Science, Service, Stewardship

Alaska Fisheries Science Center

Age Estimation and Validation of Pacific Cod *(Gadus macrocephalus)* at the Alaska Fisheries Science Center

NOAA FISHERIES SERVICE

Overview

- Age & Growth Program process
- Pacific cod ageing at AFSC
  - Annual production (numbers)
  - QA/QC (precision)
  - Issues encountered with ageing
- Current work on validation (C-14, O-18)

Age and Growth (Ageing production process)

Age validation & life history studies

Scientific Activities

- Age validation (^{14}C, $^{18}0$, 226Ra/210Pb)
- Growth/life history variability
- Essential habitat (otolith microchem)

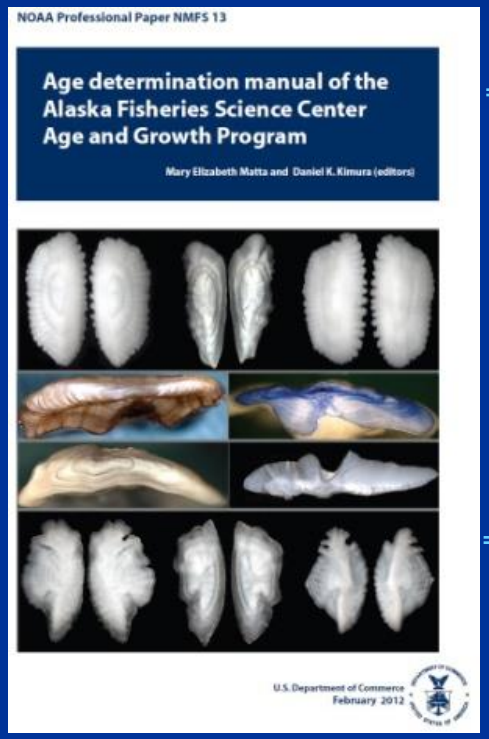
Age determination & growth studies

Support Activities

Reading forms

Inform age determination

Publications



Error checks

Reader age

QA/QC

20% random subsample

Final age

Tester age

Discrepancy Program

Agree Program

QA/QC

Report to requestor

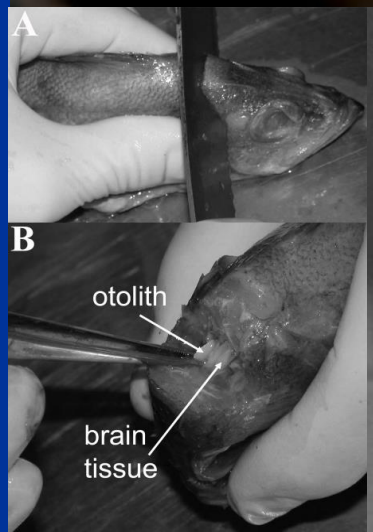
PE
CV
APE
symmetry (bias)

