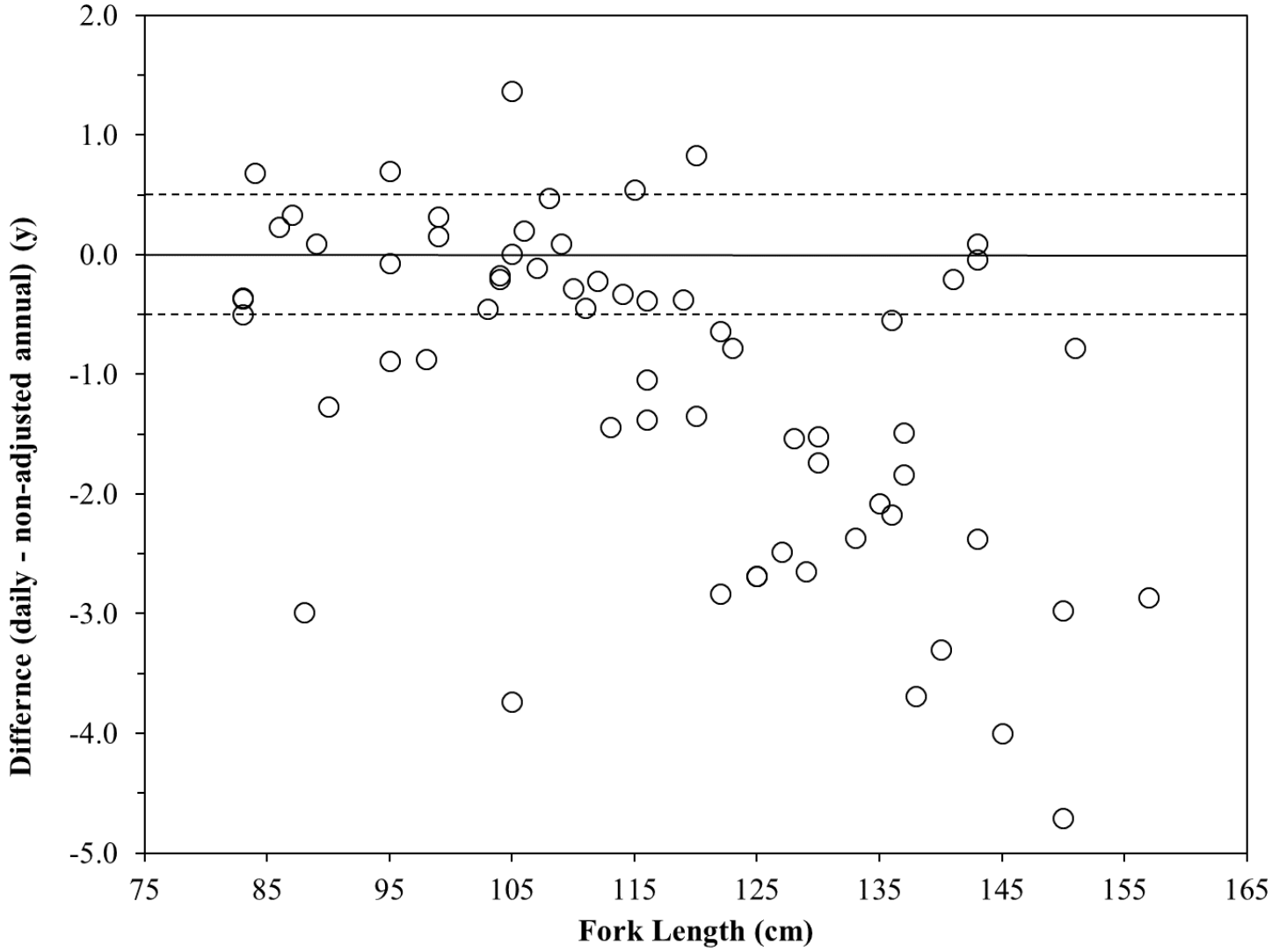


Results

- For YFT > 120 cm, the adjusted annual age estimates are on average 1.9 year
  to 4.7 years) older compared to the estimated age at length from the daily inc
  counts.

