

# Chinook Salmon Scale Reader Measurement Training

2014 Chinook Salmon LOA Aging meeting

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# Outline

## Introduction

- Scale measurement
- Training

## Reader consistency

- MANOVA
- Examples

## Measurement accuracy

Biological data

## Reader agreement:

- *Kappa*

## Discussion

# Introduction: Scale measurement

Purpose: Measure historical annual salmon growth to answer research hypotheses

Readers mark:

- Annuli (FW1, SW1, SW2, etc)
- Freshwater plus

# Introduction: Scale measurement

Process:

Bring ASL and Sample data into database

Scan

- ScreenScan

- Save image name to database

Measure

- Image Pro Plus macro

- Save measurements to text file

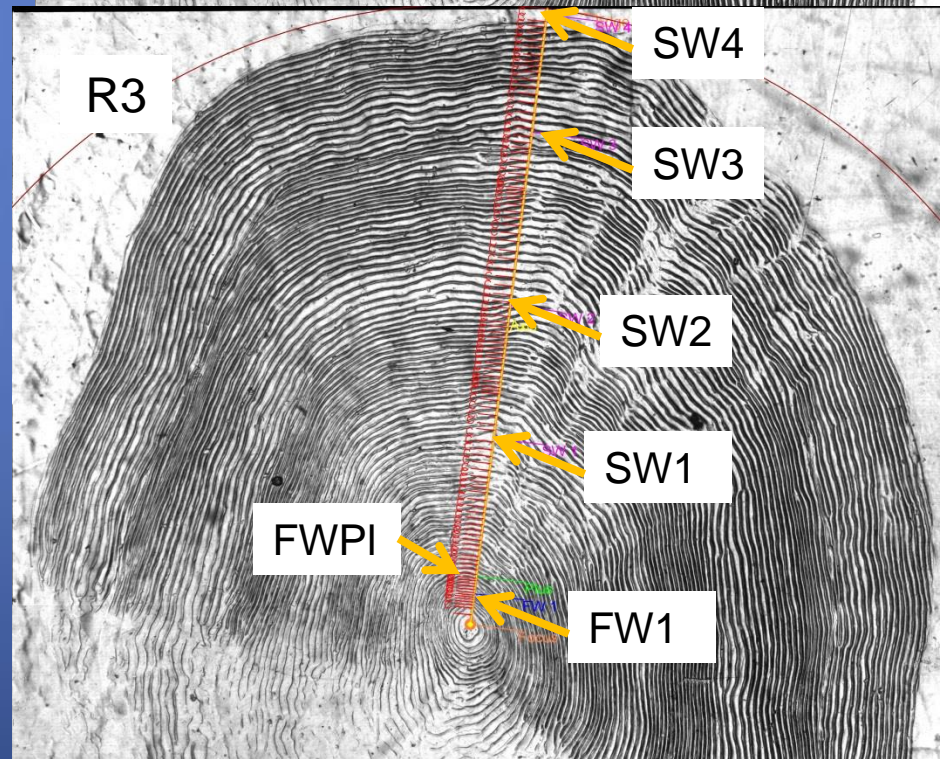
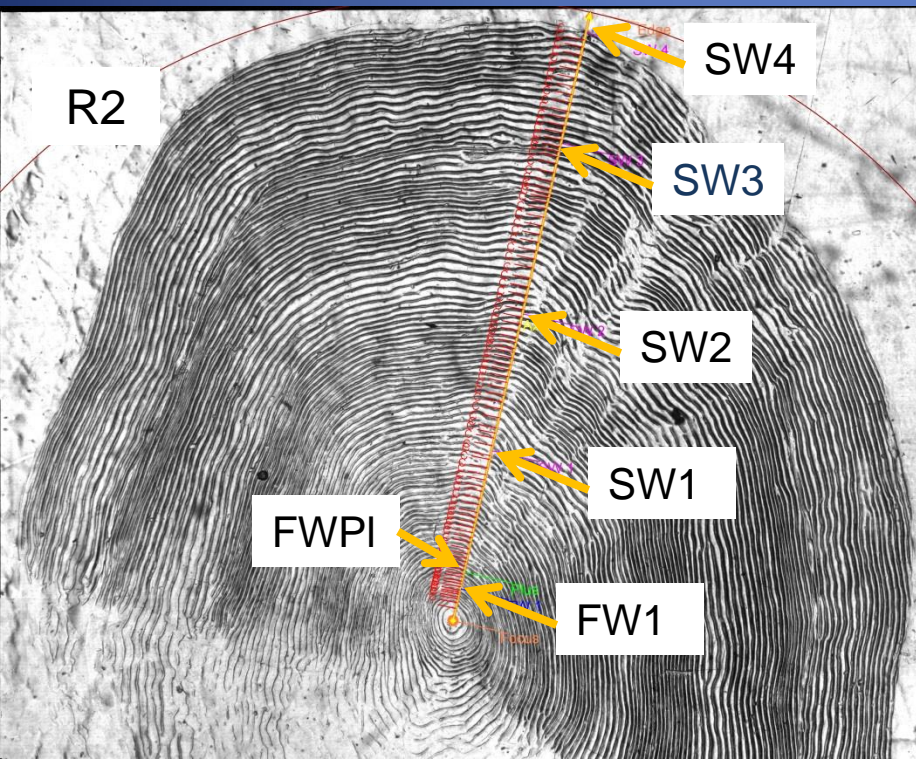
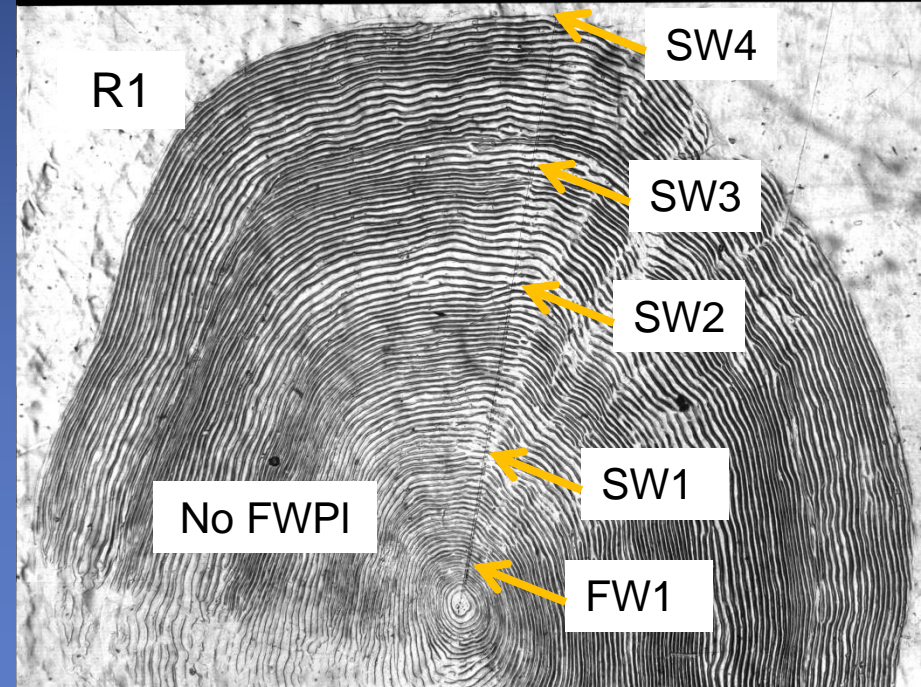
- Import measurements to database

