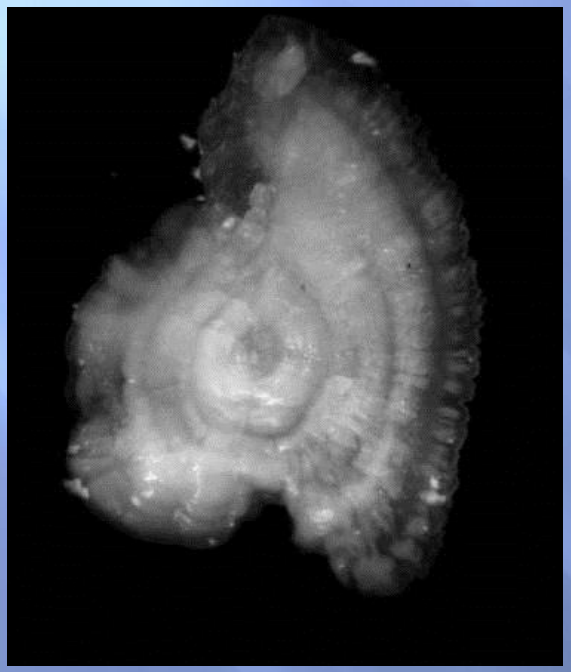
WHO SAYS FISH CAN'T BE SENSITIVE?

Why Use (Sagittal) Otoliths To Mark Fish?

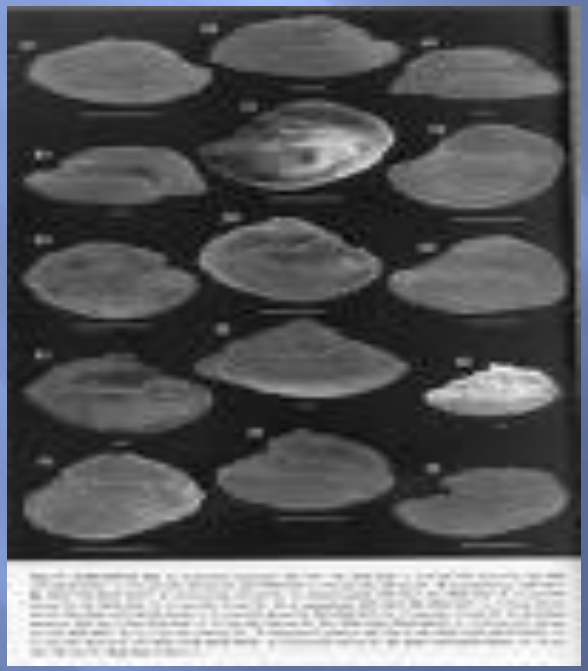
- Their developmental sensitivity to biological & environmental change makes them easy to mark.

Otoliths are sensitive to stress . . .

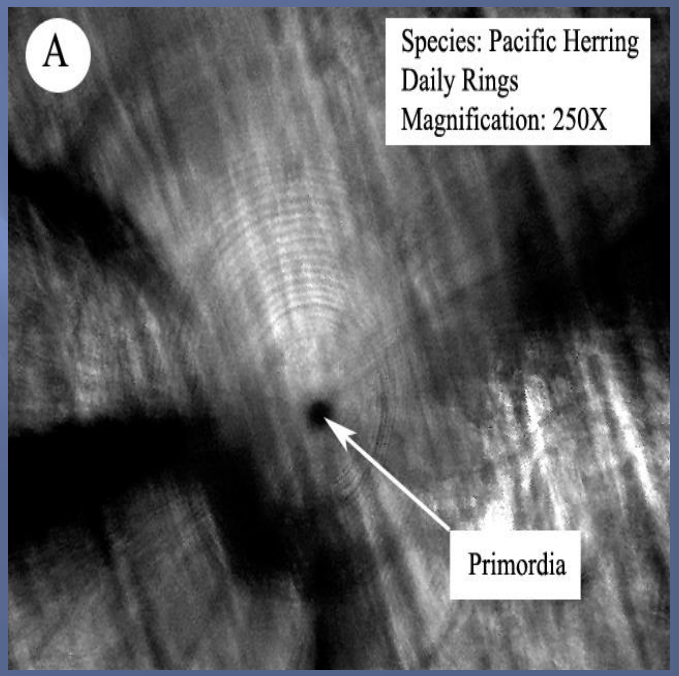
Annual Rings
Seasonal changes in diet & growth rate



Overall Shape
Env. Disturb. (cyclones, etc)

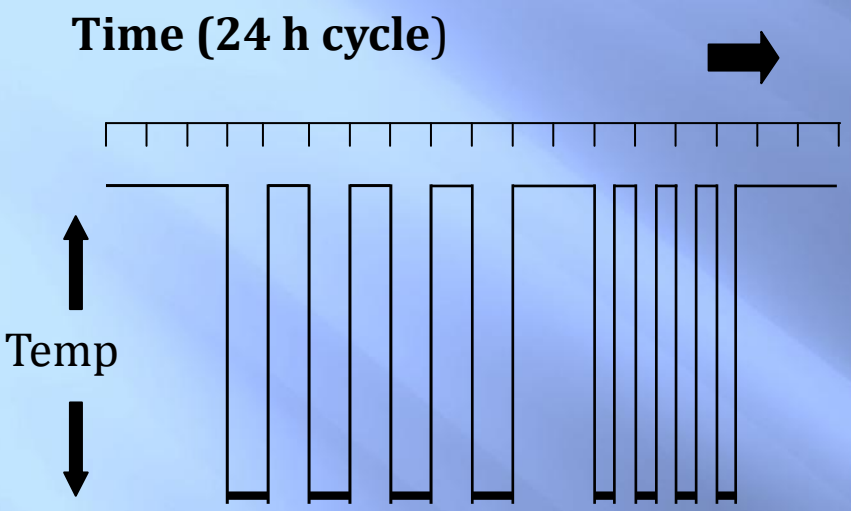


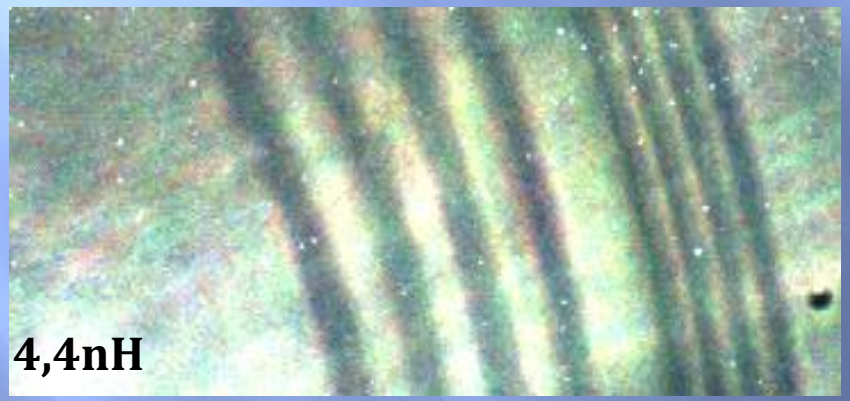
Daily rings
Diurnal hormone cycles
Hatching, Smoltification



Otolith Marking Thru Stress

A) Thermal Marks

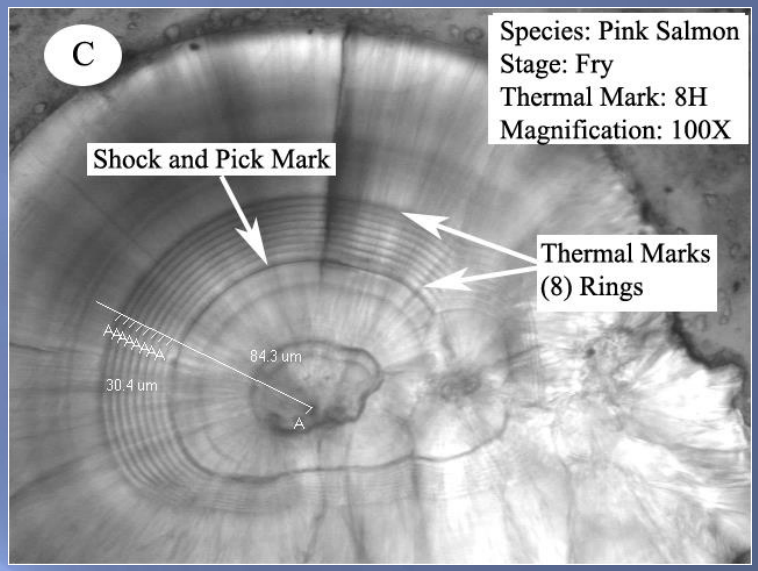




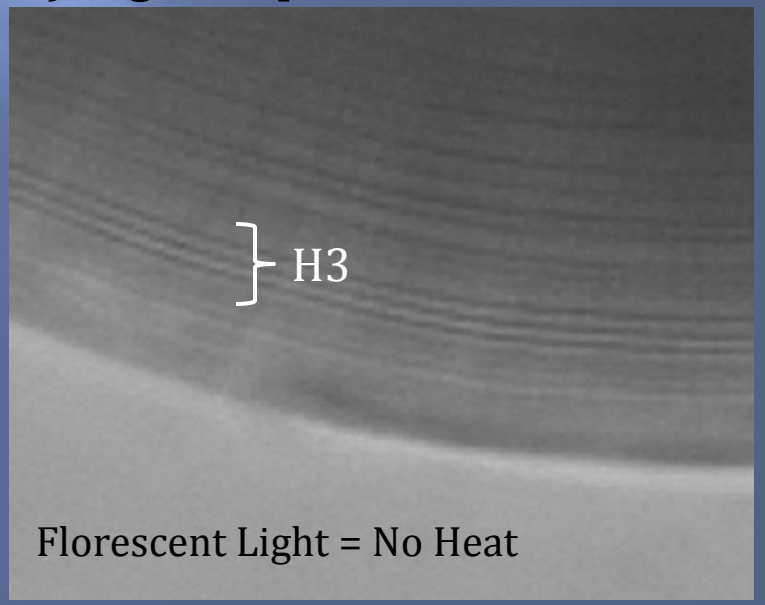
B) Dry Marking

Eggs exposed to air at to create ring.
Thermal stress associated with this exposure

