Cobia Research in SC and Beyond

Management Implications Along the Southeastern US Coast

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Cobia

- Pelagic, migratory species
- Commercial and recreational importance
- Harvests declining since 1996
- Recreational pressure increasing
  - Inshore aggregations
  - Overfishing potential
- Single stock management
  - GMFMC; SAFMC
- Cobia have been managed as an incidental catch species, mostly as bycatch…
- Not as much data on cobia as we would like…

SC Cobia Research

- Life History
  - Spawning aggregations
  - Sexual Maturity
  - Age-Growth-Overfishing implications?
  - Estuarine vs. pelagic
  - Movement-migration
  - Genetics
- Aquaculture
- Stocking research

Cobia research in SC has been supported by HHIFC, BFC, CCA, Charter boat captains, volunteers, tournament directors and participants, Friends of Waddell without which we would not have the data we have today.

Cobia work-up

- Samples collected from local fishing tournaments
- Total length, fork length, and weight recorded
- Gonads weighed and cross sections preserved in formalin (sex determined)
- Otoliths removed
- Fin clip preserved in sarkosyl-urea solution
- Stomachs emptied and contents preserved in formalin
- Freezer/cooler program only contributed racks (Charter captains)
  - Length good indicator of weight
  - Female more variable due to spawning condition (27.22 kg with 5.0 kg ovaries - 18.37%)

Gonad Processing

- 148 female fish
- “Staged” each slide based on ovarian maturity
  - Stage based on oocyte diameter and structures present
  - Looking for fish getting ready to spawn or that have just spawned

Late Developing Gravid Recently Spawned

2007 Summary

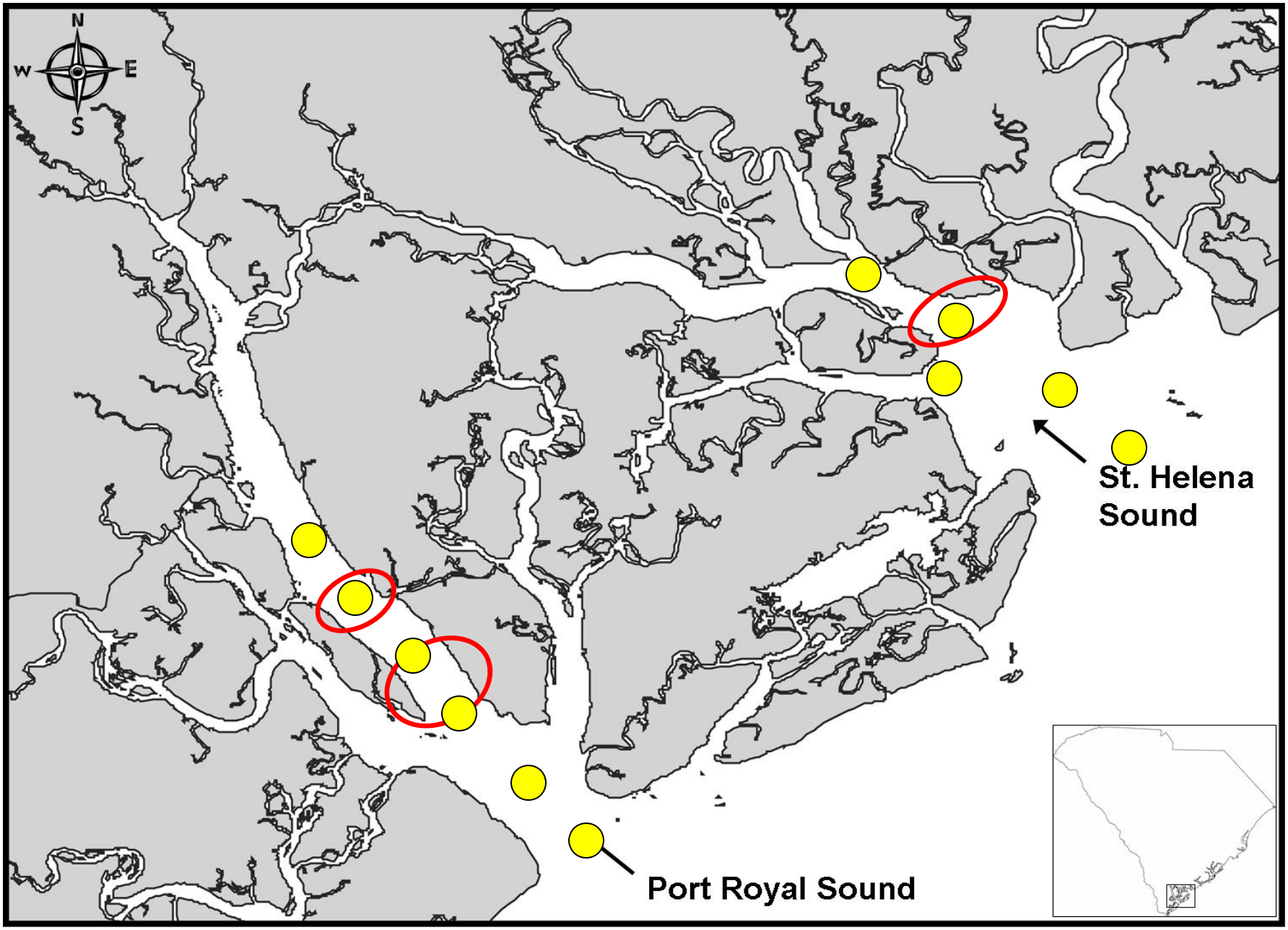
	Age											
Stage	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**?**	**Total**
Early Developing	1	1			1							3
Late Developing	1	89	4	10	4	5	1	4	1	2	4	125
Gravid		3				1						4
Recent Spawn		7										7
Prior Spawn		8										9
Spent		1										1
Total	2	109	4	10	5	6	1	4	1	2	4	148

What does it mean?

