



Greater Amberjack Abundance, Distribution, and Movement in U.S. Waters in the South Atlantic and Gulf of Mexico

S. Powers, M. Albins, K. Boswell, J. Buckel, M. Catalano, G. Chiu, M. Dance, M. Drymon, J. Hoenig, S. Midway,
S. Murawski, N. Phillips, J. Rooker, E. Saillant, S. Scyphers, L. Stokes, G. Stunz, T. Switzer, D. Wells



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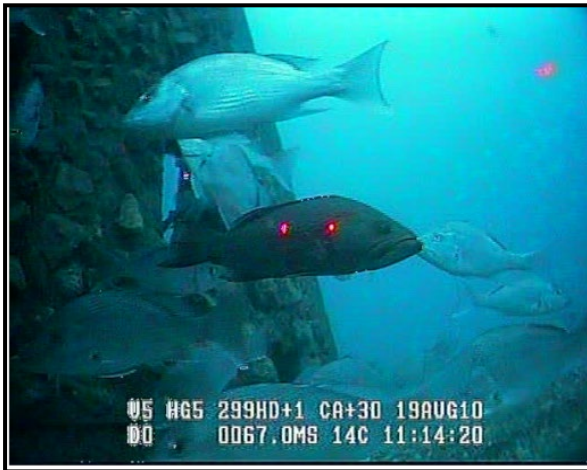
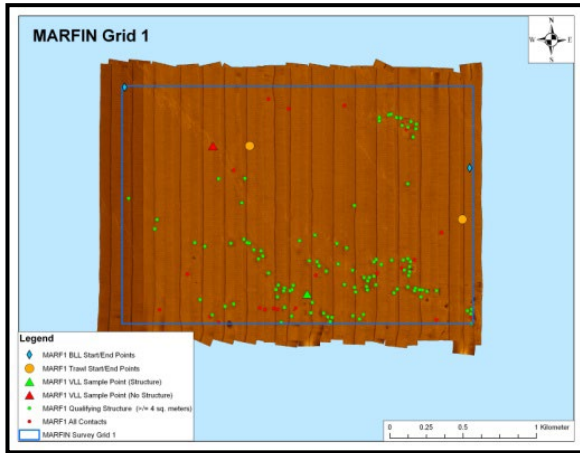
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Background: motivation for the study

- Reef fish management in SE US has been contentious
- Disagreements regarding stock status and catch levels
- Caused public to question scientific basis for management decisions
- In response, US Congress funded three large-scale studies to...
 - Fill critical knowledge gaps
 - Use latest technologies to estimate absolute abundance (independent of current age-structured stock assessment approach)
- These included:
 - Red Snapper (Gulf of America, Stunz et al)
 - Red Snapper (South Atlantic, Patterson et al)
 - Greater Amberjack (Gulf and South Atlantic US, Powers et al)
 - Current project
 - Began in 2021

Why an absolute abundance estimate?



- Most fisheries are managed based on recorded catch. In fact, most stock assessment models are based on the assumptions that you know catch with great certainty and you know the length (or preferable age composition of the catch)
- An alternative is to have sufficient scientific surveys to construct a fisheries-independent estimate of abundance
- Most data rich assessments have some of both, although catch information still dominates

What is an absolute abundance estimate?

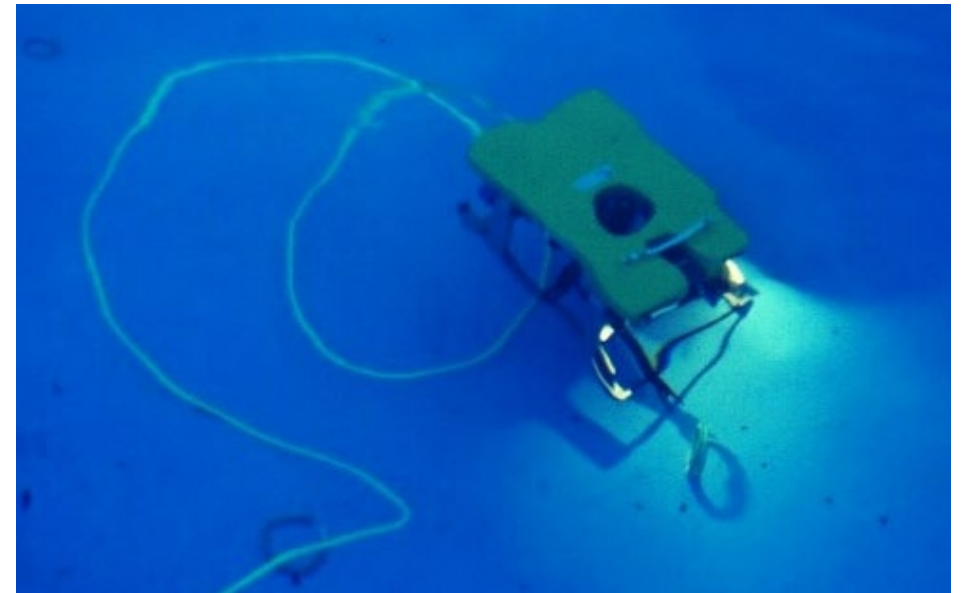


- An estimate of total abundance based on direct observations of fish abundance
- The intent is to scale up currently rigorous fishery independent assessments to stand alone but also inform traditional stock assessments
- It is not model free, we can not count each fish individually. We must extrapolate our observations at some point and that requires a different type of statistical modeling

Development of fishery-independent surveys

- Core to all three of these projects has been the development and refinement of fishery-independent surveys
- Gulf of America: recent progress on combined video (SEADAR 70) or G-Fisher based index (2026 Interim Analysis to GOA SSC)
- South Atlantic: video index (2011-2017) developed for SEDAR 59 with video from SERFS program
 - Trap samples from SERFS and earlier MARMAP also investigated, but sample sizes limited

Great Red Snapper Count (GRSC)



What we learned from GRSC



Photo by David Hay Jones



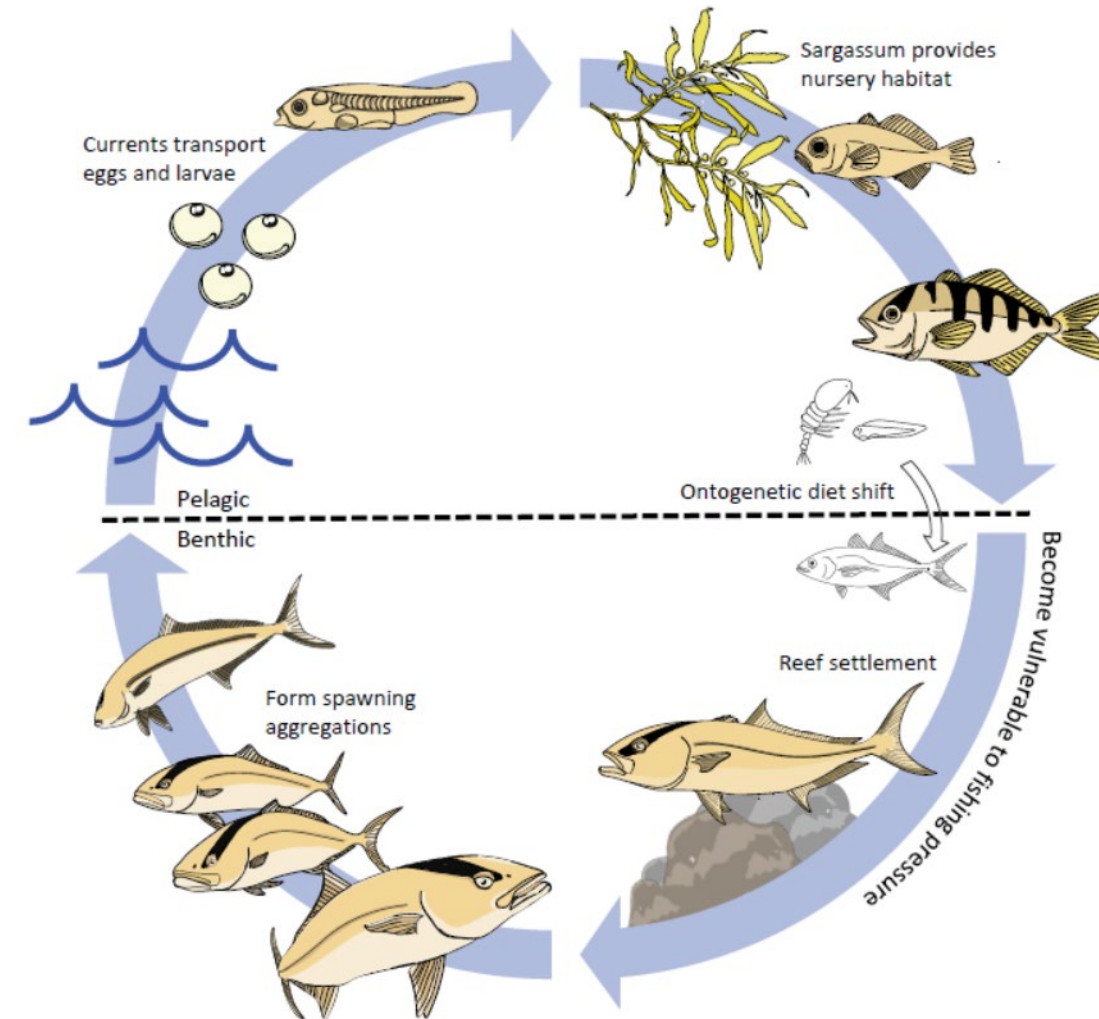
- 2.5 times as many age 2+ red snapper in Gulf then current NMFS stock assessment predicts
- Why?
 - The GRSC estimated total population not just what was exploited by the fishery
 - How can we use it for management advice?
- What have we learned in GRSC that can inform Greater Amberjack Count
 - Complete engagement with statistics team throughout process
 - Understand gear performance and efficiency
 - Greater involvement of NMFS with the goal of reconciling stock assessments
 - Better habitat maps

GAI Count

- Builds on successes and lessons-learned from GRSC
- Overarching goals:
 - Provide independent estimate of GAI absolute abundance in US GoA and SA using fisheries independent sampling
 - Expand general biological knowledge (spatial ecology, movement, connectivity, growth, mortality, etc.) of GAI to inform management decision-making and to address key assumptions of abundance estimate

Background: Greater Amberjack Life History

- Reported max age: 17
- Rapid growth until age 9-10
- Review by Shultz et al. 2025 (Ch. 2)



Background: Current stock status

- Two stocks
 - Gulf of America (GoA)
 - South Atlantic (SA)
- GoA
 - Most recent assessment (2021 SEDAR 70) found that stock was overfished and undergoing overfishing
 - Recent catch data (2023) indicate stock no longer undergoing overfishing
- SA
 - Most recent assessment (2020 SEDAR 59) found stock was not overfished or undergoing overfishing
 - Recent catch data also indicate stock is not undergoing overfishing

GoA, 2021 SEDAR 70

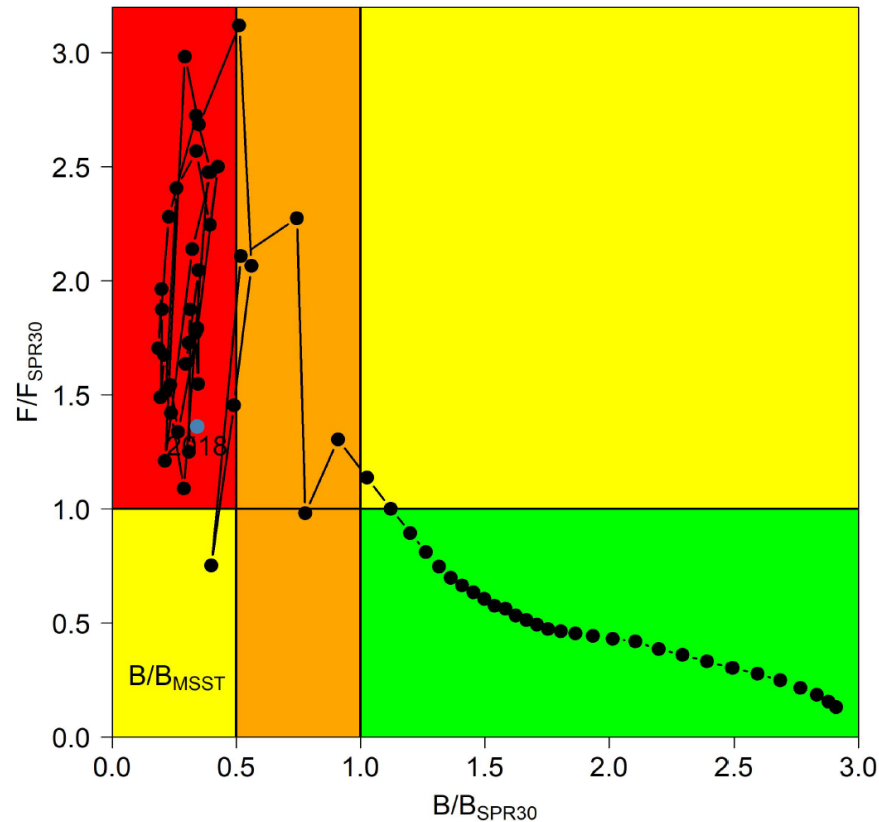


Figure 68. Kobe plot illustrating the trajectory of stock status. The orange coloring indicates regions where the stock is below the biomass target but above the biomass threshold ($MSST = 0.5 \times SSB_{SPR30\%}$). The 2018 terminal year stock status is indicated by the gray dot. See **Table 24** for specifics on the years above $F/F_{SPR30}=1$ and below $B/B_{MSST}<0.5$.

Table 12 Continued. Predicted biomass (metric tons), spawning stock biomass (SSB, metric tons), abundance (1000s of fish), age-0 recruits (1000s of fish), and SSB ratio (SSB/SSB_0) for Gulf of Mexico Greater Amberjack.

Year	Biomass	SSB	Abundance	Recruits	SSB/SSB ₀
1987	9,503	3,639	3,832	1,565	0.153
1988	6,851	2,495	2,259	5,912	0.105
1989	6,019	2,086	3,800	2,944	0.088
1990	5,827	1,513	3,157	962	0.064
1991	7,314	2,298	2,307	1,610	0.097
1992	6,624	2,826	1,951	1,240	0.119
1993	5,088	2,408	1,530	1,579	0.101
1994	3,807	1,621	1,481	1,190	0.068
1995	3,464	1,327	1,341	870	0.056
1996	3,591	1,413	1,168	1,533	0.060
1997	3,501	1,433	1,360	1,992	0.060
1998	3,626	1,391	1,694	1,243	0.059
1999	4,223	1,495	1,554	3,675	0.063
2000	4,883	1,662	2,612	4,267	0.070
2001	6,194	1,896	3,509	2,294	0.080
2002	7,753	2,440	3,102	1,727	0.103
2003	7,974	3,032	2,506	2,289	0.128
2004	6,537	2,801	2,308	1,284	0.118
2005	5,628	2,413	1,797	1,628	0.102
2006	4,556	1,841	1,643	2,683	0.078
2007	4,217	1,538	2,103	2,357	0.065
2008	5,049	1,685	2,310	2,643	0.071
2009	5,942	2,060	2,565	1,878	0.087
2010	6,951	2,757	2,395	1,323	0.116
2011	5,803	2,394	1,809	2,099	0.101
2012	5,560	2,463	1,975	2,135	0.104
2013	5,633	2,475	2,113	1,665	0.104
2014	5,267	2,113	1,904	2,272	0.089
2015	5,386	2,197	2,132	1,053	0.093
2016	5,330	2,238	1,667	1,020	0.094
2017	4,847	2,199	1,372	1,244	0.093
2018	4,850	2,432	1,385	1,813	0.103

SA, 2020 SEDAR 59

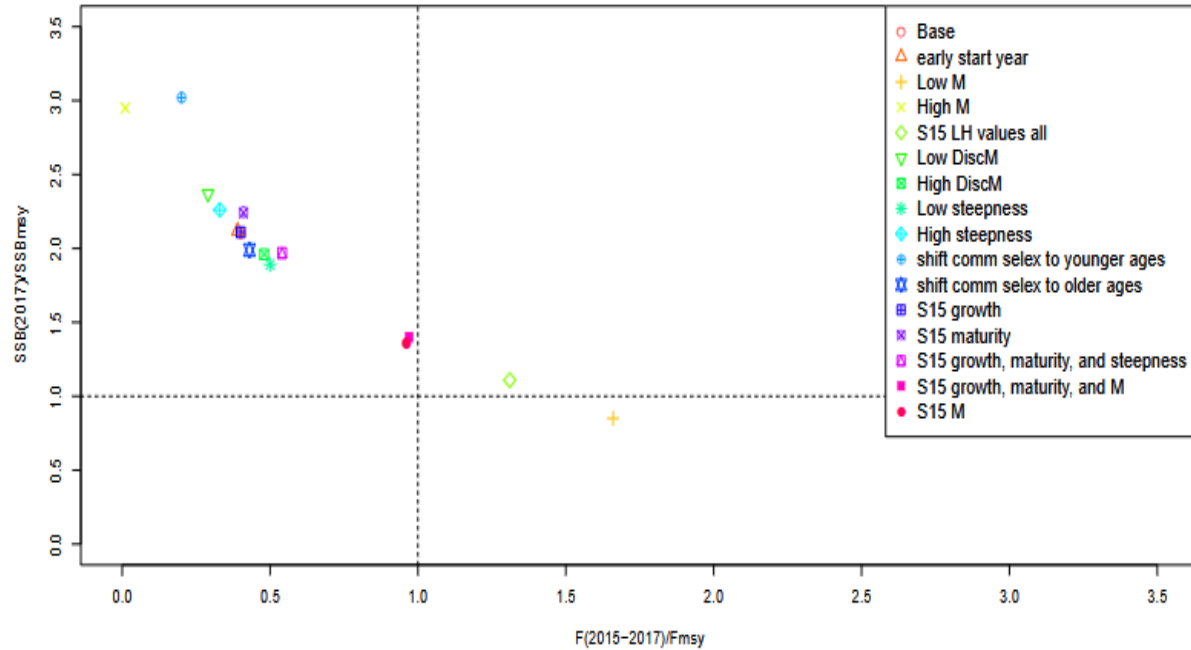


Table 6. Estimated total *abundance at age (1000 fish)* at start of year.

