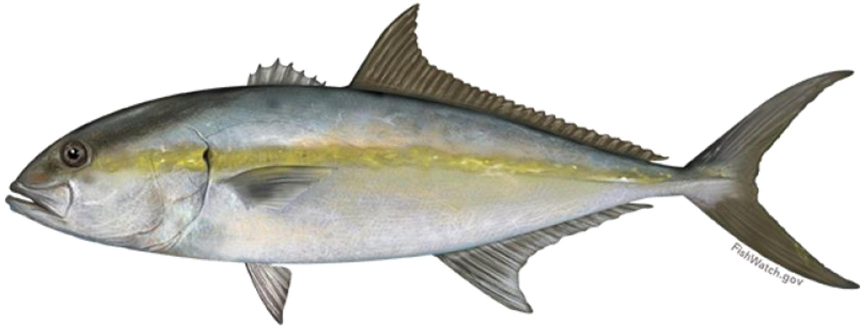
NOAA FISHERIES



Sea Grant

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

Northeastern University
Mississippi State University
FIU Florida International University
University of South Alabama
NC State University
The University of Southern Mississippi
Southern Methodist University
Texas A&M University Corpus Christi
USF University of South Florida
Auburn University
VIMS William & Mary Virginia Institute of Marine Science
LSU Louisiana State University
Texas A&M University Galveston Campus
Florida Fish and Wildlife Conservation Commission

Rationale

- 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
- Stakeholder buy-in is critical to effective management
- In response, US Congress has funded two independent studies to provide independent estimate of absolute abundance, help guide future management, build stakeholder confidence:
  - Great Red Snapper Count – GoM (completed)
  - Great(er) Amberjack Count – GoM and SA (ongoing)

GAJ Count

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

GAJ Count

- Challenges:
  - GAJC will be more challenging than GRSC simply because…
    - We know less about GAJ than we do about RS
    - GAJ move more than RS
    - Larger area (GoM + SA)
    - Less time → reduced capacity for gathering preliminary data, planning, adapting
  - Like GRSC:
    - Lack detailed, comprehensive knowledge of bottom habitats
    - While confident in ability to estimate abundance at local scales, “scaling-up” to larger geographic frame can be problematic

Phased approach

P I

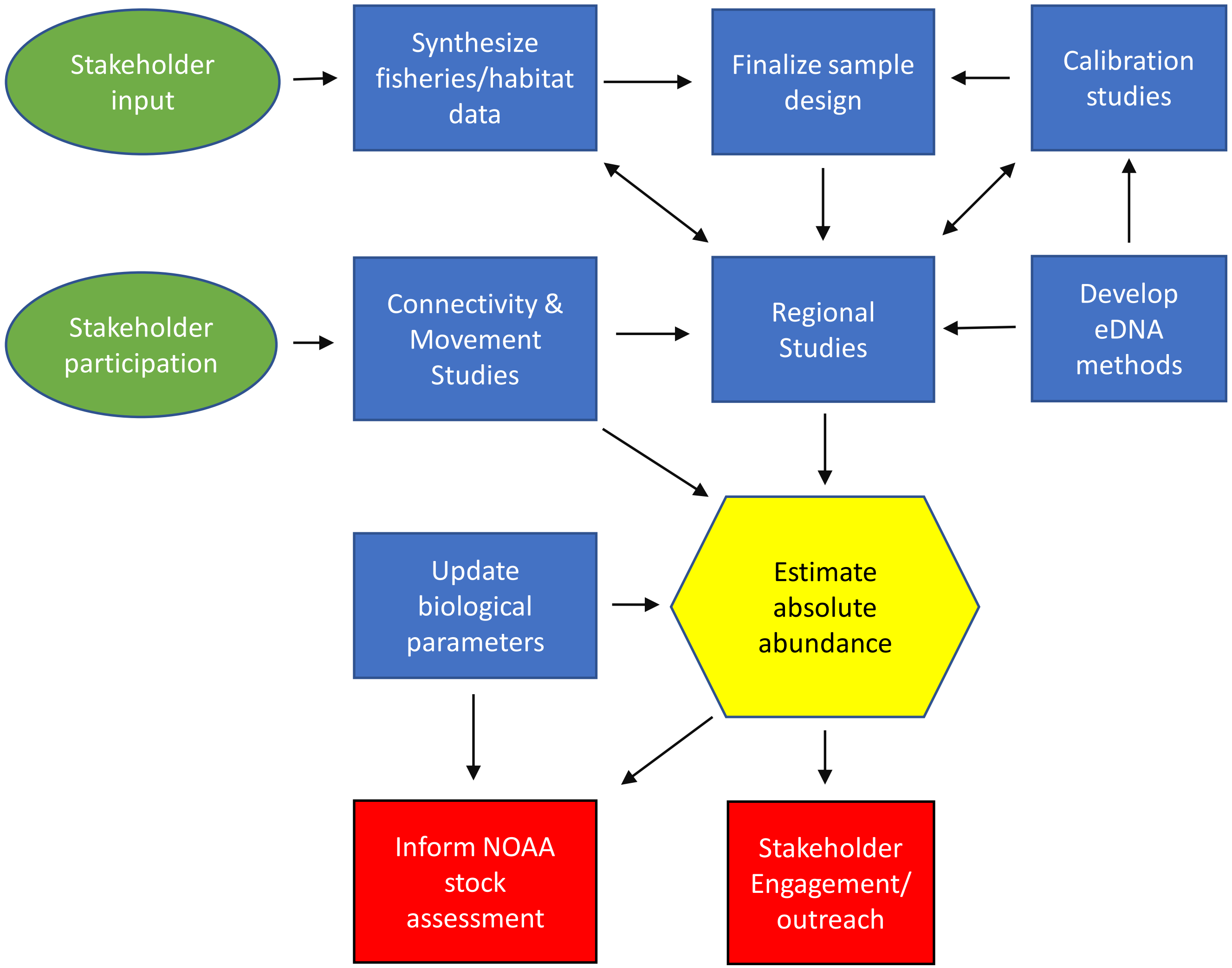
- Synthesize existing fisheries and habitat data (incl. LEK)
- Calibrate sampling gears
- Develop eDNA methods
- Sampling design based on abundance estimates from existing data

P II

- Regional studies using region- and habitat-appropriate calibrated gears
- Connectivity and movement studies with stakeholder participation

P III

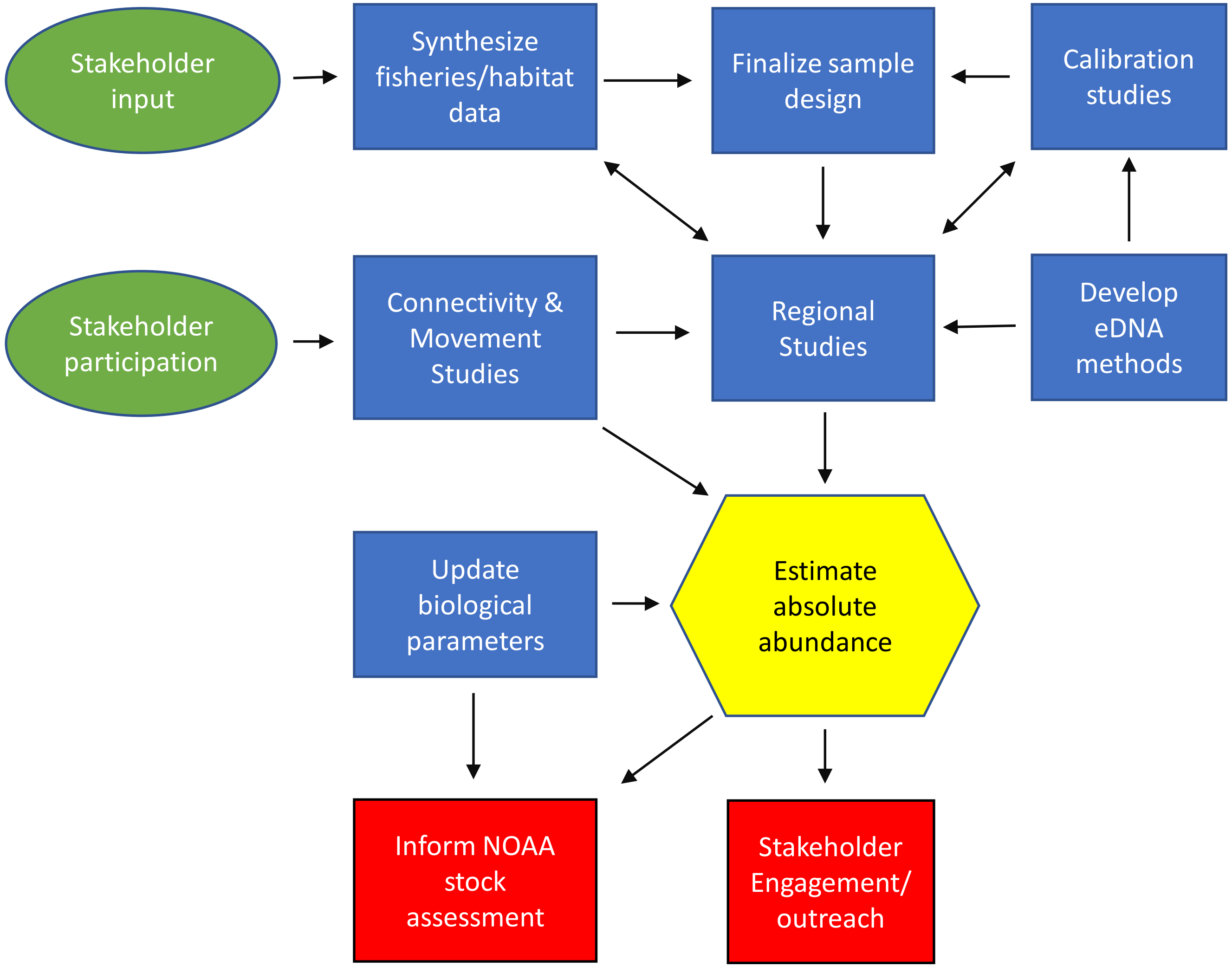
- Estimate region:habitat-specific and overall abundance estimates
- Update basic biological parameters
- Inform NOAA stock assessments
- Communicate results with stakeholders



