

Bigeye annual & daily increment deposition rates: strontium-marking experiments

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IATTC Workshop on age and growth of BET and YFT in the Pacific Ocean

23 January 2019

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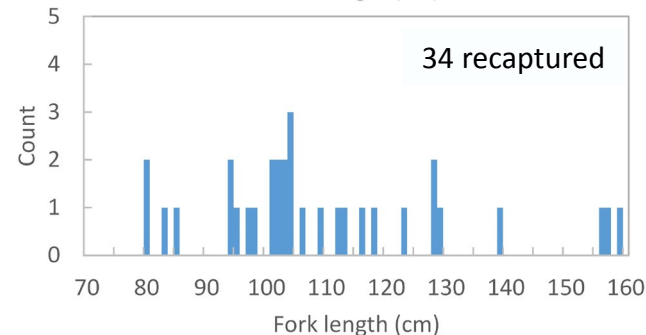
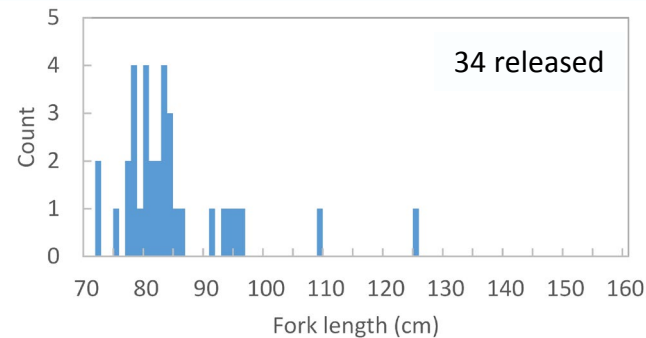
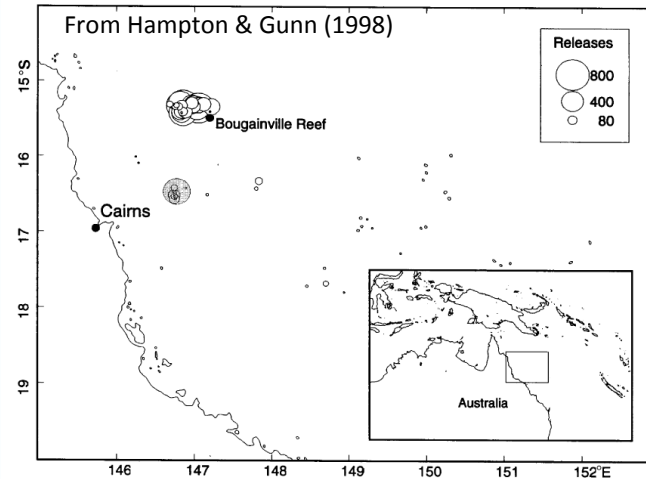


History of WCPO BET ageing (CSIRO/SPC)

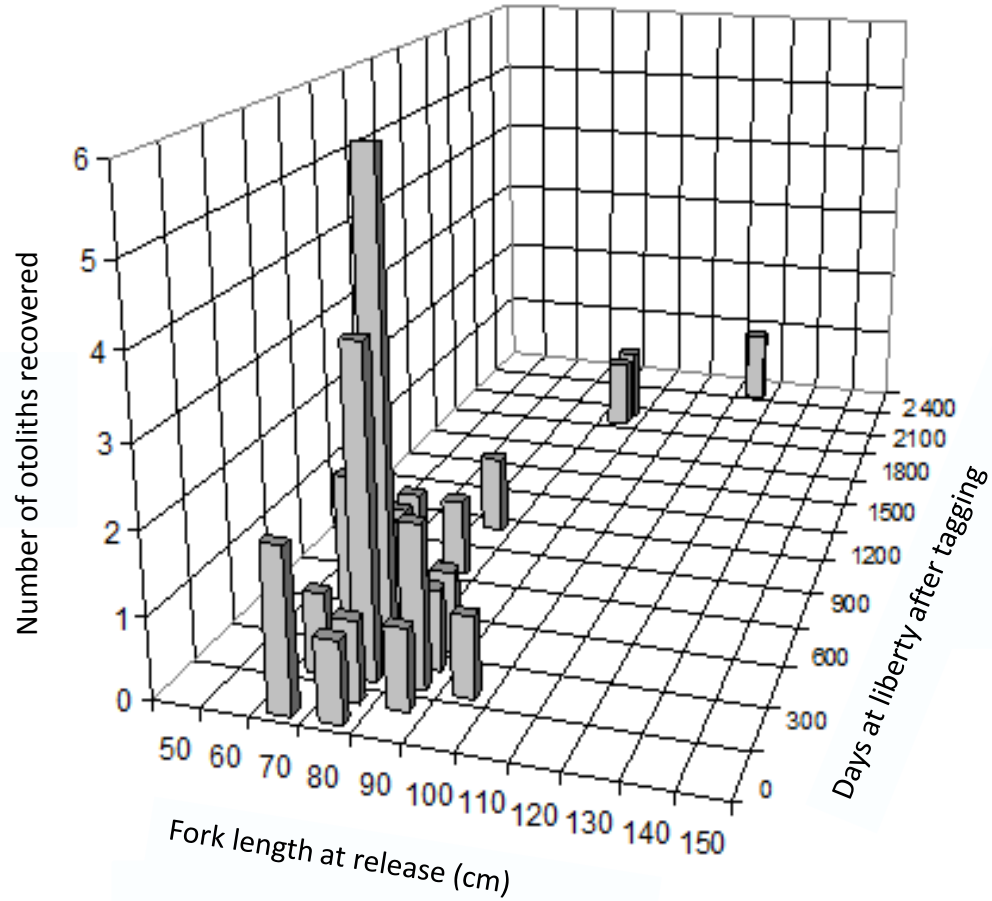
Year	Project	Publication
1990s	SPC daily ageing and tagging data (SPC) VB composite model	Lehodey & Leroy (1999)
1990s - early 2000s	Sr-marking experiment: daily & annual age validation) (CSIRO/SPC)	Clear et al. (2000); Farley et al. (2003)
2000s	Australian AFZ age & growth study (CSIRO/SPC)	Farley et al. (2006)
2009-2011	WCPFC pilot project (SPC/CSIRO/FAS) Preliminary growth curve	Nicol et al. (2011)
2012-2017	Full project (CSIRO/FAS/SPC) Incl. daily-annual age comparison study	Farley et al. (2017) Williams et al. (2013)
2018	Updated growth (CSIRO/FAS/SPC/NRIFSF)	Farley et al. (2018)

