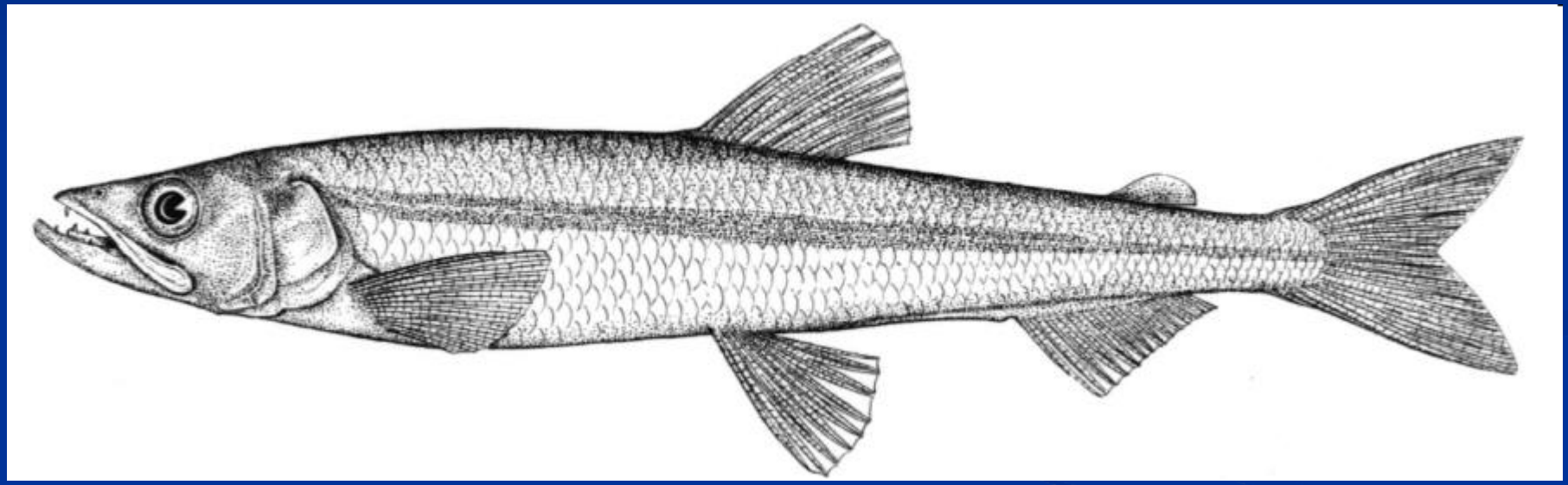
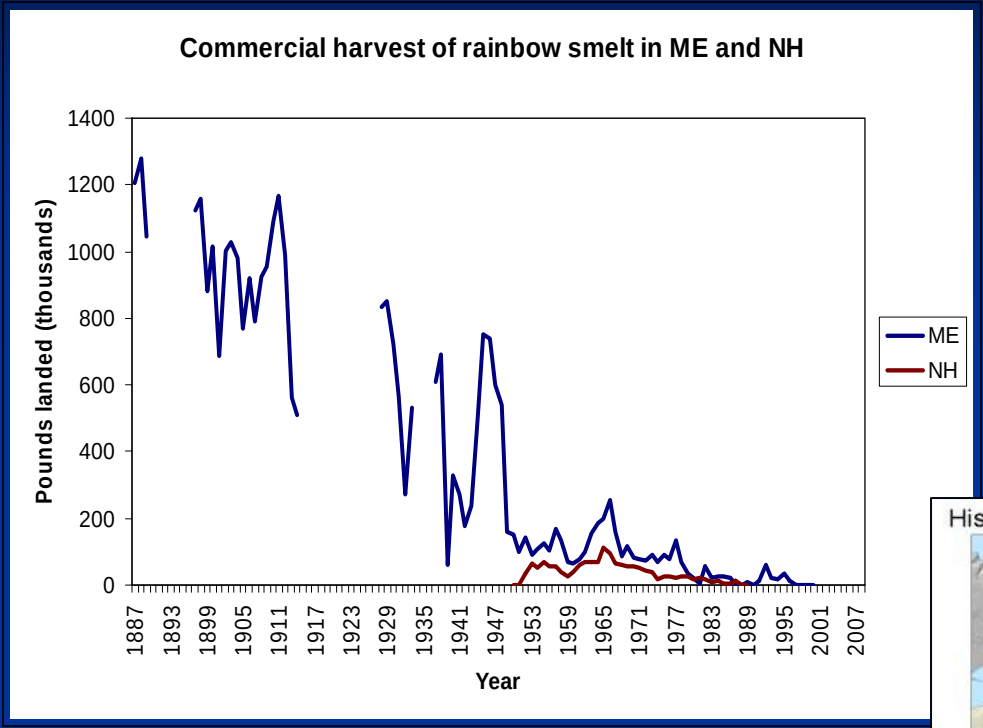
Monitoring within-season spawning behavior by rainbow smelt using passive integrated transponder (PIT) systems

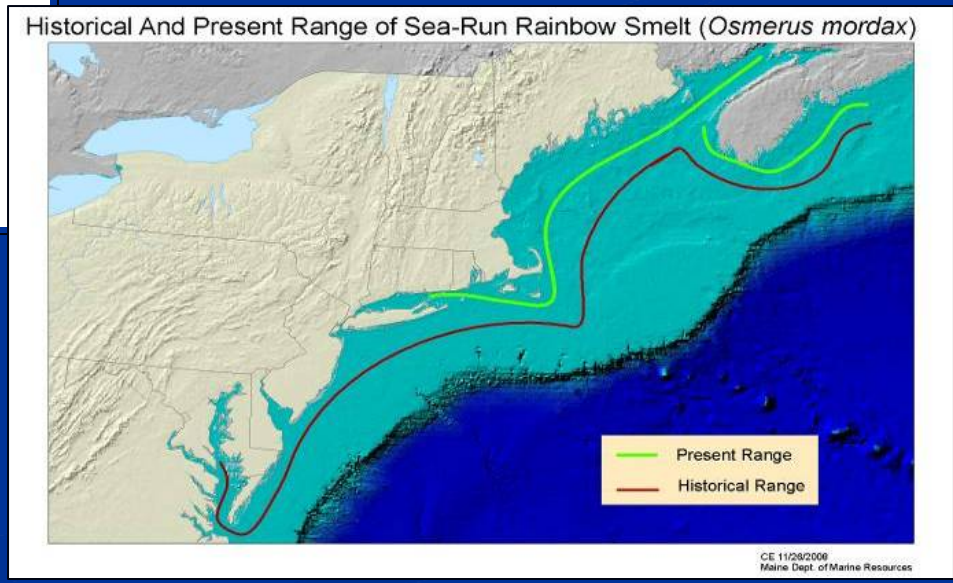


Claire Enterline, Maine Department of Marine Resources
Alex Haro, S. O. Conte Anadromous Fish Research Laboratory, U. S. Geological Survey
Brad Chase, Massachusetts Division of Marine Fisheries