Year	1	2	3	4	5	6	7	8	9	10	Total
1980	1401.81	613.63	324.18	178.68	104.28	63.26	39.15	24.72	15.76	28.53	2793.99
1981	1401.81	599.32	327.86	182.87	107.09	64.99	40.22	25.39	16.19	29.31	2795.06
1982	1400.84	603.48	303.09	166.10	97.77	59.50	36.84	23.26	14.83	26.84	2732.54
1983	1398.66	606.65	324.67	172.59	99.86	61.06	37.91	23.94	15.27	27.63	2768.23
1984	1401.64	612.87	331.95	191.46	108.02	64.97	40.52	25.67	16.37	29.63	2823.10
1985	1404.59	603.55	332.18	191.75	116.83	68.48	42.01	26.73	17.10	30.97	2834.19
1986	1405.38	605.47	323.39	187.86	114.66	72.59	43.40	27.16	17.46	31.71	2829.07
1987	1402.81	548.74	307.68	163.51	98.32	62.19	40.16	24.49	15.48	28.31	2691.68
1988	1395.90	587.86	290.93	163.96	85.98	53.18	34.29	22.59	13.92	25.13	2673.73
1989	1391.06	602.97	299.95	143.25	78.73	42.41	26.73	17.58	11.70	20.43	2634.81
1990	1609.75	602.54	308.20	145.65	65.84	37.00	20.31	13.06	8.68	16.01	2827.04
1991	1712.31	684.49	262.76	105.07	42.75	19.51	11.16	6.25	4.06	7.75	2856.11
1992	1530.62	715.00	353.15	114.50	34.80	14.00	6.50	3.79	2.15	4.09	2778.61
1993	1297.42	642.42	363.69	148.01	35.65	10.68	4.37	2.07	1.22	2.03	2507.55
1994	1080.29	550.47	340.22	177.83	61.52	14.90	4.55	1.90	0.91	1.44	2234.02
1995	985.41	466.67	288.06	164.73	74.75	26.09	6.44	2.00	0.84	1.05	2016.05
1996	690.46	421.69	251.56	150.34	77.12	35.48	12.62	3.18	1.00	0.96	1644.39
1997	674.93	284.15	215.57	120.12	65.57	34.21	16.04	5.82	1.48	0.92	1418.82
1998	1315.89	291.59	154.72	115.77	58.73	32.58	17.32	8.28	3.04	1.26	1999.19
1999	1305.32	568.36	157.82	82.59	56.96	29.41	16.62	9.02	4.36	2.28	2232.75
2000	1184.76	550.68	289.99	75.64	36.74	25.83	13.59	7.84	4.29	3.19	2192.56
2001	2116.92	506.04	293.55	152.27	37.43	18.57	13.30	7.14	4.16	4.01	3153.41
2002	1035.96	917.48	259.74	144.08	70.94	17.83	9.02	6.59	3.57	4.13	2469.36
2003	807.16	441.18	480.01	132.67	70.37	35.47	9.09	4.69	3.46	4.09	1988.19
2004	887.85	338.20	233.03	253.99	69.25	37.77	19.41	5.07	2.64	4.30	1851.52
2005	782.42	378.32	183.96	129.82	138.70	38.85	21.60	11.32	2.99	4.13	1692.12
2006	1897.35	332.65	206.92	103.43	71.37	78.29	22.35	12.68	6.71	4.27	2736.02
2007	1740.63	816.14	166.47	99.31	49.35	35.08	39.24	11.43	6.55	5.73	2969.92
2008	1768.64	750.03	425.51	85.80	50.28	25.69	18.61	21.24	6.25	6.78	3158.84
2009	1253.02	733.95	392.11	218.87	42.84	25.76	13.41	9.92	11.43	7.08	2708.39
2010	1444.55	523.73	389.81	208.42	113.64	22.84	14.00	7.44	5.55	10.47	2740.45
2011	1157.35	617.77	270.01	194.63	100.47	56.17	11.51	7.20	3.86	8.40	2427.36
2012	2091.73	500.10	339.34	152.85	107.51	56.96	32.46	6.78	4.28	7.38	3299.41
2013	1601.74	903.67	266.45	181.64	80.04	57.82	31.23	18.16	3.83	6.65	3151.24
2014	2395.87	687.09	486.85	146.31	98.40	44.59	32.84	18.09	10.62	6.20	3926.85
2015	1815.80	1017.07	365.55	260.23	76.70	53.00	24.48	18.39	10.24	9.61	3651.06
2016	1383.63	749.95	529.40	189.36	134.47	40.84	28.77	13.56	10.29	11.21	3091.48
2017	1138.59	564.39	387.99	271.84	97.43	71.34	22.09	15.88	7.56	12.11	2589.21
2018	1401.47	463.43	296.75	205.67	144.73	53.50	39.94	12.62	9.16	11.46	2638.74

Project challenges

- Major challenges (primarily for abundance estimation)
 - Lack of comprehensive habitat maps
 - Species identification
 - Regional and depth-based differences in water clarity and nepheloid layer
 - Differences in gear efficiency across habitat types (expansive low-relief natural habitat vs small-footprint, high-relief, artificial habitats)
 - Additivity of abundance estimate across regions, habitats, and gears
 - Understanding effective sampling area of gears
- Proposed methods to overcome these
 - Leverage existing and supplemental habitat mapping
 - Unifying gear: active acoustics
 - eDNA
 - Gear calibration studies (Bayesian model converts ratios and counts to common currency)
 - Using VPS data to estimate small-scale fish movement

Project objectives

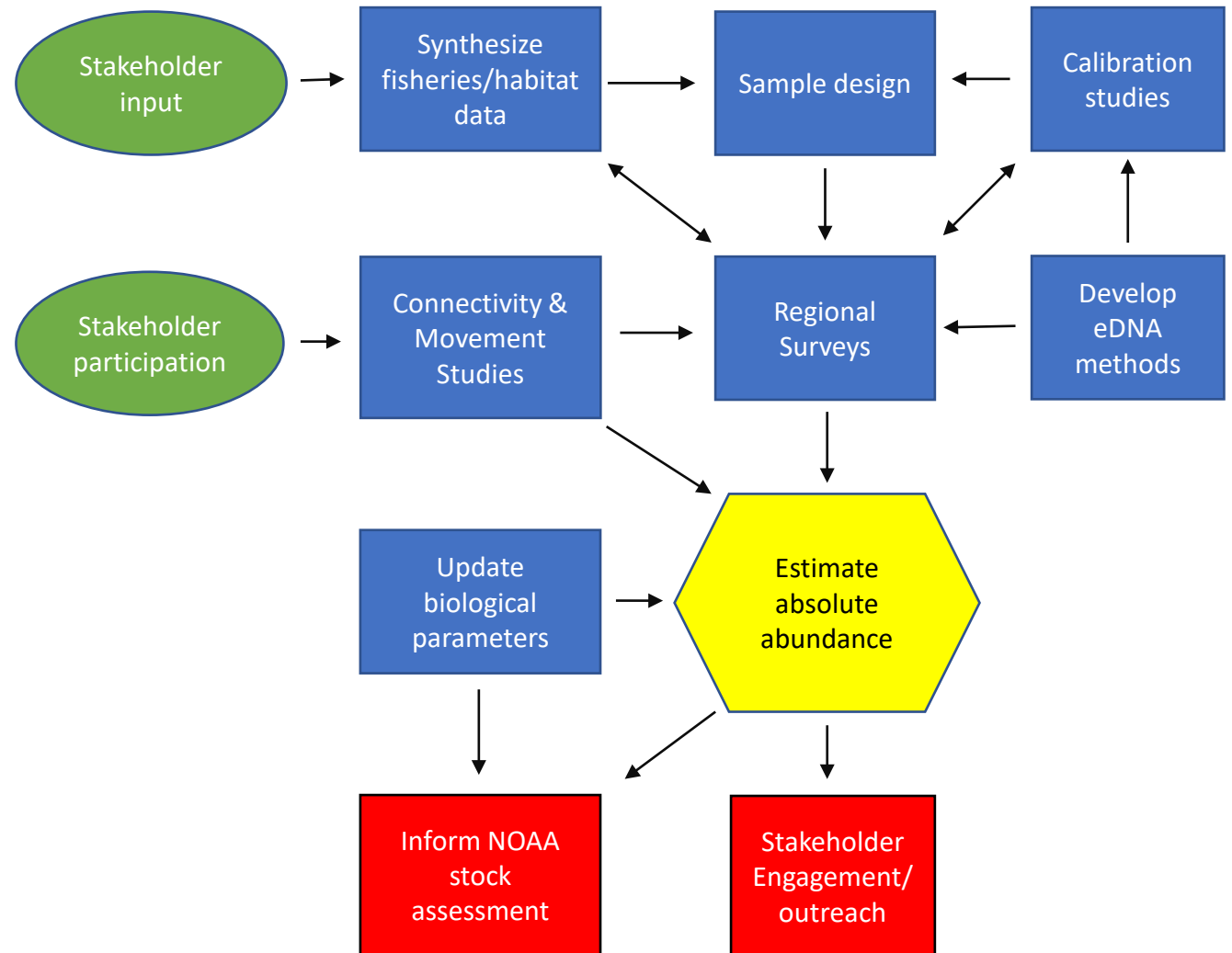
1. Synthesize existing bottom habitat observations
2. Synthesize existing abundance data - catch data and stakeholder knowledge
3. Comprehensive study to estimate regional, habitat-specific absolute abundance using video and active acoustics
4. Determine movement and connectivity using acoustic telemetry, conventional tagging, and genetic markers
5. Assess efficacy of eDNA to determine presence/relative abundance of GAJ and related species
6. Update biological information across study region
7. Engage in outreach to facilitate stakeholder input and communicate results

Phased approach

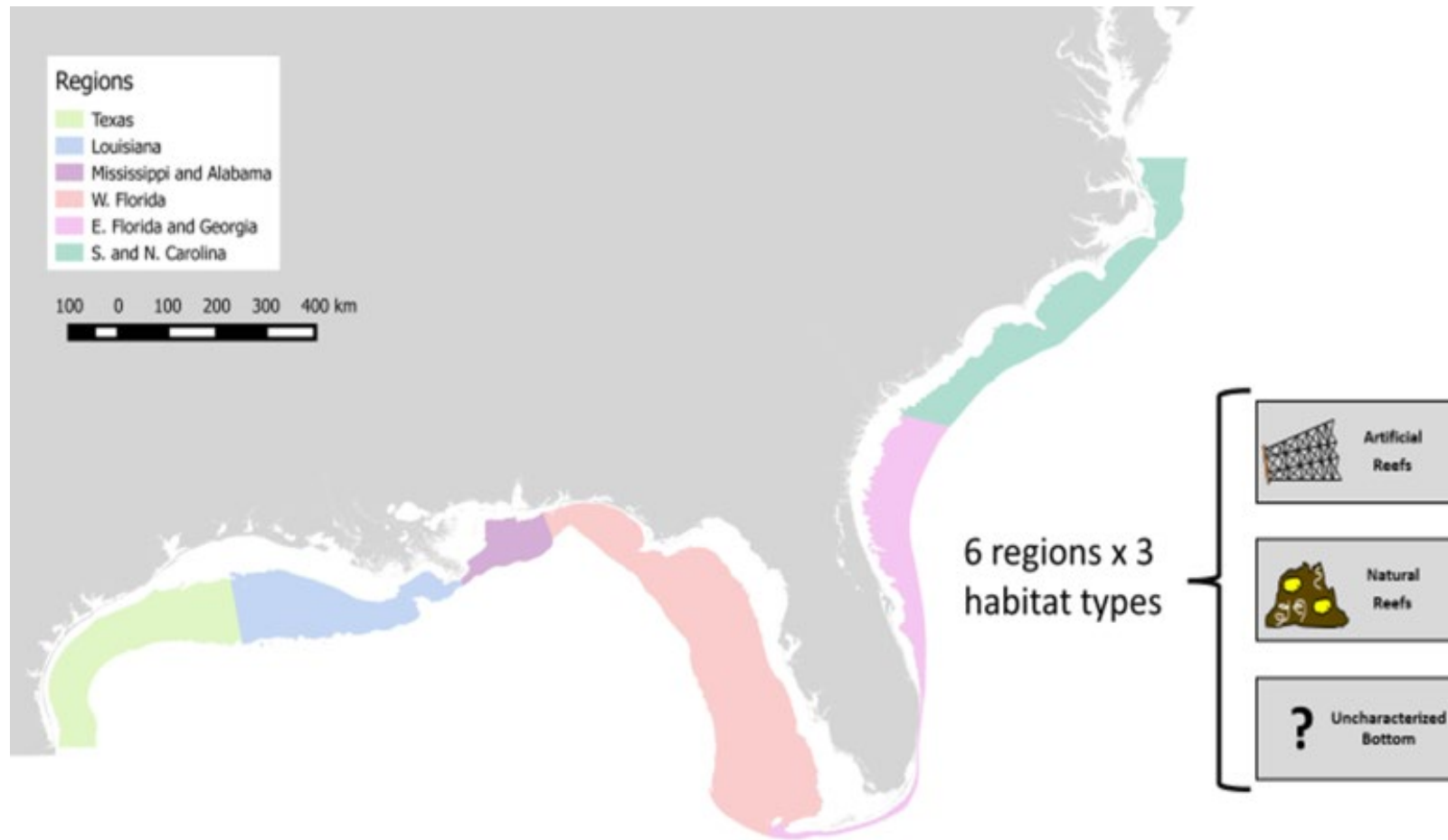
- Phase I
- Phase II
- Phase III

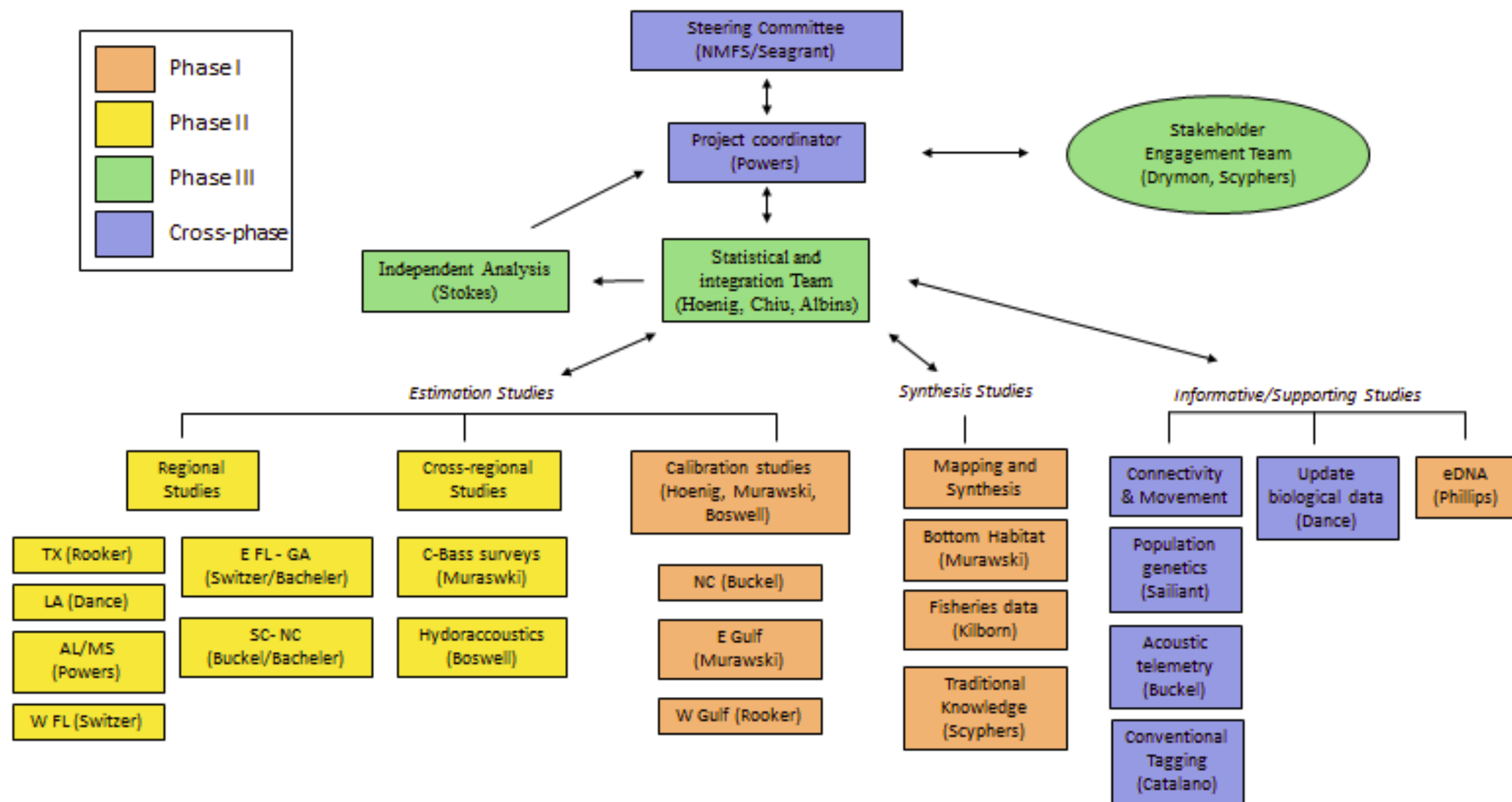
Key features:

- **Adaptable** to differences across regions and habitats
- **Scalable** from local to regional
- **Efficient** sample design based on existing catch data and stakeholder knowledge



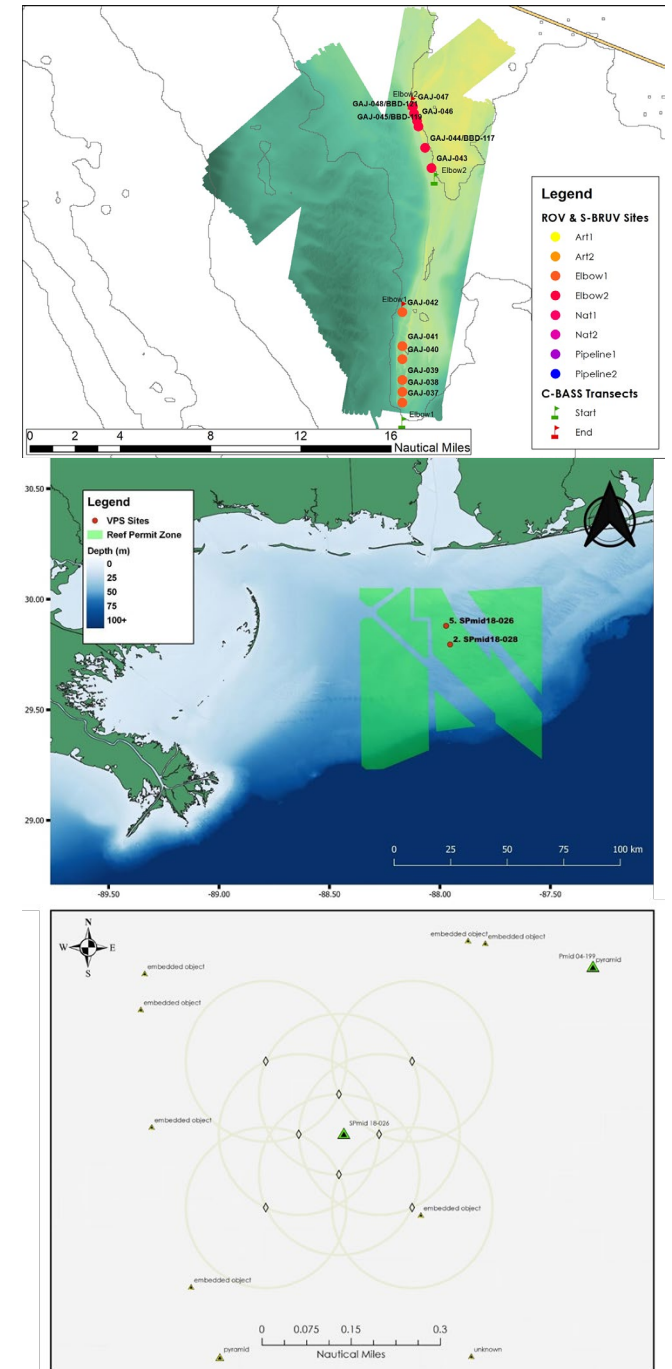
Regional approach





Three calibration studies (Ch. 9)

- Florida (May 4-10, 2022)
 - Always-on acoustics of limited value
 - Need to compare different acoustic freq.
 - Need ground-truth
- Alabama (Aug. 21-Sept. 2, 2022)
 - Incorporated two acoustic survey test patterns
 - Incorporated multiple acoustic freq.
 - Incorporated VPS + visual tags for ground truth (Mark-recap abund. est.)
 - Generally weak relationships among gears
 - Need more gear comparisons at wider range of habitat types
- Alabama (Mar. 30-Apr. 24, 2024)
 - Used best acoustic survey pattern and freq. from prev. calib.
 - Incorporated VPS + visual tags for ground truth (Mark-recap abund. est.)
 - Allocated 50% effort to two VPS array sites and 50% effort to variety of habitat types (large, small, artificial, natural, etc.)
 - Incorporated camera-corrected acoustic counts in analysis



Bayesian calibration model (Ch. 9)

- First in literature to develop **methodology** that simultaneously accounts for multiple camera types and echosounder, **operationalized** as **calibration formulae** and **interactive widget**
 - Already gave 4 invited presentations on this work, journal submission under review
- CASE 1: MaxN from survey with specified camera type, no echosounder =>
 - Camera-specific formula gives **prediction confidence interval for absolute abundance**
- CASE 2: MaxN from survey with specified camera type AND echosounder =>
 - Camera-specific formula gives **prediction confidence interval for echosounder deflation factor to remove non-GAJ**

Cornell University

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arXiv > stat > arXiv:2505.05767

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[Submitted on 9 May 2025]

Model-based calibration of gear-specific fish abundance survey data as a change-of-support problem

Grace S. Chiu, Anton H. Westveld, Mark A. Albins, Kevin M. Boswell, John M. Hoenig, Sean P. Powers, S. Lynne Stokes, Allison L. White

In a continental-scale fish abundance study, a major challenge in deriving an absolute abundance estimate lies in the fact that regional surveys deploy different gear types, each with its unique field of view, producing gear-specific relative abundance data. Thus, data from regional surveys in the study must be

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Model-based calibration formulas based on experimental data (n=21)

Camera type

- ☐ Drop
- ☐ SBRUV
- ☒ Trap
- ☐ ROV

Was your camera paired with the echosounder?

☒ FALSE ☐ TRUE

INSTRUCTIONS FOR 'TRUE' (CAMERA PAIRED WITH ECHOSOUNDER):
Ignore the sliders, and enter your camera's MaxN and ratio. Use the mouse to rotate the 3D plot. The black dot shows the pooled camera ratio predicted from your camera's MaxN and ratio, respectively, using frequentist linear regression. Use this predicted ratio to adjust your echosounder count. Precise values of the prediction, prediction standard error, and covariance among regression coefficients are displayed above the 3D plot.

INSTRUCTIONS FOR 'FALSE' (CAMERA ONLY, NO ACOUSTIC DATA):
Ignore the input boxes for MaxN and ratio. Use the sliders to adjust axis ranges. Click on the white line evaluated at any MaxN value to see the display (below the plot, left box) of the Bayesian estimate for mean abundance, then hover over the wispy blue area at the same MaxN value above the white line to see the display (below the plot, right box) of the approximate value of 'estimate + 2SE'.