Tagging program – Coral Sea

- 3 x SPC/CSIRO tagging programs
- 1990s to early-2000s
- BET (& YFT) injected with SrCl_2 solution (250 mg g^{-1}) & released
- 34 BET recaptured
 - 72-125 cm at release
 - 85-157 cm at recapture
 - At liberty 207 days to 6.6 years



Recaptured BET



Otoliths analysed for annual age validation

* for daily age validation

Fish number	Release			Recapture			Days at liberty	Years at liberty	Growth (cm)	Growth /yr
	Date	FL (cm)	Position	Date	FL (cm)	Position				
* 591	9/10/1995	80	17.15°S 147.97°E	2/11/1998	139	17.10°S 146.80°E	1120	3.1	59	19.2
* 37	13/11/1992	72	16.58°S 146.73°E	31/07/1993	85	16.5°S 146.38°E	260	0.7	13	18.3
57	6/10/1995	75	17.15°S 147.97°E	14/08/1997	128	18.25°S 151.91°E	678	1.9	53	28.5
* 59	12/11/1992	96	16.48°S 147.77°E	15/07/1998	159	16.96°S 146.89°E	2071	5.7	63	11.1
* 62	9/10/1995	109	17.15°S 147.97°E	3/05/1996	123	17.28°S 147.16°E	207	0.6	14	24.7
63	6/10/1995	83	17.15°S 147.97°E	10/06/1996	94	17.61°S 147.94°E	248	0.7	11	16.2
64	6/10/1995	79	17.15°S 147.97°E	-	-	-	-	-	-	-
* 65	9/10/1995	78	17.15°S 147.97°E	26/01/1998	128	16.66°S 146.93°E	840	2.3	50	21.7
* 66	9/10/1995	84	17.15°S 147.97°E	18/12/1997	129	16.96°S 147.16°E	801	2.2	45	20.5
* 67	9/10/1995	78	17.15°S 147.97°E	4/11/1997		16.16°S 146.41°E	757	2.1		
2820	9/10/1995	125	17.15°S 147.97°E	25/5/2002	157	17.78°S 147.70°E	2420	6.6	32	4.8