Phased approach

Key features:

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



Specific 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 hydroacoustics
4. Determine movement and connectivity using acoustic telemetry, conventional tagging, and genetic markers
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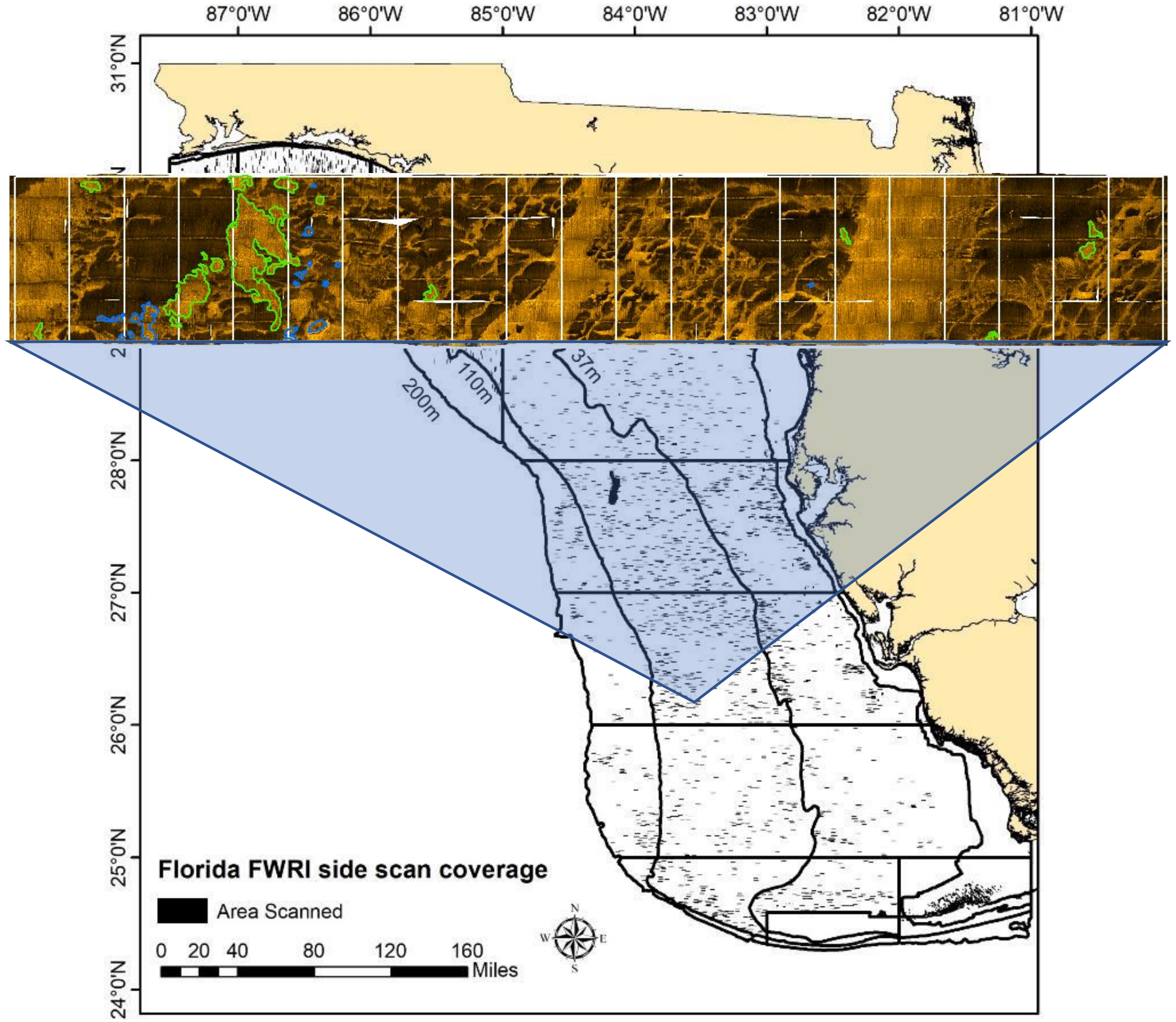
Objective 1: Synthesize habitat data

- Existing sources of habitat data
  - partial coverage
  - variable resolution
- No existing comprehensive maps for entire region
- In process of compiling existing habitat data into comprehensive GIS product across GoM-SA region
- Will inform sampling design, and ultimately, final estimates



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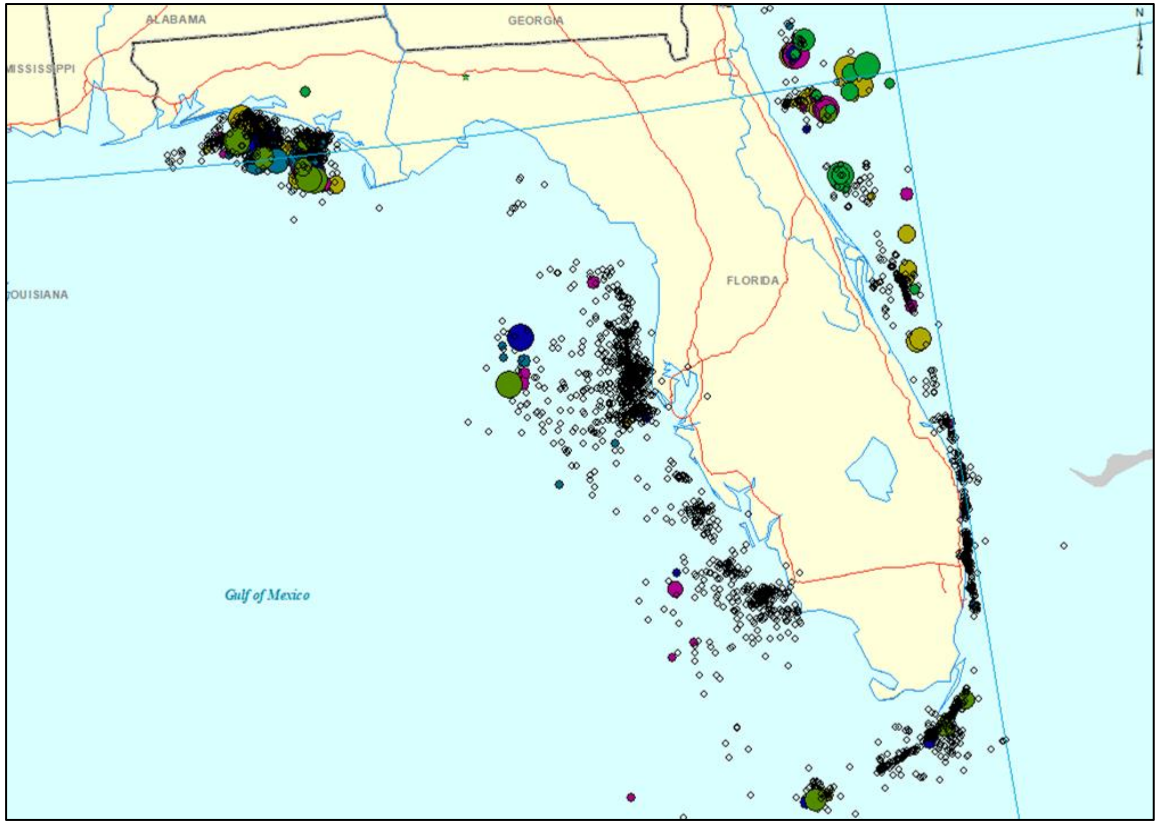
Objective 2: Synthesize abundance data