Statistical precision

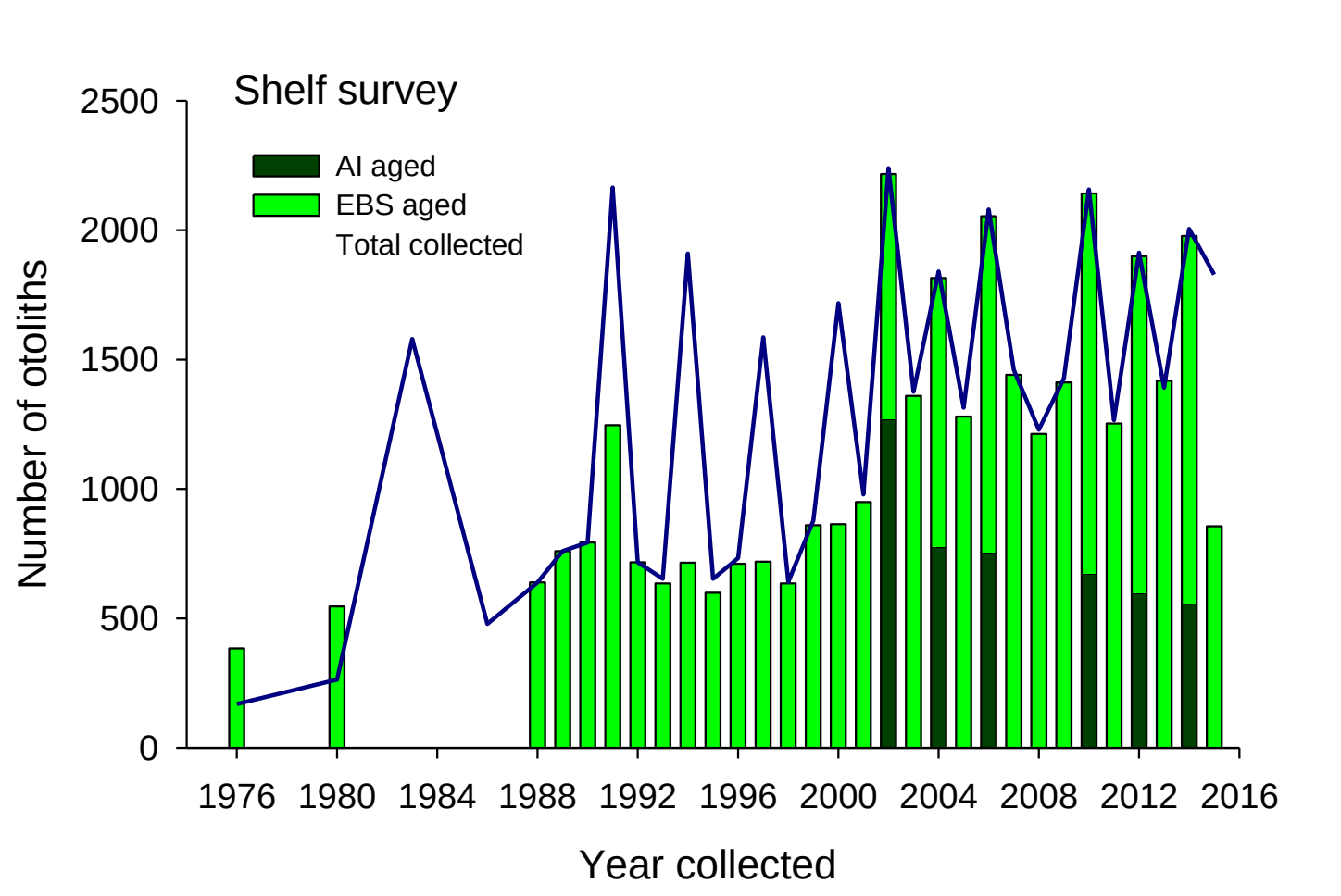
Distribution Databases

- RACEBASE
- NORPAC
- QAQC Reports (Requestor)
- Web tools

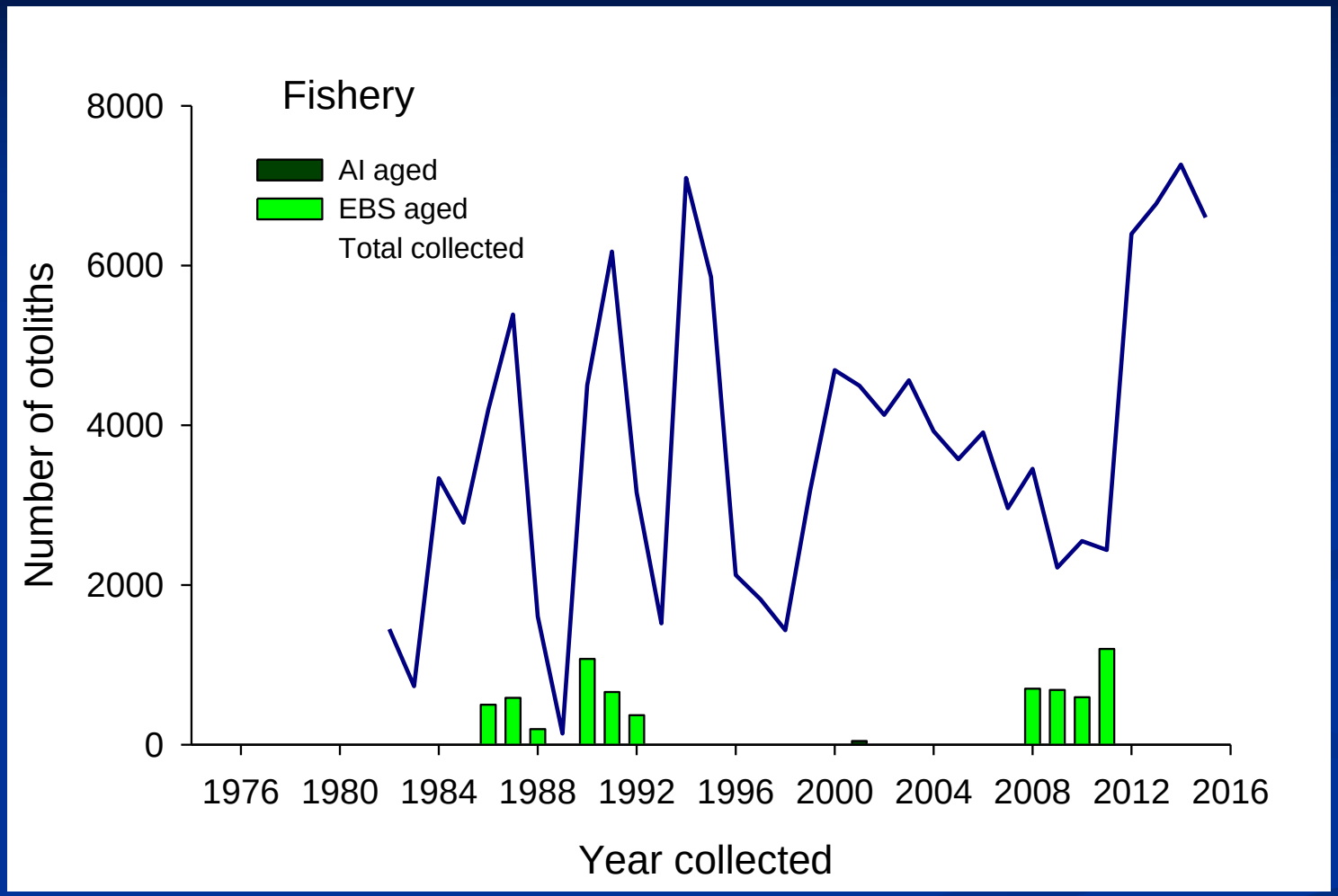
Age determination



Annual Otolith Production

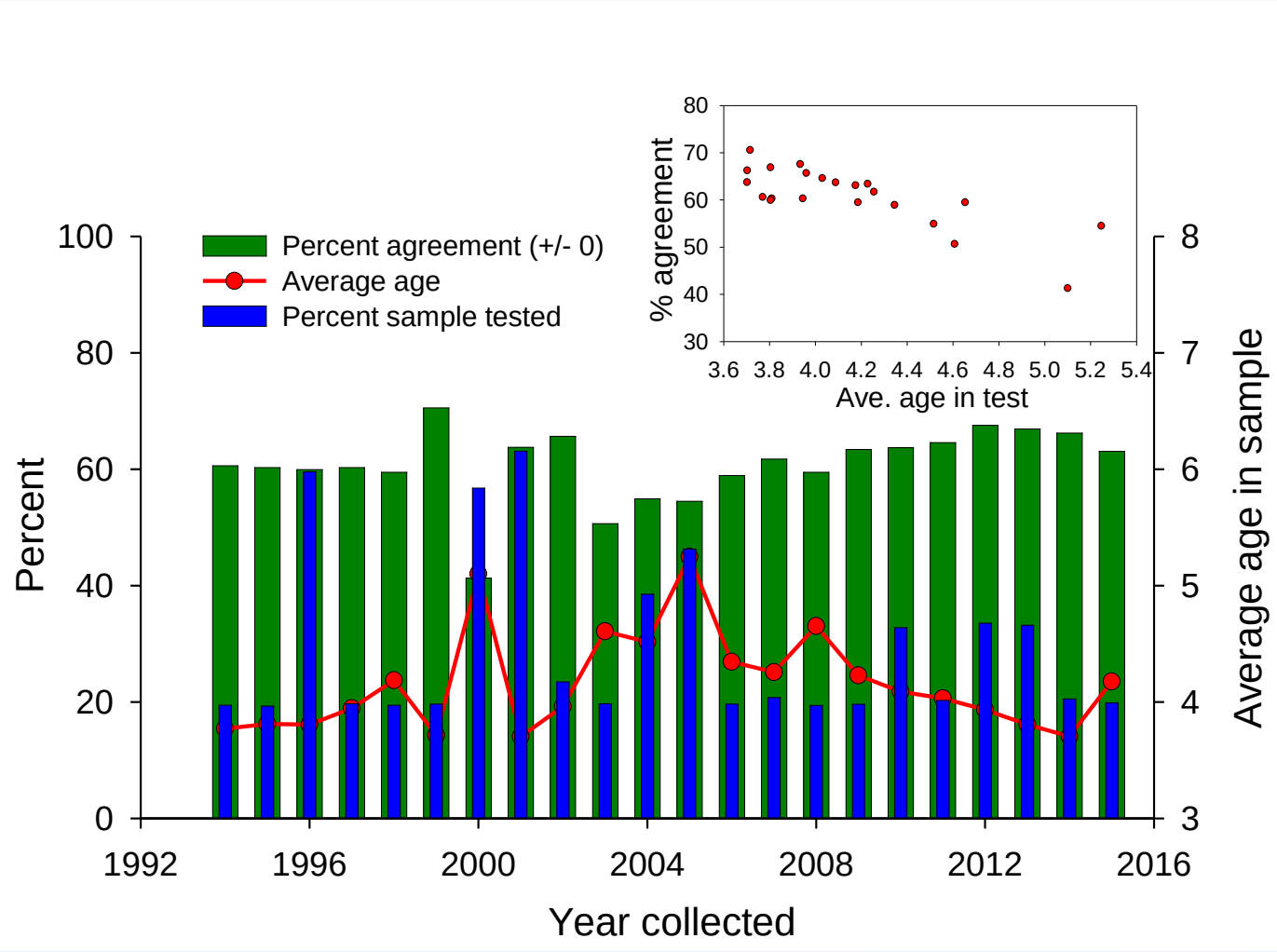


Annual Otolith Production



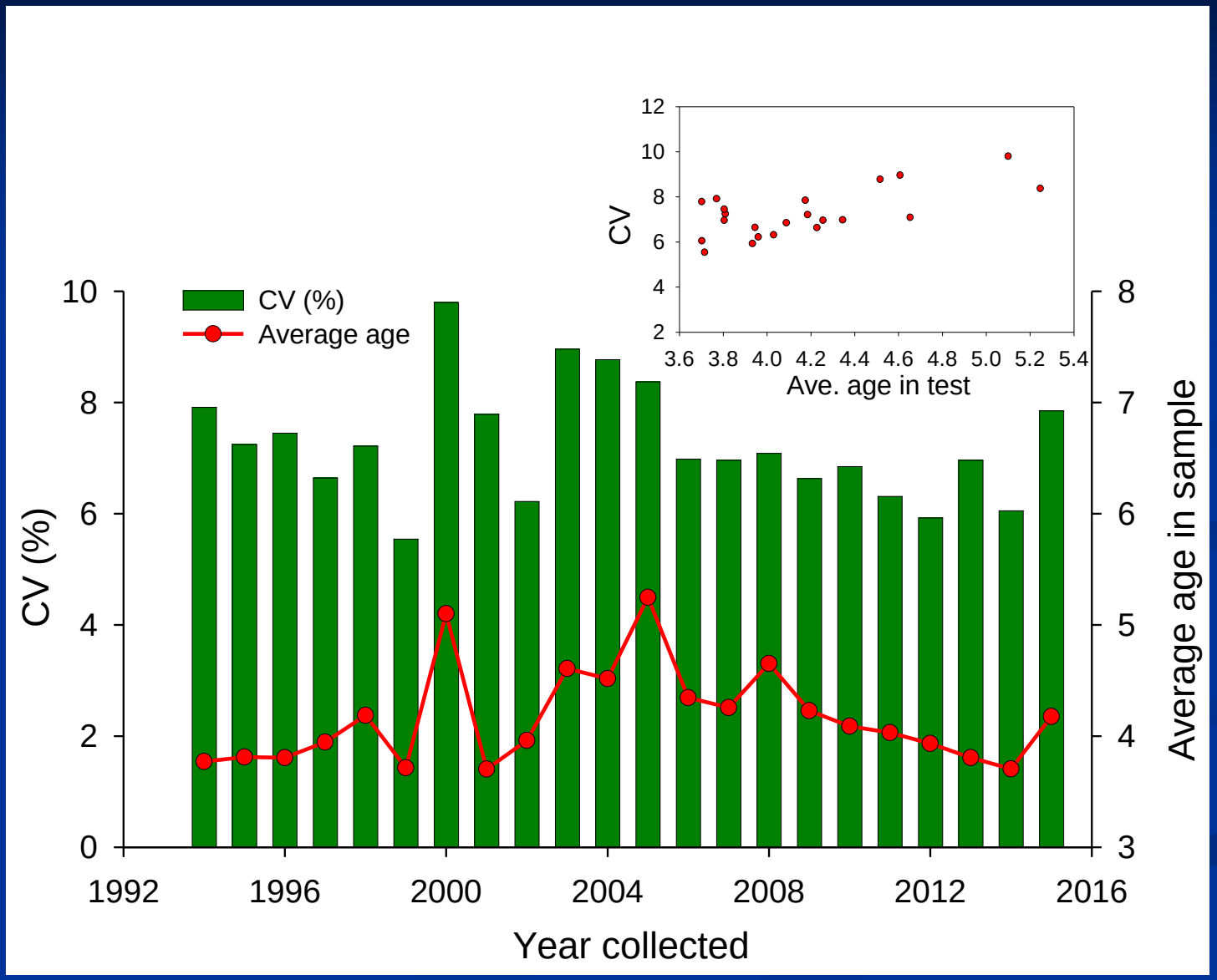
QA/QC of production

Released cruises since 2002



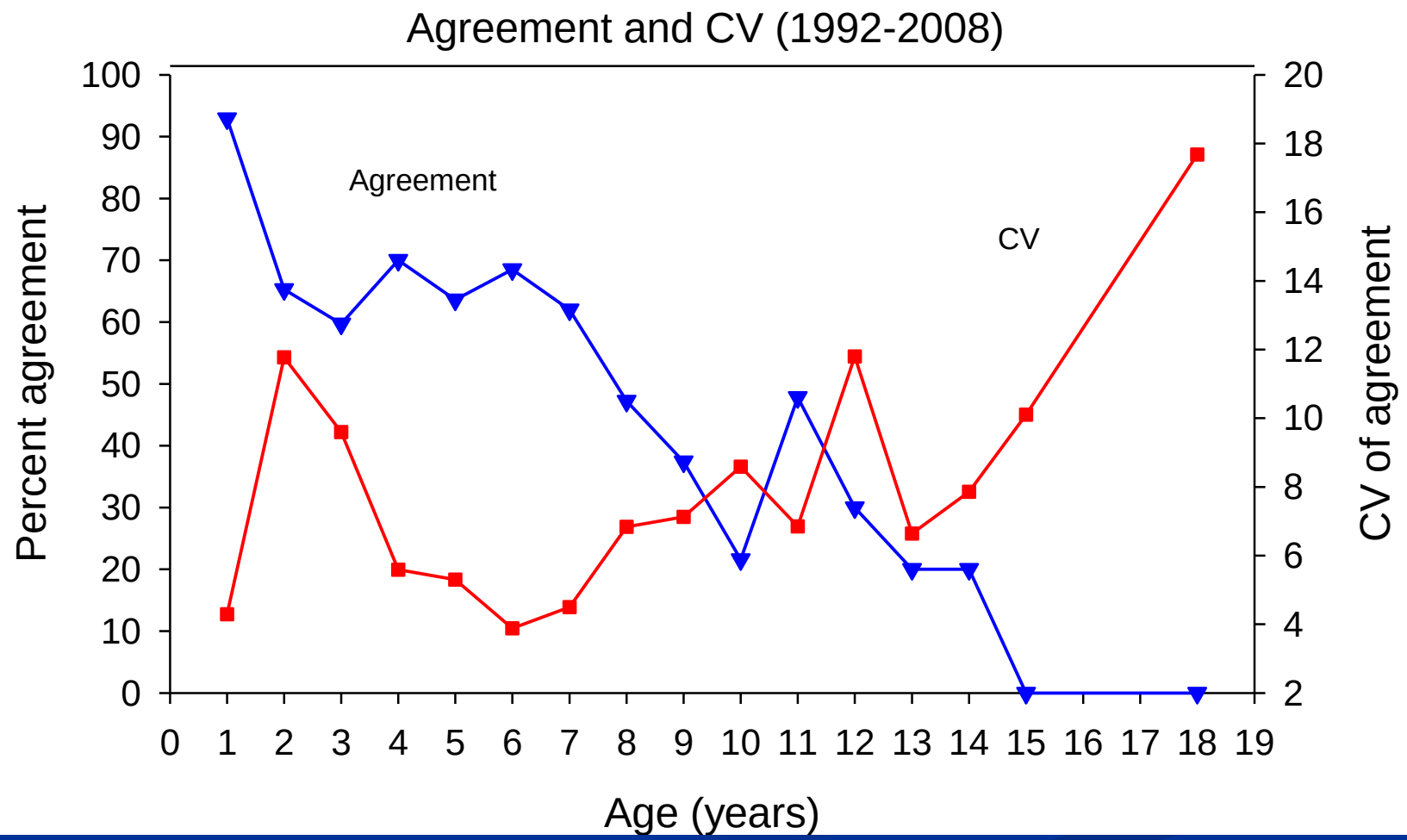
QA/QC of production

Released cruises since 2002



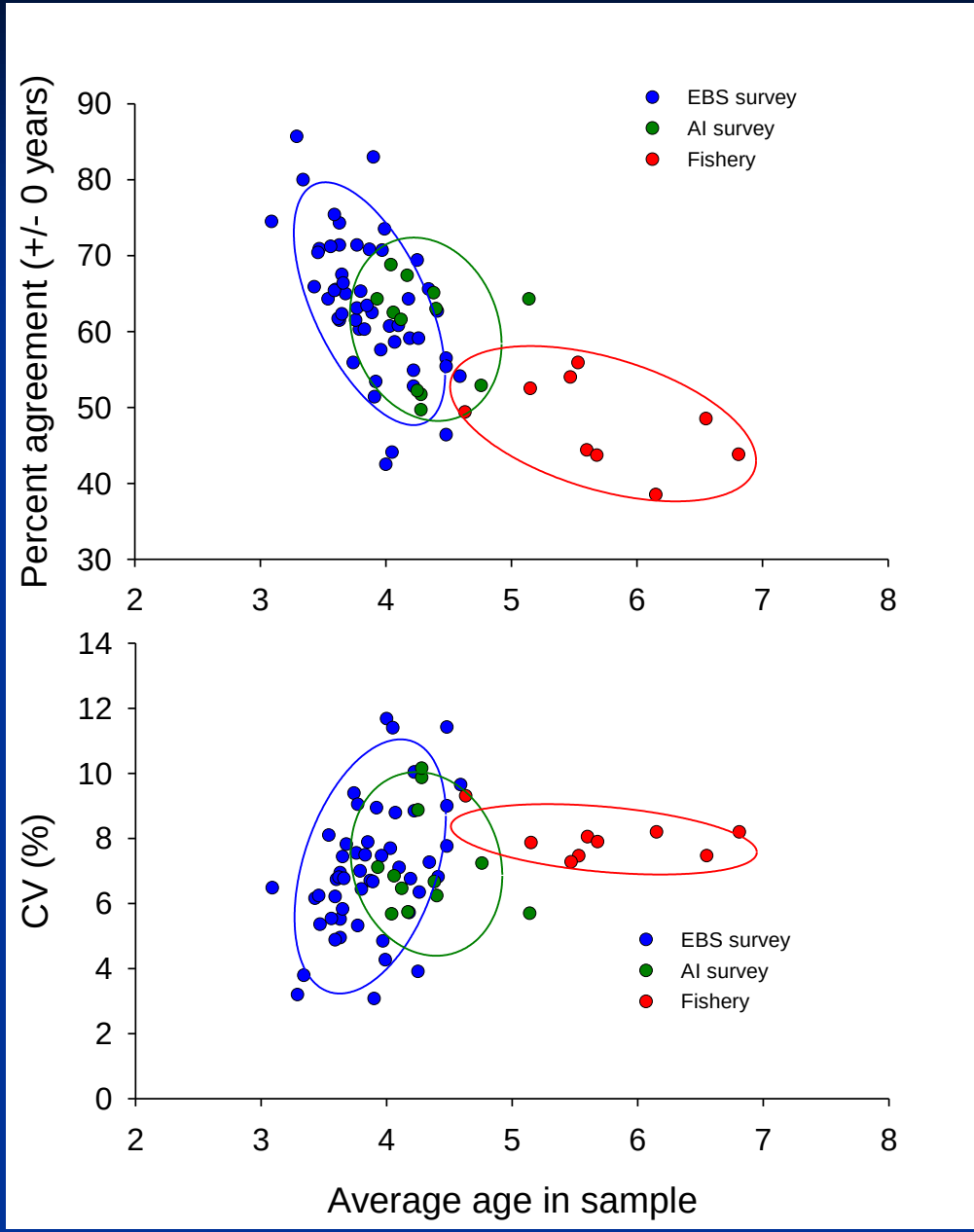