SrCl₂ mark examined under SEM

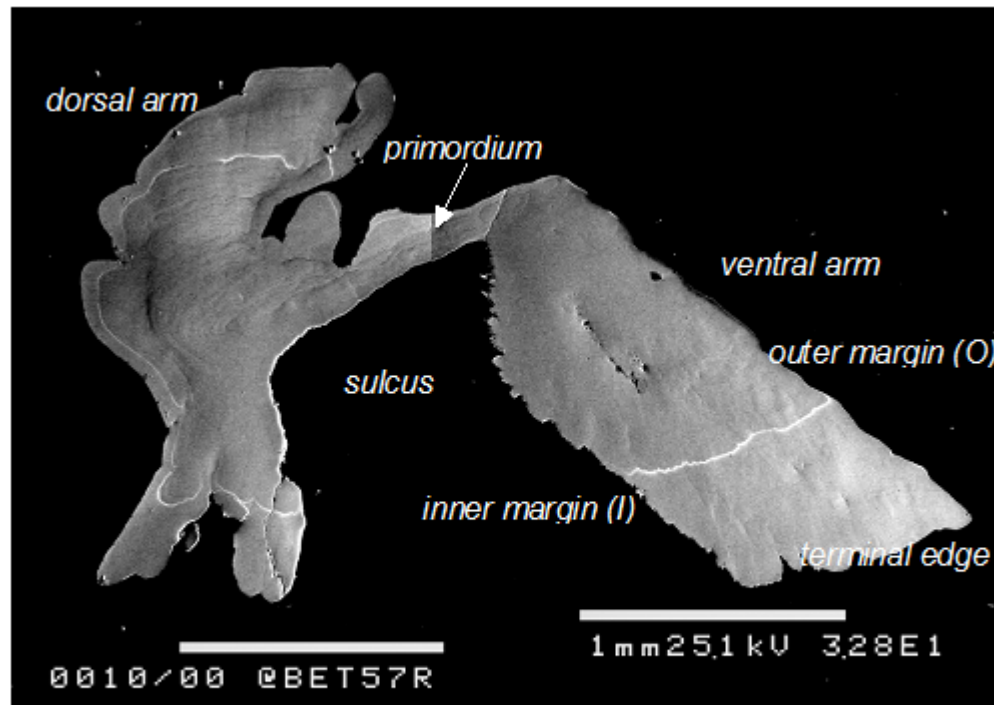
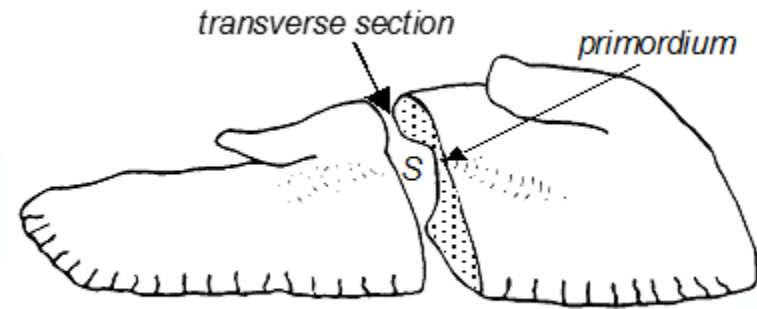
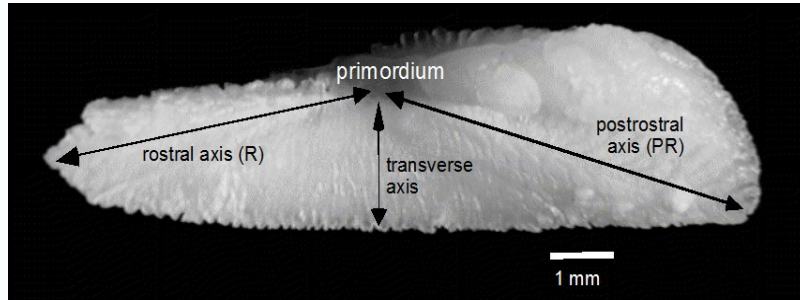
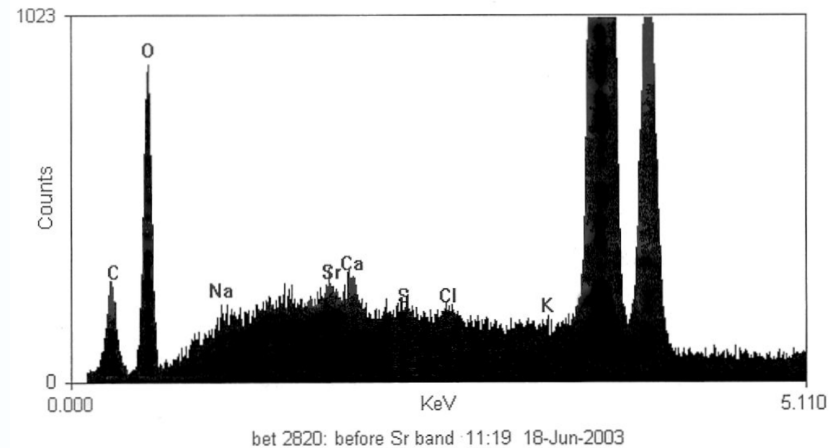


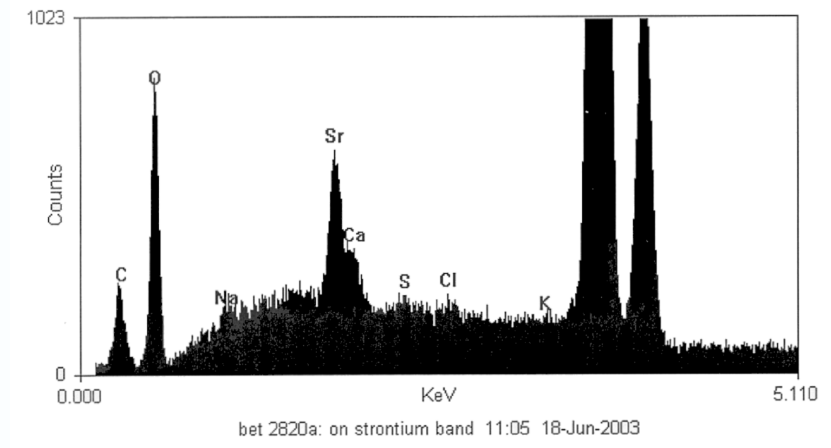
Figure 7.2.3. SEM micrograph of a longitudinal section (bigeye #57). Sr-marks were obvious as bright bands across the growth axes.