NOTE: This notion of '2SE' is very rough, due to all blue lines collectively forming the entire Bayesian posterior distribution, as opposed to a 95% credible region from the posterior. Alternatively, compute the SE based on the posterior statistics shown above the plot.

x-axis range: 0 50 100 150 200 250 300 350 400 450 500

y-axis range: 0 50 100 150 200 250 300 350 400 450 500

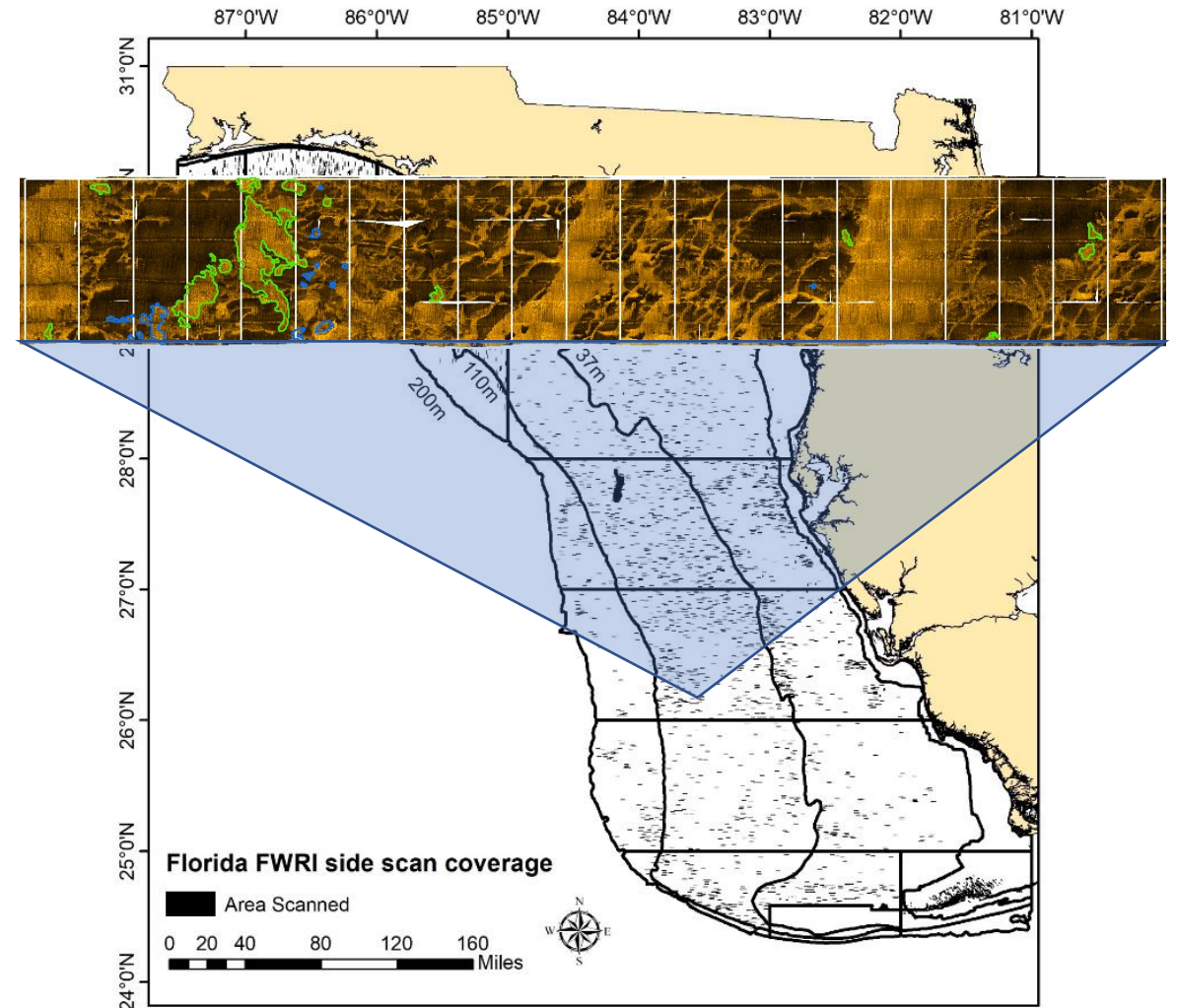
Observed MaxN: 0

Observed GAJ-to-GAJlike ratio: 0.5

[1] "posterior statistics:"

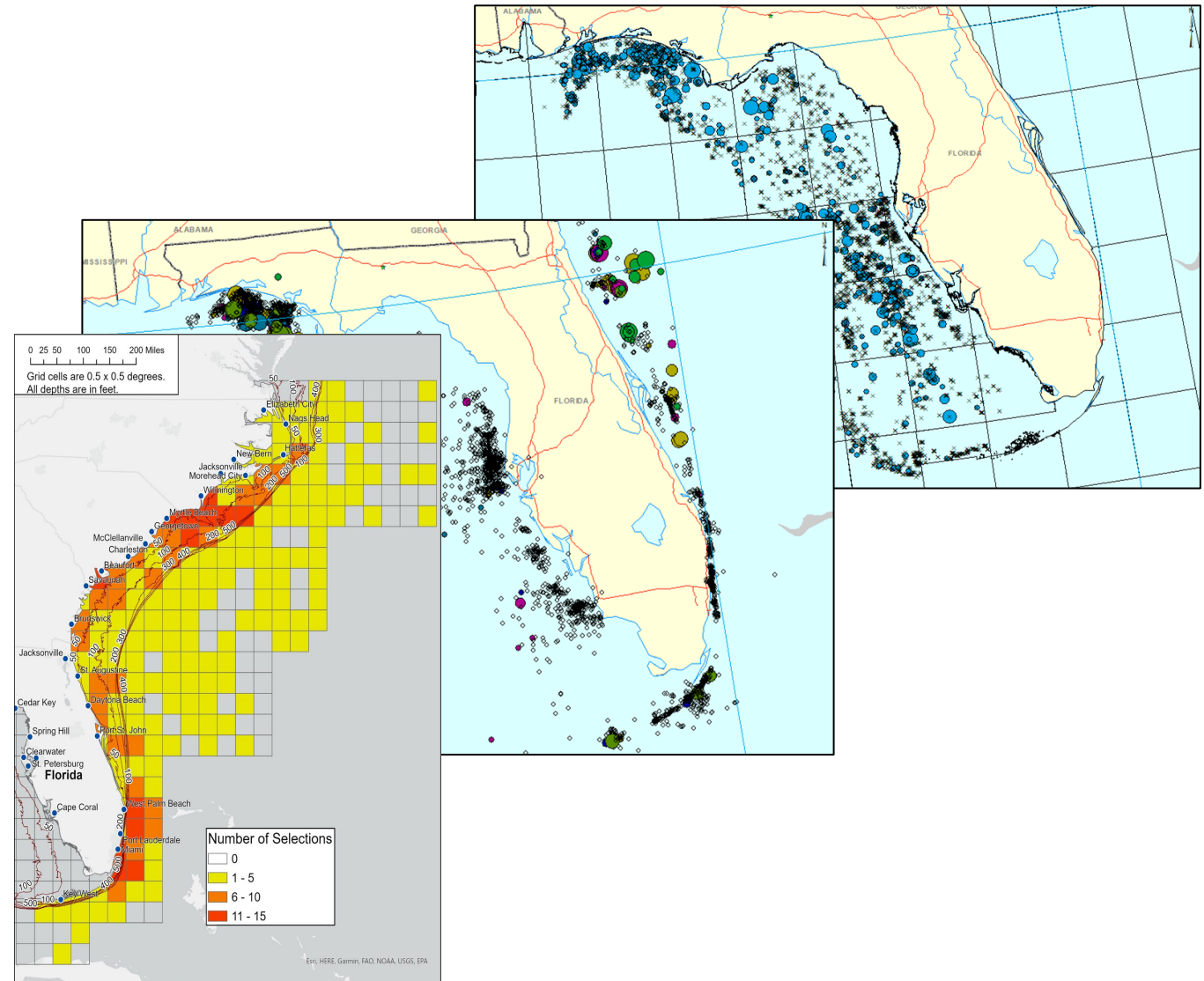
Objective 1: Synthesize habitat data

- No existing comprehensive maps for entire region
- Existing sources of habitat data
 - Regional
 - Partial coverage
 - Variable resolution
- Compile best habitat data available for each region
- Conduct limited supplemental habitat mapping in regions where necessary (SA)
- Inform sampling design, and ultimately, provide basis for extrapolation of density estimates to absolute abundance
- Note: abundance estimates should be viewed in context of limited habitat information (some high CVs due to uncertainty in habitat location/extent)



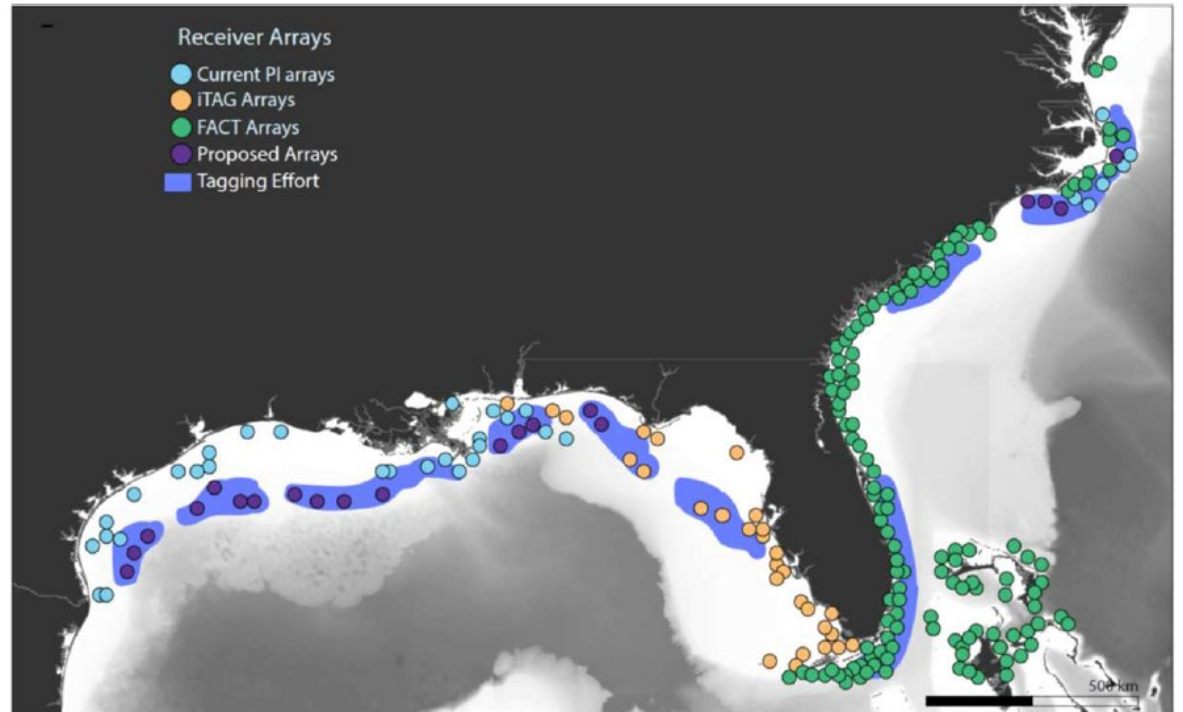
Objective 2: Synthesize abundance data

- Existing fishery dependent and fishery independent catch data
- Existing stakeholder knowledge (LEK)
- Inform expectations in terms of presence/absence, relative abundance and variance
- Can be used to create efficient sample designs
 - Sample more where abundance and variance are high
 - Sample less where these are low



Objective 4: Movement, connectivity, & mortality

- GoM and SA managed as separate, non-mixing stocks, but little known about migratory behavior and population connectivity
- Combined strategy:
 - Internal acoustic tags + extensive receiver array
 - High-reward external tags
 - Population genetics
- Opportunity for angler engagement

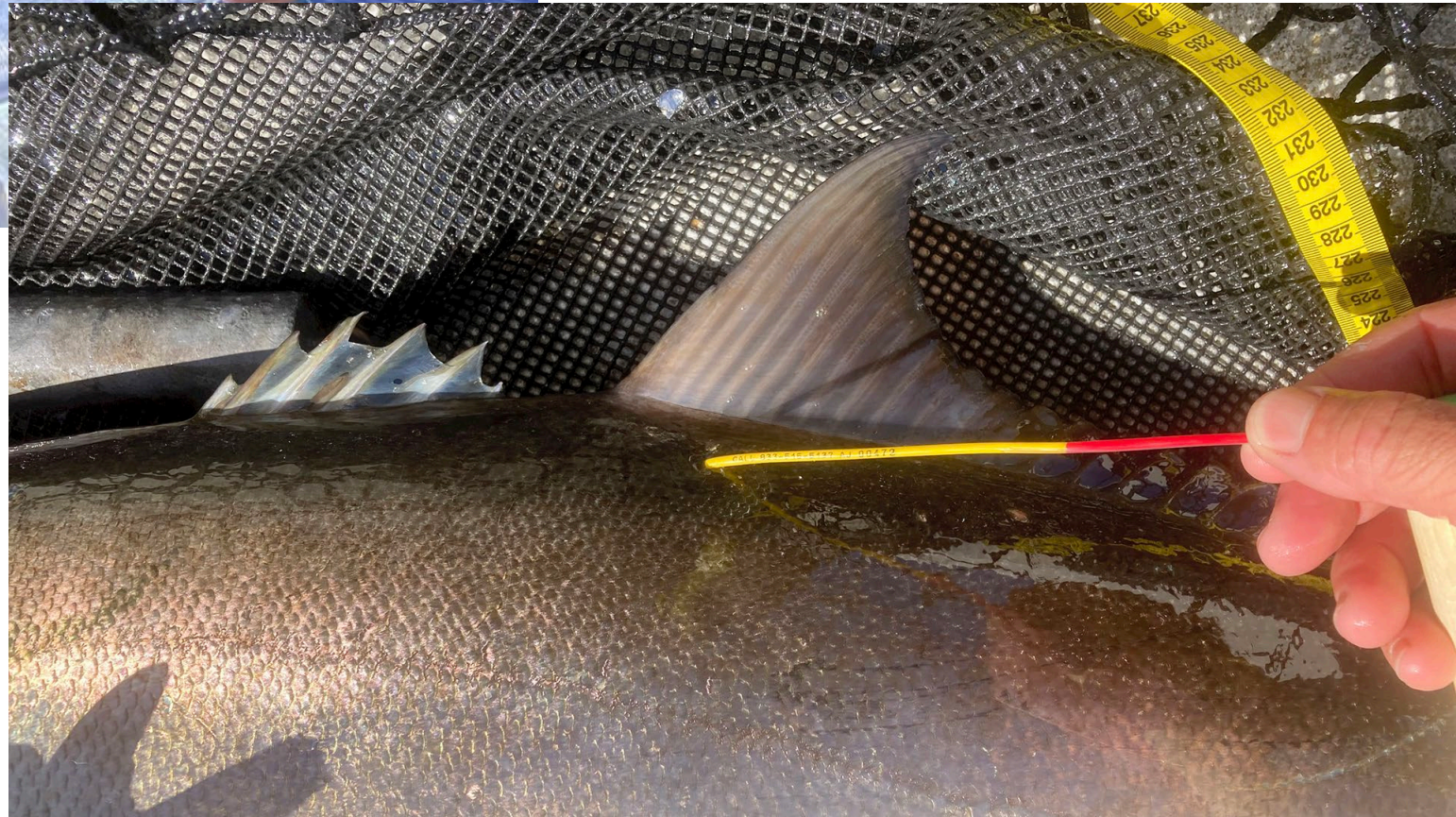




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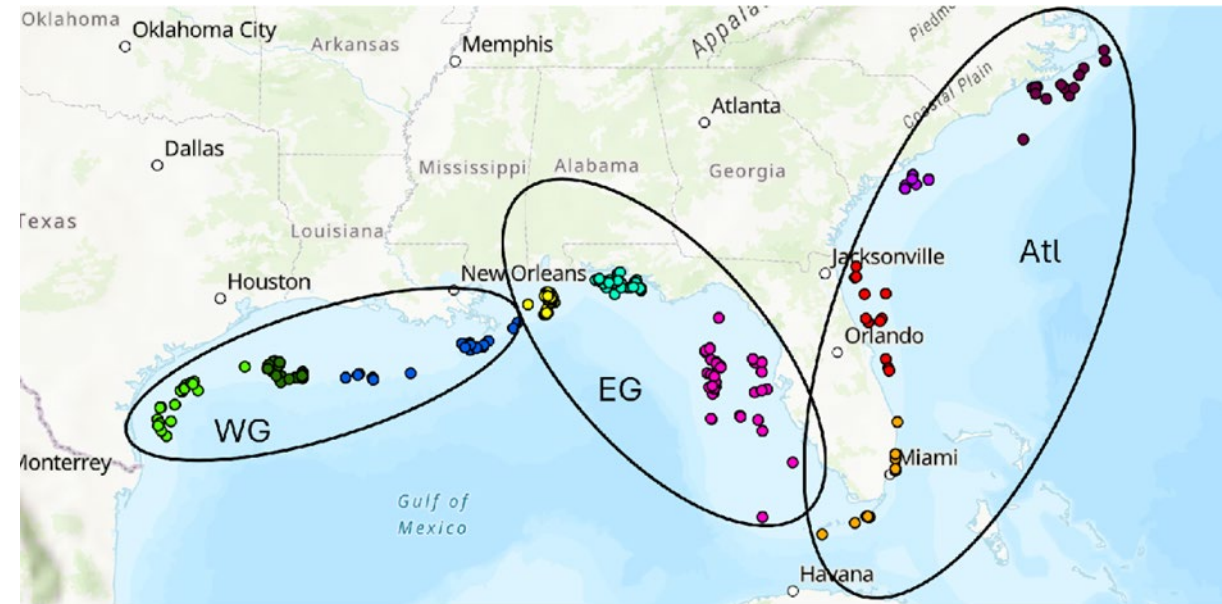
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Population genomics: methods (Ch. 3)

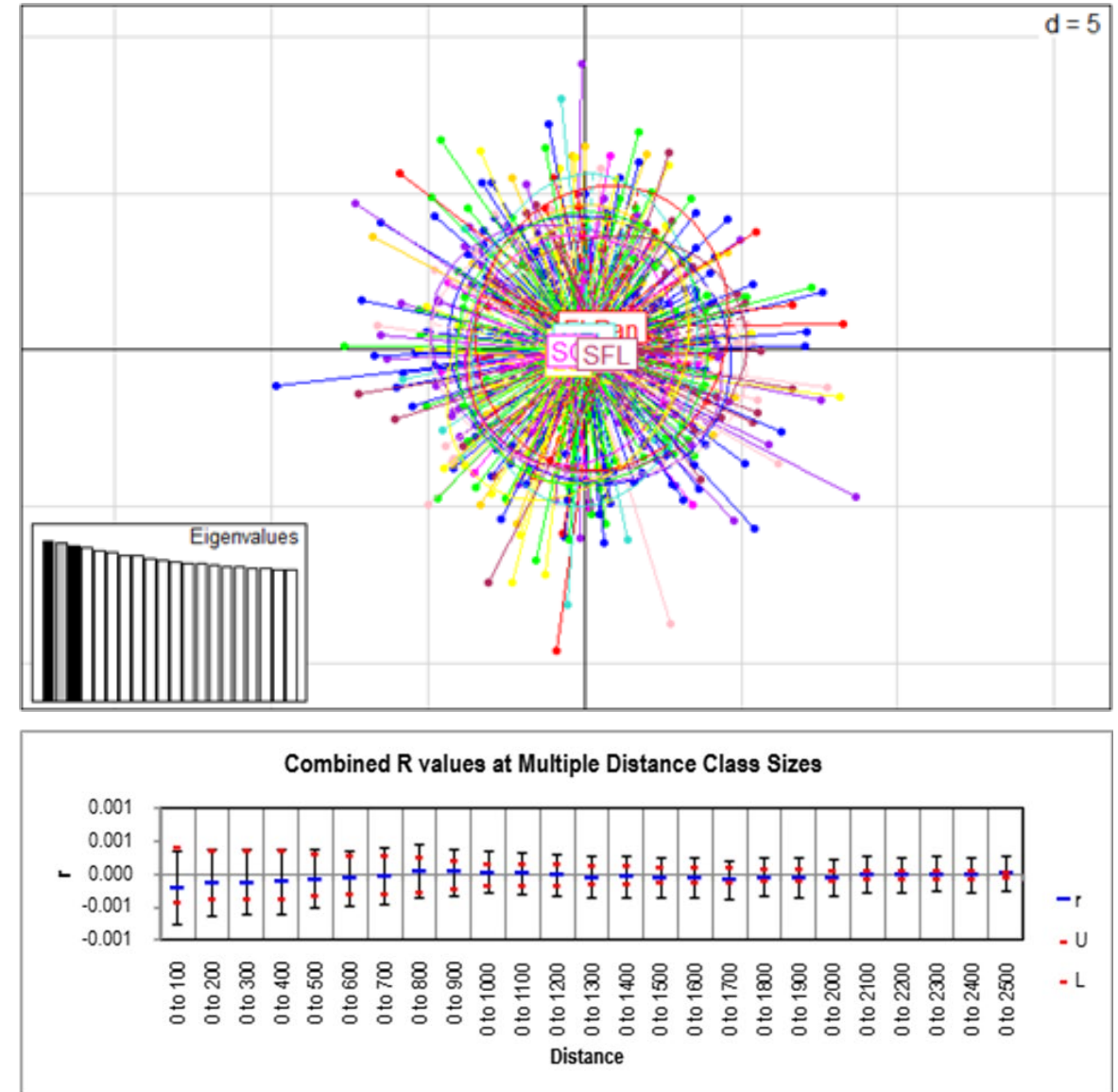
- Previous pop gen studies limited by incomplete geographic sampling and small number of markers
- Current study aimed to address these limitations through comprehensive spatial sampling and genome scans involving thousands of SNP markers



Sampling region	2021	2022	2023
North Carolina	7	128	19
South Carolina	-	3	32
Southeast Florida	-	45	57
Southwest Florida	-	88	48
Alabama	15	100	106
Louisiana	-	74	15
Texas-Galv	-	75	-
Texas-CC	-	49	53

Population genomics: results (Ch. 3)

- No evidence of divergence between GoA and SA stocks or other subdivisions within US waters
- This unexpected result could indicate recent/ongoing mixing of previously divergent units
- Could be examined further using higher density genome scans and analysis of identity-by-descent
- Future work should include southern GoA and Caribbean samples to assess their degree of connectivity with US stocks