C) Mechanical Shock



D) Light Exposure

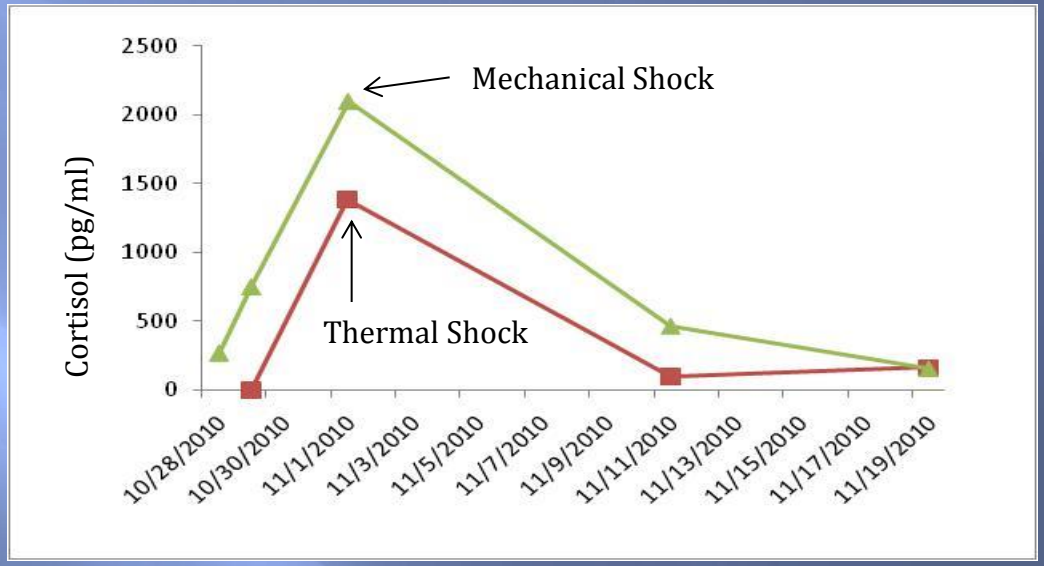


Stress can affect health and physiology

Hatchery Stress

- Marking
- High Densities
- Mechanical Shock
- Disease
- Inbreeding
- Noise

How do fish respond to these stressors?



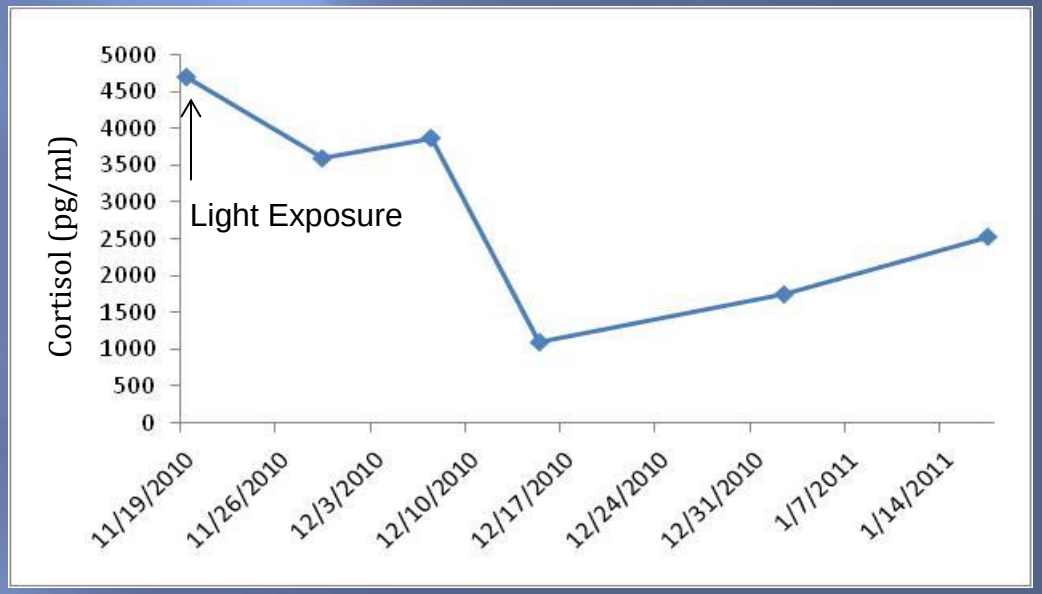
Cortisol (*Adrenal "Stress" Hormone*):

Small increases :

– A burst of energy & immunity
– Lower pain sensitivity
– Maintenance of homeostasis

Higher / Prolonged exposure:

– Impaired cognition
– Decreased bone & muscle
– High blood pressure
– Lowered immunity
– Slowed healing



Does stress affect more than blood chemistry?

Does Genetic Stress (hybridization) and Thermal Stress Affect Otolith Development?

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University of Alaska, Fairbanks - SFOS, Juneau
Alaska Department of Fish and Game - MTA Lab
National Marine Fisheries Service
Alaska Sea Grant

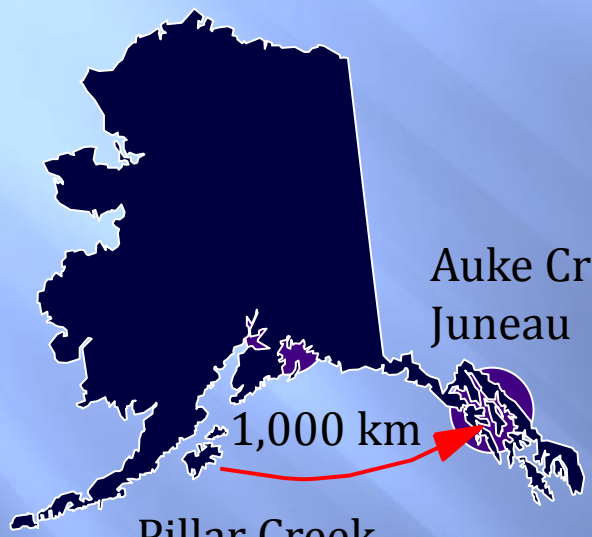
Controlled Mating & Rearing Environments

A) Control Embryos

Parents: Native Auke Creek Pinks

B) Hybrid Embryos

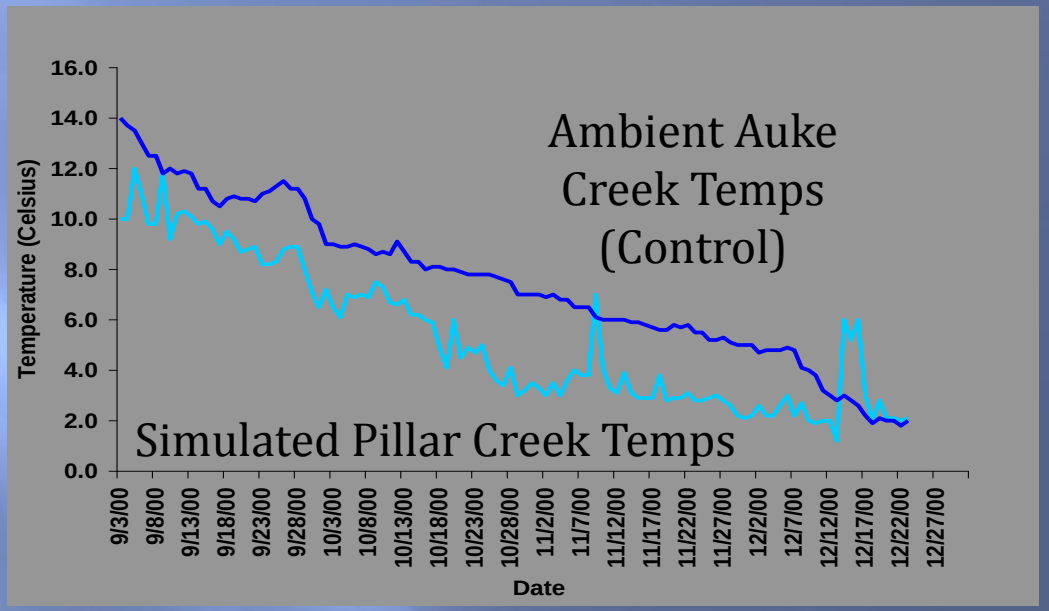
Parents: F_2 Hybrid Pinks
{Auke Dams X Pillar Sires}



