Fish Tales & Trails: 30+ Years of Chasing the Elusive Striped Bass

April 10, 2013

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East Carolina University

Presentation Overview

- 1st Decade, 1974-1983 “Everything is known about striped bass, why study it??
- 2nd Decade, 1984-1993 “I get the large-scale movement patterns (and I can pronounce all the French-named watersheds in Atlantic Canada)”
- 3rd Decade, 1994-2003 “Making the Switch from Large-Scale Migration to Regional and Small-Scale Movements
- 4th Decade, 2004-2013 “Exciting Times about small scale movements - the more I know, the less I know. But I am not giving up!”

I Was Smart in Graduate School

- Switched from fish (MS) to shrimp.
- NC State was in the finals when I fell off the NMFS Beaufort Lab seawall (no repeat performance).
- Wilson Laney ran the boat up on the dock at extreme high tide.
- Didn't understand how anyone could find out more about striped bass than was already known.

1st Decade, 1974-1983

Brush With Greatness

- David Whitehurst – Stuanton River State Fish Hatchery.
- Ecological Services Group (TI, NY) – key species were striped bass, American shad, Atlantic tomcod.
- USFWS – Anadromous Fish in the Southeastern US and Recommendations for the Development of a Management Plan
- Richard B. Russell Bldg, Atlanta – most lunch mates had been to Manchester, Iowa

1st Decade, 1974-1983

Unity College in Maine

- Introduced to Dr. Michael J. Dadswell
- Students make great volunteers and good field hands (but eat a lot).
- Canadian graduate students drink all day and stay up all night.
- Terrific stamina – full day drift on a complete tidal cycle.
- No one was working on striped bass or river herring (gaspereau).

1st Decade, 1974-1983

Long Distance Migration Studies

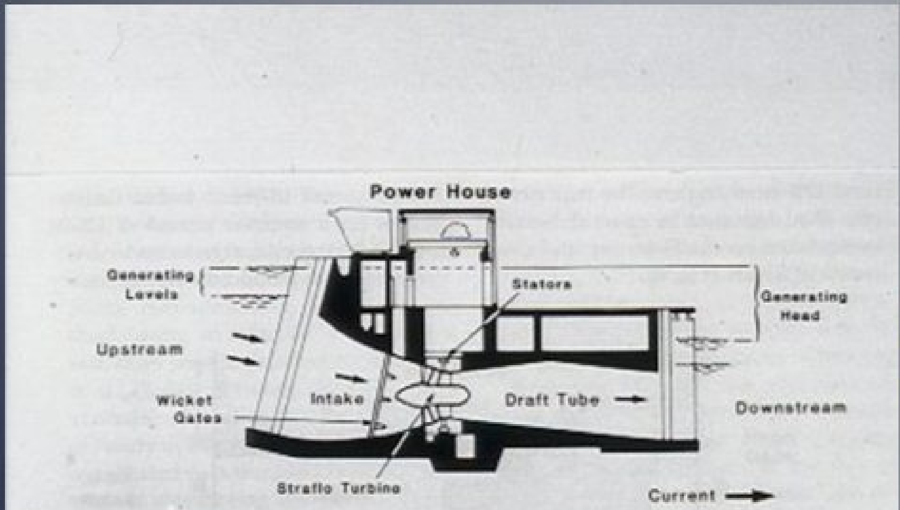


Figure 4. Cutaway view of the STRAFLO turbine at Annapolis Royal.

•Kathy Docktor and Robin Clark, Unity College, 1982

Maritimes and World's Highest Tides

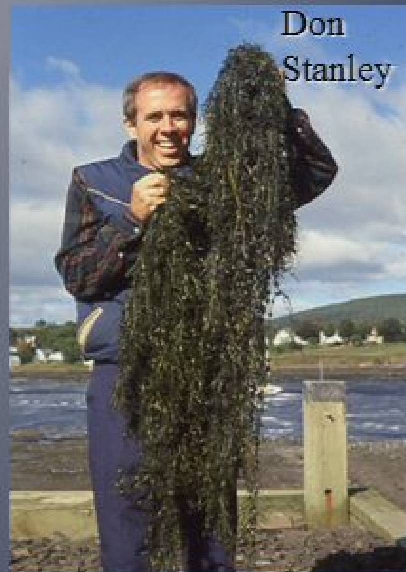
2nd Decade, 1984-1993

Tidal Power Potential

2nd Decade, 1984-1993

Tidal Power, Minas Basin, and Large Scale Migration

Tom going to the weir, Five Islands, NS



2nd Decade, 1984-1993

Tidal Power, Minas Basin, and Large Scale Migration

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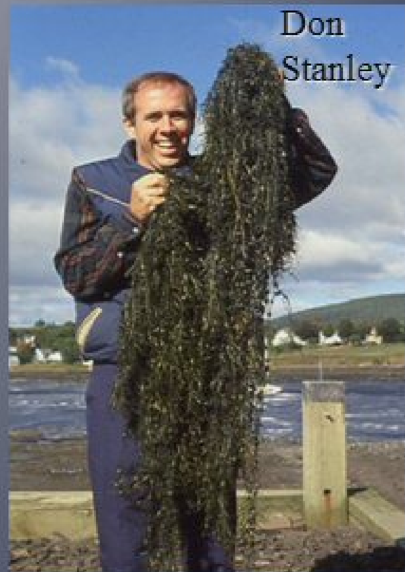
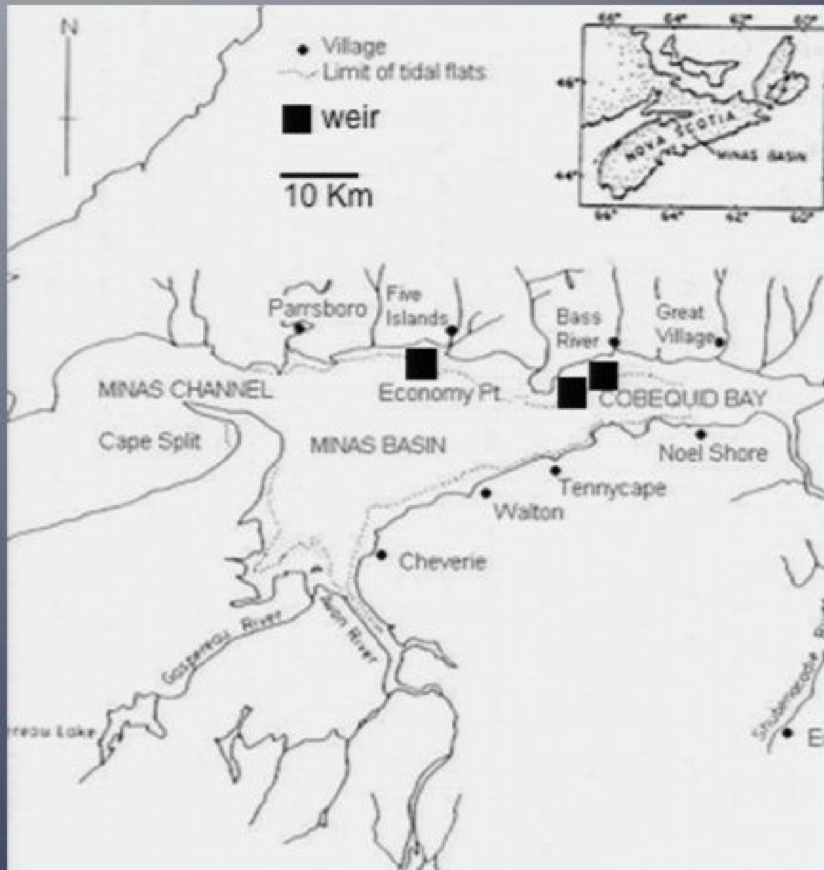


2nd Decade, 1984-1993

Study Site, Methods, Results

- Captures May thru December.
- 1,864 collected in weirs.
- 1,431 released.
- 21.3% recapture rate.
- All recaptures outside the Bay were >390 FL at time of release.
- Fastest – 17.8 km/day to Rhode Island (45 days)
- Annual pattern of recaptures



2nd Decade, 1984-1993

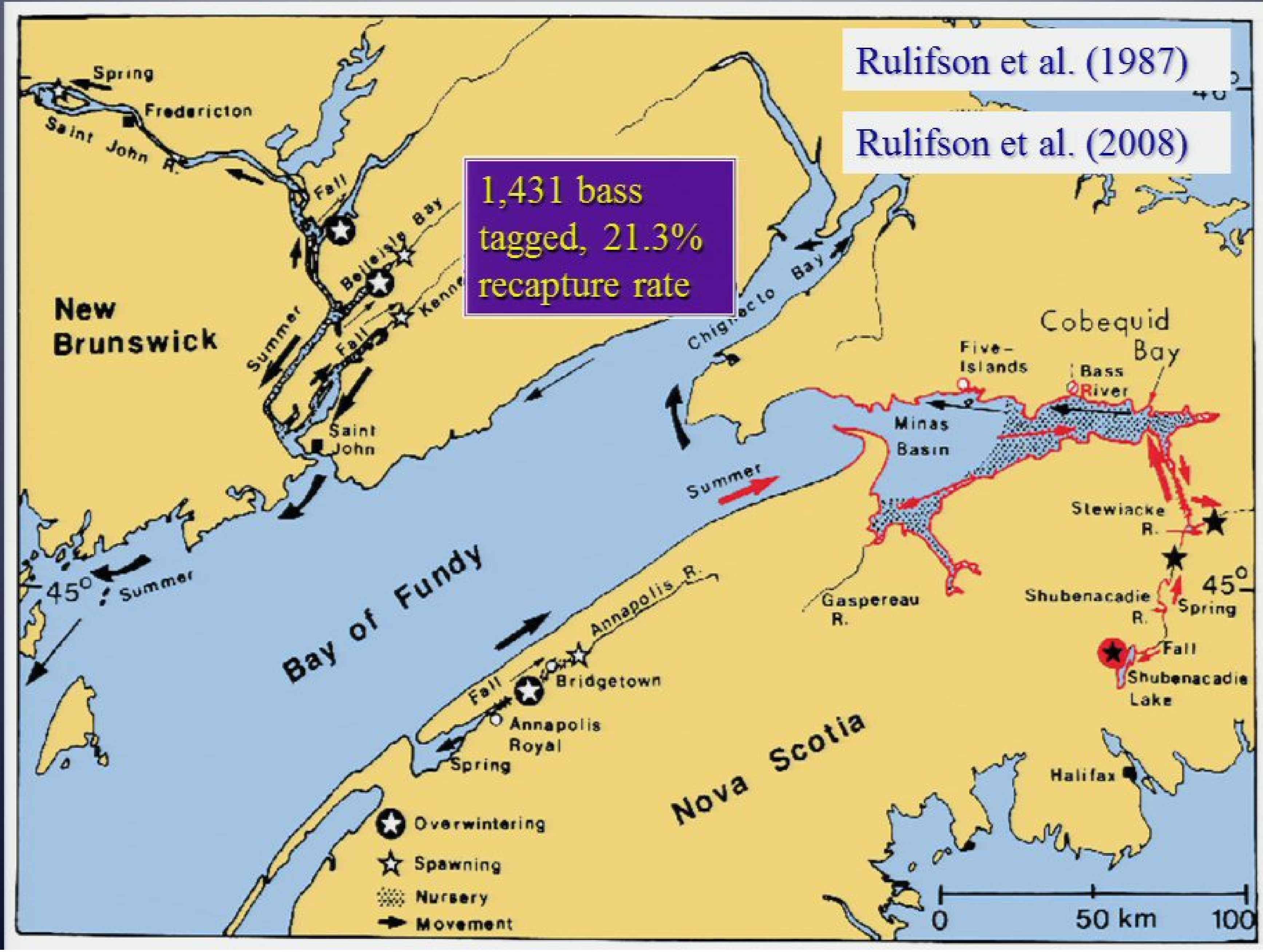
Striped Bass Tagging, 1985-6

Young Sean McKenna (NCDMF, retired)

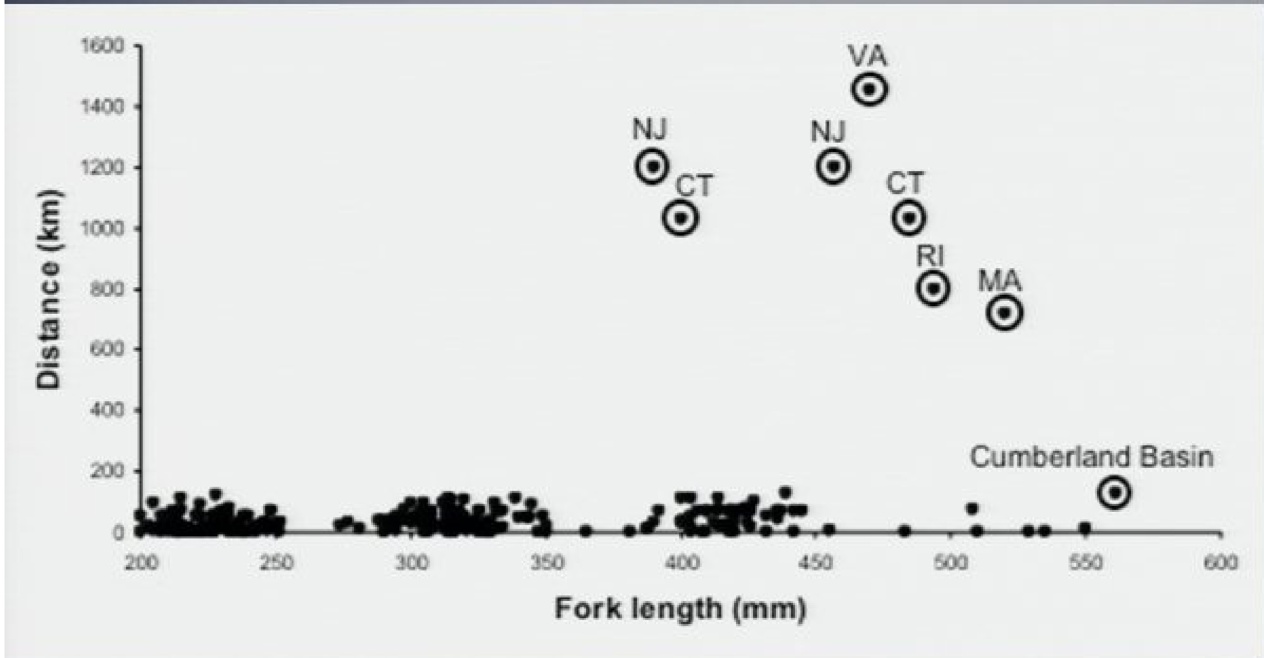
Tom and Gerry, last horse-drawn weir operator in Canada

2nd Decade, 1984-1993

Striped Bass Move Counterclockwise around the Bay, Following Currents



Smaller Striped Bass are Local; Larger are Migratory



Trevor Avery, Acadia Univ., NS

- My technician, Maja Reinhartsen, retrieved the tag from a bass caught by the Shubenacadie River Fisherman's Association drift netters during a by-catch survey.

- Total Length = 107.95 cm
- Fork Length = 105.41 cm ⟸
- Weight = 16.27 kg
- Date = 10-May-2010
- Water temp = 12.8 C
- Mesh size = small (gaspereau nets)

- Tag number 00828 Gerald's Weir
- 39.6 cm FL
- 10.0 cm deep
- Broken lines
- Released October 3, 1985 2200 hours

24 years and 9 months since release. It grew 65.81 cm.

Annapolis River Sportfishery for Striped Bass

- Grant from Tidal Power Corporation to study striped bass migration into/out of Annapolis River, NS.
- Patrick Harris (ECU, Biology).
- Tag and release.
- Two fish released one day apart caught in the Connecticut River together.

Harris and Rulifson 1988

Young Patrick Harris, my first graduate student

Roanoke River Studies, 1984-1991

- Sampled fixed stations in western Albemarle Sound, delta, and mainstem Roanoke River.
- Sampling April thru June each year – mostly at night
- Chlorophyll a
- Phytoplankton
- Zooplankton
- Larval fish – targeted striped bass and white perch, but all were collected.
- Supposedly the largest food web database anywhere.

ICMR CONTRIBUTION SERIES, NO. ICMR-92-07

FOOD and FEEDING of YOUNG STRIPED BASS in ROANOKE RIVER and WESTERN ALBEMARLE SOUND, NORTH CAROLINA, 1984-1991

VOLUME I - TEXT

Completion Report for Project F-27, Striped Bass Investigations
to North Carolina Wildlife Resources Commission

R.A. RULIFSON, J.E. COOPER, D.W. STANLEY, M.E. SHEPHERD, S.F. WOOD, AND D.D. DANIEL

2nd Decade, 1984-1993

Roanoke River Studies, 1984-1991

Don Stanley and John Cooper on R/V Pirates Pride

One concern was larvae drifting past the Weyerhaueser Pulp and Paper Plant in Plymouth

2nd Decade, 1984-1993

Roanoke River Studies, 1984-1991

William Bell and John Cooper on R/V Serrana

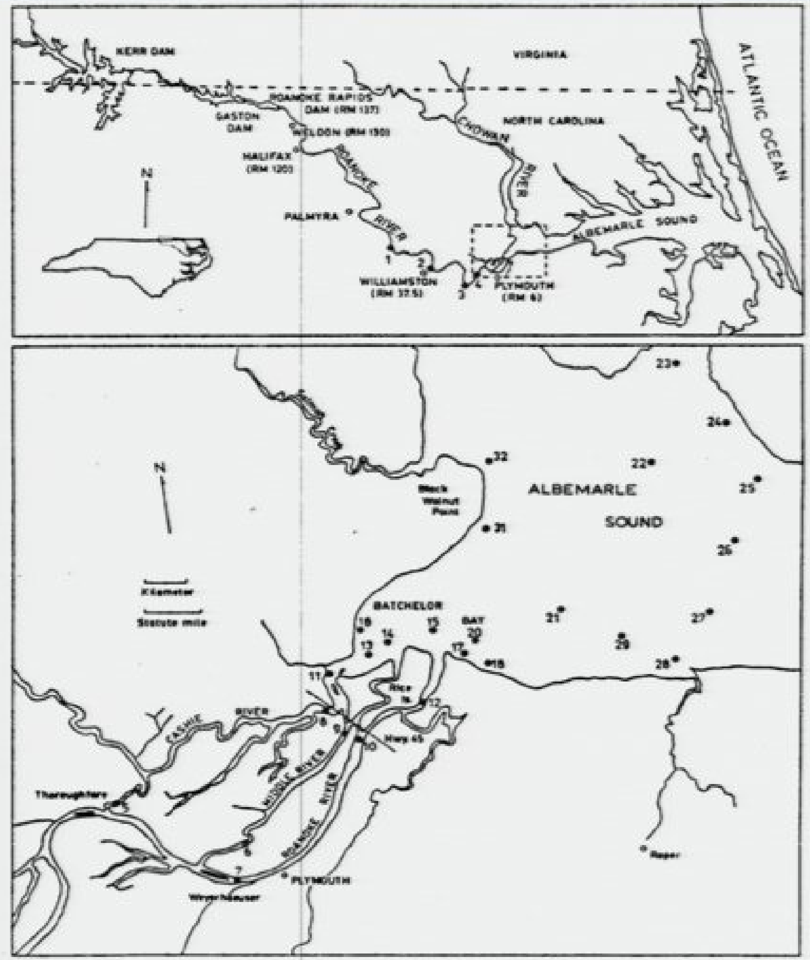
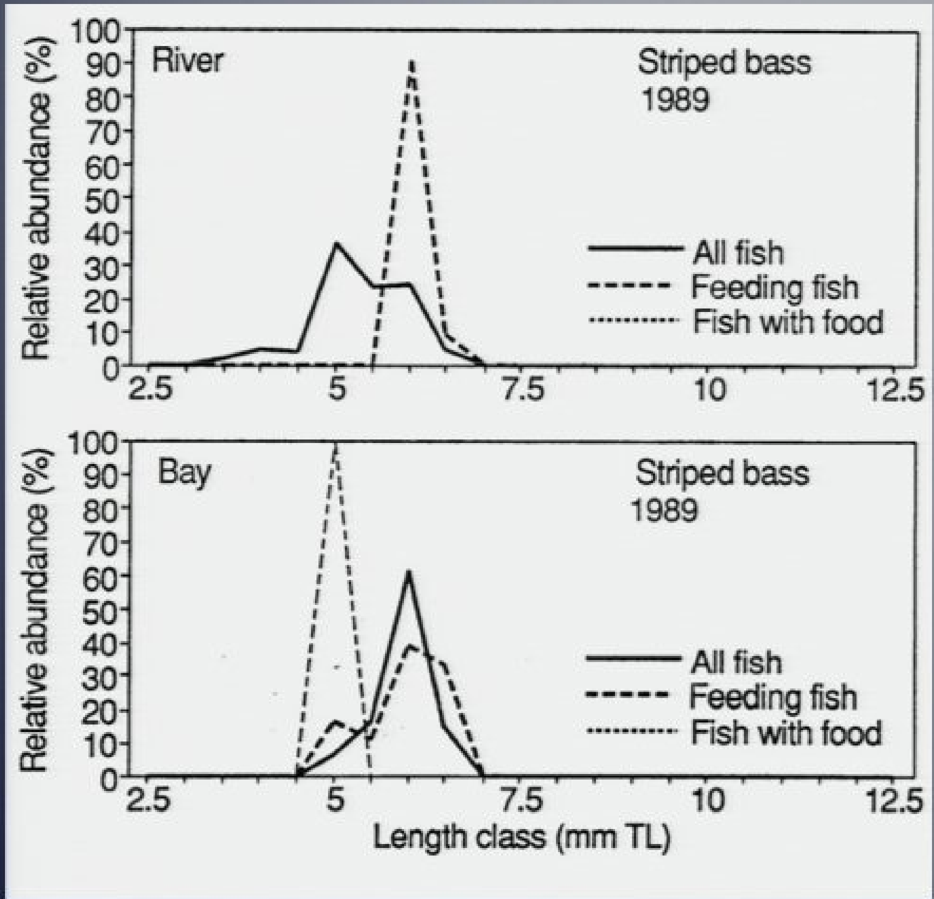


Figure 2. Map depicting the locations of sampling sites used during the period 1984-1991. Not all sites were sampled each year.