Fourth North American Workshop on Rainbow Smelt, January 24, 2011

Anadromous Rainbow Smelt: A Species of Concern in the Gulf of Maine





Once abundant from Chesapeake Bay northward, now struggling south of Maine waters

How do we understand more about the decline?

- Enhance understanding of rainbow smelt in Gulf of Maine, with particular focus on spawning populations
- Describe watershed conditions and habitats which support water quality needed for successful spawning
- Characterize spawning populations and develop local mortality and population estimates

Use these results to inform the regional conservation plan to protect smelt in the Gulf of Maine

Population characteristics

Fyke nets set at index sites during the spring spawning run annually

Compare among sites:

- Catch per unit effort (CPUE)
- Length distribution
- Sex ratios
- Age structure
  - Annual survival rates
  - Instantaneous mortality

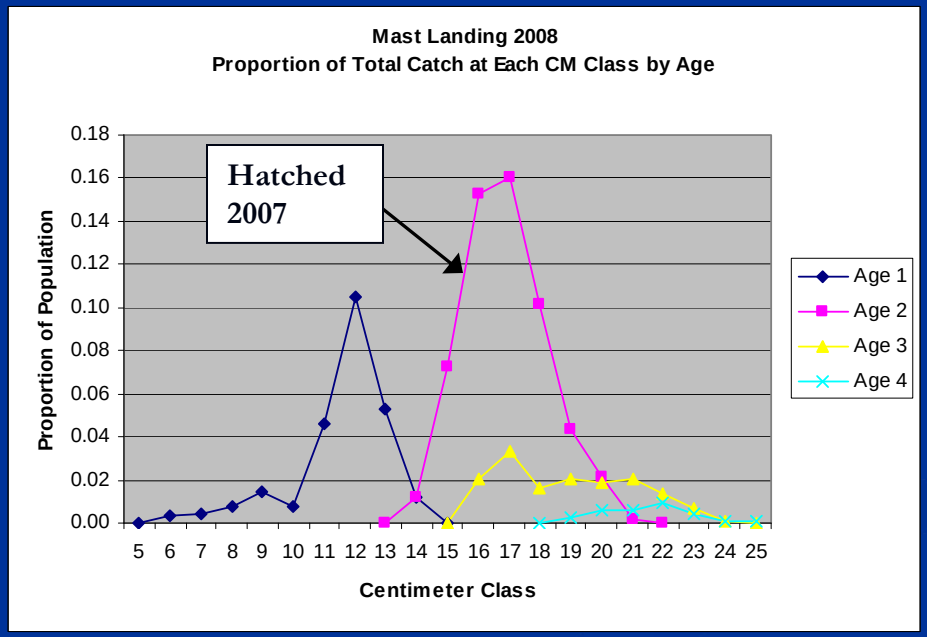
But can we use the raw catch data for mortality estimates???

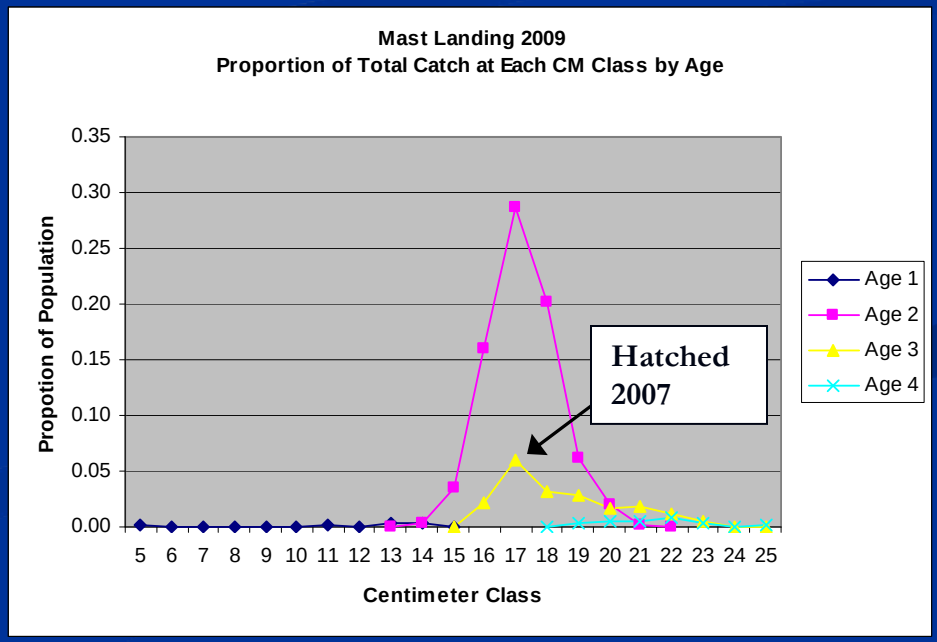
Repeat Spawning Behavior

Why does it matter?