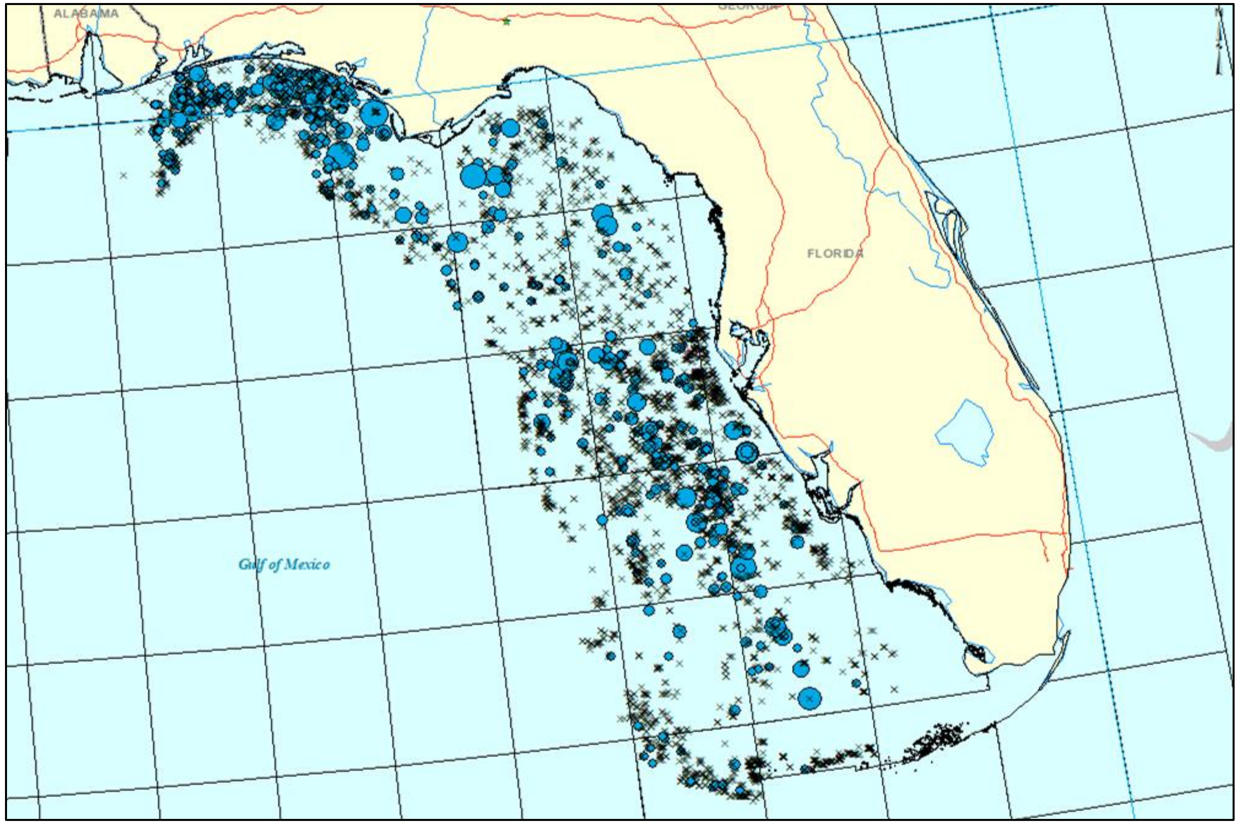
- Existing fishery dependent and fishery independent catch data

Objective 2: Synthesize abundance data

At-Sea Observer Program



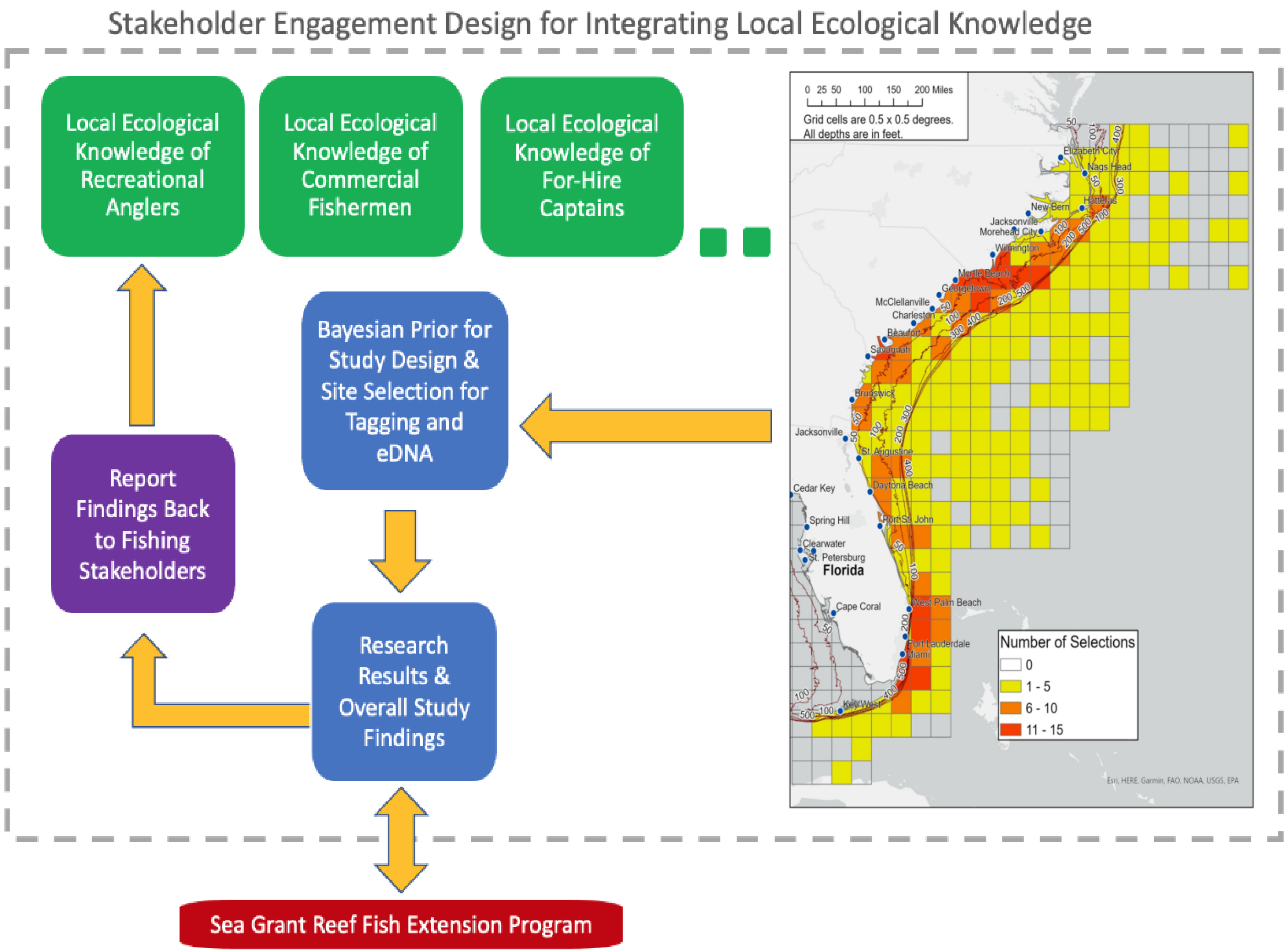
Video Survey



Objective 2: Synthesize abundance data

- Existing fishery dependent and fishery independent catch data
- Existing stakeholder knowledge (LEK)

Objective 2: Synthesize abundance data



Objective 2: Synthesize abundance data

- Existing fishery dependent and fishery independent catch data
- Existing stakeholder knowledge (LEK)
- Synthesis of these data can inform expectations in terms of presence/absence, relative abundance and variance
- Leads to more efficient sample design
  - Sample more where abundance and variance are expected to be high
  - Sample less where both of these are expected to be low