OUTBREEDING

Local Adaptation

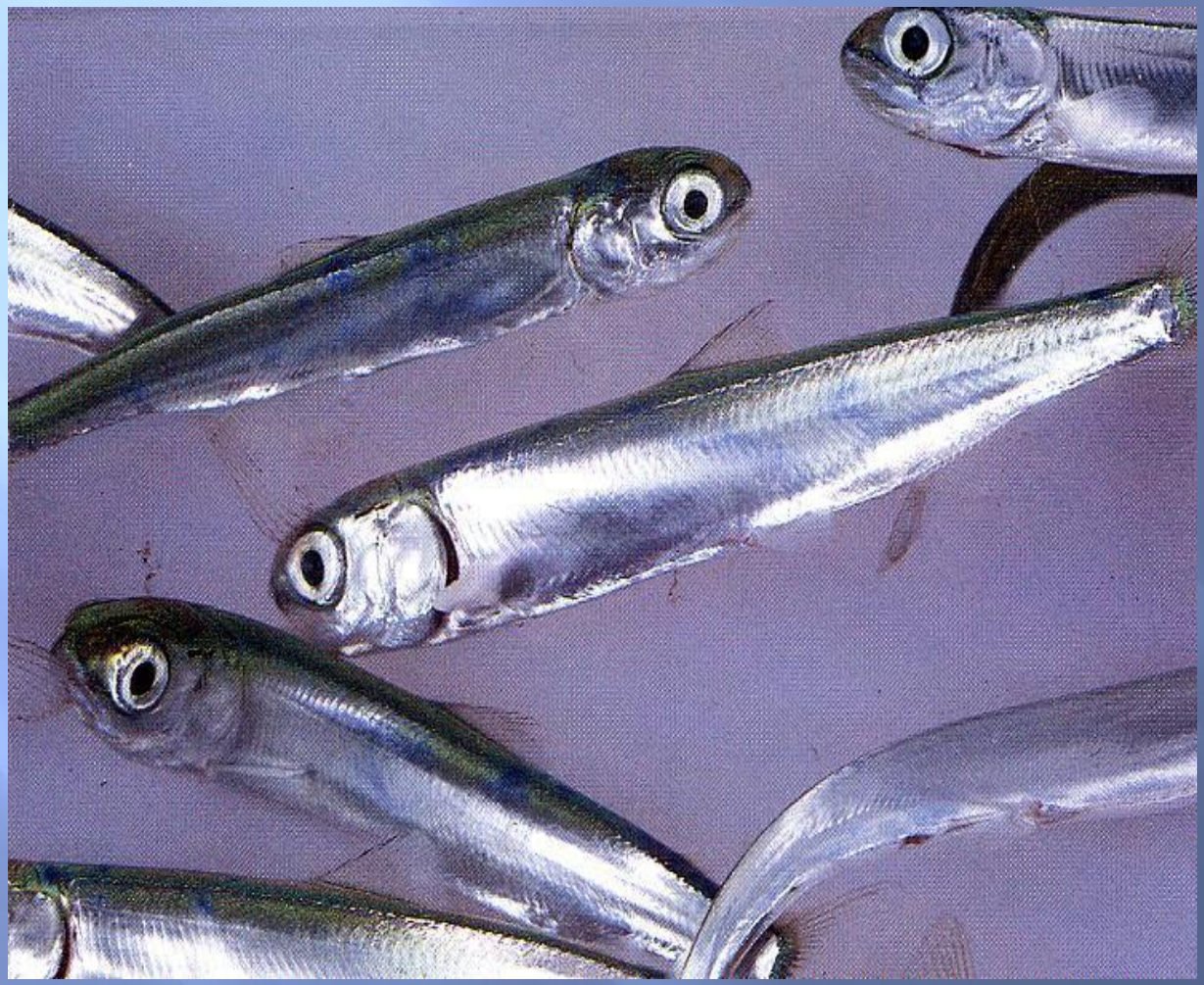
Incubation Environments

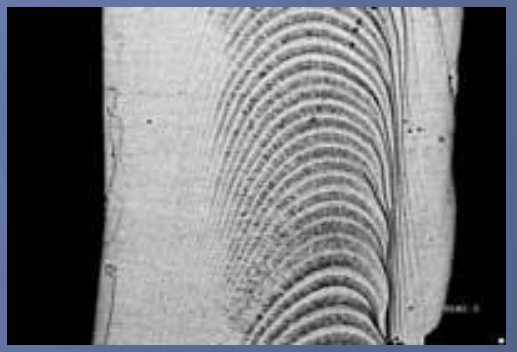


Otolith Sampling

Fry collected after 100% yolk absorption (standardization)