Review measurements

# Introduction: Training

1. Readers study image collections
2. Pass aging test: >90% for each age (Chinook: 1.3 and 1.4)
  - 50 scales total
  - All stocks
3. Consistent with production measurements (MANOVA  $P < 0.05$ )

	R1		R2		R3	
Zone	Meas.	Count	Meas.	Count	Meas.	Count
FW1	0.399	14	0.221	7	0.239	7
FWPI			0.129	6	0.125	5
SW1	0.928	22	1.036	24	0.927	22
SW2	1.124	22	1.012	22	1.083	21
SW3	0.915	15	1.305	25	1.331	23
SW4	1.224	22	0.615	11	0.834	14
Radius	4.590	95	4.317	95	4.537	92



# Scale measurement

Can be differences in:

- Transect placement
- Zone markings

Therefore, it is important to examine:

- Between and within reader consistency
- Accuracy

# Reader consistency: MANOVA

## Multiple analysis of variance (MANOVA)

$$H_0: \mu_{FW1_A} = \mu_{FW1_B} \text{ and } \mu_{SW1_A} = \mu_{SW1_B} \dots$$

- Maintains magnitude of Type I error
- Considers all zones jointly
- Considers correlation of variation between readers

## Method

Re-measure 20-50 scales

## Results

Example 1: Readers not consistent

Example 2: Readers consistent



# Reader consistency: MANOVA

Example 1: Readers not consistent

Data set-up

Reader	Fish	FW1	FWPL	SW1	SW2	SW3	SW4	SWPL
A	1	0.2296	0.2245	1.0615	0.8136	1.1993	0.2822	0
A	2	0.2594	0.1943	1.0718	0.6519	1.0375	0.6541	0
A...	...	...	...	...	...	...	...	...
B	1	0.1706	0.2428	0.9186	0.8445	1.0816	0.5286	0
B	2	0.2626	0.1223	1.0516	0.6783	0.9168	0.6696	0.1375
B								