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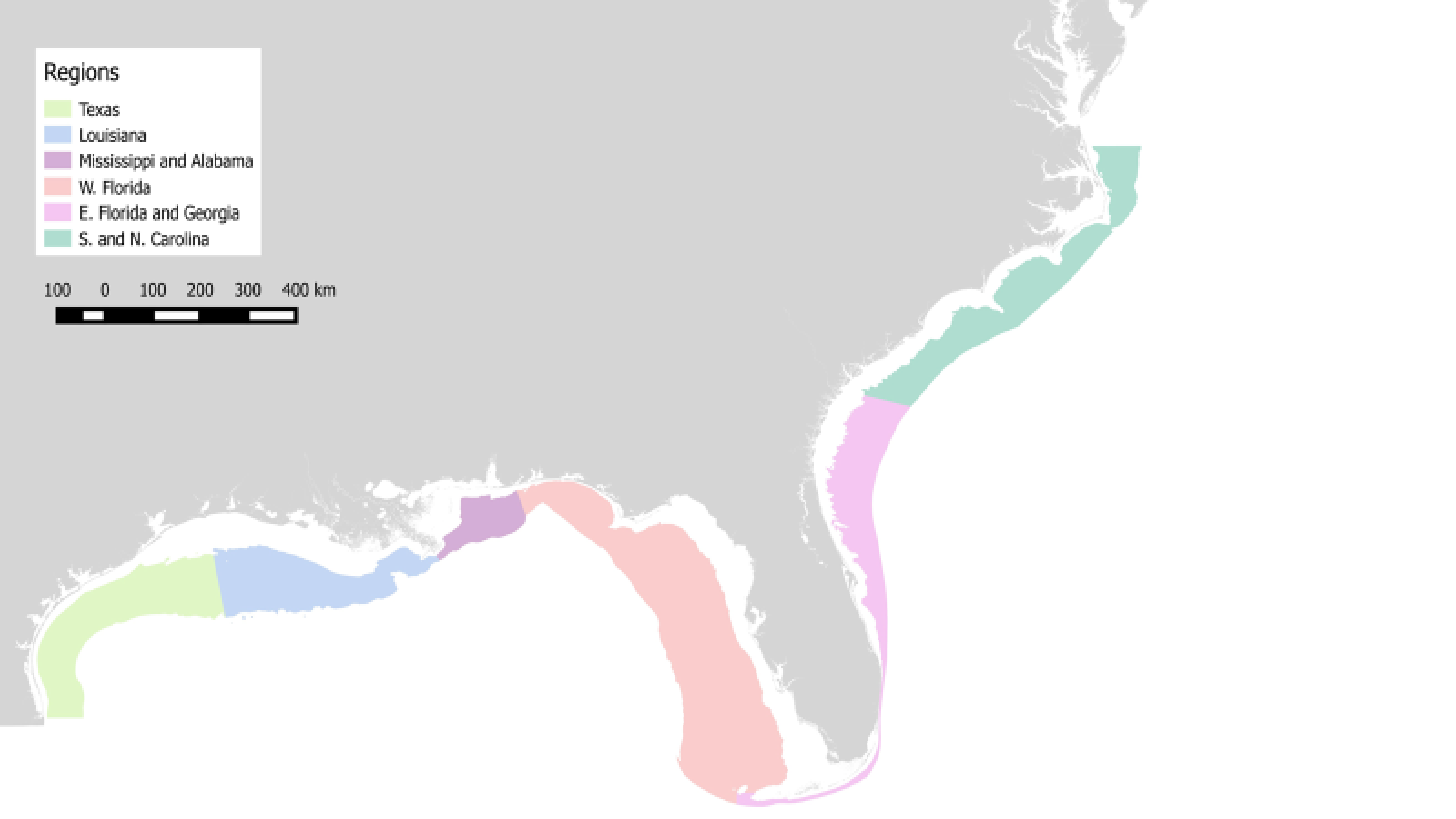
Objective 3: Estimate absolute abundance

- Sample design and framework
- Abundance sampling methods
- Calibration of gears and methods
- Cross-regional and regional workplans

Sample design and framework

- Leverage existing surveys conducted by NMFS and partner states
  - SERFS (SA), G-FISHER (GoM)
- Supplement these surveys directly (number and methods)
- Deploy independent regional and cross-regional surveys
- Sample design will inform supplemental sampling and independent sampling

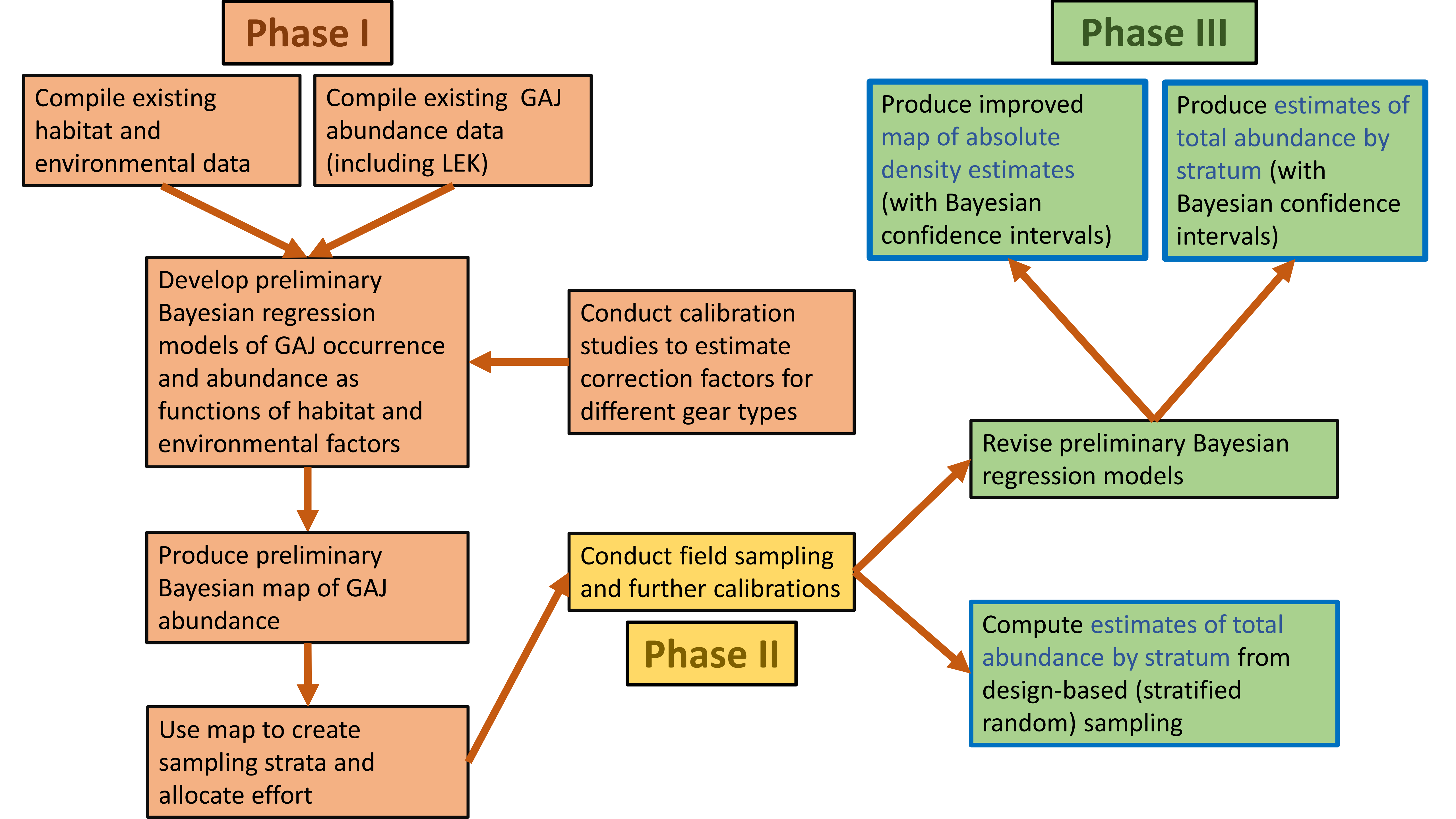

Regions
Texas
Louisiana
Mississippi and Alabama
W. Florida
E. Florida and Georgia
S. and N. Carolina
100 0 100 200 300 400 km

Sample design and framework

- Initial default (minimum) sample design will be based on stratified random or cluster sampling by…
  - Region (TX, LA, MS-AL, West FL, East FL-GA, SC-NC)
  - Habitat type (artificial structure, natural structure, uncharacterized bottom)
- Effort allocated based on results of preliminary models
- Optimize efficiency: sample more where abundance and/or variance expected to be high and less where these are expected to be low
- When leveraging existing efforts, supplementary sampling used to attain effort targets

Sample design and framework

- Estimation of region:habitat-specific GAJ abundance will be achieved by using both design-based (stratified random/cluster sampling) and model-based (hierarchical spatial regression) inference in a unified framework
- Phase I:
  - Develop preliminary Bayesian regression models/maps of GAJ occurrence and abundance as functions of habitat and environmental factors (based on data from objectives 1 & 2)
  - Use these models/maps to create sampling strata and allocate sampling effort
- Phase II: Collect data
- Phase III:
  - Use data to make design-based abundance estimates for region:habitat
  - Use data to update Bayesian models/maps of GAJ occurrence and abundance which will provide improved model-based estimates of abundance by region:habitat