Precision

Released cruises since 2002



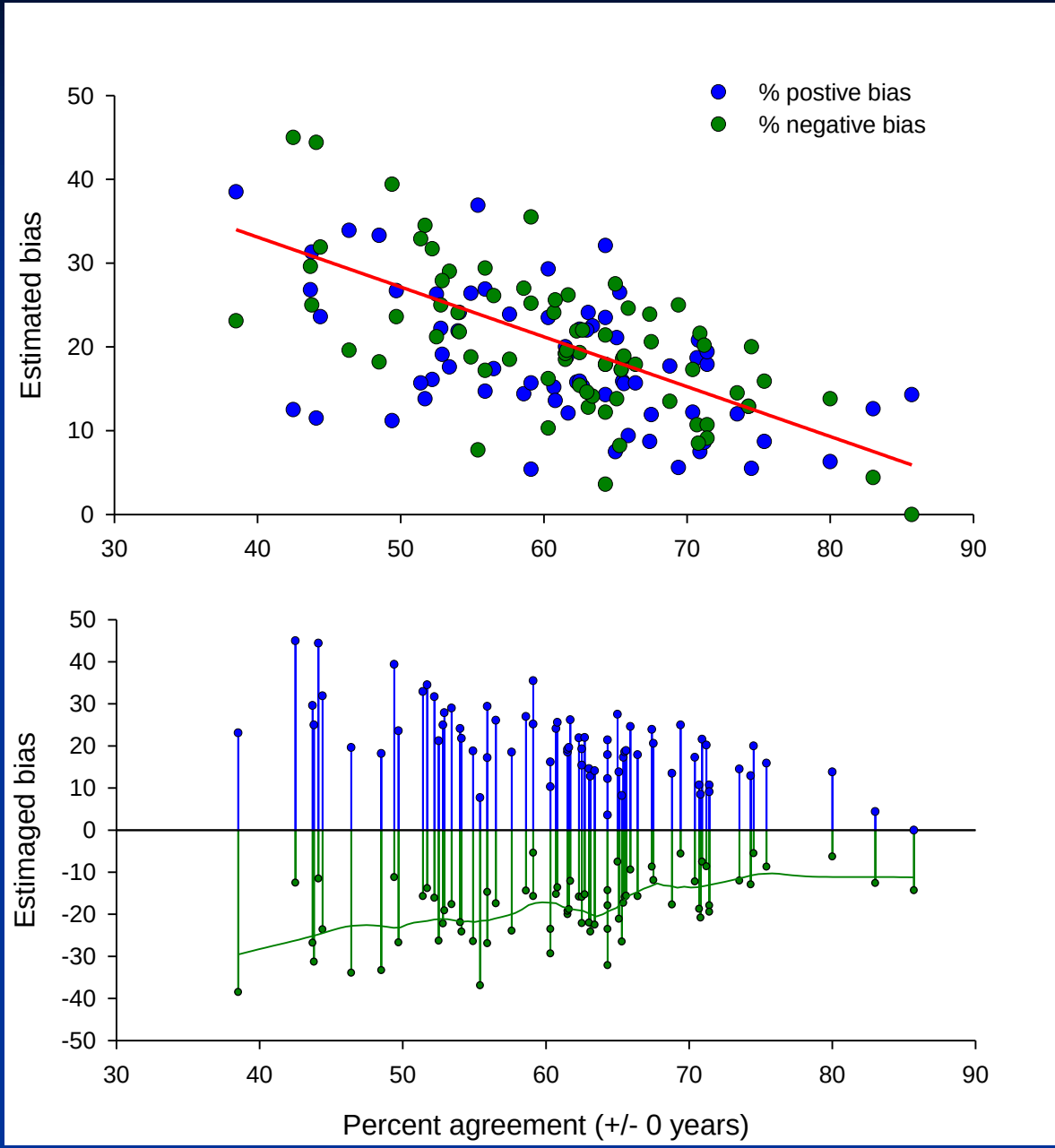
Precision

Released cruises since 2002



Relative bias

Released cruises since 2002



Mean Lengths (cm) Observed in Trawl Surveys (Roberson, 2001)

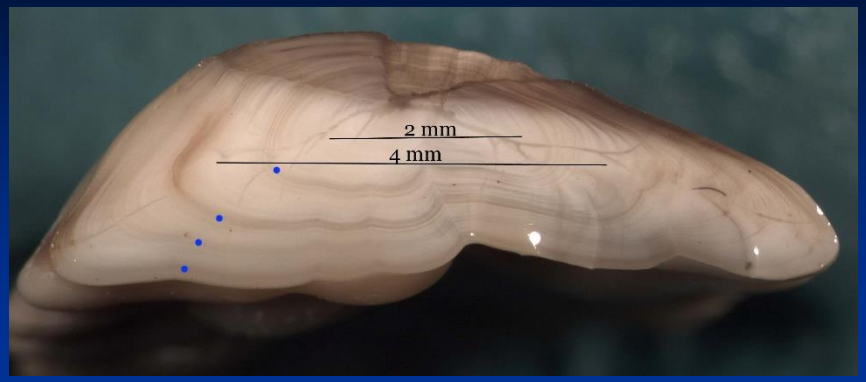
Age	1988	1989	1990	1991	1992	1977 yc Modal length
1	24.2	19.2	16.9	19.6	18.7	22
2	34.9	33.8	27.2	28.4	25.9	35
3	40.9	41.7	35.9	36.2	33.9	43
4	50.1	51.9	46.8	47.4	44.4	52
5	58.6	58.6	57.2	55.6	53.6	61

Roberson, 2001