The Match/Mismatch Hypothesis was Present in the Roanoke/Albemarle in Some Years



Feeding fish in 1989 (a flood year) were mismatched with food source.

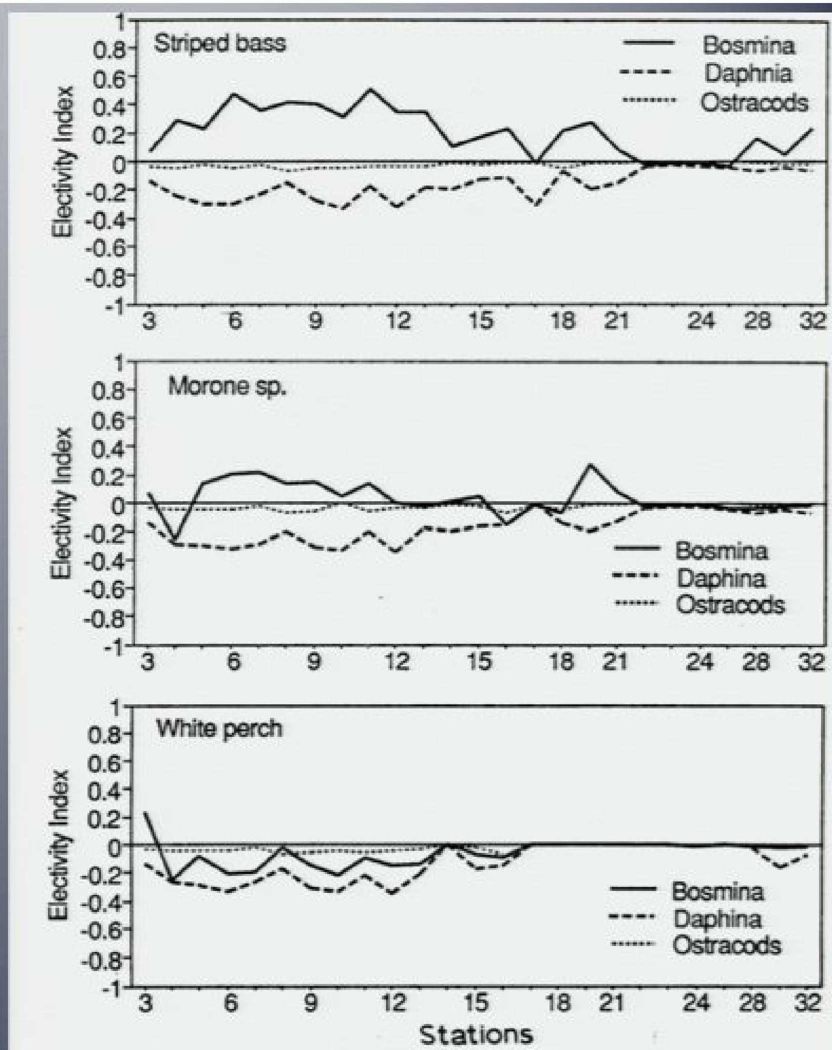


Figure 19. Strauss' linear index of electivity calculated for larval striped bass, white perch, and undifferentiated *Morone* larvae and six zooplankton taxa. Positive value indicates preference; negative value indicates avoidance or inaccessibility.

Strauss feeding electivity indices showed that striped bass may have outcompeted white perch for Bosmina (a zooplankton).

2nd Decade, 1984-1993

Estimated Egg Viabilities Were Dropping over Time

Database of W.W. Hassler, NCSU

2nd Decade, 1984-1993

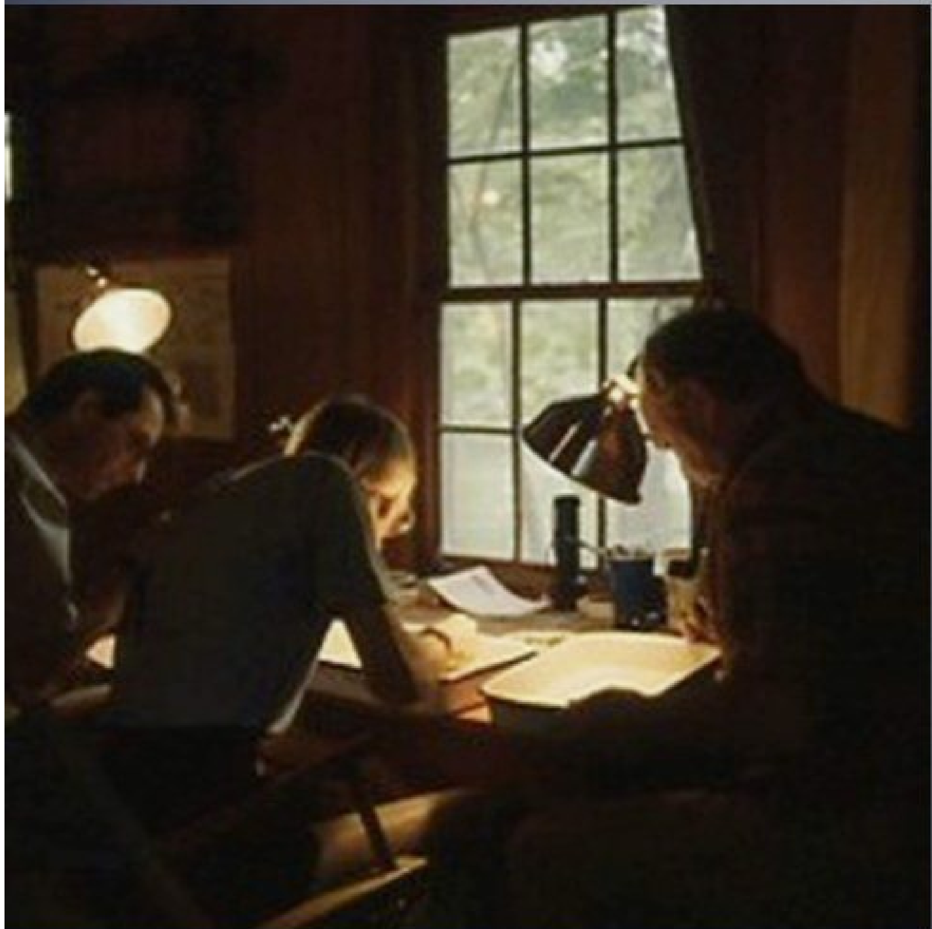
Roanoke Striped Bass Egg Studies (W.W. Hassler, 1956-1987; Rulifson 1988-1992)

- Dr. Hassler (NCSU) had been sampling the river for spawning activity each year.
- Charles Manooch (NMFS, retired), Bill Hogarth, Norman Hill, others
- Egg viability was declining over time.
- Estimate of spawned eggs did not match the estimated adult Spawning Stock Biomass.

Barnhill Landing, downstream of Halifax, NC, 1989

2nd Decade, 1984-1993

Rulifson Egg Studies 1988-1992



Rulifson, Stuart Laws, and Chuck Manooch count eggs, 1989

Stuart Laws brings in the egg nets

Mark Bowers Shows the Difference Between a Hassler net (left) and Our Nets (right)

- Samples were taken every 6 hours for 60 days
- Nets were set for 5 minutes in the current, brought half-way up after 2 min 30 seconds (oblique tow).
- Cross-sectional area of the river was recorded as well as water velocity.
- All eggs were counted in each net (high was >19,000 in one net). PIZZA NIGHT!

Rulifson Egg Studies, 1988-1992

Figure 2. Roanoke River watershed downstream of Roanoke Rapids Reservoir showing the historical sampling stations for striped bass eggs: Palmyra (1959-60), Halifax (1961-74), Barnhill's Landing (1975-81, 1989-1990), Johnson's Landing (1982-87), and Pollock's Ferry (1988).

Barnhill Landing, and the other historical locations sampled by W.W. Hassler.

Some days water level was so high that fish were spawning in the bushes, and then were caught there as waters receded.

Results from 1990

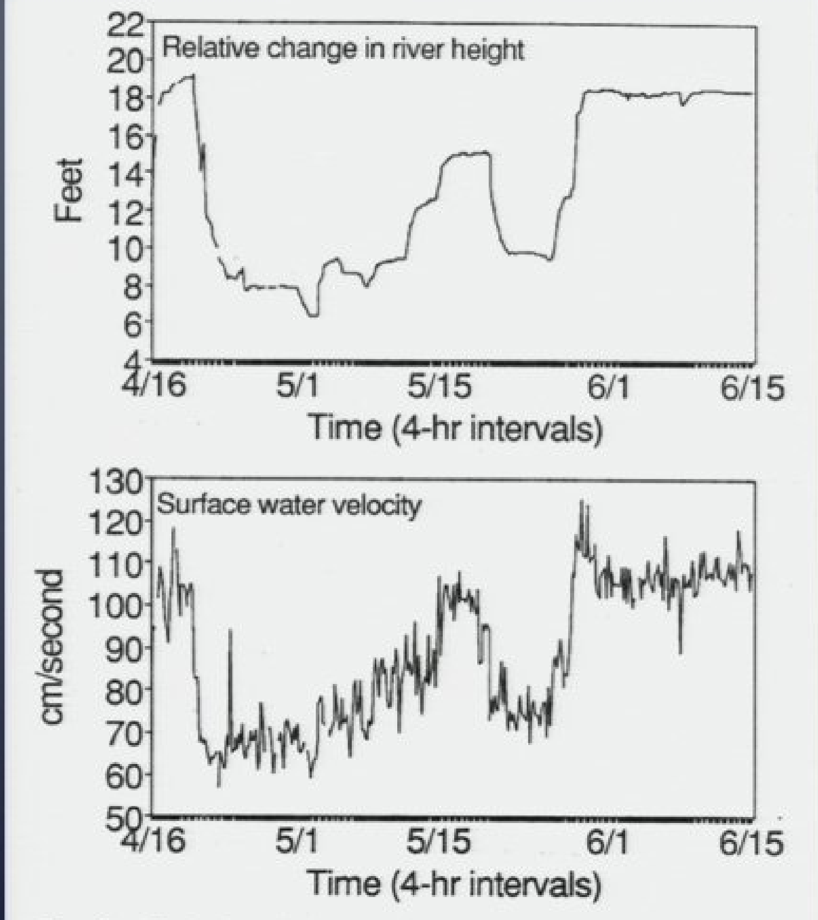


Figure 9. Relative change in river height (ft) and corresponding surface water velocity at Barnhill's Landing, Roanoke River, NC, for the period 16 April to 15 June 1990.

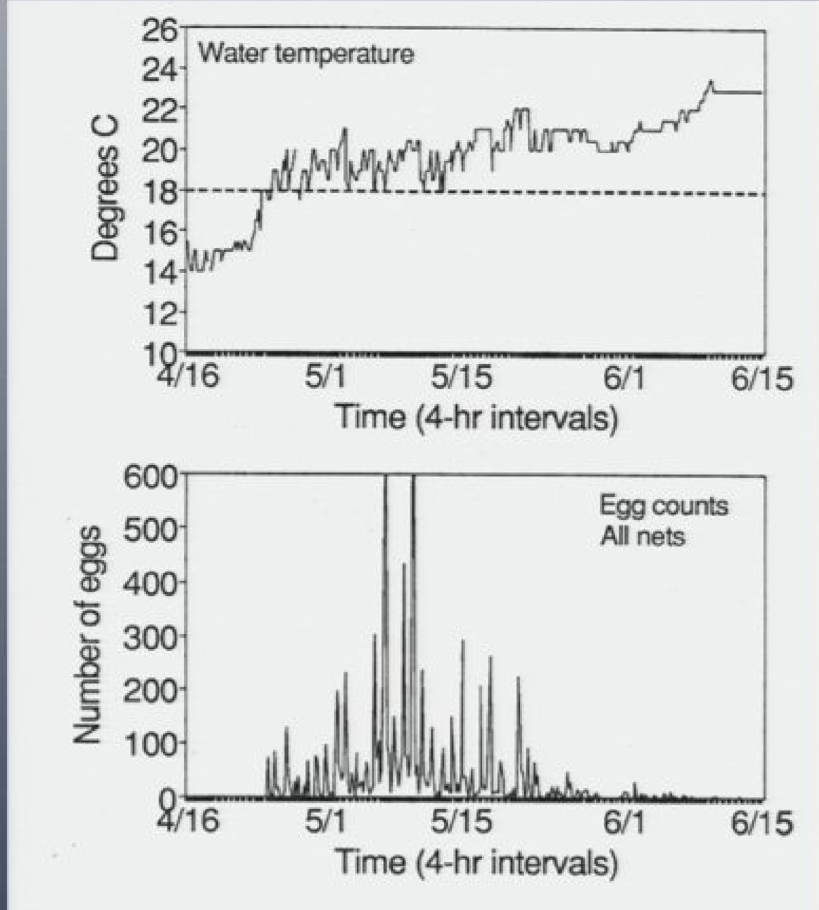


Figure 6. Number of striped bass eggs collected in all nets during each trip, and corresponding water temperatures (°C) at Barnhill's Landing, NC, for the period 16 April to 15 June 1990.

Important Results

- Agencies realized importance of regulating the flow from the Roanoke Rapids Dam upstream during the spawning season.
- Spawning initiated at 18 C.
- Spawning would cease if water releases drop river temperatures below 18 C (hypolimnetic release from the dam upstream).
- Some years all eggs would break in the stream (oil on surface, smelled fishy).

2nd Decade, 1984-1993

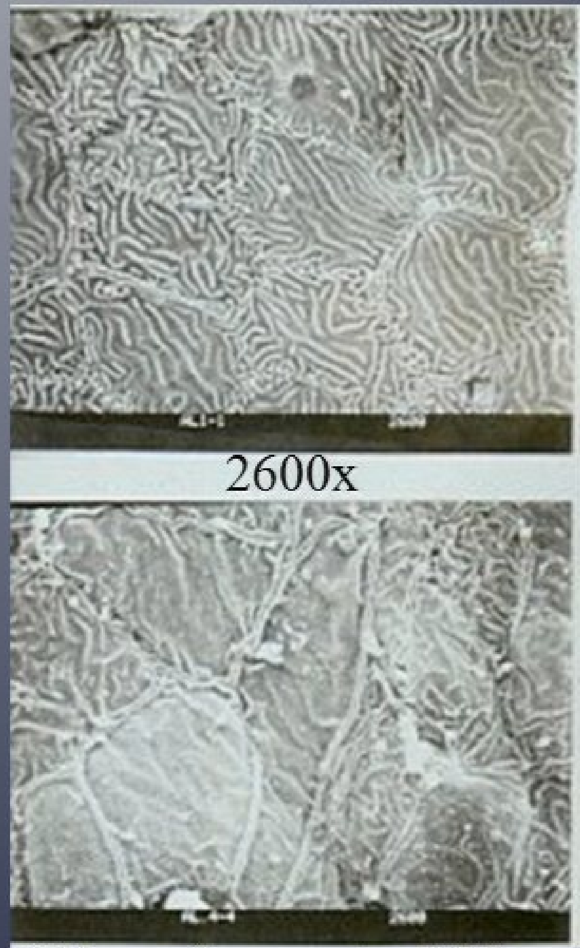
- Reservoir releases changed water quality rapidly – pH, conductivity, water temperature, turbidity, water depth.
- Adult spawning fish coming upstream need stability in water conditions in order to choose best spawning location (close to dam in high flow years, and farther downstream in low flow years).

Mark Bowers and Stuart Laws count eggs

Peter Dorton Thesis and Starvation Experiments

- Acid waters and monomeric aluminum naturally present in swampy water were hypothesized to cause mortality in larval striped bass
- Bass larvae start to eat at 4 days
- Day 6 - retinal tissue of eye and hemopoetic tissue deteriorate.
- Day 10 – muscle fiber bundles are loose, digestive tract colllapsed.

Collapse of microridge structures on the epidermis (gills are not functioning at this stage)



20 hours of exposure to pH 7.5 (above) and pH 5.5 (below) in aluminum chloride solution.

2nd Decade, 1984-1993

The Blackback-Greenback Phenomenon

- 1992 –Scott Woods goes to Stewiacke, Nova Scotia to check out these green and black striped bass.
- The phenomenon is true, and is in other Gulf of St. Lawrence watersheds as well.
- 1994 – we send a team to determine the reasons behind this phenotypic difference.

Striped Bass Spawning in a Tidal Bore River

- The Shubenacadie River is the headwaters of Cobequid Bay (the inner portion of Minas Basin).
- The headwater is Shubenacadie Grand Lake near Halifax, NS.
- Two spawning populations of striped bass were here historically.
- Fishermen always talked about green fish and black fish.
- This is the only river documented that has a spawning population of striped bass in a tidal bore river.
- River flows downstream for 11 hours, then upstream for 1 hour.
- Specialized boats are used to cope with harsh conditions – whirlpools, standing waves, strong currents.

Tidal Bore River Studies - 1994

- We used the same nets and same boat as in the Roanoke egg studies.
- Boat was V-hull and 4 feet too long.
- Also motorized – most fishermen used oars and drifted with current.
- We sampled for eggs every 1.5 hours on 12-hour or 24-hour shifts.
- Every adult fish was sampled in the fish house.

Kitty Tull, Harry Dickie, and Lee Paramore - 1994

We Lived in a "Green House"
Home Sweet Home

3rd Decade, 1994-2003

The commercial fishermen had this sign painted in our honor and installed it on the front door of the greenhouse, awaiting our return (1996?)

3rd Decade, 1994-2003

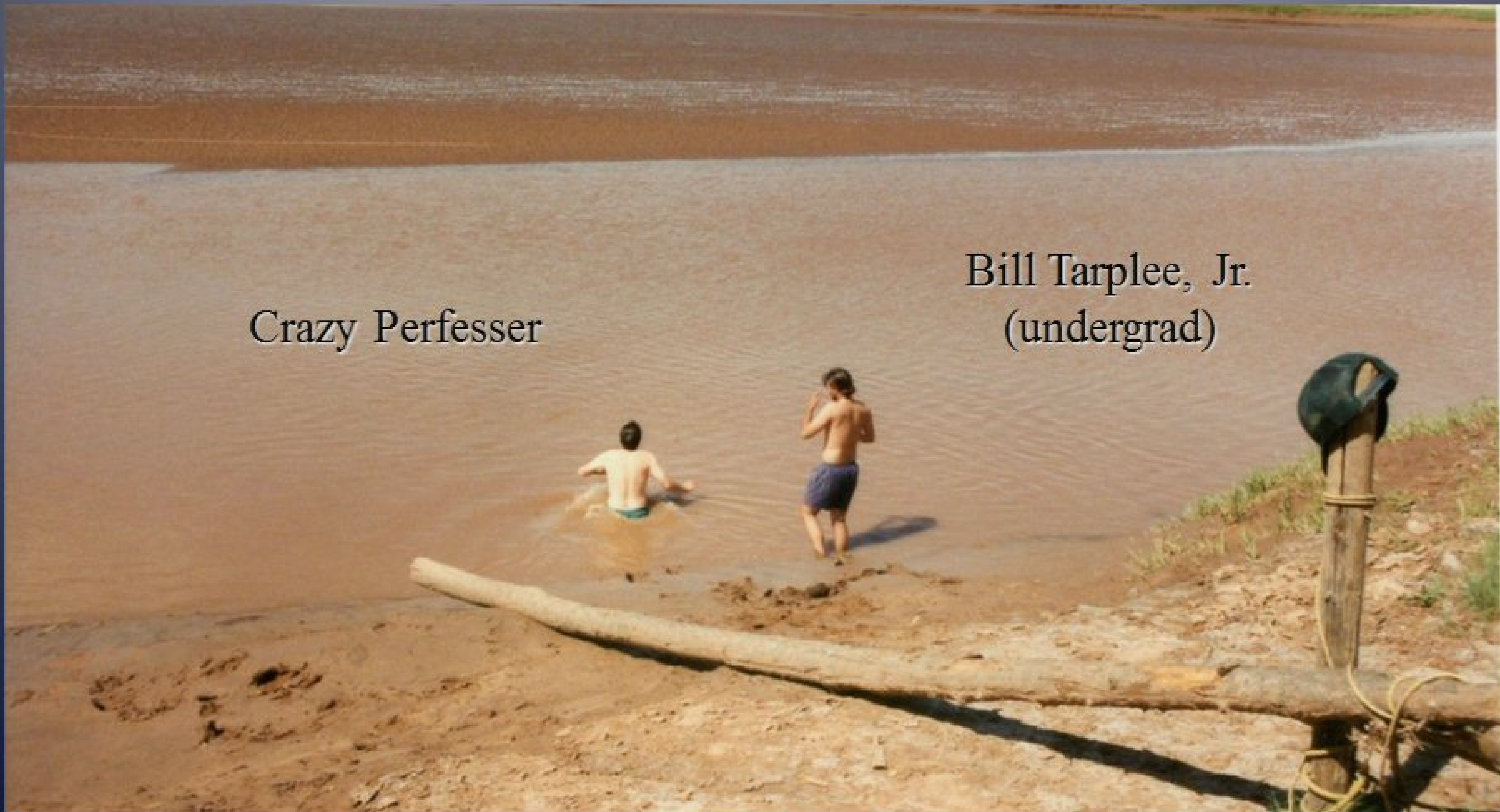
Searching on the Small Scale for Migratory Patterns

- Should we look at the population level for small movements, or at the individual level?
- All students leaving a classroom, vs individuals within that class.
- What should we use as "criteria" to determine markers as measuring "the common" as opposed to "the unique"?