Phase I
Compile existing habitat and environmental data
Compile existing GAJ abundance data (including LEK)
Develop preliminary Bayesian regression models of GAJ occurrence and abundance as functions of habitat and environmental factors
Conduct calibration studies to estimate correction factors for different gear types
Produce preliminary Bayesian map of GAJ abundance
Use map to create sampling strata and allocate effort
Conduct field sampling and further calibrations
Phase II
Phase III
Produce improved map of absolute density estimates (with Bayesian confidence intervals)
Produce estimates of total abundance by stratum (with Bayesian confidence intervals)
Revise preliminary Bayesian regression models
Compute estimates of total abundance by stratum from design-based (stratified random) sampling

Sample design and framework

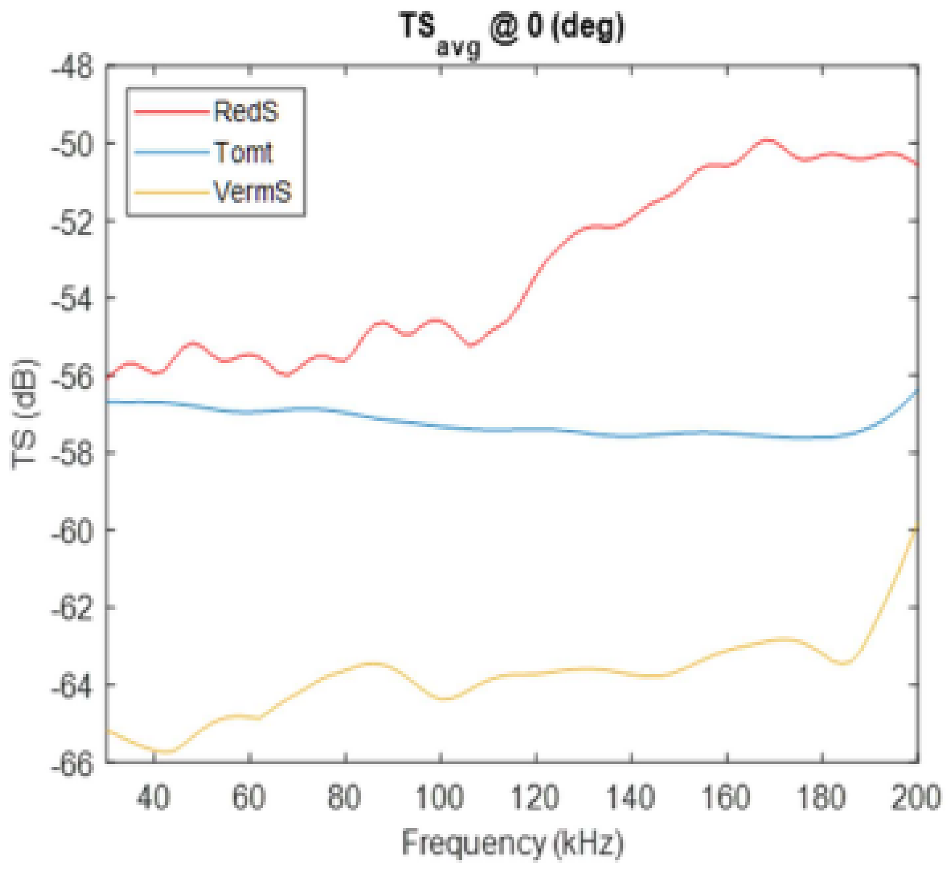
- Design-based abundance estimates
  - Model free estimates based on random sampling
  - Apply calibration coefficients for each gear type
- Model-based abundance estimates
  - Spatial regression model updated with phase II field survey data
  - Predict occurrence and abundance of GAJ across sampling region
  - Regresses abundance on habitat type, bottom type, depth, latitude/longitude
  - Residual autocorrelation included as formal component of model
  - Allows imputation of missing covariates
  - Allows nearby cells to inform each other, improving precision
  - Incorporate calibration coefficients allowing extrapolation to absolute abundance estimates
  - Model selection → regression diagnostics, information criteria, cross validation

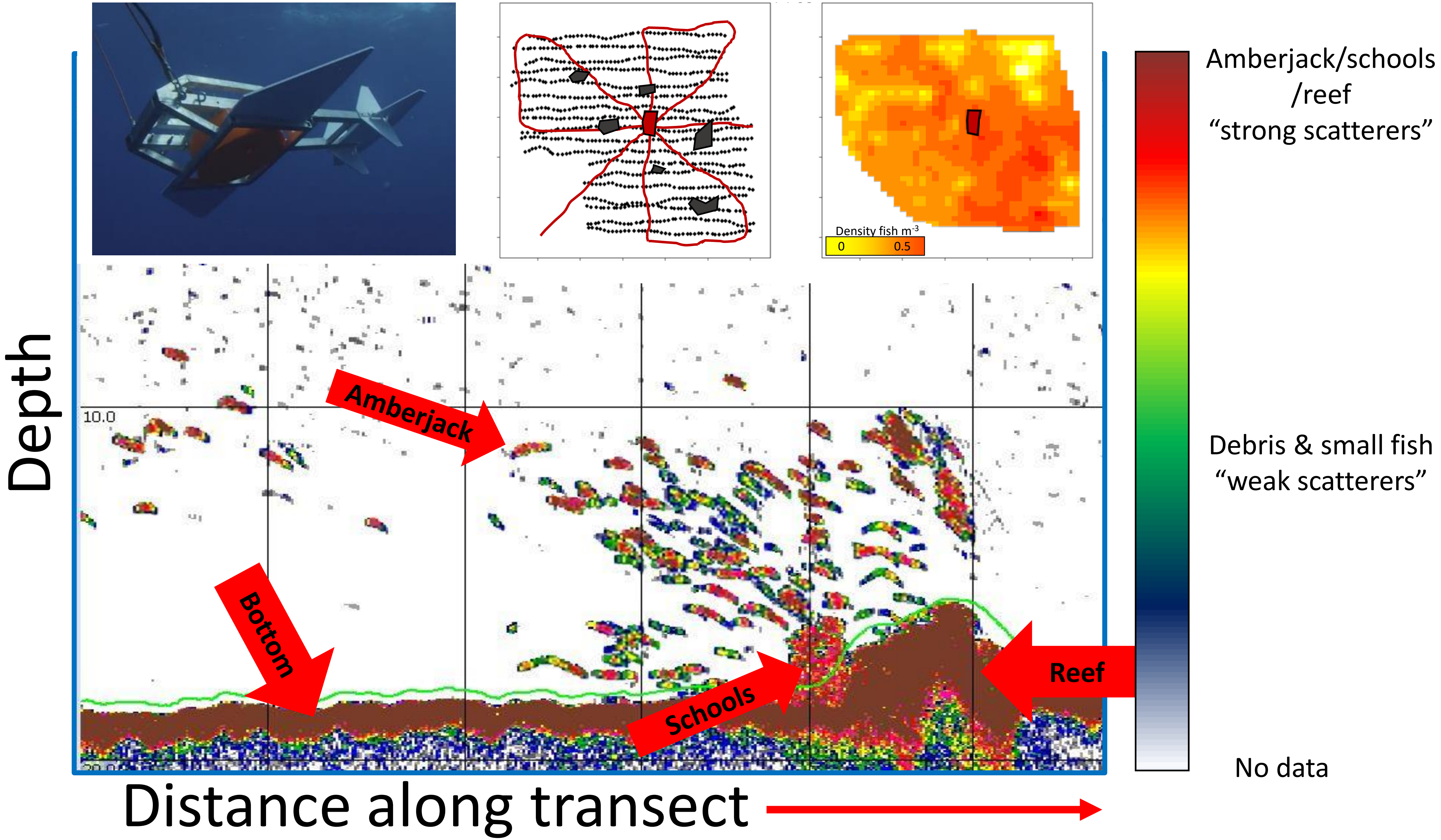
Abundance sampling methods

- In general: combine video (stationary, ROV, and towed) and hydroacoustics to measure density of GAJ
- Specific type of video will be 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
- Assess efficacy of emerging eDNA technologies at subset of stations
- Gears will be calibrated to each other and to a “ground-truth” abundance metric (Lincoln-Peterson estimate from VPS array)