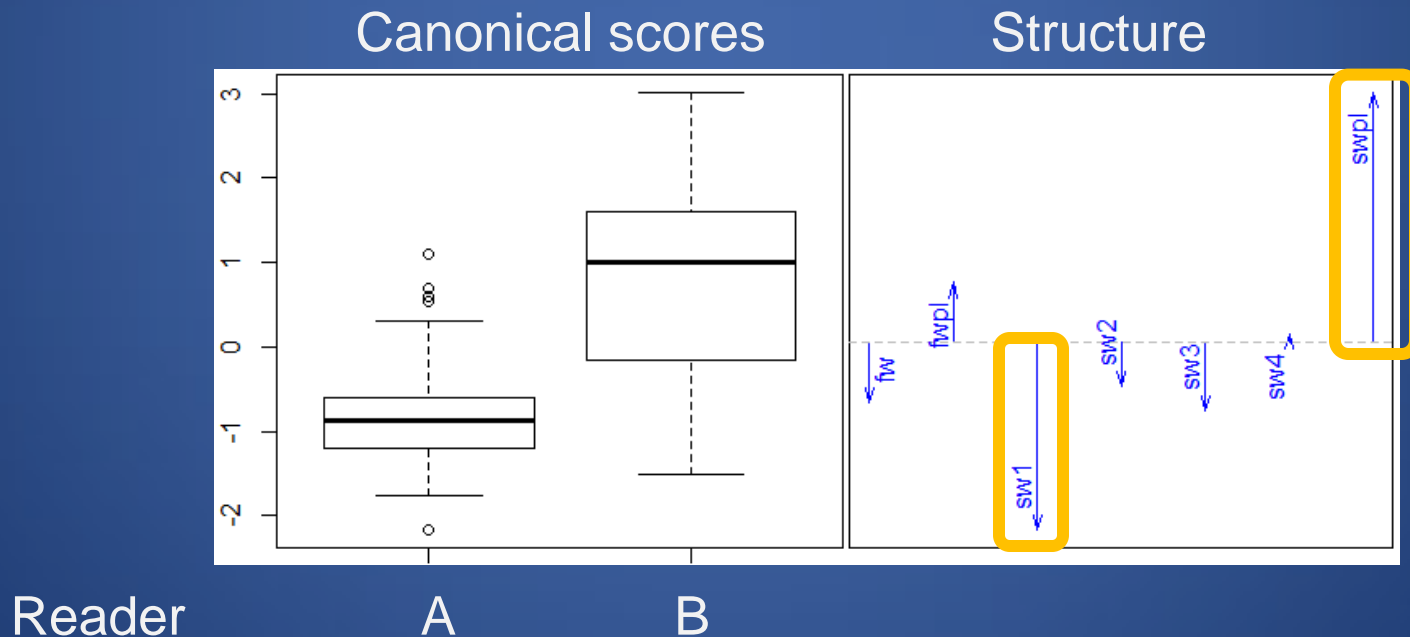
Zone average for reader

Average	Reader	FW	FWPL	SW1	SW2	SW3	SW4	SWPL
Measurement (mm)	A	0.3534	0.1474	1.2343	1.0955	1.1730	0.4585	0.0168
	B	0.3344	0.1801	1.1628	1.0590	1.1201	0.4732	0.1254
Circuli Count	A	11.3	4.7	26.7	22.0	21.2	8.3	0.3
	B	10.4	5.7	24.5	21.4	20.4	8.5	2.6

# Reader consistency: MANOVA

MANOVA results:

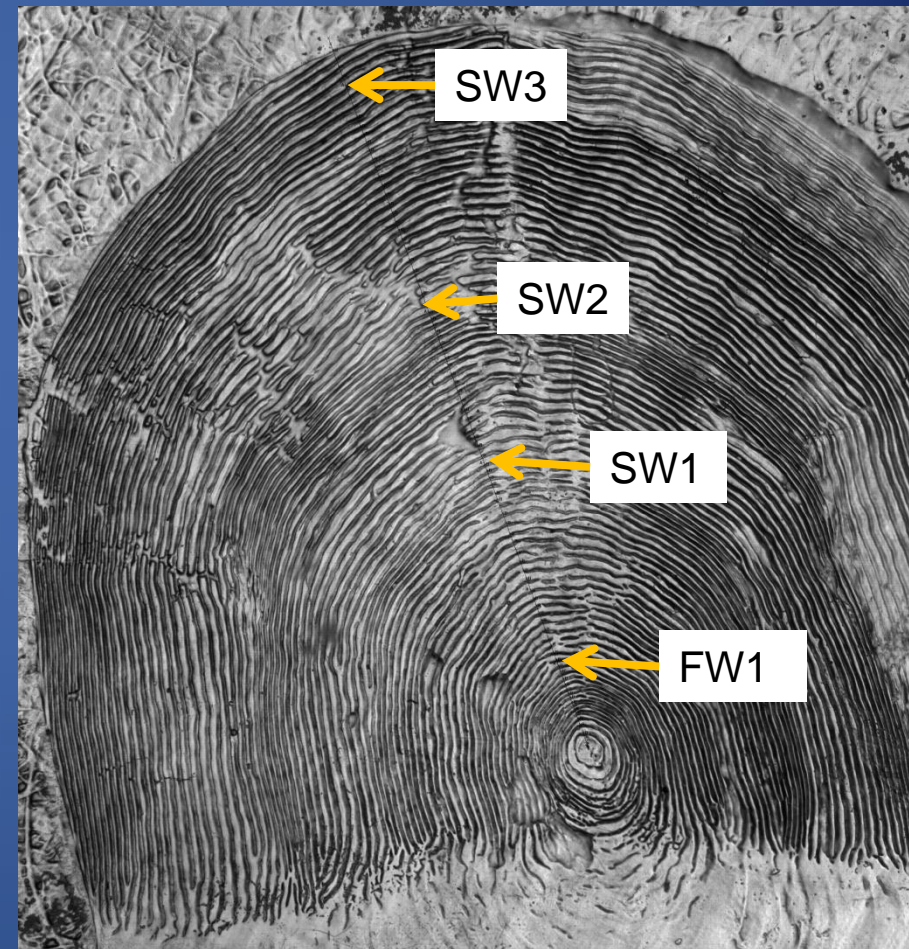
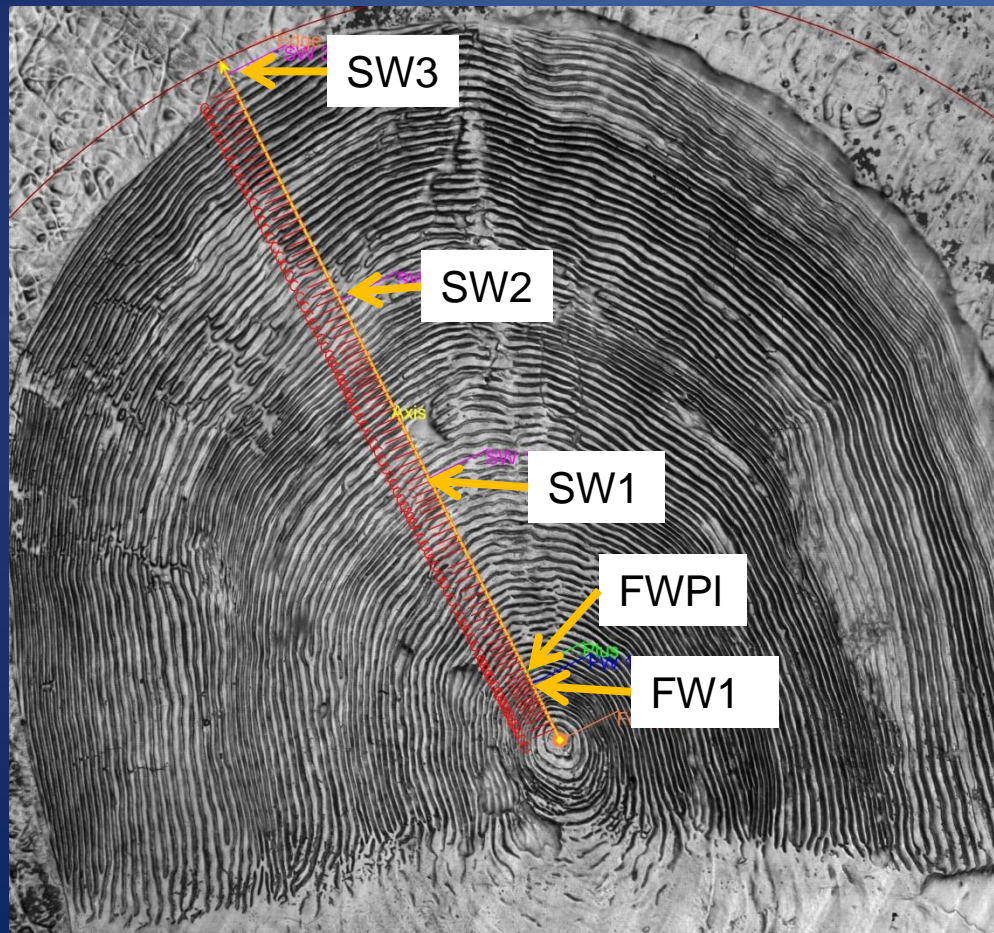
Factor	Df	Pillai	approx F	num Df	den Df	Pr(>F)
Read	1	0.37092	5.2223	7	62	<b>0.0001</b>
Residuals	68					