Energy-dispersive x-ray spectroscopy (EDS)

Background strontium



Strontium levels at mark



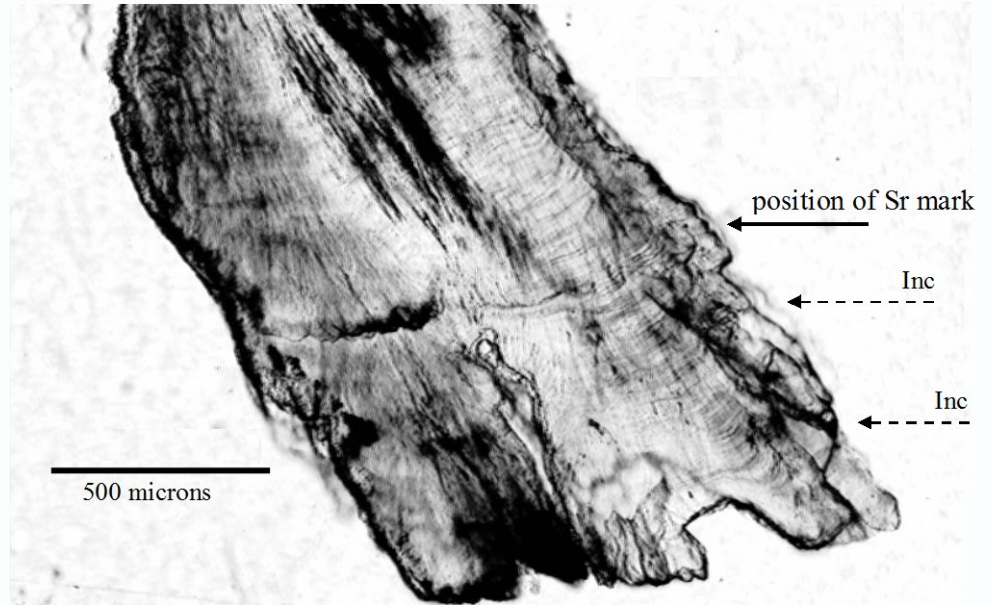
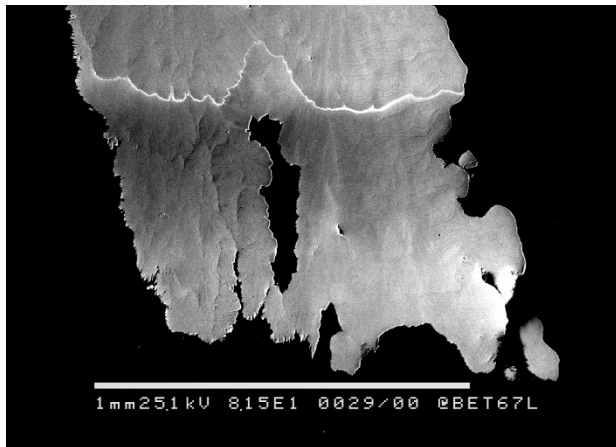
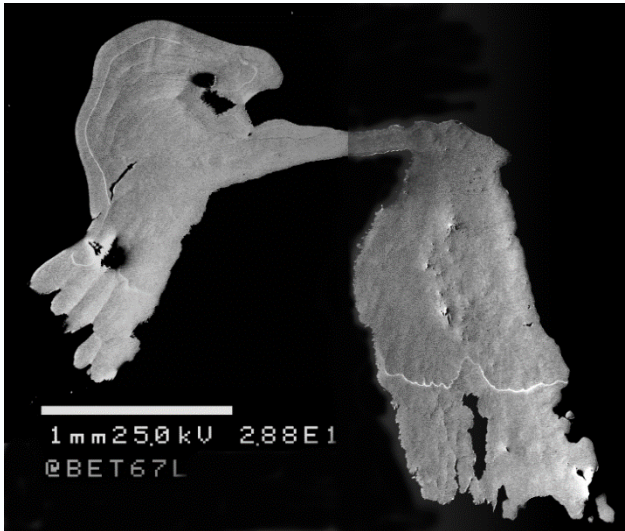
Annual age validation (11 otoliths)

Fish number	37	57	59	62	63	64	65	66	67	591	2820	
FL at tagging (cm)	72	75	96	109	83	79	78	84	78	80	125	
FL at recapture (cm)	85	128	159	123	94	-	128	129	-	139	157	
Time at liberty after tagging (days)	260 (8.5 mths)	678 (1 yr 10 mths)	2071 (5 yrs 8 mths)	207 (7 mths)	248 (8 mths)	recap. details not known	840 (2 yrs 3 mths)	801 (2 yrs 2 mths)	757 (2 yrs 1 mth)	1120 (3 yrs 1 mth)	2420 (6 yrs 7 mths)	
Number of increments after Sr mark	expected	0 or 1	1 or 2	0 or 1	0 or 1		2	2	2	3	6 or 7	
	observed	1	1	5	1	1	1	2	2	3	6	
Age estimate (this study) *	2	3	8	3	2	2	3	3	3	4	9	
Age at tagging **	1.2	1.3	2.1	2.7	1.6	1.5	1.4	1.6	1.4	1.5	3.18	
Age at recapture **	1.7	3.8	8.6	3.5	2.0	-	3.8	3.9	-	4.8	7.87	
Month of recapture	July	Aug	July	May	June		Jan	Dec	Nov	Feb	May	
distance from Sr mark to margin (cm)	Sr (O) -O	0.36	0.74	1.06	0.25	0.27	0.30	0.72	0.77	0.81	0.67	0.49
	Sr (I) -I	0.26	0.56	0.80	0.15	0.16	0.25	0.54	0.63	0.77	0.50	0.43

* Estimated by counting annual increments on sectioned sagittal otoliths.