Exploitation: methods (Ch. 5)

- Tagging took place from May 2022 to March 2024
- Tagging numbers (dart only/dart+acoustic)
 - ATL: 157/139, EGOM: 285/121, WGOM: 212/183
 - EGOM and WGOM border at Mississippi River Mouth
 - 50% double dart-tagged

Regional Total Dart Tagging Numbers and Tag Returns:

Region	Number Dart-Tagged	ATL Tag Returns	EGOM Tag Returns	WGOM Tag Returns
ATL	296	40		
EGOM	406		75	1
WGOM	395			61

Eastern
Louisiana
Recaps

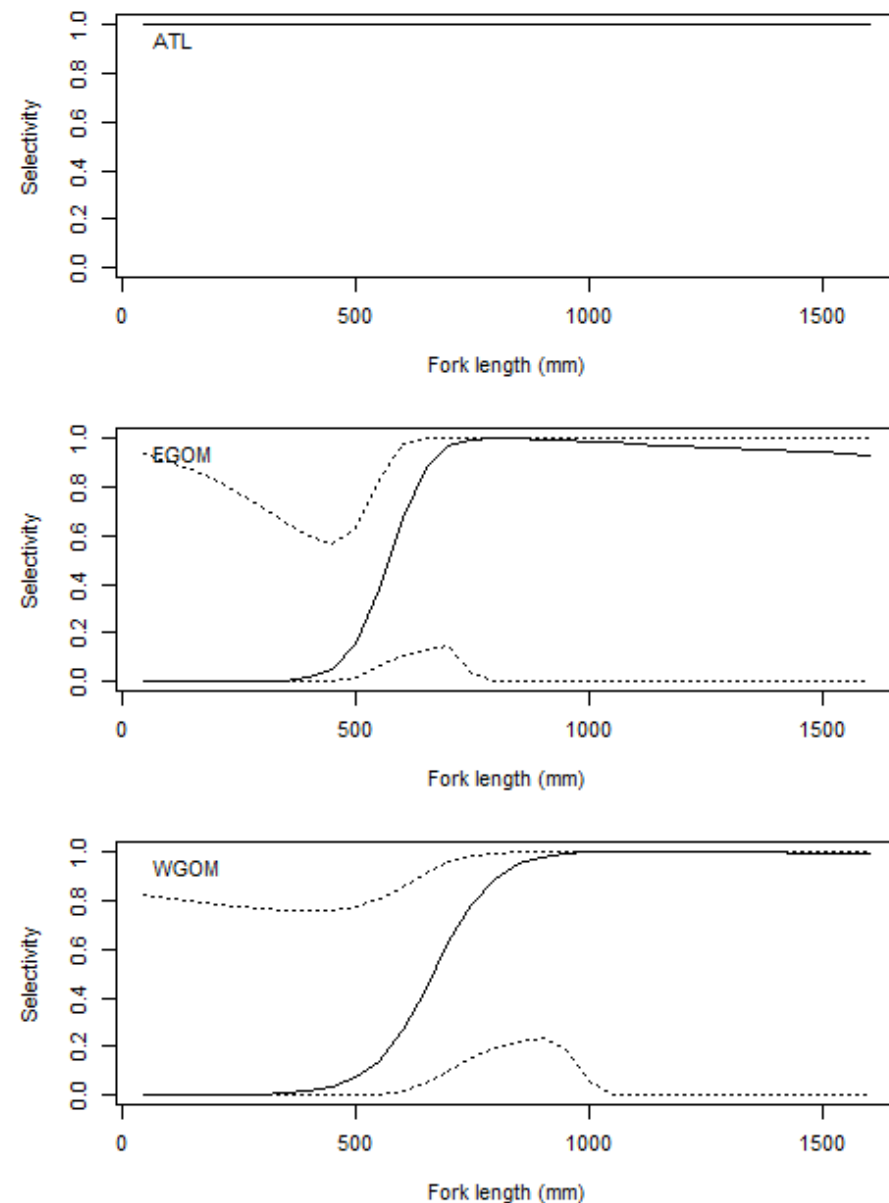


Exploitation: methods (Ch. 5)

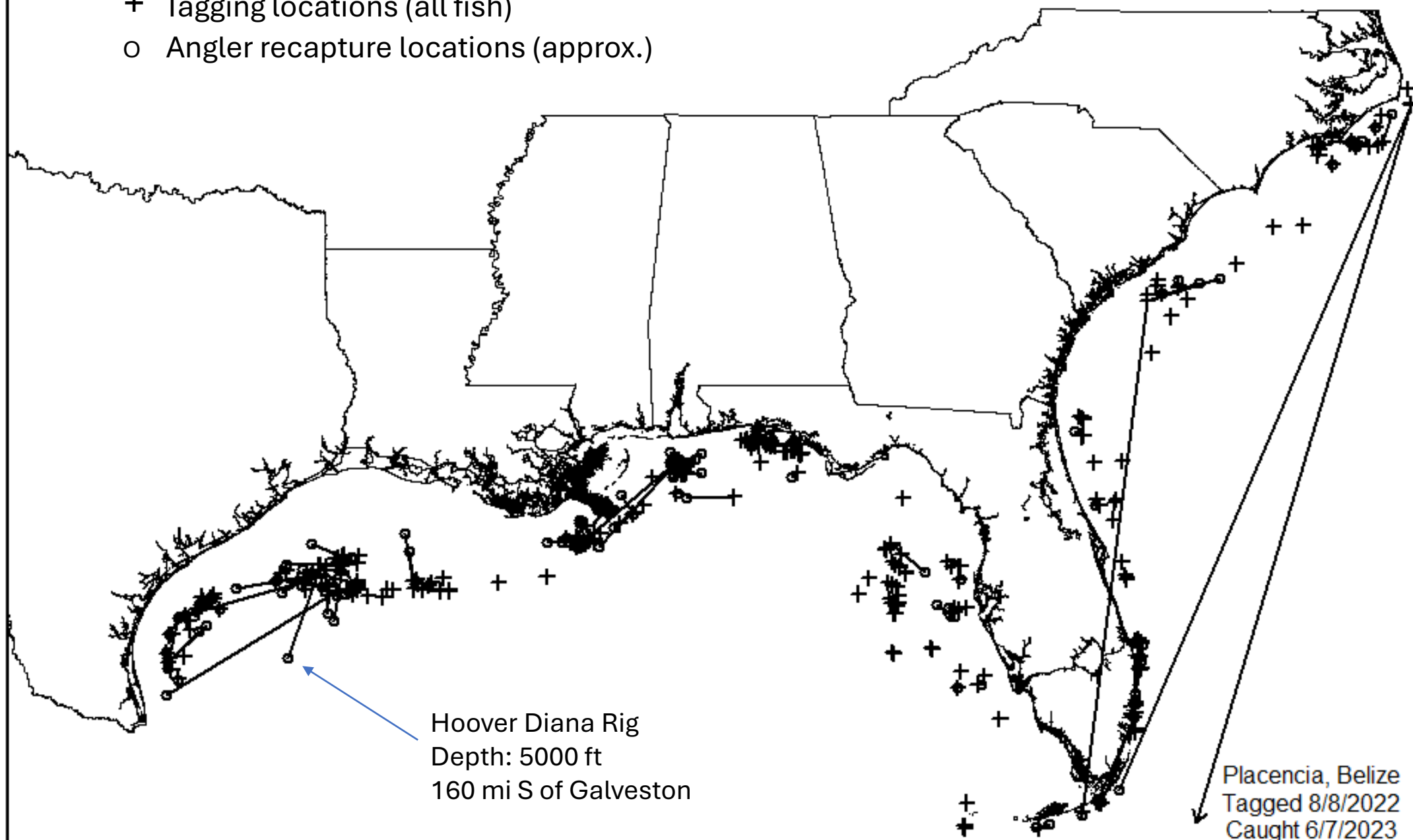
- Multistate mark-recapture models
 - Stratified by tagging region
 - Nine biological States, fourteen observed states for telemetered fish
 - Estimated monthly encounter rates by sector (rec, com)
 - Used assumed SEDAR post-release mortality rates (10% rec, 20% com)
 - Estimated monthly crew-specific acoustic detection probabilities
- Four models
 - Base model: multistate mark-recapture model fitted to dart tag returns and acoustic detection data
 - Emigration model: identical to base model but M is fixed at an assumed value and a permanent emigration rate is estimated
 - Dart tag model: multistate MR model fitted only to the dart tag returns
 - Cormack-Jolly-Seber model fitted only to the acoustic detection data

Exploitation: results (Ch. 5)

- Sigmoidal length-based retention probability consistent with length limits
- Relatively flat and uncertain length-based vulnerability to capture
- Highly variable crew-specific acoustic detection probability
- Exploitation rates lower than SEDAR estimates
 - ATL: 0.08 vs. 0.19, GOM: 0.15 vs. 0.28
 - (harvest plus dead discards)
- **Apparent** natural mortality estimate is high, likely due to emigration
 - 0.80 yr^{-1} (± 0.07) vs. 0.03 yr^{-1}
- Tag shedding rates were modest
 - Initial: 0.03 (± 0.03), Chronic monthly: 0.04 (± 0.04)
- Model-based acoustic tagging mortality similar to external estimates
 - 0.20 (± 0.20)



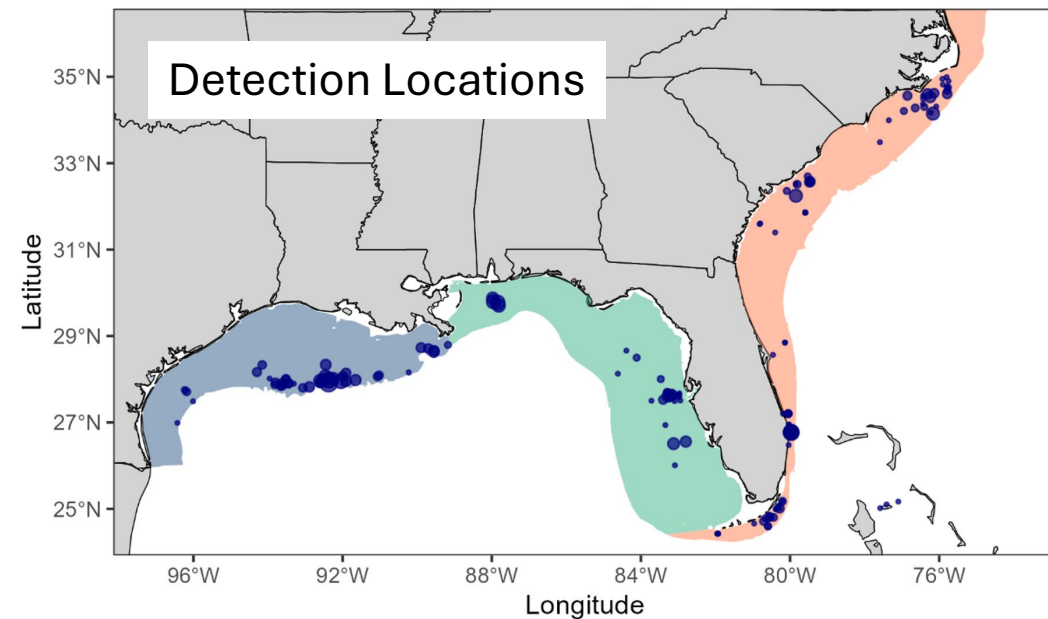
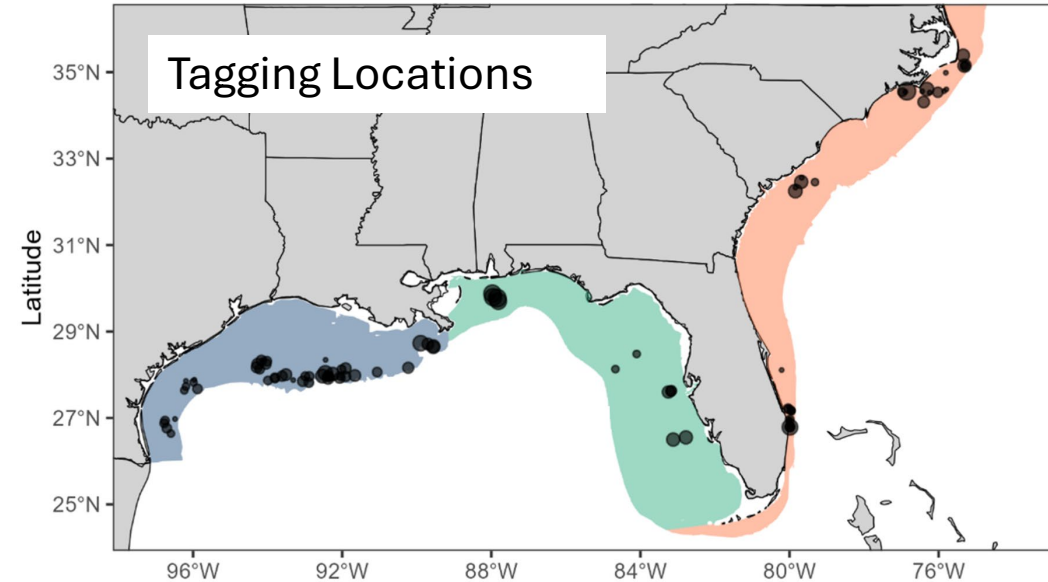
- + Tagging locations (all fish)
- o Angler recapture locations (approx.)



Movement ecology: spatial coverage (Ch. 6)

- 372 GAJ tagged for present project
- 126 tagged GAJ included from other ongoing projects
- Detected at 197 unique sites

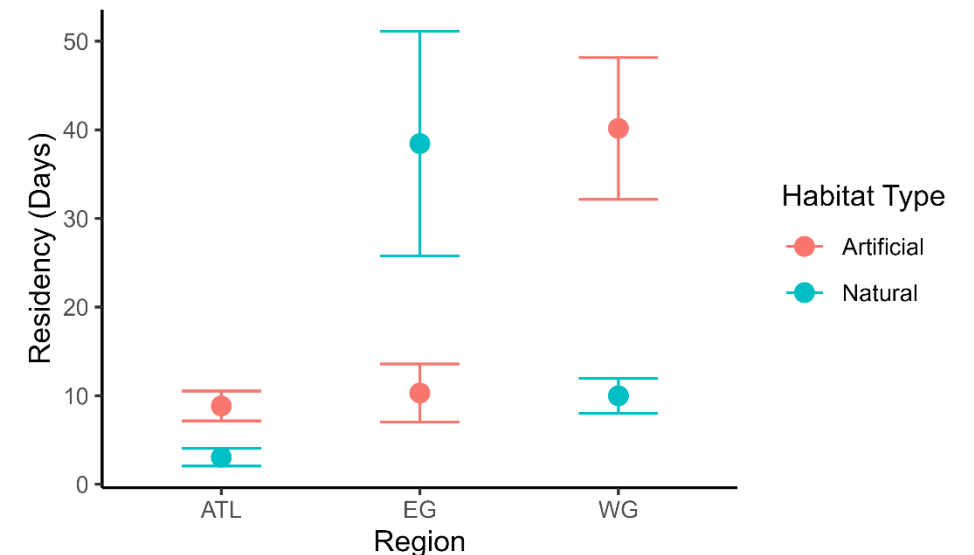
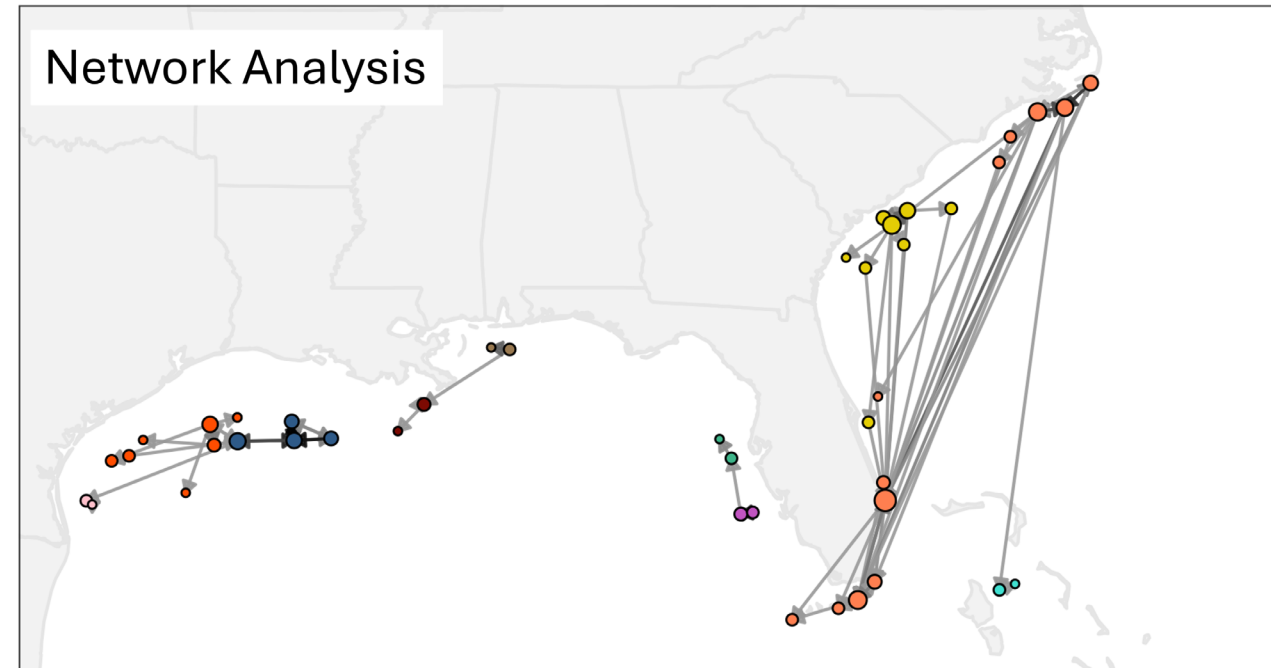
<i>Region/ State</i>	<i>N Tagged</i>	<i>N Detected</i>	<i>N Detections</i>	<i>Mean Days Detected</i>
Atlantic	149	82	1632780	53.2
E Gulf	123	98	3609482	64.3
W Gulf	226	139	3711163	162.5
Total	498	319	8953425	104.4



Movement ecology: results (Ch. 6)

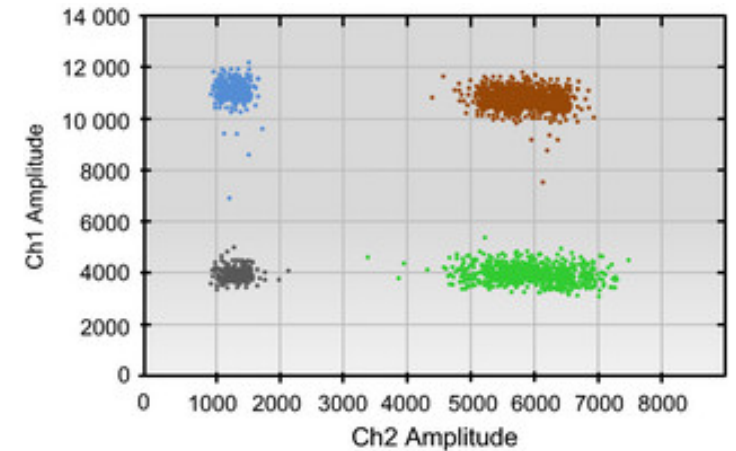
- Distinct patterns distinguish Gulf from Atlantic
- Atlantic:
 - High connectivity, seasonal migration (winter/spring)
 - Large movements entirely southward, no return migration
 - Across intl. borders (Bermuda, Belize)
- Gulf:
 - Shorter movements, longer residency periods
 - Lower connectivity, movements primarily within-state
- One movement E Gulf –W Gulf
- No movement between ATL and Gulf
- Movement across regions peaked during winter/spring coinciding with reproduction

Region	Mean Distance (km)	Max Distance (km)
Atlantic	377.8	2433.0
E Gulf	24.2	192.8
W Gulf	35.3	322.4



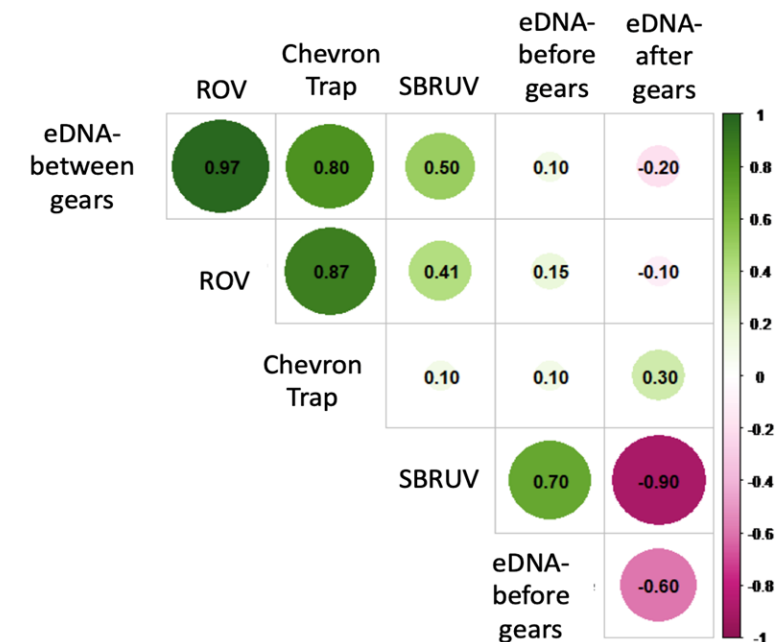
Objective 5: Environmental DNA (Ch. 4)