- Males are in spawning condition throughout recreational season
- All but 1 female in spawning condition
- 2 gravid females caught in Port Royal and St. Helena Sounds may indicate:
  - Daytime spawning
  - Some may be spawning in Sounds

Plankton sampling

- Samples from 2008-2010
  - April, May, & June
  - Time of capture, site of capture
- Plankton surveys
  - Anchored nets
  - Flood tides
  - 2 times per week


N
W
E
S
St. Helena
Sound
Port Royal Sound

Plankton Samples

- Spawning function
  - Genetic structure
  - Fidelity
  - Plankton samples
    - Positive egg & larval identification
    - 2008-2010

Implications of findings

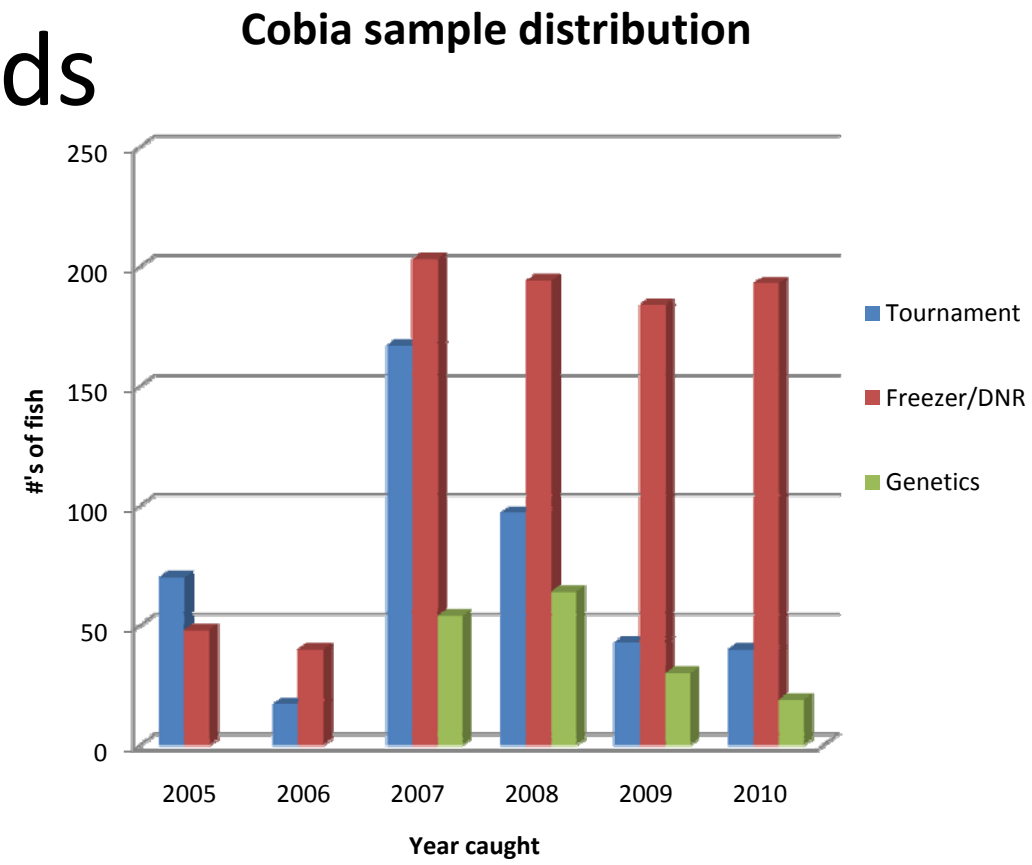
- Large recreational fishery in SC estuaries
- Current regulations allow fish over 84 cm to be caught, but…
  - Females mature at 80 cm
    - Many may not make it to their first spawn
    - First spawn not always the most productive?
  - Average fork length for age 3 female=97.5 cm
- If spawning is occurring in the estuaries, current management may need adjustment
  - Increase minimum size; implement slot limit; change in bag limit; designate spawning areas as essential habitat

Objectives

- To examine life history, primarily age structure of cobia in SC waters
- Use age and catch data to produce catch curve regressions
- Provide estimates for annual mortality and survival to fisheries managers to better manage the population
- Can these data be used as a proxy for Fisheries independent data
- Are they biased? Sample sizes high enough?
- Prepare for upcoming SEDAR assessment

Sampling methods

- Offshore, Port Royal, and St. Helena Sounds
- 2005-2006 Graduate Student 2007-2010 SCDNR
- Data collection: Total length, fork length, total weight, site and time of capture, gonads, fin clip, otoliths, and stomach contents