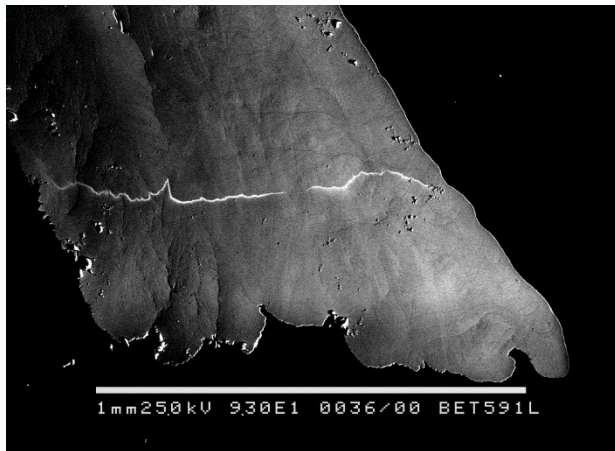
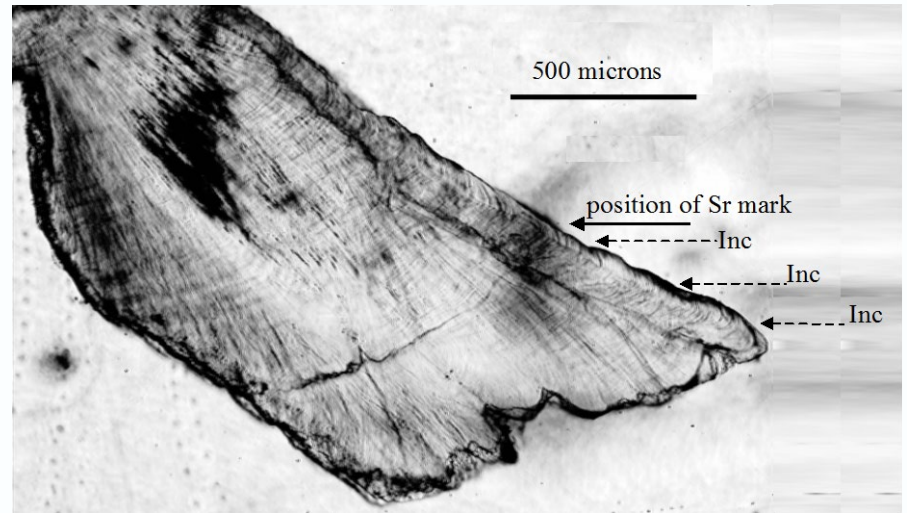
** Estimated using results from a study of otolith microincrements and tagging data (Hampton et al. 1998).

Examples: #67



BET 67 - at liberty 2 years, 1 month
Expect 2 increments
Counted 2
Total zones 3
78 cm at release
NA cm at recapture

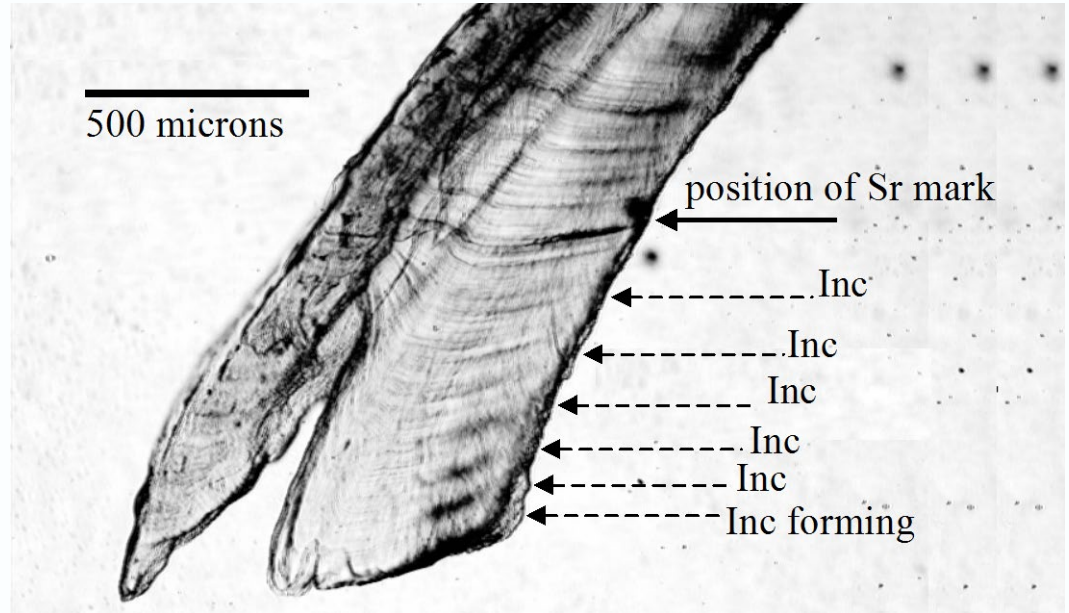
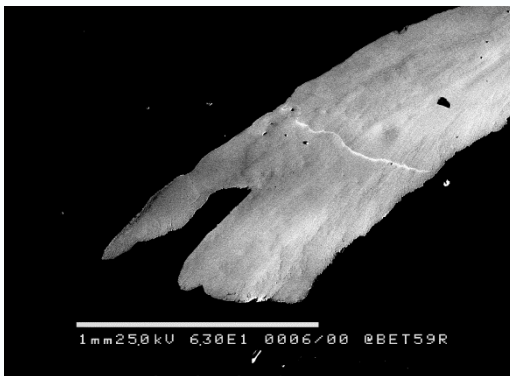
Examples: #591