Murawski and Cole (1978) found higher instantaneous mortality rates using age cohort movement through time compared to mean length over time

Proportion of total catch in each age class				
	Age			
Year	1	2	3	4
2008	25.3%	**56.6%**	15.0%	3.1%
2009	0.9%	**76.9%**	**19.4%**	2.7%
2010	72.4%	16.7%	**8.3%**	2.6%





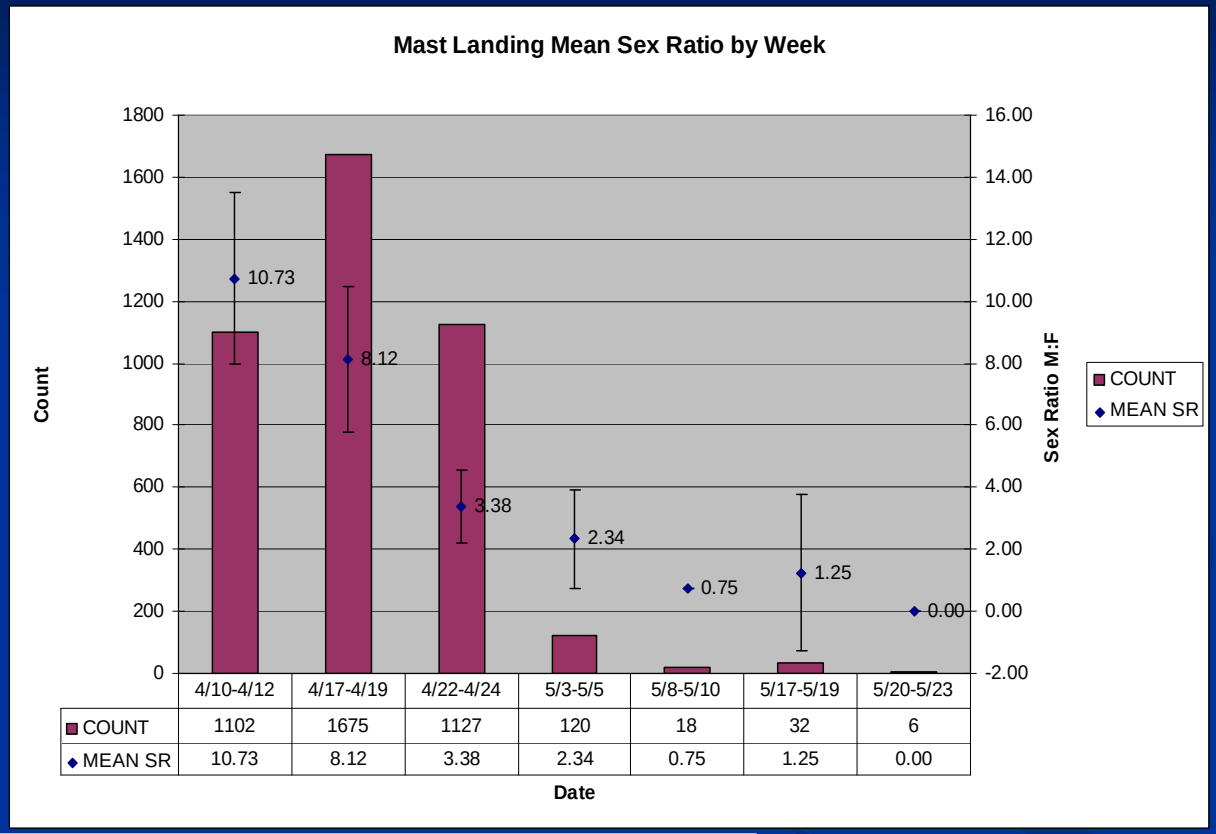
Evidence of Repeat Spawning in Smelt

- Males have a longer physiological spawning period
- Multiple males attending to one female increases fertility success
- Historical mark and recapture studies found same male at the same and different spawning sites within a given year

Sources: Clayton 1976; Langlois 1935; Marcotte and Tremblay 1948; Murawski et al. 1980; Purchase et al. 2007; Rupp 1968