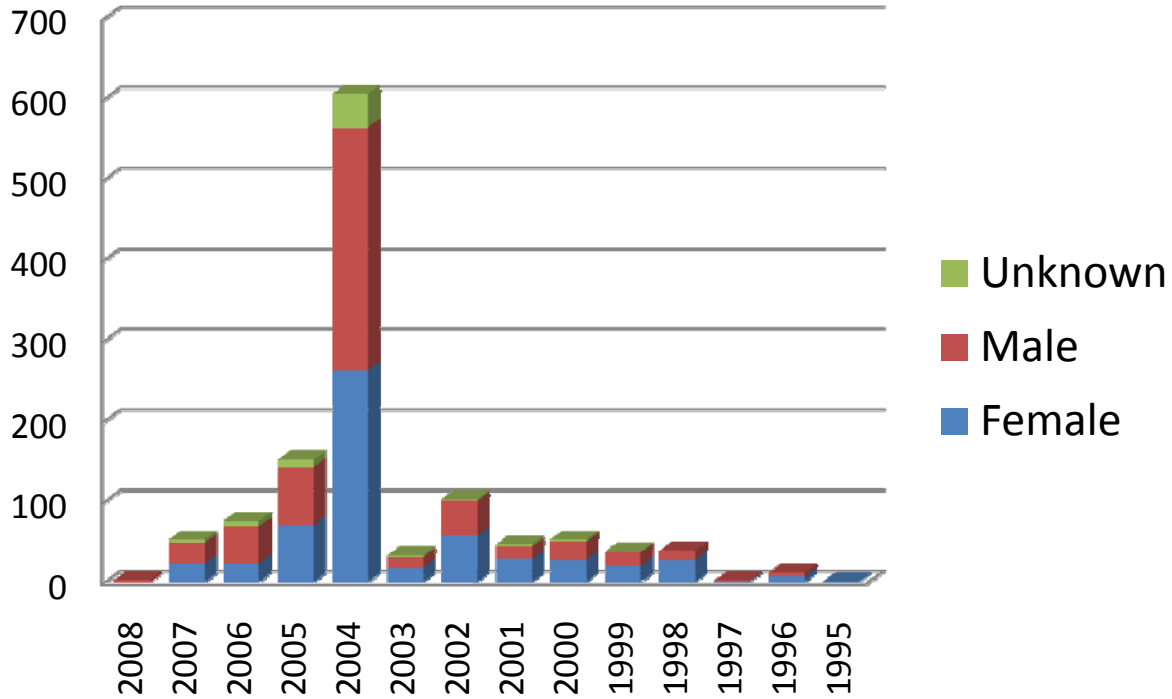


Otolith Ageing

- Standard otolith procedures
- Hyaline and opaque regions
- SCDNR age validation using cultured fish (lab and tag recapture)
- 2 independent readers
  - <5% discrepancy

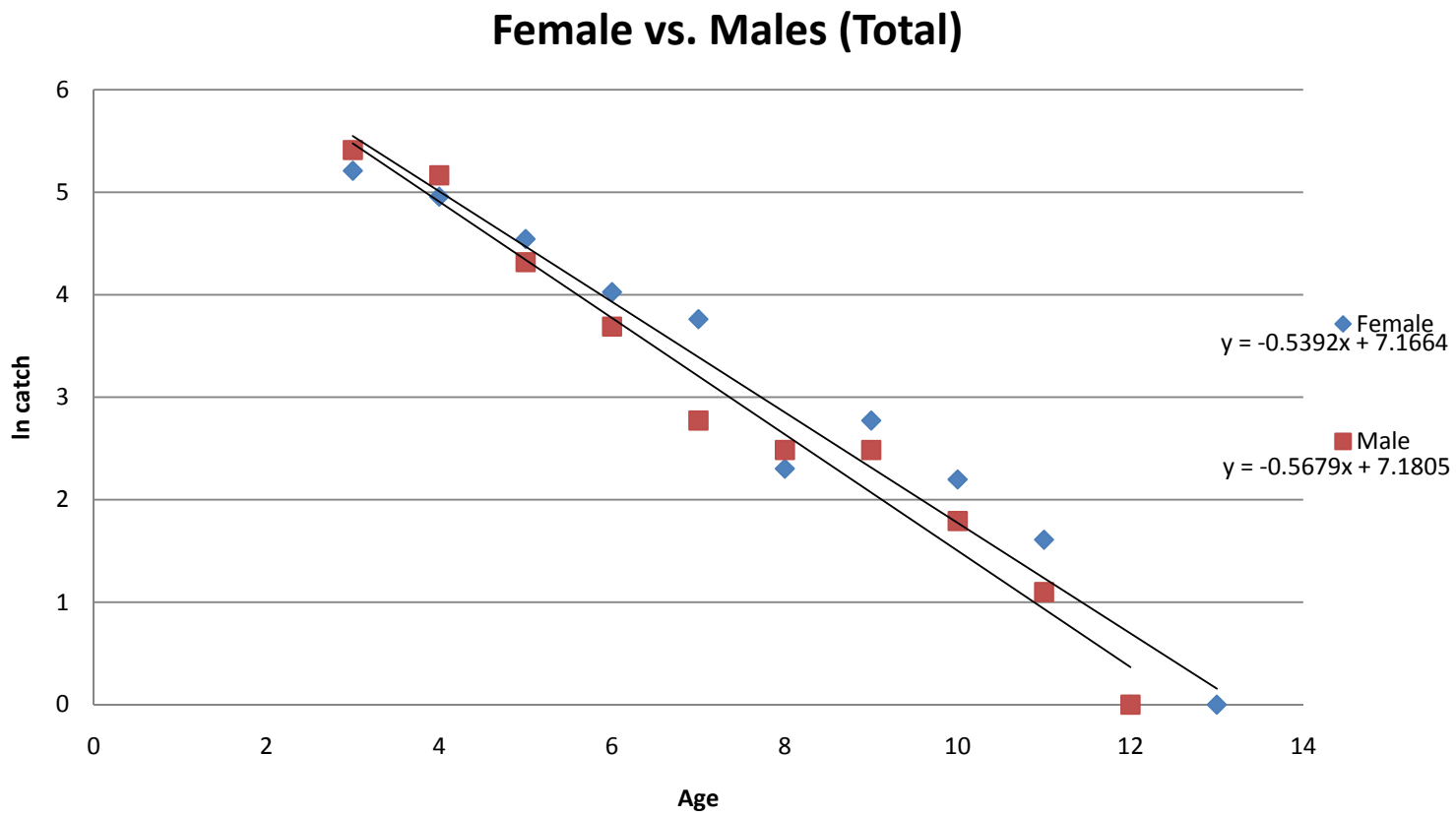
Total catch by year-class 2005-2010

Year	Sample Size (n)
2010	217
2009	205
2008	283
2007	347
2006	53
2005	113
Combined (2005-2010)	1218