Fish length-at-age (cm) estimated from back-calculations, the original 1992 ages, and a re-ageing of some of the 1992 otoliths using the new ageing criteria.

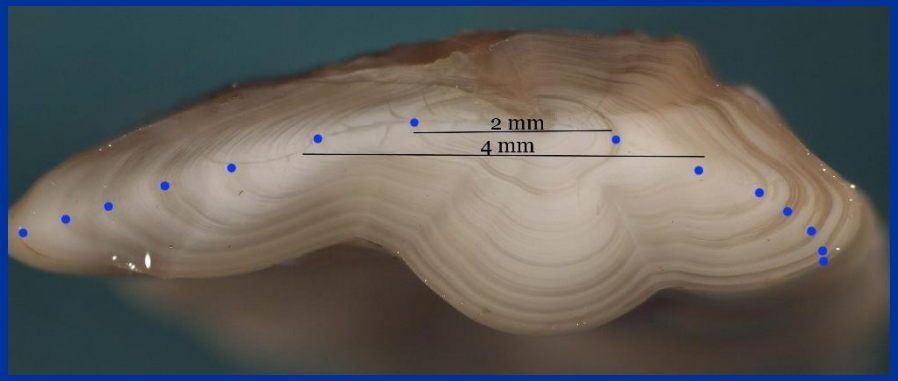
	1989		1992	
Fish age	**Back-calculations not counting checks**	**Back-calculations counting checks**	**Original ages**	**Re-ages using new ageing criteria**
1	20.7	16.6	18.7	20.8
2	32.5	26.6	26.0	31.8
3	41.9	35.2	33.9	40.2
4	51.1	43.2	44.5	43.9

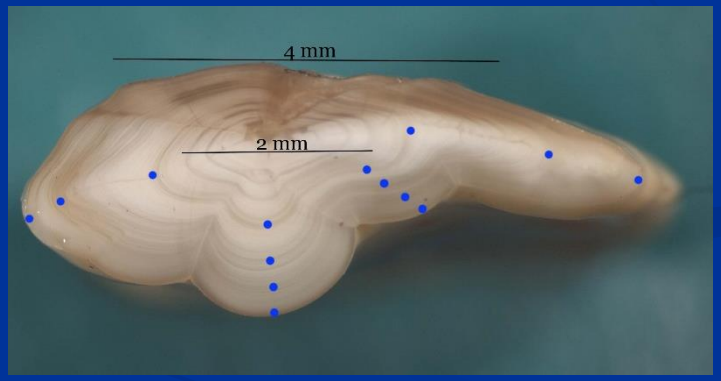
Ageing issues: the good, the bad and the ugly