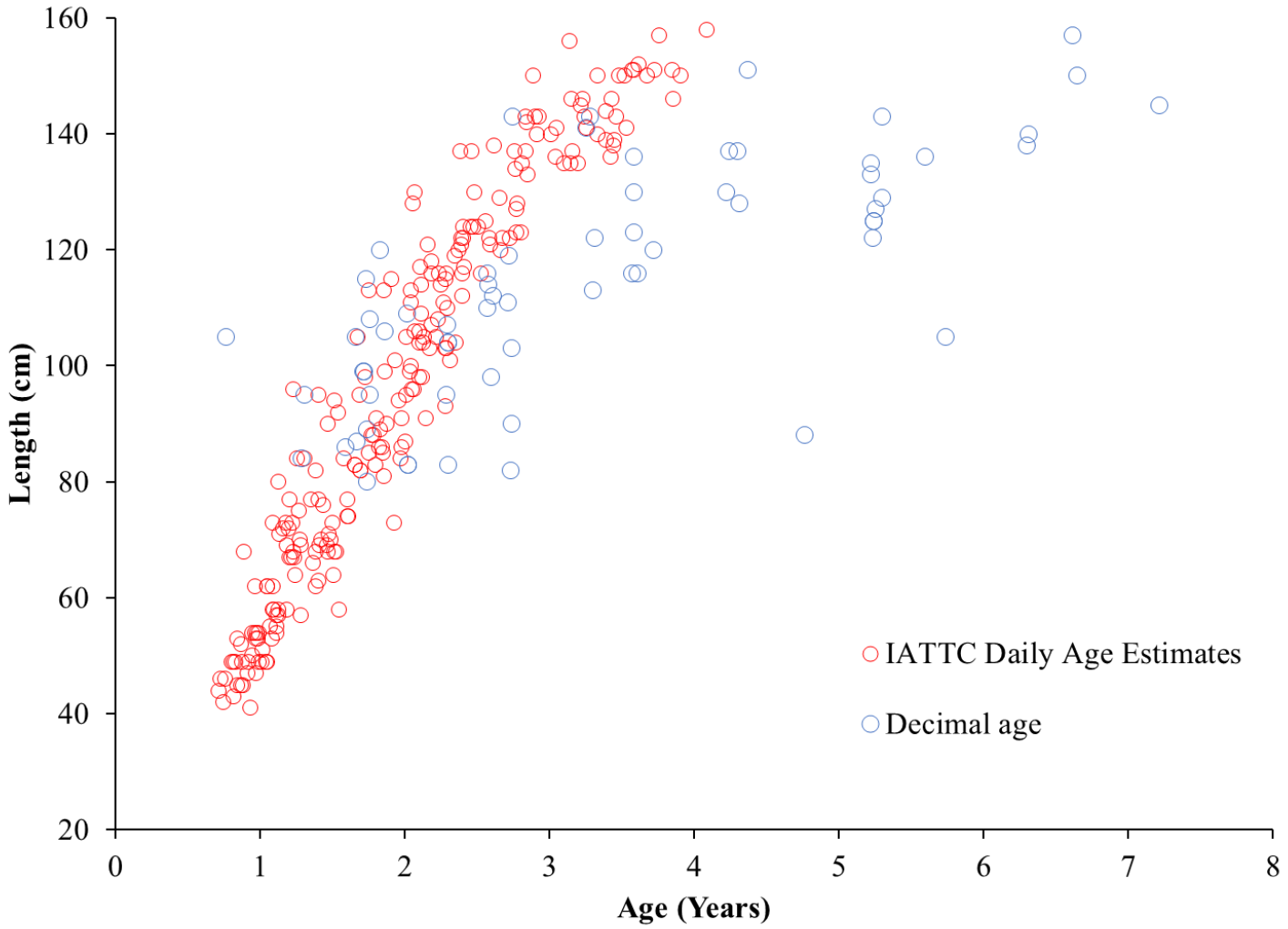
Results

Differences between ages estimated from daily and decimal age from zone counts by fork le



Results

Age estimates from daily and decimal age from YFT otoliths from the EPO



Conclusions

- There appears to be some fundamental issues in the objective discrimination of increments based on the comparative evaluations from 67 pairs of otoliths from from the EPO.

- There appears to be a systematic overestimation of ages from the annual zone c compounded by the application of the algorithm to adjust edge type, compared increment counts for fish > 110 cm.

Acknowledgements

IATTC
Fish Ageing Services, Ltd.
SPC OFP
CSIRO
Jeanne Wexler

Questions

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Photo: Jeff