Mint Museum, Charlotte

3rd Decade, 1994-2003

Setting up for the Egg Study – measure the distance across during low tide



3rd Decade, 1994-2003

Setting up for the Egg Study – measure the distance across during low tide

3rd Decade, 1994-2003

Setting up for the Egg Study – This area had quicksand

3rd Decade, 1994-2003

Results of the Egg Study

- Striped bass spawned at 18° C on a neap tide.
- Spawning took place upstream in the Stewiacke River.
- Eggs drifted downstream –
  - <10 hrs old, then
  - Upstream (no sample during tidal bore), then
  - Downstream, mix of 10-18 hrs old, plus < 10 hrs old.

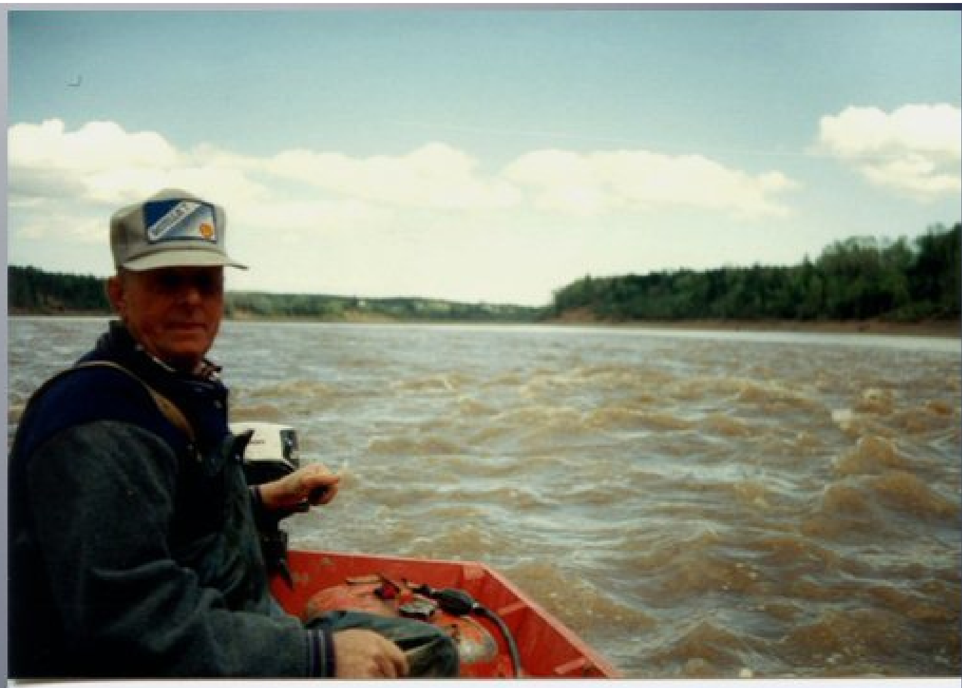
Eggs left the samples at about 40 hrs old.

WHERE DID THEY HATCH?

WHERE ARE THE LARVAE AND JUVENILES?

Ralph Meadows, fisherman, and Kitty Tull count eggs

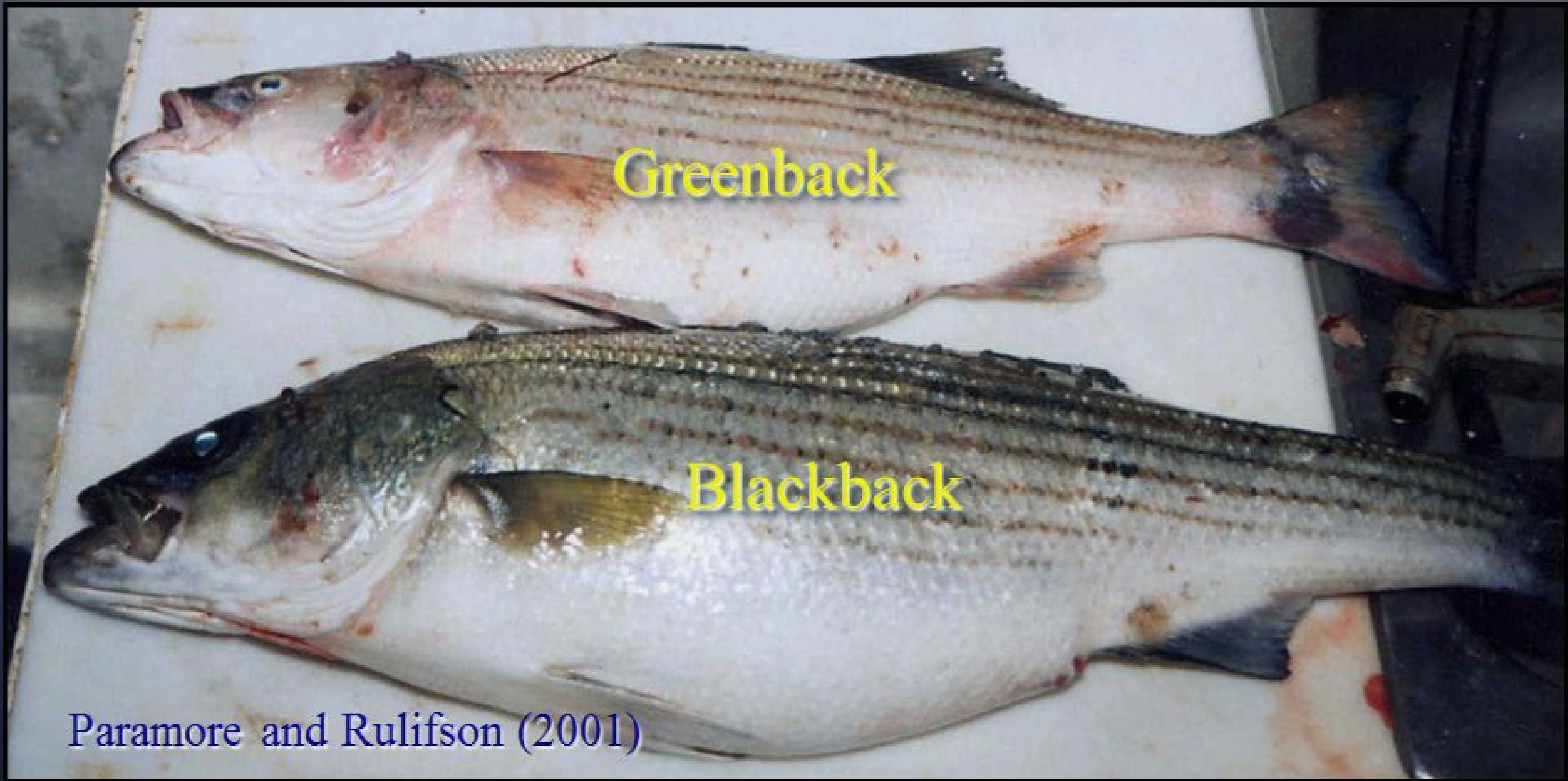
Use Multiple Methods to Increase Power of Population Discrimination



Multiple methods can corroborate evidence of migration from different angles.

- Food habits (short term, hours to a day)
- Tissue fatty acids (months)
- Genetics (differences within/among populations)
- Trace element deposition in otoliths (lifetime)

Shubenacadie/Stewiacke Population has Two Phenotypes



This "Greenback/Blackback phenomenon" was also reported to me in the Miramichi and other Gulf of St. Lawrence watersheds by commercial fishermen

Paramore and Rulifson (2001)

Stomach Contents of Striped Bass

Food item	Combined		Black		Green		Mottled*	
	A	B	A	B	A	B	A	B
Cod sp.	30.0	18.3	71.4	61.9	33.3	6.2	75.0	28.3
Alewife	13.3	63.6	0.0	0.0	66.6	91.1	50.0	17.6
Blueback herring	3.3	10.0	0.0	0.0	0.0	0.0	25.0	51.7
Stickleback sp.	6.7	2.2	28.6	19.6	0.0	0.0	0.0	0.0
Anchovy sp.	6.7	0.5	28.6	12.5	0.0	0.0	0.0	0.0
American eel	6.7	0.5	28.6	3.1	0.0	0.0	0.0	0.0
Flounder sp.	3.3	0.5	0.0	0.0	33.3	1.5	0.0	0.0
Fish parts	30.0	4.4	85.7	2.9	33.3	1.2	25.0	2.4

A = % occurrence **B = % by weight**

*External color patterns must be ephemeral; rate of change unknown.

Fatty Acids in Tissues from Two Phenotypes

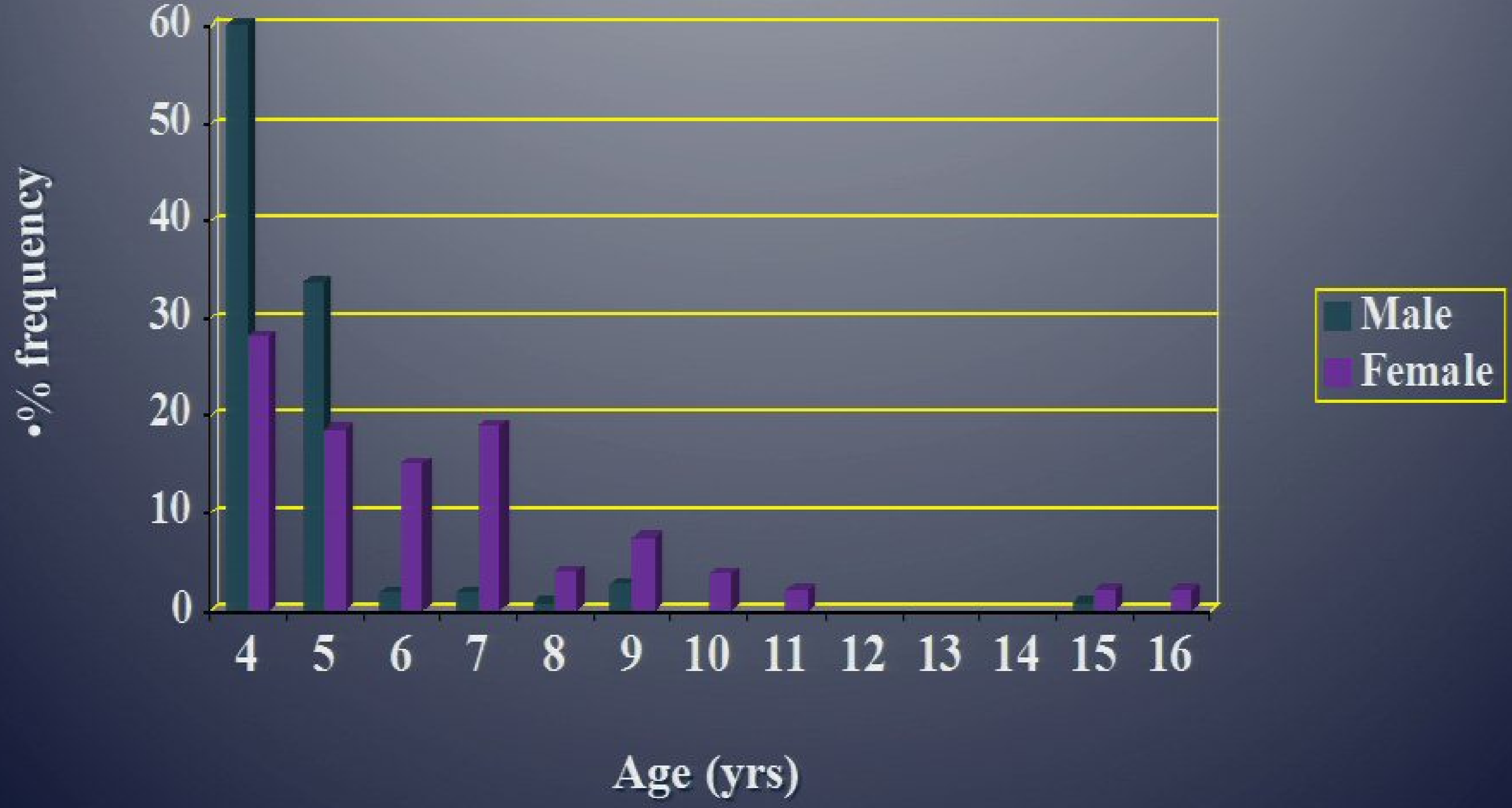
Fatty Acids that were significantly different based on independent t-test with $p<0.05$. SE in ( ).

Phospholipids:	Blackbacks (n=4)	Greenbacks (n=4)
• 20:4n6	6.1%	2.8%
(FW food web)	(1.1)	(0.2)
• 20:5n3	10.5%	14.0%
(Marine food web)	(0.6)	(1.2)

Neutral lipids: No significant differences detected.

Gallagher et al. (1998); Paramore and Rulifson (2001)

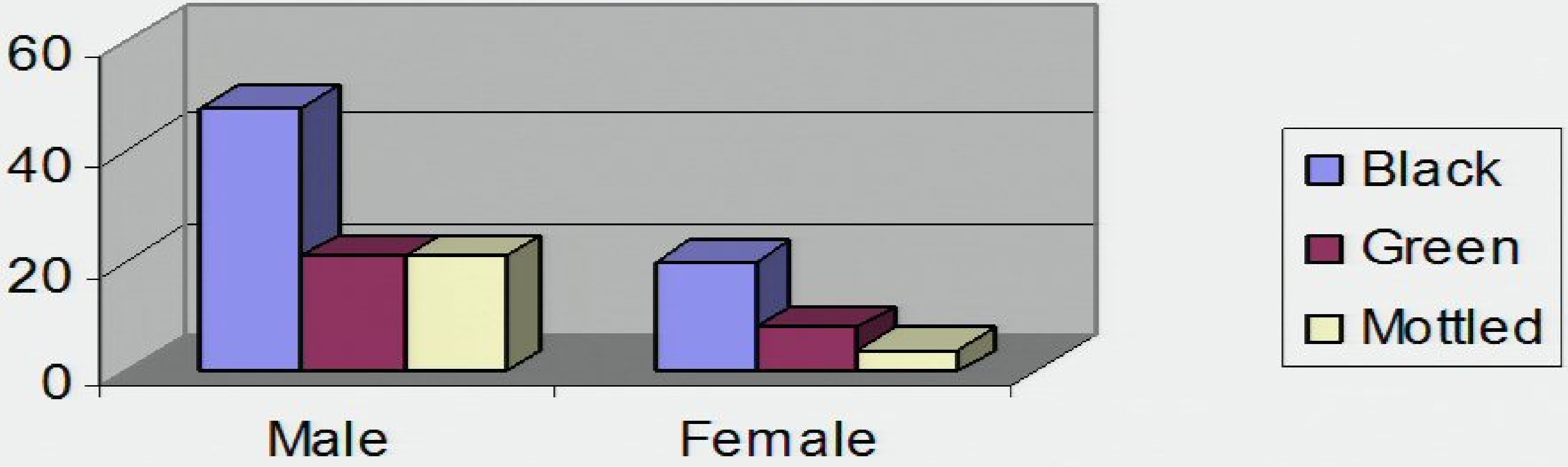
Age Frequency Distribution Does not Tell Us Contingents Based on Length



Paramore and Rulifson (2001)

Period 1

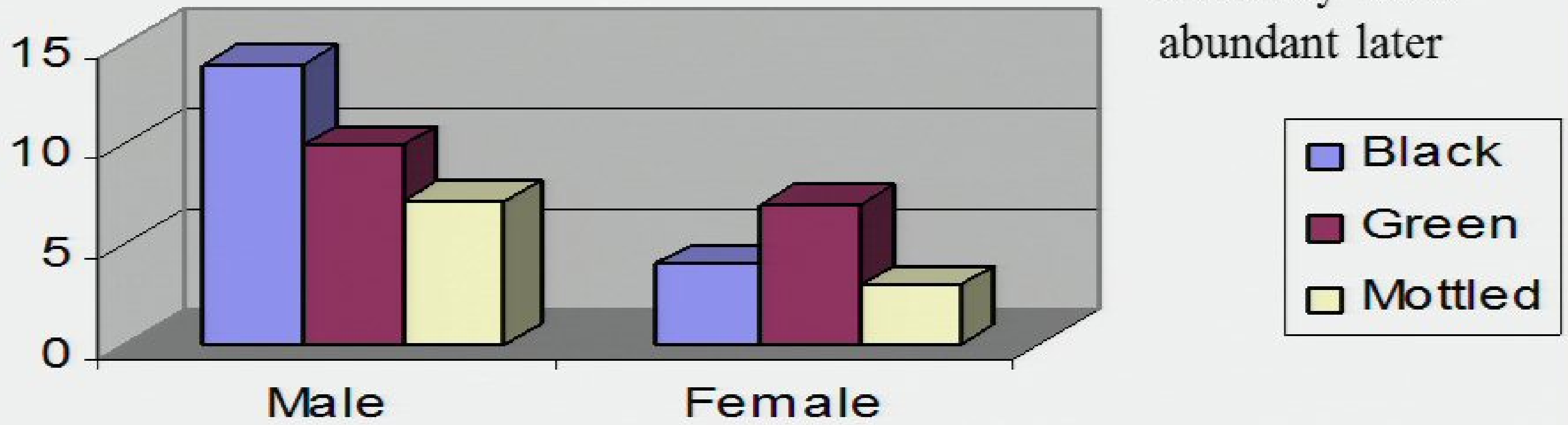
May 11-24



Period 2

May 25-June 7

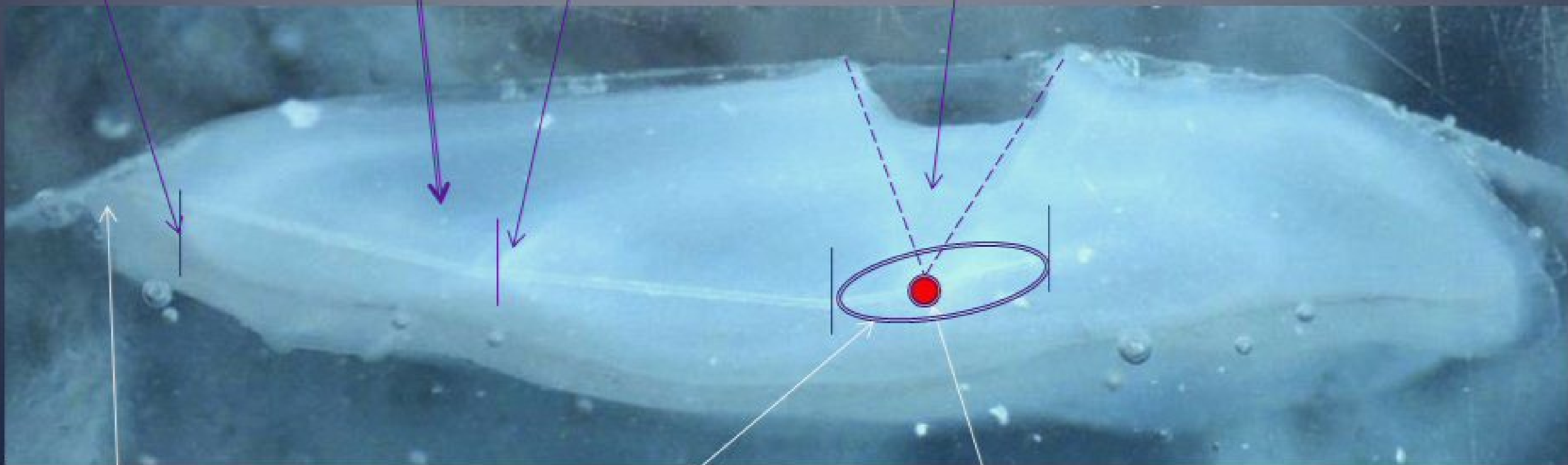
Green fish were relatively more abundant later



And then we remember that fish have ears!