Sex Ratios as Evidence of Repeat Spawning

The repeat spawning problem identified by skewed sex ratio



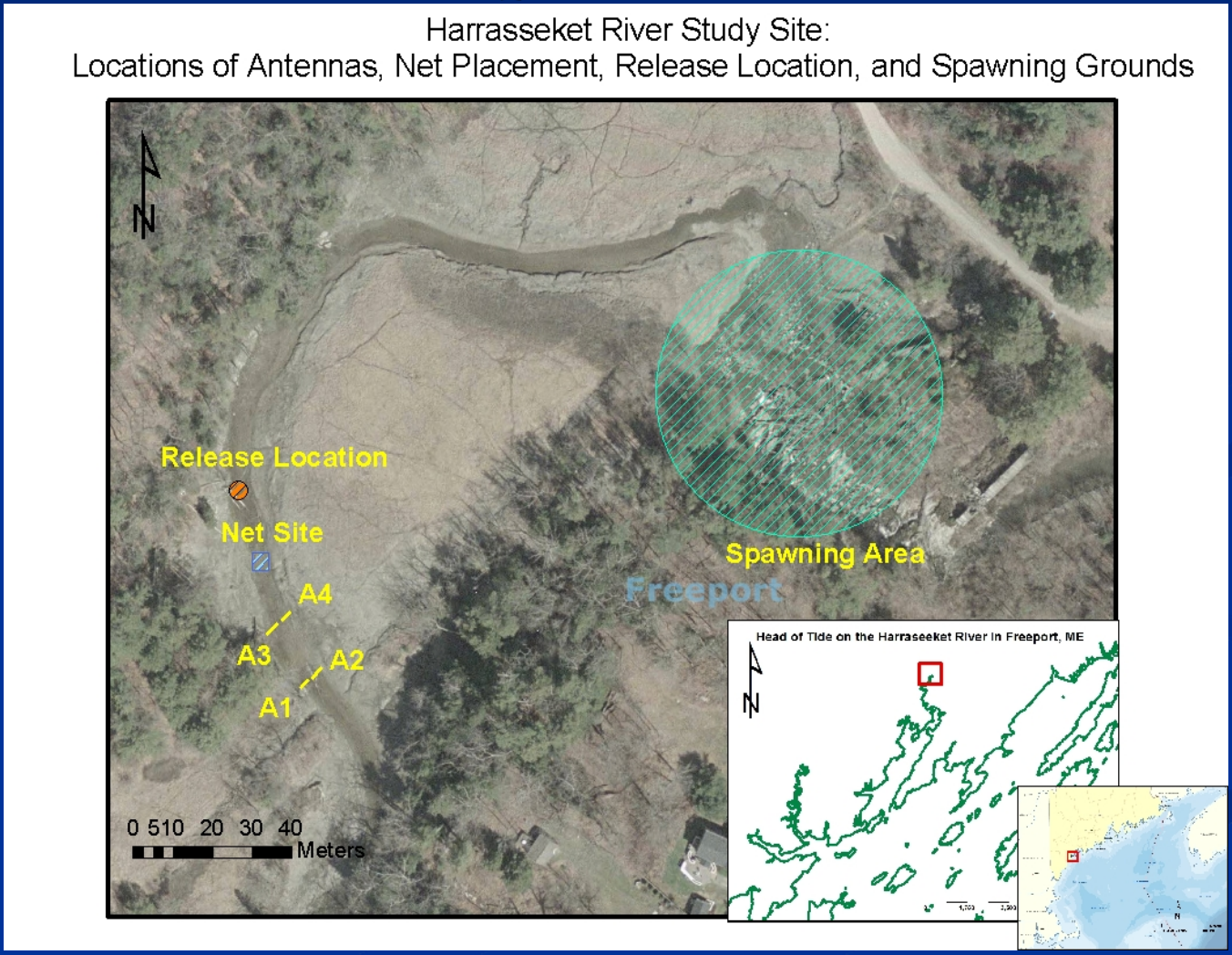
2008 Season: Sex Ratio Comparison

	Harraseeket River: Spawning Season	Harraseeket River: Summer Trawl	Casco Bay: Fall Trawl Survey
Proportion of females	14.6%	58.2%	46.2%

Quantifying Repeat Spawning Behavior in the Harraseeket River

Passive Integrated Transponder (PIT) systems using solar power monitor movement into and out of the spawning grounds 24/7 for 10 weeks March – May fully encompassing the spawning season

Study Site: Mast Landing, Head of Tide of the Harraseeket River, Freeport, Maine



Assessing Repeat Spawning: Methods

Smelt caught as part of Maine DMR's spawning survey

- Fyke net placed upstream of PIT antennas 3x week for 10 weeks March – May fully encompassing the spawning season
- Smelt are sexed and measured
- Up to 60 smelt per week are tagged with a 23mm PIT tag depending on sex and age as determined by length
  - 10 males and 10 females of each Age Class:
    - Age 1 (<169mm)
    - Age 2 (170mm-209mm)
    - Age 3+ (>210mm)
- Up to 600 smelt tagged each season
- Each PIT tagged smelt also receives a Visible Implant Elastomer (VIE) external mark for easy identification

Study repeated annually 2009 - 2012

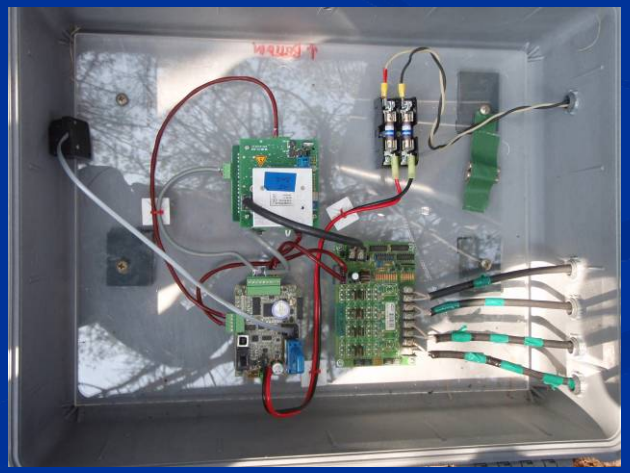
Solar Powered Half-Duplex Antenna System

- Radio Frequency Identification (RFID)
- Half-Duplex signals charge each tag, pause and wait for a response
  - Full Duplex Systems listen continuously
- Half Duplex system more tolerant of tidal conditions, small changes in shape of antennas
- Multiplexer system divides the reader's attention between four antennas, dividing the read rate but using less power
- Antennas are made of welding wire looped around sections of the river