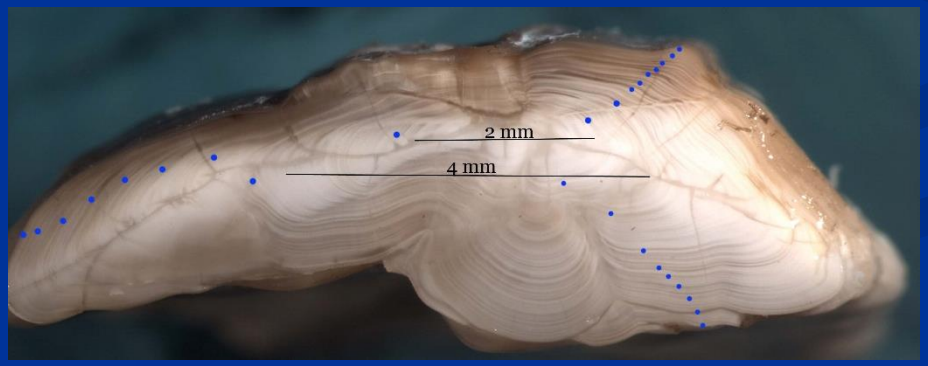


the good

the bad

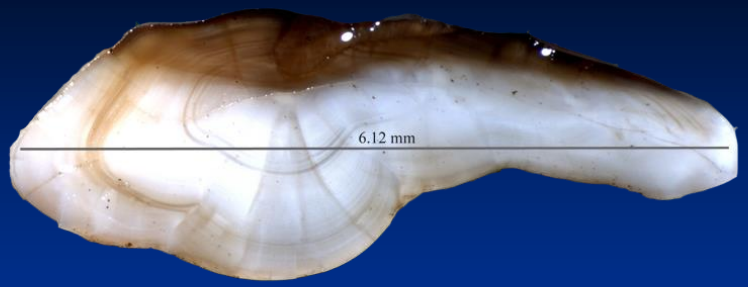




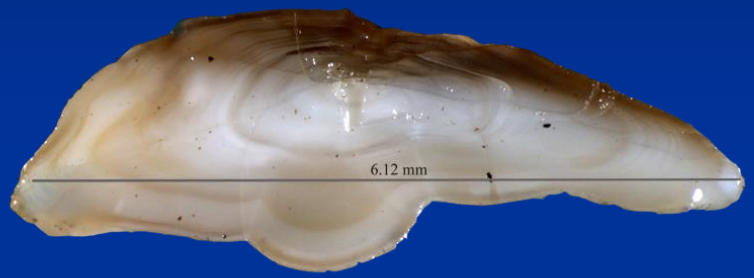


the ugly

Edge type issues



500 mm
Female
June 7, 1993



390 mm
Male
June 18, 1993

420 mm
Male
June 18, 1993

660 mm
Female
July 5, 1982

Possible causes of Pacific cod ageing dilemma

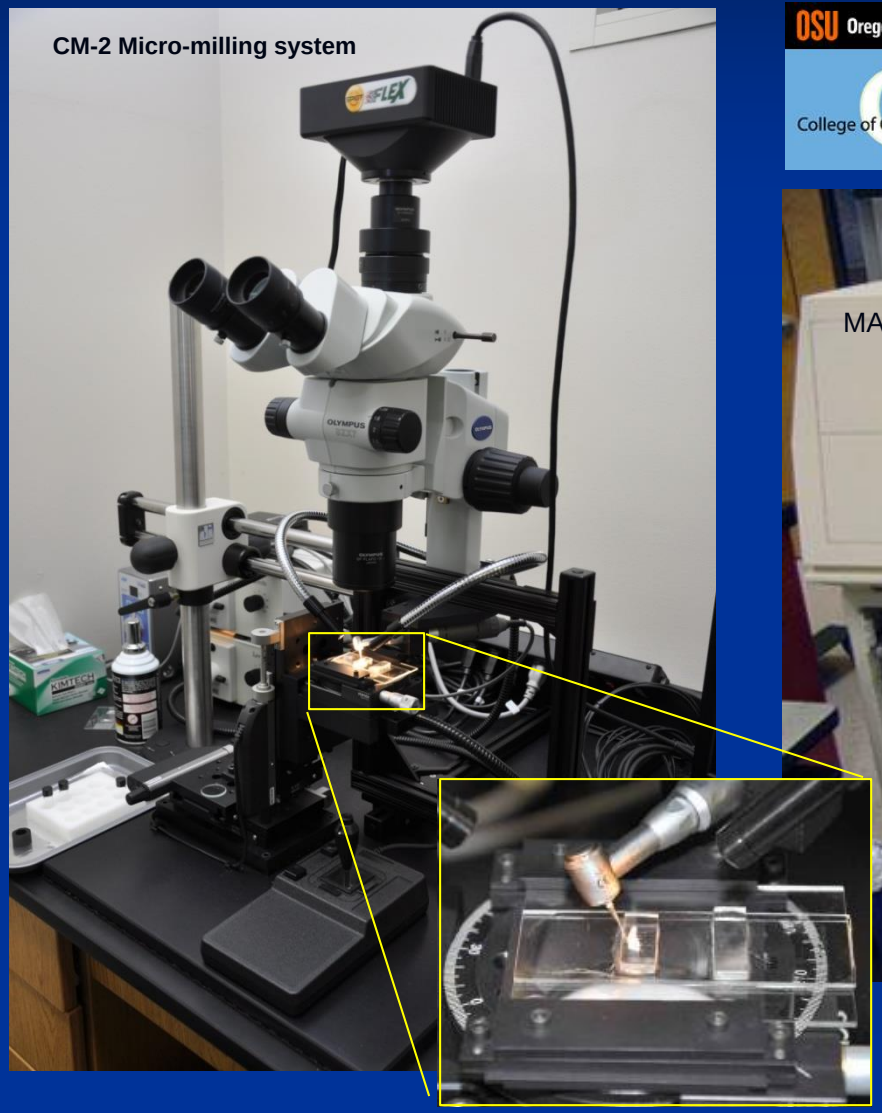
- Environmental conditions affecting growth – sampling artifacts/spatial variability (NPRB Project #1501)
- Ageing sample prep & methodology (changed to toasting – 2001)
- Applying consistent ageing criteria among readers
- Problematic otolith pattern (NPRB Project #1105)
  - False annuli in early years (occasional inside the 1st annulus)
  - Interpreting older growth patterns
  - Edge type decisions

Present/ongoing work

- Better understand edge type chronology (MIA)
- Current and future validation studies
  - Stable isotopes (O-18, C-13)
  - Bomb-produced C-14 study

Age validation: oxygen isotopes ^{18}O

Alaska Fisheries Science Center
NATIONAL MARINE FISHERIES SERVICE – NOAA FISHERIES

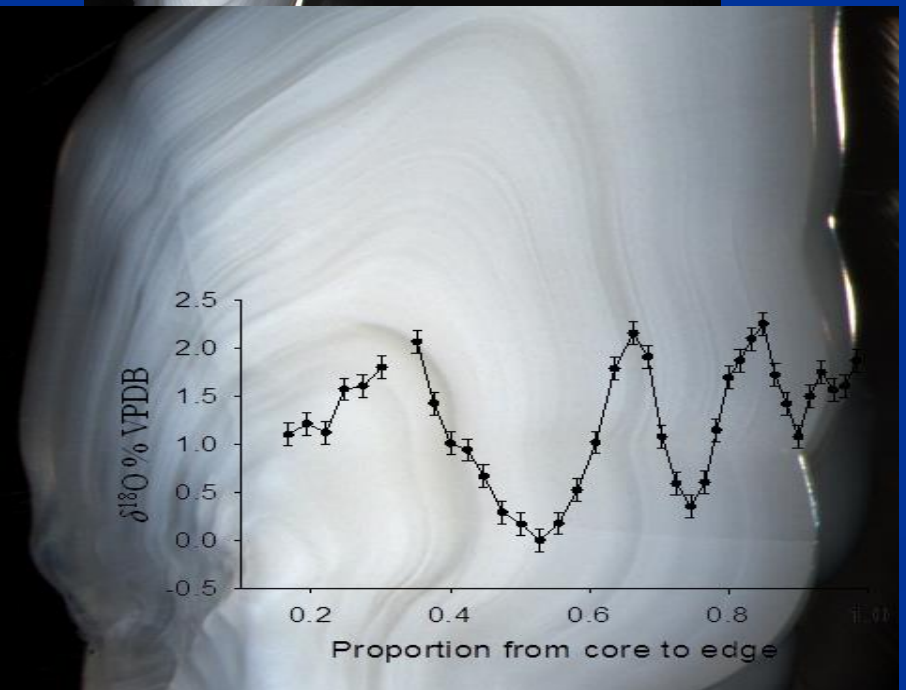


OSU Oregon State University
College of Oceanic and Atmospheric Sciences COAS Stable Isotope Lab