BET 591 - at liberty 3 years, 1 month
Expect 3 increments
Counted 3
Total zones 4
80 cm at release
139 cm at recapture

Q: variable otolith growth?

Examples: #59



BET 59 - at liberty 5 years, 8 months

Expected 5 or 6 increments

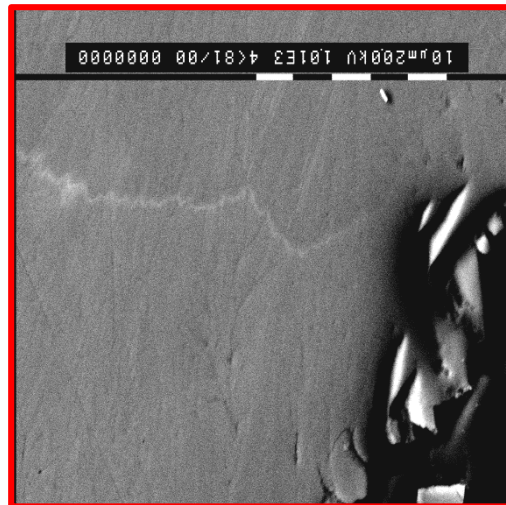
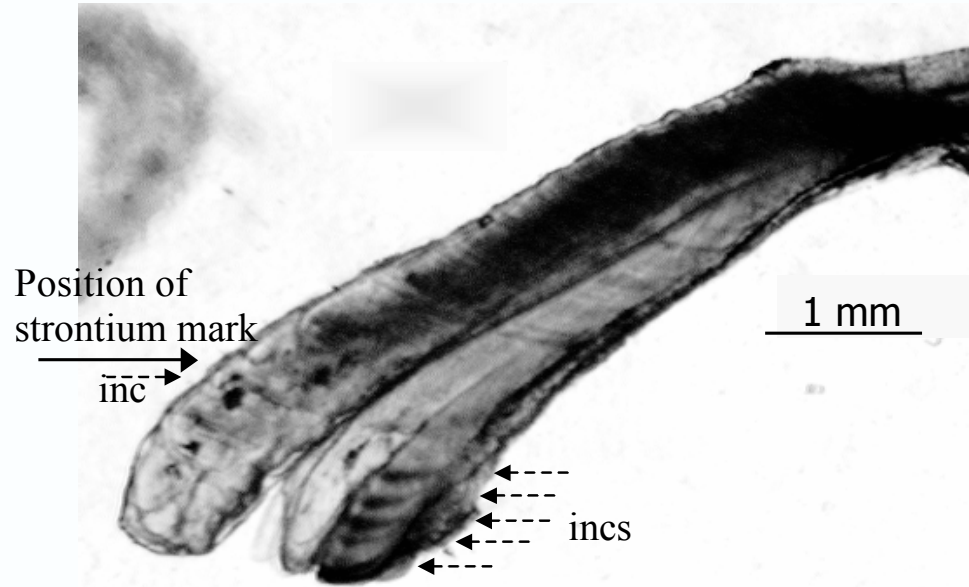
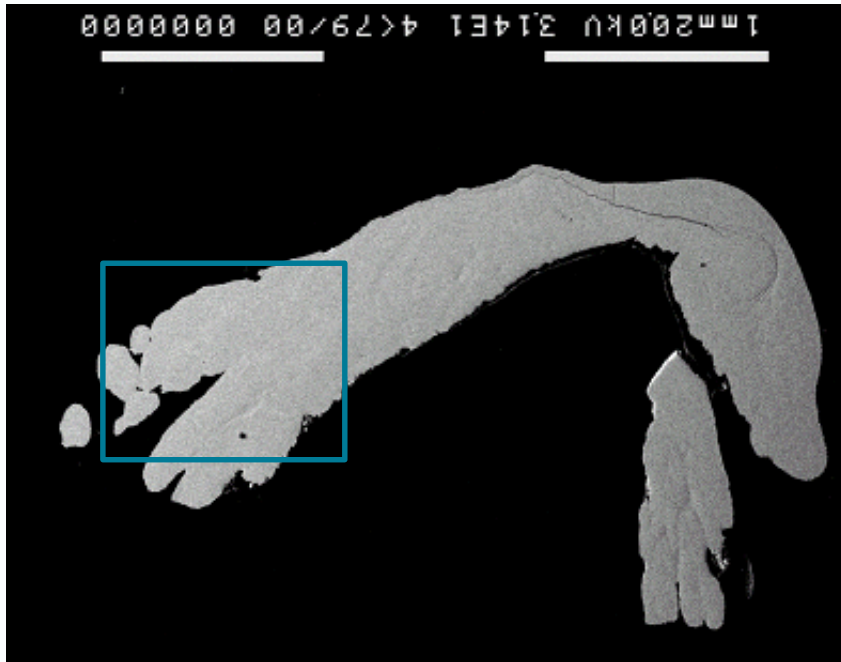
Counted 5