# Reader consistency: MANOVA

Reader A

Reader B



# Reader consistency: MANOVA

Example 2: Readers consistent

Data set-up

Reader	Fish	FW1	FWPL	SW1	SW2	SW3	SW4	SWPL
A	1	0.228	0.1045	1.0053	1.0672	0.6429	0.8283	0
A	2	0.2962	0.1001	1.2758	1.179	1.9878	0	0.2693
A	...	...	...	...	...	...	...	...
B	1	0.213	0.0696	0.8741	0.9342	0.8132	0.5104	0
B	2	0.3513	0	1.1493	0.8328	2.1536	0	0
B	...	...	...	...	...	...	...	...

Zone average for reader

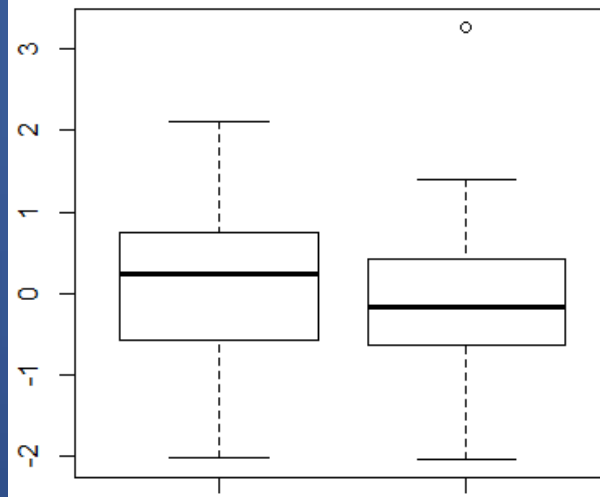
Average Measurement (mm)	Reader	FW	FWPL	SW1	SW2	SW3	SW4	SWPL
Circuli Count	A	11.3	3.3	27.9	22.0	19.3	10.6	0.2
	B	10.1	3.8	27.9	20.9	20.0	9.2	0.2

# Reader consistency: MANOVA

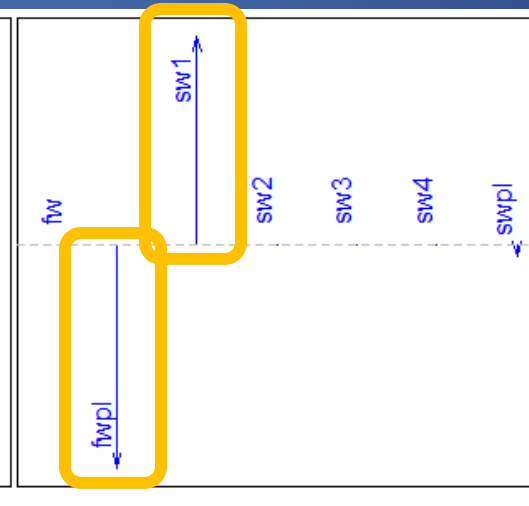
MANOVA results:

Factor	Df	Pillai	approx F	num Df	den Df	Pr(>F)
Reader	1	0.0079	0.0916	7	81	<b>0.9986</b>
Residuals	87					

Canonical scores



Structure



Reader

A

B

# Reader consistency

MANOVA tests occur:

- Each new species
- Each new reader for a system
- At completion of each system
- After scales have been remeasured for accuracy

# Reader accuracy

Review measurement for a system by:

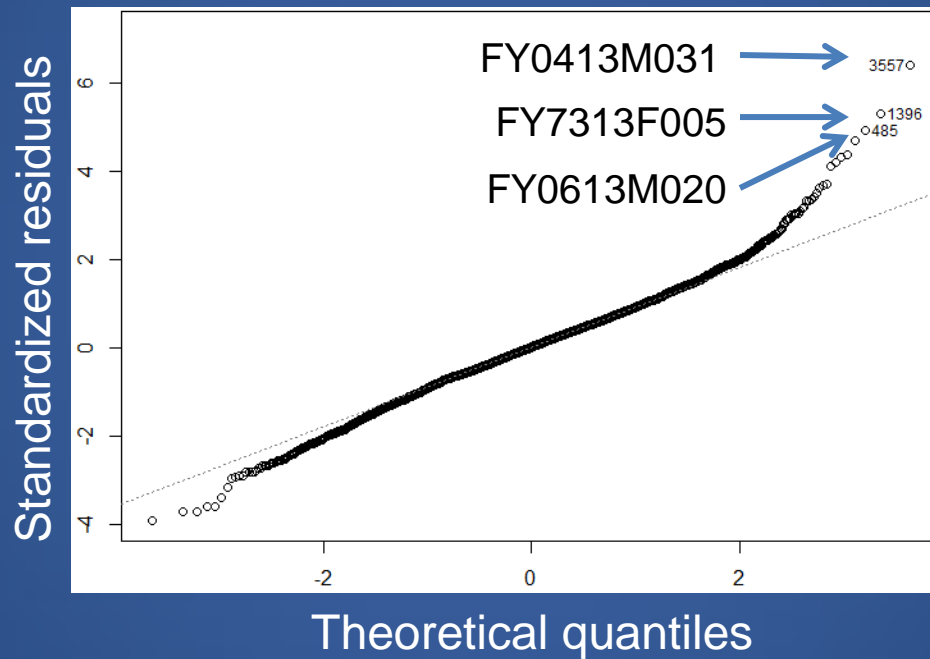
- Passing validation during import process, number of zones matches age
- Largest and smallest zone measurement, circuli count, and circuli spacing examined
- Examining outlier for each zone:

$$Zone_C = Age + Length + Sex$$

where  $Zone_C$  is zone radius, circuli count, or average circuli spacing

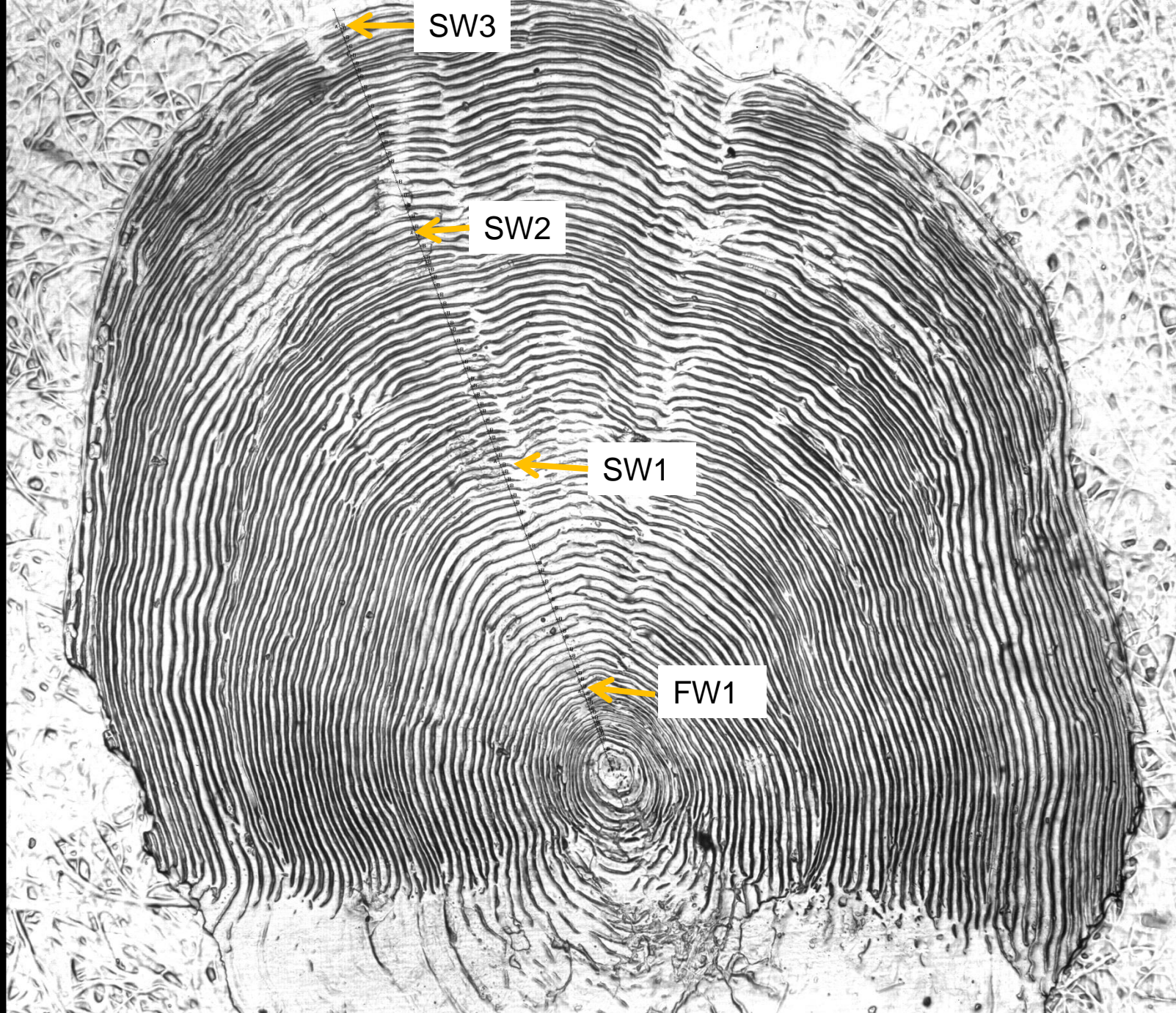
# Reader accuracy: Linear model

Normal Q-Q



$$SW1_{\text{radius}} = \text{Age} + \text{Length} + \text{Sex} \quad N = 3796$$



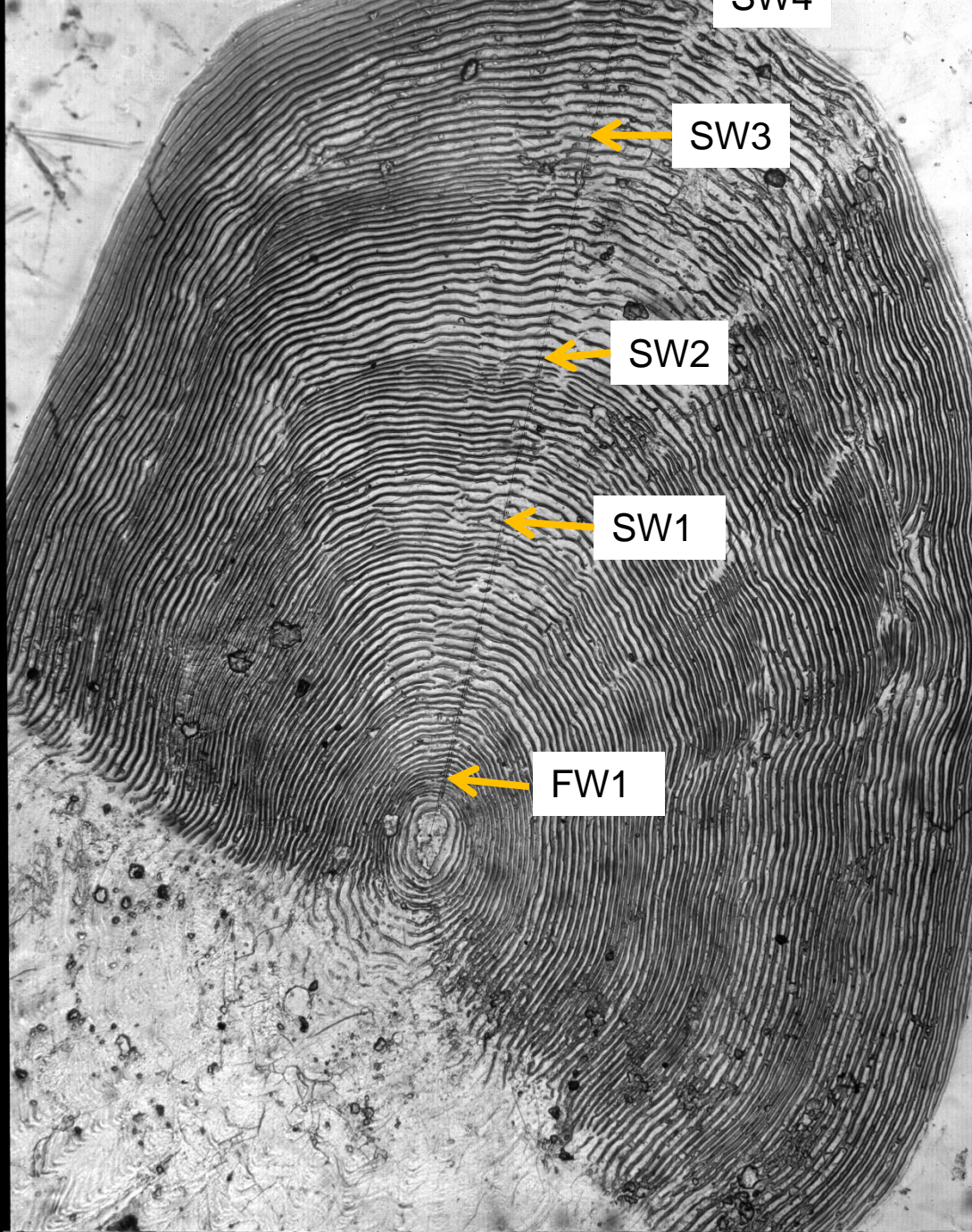


SW3

SW2

SW1

FW1



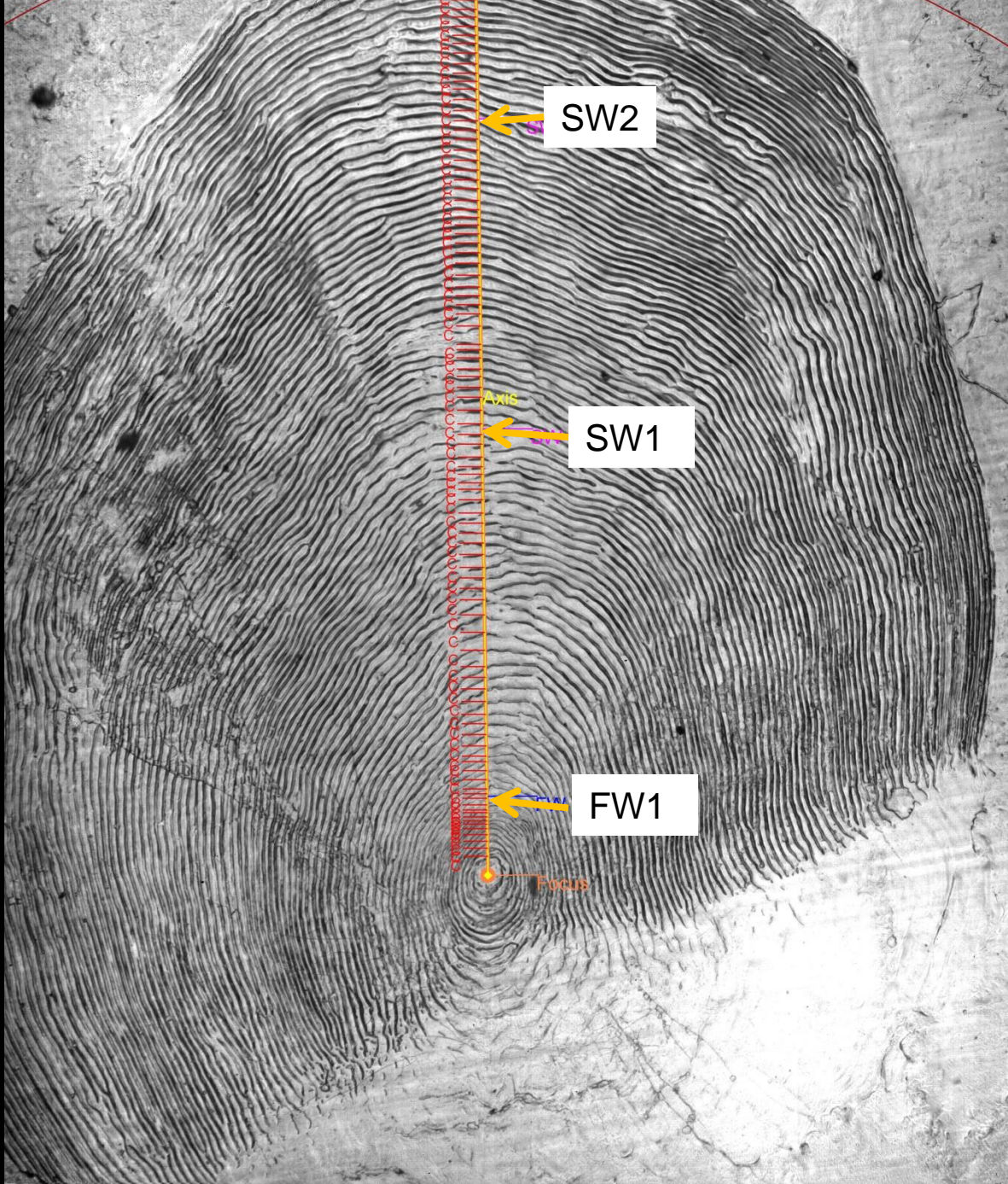
SW4

SW3

SW2

SW1

FW1



SW2

SW1

FW1

Axis

Focus

# Reader accuracy

Outliers are:

- Unreasonable annulus placement
- Non-preferred, regenerated, or resorbed scales
- Overlapping juvenile patterns:
  - Freshwater annulus