Pacific cod age validation study using $\delta^{18}O$

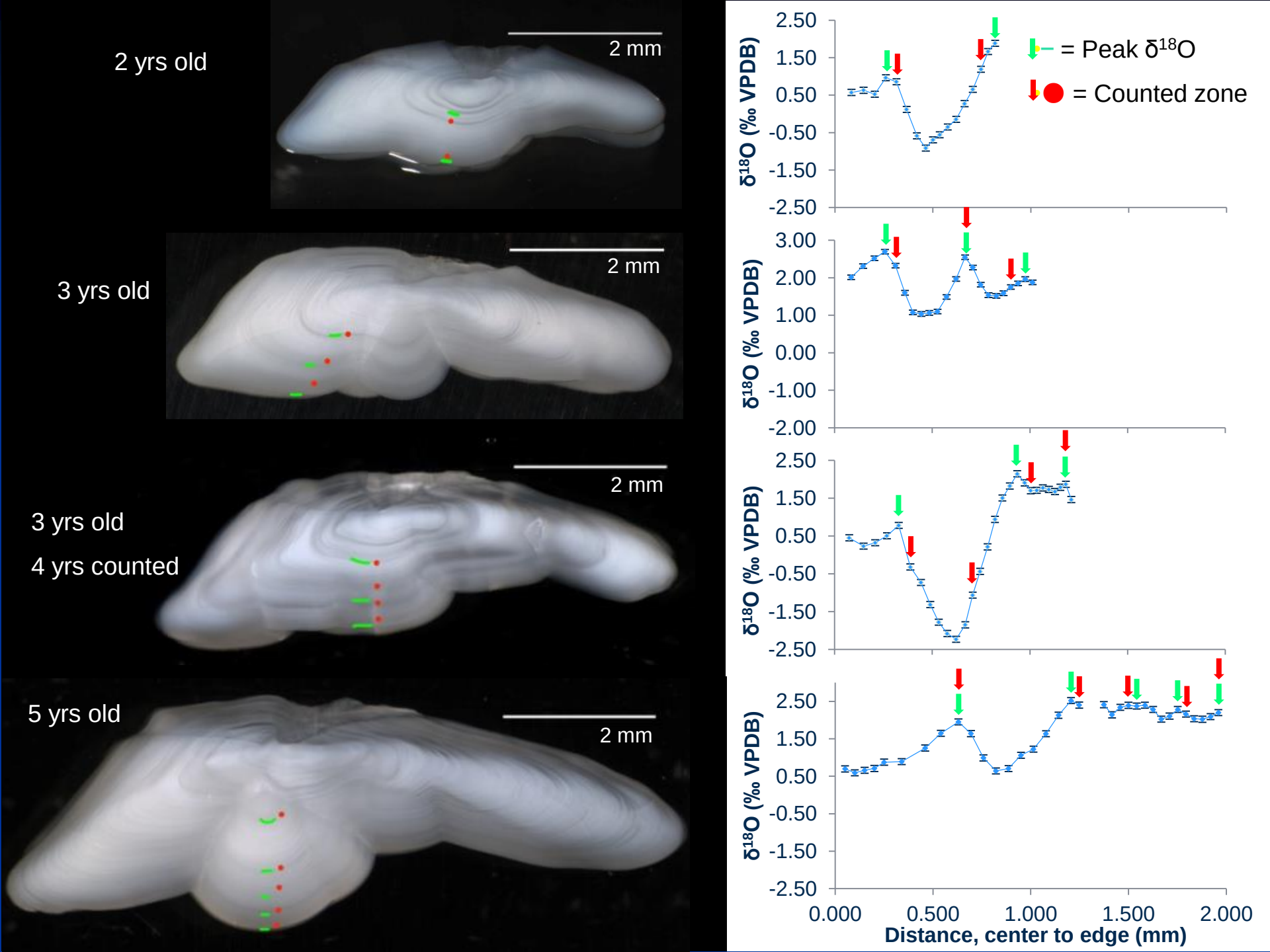
Computer aided milliing paths

Sequence of milled samples

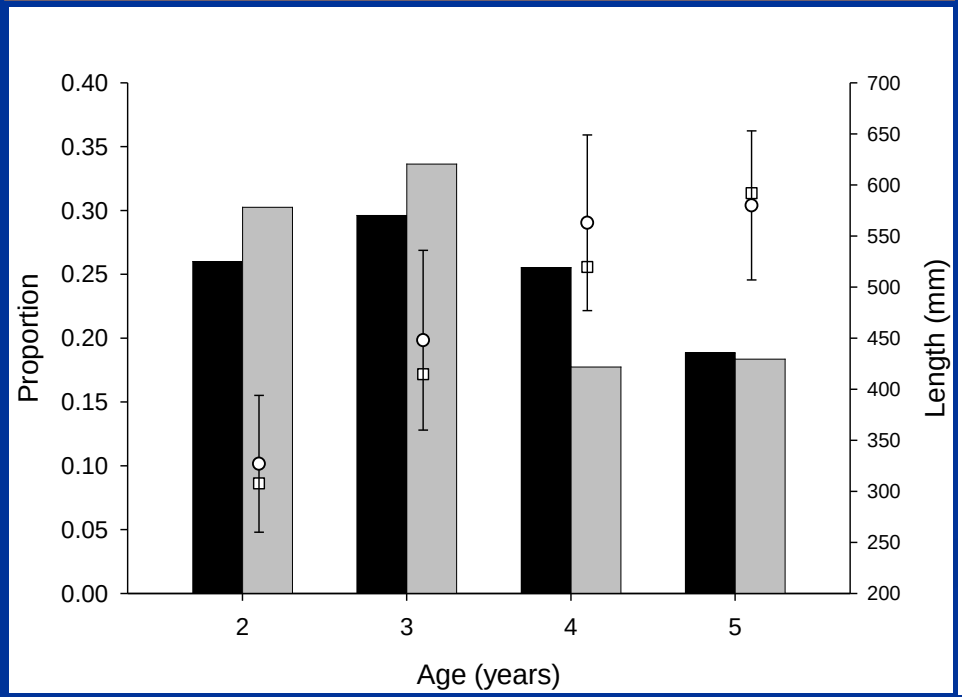


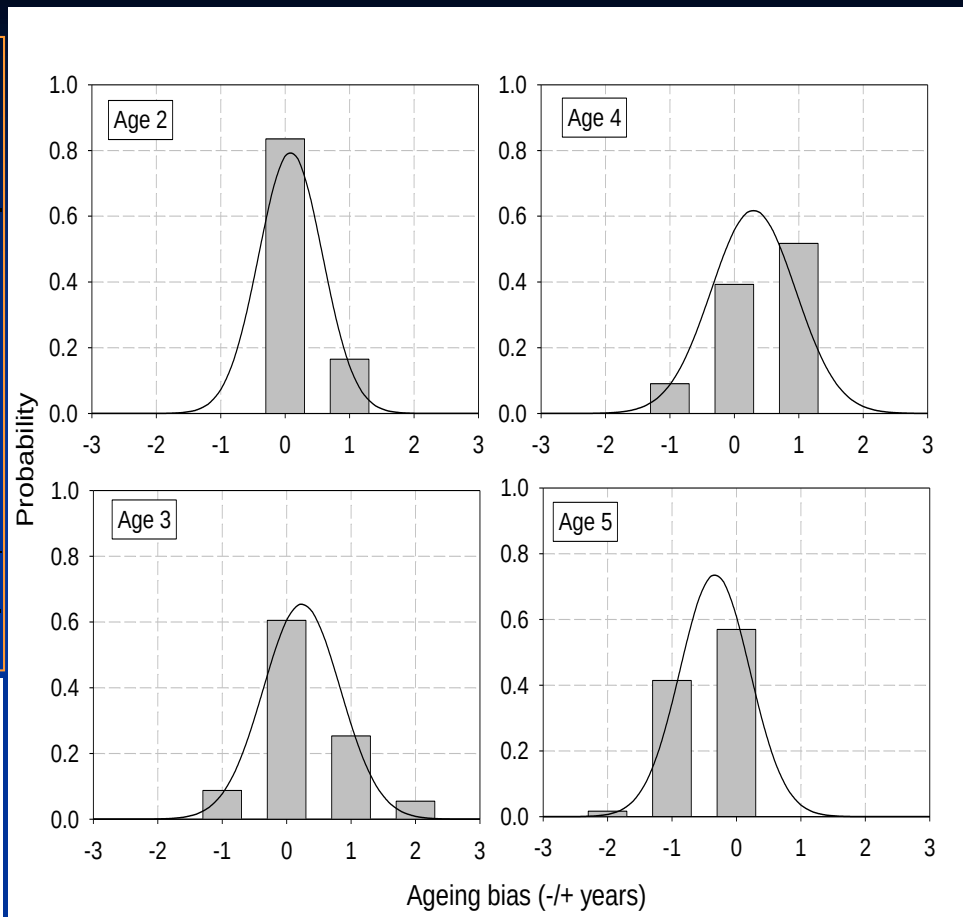
n = 39

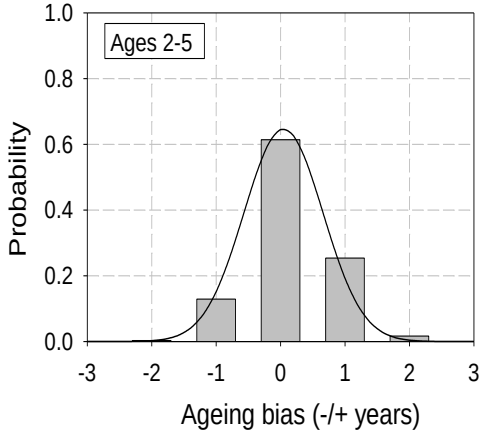
20-30 ug


2 yrs old
2 mm
3 yrs old
2 mm
3 yrs old
4 yrs counted
2 mm
5 yrs old
2 mm
= Peak δ18O
= Counted zone
δ18O (‰ VPDB)
2.50
1.50
0.50
-0.50
-1.50
-2.50
3.00
2.00
1.00
0.00
-1.00
-2.00
0.000
0.500
1.000
1.500
2.000
Distance, center to edge (mm)

Estimated Age (year)	True age (number of $\delta^{18}O$ maxima) 1	2	3	4	5	6	total
1	-	3	-	-	-	-	**3**
2	-	**31**	4	-	-	-	**35**
3	-	10	**29**	1	1	-	**41**
4	-	-	13	**13**	13	-	**39**
5	-	-	2	14	**15**	-	**31**
6	-	-			3	-	**3**
total		**44**	**48**	**28**	**32**	-	**152**





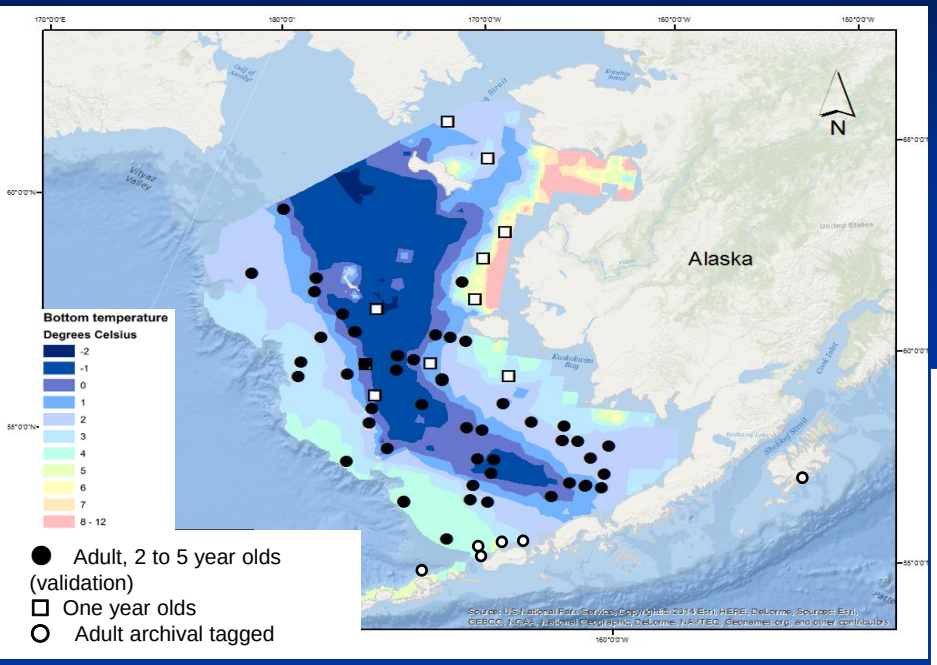


Important caveats:

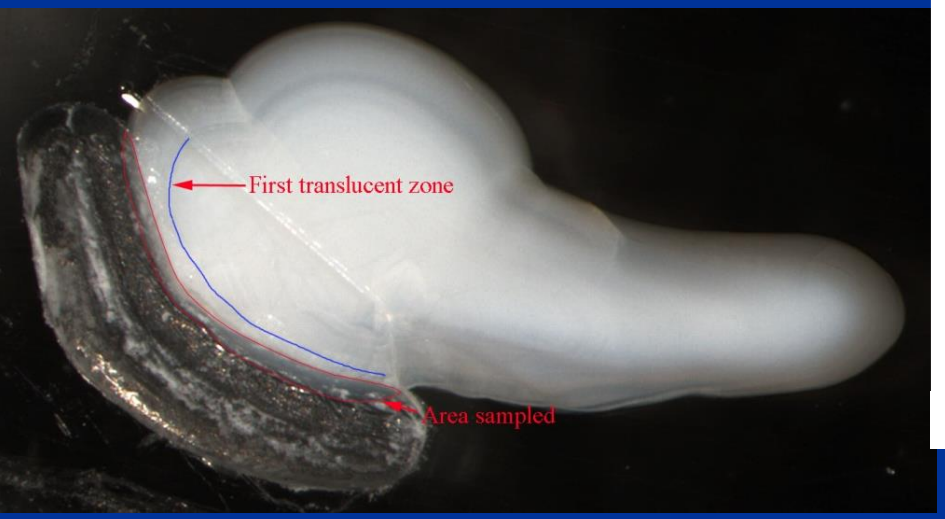
- Is temperature really the primary determinant governing $\delta^{18}O$ variation in Pacific cod otoliths?