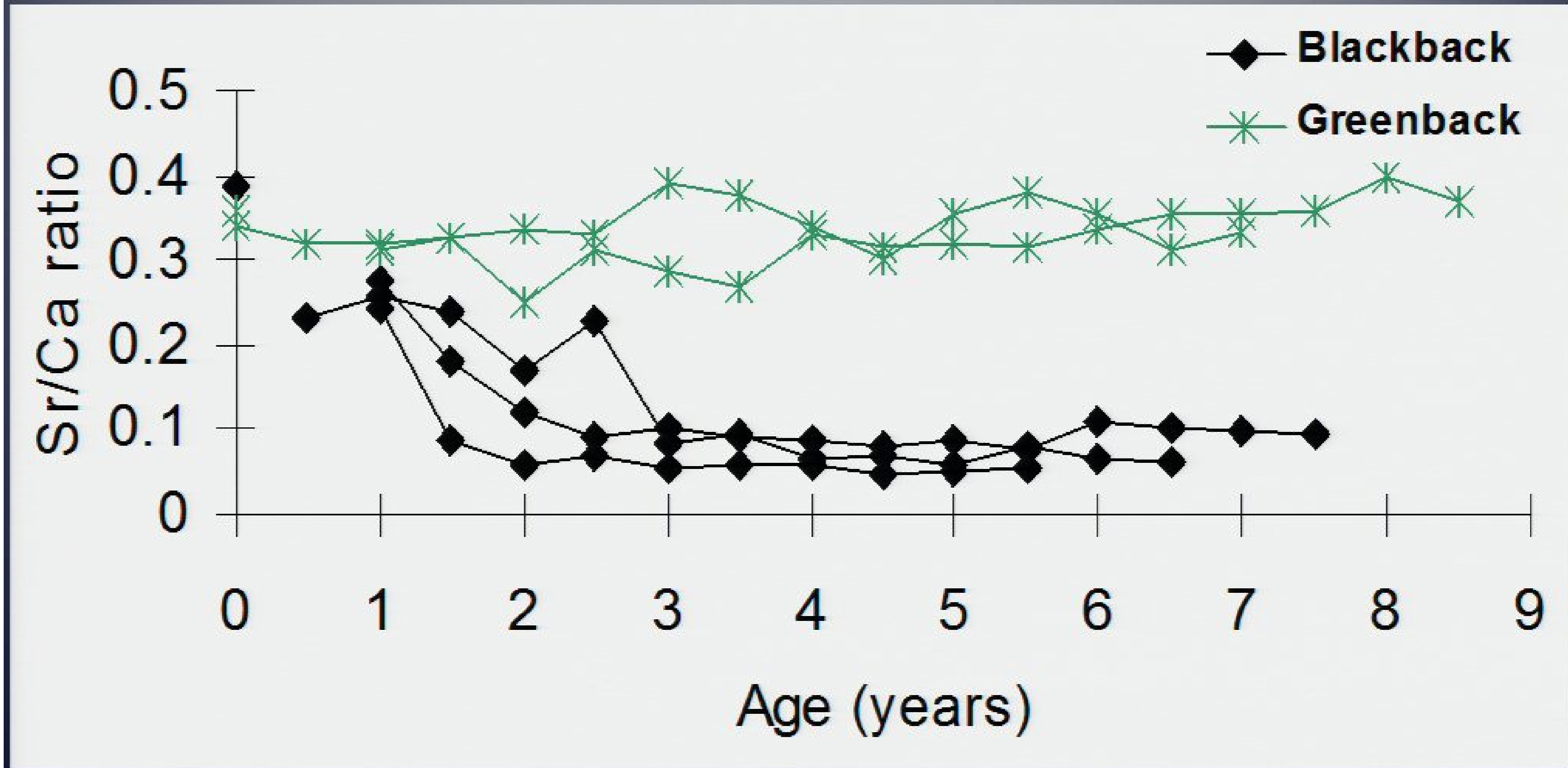
The inner ear has “ear stones”, or “ear bones” known formally as otoliths.

Parts of the Otolith



Plot of $^{86}Sr/^{48}Ca$ Ratio vs. Fish Age

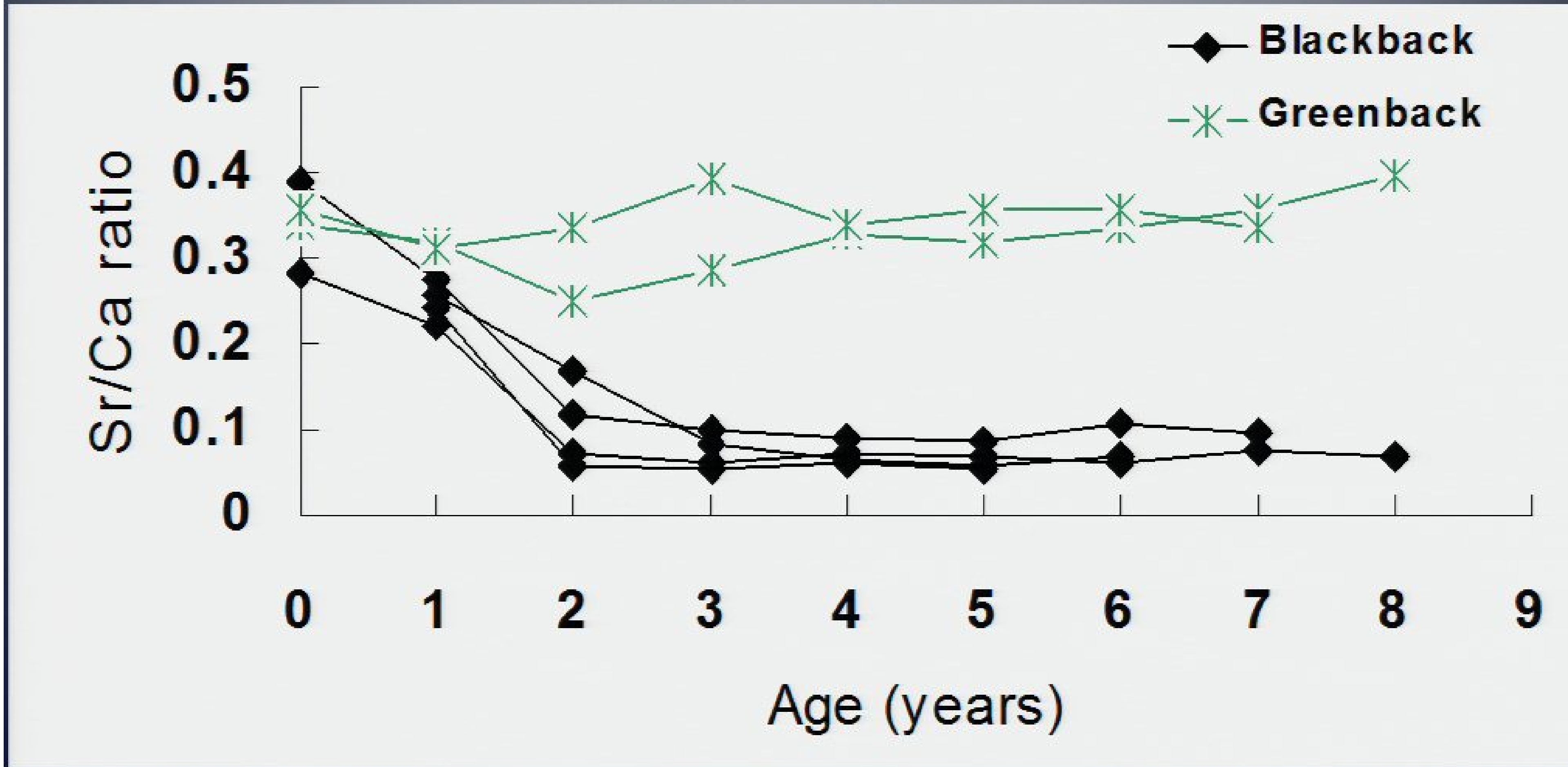
All Regions



3rd Decade, 1994-2003

Paramore and Rulifson (2001)

Plot of $^{86}Sr/^{48}Ca$ Ratio vs. Fish Age
Opaque Regions

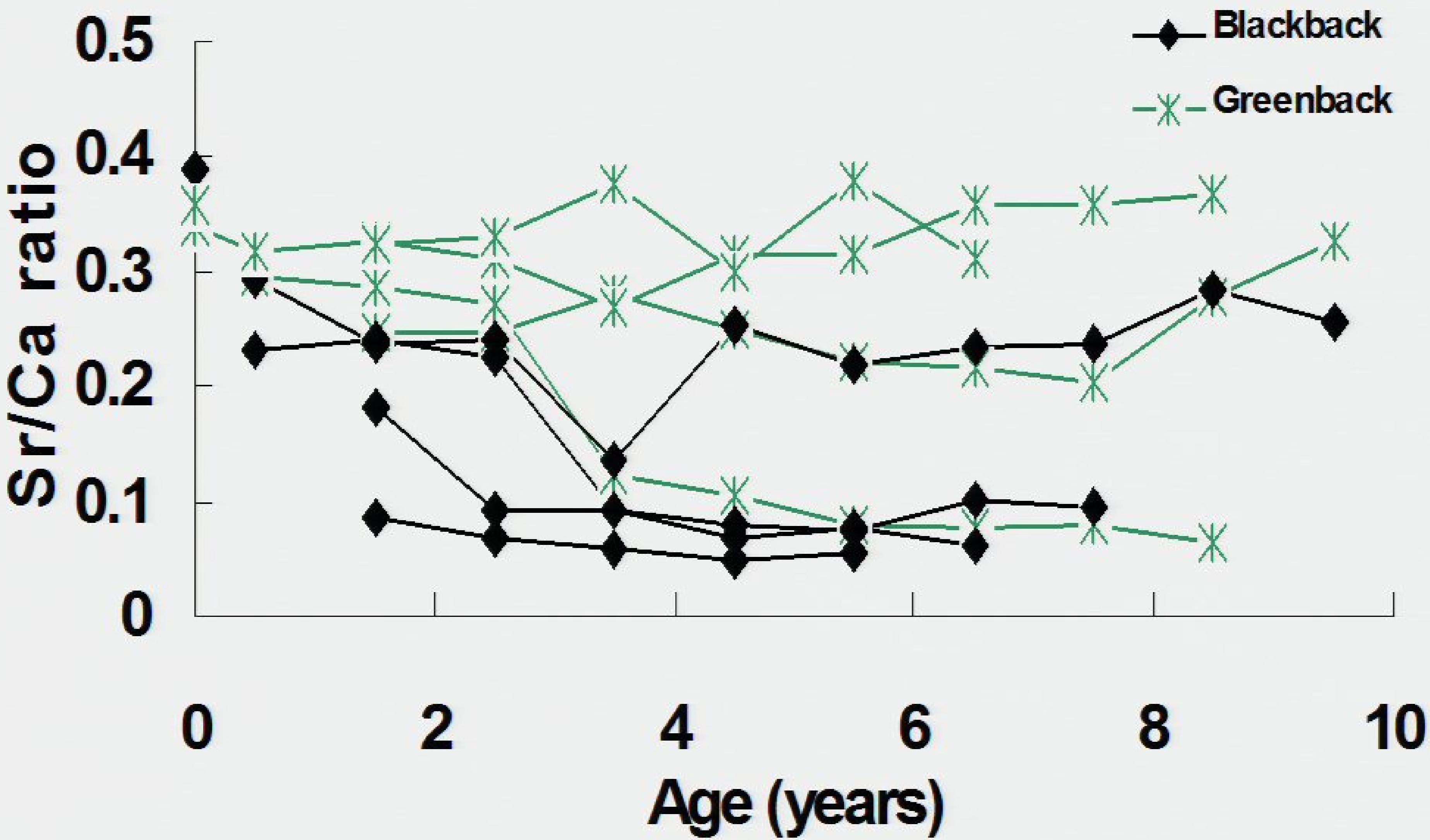


3rd Decade, 1994-2003

Paramore and Rulifson (2001)

Plot of $^{86}Sr/^{48}Ca$ Ratio vs. Fish Age

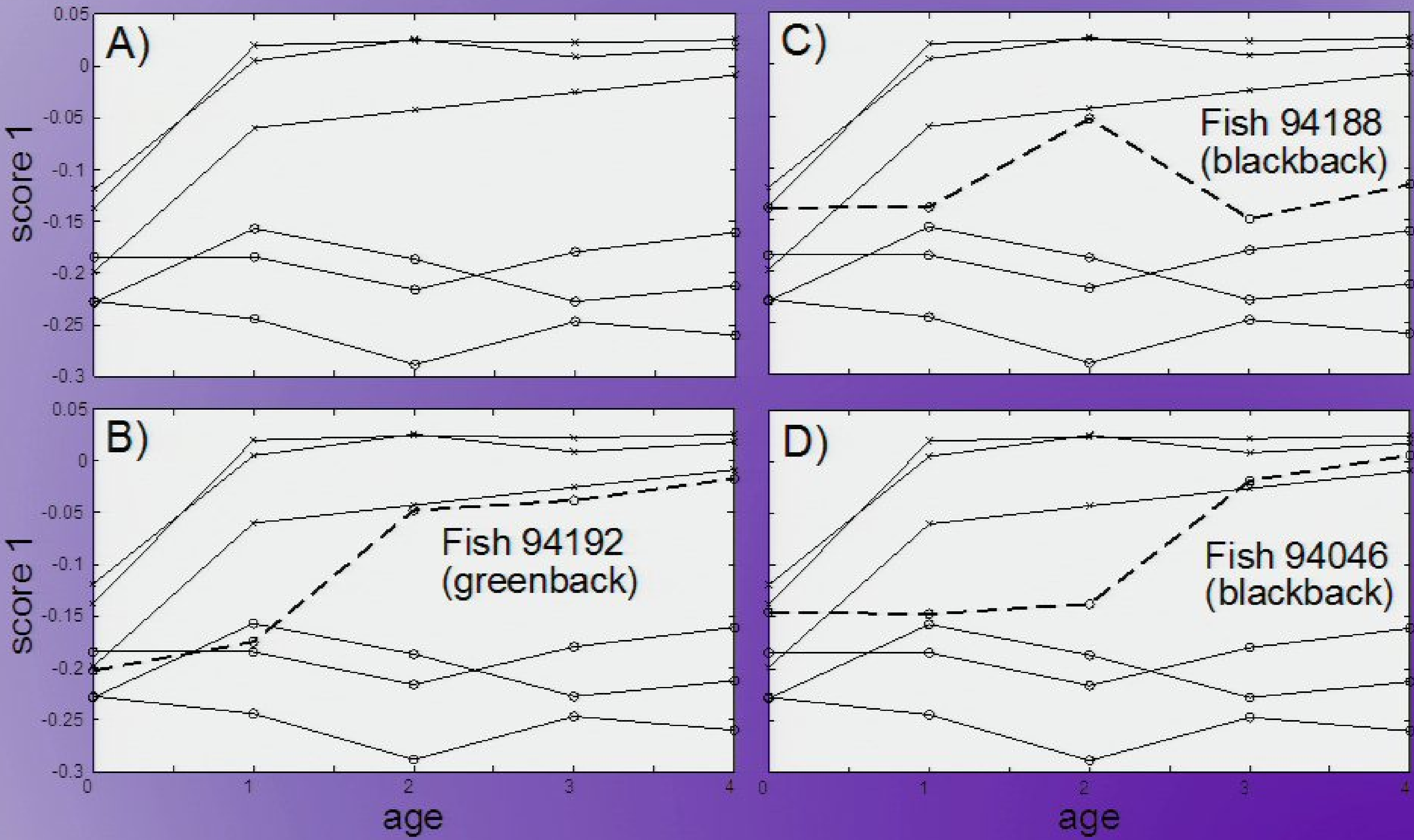
Translucent Regions



3rd Decade, 1994-2003

Paramore and Rulifson (2001)

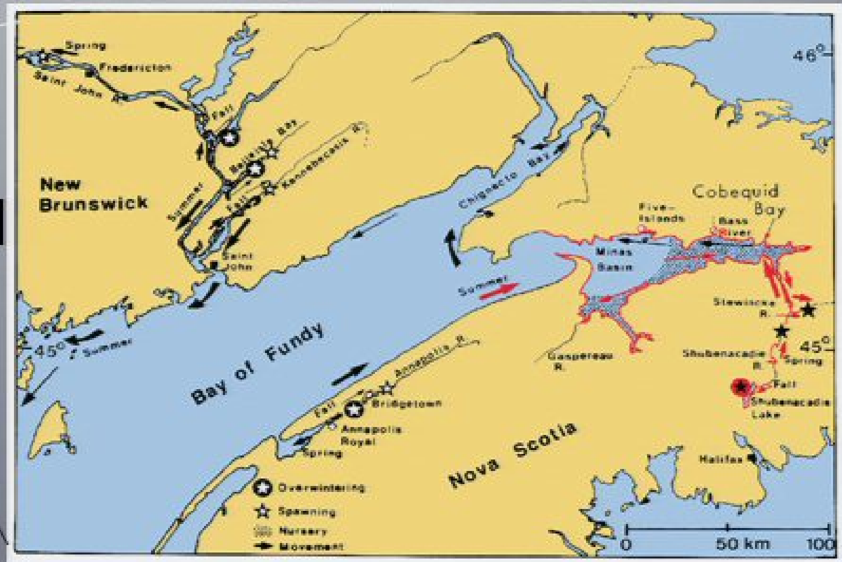
Where Have I Been?



But we don't know the genetic origin of these fish – are they from the same population, or different?

Lee Paramore's Research

- Seminal piece of research identifying that sub-units of a population of fish could come from different areas, and join together on the spawning grounds.
- Combined 4 different research tools to arrive at this conclusion:
  - Food habits (~24 hours)
  - Coloration (phenotype) – transient, length of time unknown
  - Fatty acid analysis of tissues (~ 6 months)
  - Otolith chemistry (lifetime)



- Juvenile striped bass habitat
  - Neuse- Pamlico Sound
  - Roanoke- western Albemarle Sound
  - Stewiacke- Unknown- Hypothesized to be the upper Bay of Fundy

Important Facts to Remember

Could Differences be Latitudinal, or Related to Watershed Type?

- We know (theorize) that Roanoke/Albemarle striped bass do not go to sea, and they spawn in a swift floodplain habitat.
- Shubenacadie/Stewiacke striped bass also spawn in a swift system, with a tidal bore.
- Chesapeake Bay striped bass spawn in less energetic systems, and eggs tend to ride tidal currents until hatching.
- Are all eggs created equally, or is there influence of the watershed at the population level?
- If so, is it genetic, or is it environmental?

Population Comparisons

- Lauren Bergey et al. (2003) –
  - Sampled 9 populations of striped bass in 6 hatcheries from Georgia to Prince Edward Island.
  - Eggs were measured for –
    - Diameter
    - Number of oil globules
    - Density with stage of development
    - Sinking rate in fresh water and brackish water

Egg Characteristics – Bergey et al. (2003)

1 – Lake Lanier, GA

2 - Savannah, GA

3- Dan River

4 – Roanoke River

5 – Pamunkey River

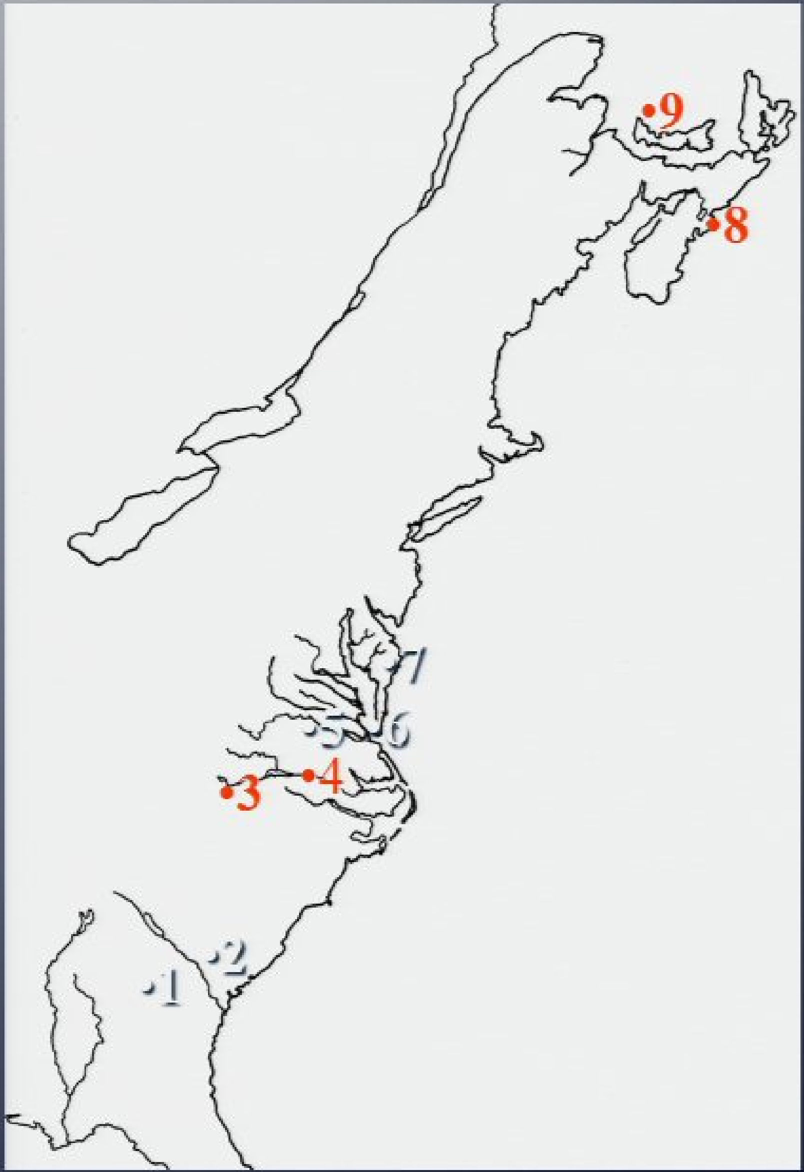
6 – Nanticoke River

7 – Choptank River

8 – Shubenacadie River

9 – Miramichi River

No latitudinal differences, but similar watersheds had striped bass populations with similar egg traits.



Do all striped bass grow similarly throughout the range?

- Can we observe this grow in the otoliths of the fish?
- Do otoliths deposit trace minerals and show daily growth in the same way throughout the range of the species?
- If so, can we use the "trace mineral records" left in the otolith as an accurate way to determine the history of where the fish lived throughout its life?