Mounted left otoliths: $n_{\text{controls}} = 960$; $n_{\text{hybrids}} = 768$

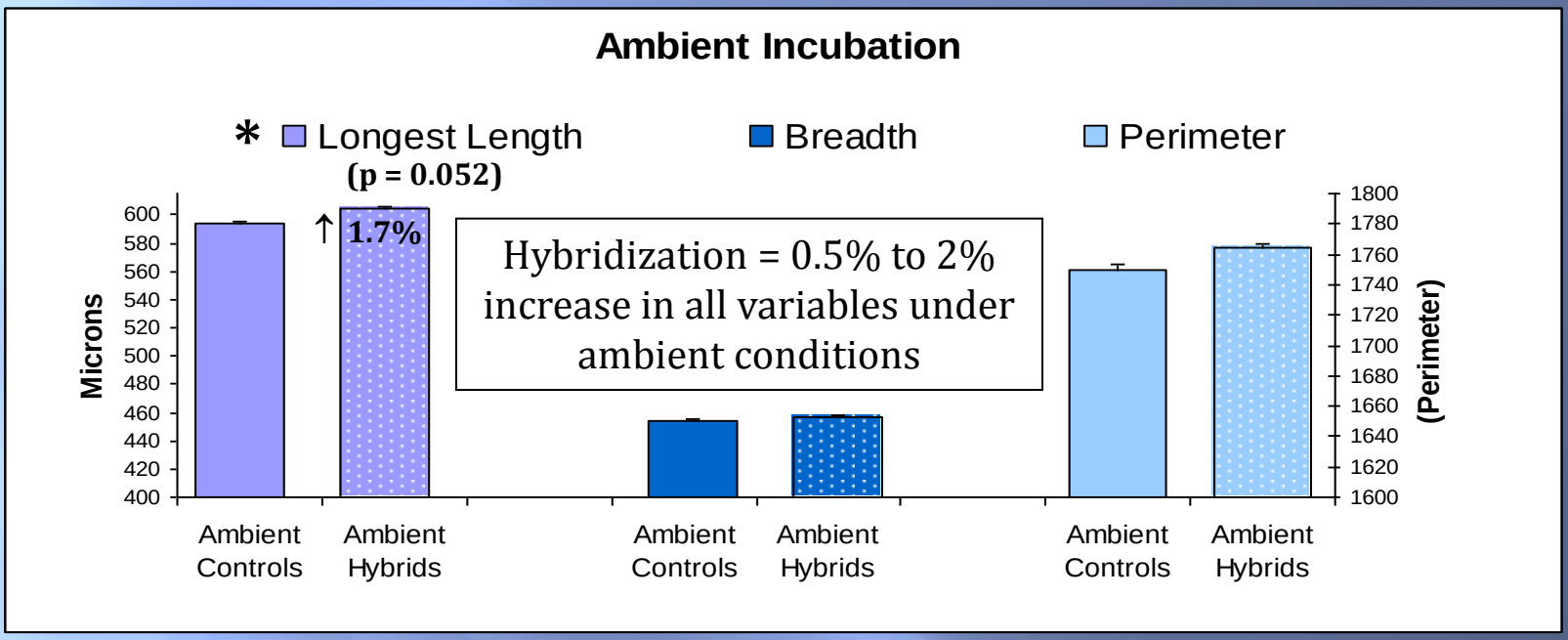


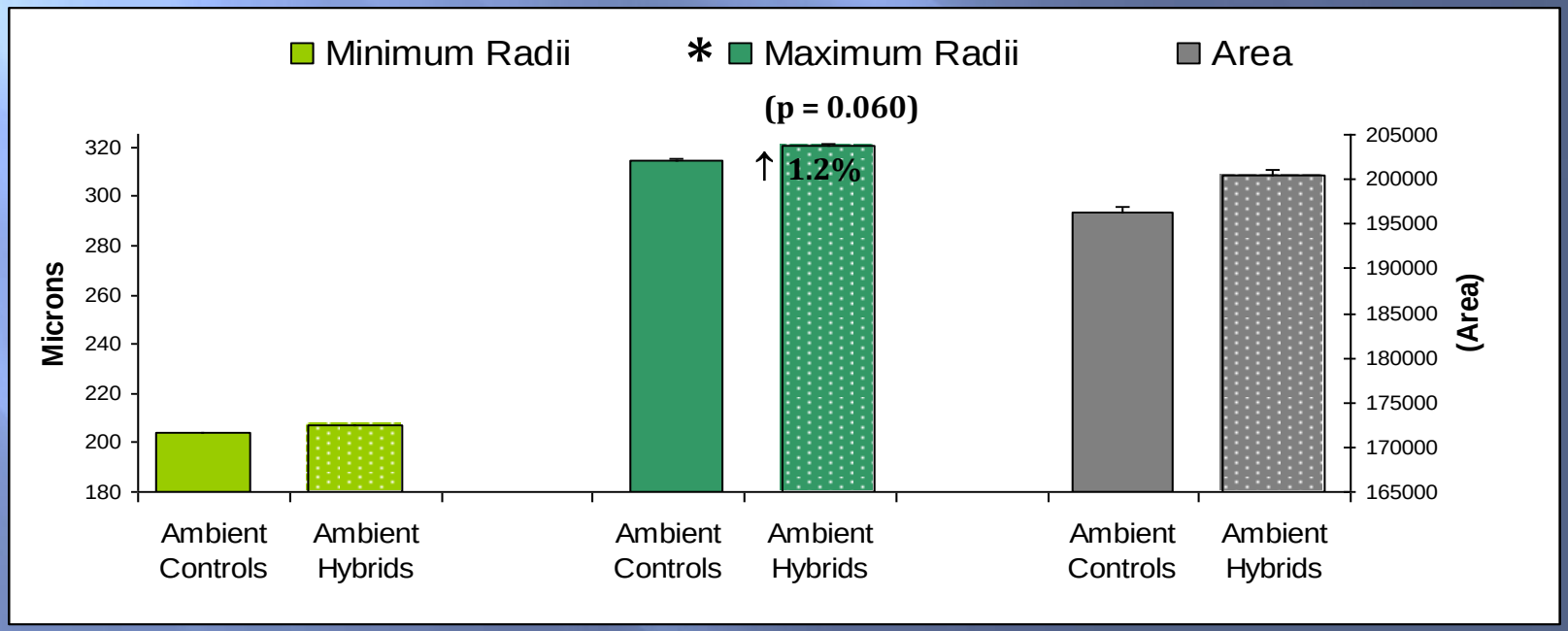


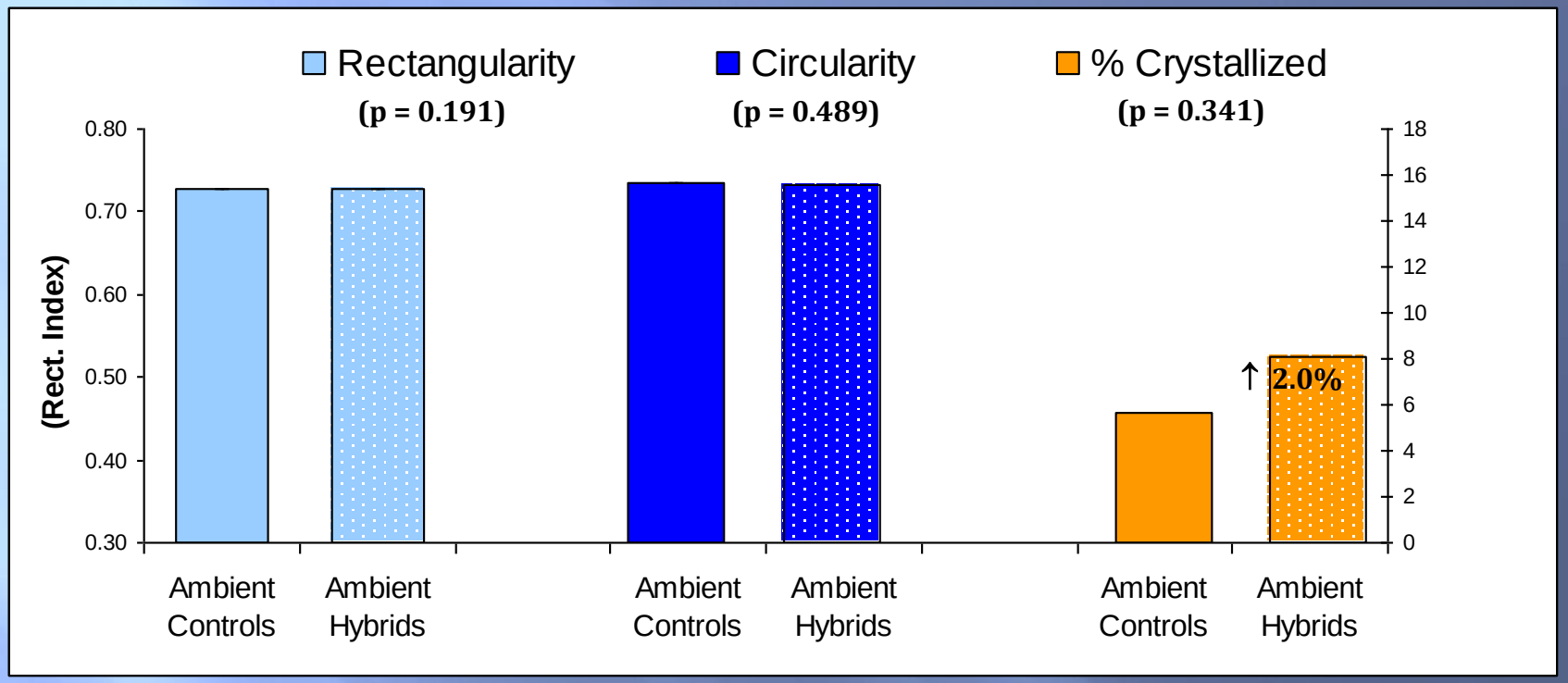
Area
Length
Breadth
Perimeter
Max Radii
Min Radii
Circularity Index
Rectangularity Index
Morphological Status
(Normal vs. Vateritic)

Hybridization Effects

* = Significant REML

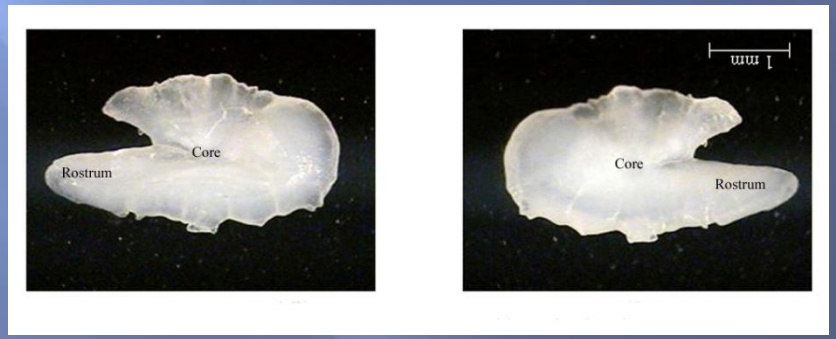






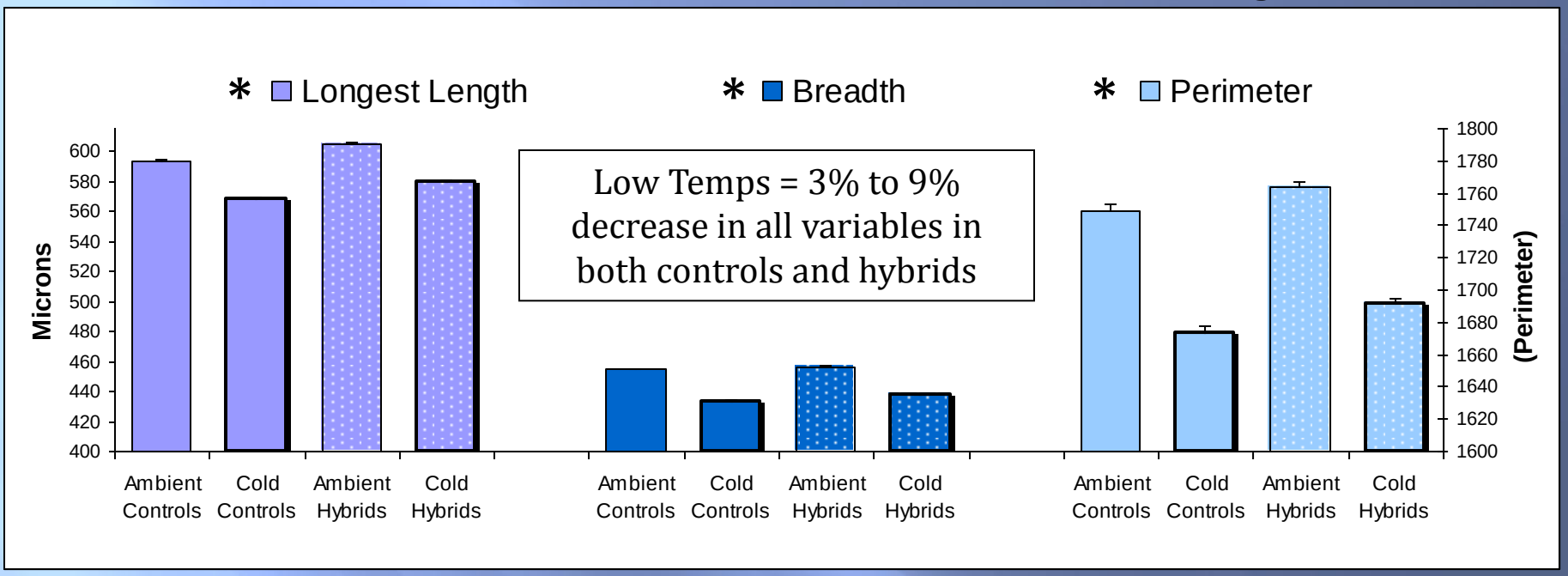
- Increases in length and max radii did not affect shape.