Hydroacoustics

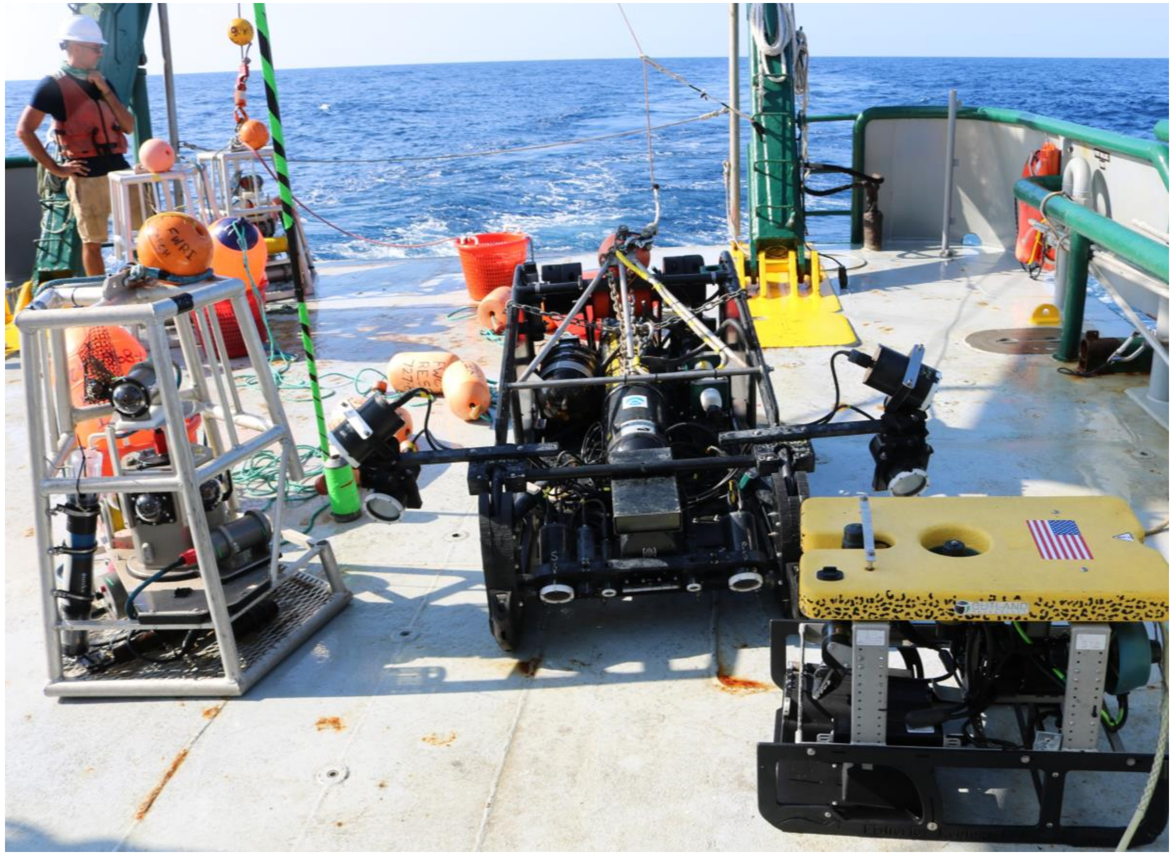
- Multi-frequency scientific echosounder system → quantitative density estimation of GAJ across habitats and regions
- Three methods applied to distinguish GAJ from other fish echo traces
  - Multifrequency volume backscatter summation
  - Target strength thresholding
  - Broadband classification
  - CT scans of live fish to develop acoustic signature models of GAJ and related species




Density fish m-3
0
0.5
10.0
Amberjack
Bottom
Schools
Reef
Depth
Distance along transect
Amberjack/schools
/reef
“strong scatterers”
Debris & small fish
“weak scatterers”
No data

Video

- Video types for different habitats
  - Baited drop cameras – artificial and natural reefs, all regions
  - ROV mounted cameras – artificial and natural reefs, GoM regions
  - Towed cameras – uncharacterized bottom, all regions



Video

- Most common method to quantify trends in abundance of reef-associated fishes
- Advantages
  - Non-extractive
  - Low-risk
  - Archival
- Disadvantages
  - Processing time
  - Fish behavior
  - Variable probability of detection
  - Can be difficult to estimate associated area

Video

- Need dedicated efforts to understand potential biases and how they influence probability of detection:
  - Attraction/avoidance
  - Influence of bait
  - Enumeration methods
  - Identification difficulties
- Calibration studies and coupling with hydroacoustics will help to address these

Calibration of gears and methods

- Comparisons of camera gears
  - Baited vs. un-baited stationary cameras
  - Stationary vs. ROV
  - Stationary vs. towed
  - ROV vs. towed
- Acoustics vs. all camera gears
- All gears (cameras and acoustics) vs. ground-truth (Lincoln-Peterson estimate of abundance within a VPS array)
- eDNA vs. all other gears
- Repeat drops (24-hr) of stationary camera

Regional work plans

Region	State	Habitat Type	Gear Used				Number of Stations
			EK80	SCA	ROV	Tow	
Western Gulf of Mexico	TX	Natural Bottom					240
		Artificial					170
		Uncharacterized Bottom					3000
	LA	Natural Bottom					165
		Artificial					150
		Uncharacterized Bottom					3000
Eastern Gulf of Mexico	MS/AL	Natural Bottom					70
		Artificial					50
		Uncharacterized Bottom					1700
	WFL	Natural Bottom					850
		Artificial					150
		Uncharacterized Bottom					5700
South Atlantic	EFL/GA	Natural Bottom					1000
		Artificial					100
		Uncharacterized Bottom					5700
	SC/NC	Natural Bottom					1000
		Artificial					50
		Uncharacterized Bottom					5700

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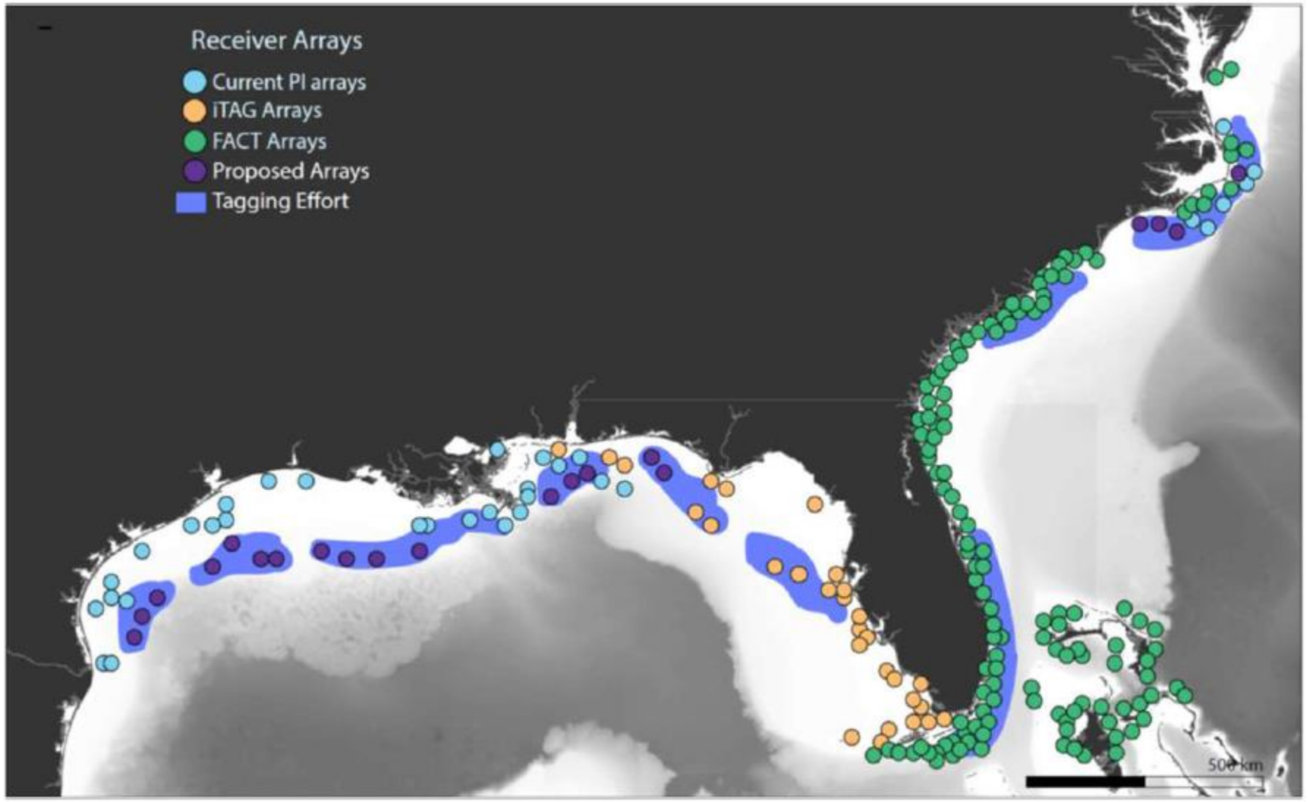
Objective 4: Movement, connectivity, & mortality

- 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
- Alternate estimates of abundance
  - Tagging-based using landings and estimated exploitation rate
  - Genetics-based using frequency of parent-offspring or sibling pairs in the sample (if additional funding is identified)