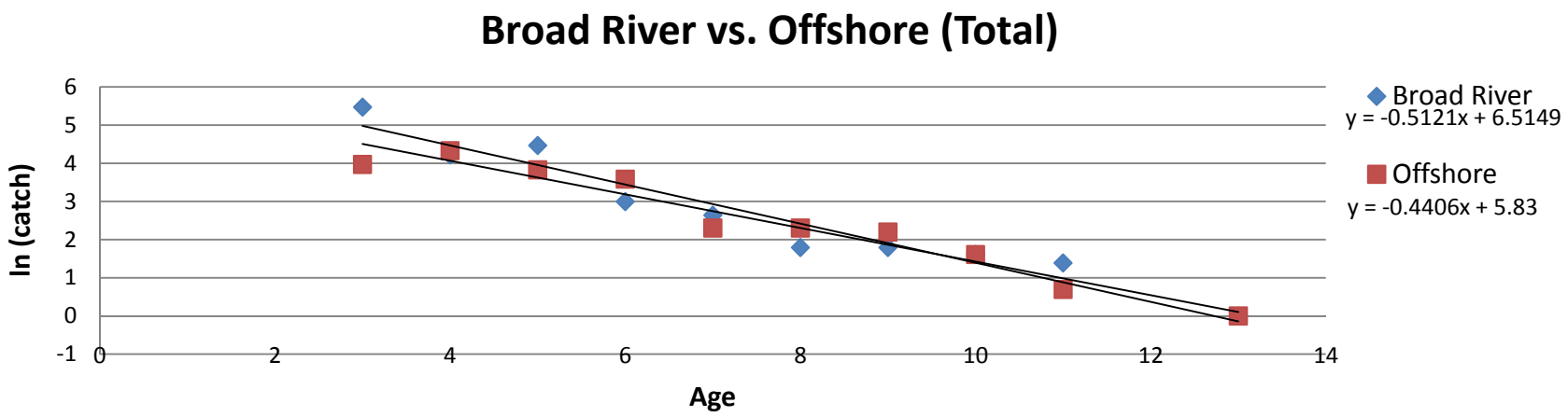
- Year-class highly variable (2004 yc 50% of total catch)
- Sex ratios similar
- Maximum age 13
- Survival past initial recruitment into the creel
  - Able to contribute to the spawning population for multiple years (2004 yc 25% total catch in 2010)

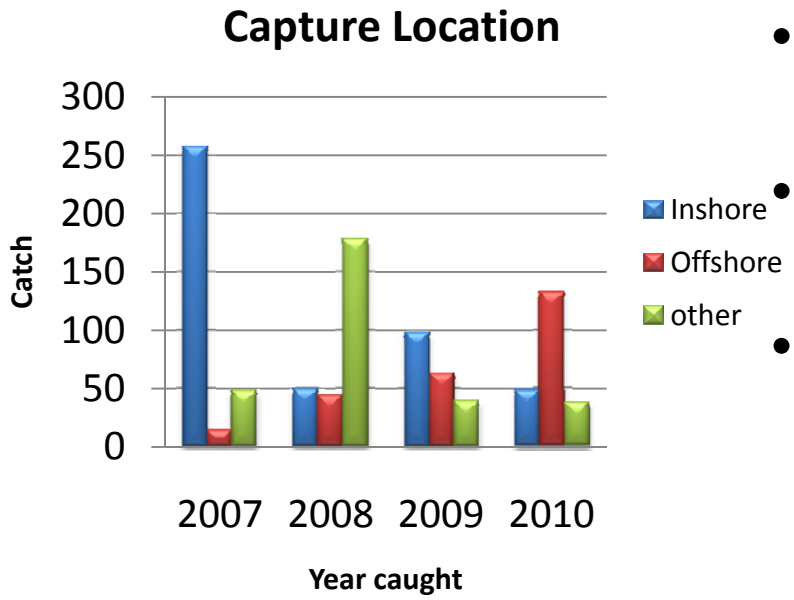
Male vs. Female



- Catch data may be bias towards females (tournaments)
- General Linear model showed no significant differences between sex in any year
- Annual survival of females and males from 2005-2010 similar (56% and 58%)