Solar Power

-> Powers 12V Batteries

-> Powers Reader and Multiplexer



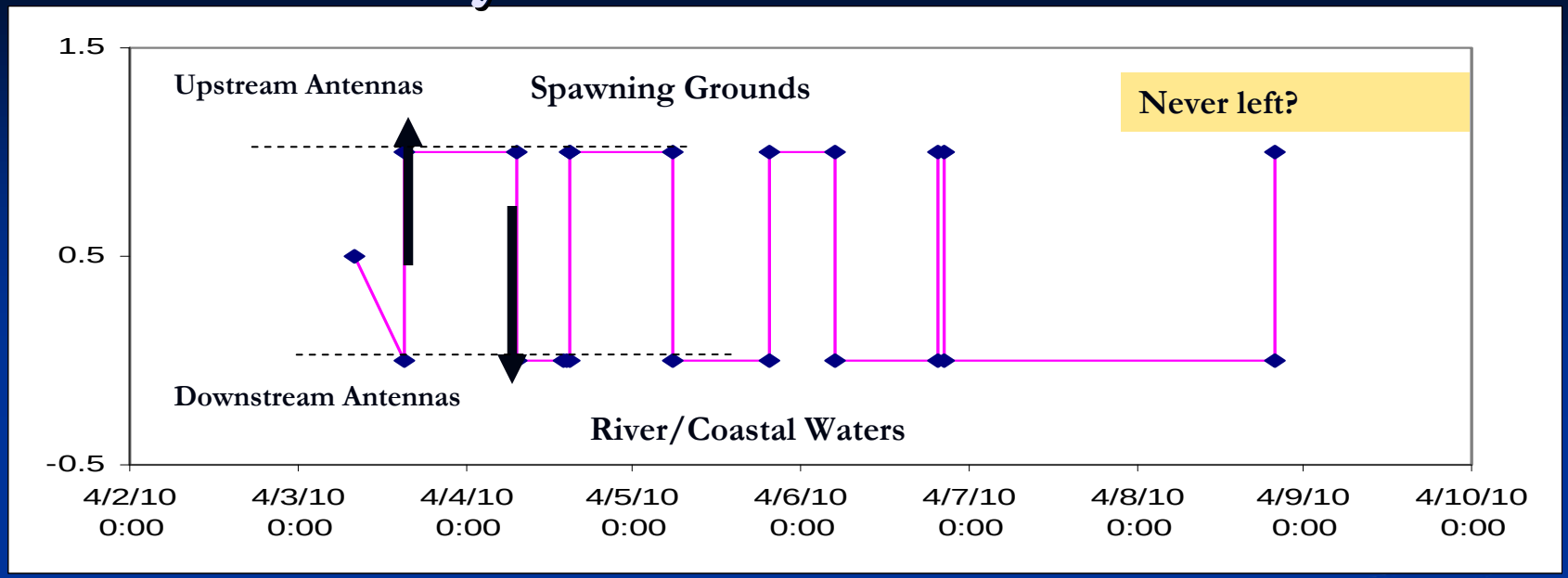
-> Powers Four Antennas

Solar Powered Half-Duplex Antenna System

Challenges:

- Antennas do not have the same shape
- Extremely large system
- Tidal and temperature changes
- Ice and heavy spring flows
- Continuous cloudy days may cause power shortage

Preliminary Results: Antenna Performance



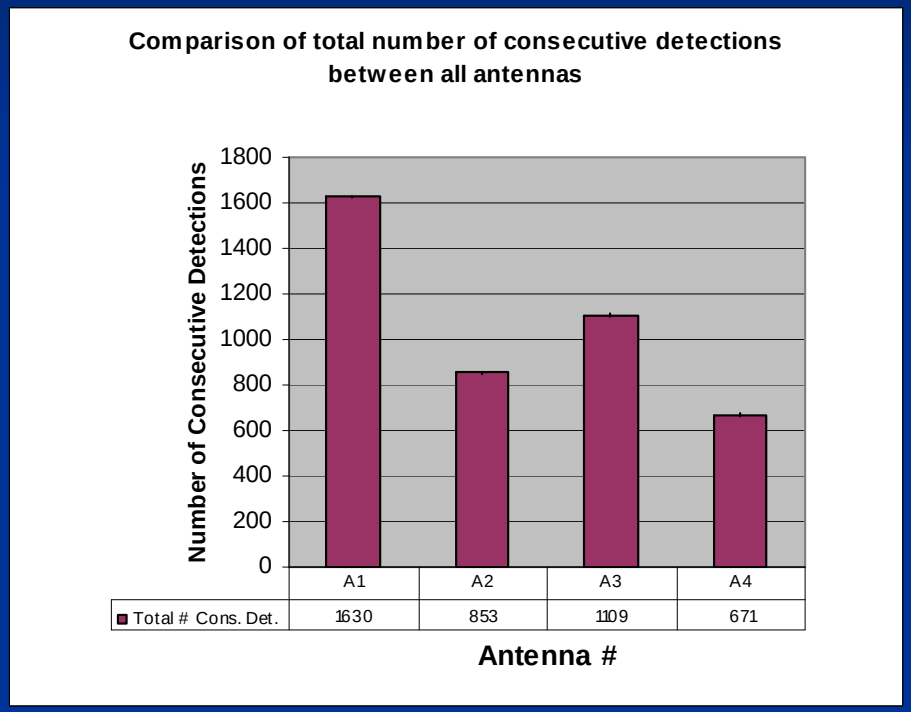
- Antenna efficiency calculated using number of 'missed' detections with number of total number of detections

  System Efficiency: 82.5% in 2009; 82.1% in 2010

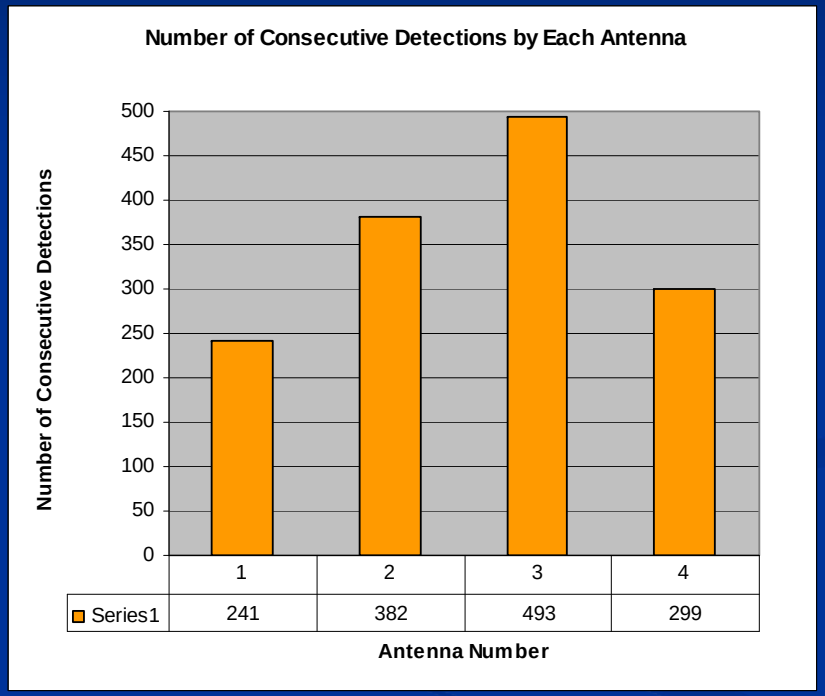
- Many times the after-spawning descent was missed – fast movement downstream with the tide? Fishing?