- Dias et al. 2025 (Ch. 4)
- Investigate efficacy of, and use, eDNA to assess presence and relative abundance of GAJ and closely related species
- Develop novel eDNA tools (ddPCR assay) specific to GAJ and compare performance to other gears during calibrations and regular surveys
 - Confirm identification of species
 - Estimate “sampling” vs. “structural” zeros
 - Provide relative abundance estimates
- Proving ground for the use of eDNA tools to study distribution and abundance of marine fishes



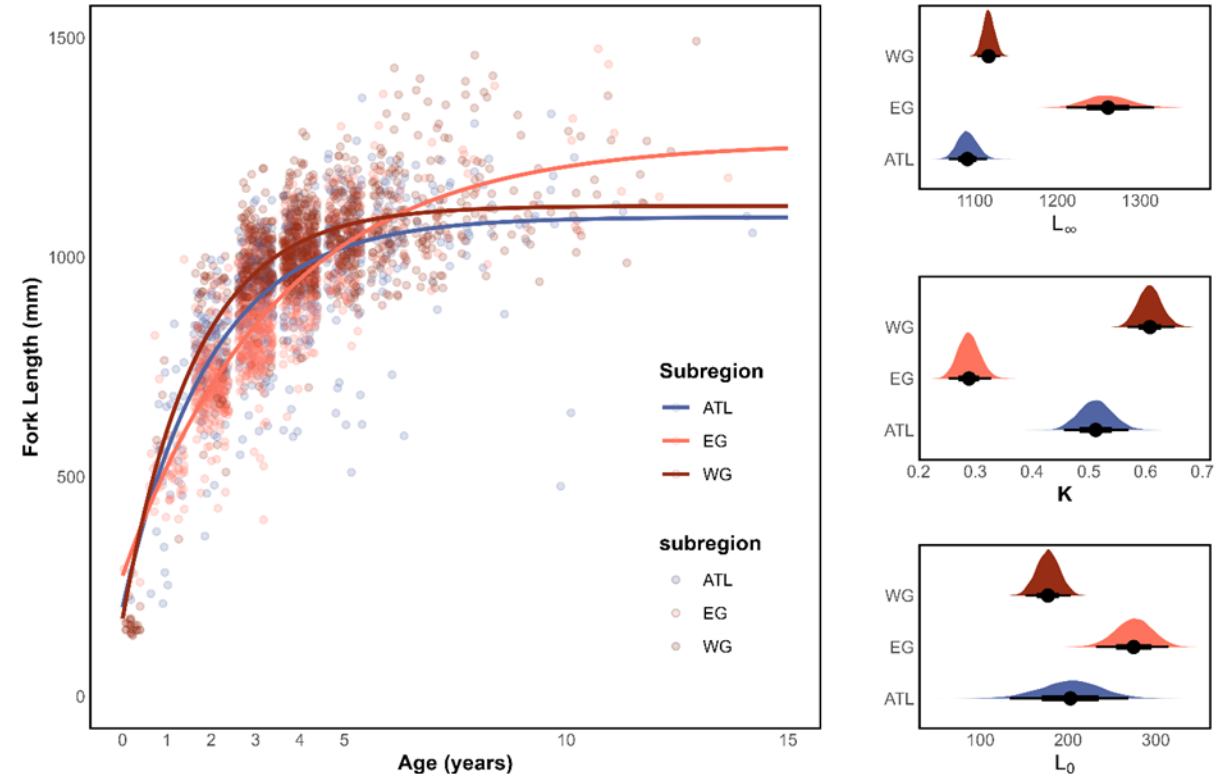
Environmental DNA: results (Ch. 4)

- Demonstrated that eDNA approaches can be integrated into fisheries cruises, offering a fast, cost-effective tool
- Detection & concentrations of *Seriola* spp. DNA from seawater samples aligned with estimates from other gears
- Concentrations of *S. dumerili* eDNA were highly correlated with ROV abundance estimates
- Use of passive eDNA sampling sponges on the ROV improved detection capabilities



Objective 6: Update biological information (Ch. 7)

- Recent stock assessments recommended expanded demographic sampling of GAJ
- Age and growth information from W-GoM has been extremely limited
- Used fishery dependent and independent collections to update biological information and refine age-length keys
- Observed growth differences support stock delineation between GoA and SA

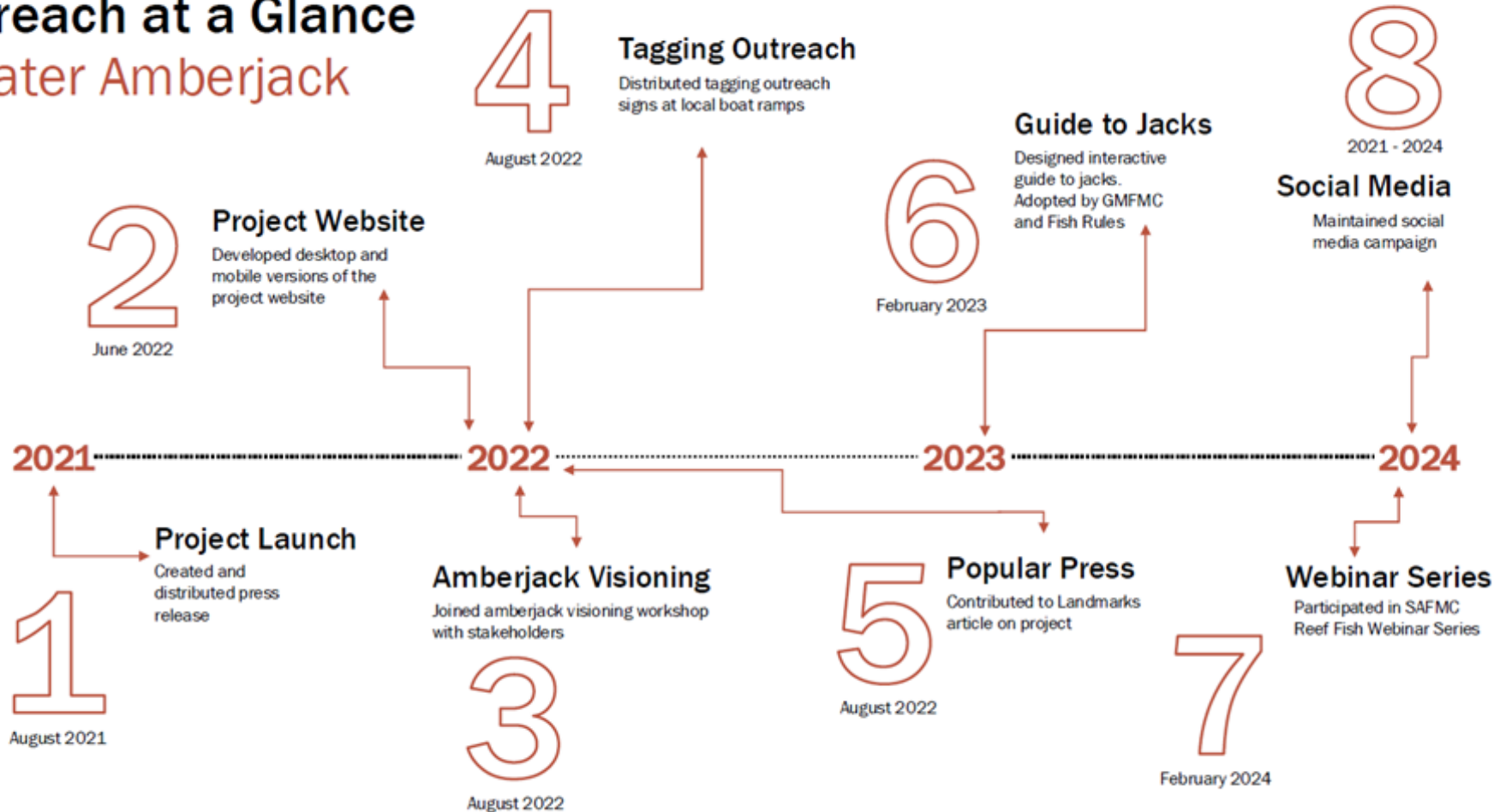


Objective 7: Stakeholder engagement

- Working closely with established groups (e.g., GAJ Visioning Team, Sea Grant Reef Fish Extension Collaborative, etc.) to facilitate communication and cooperation with stakeholders
- Start-to-finish:
 - GAJ Visioning Team collected stakeholder input – used to formulate goals of RFP – Funded research is responsive to priorities of RFP
 - Incorporation of LEK in study design
 - Active engagement with for-hire fishing sector to provide platforms for scientific sampling
 - Dependent on commercial and recreational anglers for high-reward conventional tag returns
 - Dedicated effort to communicate results broadly at conclusion of study

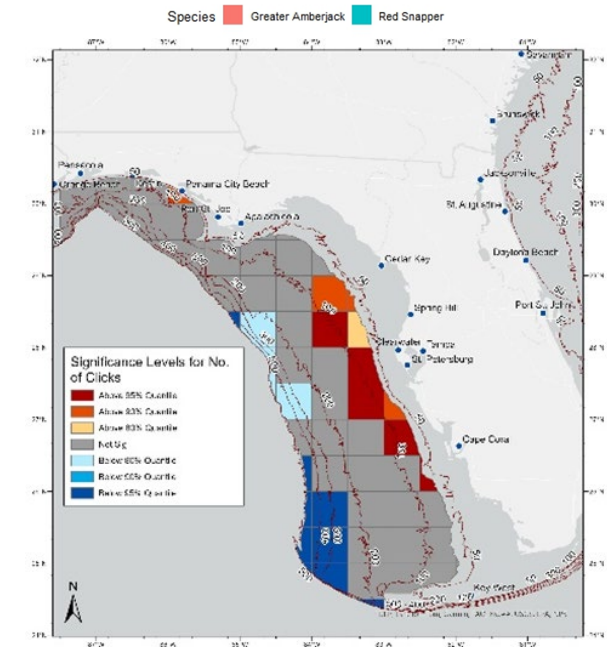
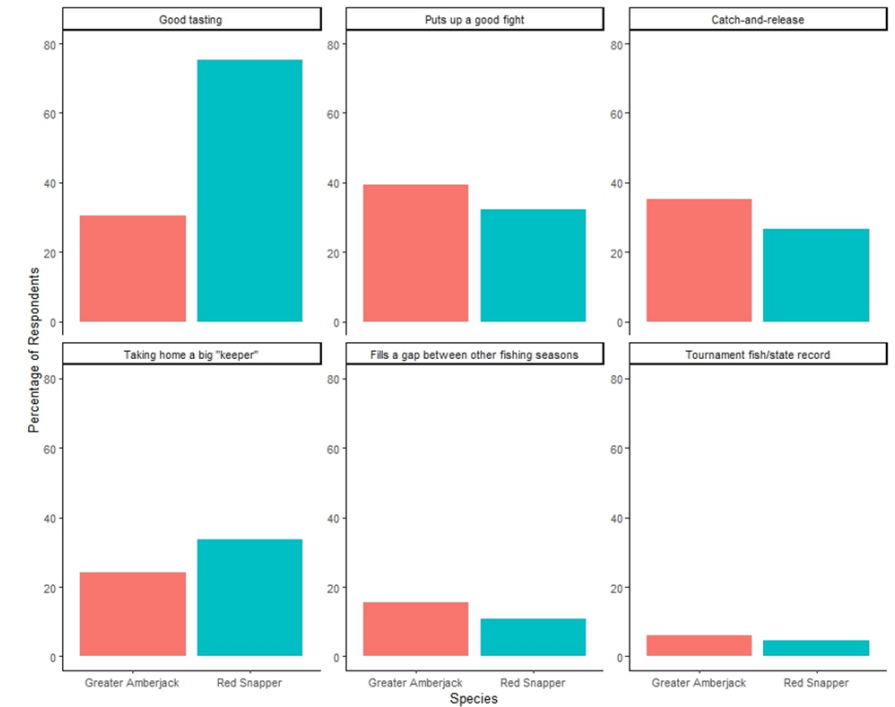
Public outreach (Ch. 12)

Outreach at a Glance Greater Amberjack



Co-produced science-angler involvement (Ch. 13)

- Explored human dimensions of understudied fishery
- Measured perceptions of biological trends and habitat preferences
- Examined differences in species-specific perceptions (compared to Red Snapper)
- Developed novel and statistically rigorous participatory mapping experiment to integrate LEK into design of abundance survey

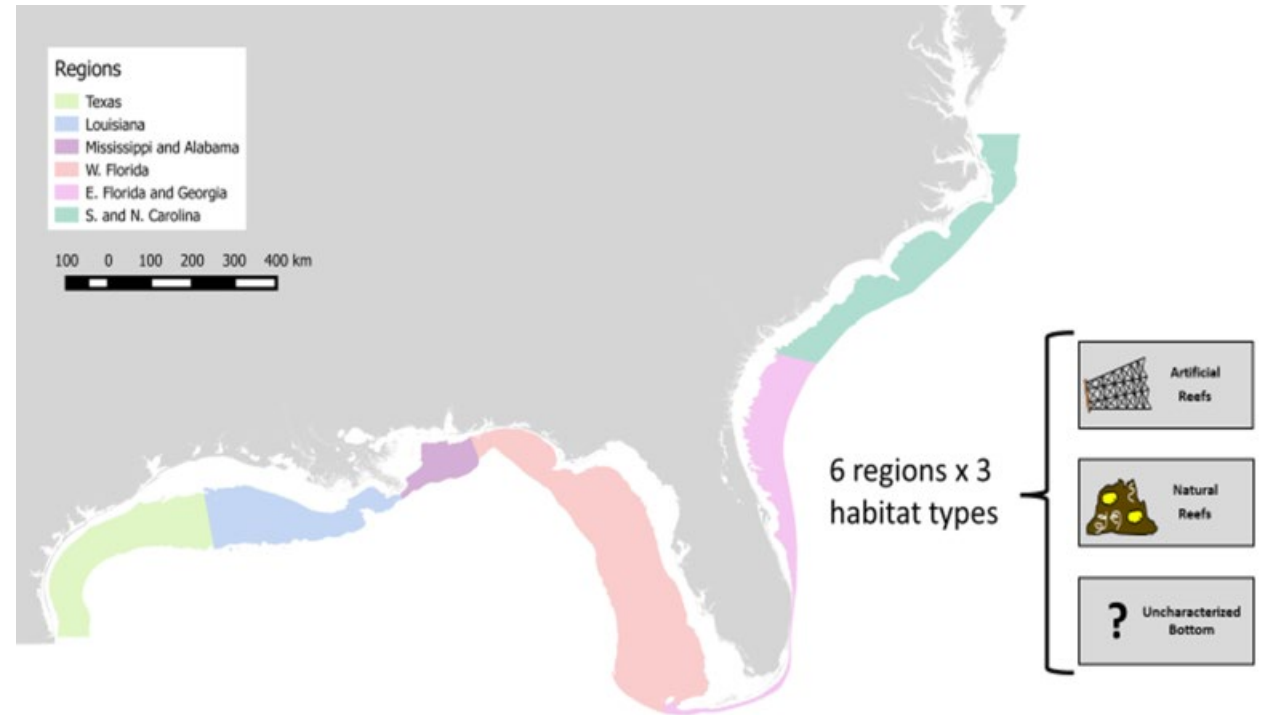


Objective 3: Estimate absolute abundance

- Sample design and framework (Ch. 10)
- Abundance sampling methods (Ch. 11)
- Results (Ch. 11)

Sample design and framework (Ch. 10)

- Sample design for each region based on stratified two-stage random sampling
- Probability sample designs executed independently in each region (W GoA, AL/MS, W FL, SA)
- Stratified by region, depth, habitat type

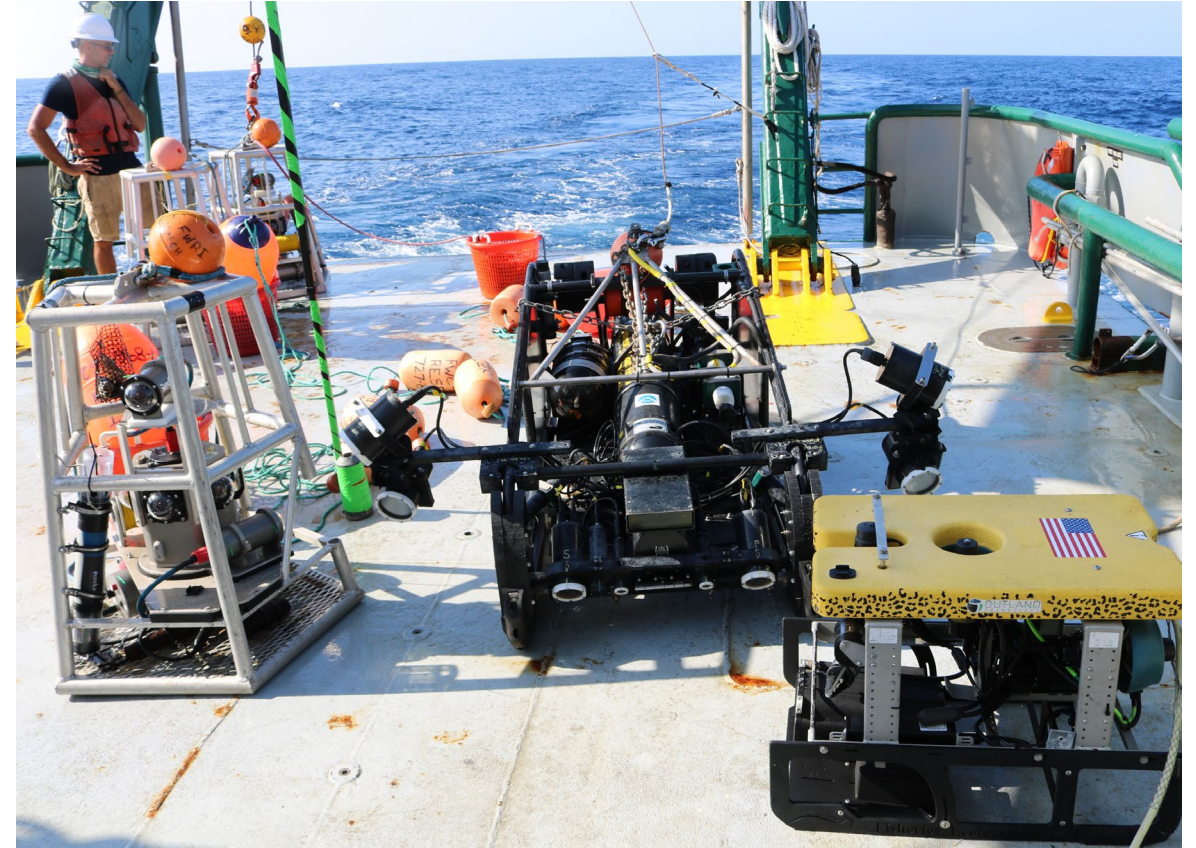


Abundance sampling methods (Ch. 11)

- Absolute abundance estimates require observations of both fish **count** and effective **area** sampled in order to estimate stratum-specific density
- Camera-only approach:
 - Count: GAJ MaxN (avoids double counting)
 - Area: estimate effective sampling area (ESA) of camera gears based on best information available for each gear
- Camera-corrected active acoustics approach:
 - Active acoustics provides count of large-bodied, water-column fishes (LBWCF) in a known area or volume of water
 - Use cameras to estimate ratio of GAJ to LBWC fish and use this ratio to correct acoustic count
- Specific type of video is habitat- and region-specific due to advantages of each gear type
 - E.g. towed cameras effective for sampling large swathes of low-relief habitat, ROV effective for sampling high-relief artificial habitat

Video

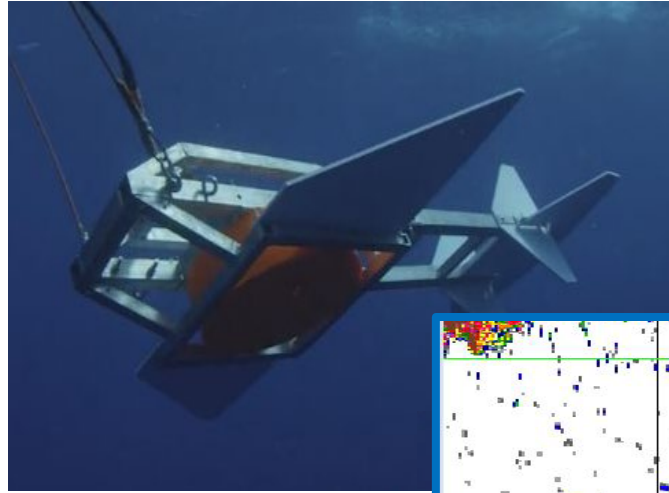
- Vertical drop cameras
 - All habitats
 - Western Gulf
- ROV mounted cameras
 - Artificial and Natural reefs
 - Mississippi and Alabama
- Baited stationary cameras (BRUVs)
 - Artificial and Natural reefs
 - West Florida and South Atlantic
- Towed cameras
 - Uncharacterized bottom
 - MS, AL, WFL, and SA
- Camera gears used either calibrated stereo cameras or paired lasers to collect size data