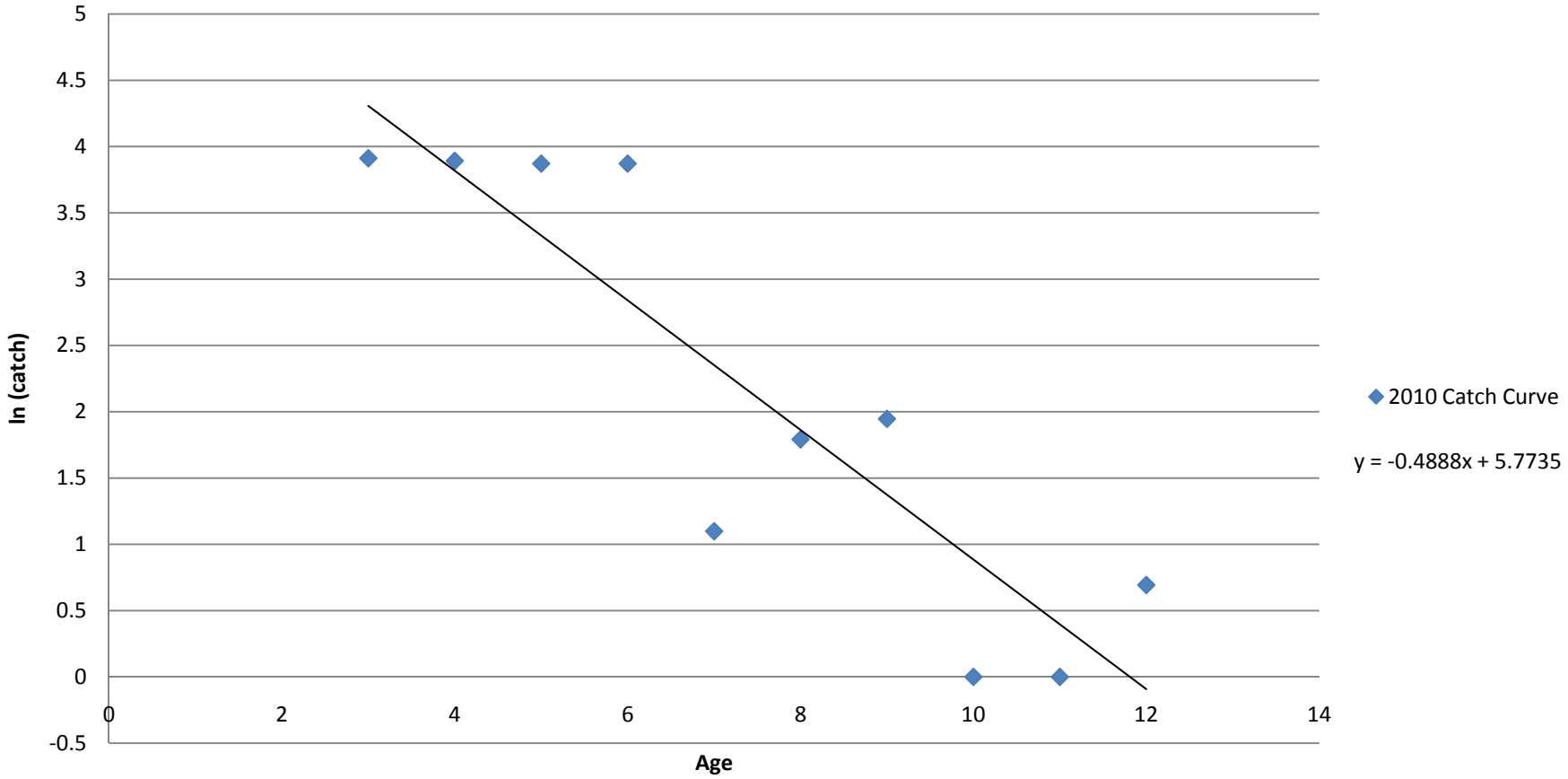
Inshore vs. Offshore Samples





- Inshore and offshore different genetic stocks
- General linear model showed no significant
- Survival for 2007-2010 combined
  - 60% Inshore
  - 64% Offshore

Catch Curve 2010



- Instantaneous rates of mortality (Z) (Z= 0.49)
- Annual survival rate (S=.6126 or 61.26%)
- Annual mortality rate (A= 38.74%)

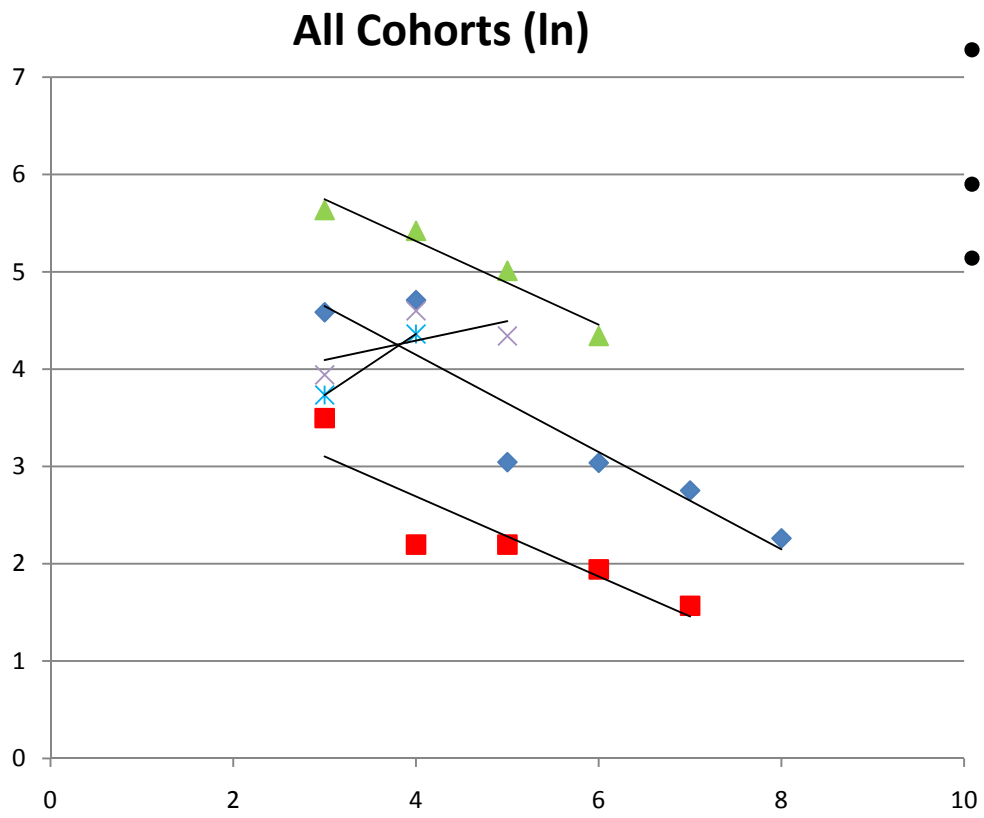
Annual mortality and survival

Year	Sample Size (n)	Instantaneous rate of Mortality (Z)	Annual Survival Rate (S) %	Annual Mortality Rate (A) %
2010	217	0.49	61.3	38.7
2009	205	0.37	69.1	30.9
2008	283	0.44	64.4	35.6
2007	347	0.46	63.0	37.0
2006	53	0.28	75.3	24.7
2005	113	0.38	68.5	31.5
Combined (2005-2010)	1218	0.56	57.1	42.9

- With year-class variation, annual survival relatively constant
- 2006 likely due to sample size (53)
  - Annual survival (61-69%) close to initial assessment (66%) in 1983 using Robson and Chapman model

Cohort catch-curve

Year Class	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	Weighted to 347
Year Caught 2005						12	98	46	49	55	64	0	18	3	
2006					46	33	111	39	52	39	20	0	7		
2007			1	4	280	9	21	7	13	3	4	1	4		
2008			2	51	226	9	21	11	11	7	7	1			
2009		5	42	99	150	7	16	5	9	7	5	0	2		
2010	5	80	78	77	77	5	10	11	2	0	3				



- Standardized for comparison
- Year-class strength visible
- Positive catch curve with minimal data
  - High saturation of the 2004 cohort
  - Age 3 fish not fully recruited to sampling method
  - Migration patterns (Movement within another estuary)