Performance Differs Between Antennas

2009



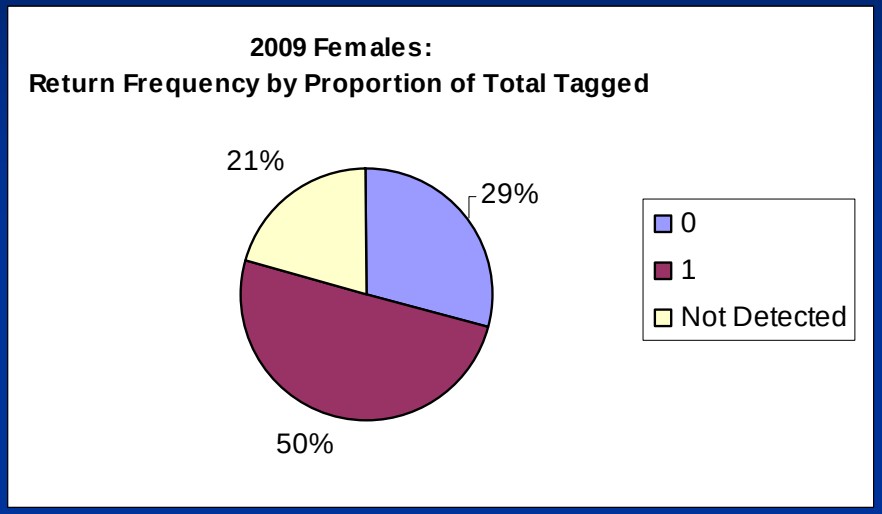
2010

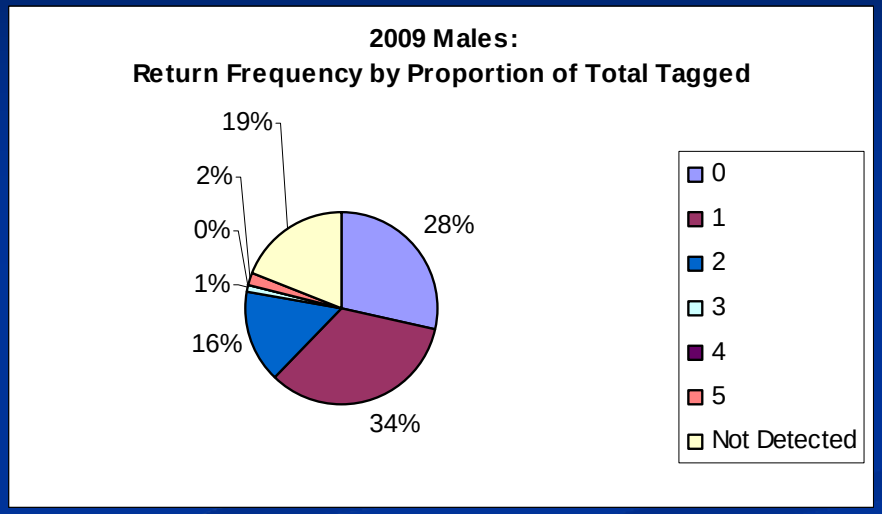


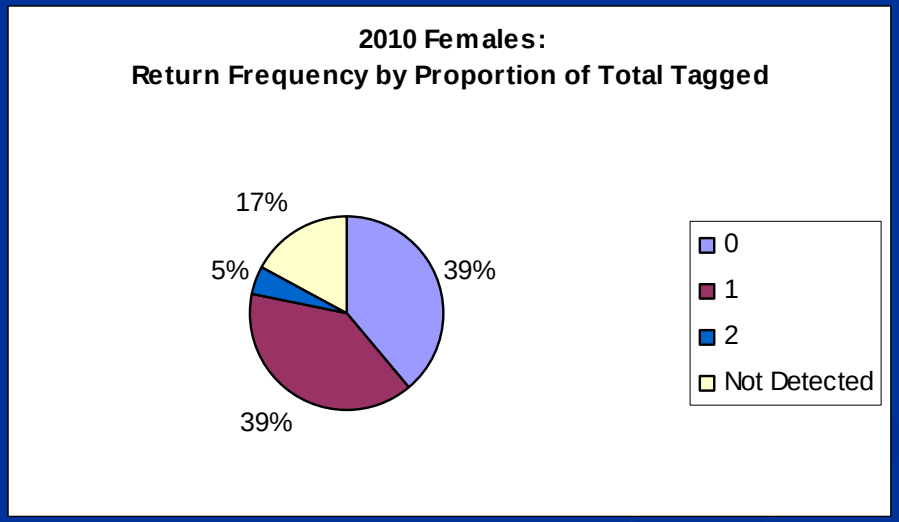
- Antenna performance measured by the consecutive number of detections by each antenna