Total count 8

96 cm at release

159 cm at recapture

Examples: #2820



BET 2820 - at liberty 6 yr 7 month
Expect 6 or 7 increments
Counted 6
Total count 9
125 cm at release
157 cm at recapture

Conclusion

- Annual periodicity of increments for age 2 to 9 years was validated.

Daily age to locate 1-2 annual zones

- SPC daily ageing (n=113)
- Transverse sections
- Measure to:
 - Y1 = 365th daily increment
 - Y2 = 730th daily increment
- Compare with location of annual zones

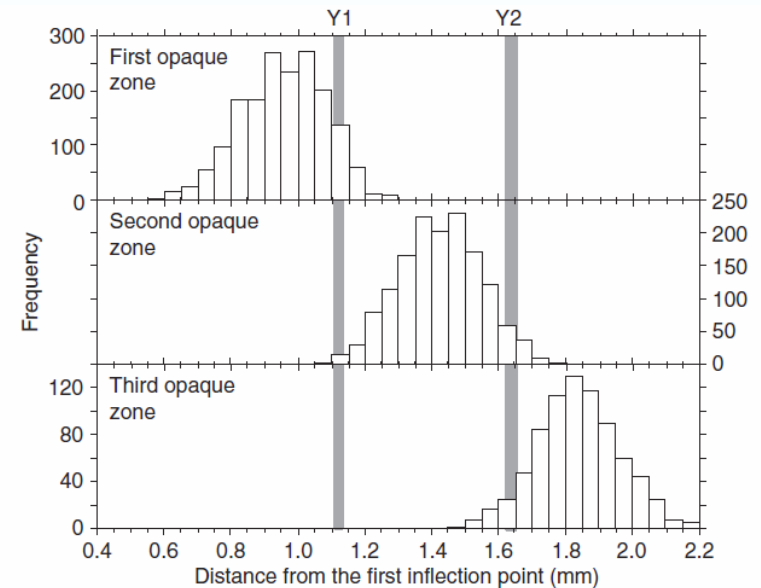
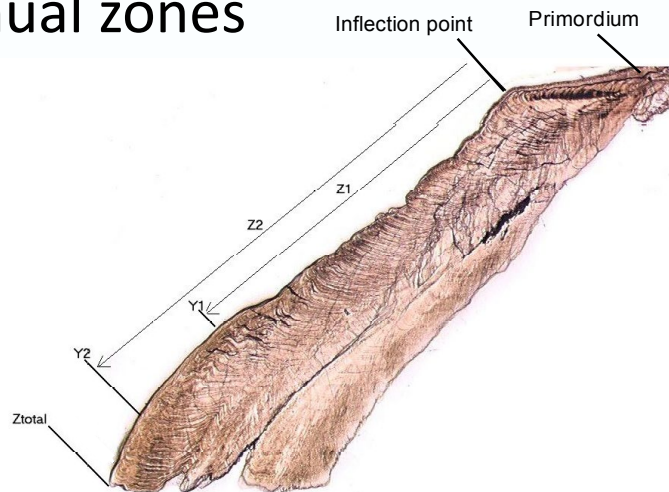
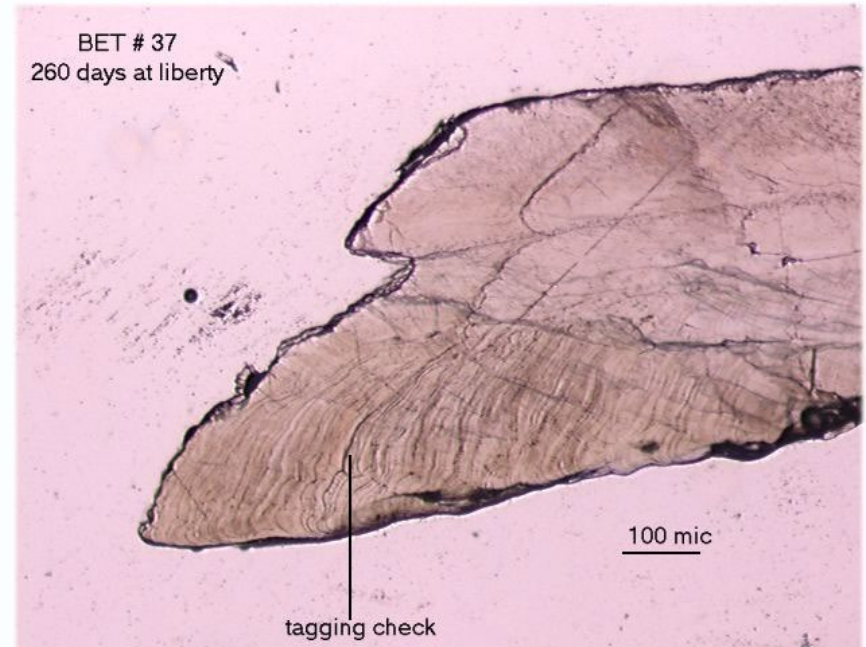