Validation of Daily Increment Formation on Otoliths with Applications to Wild Striped Bass (*Morone saxatilis*) at the Northern Limit of Its Range

by

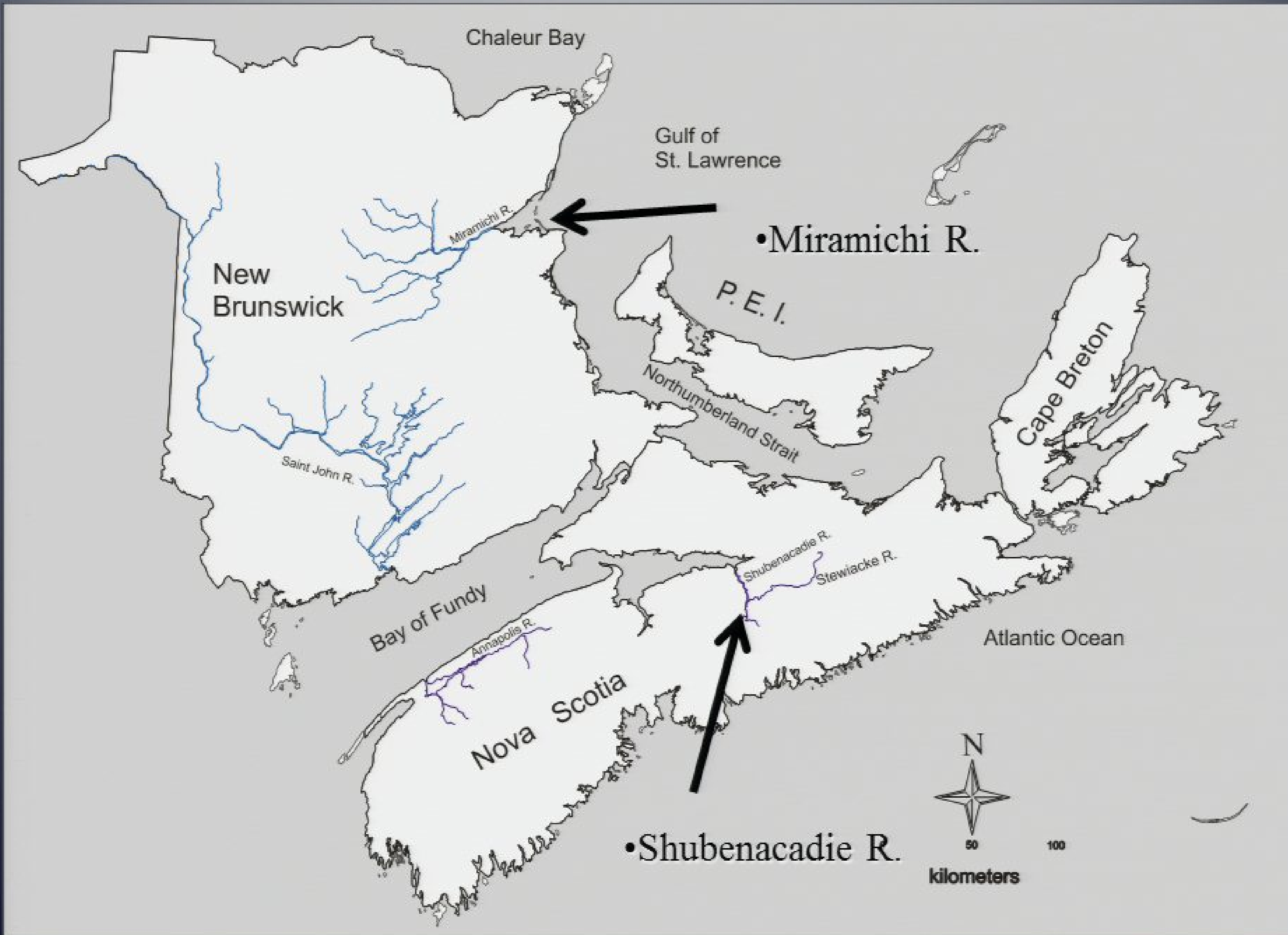
Scott G. Douglas
Acadia University
Wolfville, Nova Scotia
1996-97

Otoliths and their development

- Calcified "ear bones"
  - Sound detection
  - Equilibrium maintenance
- Daily increments discovered in 1971
- Manipulation of environmental variables can alter the periodicity
- Cause of ring formation is not well understood
- Endogenous circadian rhythm

Striped bass in eastern Canada

- Two self-sustaining populations left in eastern Canada:
  - **Northwest Miramichi** River population
    - Gulf of St. Lawrence, New Brunswick
  - **Shubenacadie-Stewiacke** River population
    - Bay of Fundy, Nova Scotia
- Considered genetically discrete


Chaleur Bay
Gulf of
St. Lawrence
Miramichi R.
•Miramichi R.
New
Brunswick
P. E. I.
Cape Breton
Northumberland Strait
Saint John R.
Shubenacadie R.
Stewiacke R.
Bay of Fundy
Annapolis R.
Atlantic Ocean
Nova Scotia
N
•Shubenacadie R.
50
100
kilometers

Why Study Otoliths and Striped Bass at the Northern Limit of its Range ?

3rd Decade, 1994-2003

Why Study Otoliths and Striped Bass at the Northern Limit of its Range ?

- Daily aging technique **needs** to be validated for northern striped bass
  - Required before studies with wild fish are conducted
  - Establish criteria needed to age wild young-of-the-year (YOY)
  - Has been validated in the south and center of its range

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  - Establish criteria needed to age wild young-of-the-year (YOY)
  - Has been validated in the south and center of its range
- The striped bass growth debate: Genetics or Environment
  - "Countergradient variation" hypothesis

Why Study Otoliths and Striped Bass at the Northern Limit of its Range ?

- Daily aging technique **needs** to be validated for northern striped bass
  - Required before studies with wild fish are conducted
  - Establish criteria needed to age wild young-of-the-year (YOY)
  - Has been validated in the south and center of its range
- The striped bass growth debate: Genetics or Environment
  - "Countergradient variation" hypothesis
- Increasing interest in striped bass aquaculture and enhancement
  - Questions about preferred broodstock for optimum growth

3rd Decade, 1994-2003

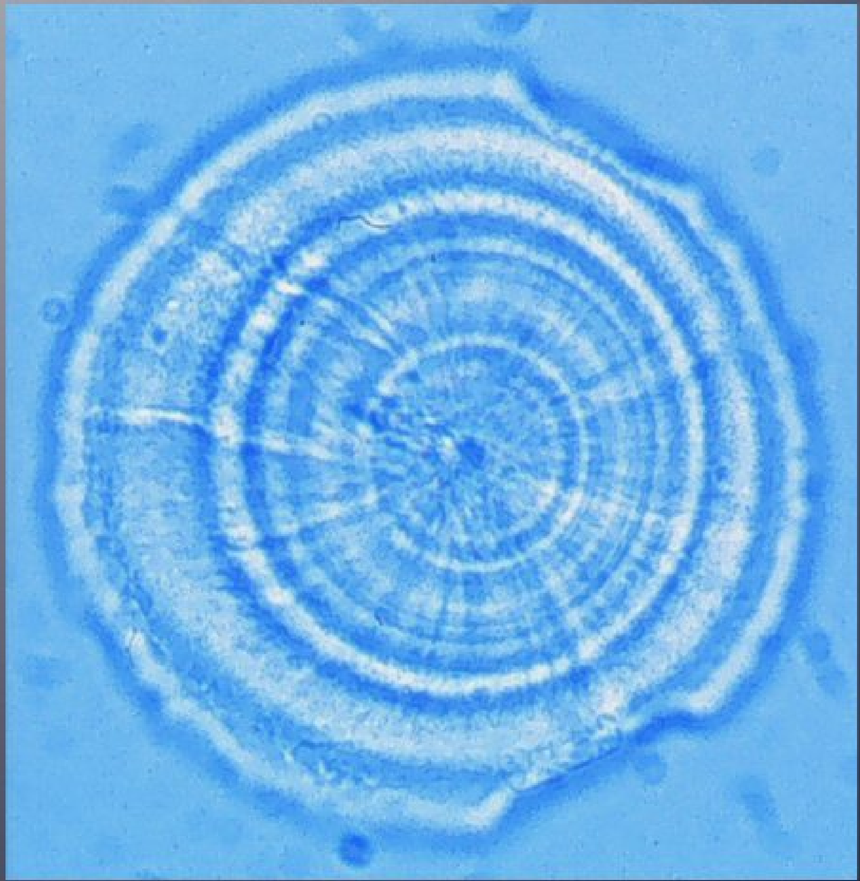
Broodstock (Shubenacadie)

- TRBH (greenhouse)
- Covered steel tanks
- Natural photoperiod
- River/pond water
- Spawned naturally
- Hatching began 50 hrs. after fertilization
- Hatching complete by hour 60
- Hatch date of June 8, 1996

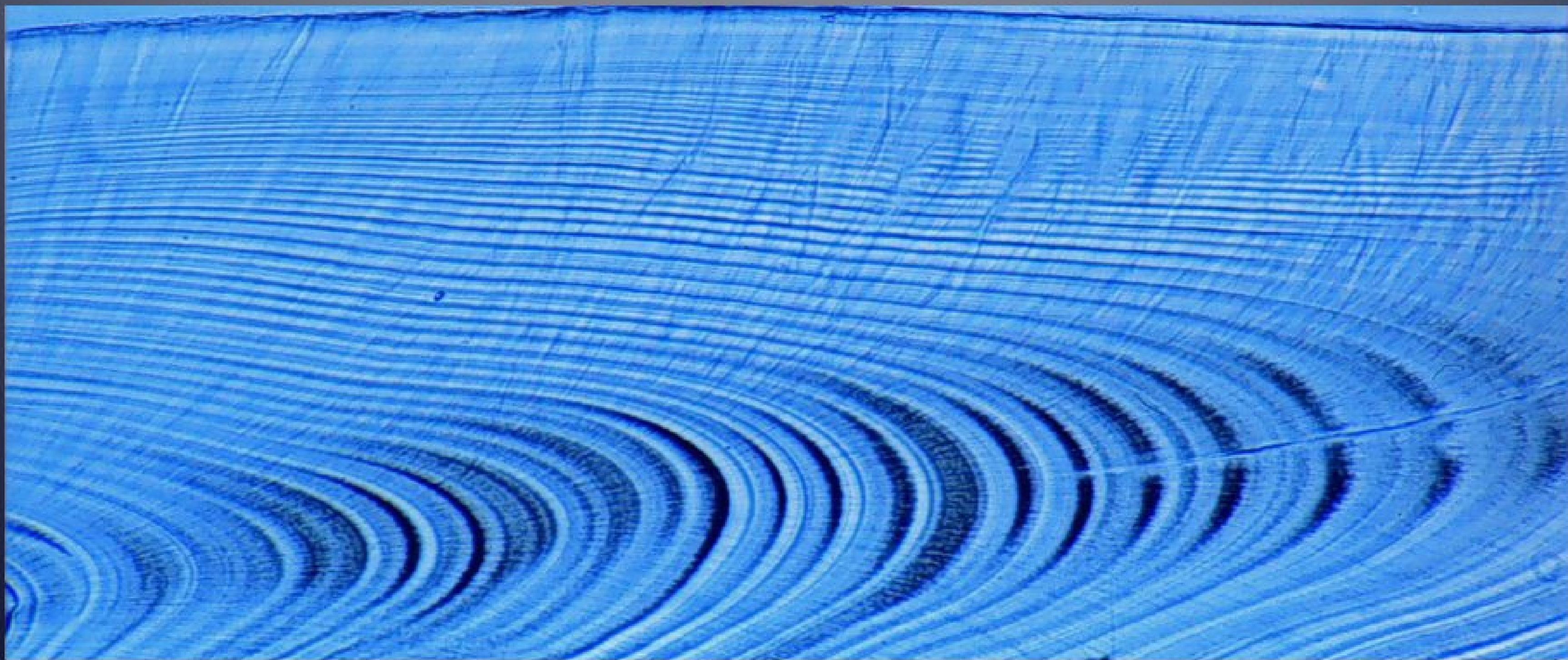
3rd Decade, 1994-2003

Otolith Reading

- Incremental and discontinuous zones
- Read under oil immersion at 100x
- From core to edge, along ventral and/or dorsal axes
- Read blind (age and origin ?)
- Random samples
- Counts were averaged



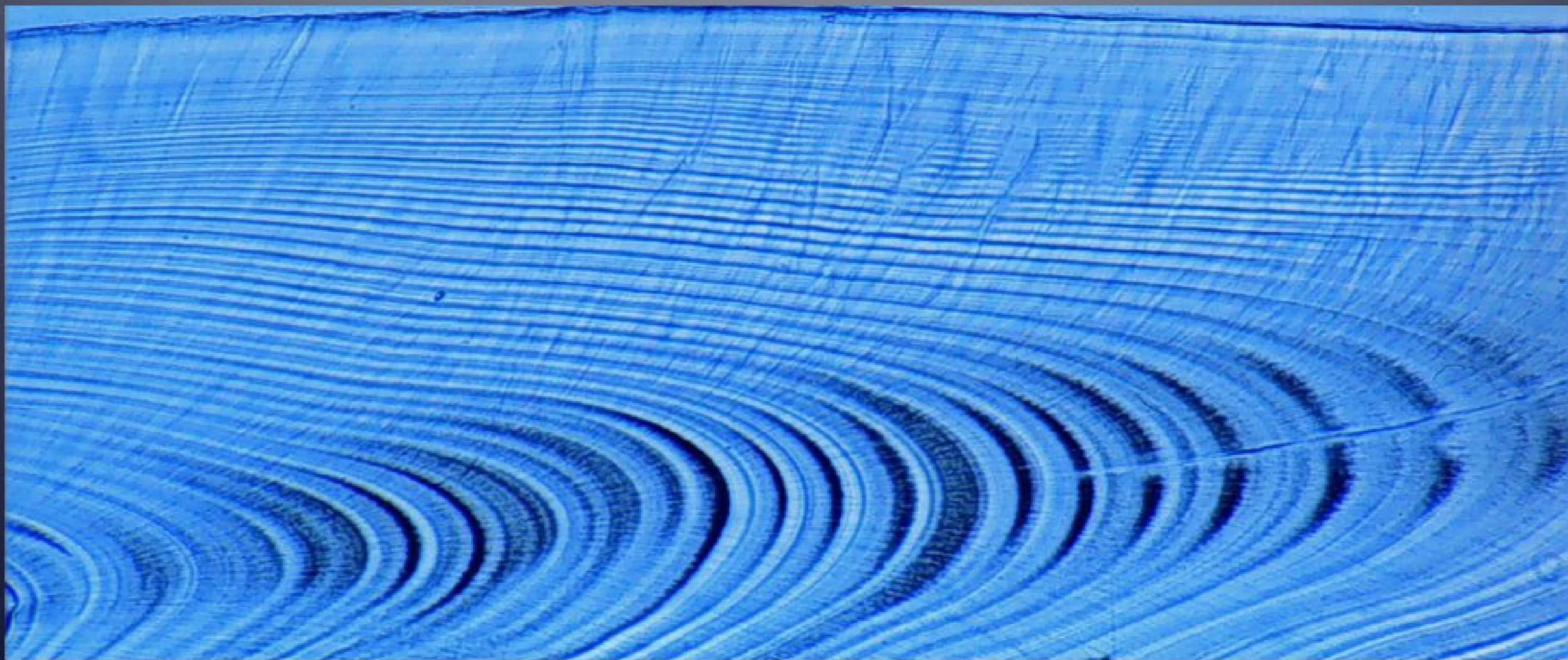
Results (Hatchery)



3rd Decade, 1994-2003

Results (Hatchery)

- Increments were highly discernible with light microscopy



3rd Decade, 1994-2003

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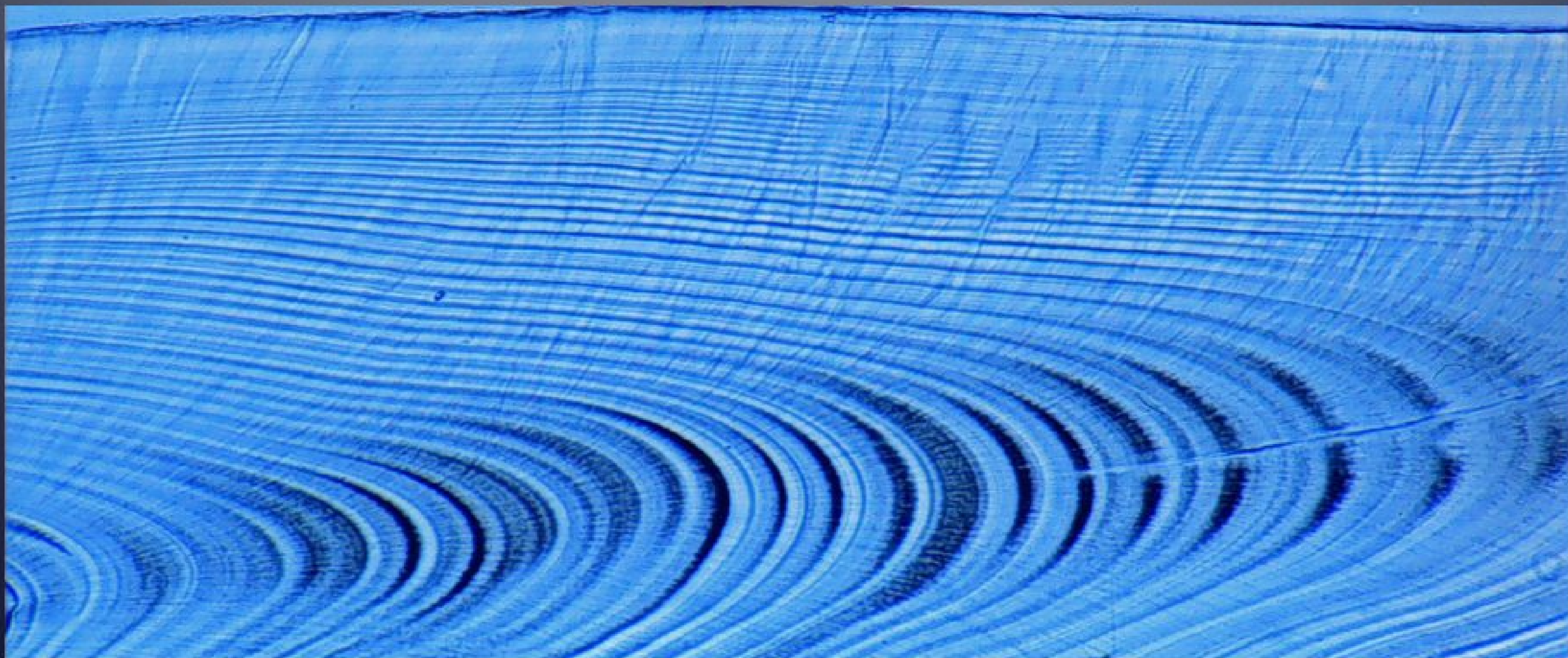
- Increments were highly discernible with light microscopy
- Increments were counted up to 113 dph (last day of experiment)



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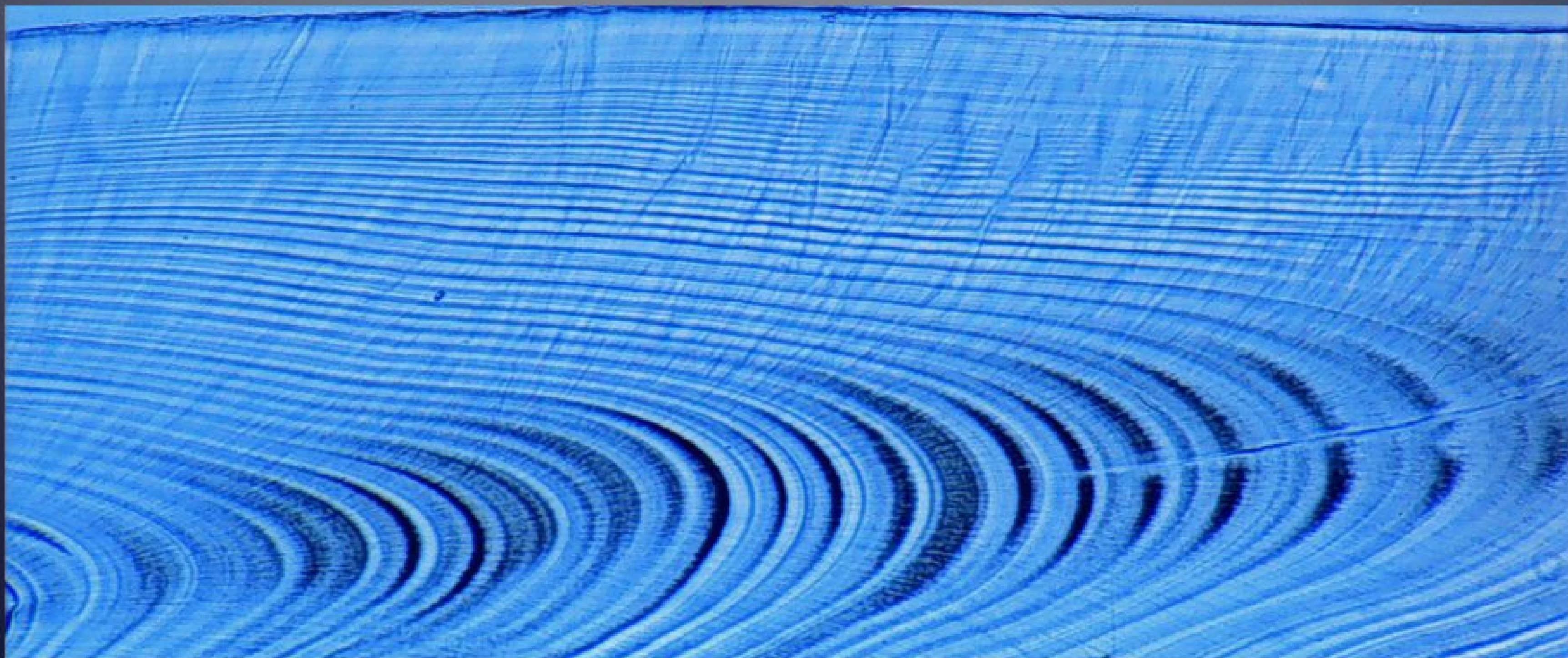