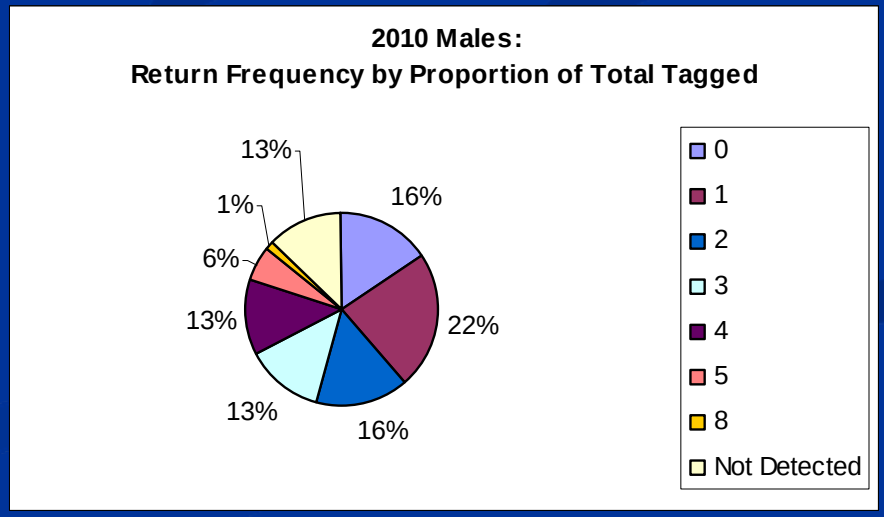
Return Frequency by Gender and Year

Males returned more often than females in both 2009 and 2010







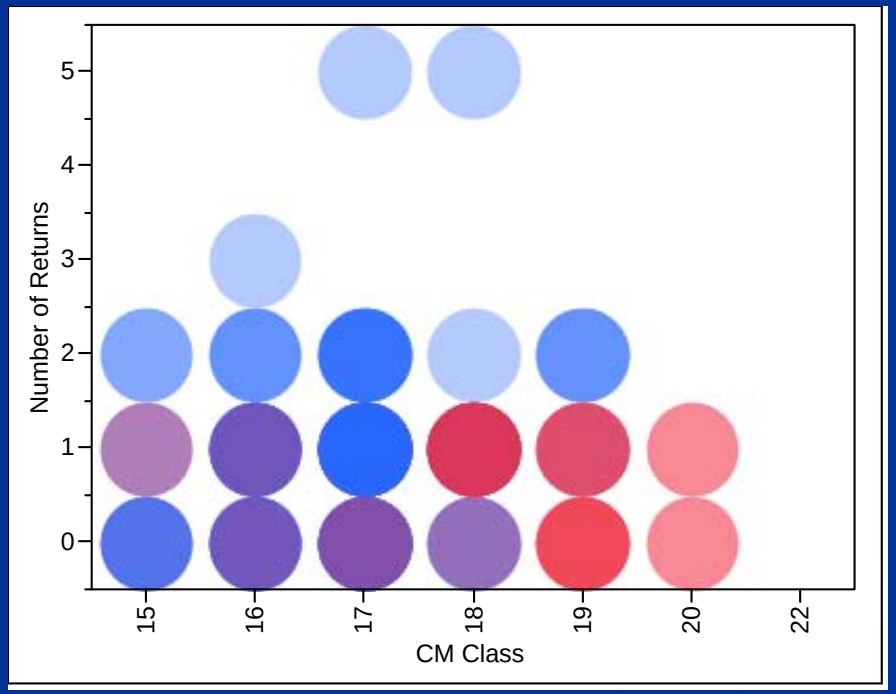


Sample Composition and Return Frequency

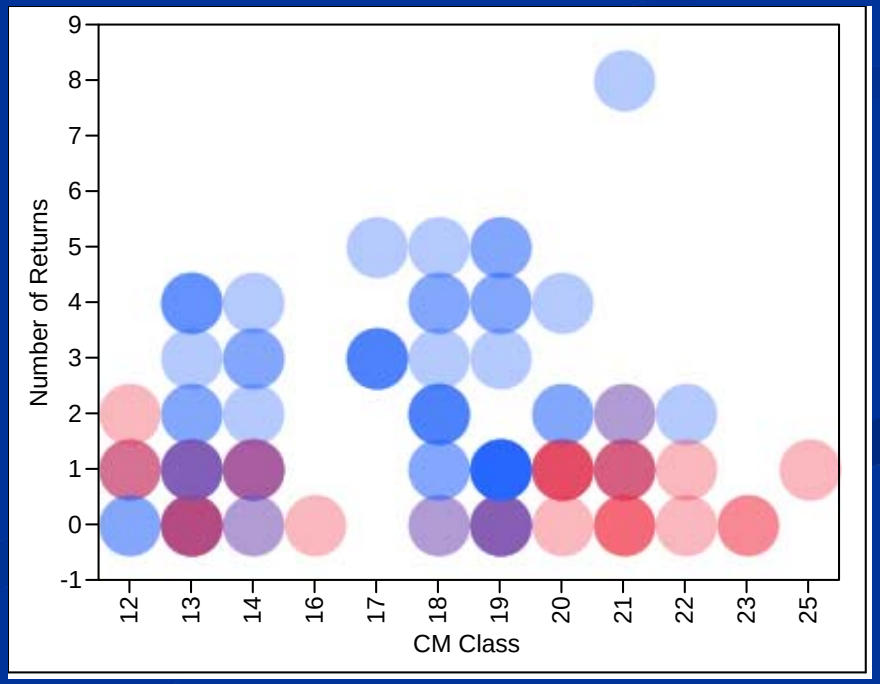
- The size range was much larger in 2010
- Probable Age 2 males seem to return more often (>4 times)

Sample Composition: Summary	2009		2010	
	F	M	F	M
Sample Size	48	95	41	70
Average Length	183.46	172.49	180.78	170.54
Minimum Length	**155**	**152**	**127**	**128**
Maximum Length	**206**	**227**	**256**	**225**
Total Number of Fish Returning >1	24	50	18	50

2009: Number of Returns by Sex and Length



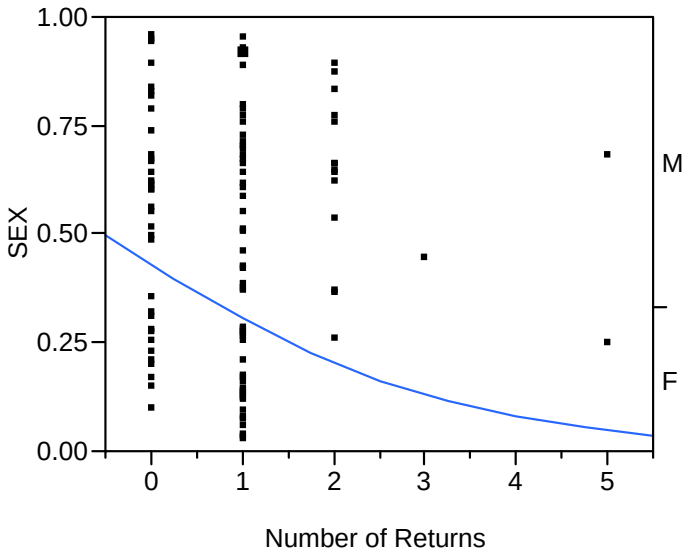
2010: Number of Returns by Sex and Length



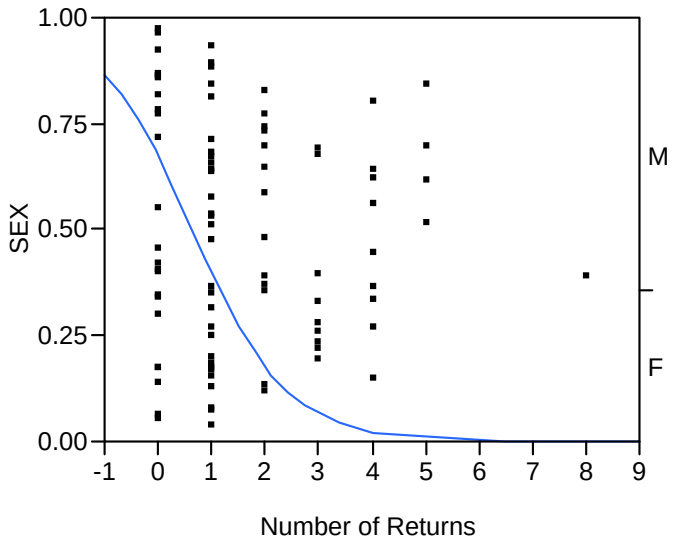
Likelihood of Repeat Spawning by Gender

- The probability of returning two or more times is significantly less for females than males
  - Logistic Regression: 2009 Prob>Chi Square=0.0366<0.05
    2010 Prob>Chi Square<0.001<<0.05

2009: Probability of Return by Sex



2010: Probability of Return by Sex



Are All Returns Repeat Spawning?