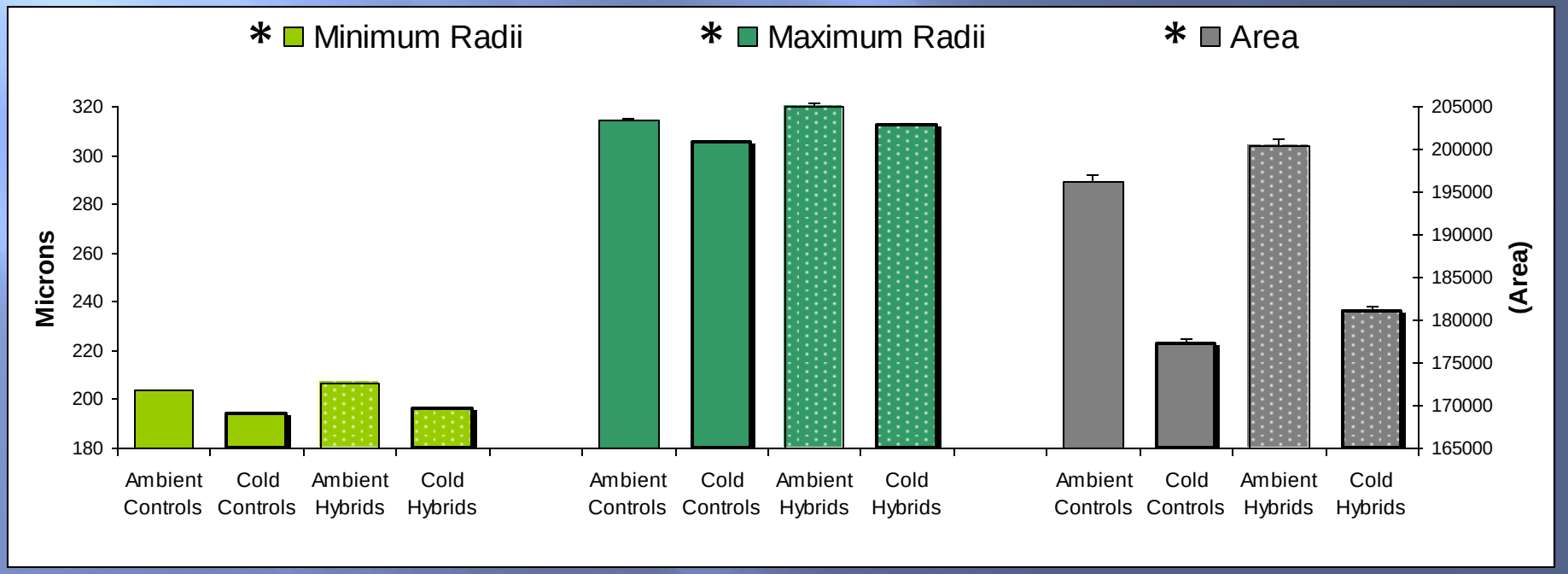
SHAPE CONSERVED

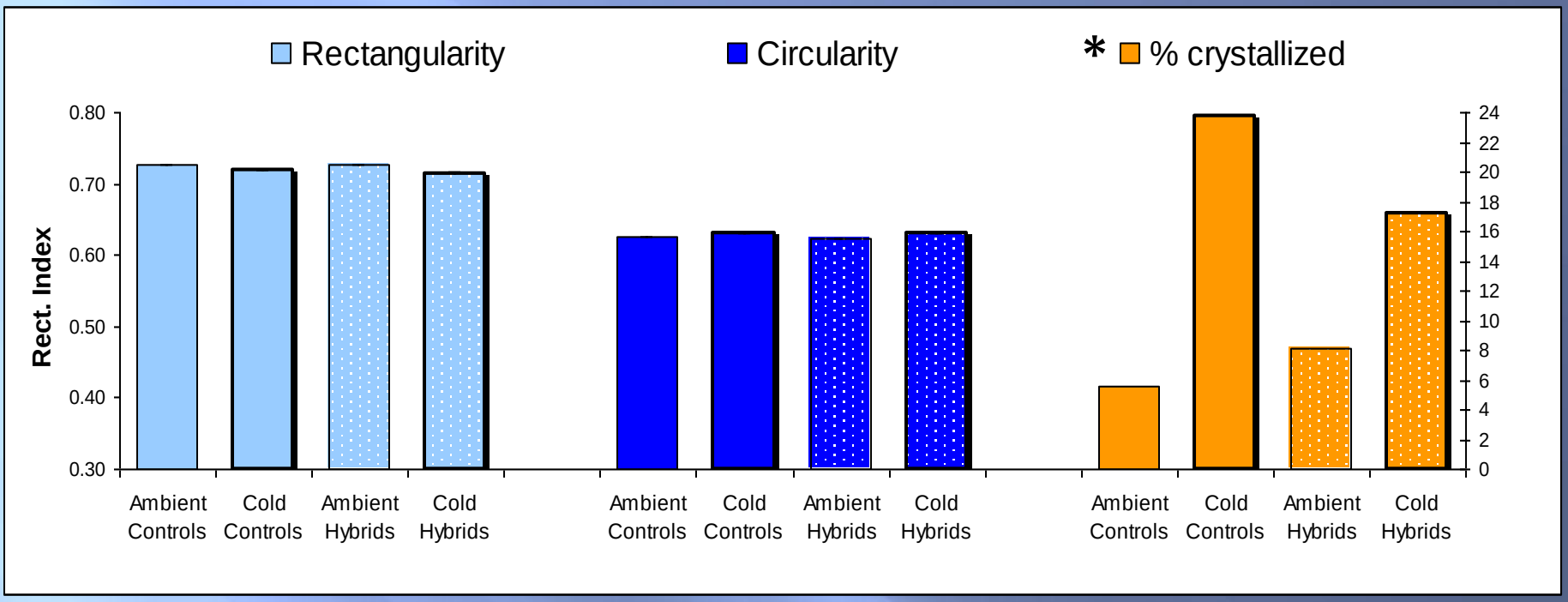


Temperature Effects (Left Otoliths):

* = Significant REML

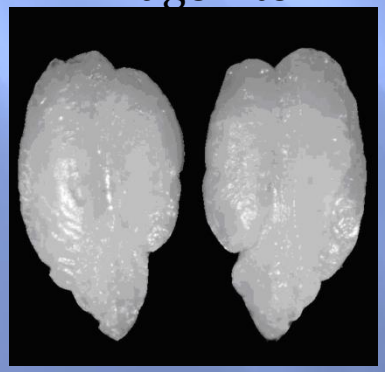






- Temperature influenced each trait similarly in both crosses, so shape was relatively unchanged.

Aragonite

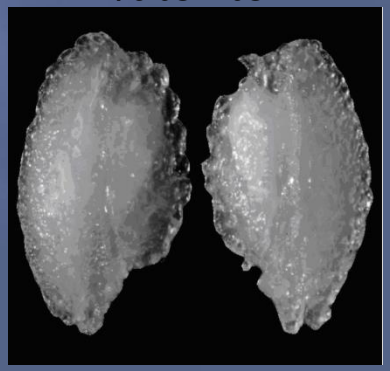


<u>Occurrence of Vaterite (Crystallized) Otoliths</u>:

Controls: Cooler Incubation = 4 fold increase

Hybrids: Cooler Incubation = 2 fold increase

Vaterite



Conclusions

1) Thermal stress strongly influenced otolith development.

2) Hybridization (genetic stress) had a small effect on otolith morphology.

3) Vateritic otoliths were correlated with low incubation temperatures.

Hatcheries are Stressful
High Incidence of Vateritic otoliths

What were the physiological repercussions?

THE EFFECT OF VATERITIC SAGITTAE ON SOUND RECEPTION AND OTOLITH MORPHOLOGY IN CHINOOK SALMON

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D. Miller, R. Josephson, & A. Popper

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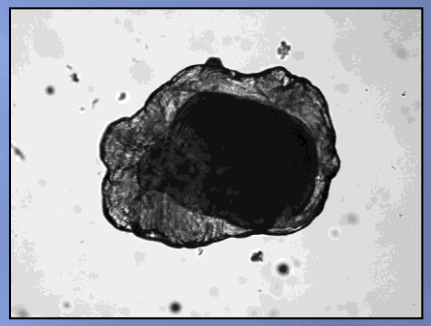
Alaska Department of Fish and Game
National Marine Fisheries Service
National Institute of Deafness & Other Communication Disorders

Can Vaterite Deposition Change Otolith Structure?

- Aragonite Density = 2.93 cm^3
- Vaterite Density = 2.65 cm^3
- Shape



Do these alterations affect the function of the inner ear?

Objectives

1) Determine if vateritic sagittae affects hearing.

2) Determine if vaterite deposition affected sagittal shape and density.

How can you tell if a fish is listening?