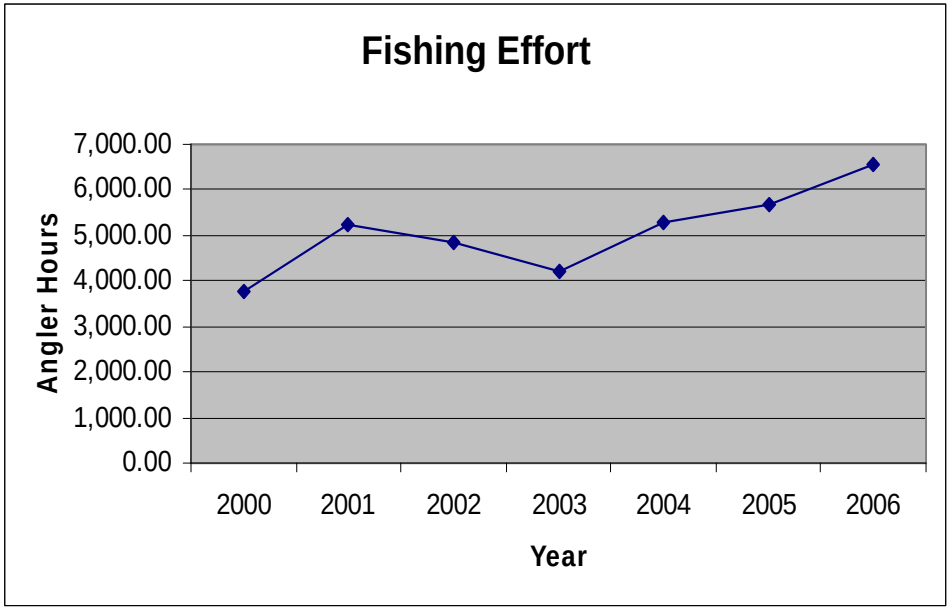
Cohort annual mortality and survival

Year	Sample Size (n)	Instantaneous rate of Mortality (Z)	Annual Survival Rate (S) %	Annual Mortality Rate (A) %
2002 cohort	277	0.50	60.7	39.3
2003 cohort	62	0.41	66.4	33.6
2004 cohort	732	0.43	65.1	34.9
2005 cohort	228	NA	NA	NA
2006 cohort	120	NA	NA	NA

- Survival around 61-66% with a minimum of 4 data points
- Similar survival rates to yearly catch curve
- 2005-2006 cohorts NA due to positive slope of catch curve

Possible decrease in population size?

- The trend in age data suggest a decrease in age over time (4.98-3.56)
  - Implying fish are being harvested once they reach the minimum legal size limit (3 years old) and few escape to larger size
  - Year class strength
  - Fewer large ripe female (reduction in fecundity)
- Assumptions of catch curve
  - 1) sample may not be a random expression of age structure (smaller fish may be more susceptible to sampling methods)
  - 2) fishing mortality rate may not be equal among age classes (selective harvest by environmentally conscious anglers)
  - 3) mortality rate may change over time (increased fishing pressure)
  - 4) highly variable year class contributions
- Increase in fishing pressure
  - 75% increase in 4 years
- Hyperstability
  - CPUE stays constant while population actually decreasing
  - Fish that show high site fidelity and where anglers know where to catch