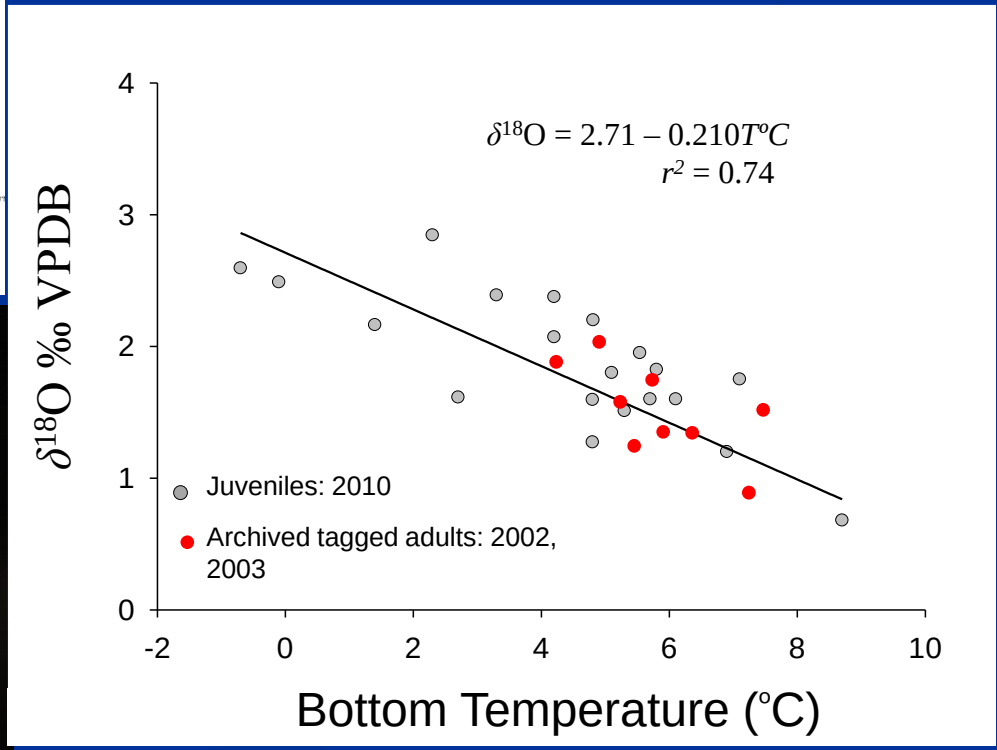
- Is our sampling resolution (micro-milling) sufficient to capture temperature seasonality represented in otolith $\delta^{18}O$ signatures?

Tested empirical temperature - $\delta^{18}O$ fractionation

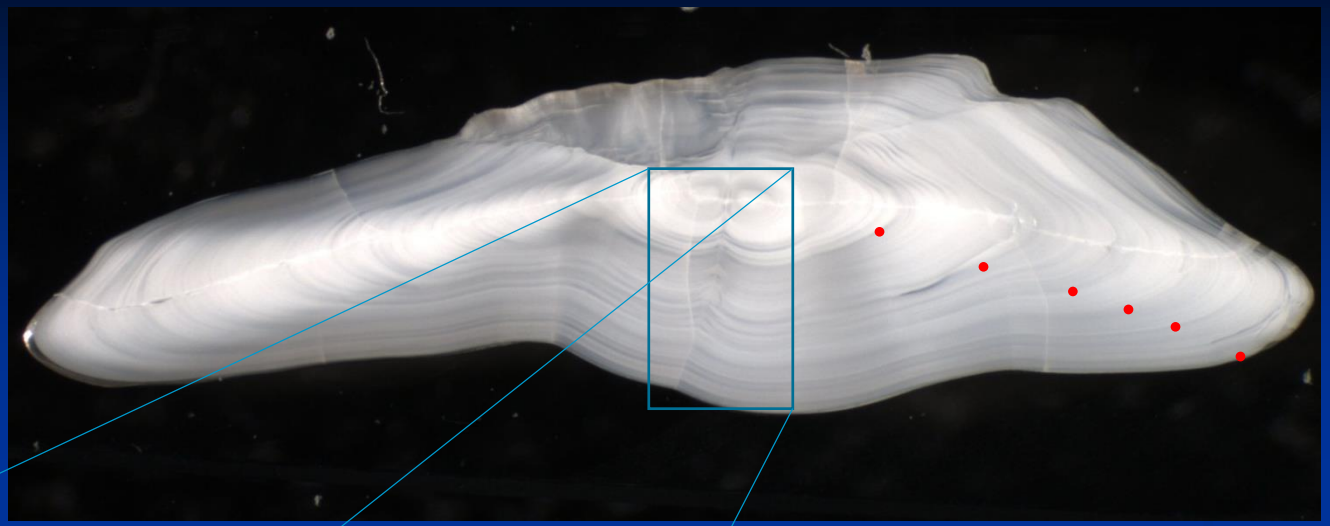


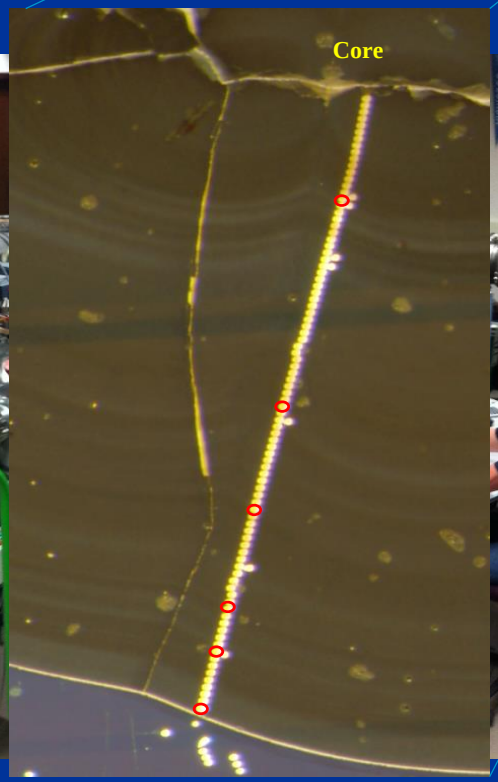
Results: *Temperature is a primary determinant is $\delta^{18}O$ in Pcod otoliths, presumably influenced by seasonal temp cycles*