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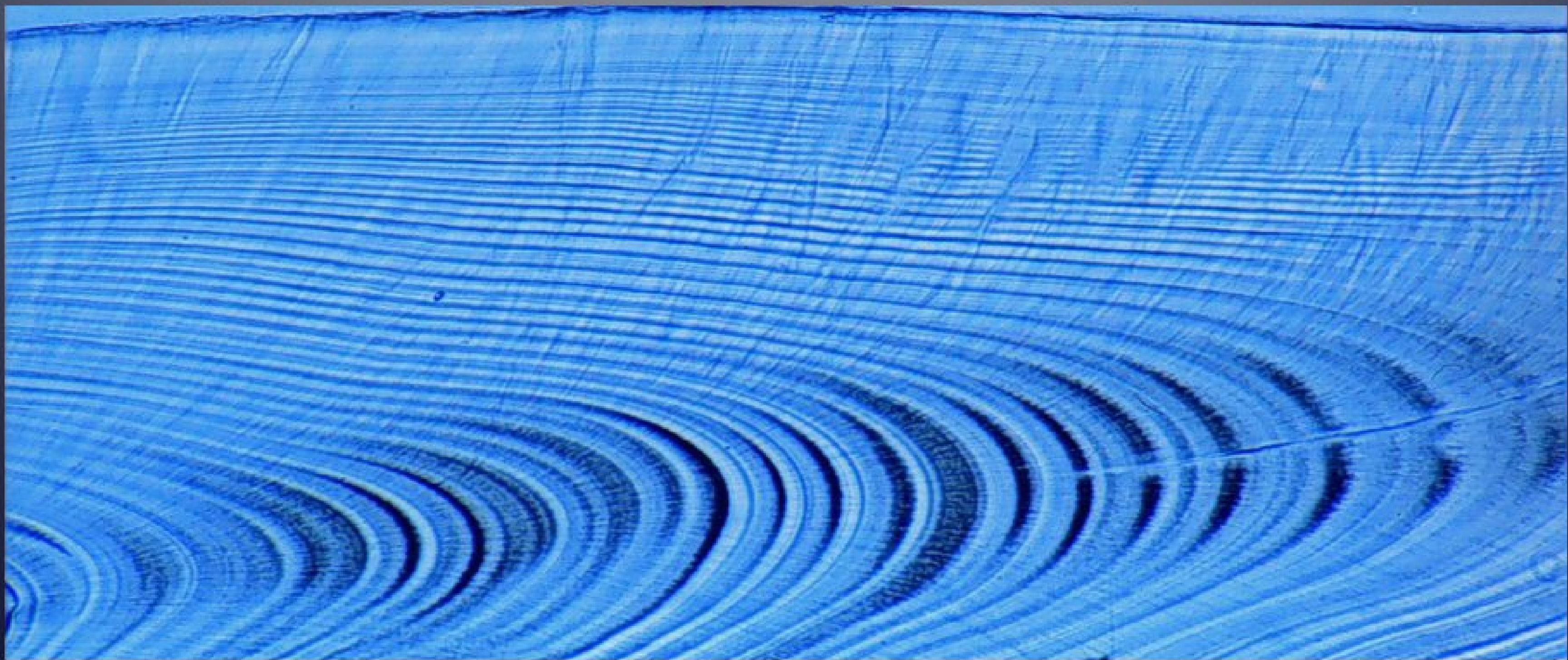


3rd Decade, 1994-2003

Hatchery growth

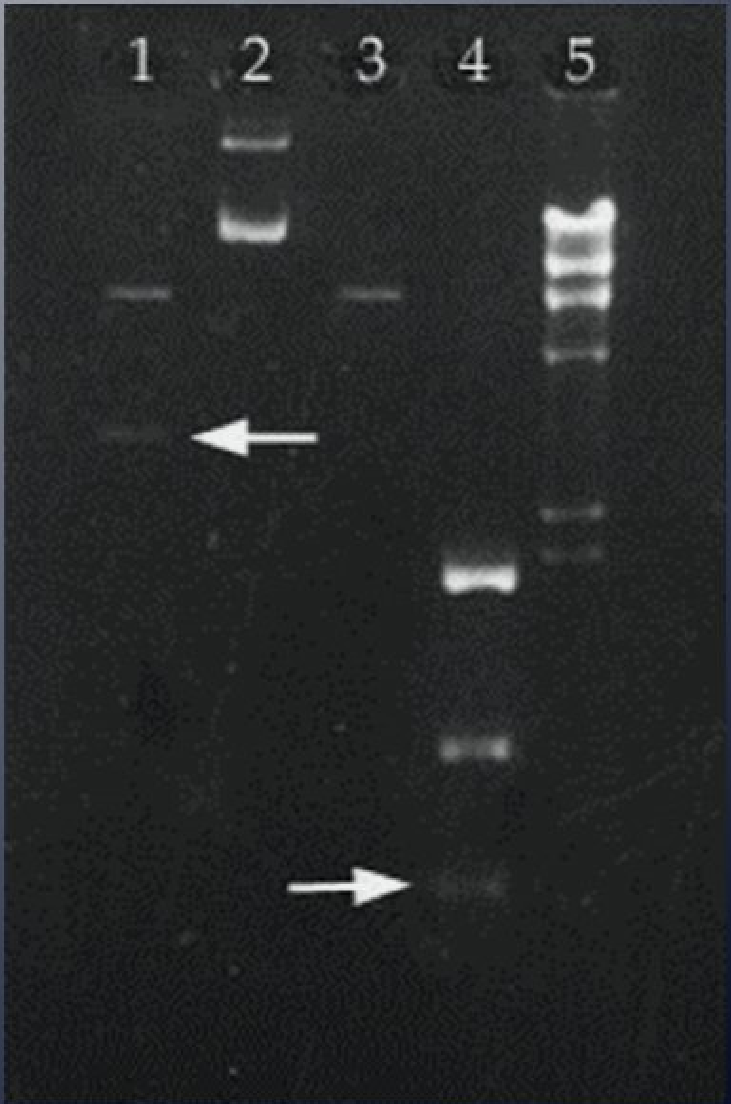
- No difference in growth between hatchery-reared Shubenacadie and Miramichi striped bass
- Suggests that growth is influenced by environmental variables
- Challenges the general application of the "countergradient variation" hypothesis
- Size at age is likely to be the same for both northern populations
  - Aquaculture industry
  - Stocking initiatives

Wild NW Miramichi growth

- Growth of hatchery-reared striped bass was better than wild NW Miramichi fish
- Growth appears to be highly dependent upon environmental conditions experienced by wild YOY
- Environmental conditions during the first growing season may ultimately define recruitment to the adult population

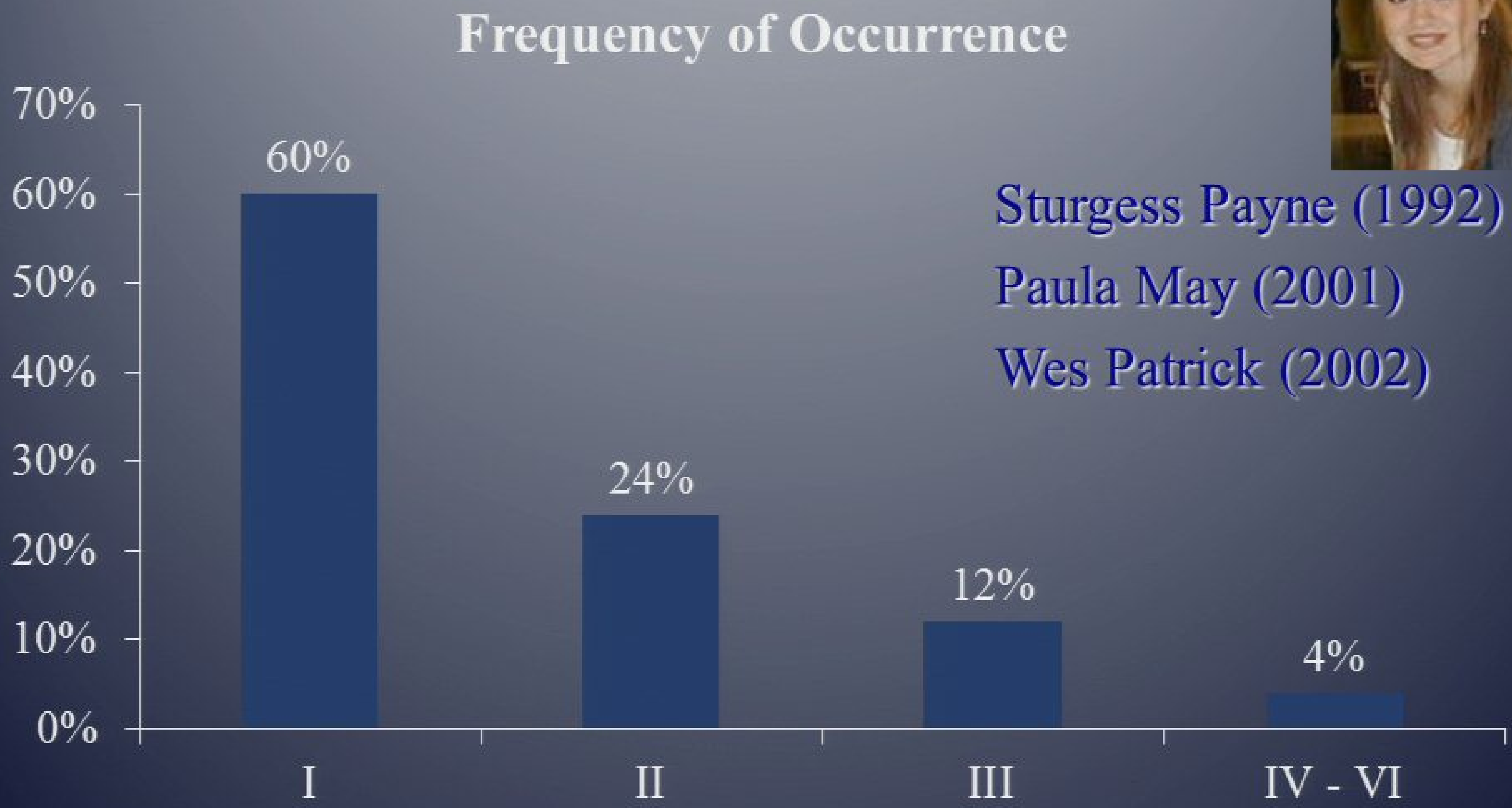
What Will Genetics Tell Us?

- Our studies in the 1990s and early 2000s used specific cutters on mtDNA.
- Results differed based on which cutters were used.
- Wirgin – sampled Roanoke River, got homogeneity
- Stellwag and Rulifson – sampled same season and year as Wirgin, used different cutters and got heterogeneity.



4th Decade, 2004-2013

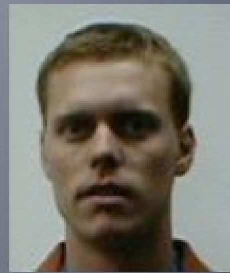
Genotypes from mtDNA Sequencing = Roanoke River Heterogeneity*



Sturgess Payne (1992)
Paula May (2001)
Wes Patrick (2002)

*Three different studies and two different techniques gave the same results. This is the distribution from Patrick (2002).

Combining Genetics with Otolith Microchemistry

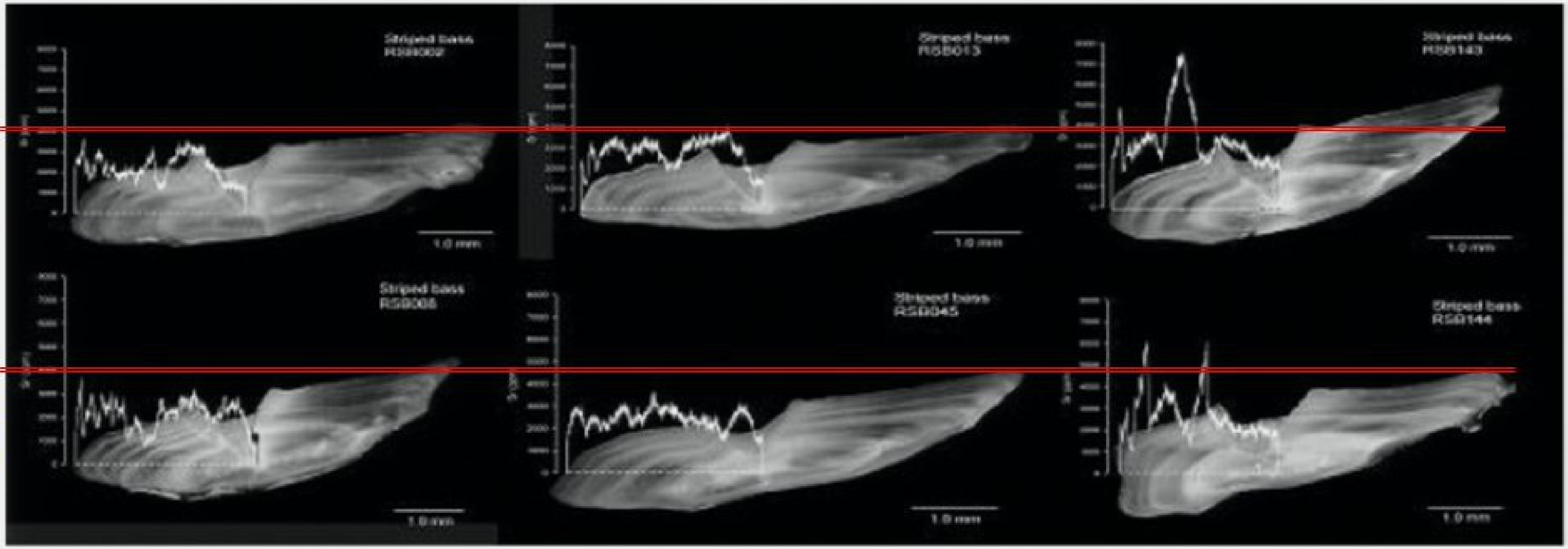


- Morris et al. (2005)
  - Genotypes I, II, and III
  - Sr concentrations proxy for marine migration

I II III

F

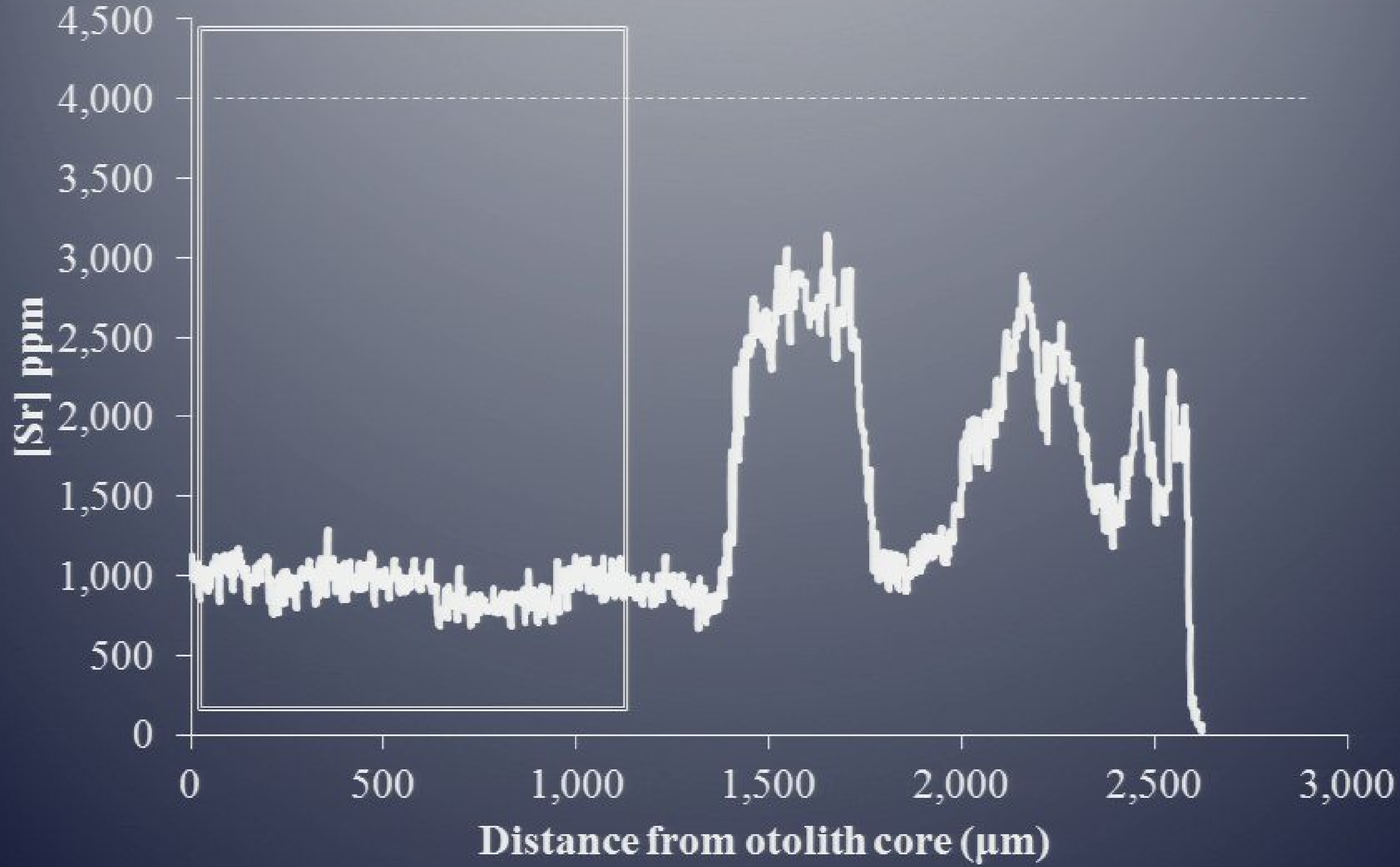
M



Significance of Preliminary Findings (Morris et al. 2005)

- Suggests linkage between marine migration and genotype III striped bass
- Management applications
  - Allocation – Marine migration 12% vs 3% of time.
  - Spatially adjust fishing effort.
  - Restoration of striped bass watersheds with sub-optimal estuarine habitat.
- Patrick (2010) found no evidence of genetic-based diadromy with the genetic markers used.

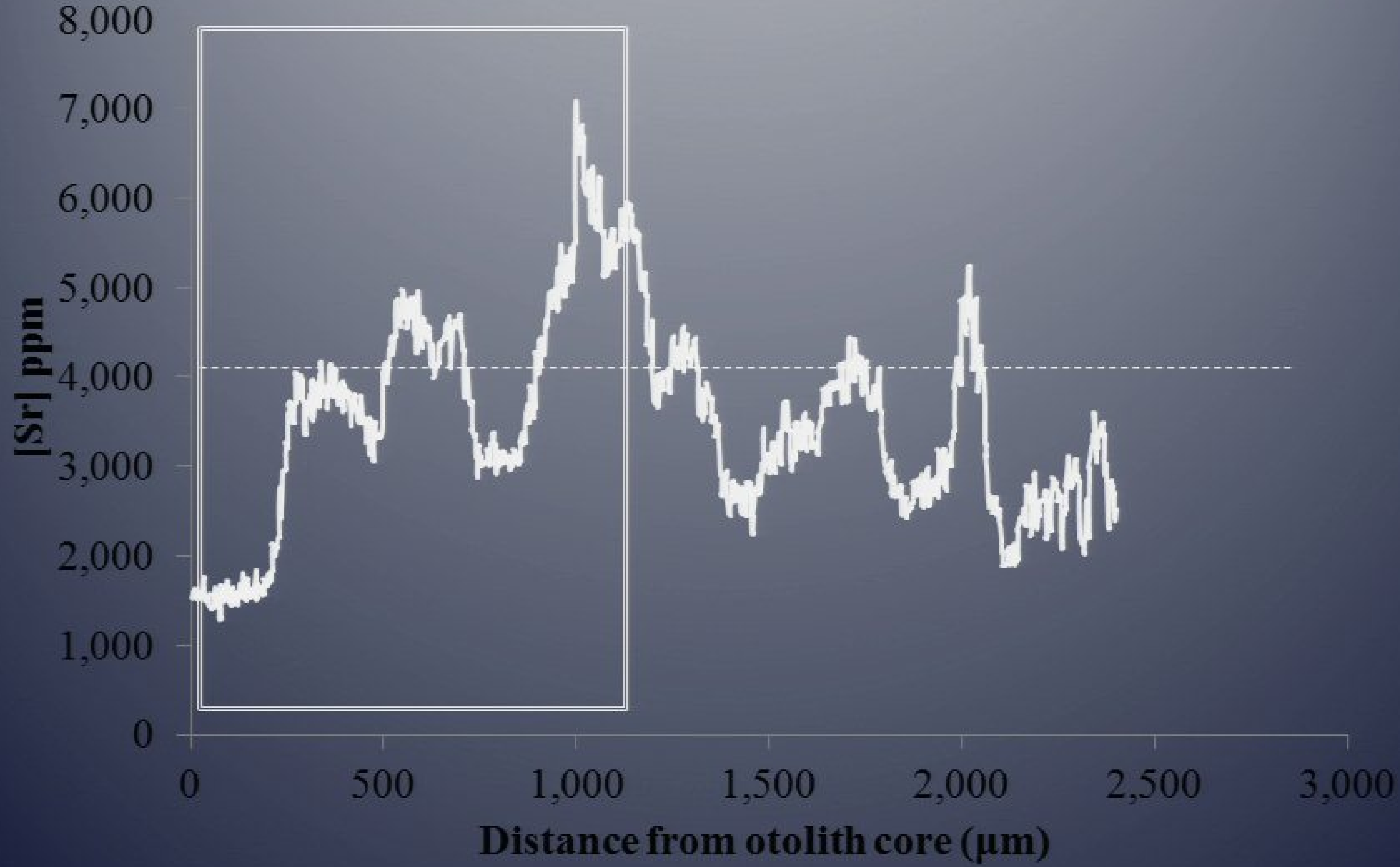
Resident Striped Bass (55%)



4th Decade, 2004-2013

Wes Patrick (2010)