Auditory Brainstem Response (ABR)

- Electrophysiological method of measuring neural responses to sound
- Finds the minimum "Sound Pressure Level" (SPL) needed to hear a signal (dB)
- ABR conducted blind re: otolith composition

Frequencies Tested

100 Hz	200 Hz	250 Hz	300 Hz
400 Hz	600 Hz	800 Hz	1000 Hz

Species Tested

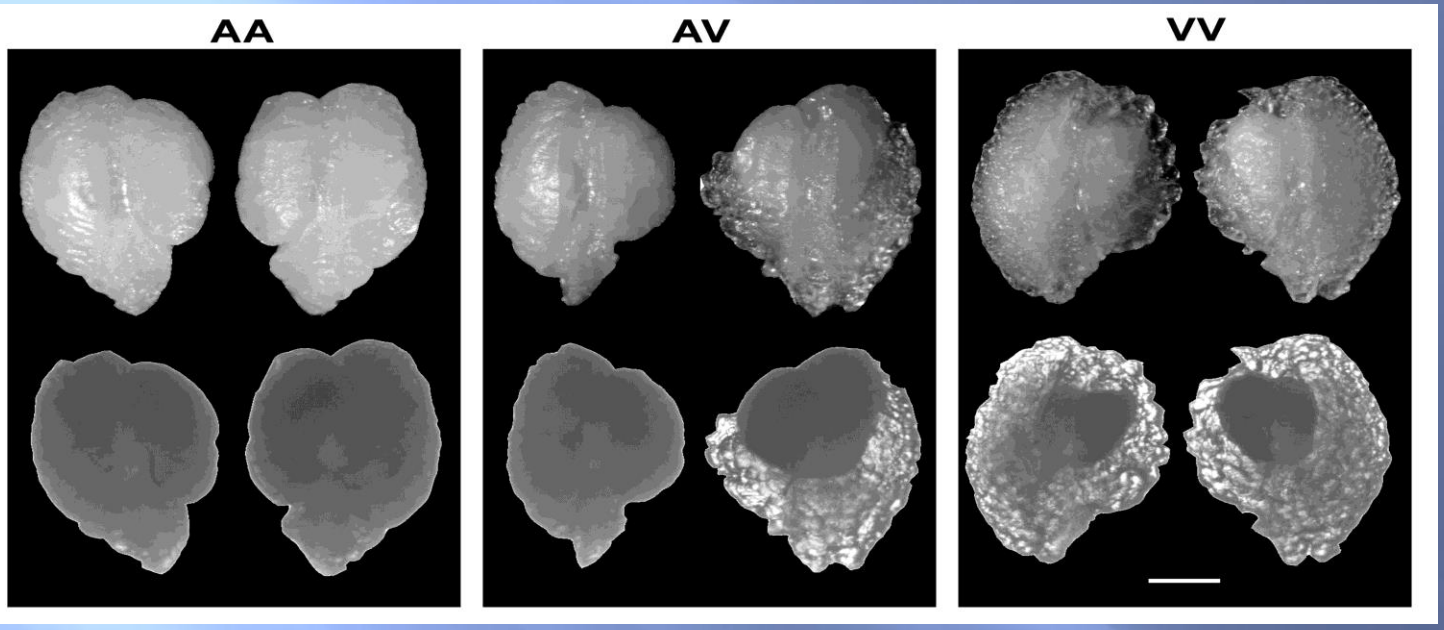
- 40 Fall-run Juvenile Chinook Salmon:
  Coleman National Hatchery, Anderson, CA

- Known to produce fish w/ vateritic sagittae

After testing, fish used for parts . . .

Otolith Type

Fish Placed into 3 groups (blind to ABR Results)



20 (50%) – AA

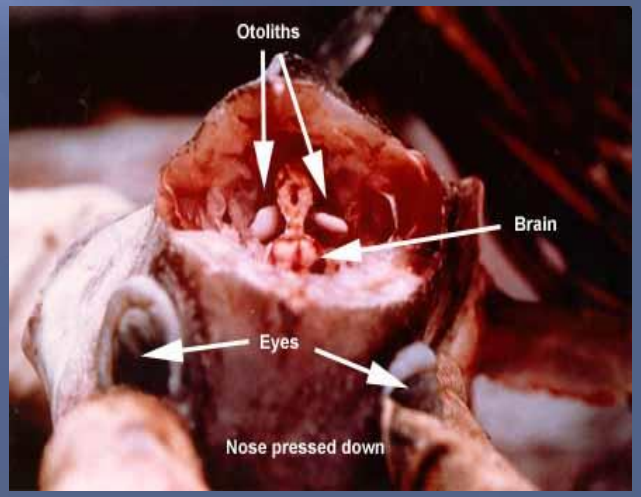
12 (30%) – VV

8 (20%) – AV

Otolith Morphology

To asses the impact of vaterite deposition on the otolith structure

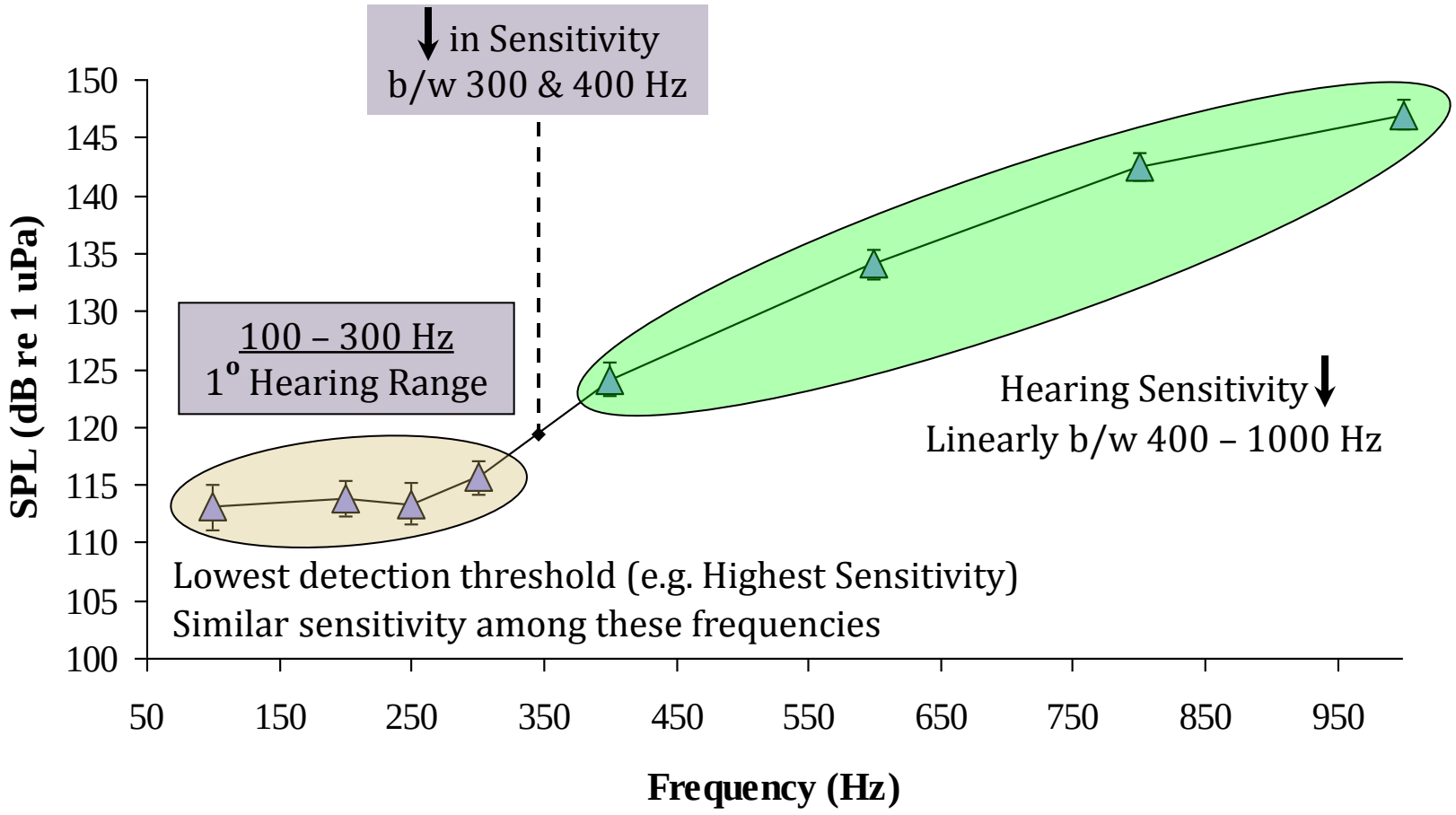
- Area
- Length
- Breadth
- Perimeter
- Circularity Index
- Mass
- Mass : Area
- Volume