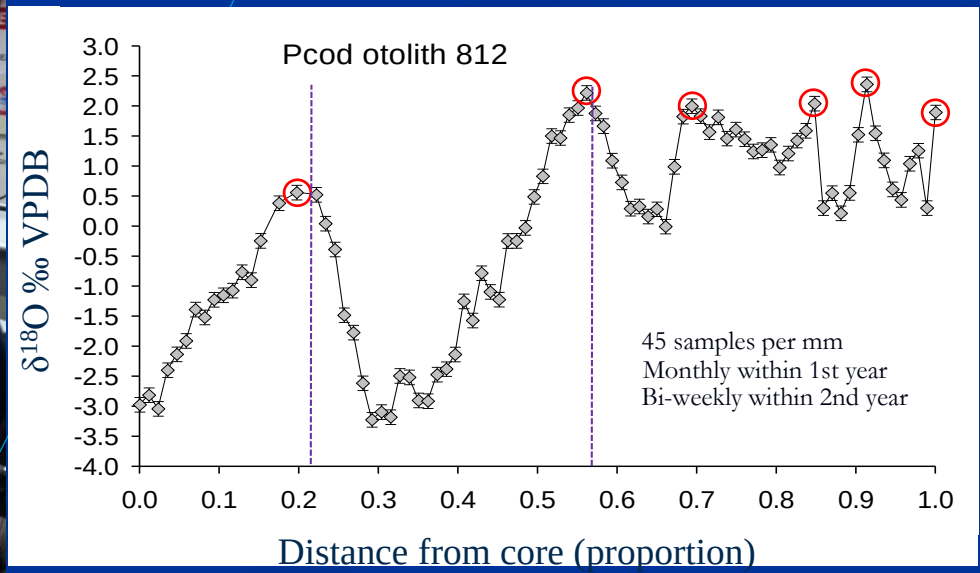




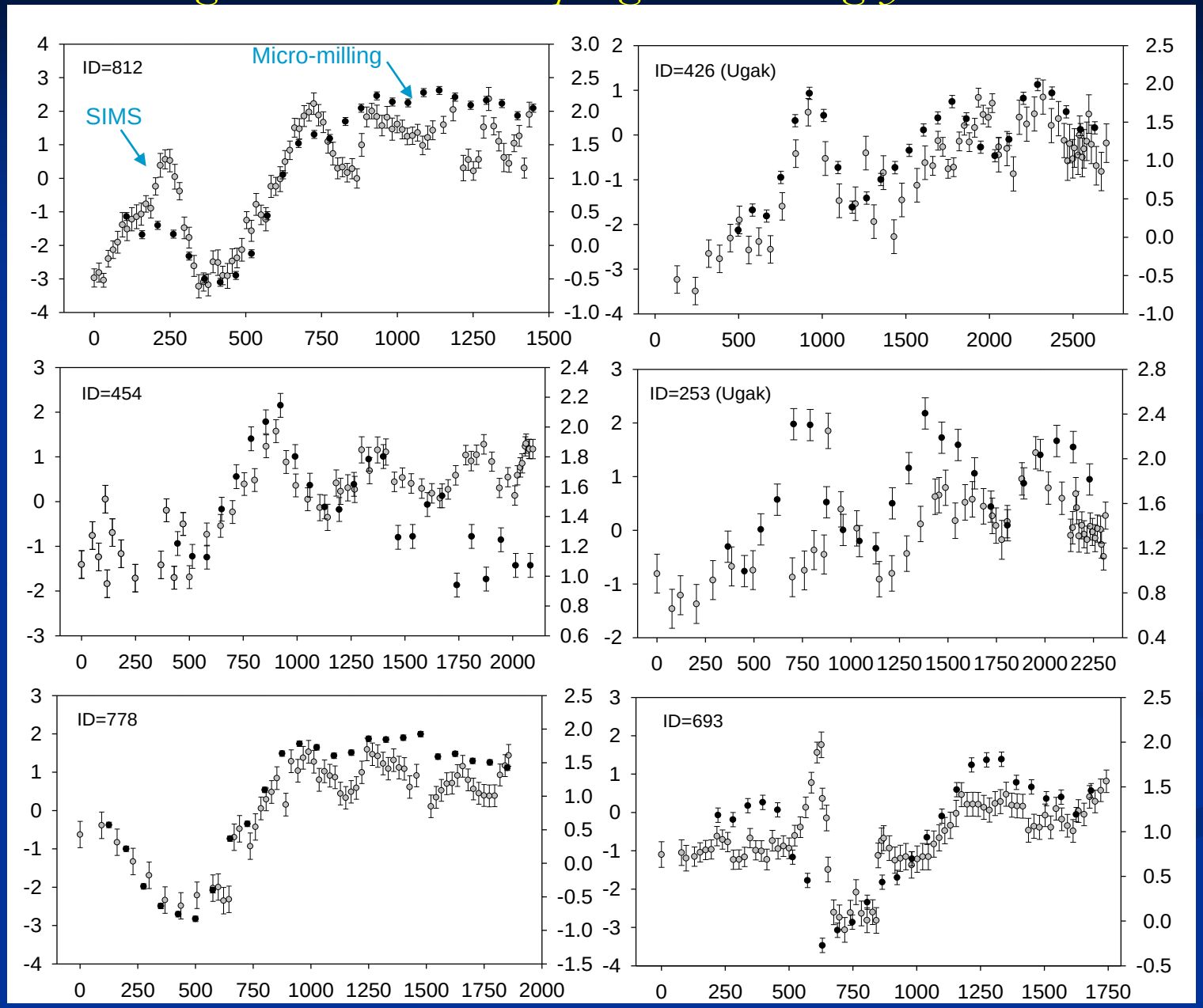
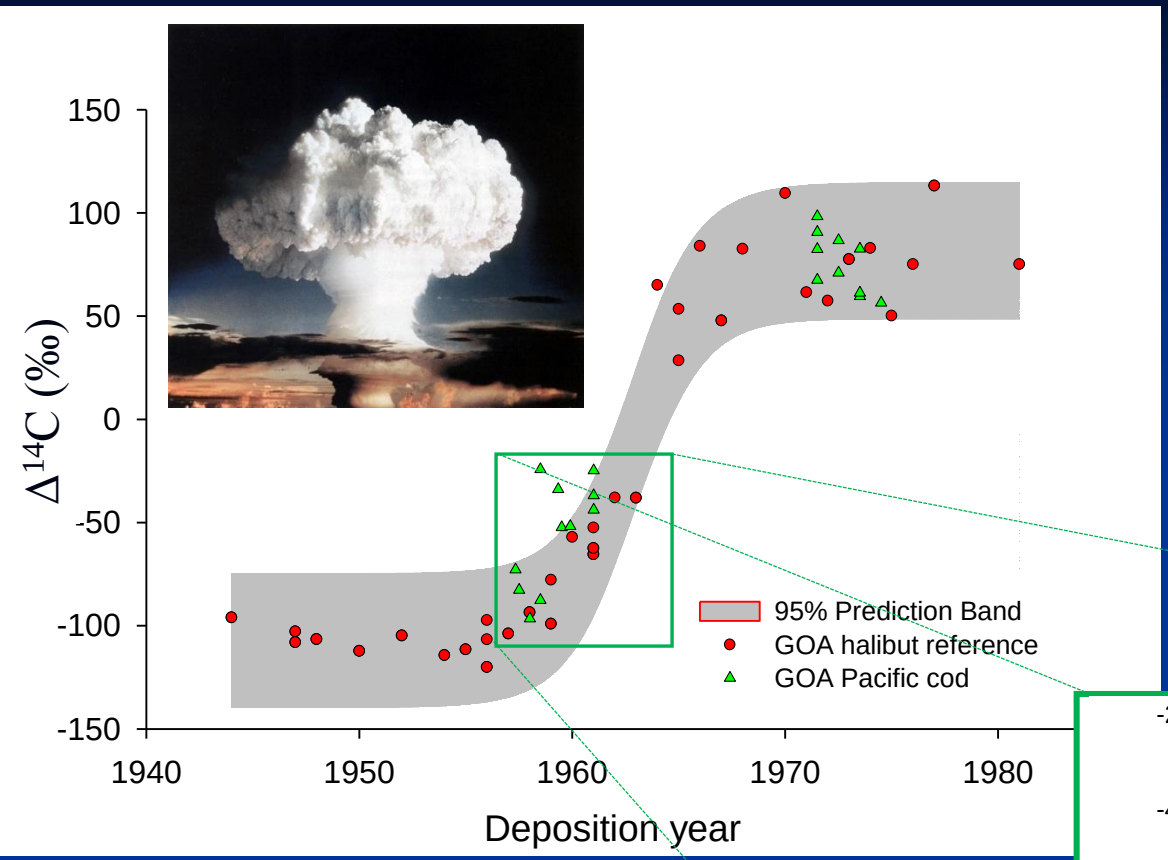
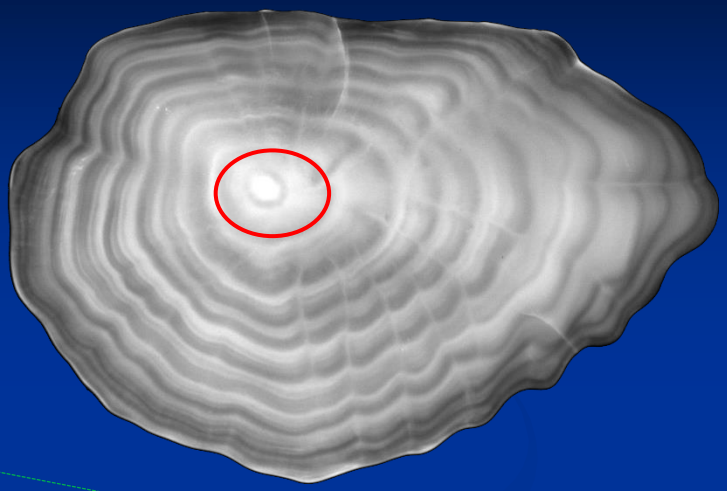
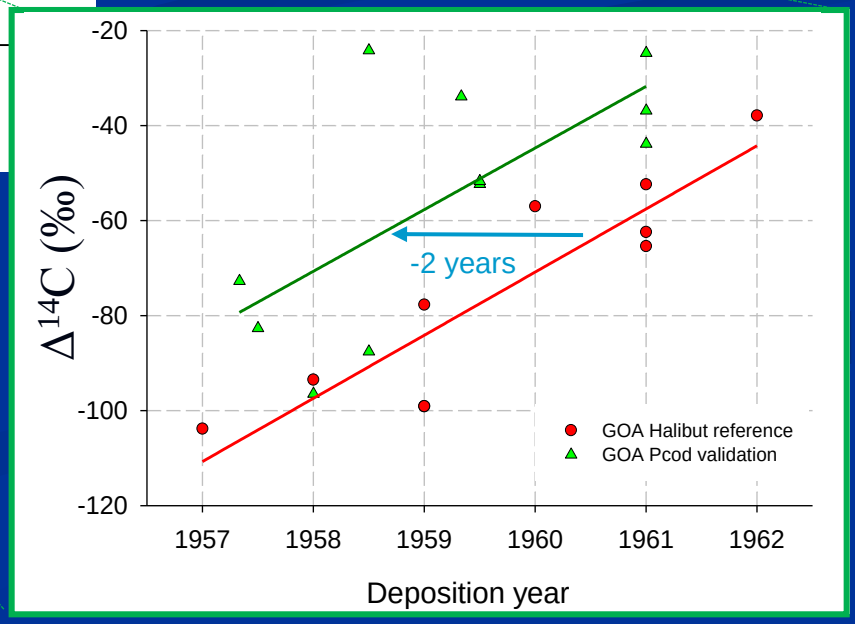
Compared $\delta^{18}O$ signatures of micro-milled vs. ion prob-SIMS







Results: *SIMS resulted in higher sampling resolution, but $\delta^{18}O$ signatures between sampling methods largely consistent*



Bomb-produced radiocarbon $\Delta^{14}C$ study