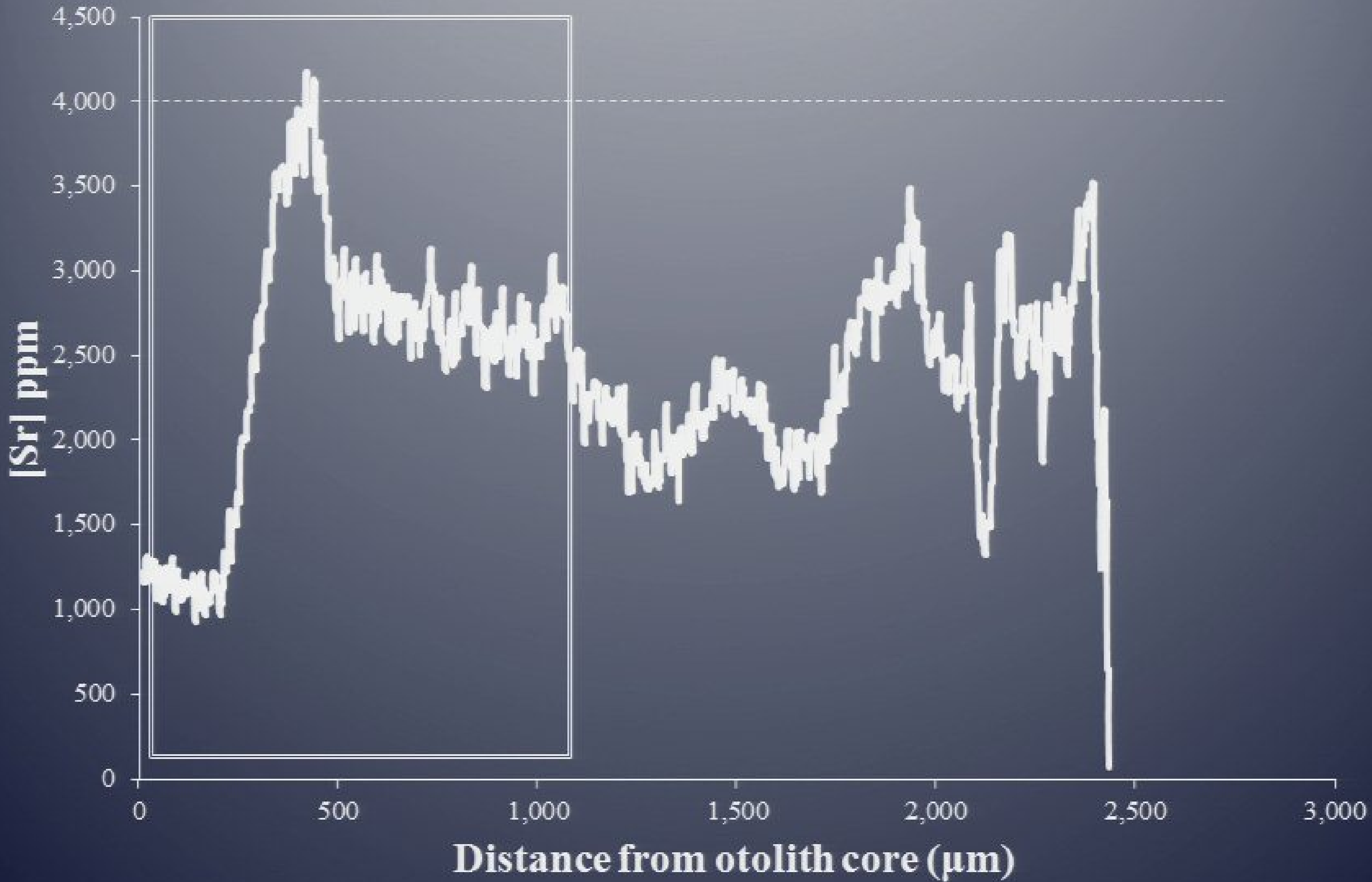
Stager Striped Bass (27%)



4th Decade, 2004-2013

Wes Patrick (2010)

Sprinter Striped Bass (18%)

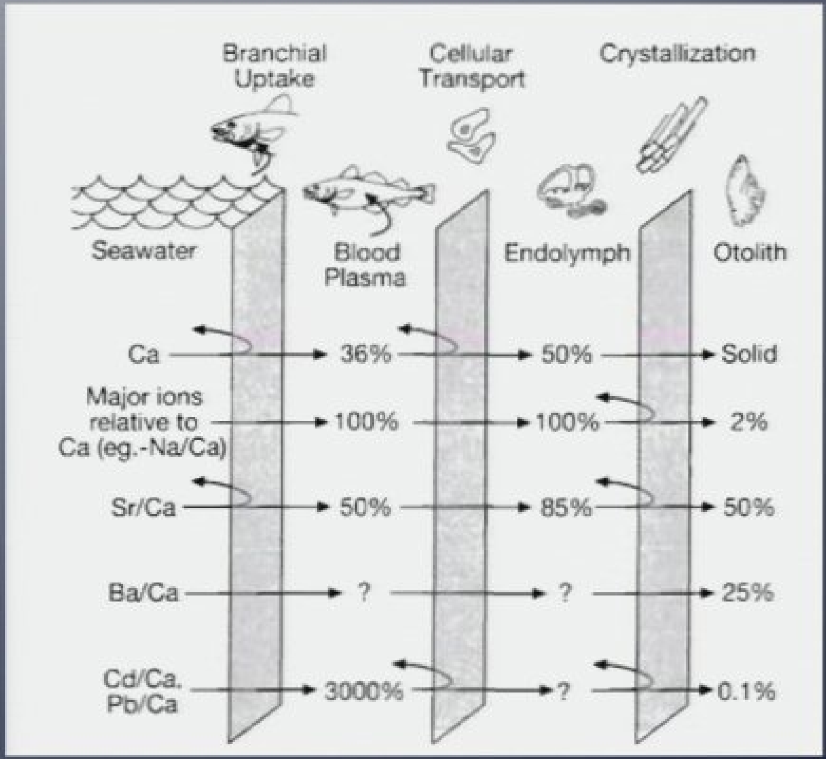


4th Decade, 2004-2013

Wes Patrick (2010)

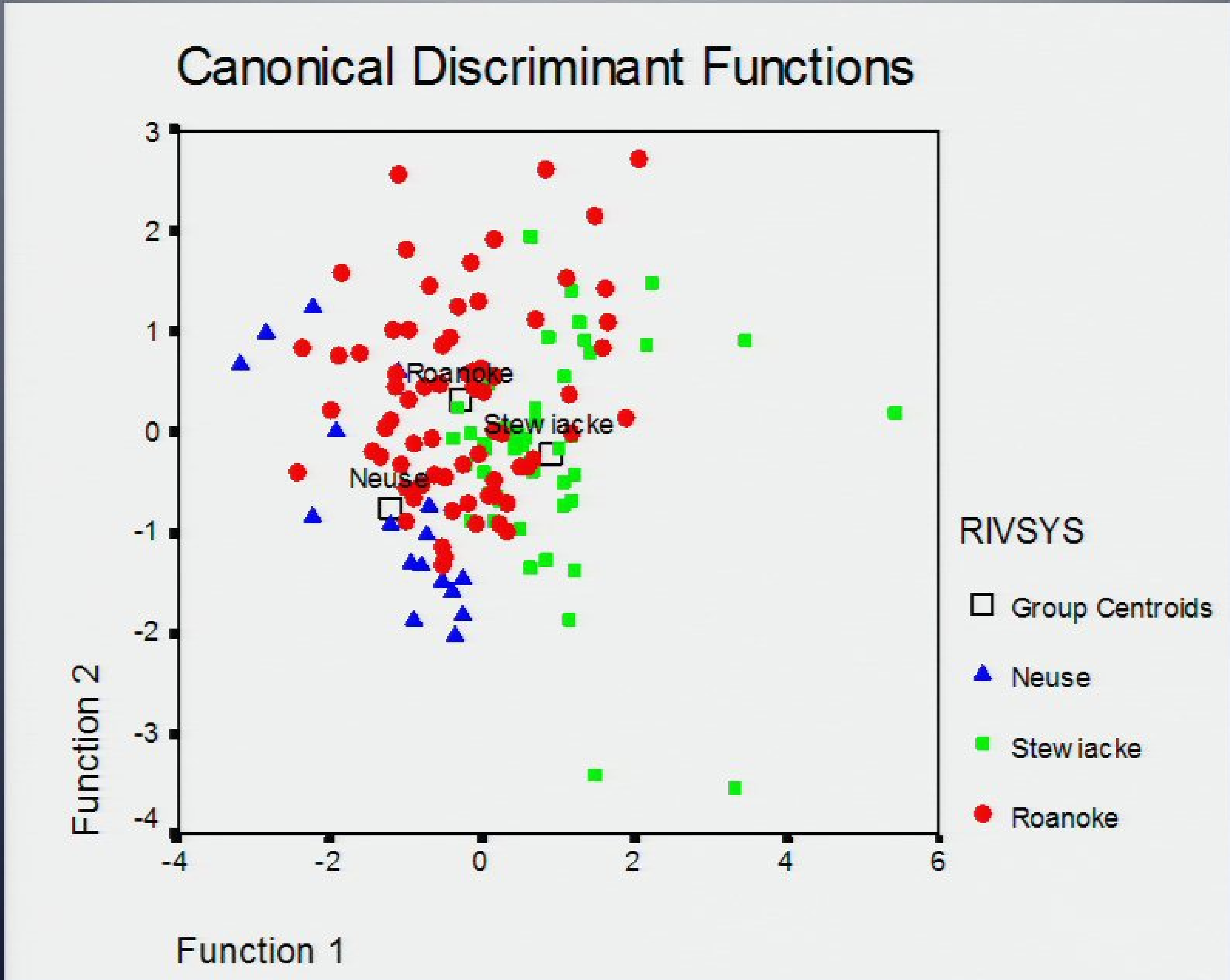
Otolith Microchemistry

- Campana et. al. (1999)
- Ratios of trace elements in otoliths will reflect the ratios in the water
- Act as a marker for determining migrations of different stocks



- Campana 1999

Watershed Signatures (Morris)

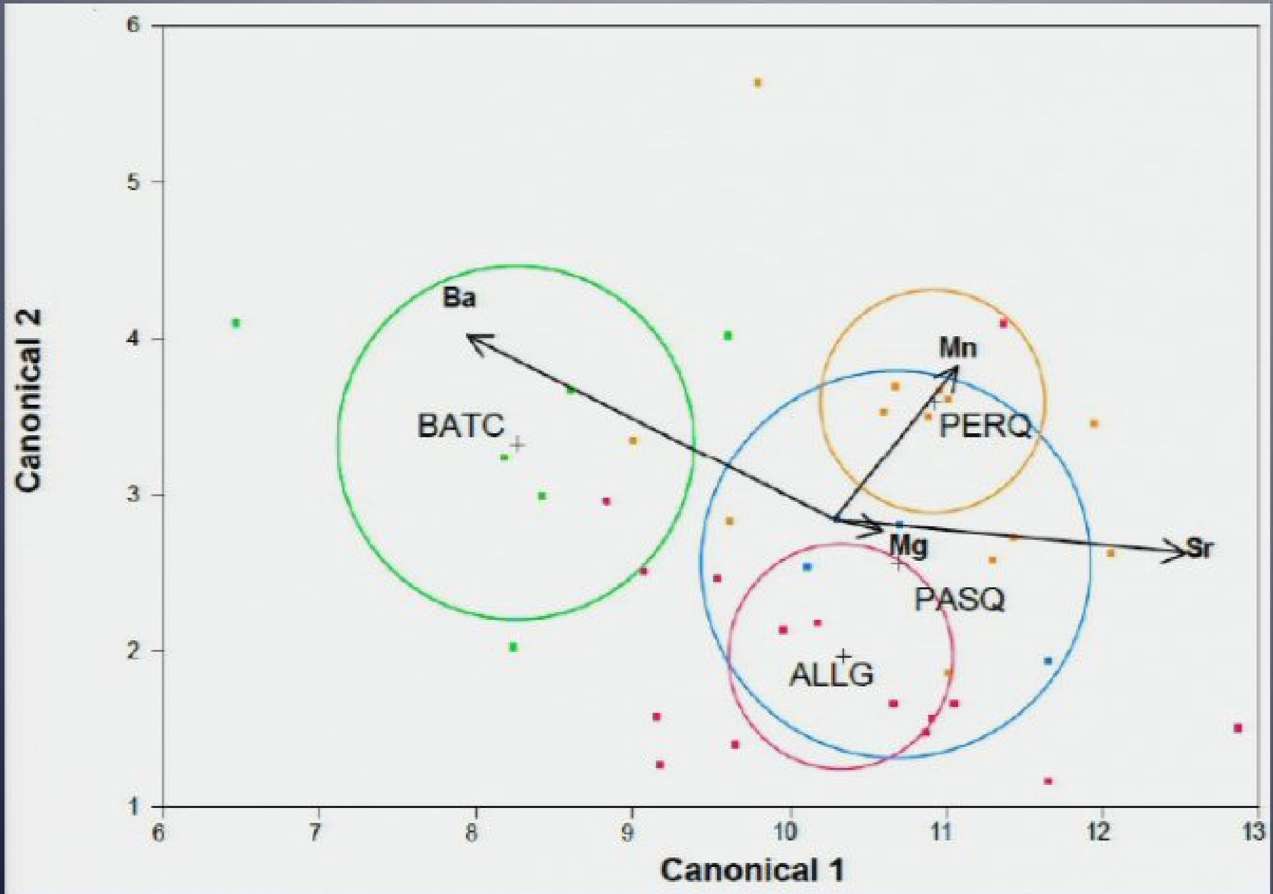


John Mohan

- Sampled watersheds to determine trace elemental "fingerprints"
- Placed cages with YOY striped bass in the different watersheds
- Collected wild YOY striped bass throughout Albemarle Sound
- Do young YOY striped bass pick up the watershed signal into their otoliths?
- If so, how long does it take?

4th Decade, 2004-2013

Separation of YOY Striped Bass Otoliths Using Four Trace Elements

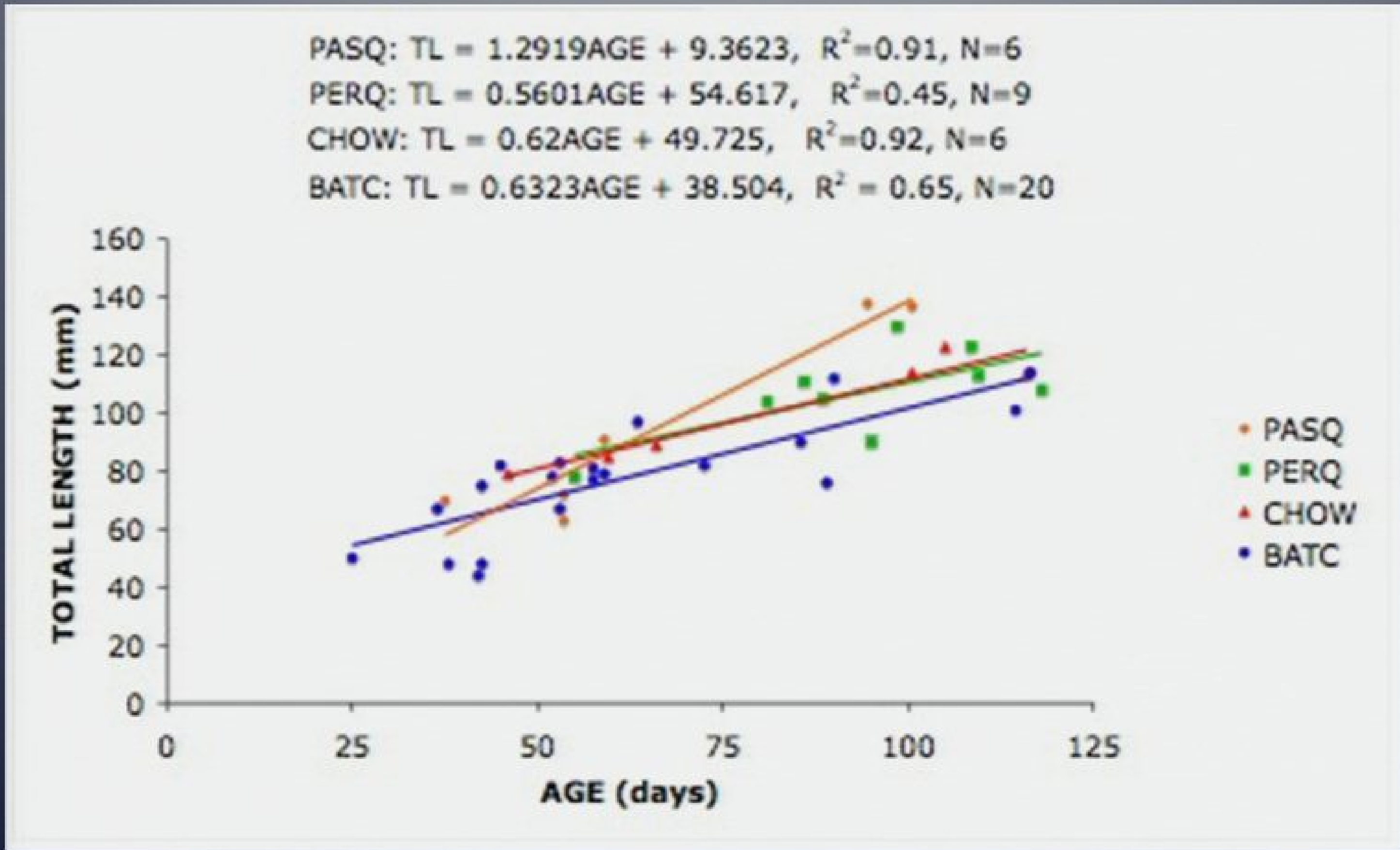


- Ba = Barium
- Mn = Manganese
- Mg = Magnesium
- Sr = Strontium

4th Decade, 2004-2013

Growth (Mohan)

- Age VS total length (TL)



Watershed Fingerprinting for Trace Elements (John Mohan, Dan Zapf, Evan Knight, Coley Hughes, Jeff Dobbs)

Striped Bass Source Used at Each Hatchery for Production, 1878-2008

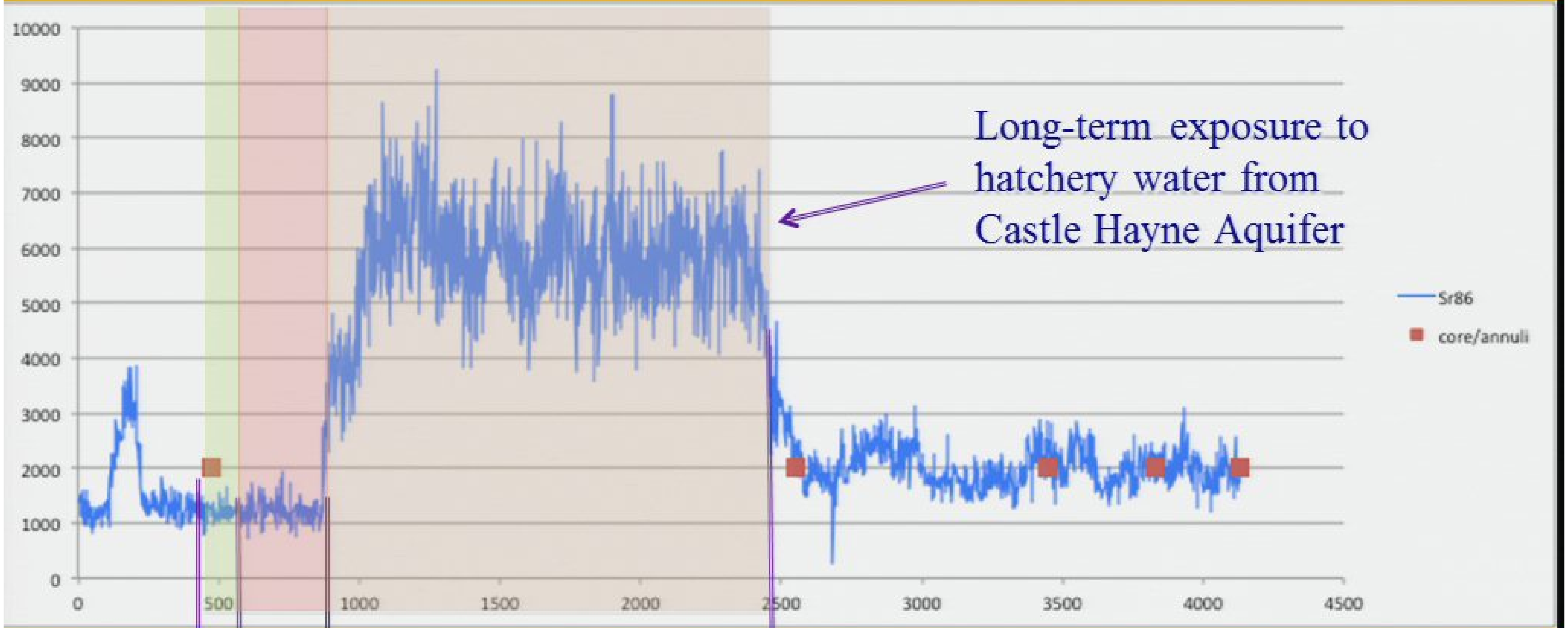
Table 8. Striped bass strains used at each hatchery for production 1873-2008.