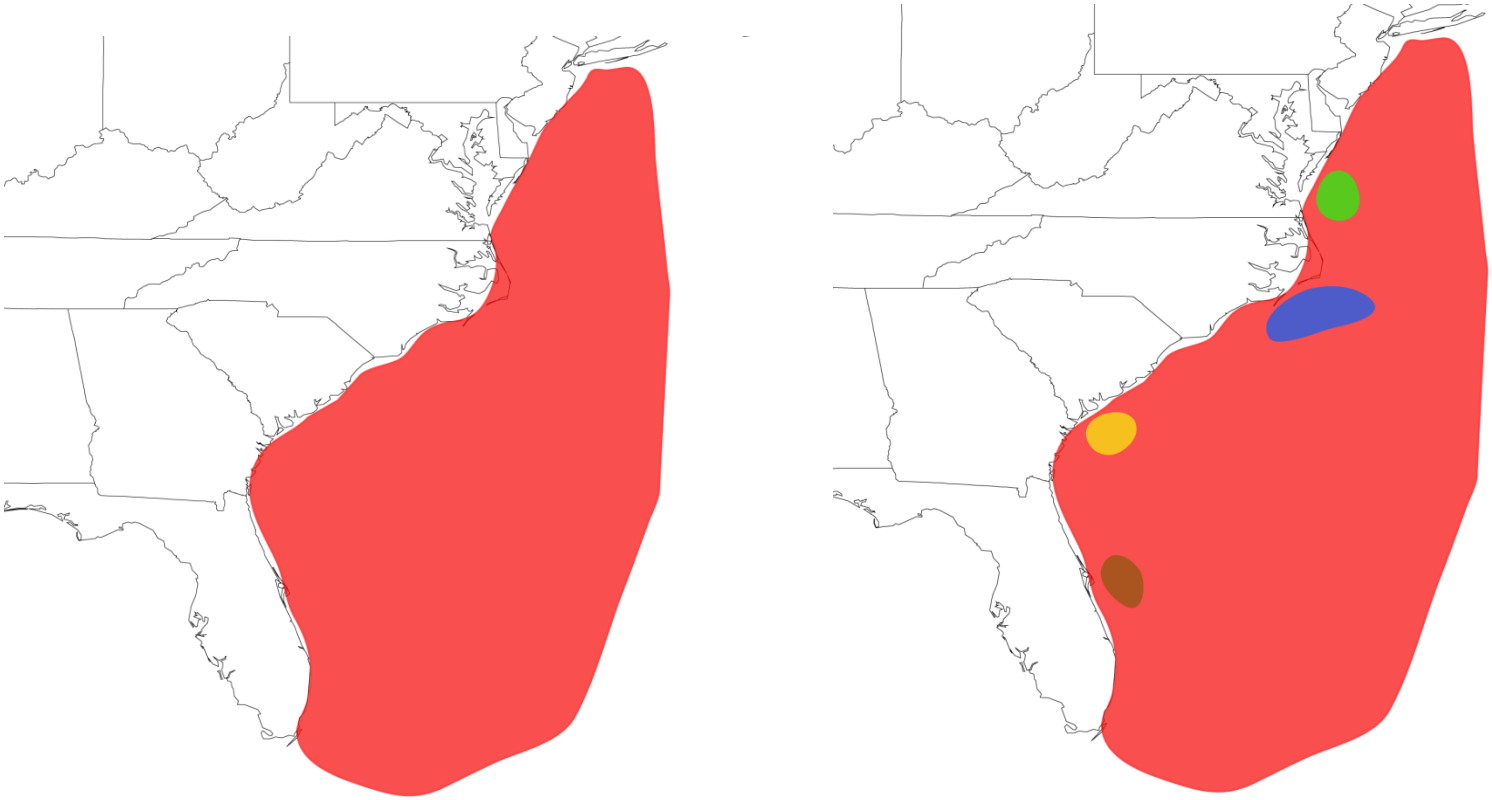
Conclusions

- Year-class is highly variable
- Male vs. female and Inshore vs. offshore showed no significant differences (able to pool data)
- Yearly and cohort catch curves similar (61-69%)
- Mortality rates critical for determining abundance of fish populations
  - Need recruitment rates (CPUE data difficult to obtain)
- Without this strong 2004 year-class, mortality rates could be much higher on other cohorts
- Fisheries-Independent sampling

Genetic Research Questions

- Genetic composition?
  - Population structure
  - Migration
  - Estuarine fidelity
- Role of seasonal inshore aggregatio
  - Challenges…
    - Relatively little known
    - Potential long distance migration
      - Distribution
      - Pelagic, oceanic nature
    - Annual inshore aggregations
    - GOM reproductive groups??

Moderate Scale: Along Atlantic coast?



Tools

- Suite of microsatellite loci
- Cultured fish

Year class	Experimental treatment	Mean TL (mm)	Number released
2004	Small juveniles	97	1,128
	Large juveniles	331	860
	Yearlings	496	95
2005	Small juveniles	55	3,200
	Large juveniles	230	516
	Yearlings	545	385
2007	Small juveniles, early release	69	33,848
	Small juveniles, middle release	105	19,416
	Large juveniles, late release	250	409
	Yearlings	541	59
2008	Large juveniles	249	2,000
	Yearlings	533	54
2009	Large juveniles	235	1,392

Multiplex Group	Locus	Repeat Motif	Size Range (bp)	# of Alleles
1	Rca-H10	CA	119-139	10
	Rca-A04	$(CA)_9(CACT)_4$	196-206	8
	Rca-E02	CT	297-315	6
2	Rca-A11	GT	165-201	14
	Rca-H09	GATA	168-224	17
	Rca-E08	CA	181-229	7
	Rca-C06	GATA	336-404	18
3	Rca-D10	CTAT	143-223	23
	Rca-E11	CA	167-183	6
	Rca-C04	GT	217-253	16

- Mendelian inheritance, HWE, linkage
- Marker confidence
  - PCC: >99.99%
  - Parent pair non-exclusion: 2.0×10^{-7}
  - Identity non-exclusion: 9.7×10^{-12}

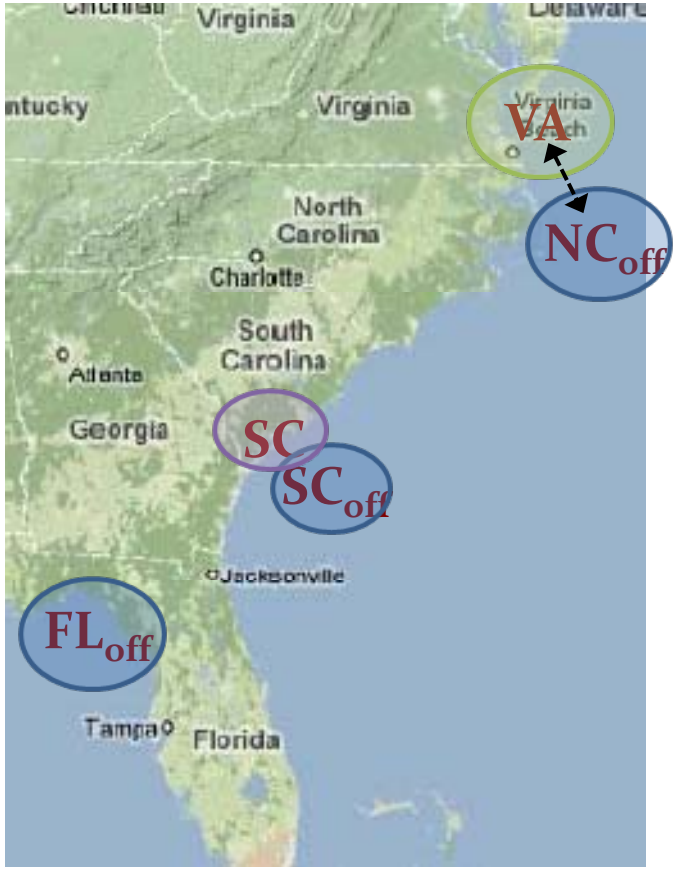
Sample Collections

- Cooperating anglers, SCDNR staff
- April –July
- Broodstock and field samples genotyped
- Field samples otolith-aged

  - 2008
    - SC (n=75)
    - SC_{off} (n=55)
    - VA (n=36)
    - FL_{off} (n=16)
    - NC_{off} (n=84)
  - 2009
    - SC (n=190)
    - SC_{off} (n=65)
    - NC_{off} (n=58)

Population Structure

- Pairwise
  - Distribution (G-test)
  - ρ_{ST}
- AMOVA
- IBD/Spatial autocorrelation