Objective 4: Movement, connectivity, & mortality

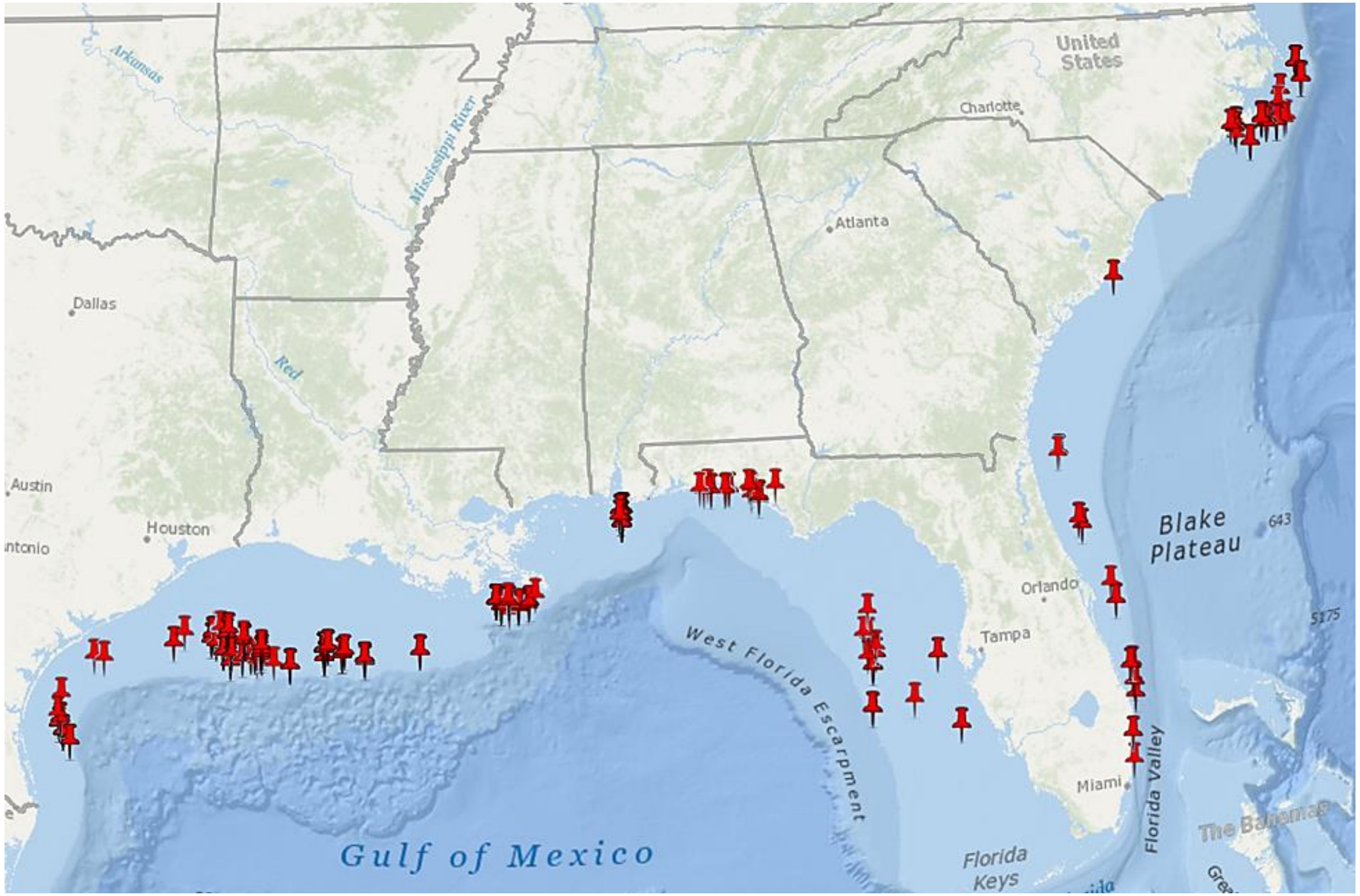
Acoustic and high-reward external tags

- Reef residency, site fidelity
- Seasonal movements and connectivity among habitats
- Exchange and mixing between regions
- Fishing and natural mortality rates



Tag deployments to-date

Region	Conv.	Acoustic	Conv. Returns
SA	156	74	7
E-GoM	109	39	2
W-GoM	225	115	13



Objective 4: Movement, connectivity, & mortality

Population genetics

- Double-digest restriction-site associated DNA sequencing → stock structure, connectivity
- Previous studies suggest two-stock model, but without clear geographic delineation
- Limited by incomplete sampling of geographic range and small numbers of genetic markers
- Current study will use genome scans (1000s of SNP markers) and comprehensive geographic sampling from North Carolina to South Texas

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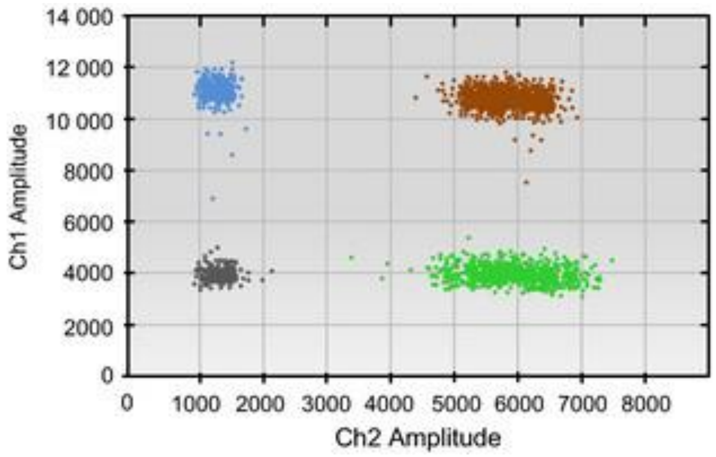
Objective 5: Environmental DNA

- Investigate efficacy of 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
- Potential to confirm identification of species and help estimate the prevalence of “sampling” vs. “structural” zeros
- Proving ground for the use of eDNA tools in multi-disciplinary approaches to study distribution and abundance of marine fishes



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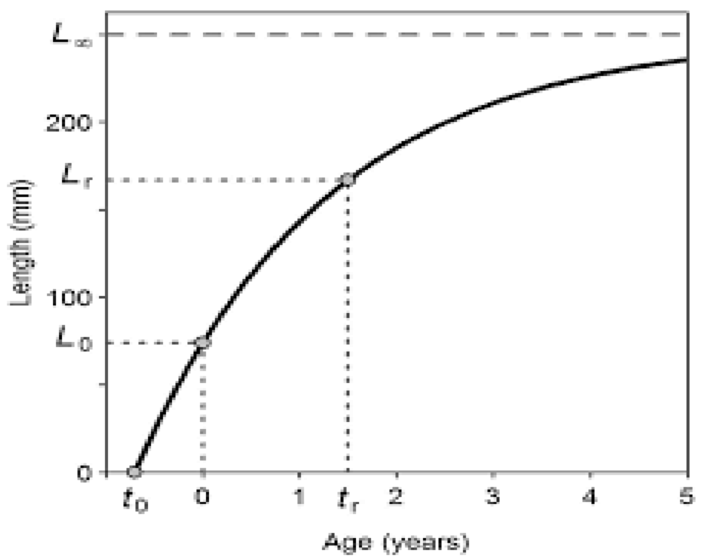
Objective 6: Update biological information

- Recent stock assessments recommended expanded demographic sampling of GAJ
- Age and growth information from W-GoM has been extremely limited
- Will use fishery dependent and fishery independent collections to update biological information and develop age-length keys
- Archive samples that can be used (with additional funding) to update reproductive indices (fecundity, spawning season, etc.)