Audiograms

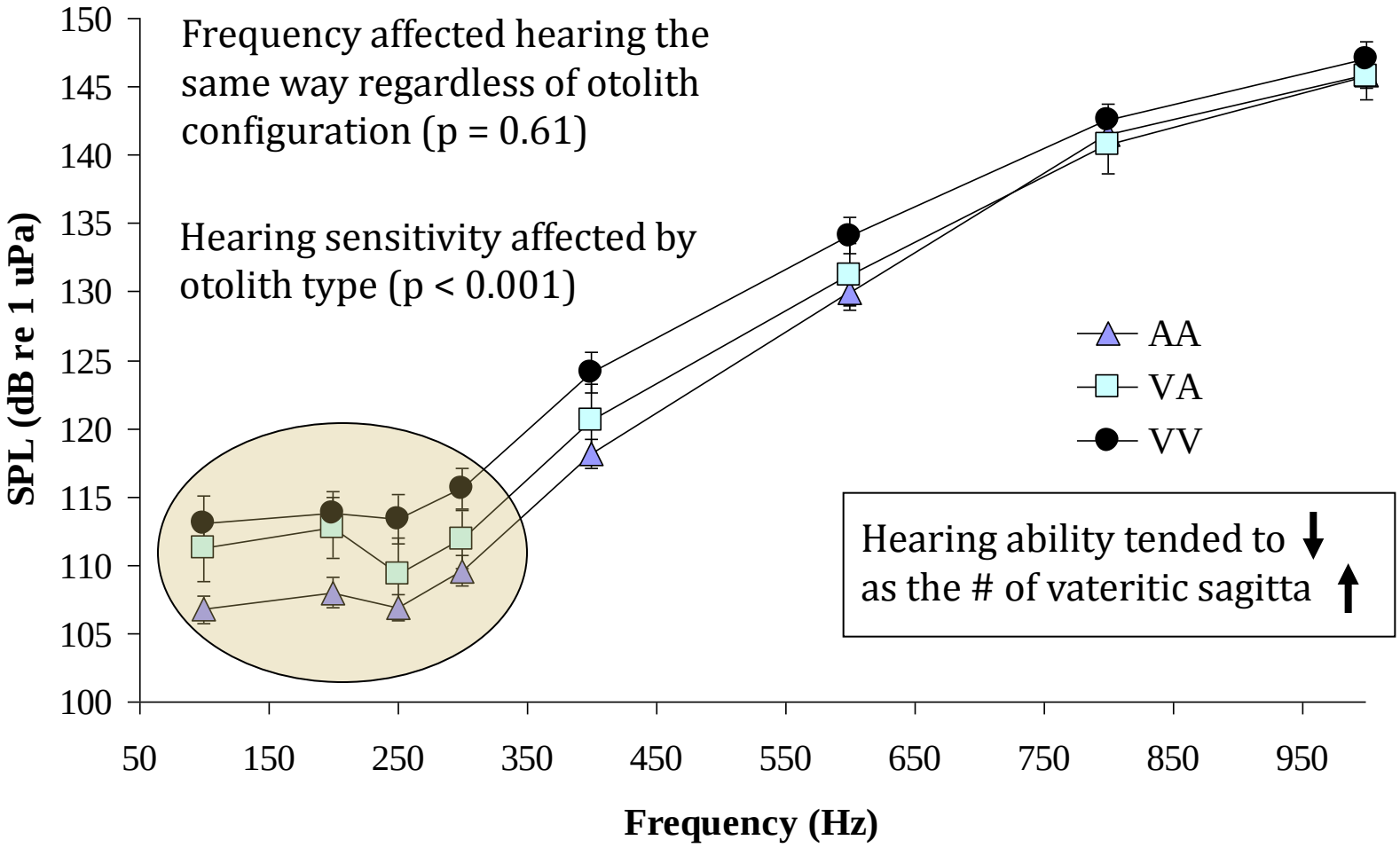
Controls (AA) – Hearing Acuity affected by frequency of signal . . .

NOTE: Lower SPLs = Greater Hearing Sensitivity

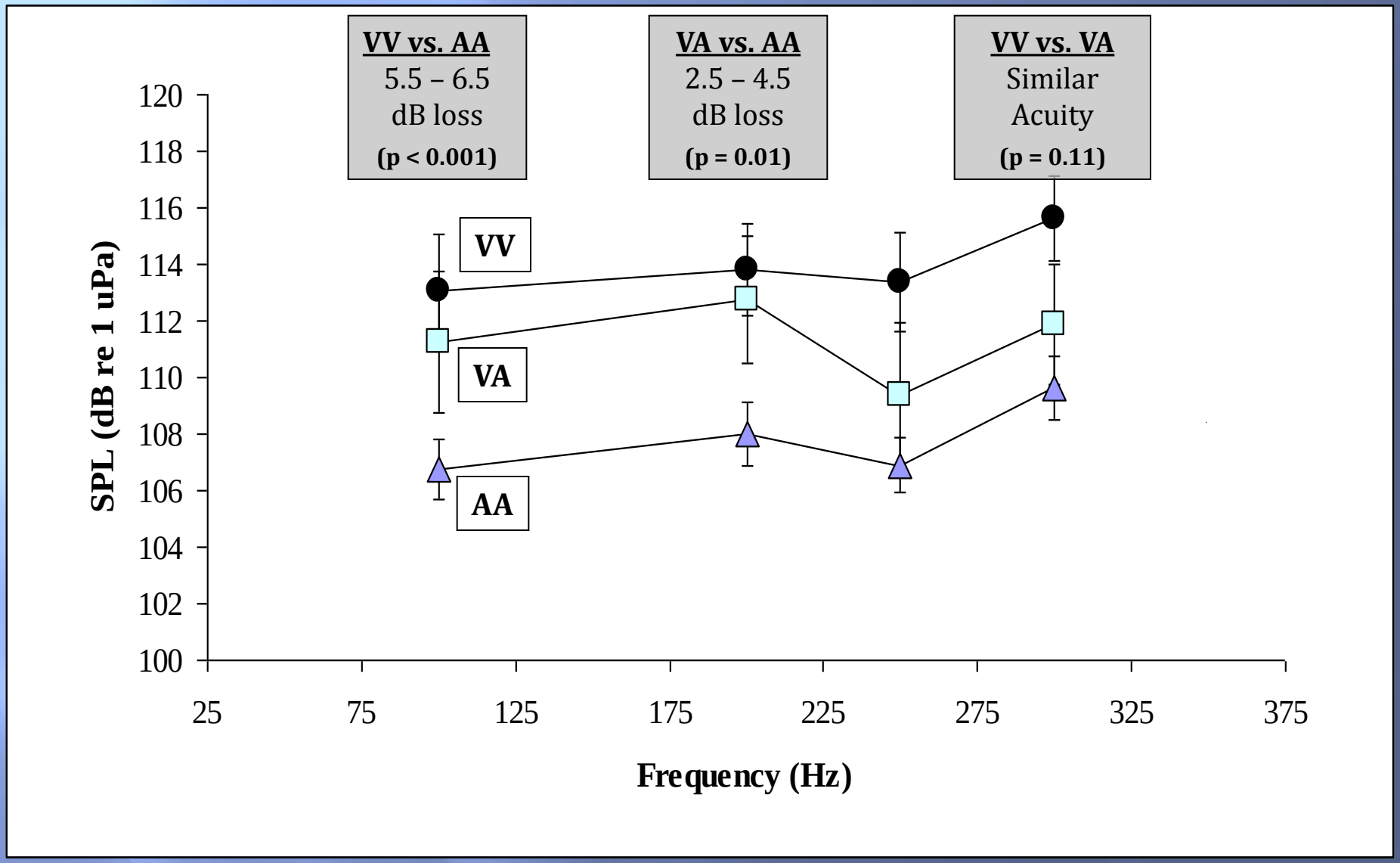


So how did vateritic sagittae affect hearing?

The Big Picture . . .



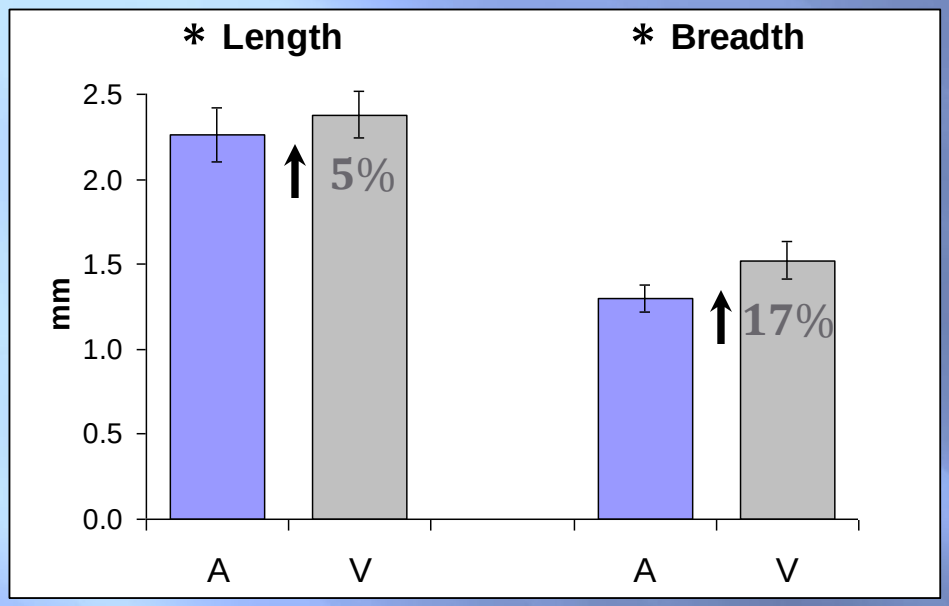
100 – 300 Hz : The Primary Hearing Range