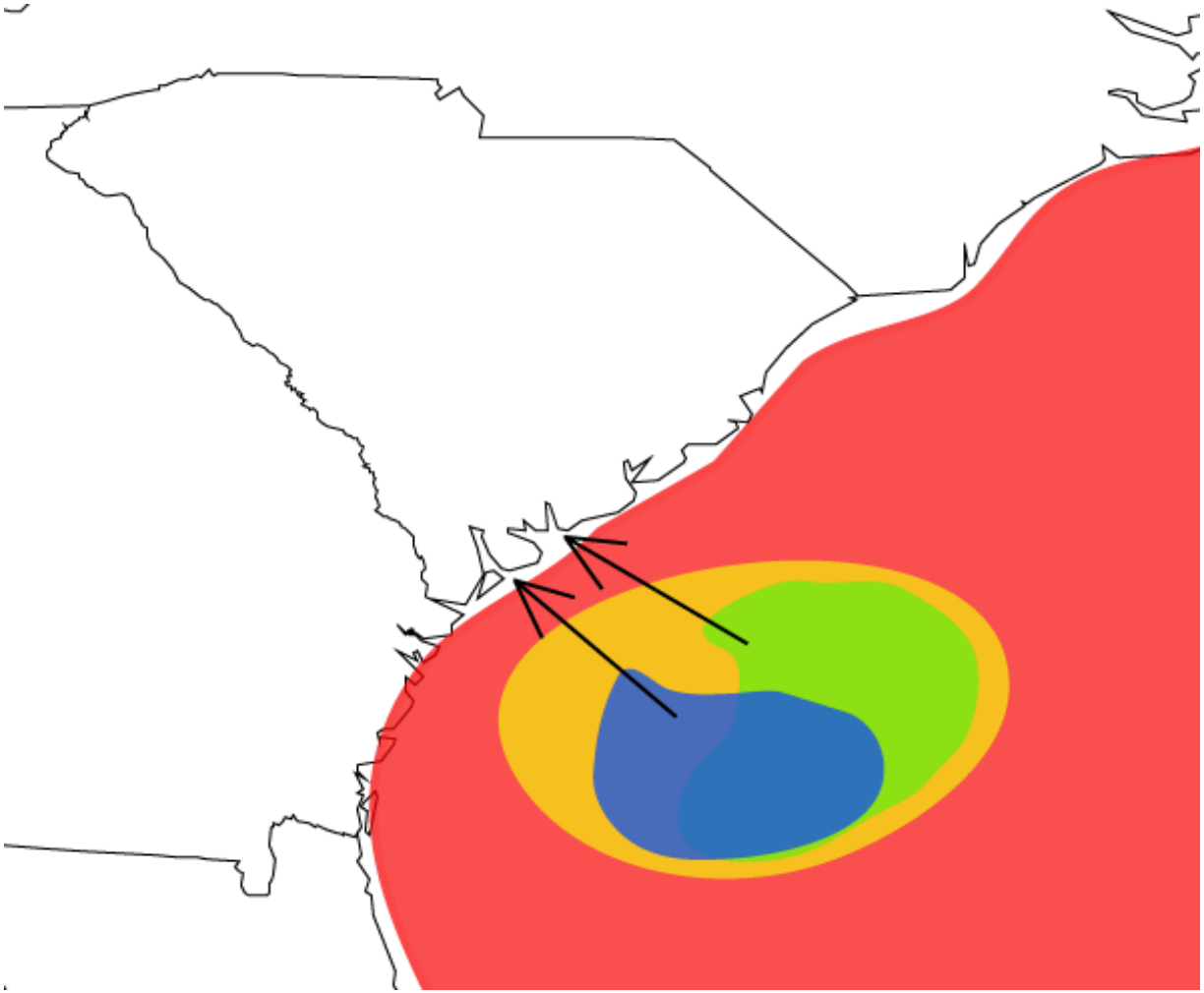
- Homogenous offshore group
- Distinct inshore aggregations

2008:
- G: p=0.000; ρ_{ST}: 0.032,p=0.000
- G: p=0.000-0.003; ρ_{ST}: 0.007-0.025, p<0.05
- AMOVA: ρ_{ST}: 0.014, p=0.000

2009: G: p=0.000; ρ_{ST}: 0.016-0.019, p=0.000

- Overall ‘little’ isolation

Local Scale: Between SC Estuaries



Movement & Estuarine Fidelity

- Hatchery contribution
  - 2007: 3 fish from 2004/2005 YC → 1.1%
  - 2008: 2 fish from 2004 YC → 1.1%
  - 2009: 6 fish from 2007 YC → 46.1%
  - All within their stocked estuary
- Multiple wild recaptures
  - 2007 & 2008 within Port Royal Sound
- External tag recaptures (2005 YC)
  - 56 recaptures over 4 years
  - 54 from Port Royal Sound area
    - 2 offshore: 1 Charleston, 1 Florida

Appropriate Management Unit?

- Based on offshore collections
  - High movement along SE US and within GOM
  - Single population management as overfishing in one offshore area would impact another…
- Based on inshore aggregations
  - Suggestion of distinct population segments (DPSs)
  - Indications of estuarine fidelity
  - DPSs managed separately as localized inshore fishing pressure would primarily impact the local population

Cobia Returns

- Fish released in spring stay in Broad River and mix with wild population
- Fish released in fall immediately move south
- All fish at large for over 1 year were recaptured in Broad River
- 2 genetic identifications on year class 04 and 05 were fish caught in 2007

Year Class	Size at release	Number	Location	Days at Large
2001	medium	1	Cocoa Beach, FL	18
2001	medium	1	Broad River, SC	1460
2004	small	1	Broad River, SC	1095
2004	large	6	Broad River, SC	<40
2005	small	1	Broad River, SC	730
2005	medium	1	West Palm Beach, FL	118
2005	large	47	Broad River, SC	<40
2005	X-large	1	Georgia	6

2007 Releases/2009 Recruits

- 33,848 small juveniles early in the season
- 19,416 small juveniles late in the season
- 409 medium juveniles
- 59 yearlings

- From the 2009 field collections:
- A total of 13 fish were from the 2007YC
- 6 of those were stocked fish (46% contribution to the year class)
- Recaptured fish were all stocked as small juveniles (3 from early and 3 from late releases)

Something to think about…

- Annual survival estimates pretty good
- What about hyperstability?
- No fisheries independent random sampling?

- Spawning aggregation
- Distinct population segment
- Mixed population for most of the year

- Increased human populations and fishing pressure
- Big impact from stocked fish