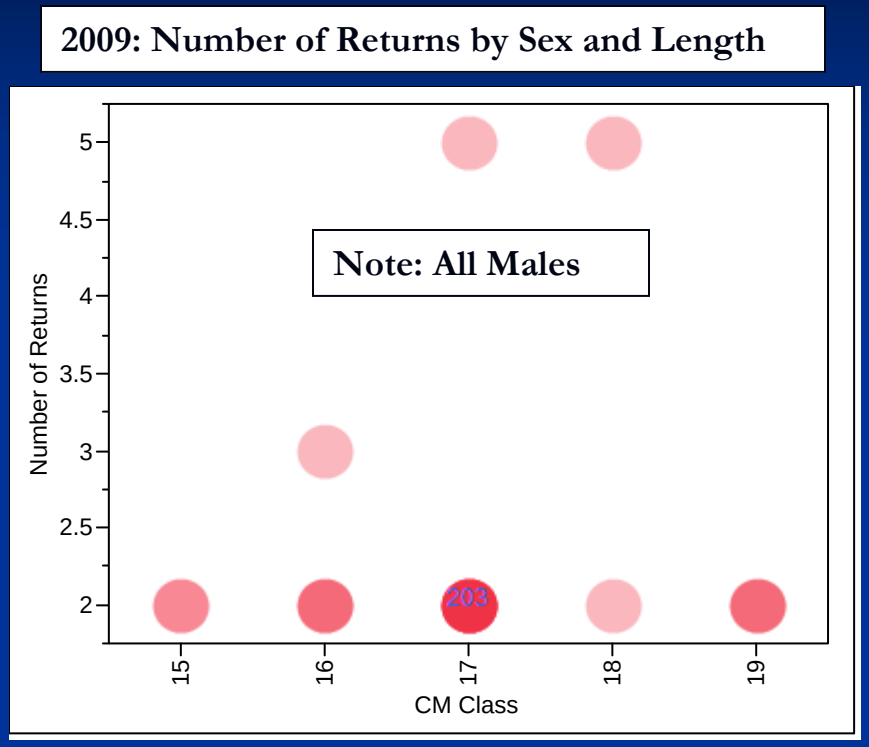
- The majority of 1st returns occurred the night of tagging

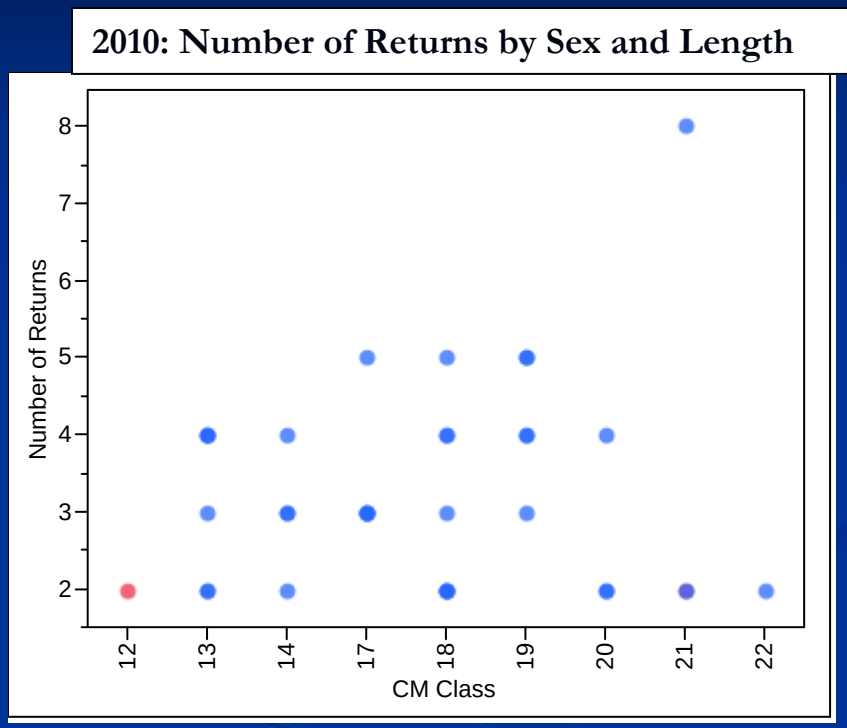
→ Interruption of normal spawning behavior

Exclude the first return from analyses

Proportion of Fish Returning the 1st Night After Tagging				
	2009		2010	
	Female	Male	Female	Male
Returned 1st Night After Tagging	100%	88%	100%	76%

Revised Return Frequency





- When first return is excluded, repeat spawning is almost exclusively a male phenomena, dominated by probable Age 2 males
  - One female returned 2x in 2010

Where do we go from here?

- The rate of repeat spawning may vary by year and dominant age class
  - Replicate study 2009-2012
- Confirm ages of tagged fish
  - Develop age specific repeat spawning rates
- Replicate study at another site
  - Compare repeat spawning rates by sex and age
- Use data combined from multiple years to establish age specific repeat spawning rates
  - Tune mortality estimates

Project Partners

Maine Department of Marine Resources

New Hampshire Department of Fish and Game

Great Bay National Estuarine Research Reserve

Massachusetts Division of Marine Fisheries

University of New Hampshire

USGS Conte Anadromous Fish Research Laboratory

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Questions?

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