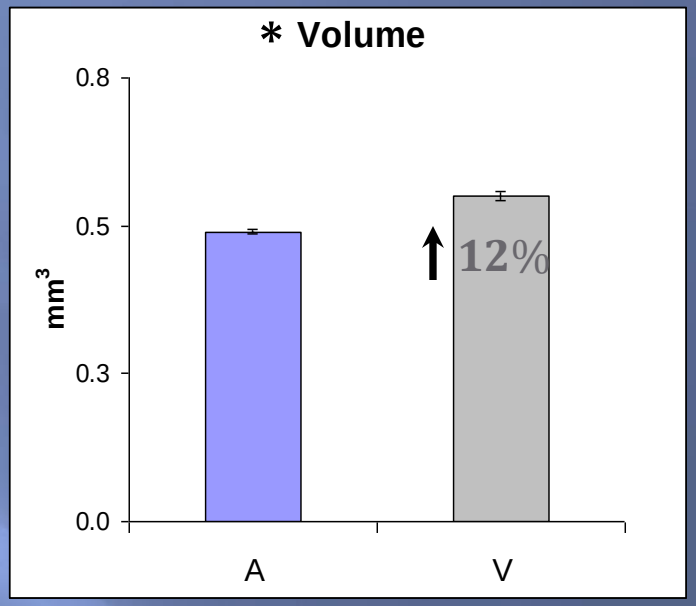


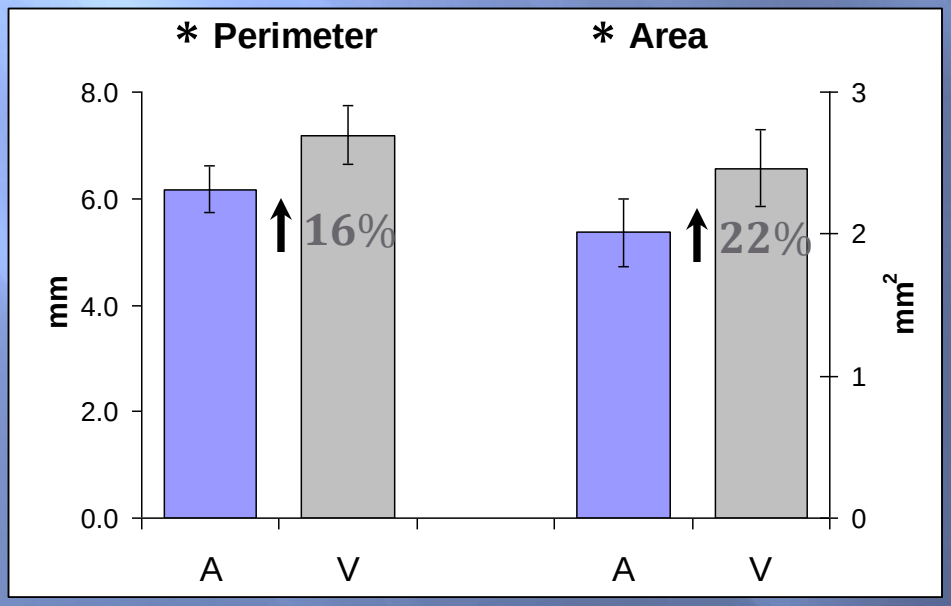
- 1 or 2 vateritic sagittae impaired hearing in the 1° range
- Loss of hearing the same regardless of the # of vateritic sagitta

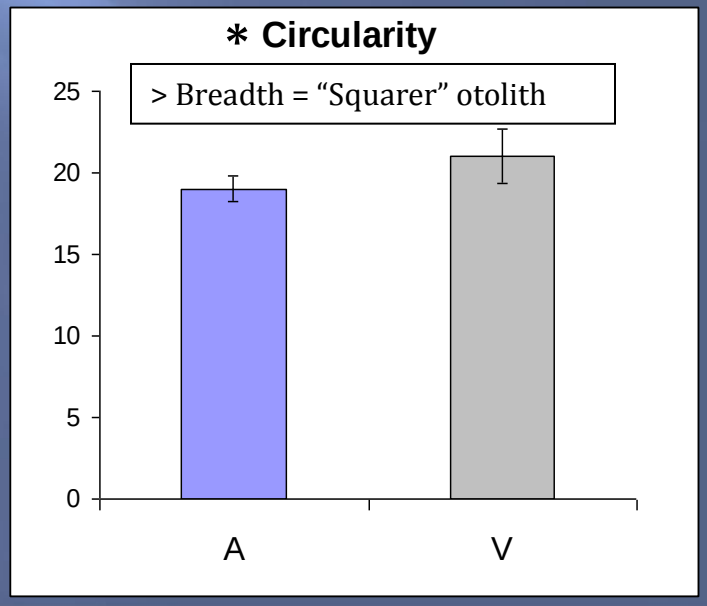
Otolith Morphology

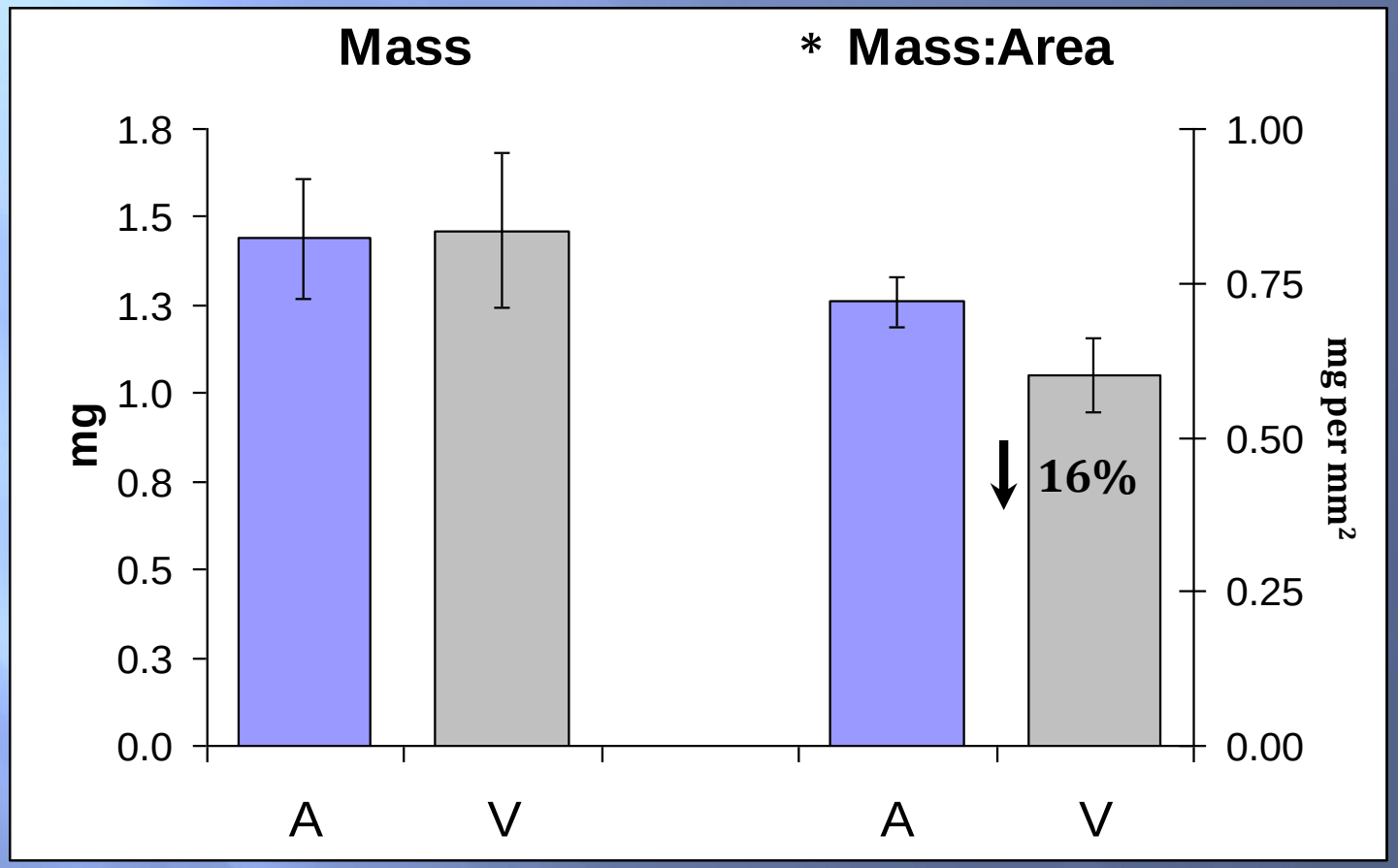
- Vaterite Deposition affected otolith shape











- No difference in mass
- Vaterite were lighter per mm^2

Note RE: **Asteriscus**

- Collected opportunistically
- Examined qualitatively

Ear w/
Normal Sagitta

Normal
Asteriscus

Usually composed of
vaterite in teleosts

Ear w/
Vateritic Sagitta

Absent
Asteriscus

Permanent Loss / Reduction?
Delayed development?

Conclusions

1) Vateritic sagittae were associated with hearing loss, particularly over the most sensitive portion of their hearing range (100 – 300 Hz).

2) Auditory thresholds in the primary hearing range were similar among fish with 1 or 2 vateritic sagitta.

3) Vateritic sagittae were larger, squarer, and less dense than normal otoliths.

4) Reduced asteriscus development was associated with vateritic sagittae.

Hypothesis: The loss of density resulting from vaterite formation prevents the otolith from efficiently stimulating the sensory epithelium, thereby causing a decrease in auditory sensitivity.

Fish otoliths are sensitive to stress.

Hatcheries are expose fish to stress early in their development when they are most vulnerable.

Do captive environments create enough stress to adversely affect other aspects of fish development?

a) Examine the effects of acute and chronic hatchery-induced stress on larval salmon physiology, development, and morphology.

b) Determine the level at which a physiological indicators (e.g. cortisol) corresponds to stress exposure and physical alteration.