	Appalachicola	Blackwater River	Chesapeake Bay	Gulf	Hudson River	Maryland	Roanoke River/Albemarle Sound	St. Johns River	Santee-Cooper	Savannah River
Blackwater (FL)	X	X	X	X	X	X	X	X	X	X
Bowens Mill (GA)				X					X	X
Buller (SC)							X		X	
Cheraw (SC)							X		X	
Cohen Campbell (VA)			X				X			
Cordele (GA)				X					X	X
Dawson (GA)				X			X		X	X
Edenton NFH (NC)			X		X	X	X			
Fayetteville (NC)							X			
Front Royal (VA)			X				X			
Harrison Lake NFH (VA)			X				X			
Dennis Wildlife Center (SC)				X			X		X	X
King & Queen (VA)			X				X			
Marion (NC)							X			
McKinney Lake NFH (NC)			X				X			
McDuffie (GA)				X						X
Orangeburg NFH (SC)			X				X		X	X
Richloam (FL)	X	X	X			X	X	X	X	X
Richmond Hill (GA)				X						X
Spring Stevens (SC)							X		X	
Table Rock (NC)							X			
Vic Thomas (VA)			X				X			
Walton (GA)			X							X
Warm Springs NFH (GA)				X						
Watha (NC)							X			
Welaka NFH (FL)	X	X	X	X		X	X	X	X	X
Weldon (NC)							X			

Woodroffe (2011)

- Coastwide stocking since 1878 pretty much precludes using genetics as a valuable marker for population and migration studies. (Woodroffe 2011).
- Multiple methods can confirm hypotheses by coming at the problem from different angles – food habits, PUFA, otoliths, and possibly genetics combined.
- Large scale patterns mask real patterns of sub-populations, contingents, aggregations.
- Traditional mark and recapture studies should now be combined with other methods to enable detail at the smaller scale (e.g., acoustic telemetry)

Typical Hatchery Fish Signature*



Phase II Period

Dobbs and Rulifson, unpublished

Maternal Contribution

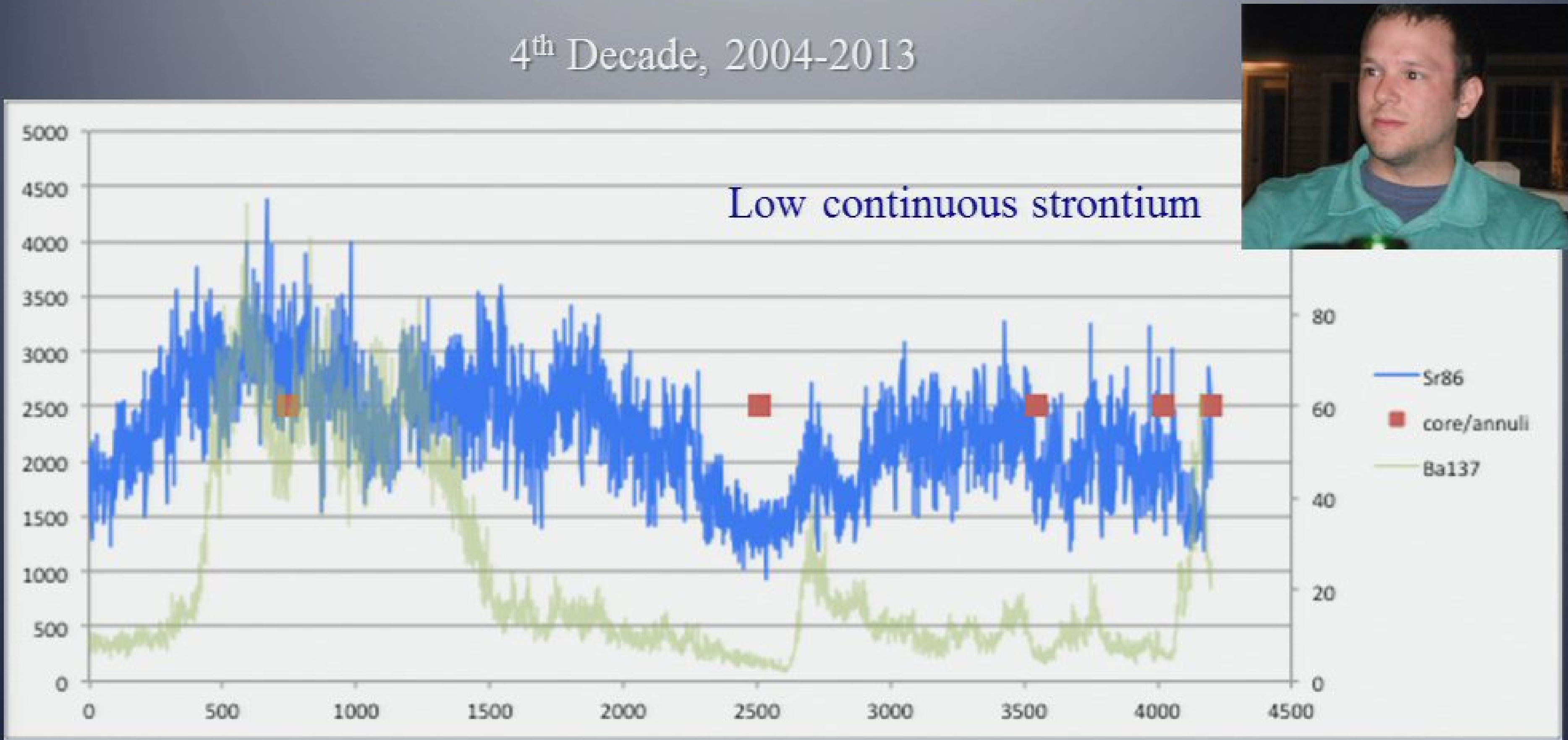
Phase I Period

Stocked into Neuse River at Bridgeton Boat Launch

*OTC marks are often missing!

Wild Fish from Neuse River

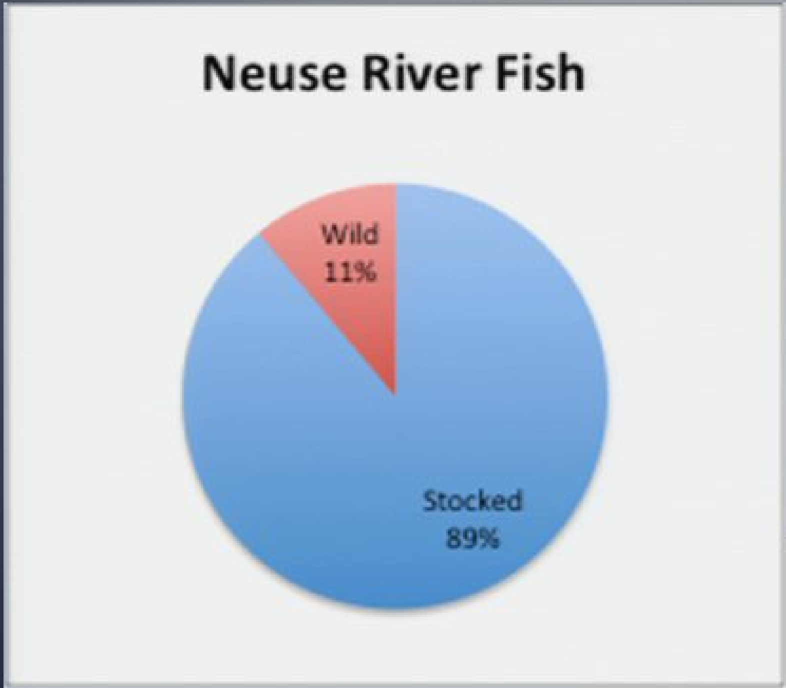
4th Decade, 2004-2013

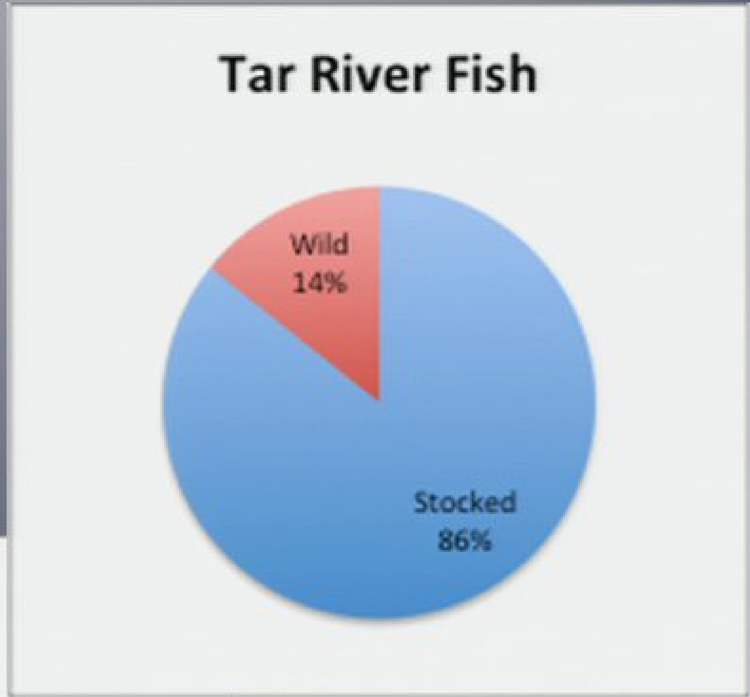


- High Barium at year 4 suggests spawning run to freshwater upstream section of river?
- What does high peak after year 1 indicate?

Dobbs and Rulifson, unpublished

Proportions of Fish by Origin in Pamlico Sound, NC





4th Decade, 2004-2013

Dobbs and Rulifson, unpublished

Fish Timeline

- Eggs -aquifer
- Otolith forming

- Hatch – aquifer
- *Watha mix –Peedee? and Black Creek?*
- Otolith formed

- Stocked at 5 days – creek water

- July (appox 40 days) – Castle Hayne

Late Nov early Dec stock as phase II fish (6 to 8 inches)

NSP12 159 53 Otolith less 24 hr Larvae

Brie Elking

- Otolith formation in developing embryo is not reported in the literature (3 days).
- This means that material for construction must be maternal contribution (i.e., gills are not working yet)
  - (Elking, unpublished)

Edenton Pond Sampling

- 5 Ponds Sampled
  - Filled with creek water
- Only retrieved fish from 4

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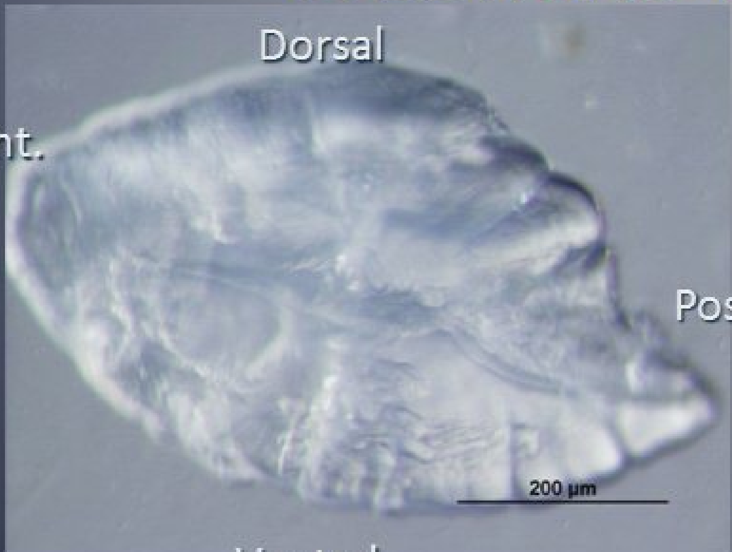
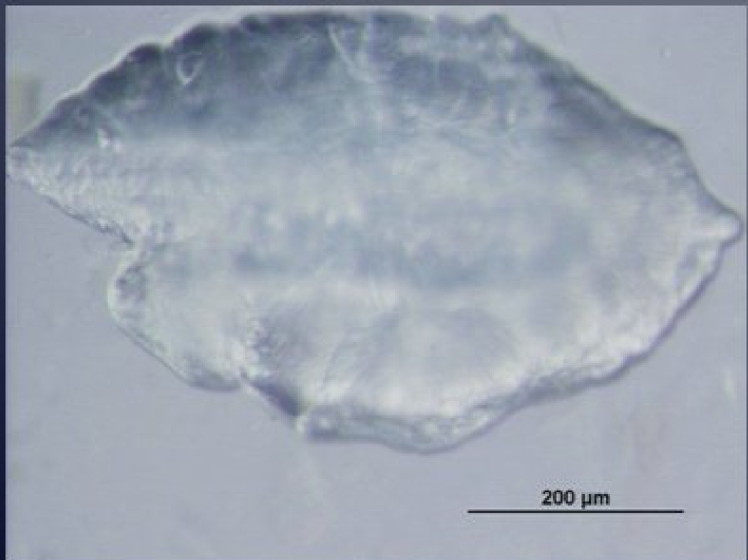
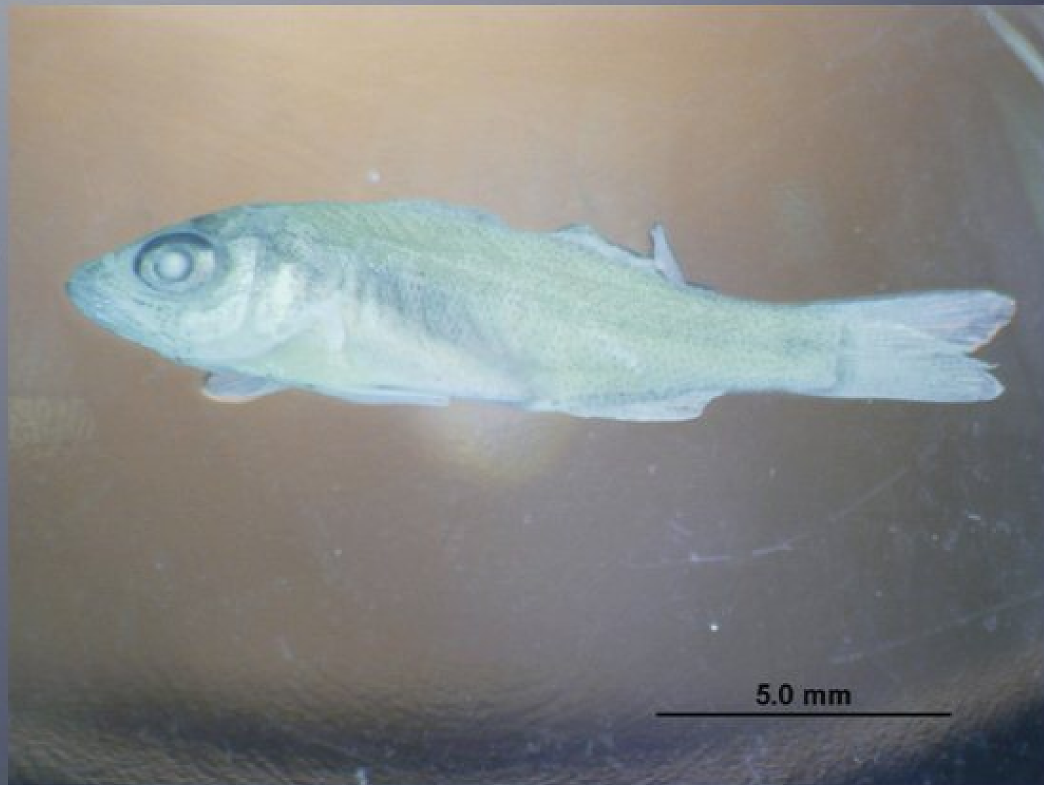
Otoliths Post Extraction



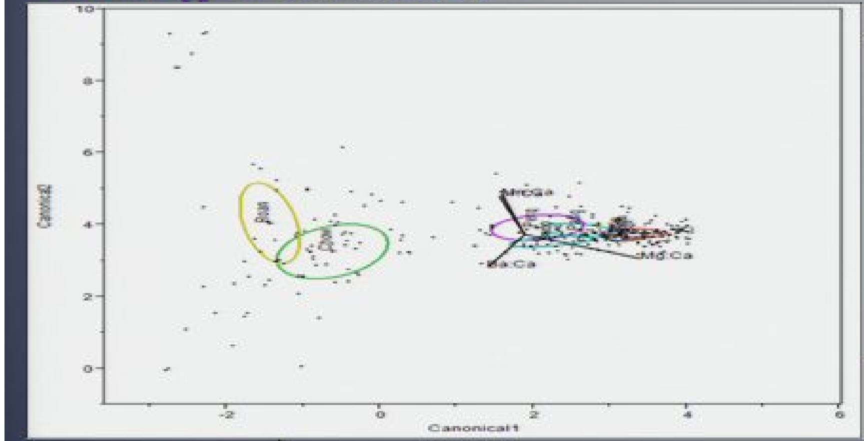


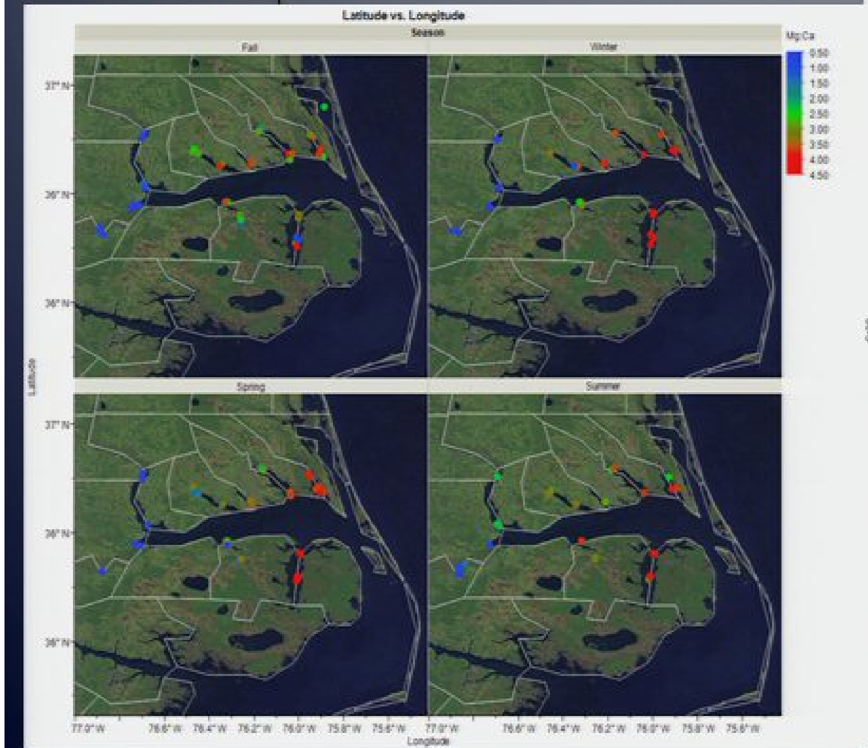


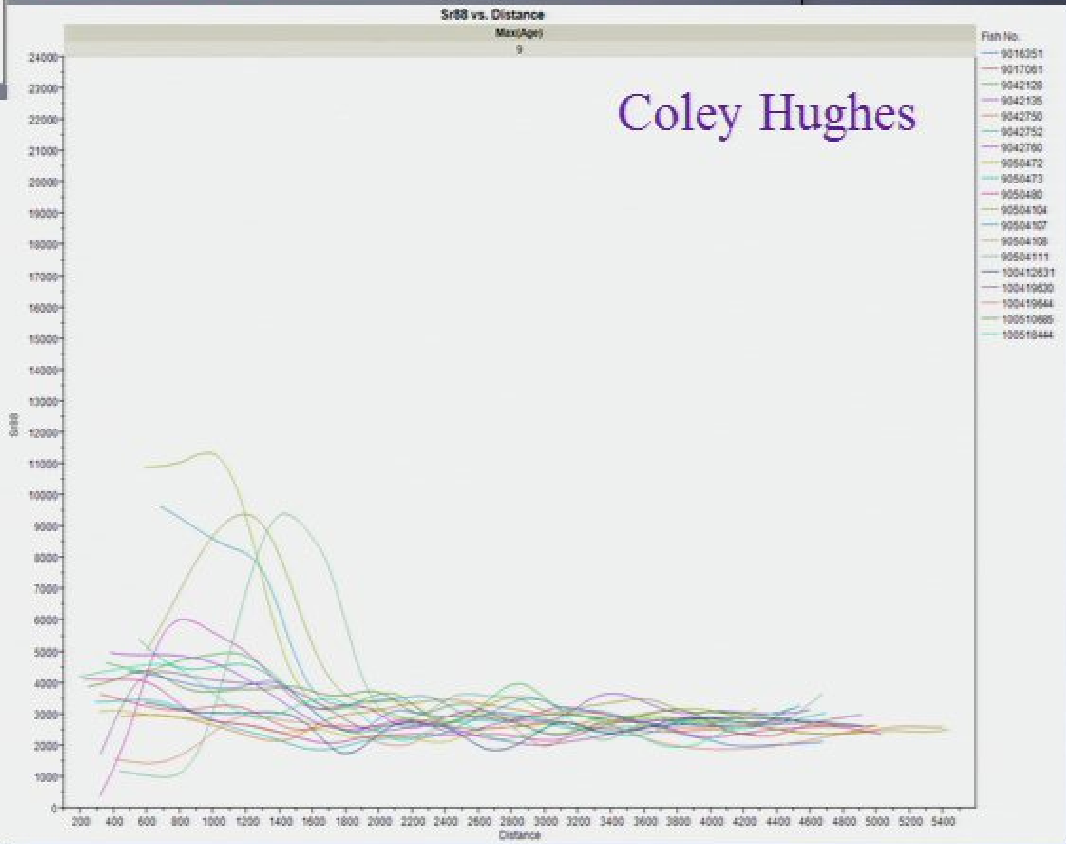
- **30 D NSP12 162 54 Fish 5**

- (Elking, unpublished)

•Otolith Microchemistry to Determine Natal Origin and Movement of Striped Bass (Morone saxatilis) in Albemarle Sound/Roanoke River Management Areas







Coley Hughes

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  - NCWRC
  - NCDMF
  - DFO Canada
  - NSF
  - NC Sea Grant
- Office of Sponsored Programs staff
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- Bill Queen and John Rummel
- Commercial fishermen in NC, VA, MD, RI, MA, Nova Scotia, and New Brunswick

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End of slide show, click to exit.