Fig. 8. Histograms of the distance from the inflection point to the first, second and third opaque zones on otoliths measured for annual age estimation. Grey stripes represent the mean distance \pm s.d. to the 365th increment (age 1; Y1) and the 730th increment (age 2; Y2) from microincrement analysis.

Farley et al. (2006)

Daily age validation – SEM otolith and sister

Both read under light microscope (x 100) and image analysis system



- Transverse sections
- Reader told position of Sr mark only
- Usually observed a tagging 'check'. Growth disruption after tagging?

Results

Table 7.3.2. Results of microincrement counts on strontium-marked otoliths

Fish no.	Release fork length (cm)	Recapture fork length (cm)	Days at Liberty	Otolith analysed in the SEM				Sister Otolith			
				Count 1	Count 2	Reading Score	% mean difference from days at liberty	Count 1	Count 2	Reading Score	% mean difference from days at liberty
37	72	85	260	218	216	A	16.5				
57	75	128	678	587	570	B	14.7	530	560	C	19.6
62	109	123	207	155	137	C	29.4	144	146	A	30.0
63	83	94	248	230	228	B	7.7	184	200	C	22.6
65	78	128	840	597	666	B-	24.7				
66	84	129	801			broken		567	582	C	28.3
67	78	unknown	757					570	532	B	27.2

A= count with high confidence, all areas have visible microincrements

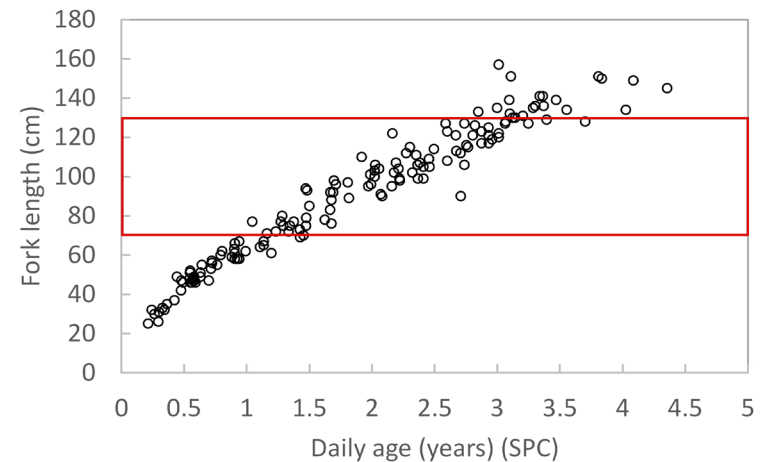
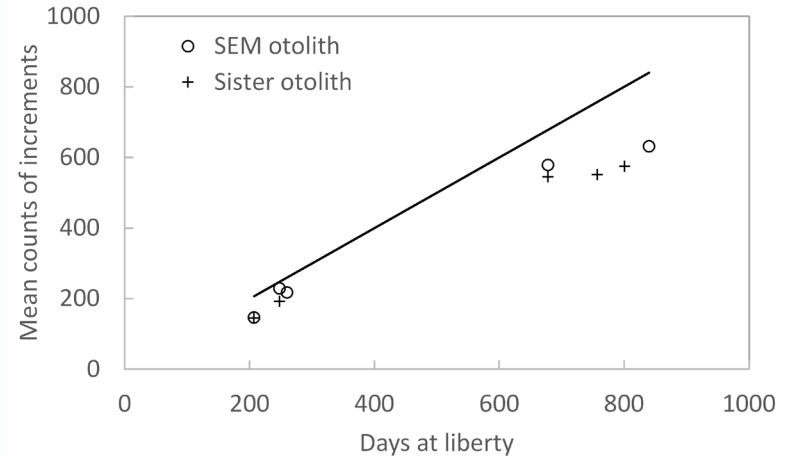
B= count with confidence, most areas have visible microincrements but a few areas are unreadable

C= count with low confidence, many areas along the section are unreadable

- “Otoliths were from fish larger than normally considered for microincrement counts”
- But all <130 cm FL at recapture

Daily age validation

- All micro-increments counts underestimated the days at liberty
- Mean difference 7.7% to 30.0% lower
- Age estimates in days for BET 72 - 129 cm FL are not reliable



Conclusions

- Annual periodicity of increments for age 2 to 9 years was validated.
- Location of first increment verified – daily ageing TS
- Age estimates in days for fish 72 - 129 cm FL are not reliable