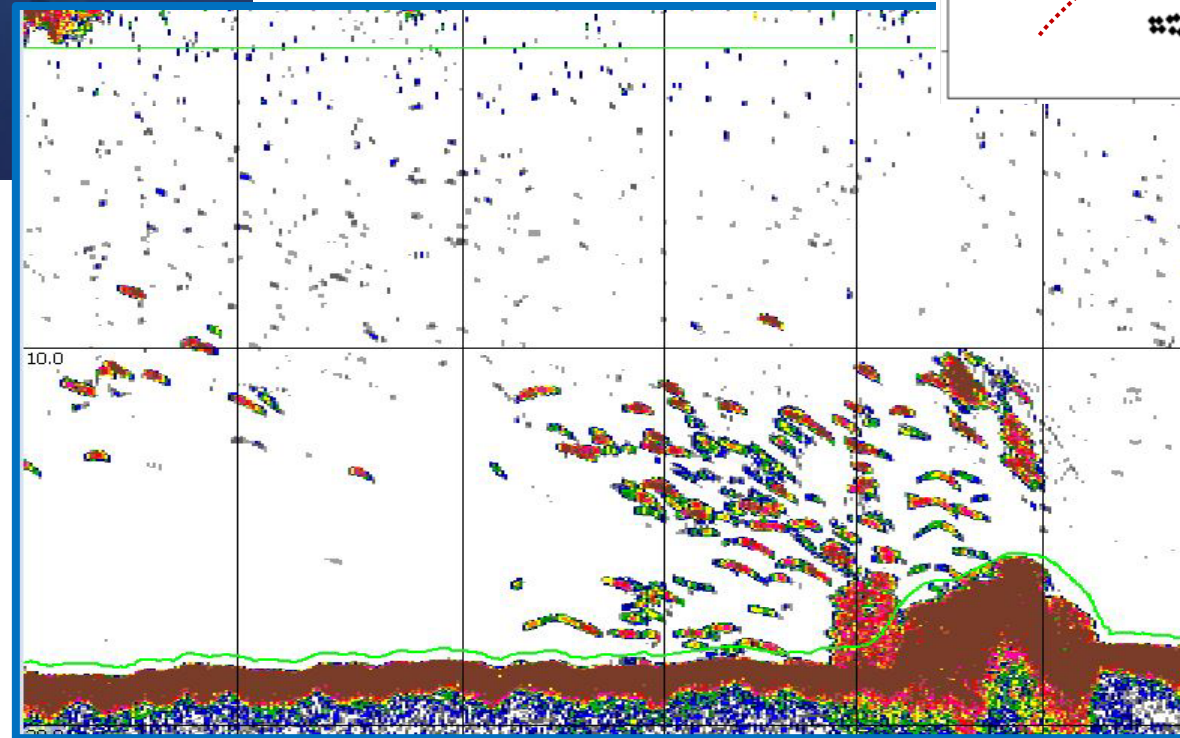
Footage from USA ROV (3 species of *Seriola*)



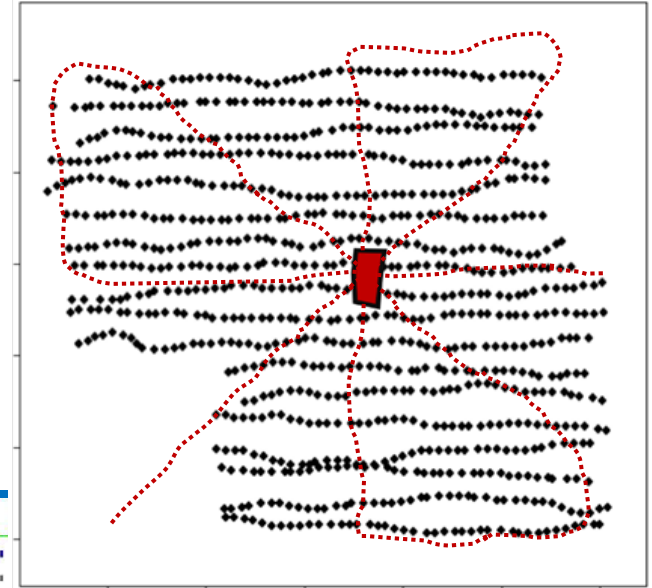
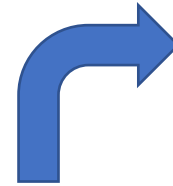
Active acoustics



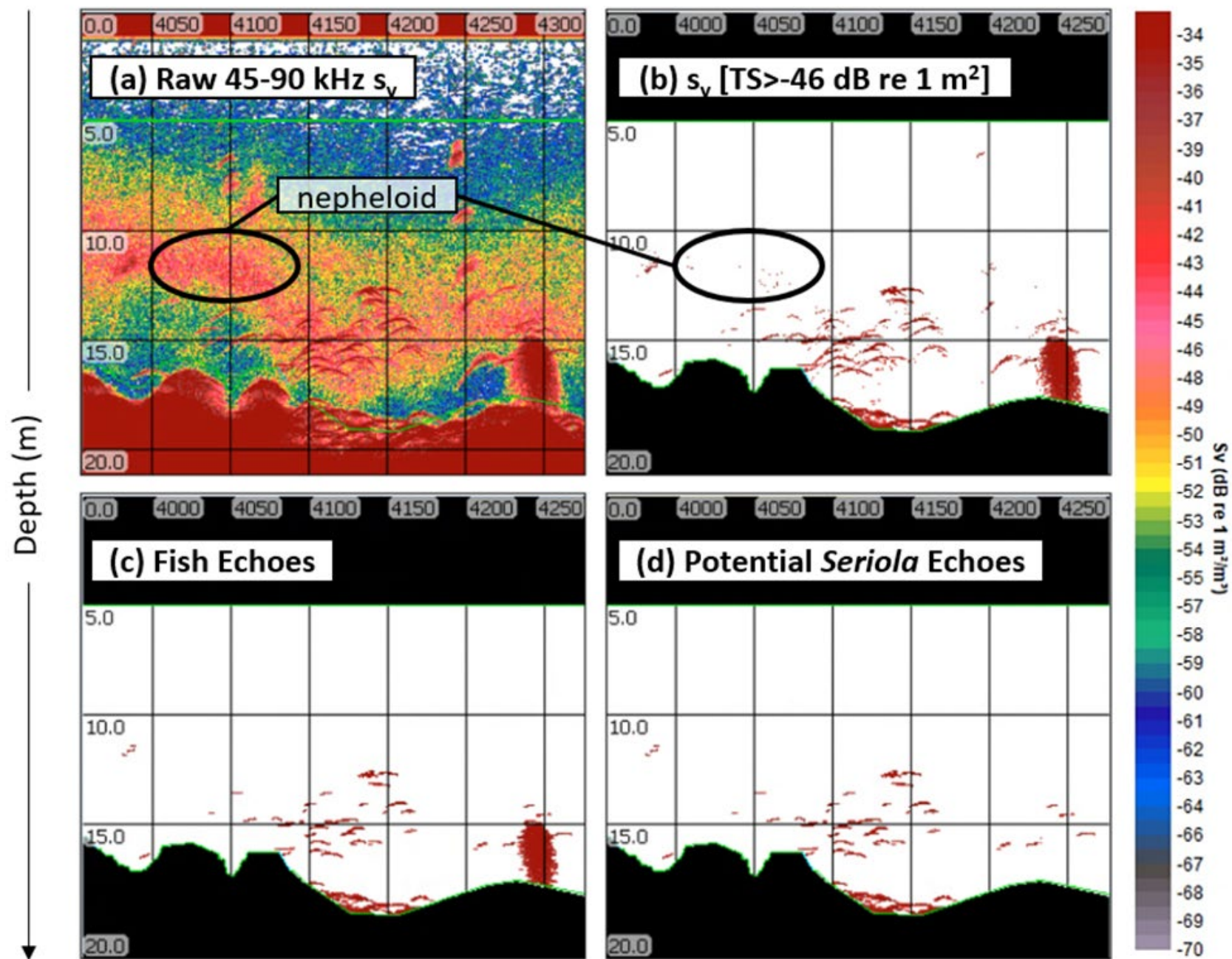
Depth

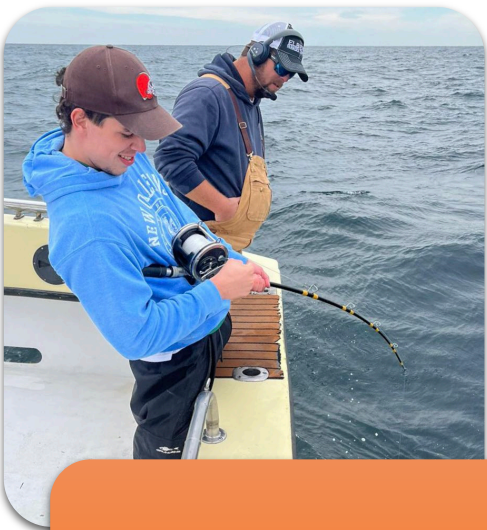


Distance along transect



Pings

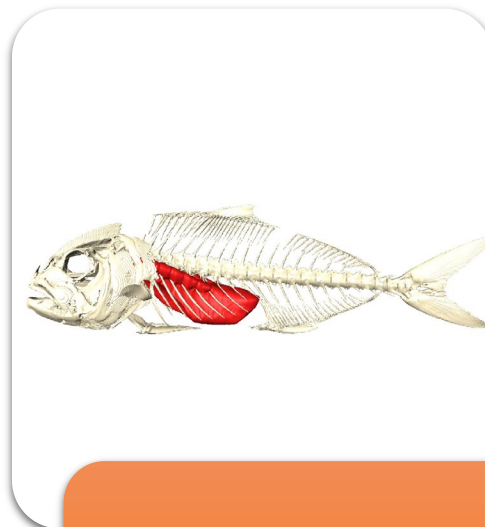




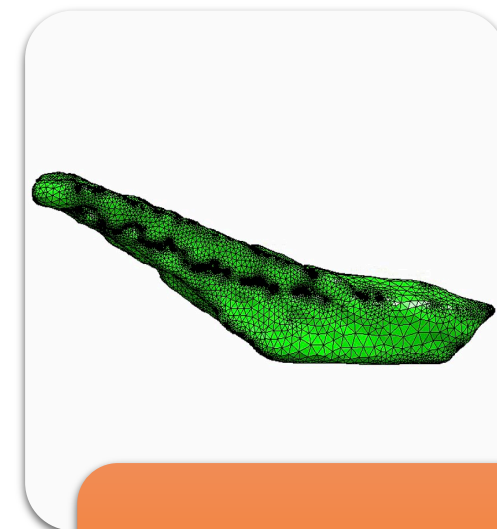
GAJ Collection



CT Scanning



**Model
Processing**



**Backscatter
Modeling**



DISL FISH #6

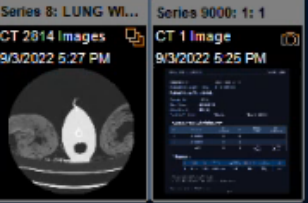
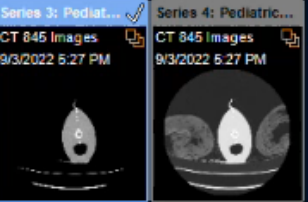
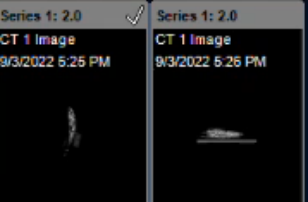
ID: 20220903172...

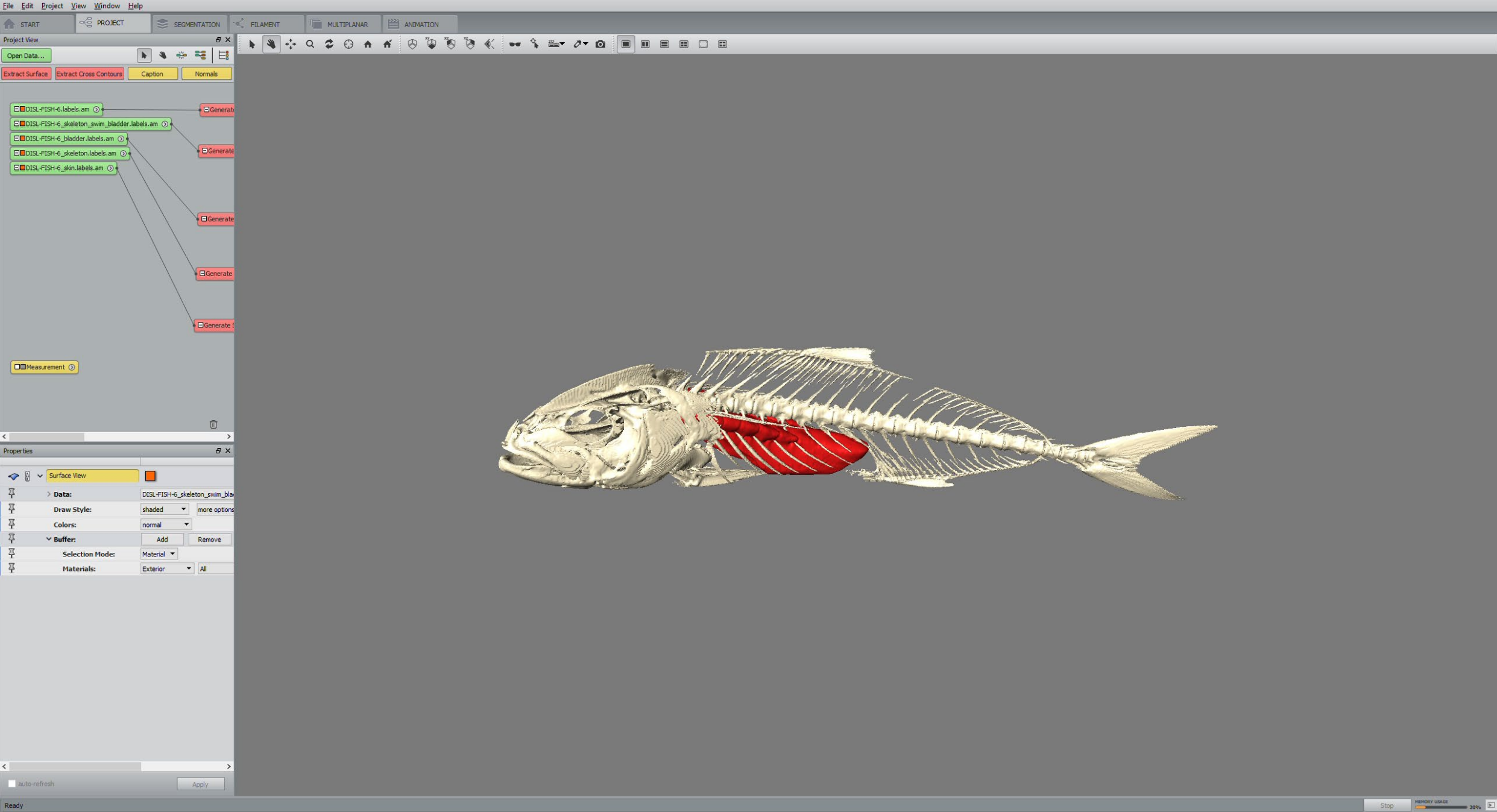
Birth Date:

Gender:

Series 3: Pediatric 1.0

DISL FISH #6
20220903172057
Pediatric 1.0
9/3/2022
5:26 PM
Scan Nr. 3 - Slice 1/845
Filter LARGE EC





Example Output

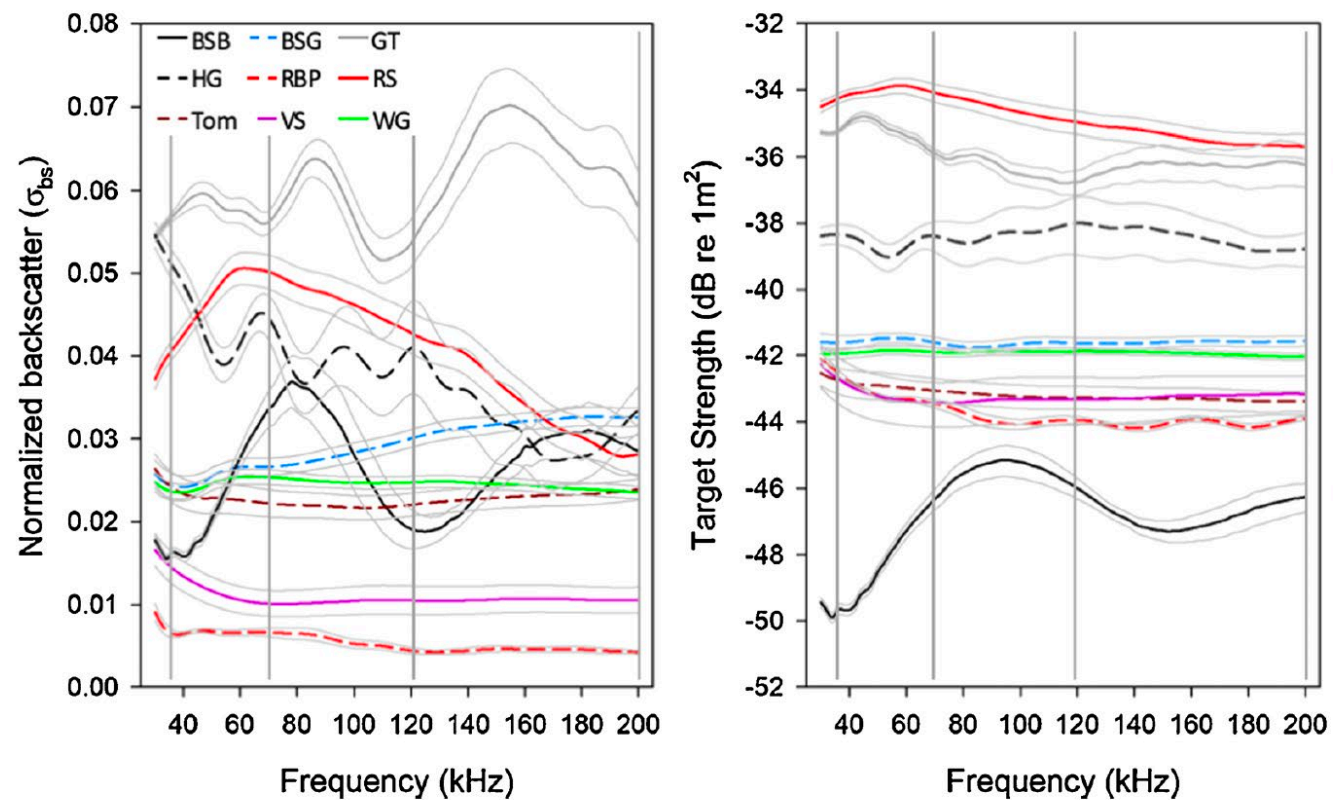


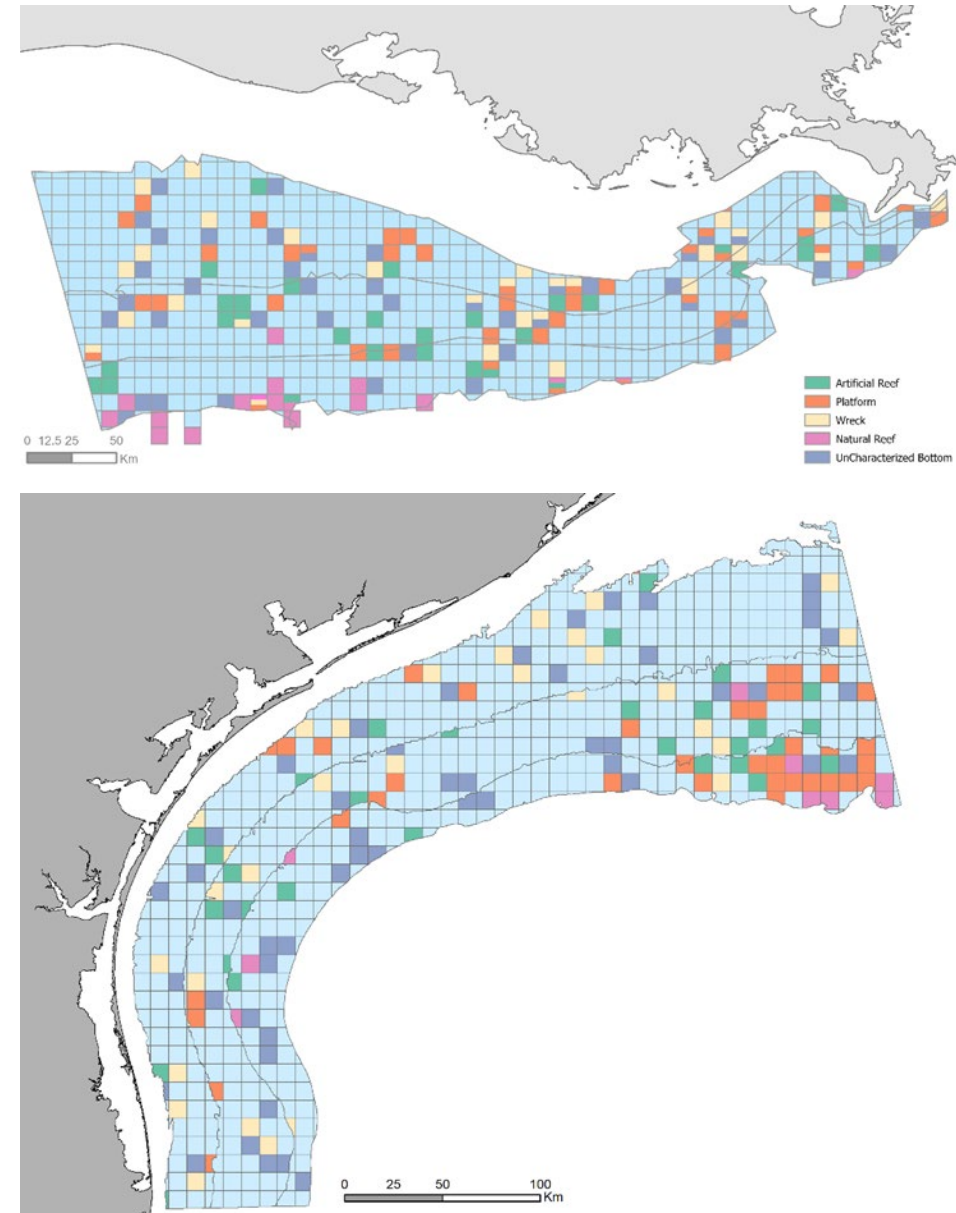
Fig. 6. Species specific averaged σ_{bs} response (m²) with 95 % confidence intervals (broken lines) around the mean (solid line). Vertical reference lines represent nominal operating frequencies in fisheries acoustics (38, 70, 120, and 200 kHz).