  - Freshwater plus growth
  - Intermediate growth in brackish water
  - Growth variable temperatures, prey, and competition in near-shore marine waters
  - A second freshwater annulus
  - No freshwater annulus
- Mis-aged scales

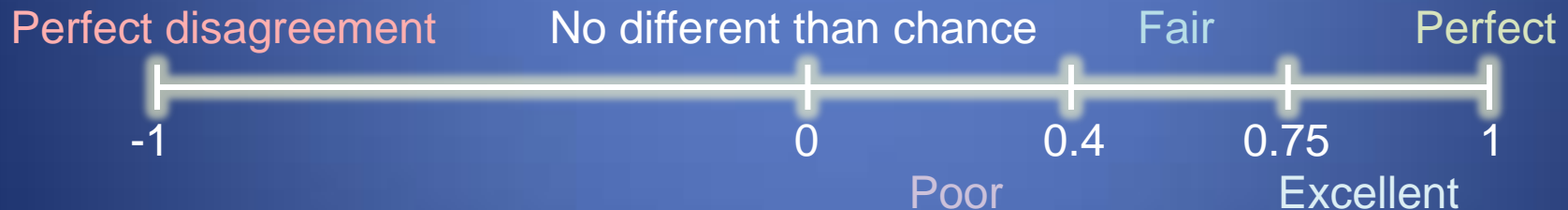
# Reader agreement: *Kappa*

Method for measuring reader agreement on two or more choices

Accounts for agreement that occurs by chance:

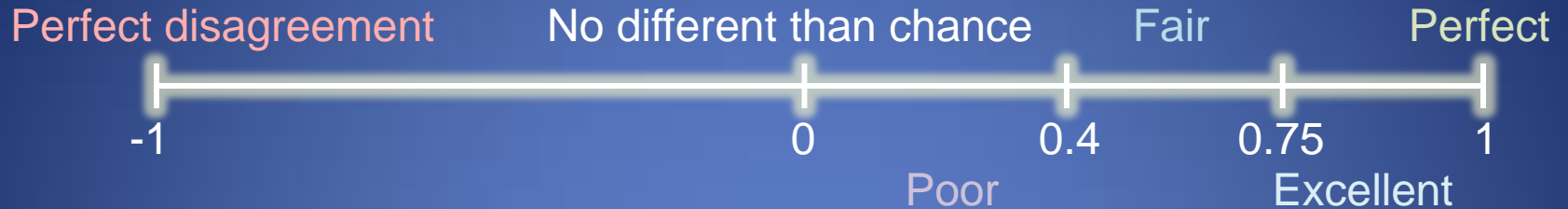
$$\kappa = \frac{p_o - p_e}{1 - p_e}$$

$p_o$  = observed,  
 $p_e$  = expected



Potential: Evaluate reader age agreement

# Kappa: Example results



Agreement matrix:

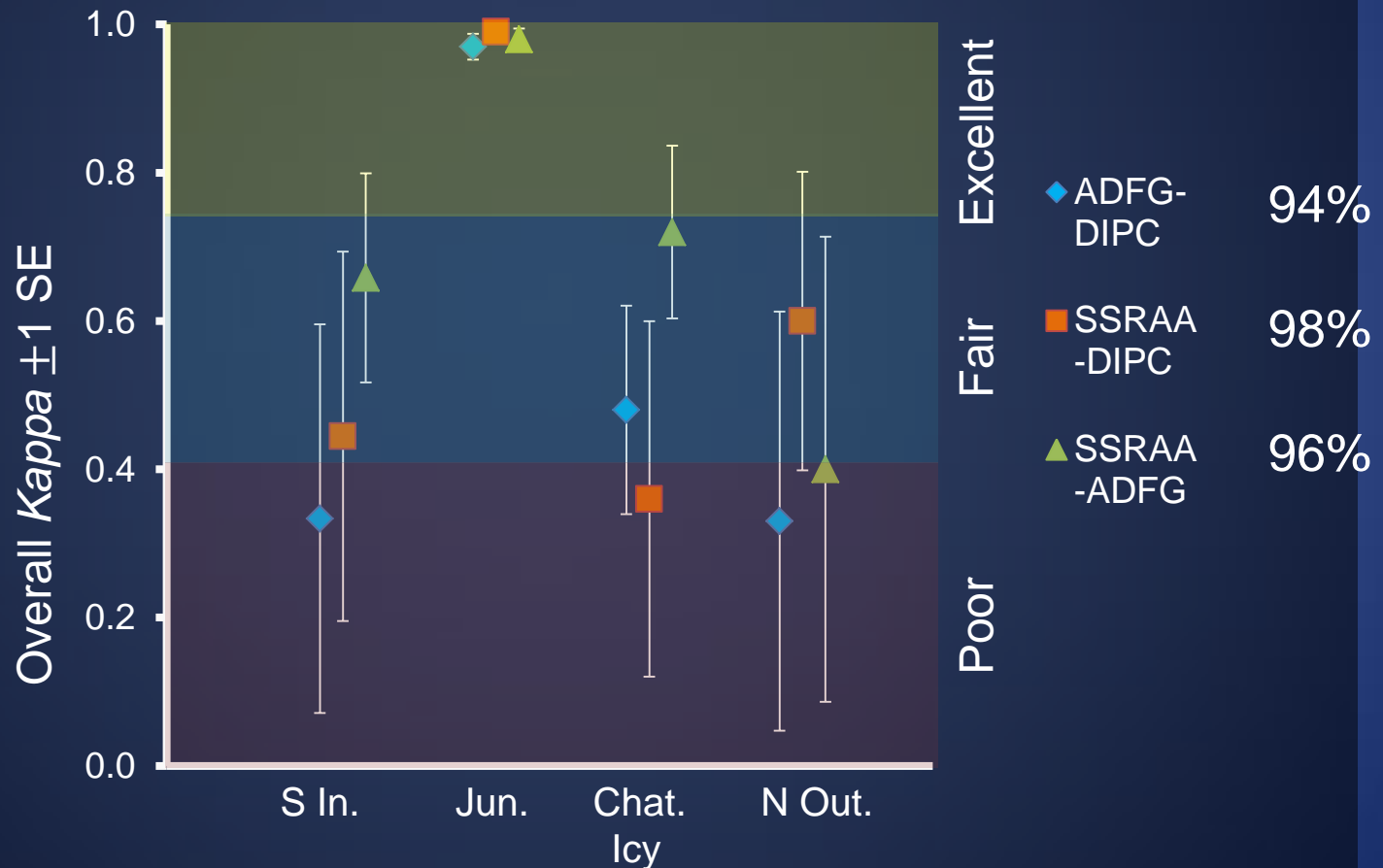
		Reader A				
		2.3	1.3	1.4	1.5	1.6
Reader B	2.3	5				
	1.3		12	15	1	
	1.4			178	27	
	1.5		1	1	100	1
	1.6					20

Results:

	Kappa	S.E.(0)
Overall	0.78	0.04
2.3	1.00	0.05
1.3	0.56	0.05
1.4	0.76	0.05
1.5	0.80	0.05
1.6	0.97	0.05

# Kappa: Example results

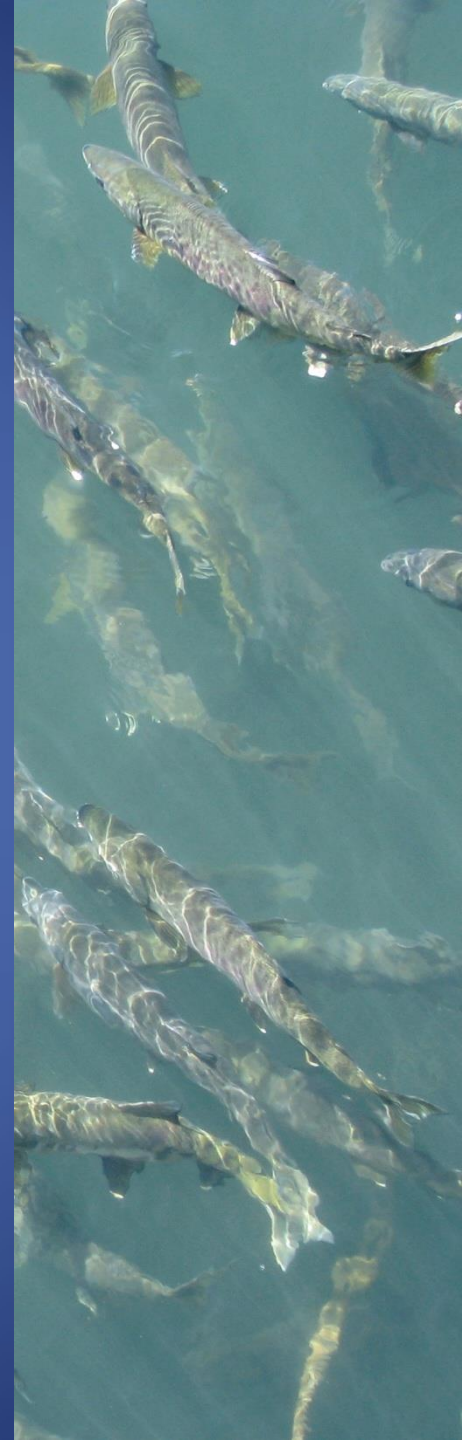
2009 SEAK chum salmon thermal mark agreement



# Discussion

Reader comparisons used to identify zones with the biggest differences between readers to work towards reader consistency

Desire to develop a time series of salmon scales from various environments and stocks to characterize scale patterns for a reference collection and improve accuracy





# Acknowledgements

- Thanks to the many ADF&G SCALE salmon scale readers
- MTA IT Team
- ADF&G regional offices that allowed access to scale collections