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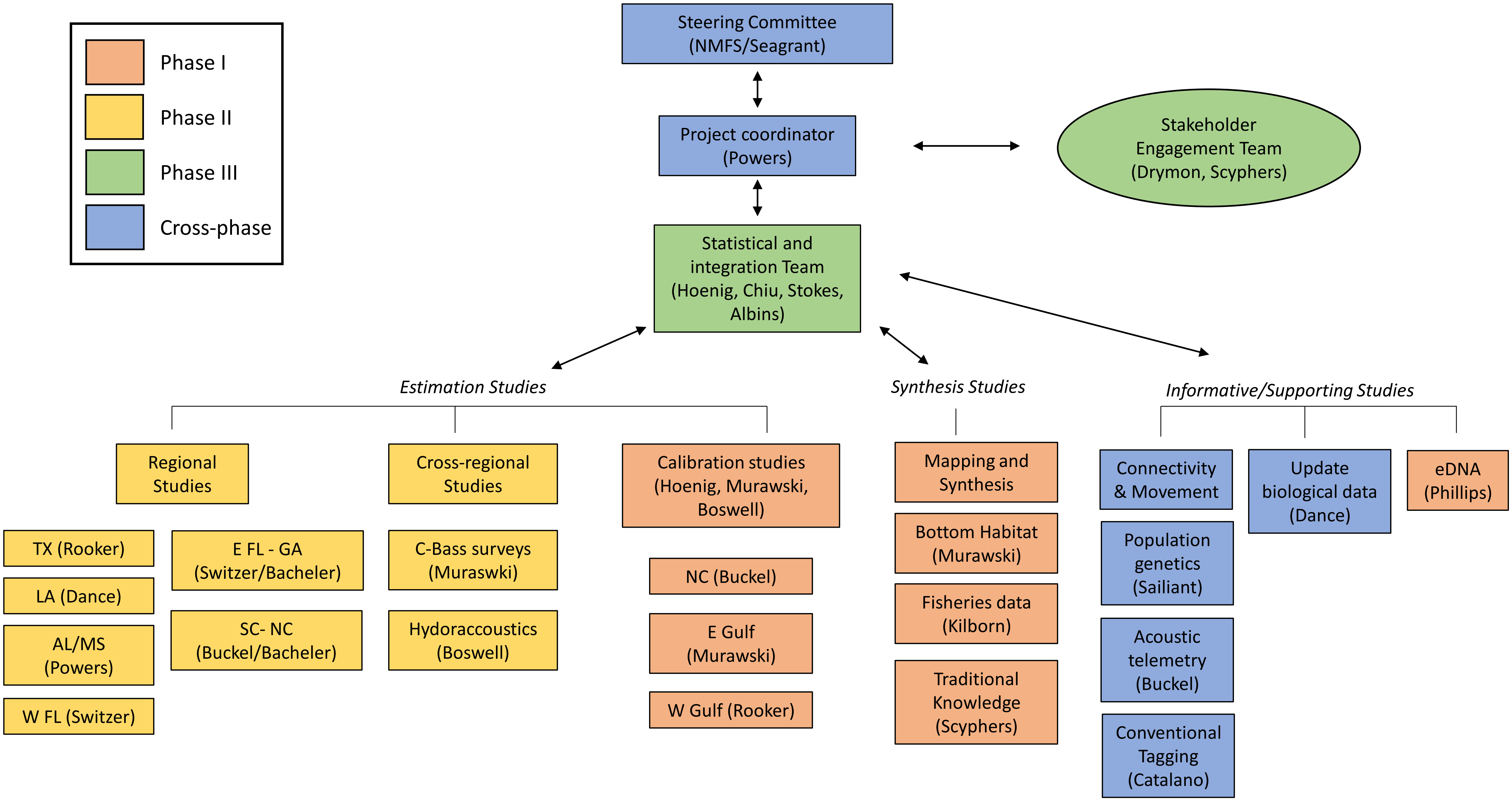
Objective 7: Stakeholder engagement

- Research Team plans to work 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
  - Will work with established outreach groups at close of project to communicate results

Project management and coordination

- Highly qualified team of investigators with many years of experience at interface of science and management, led by Dr. Sean Powers (USA-DISL),
- PI Coordinating Committee meets regularly
- Input and exchange with NMFS throughout the project including meetings at critical transition points (e.g. between Phases I and II) for early feedback
- Outreach and engagement team to communicate progress and seek continued input from stakeholders
- Plan to release final abundance and variance estimates only after completion of NMFS, SSC, and independent review



Phase I
Phase II
Phase III
Cross-phase
Steering Committee (NMFS/Seagrant)
Project coordinator (Powers)
Stakeholder Engagement Team (Drymon, Scyphers)
Statistical and integration Team (Hoenig, Chiu, Stokes, Albins)
Estimation Studies
Synthesis Studies
Informative/Supporting Studies
Regional Studies
Cross-regional Studies
Calibration studies (Hoenig, Murawski, Boswell)
Mapping and Synthesis
Connectivity & Movement
Update biological data (Dance)
eDNA (Phillips)
TX (Rooker)
LA (Dance)
AL/MS (Powers)
W FL (Switzer)
E FL - GA (Switzer/Bacheler)
SC- NC (Buckel/Bacheler)
C-Bass surveys (Muraswki)
Hydoraccoustics (Boswell)
NC (Buckel)
E Gulf (Murawski)
W Gulf (Rooker)
Bottom Habitat (Murawski)
Fisheries data (Kilborn)
Traditional Knowledge (Scyphers)
Population genetics (Sailiant)
Acoustic telemetry (Buckel)
Conventional Tagging (Catalano)

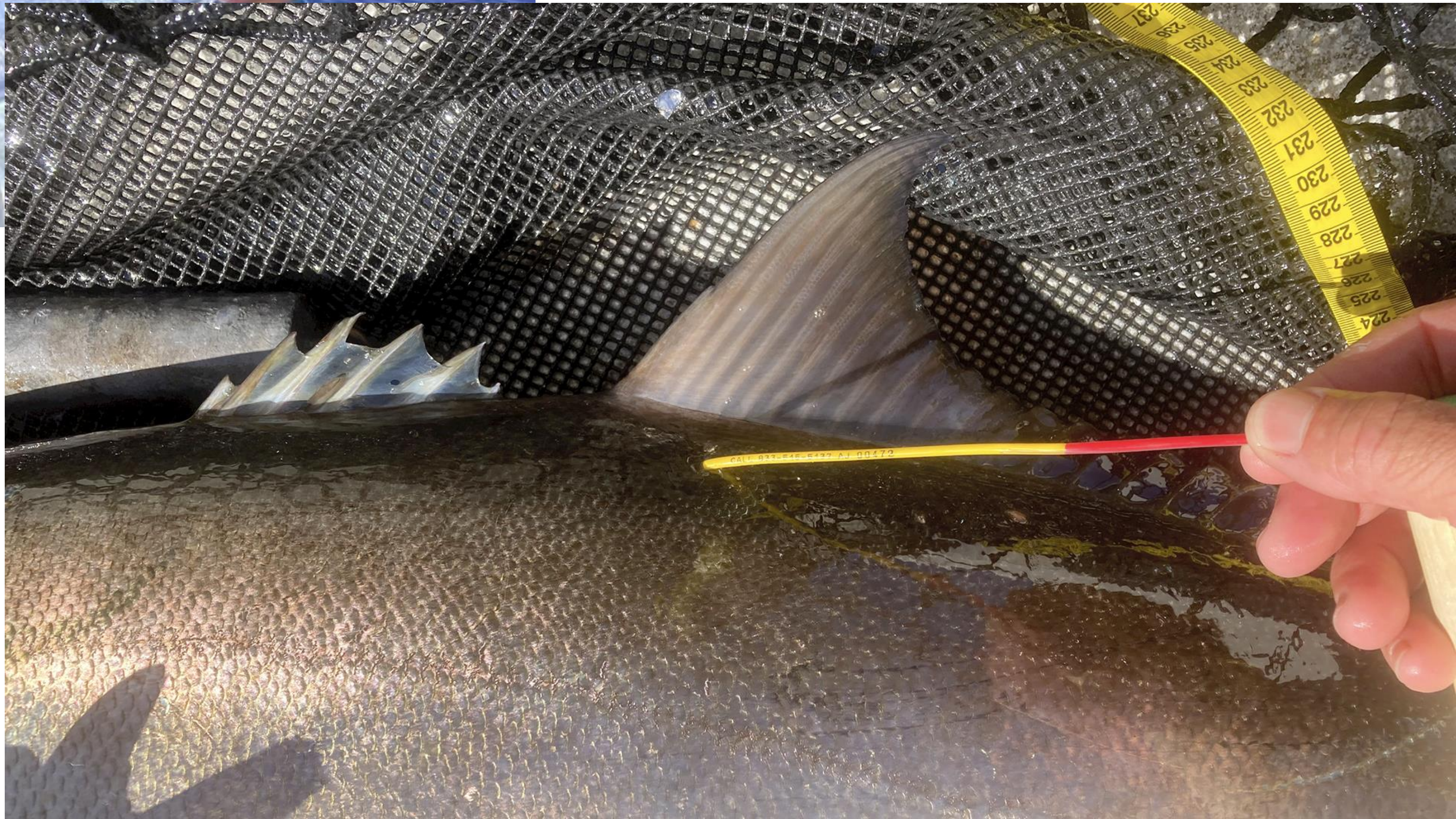
Expected impacts and application of results

- Large-scale survey using novel integrated sampling approaches
- Leverage existing data sets and ongoing research to augment data collection and cost effectiveness
- Primary benefits:
  - Independent, robust estimate of absolute abundance of age 1+ GAJ in GoM and SA
  - Improved understanding of spatial and habitat-related distribution of the species
  - Improved understanding of population and movement dynamics of GAJ in region
  - Development of an approach and analysis framework that can be applied to future GAJ abundance estimates and those for other reef-fish species
- Secondary benefits:
  - Estimates of GAJ growth, mortality, site fidelity, population connectivity
  - Improved understanding of reef fish community structure across study region

$250

1-833-515-5137

https://agriculture.auburn.edu/research/faas/quantitative-fisheries-lab/greater-amberjack-project-tag-reporting/



Questions?