Regional sample designs and results (Ch. 11)

- Western Gulf of America (WGoM)
- Alabama and Mississippi (AL/MS)
- Western Florida (WFL)
- South Atlantic (SA)

Western Gulf of America: sample design (Ch. 11.1)

- Stratified random design
- Three depth zones:
 - shallow (20-40m)
 - mid (40-70m)
 - outer shelf (70-150m)
- Habitats:
 - Artificial reefs (AR)
 - Standing gas platforms (P)
 - Natural reefs (NR)
 - Uncharacterized bottom (UCB)
- Survey locations randomly selected in two stages for each habitat type
 - PSU = 5-km x 5-km grid cell
 - SSU = single location within cell
- Effort proportional to available habitat area in each depth zone

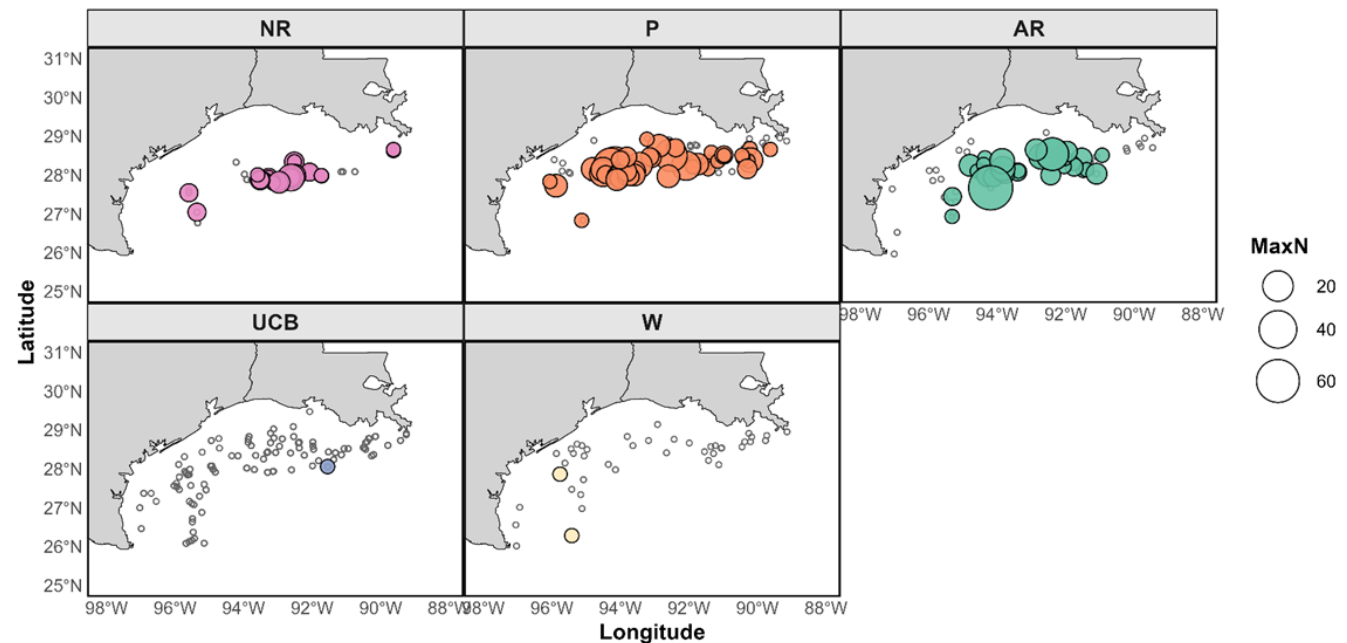


Western Gulf of America: survey methods (Ch. 11.1)

- Hydroacoustic and camera gears deployed at each location
- Same active acoustic gear as used in other regions
- Camera: SeaGIS underwater stereo video system
- Vertical transect used to sample entire water column while minimizing attraction, double counting, and risk of gear entanglement
- Artificial reefs, oil and gas platforms: A single vertical camera transect was conducted adjacent to target structure on down-current side
- Natural reefs and UCB: five vertical camera transects were conducted within the
- Both total count and MaxN counts used to produce alternative abundance estimates
- Camera ESA was based on area of target habitat within areal 360-degree view of camera (118.36m^2 for artificial structures and 236.72m^2 for natural and UCB)

Western Gulf of America: results (Ch. 11.1)

- GAJ densities varied by depth, habitat, and state, with the highest densities observed in the two deeper zones
- GAJ densities on natural reefs were higher in LA than TX
- GAJ densities on artificial reefs were higher in LA than TX
- GAJ densities on UCB in TX was effectively zero across all depths, while estimates in LA were elevated with high uncertainty in the outer shelf zone

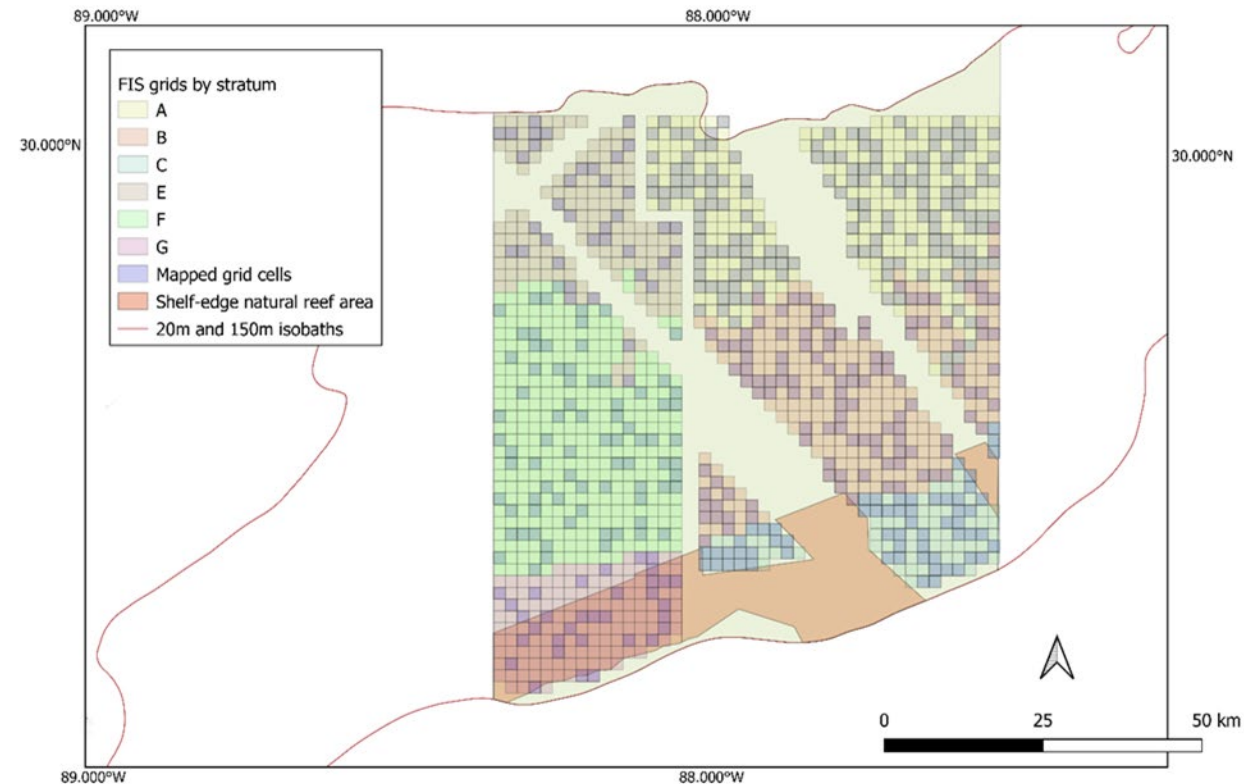


Western Gulf of America: results (Ch. 11.1)

- The camera-only absolute abundance estimate based on the MaxN count for the Western GoM was 2,553 (SE: 1,733, CV: 68%) [thousands of fish]
 - The very high uncertainty in this estimate is due to the large variance around the UCB estimate (1,731, SE: 1,709, CV: 99%) caused by isolated high densities of fish on unmapped hardbottom within our UCB stratum
- The camera-corrected acoustic absolute abundance estimate was 616 (SE: 212, CV: 34%) [thousands of fish]

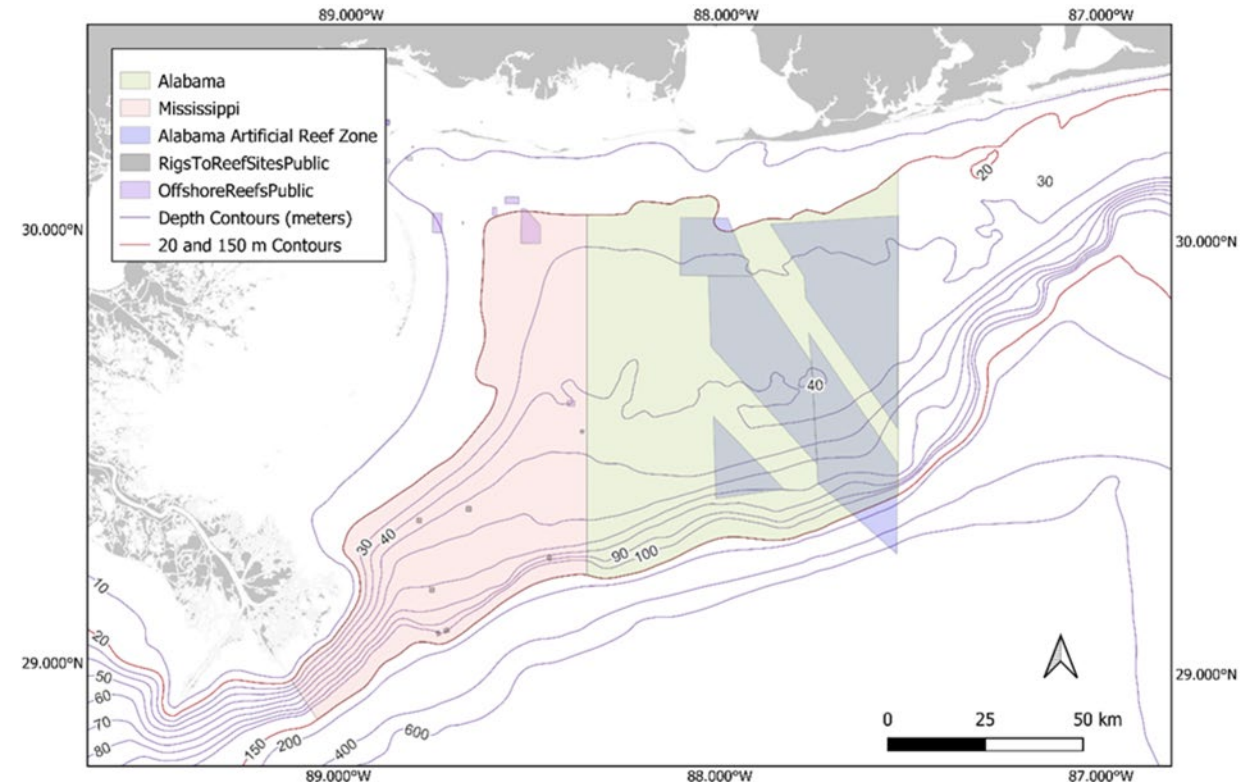
Alabama-Mississippi: sample design (Ch. 11.2)

- Leveraged existing long-term fisheries independent survey in AL
- Differences in existing habitat data
 - AL: long-term, randomized design, side-scan mapping effort allowing estimation of habitat areas of natural and artificial reefs across a range of relief categories as well as areas of unconsolidated (sand and mud) bottom
 - MS: no mapping
- Necessitated different sampling designs for the two sub-regions



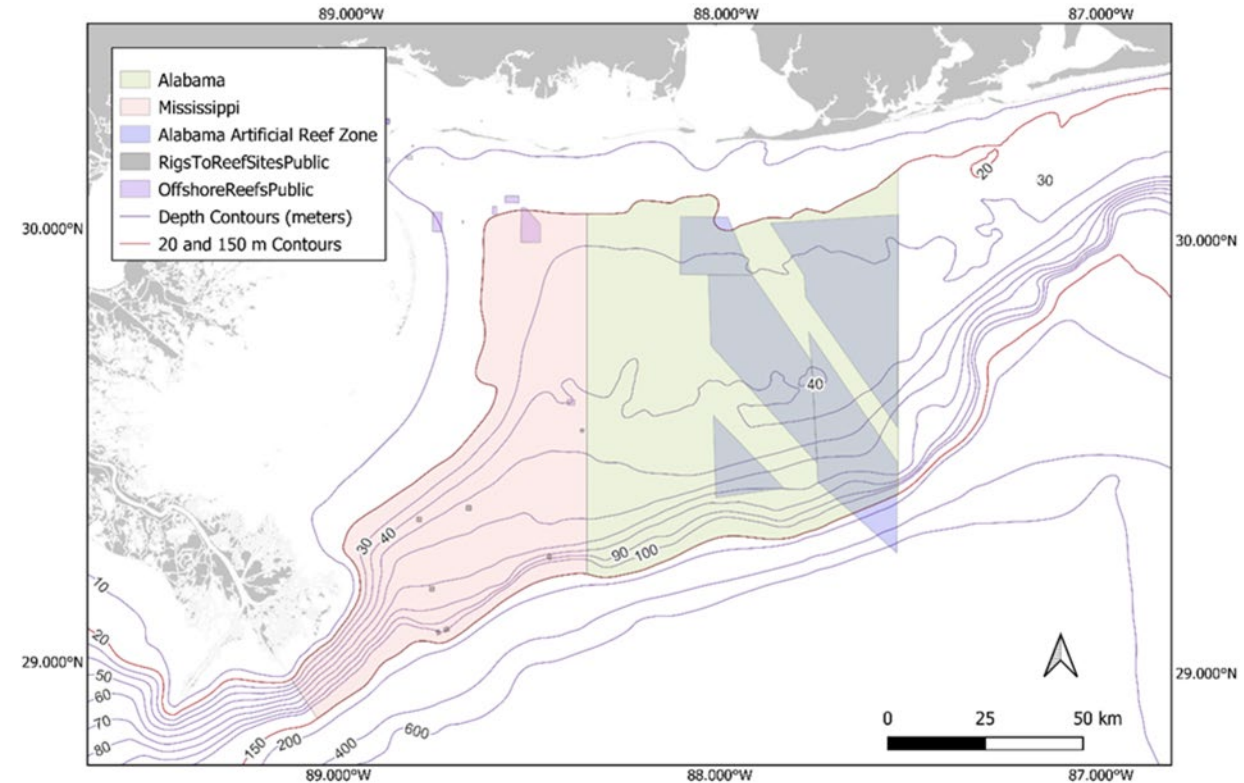
Alabama-Mississippi: sample design (Ch. 11.2)

- Alabama sampling design (hardbottom)
 - Two-stage randomized cluster sampling
 - PSUs: existing mapped grid cells (2-km x 2-km)
 - SSUs: randomly selected artificial and natural reefs
 - Stratified by spatial/depth zone
 - Effort proportional to area in each spatial/depth zone
 - Supplemental sampling conducted to increase representation of rare habitats (high-relief artificial, low- and high-relief natural)
 - Oil and gas platforms selected randomly from list of known active platforms
- Mississippi sampling similar to above, but based on lists of known reef locations (no natural reef sampled)



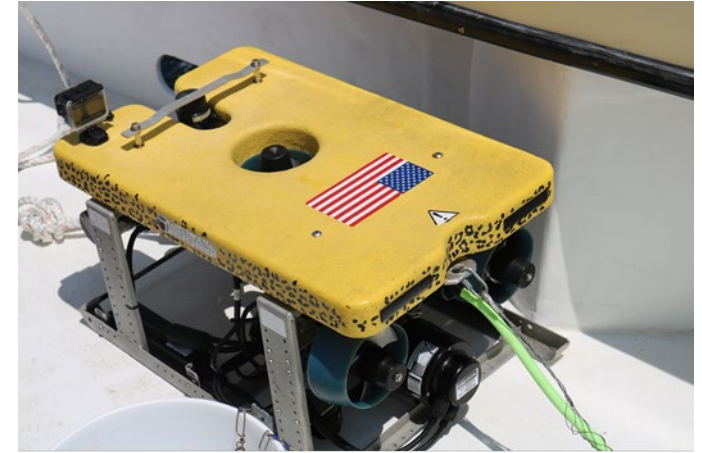
Alabama-Mississippi: sample design (Ch. 11.2)

- Alabama-Mississippi sampling design (uncharacterized bottom)
 - Randomly selected three 5' x 5' grid cells without characterized hardbottom habitats
 - Effort allocated based on previous catch data, with more effort allocated to cells with no-previous-information and cells with low and high previous catch records



Alabama-Mississippi: survey methods (Ch. 11.2)

- Hydroacoustic and camera gears deployed at most locations
- Same active acoustic gear deployment as used in other regions
- Artificial and Natural reef targets:
 - Camera: ROV mounted underwater video system with paired lasers
 - ROV positioned 5-7 m down-current, facing target reef for 5 minutes, and again at 5-7 m up-current, facing target reef for additional 5 minutes
 - Video processed for MaxN counts of all large-bodied, water column spp.
 - Camera ESA was based on area of target habitat within 360-degree circle with diameter determined by 95% KDE of acoustically tagged GAJ on VPS arrays
- UCB targets:
 - C-BASS towed camera flown approximately 2-5m above seafloor
 - Covered approximately 6.5 nm distance per transect
 - Video processed for total count in 15-second intervals
 - ESA of camera calculated as length of transect times width of camera field-of-view

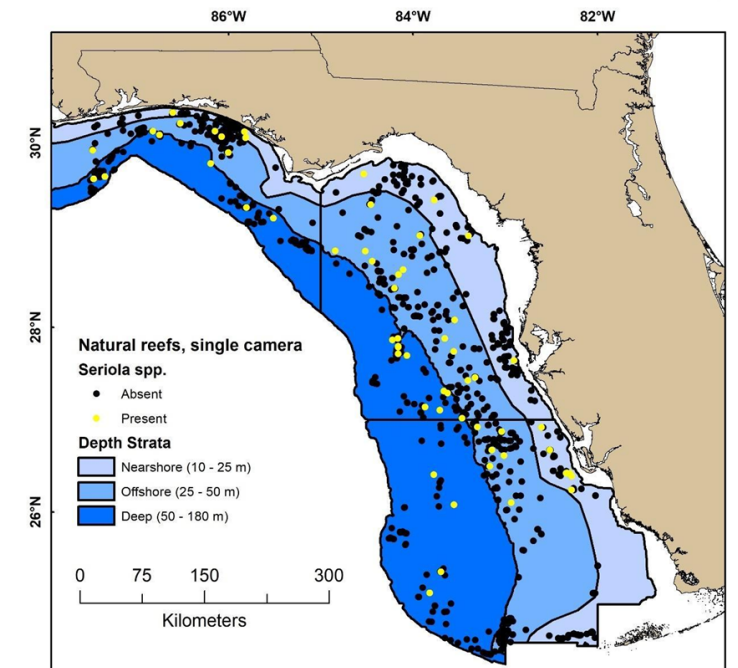
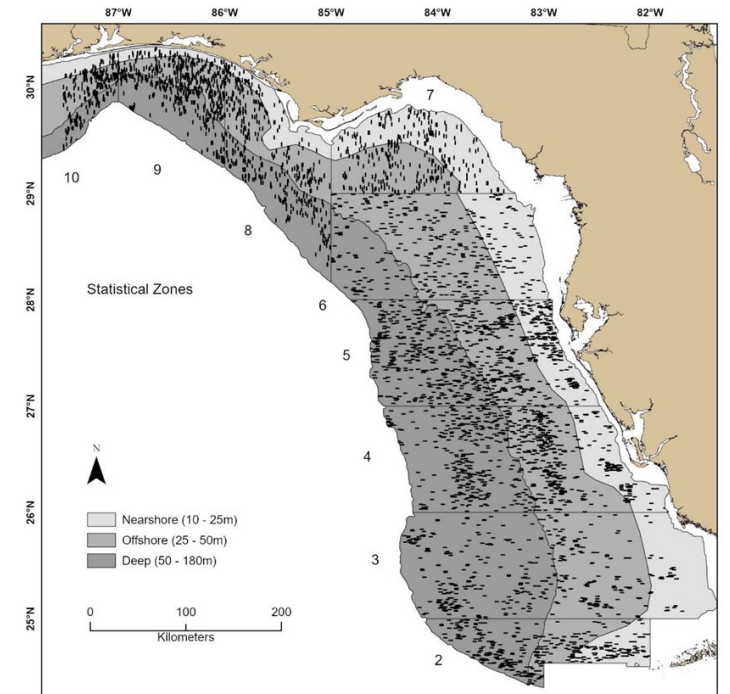


Alabama-Mississippi: results (Ch. 11.2)

- The camera-only absolute abundance estimate based on the MaxN count for the Alabama-Mississippi region was 342 (SE: 194, CV: 57%) [thousands of fish]
 - The very high uncertainty in this estimate is due to the large variance around the natural-reef estimate in the deep stratum (105, SE: 156, CV: 148%) caused by highly variable fish counts coupled with high uncertainty in habitat area in this stratum
- The camera-corrected acoustic absolute abundance estimate was 106 (SE: 4, CV: 4%) [thousands of fish]

West Florida: sample design (Ch. 11.3)

- Leveraged effort of G-FISHER survey
 - Uses stationary Stereo Baited Remote Underwater Video (SBRUV) cameras
- G-FISHER design based around standardized random habitat mapping surveys
- Stratification by region, depth, and habitat type
- Stratified-random, two-stage cluster sampling
 - PSU: 0.1nm x 0.1nm micro grids
 - SSU: random point in target habitat polygon
- Effort allocated based on habitat availability and managed species richness



West Florida: sample design (Ch. 11.3)

- G-FISHER sampling supplemented to meet needs of GAJ project
 - Active acoustics surveys at subset of G-FISHER sites
 - Full 360-degree SBRUV counts conducted at subset of G-FISHER sites
 - Abundance from regular single-camera counts compared to 360 counts to develop calibration coefficients
 - Paired baited-unbaited SBRUV trials conducted to evaluate influence of bait on counts of GAJ
 - Uncharacterized bottom surveyed using towed C-BASS camera system

West Florida: survey methods (Ch. 11.3)

- Hydroacoustic and camera gears deployed at subset of sampling locations
- Same active acoustic gear deployment as used in other regions
- Artificial and Natural reef targets:
 - Camera: stationary stereo baited remote underwater video system (SBRUV) with five independent cameras covering a horizontal FOV of ~360 degrees
 - 35-minute deployments
 - 20 minutes of video, beginning 10 minutes after reaching bottom, processed for MaxN counts of all large-bodied, water column spp.
 - Camera ESA was based on area of target habitat within 360-degree circle with diameter determined by (1) an analysis of the timing of MaxN and the average current velocity in the region and (2) a kernel density estimate of space use of GAJ during a 30 minute time interval from acoustically tagged fish in a VPS array
- UCB targets:
 - C-BASS towed camera flown approximately 2-5m above seafloor
 - Covered approximately 6.5 nm distance per transect
 - Video processed for total count in 15-second intervals
 - ESA of camera calculated as length of transect times width of camera field-of-view

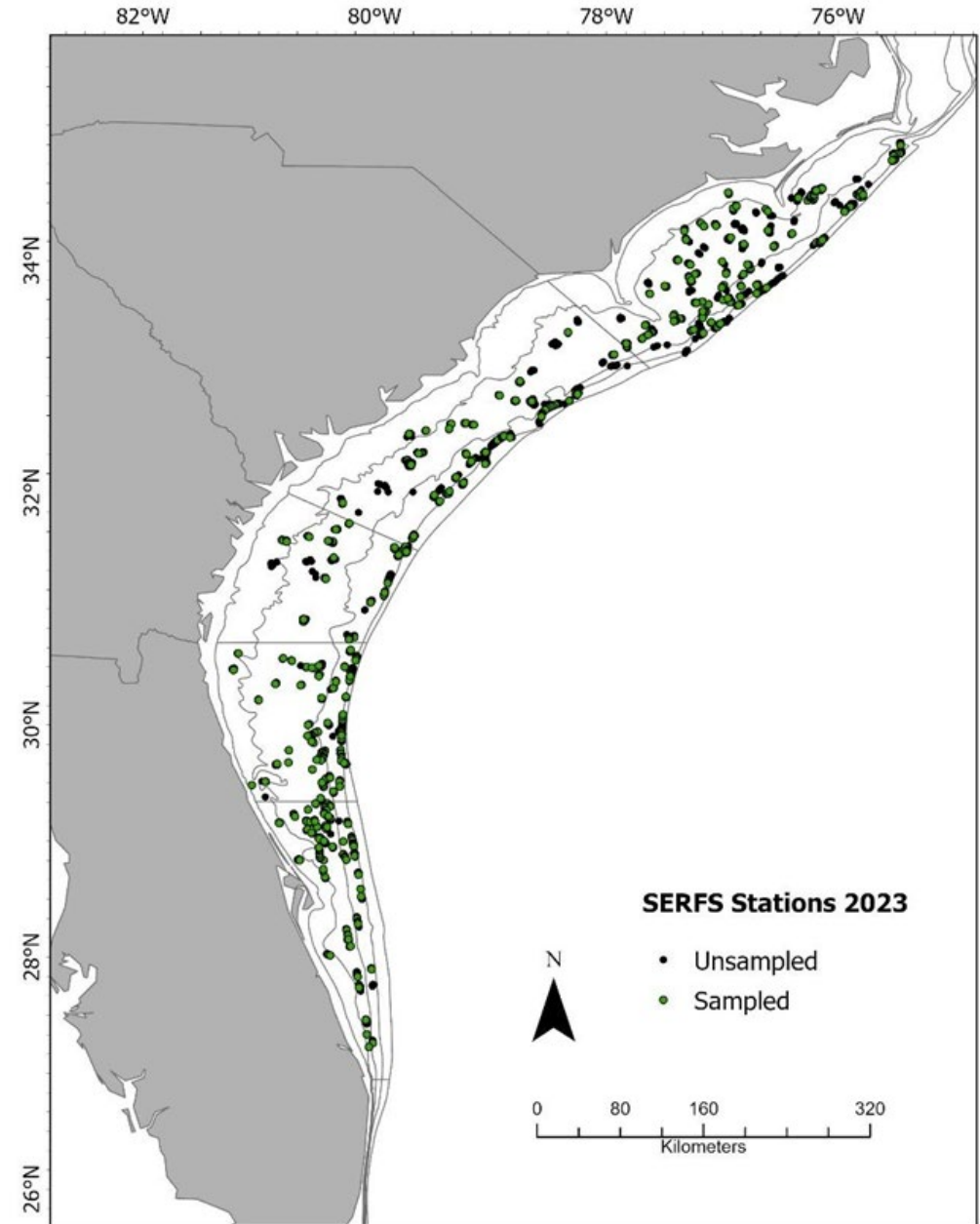


West Florida: results (Ch. 11.3)

- The camera-only absolute abundance estimate based on the MaxN count for the West Florida region was 726 (SE: 165, CV: 22.7%) [thousands of fish]
- The camera-corrected acoustic absolute abundance estimate was 550 (SE: 241, CV: 43.9%) [thousands of fish]

South Atlantic: sample design (Ch. 11.4)

- Leveraged SERFS chevron video-trap survey
 - Uses baited chevron traps equipped with trap-mounted video cameras
- SERFS sample design based on simple random selection from known list of natural hardbottom sites with new sites added each year based on exploratory sampling in previous year
- Major limitation: lack of habitat maps for the region
 - Predictive habitat maps available, but not sufficient for use in sample design or extrapolating estimates to region



South Atlantic: sample design (Ch. 11.4)

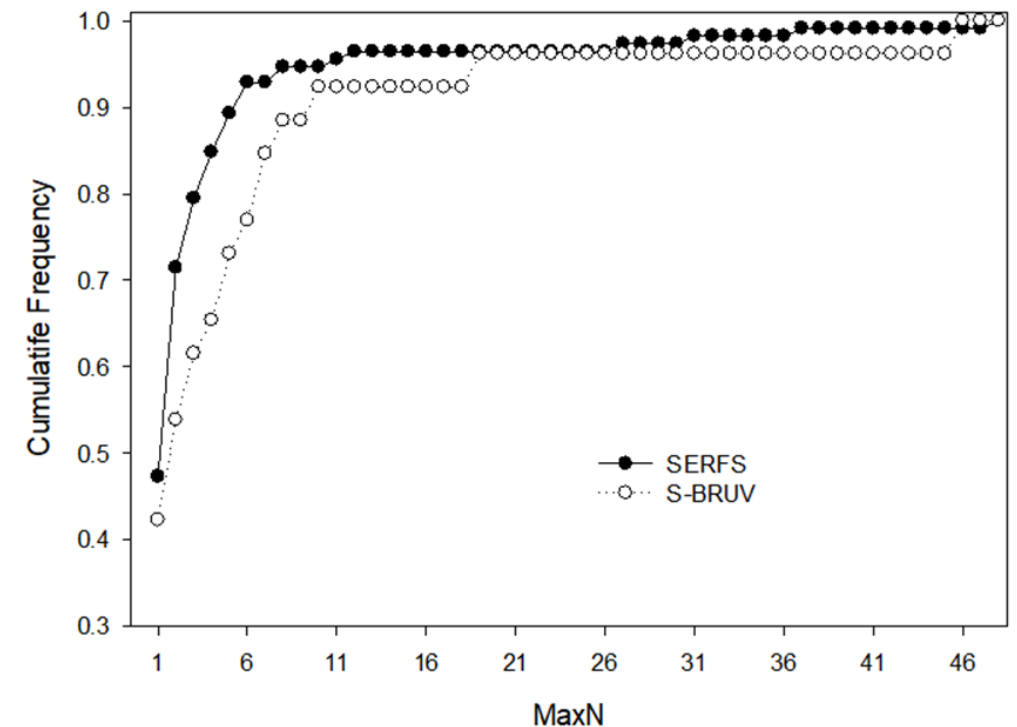
- Supplemented by GAI project sampling
 - SBRUV samples on natural and artificial hardbottom (focus on habitats/areas not covered well by SERFS)
 - Active acoustics surveys conducted in association with SBRUV deployments
 - Limited side-scan sonar mapping to validate and adjust estimates of habitat quantity from existing predictive habitat maps
 - UCB survey using C-BASS towed camera array
- Stratification for supplemental sampling (and post-stratification of SERFS observations) based on region and depth
- SBRUV site selection from SERFS list of hardbottom natural habitat as well as additional list of natural and artificial hardbottom sites from FWC and NCCOS
- South Florida treated separately due to availability of hardbottom habitat maps for this sub-region

South Atlantic: survey methods (Ch. 11.4)

- SERFS surveys:
 - Baited chevron traps soaked for 90 minutes
 - Video reads start 10 minutes after trap hits bottom and run for 20 minutes
 - SERFS uses SumCount method, but we extracted a MaxN proxy by selecting the snapshot with the largest count
- Supplemental surveys: (same as described previously in W-FL section)
 - Hydroacoustic and camera gears deployed at all SBRUV sampling locations
 - Same active acoustic gear deployment as used in other regions
 - Artificial and Natural reef targets:
 - Camera: stationary stereo baited remote underwater video system (SBRUV) with five independent cameras covering a horizontal FOV of ~360 degrees
 - 35-minute deployments
 - 20 minutes of video, beginning 10 minutes after reaching bottom, processed for MaxN counts of all large-bodied, water column spp.
 - Camera ESA was based on area of target habitat within 360-degree circle with diameter determined by (1) an analysis of the timing of MaxN and the average current velocity in the region and (2) a kernel density estimate of space use of GAJ during a 30 minute time interval from acoustically tagged fish in a VPS array
 - UCB targets:
 - C-BASS towed camera flown approximately 2-5m above seafloor
 - Covered approximately 6.5 nm distance per transect
 - Video processed for total count in 15-second intervals
 - ESA of camera calculated as length of transect times width of camera field-of-view

South Atlantic: survey methods (Ch. 11.4)

- Needed to calibrate SERFS single-camera reads to 360 SBRUV currency
- Limited paired data from Alabama Calibration study insufficient to calculate calibration coefficient for completely different region
- Developed alternate approach:
 - Compiled SERFS and SBRUV reads from common spatial footprint
 - Different gears, but same design, same species, same region
 - Generated cumulative frequency distributions for each survey independently
 - Converted all SERFS MaxN values to SBRUV spherical MaxN values based on corresponding quantiles



South Atlantic: results (Ch. 11.4)

- The camera-only absolute abundance estimate based on the MaxN count for the South Atlantic region was 3,080 (SE: 1,077; CV: 35%) [thousands of fish]
- The camera-corrected acoustic absolute abundance estimate was 3,089 (SE: 1,281; CV: 41.5%) [thousands of fish]

Absolute abundance estimates by region

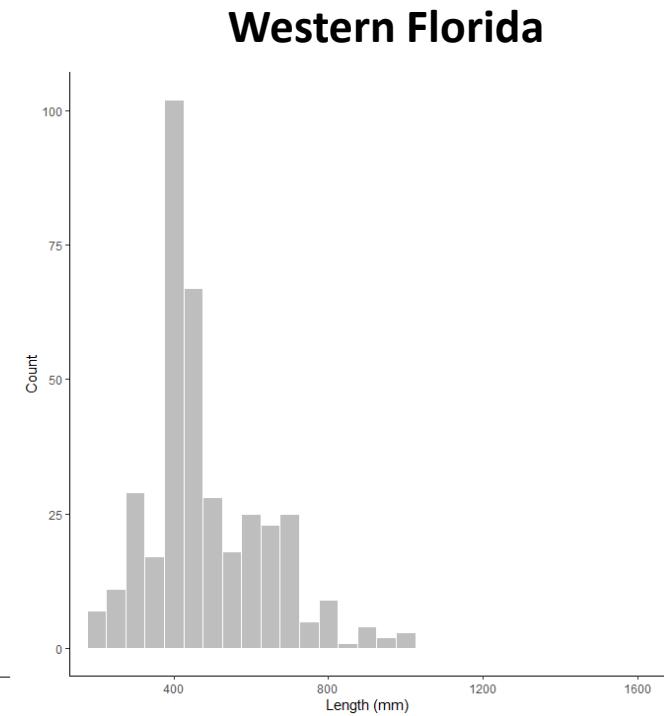
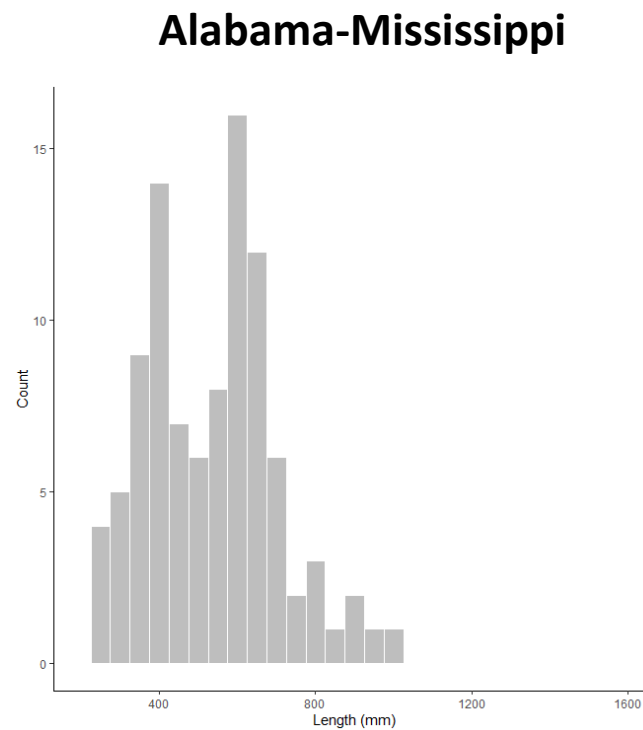
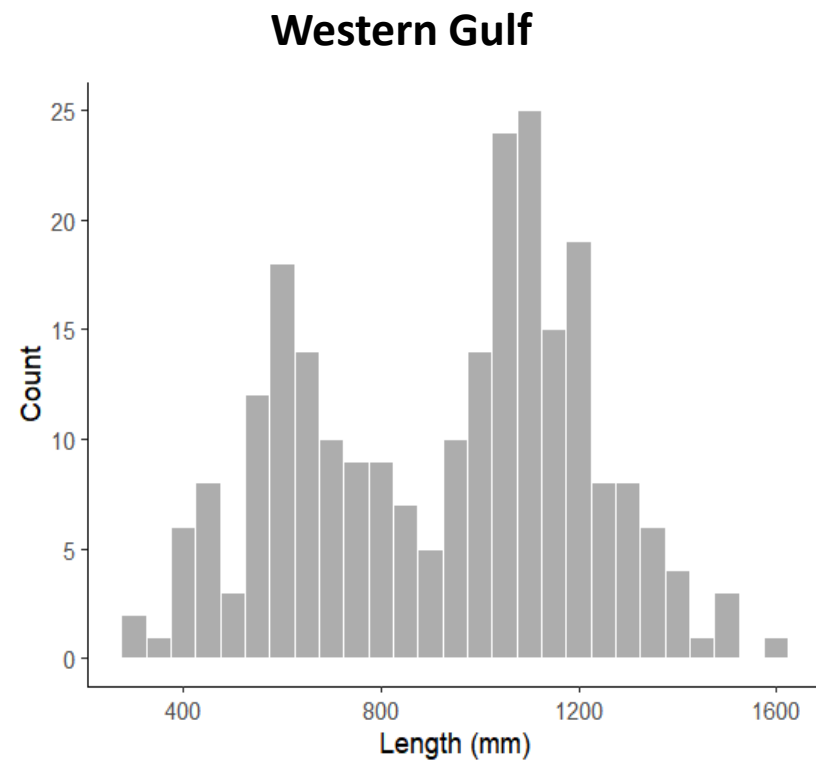
- Camera-only:

Region	Estimate	SD	CV %
Western Gulf	2,548,592	1,733,436	68.0
Alabama-Mississippi	341,528	194,394	56.9
Western Florida	726,416	164,933	22.7
<i>Total Gulf</i>	<i>3,616,536</i>	<i>1,752,082</i>	<i>48.4</i>
<i>South Atlantic</i>	<i>3,079,636</i>	<i>1,077,180</i>	<i>35.0</i>

- Acoustic:

Region	Estimate	SD	CV %
Western Gulf	615,788	211,828	34.4
Alabama-Mississippi	105,942	4,204	4.0
Western Florida	550,405	241,405	43.9
<i>Total Gulf</i>	<i>1,272,135</i>	<i>321,193</i>	<i>25.2</i>
<i>South Atlantic</i>	<i>3,089,458</i>	<i>1,281,063</i>	<i>41.5</i>

Regional size distributions



Note: very limited size data available from South Atlantic region

Caveats and future research needs

- Species identification on videos difficult for *Seriola* spp.
 - When species IDs were uncertain, we did not include those fish in our counts (leading to a conservative abundance estimate)
- MaxN is, inherently, a conservative estimate (floor) of number of fish present during sampling event
- Camera ESAs not well grounded in unified theory or empirical data
 - Fish density estimates highly sensitive to ESA
 - When in doubt, we tended to use a larger ESA, resulting in conservative density/abundance estimates
- Acoustic counts
 - Disagreement (sometimes large) between stratum-specific and regional estimates using the two methods
 - Translation of raw acoustic data into fish counts is a complex and difficult process
 - Automated filtering algorithms may work well in test cases, but not across all conditions
 - Problems with using species ratios to correct acoustic counts
 - Sites where GAJ seen on video, but no LBWCF counted using acoustics
 - Sensitive to species included in LBWCF category
 - Since our acoustic estimates are generally lower than our camera-only estimates, our species list for LBWC fish was likely too broad
- Effective gear calibrations require large investment of time and resources
 - Calibration coefficients likely habitat and region specific
- Lack of comprehensive habitat maps (fine and broadscale): major limiting factor in estimating absolute abundance

CIE Review of early draft report

- Early version of project report benefited from suggestions of SEDAR sponsored review
- Review focused primarily on one objective: abundance estimates
- Regardless of absolute abundance estimates derived, this project has fundamentally advanced our understanding of the biology and ecology of Greater Amberjack
- In revising the report, the investigators incorporated as many suggestions from the review committee as feasible
- The estimates and CVs in this presentation and in the final report are not the same ones examined by the review committee

Project webpage, Final Report and forthcoming publications

- Please see the project webpage:

<https://gulfseagrant.org/reef-fish-extension/greater-amberjack-research-program/>

- Read a full copy of the final technical report:

<https://masgc.org/assets/publications/uploads/26-029.pdf#asset:65775:url>

- And check out the interactive StoryMap:

<https://storymaps.arcgis.com/stories/535c01f8f91b4e77933603862d1f6f34>

- The results of this project will continue to be improved as publications benefit from the scientific journal peer-review process and are ultimately accepted. We encourage you to refer to those contributions as they become available.

A large school of yellow-striped snappers (Lutjanus fulvus) is shown swimming in clear, deep blue water. The fish are silvery with a distinct yellow stripe running along the side of their bodies. They are arranged in a loose, coordinated group, moving towards the right side of the frame. The lighting is bright and even, highlighting the sleek, elongated shapes of the fish and their pointed snouts. The background is a uniform, vibrant blue, suggesting an open ocean environment.

Questions