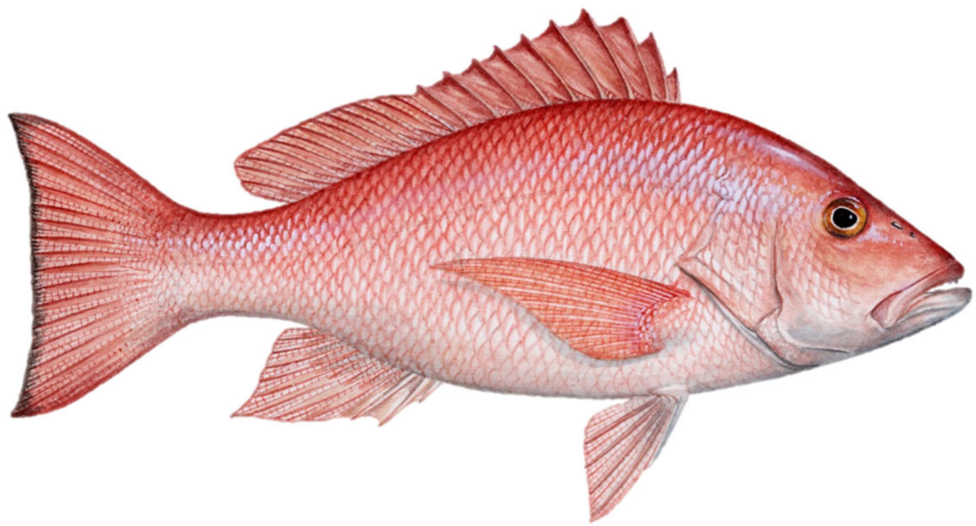
Estimation of US Atlantic Red Snapper Abundance



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NOAA

FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION

SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES

GEORGIA DEPARTMENT OF NATURAL RESOURCES COASTAL RESOURCES DIVISION

1


Study Team
Will Patterson
Joe Tarnecki
Sam Ricketts
Miaya Glabach
Dave Chagaris
Dave Portnoy
Chris Hollenbeck
Allison Monroe
Justin Schmitz
Kat Lanoue
Jeff Buckel
Paul Ruderhausen
Nathan Hostetter
Krishna Pacifici
Dan Gwinn
Viviane Zulian
Bev Sauls
Nate Bacheler
Kyle Shertzer
Eric Anderson
Chris Taylor
Marcel Reichert
Wally Bubley
Dawn Glasgow
Dawn Franco

South Atlantic Red Snapper Research Program

- Congress allocated funding to estimate red snapper age-2+ population size in US Atlantic
- South Carolina Sea Grant hosts the SARSRP; first RFP was in 2020 for $1.5M in funding
- Second SARSRP RFP issued in 2021 for $1.7M in funding, with potential for $1.6M in additional funding pending Congressional appropriation

Sea Grant
Florida • North Carolina
South Carolina • Georgia

SOUTH ATLANTIC RED SNAPPER RESEARCH PROGRAM (SARSRP)
"The South Atlantic Red Snapper Count"

REQUEST FOR PROPOSALS

Letter of Intent Deadline: November 16, 2020 at 5 pm ET
Full Proposal Deadline: February 1, 2021 at 5 pm ET

Letters of Intent must be submitted to the S.C. Sea Grant Consortium by 5:00 pm ET on November 16, 2020.

Sponsored by the Sea Grant programs of
Florida, Georgia, South Carolina and North Carolina,
with generous support provided by the
NOAA National Marine Fisheries Service.

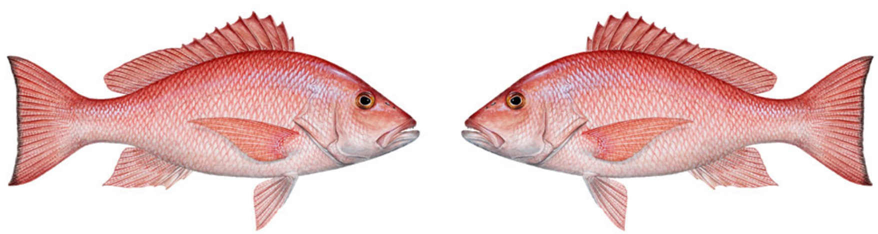
Study Objectives and Approaches

1) Estimate the distribution and density of red snapper across the US Atlantic shelf from North Carolina through the Florida Keys with ROVs in unknown or unconsolidated habitats

2) Develop a hierarchical Bayesian integrated abundance model to estimate age-2+ red snapper population size based on SERFS trap-camera, ROV, and habitat data

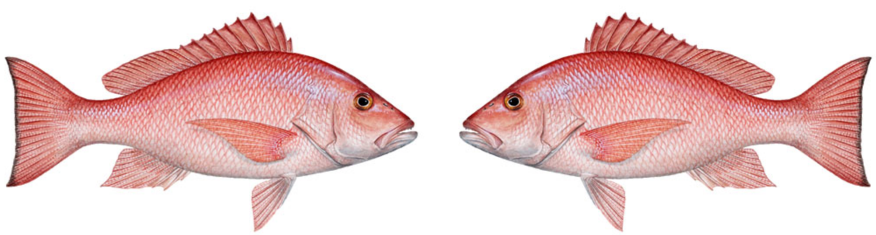
3) Conduct genetic close-kin mark recapture (CKMR) analysis to estimate age-2+ red snapper population size

4) Integrate/reconcile study results with the Atlantic red snapper stock assessment model



Study Components

I. Bayesian hierarchical integrated modeling
   A. ROV sampling on US Atlantic shelf
   B. SERFS trap-camera sampling
   C. Fisherman interviews
II. Close-kin mark-recapture
   A. *A priori*: Draft red snapper genome and Atlantic RS population dynamics
   B. Fin clip sampling
   C. Methylomic ageing from fin clip DNA
III. Integration and reconciliation with stock assessment
IV. Potential future funding



Bayesian Hierarchical Integrated Modeling

Objective:

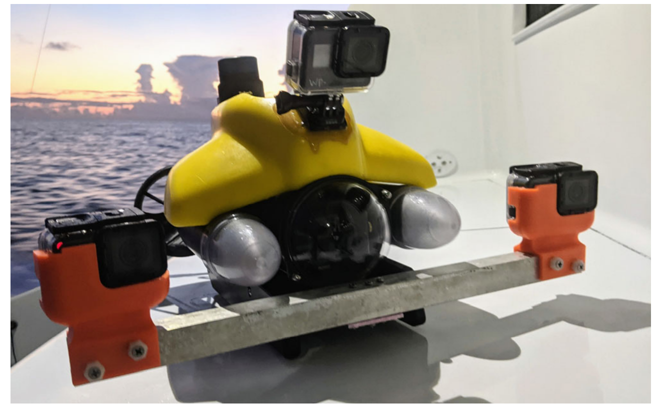
1) Estimate Atlantic red snapper population size with a CV of ≤0.3 from trap-camera, ROV, and habitat data

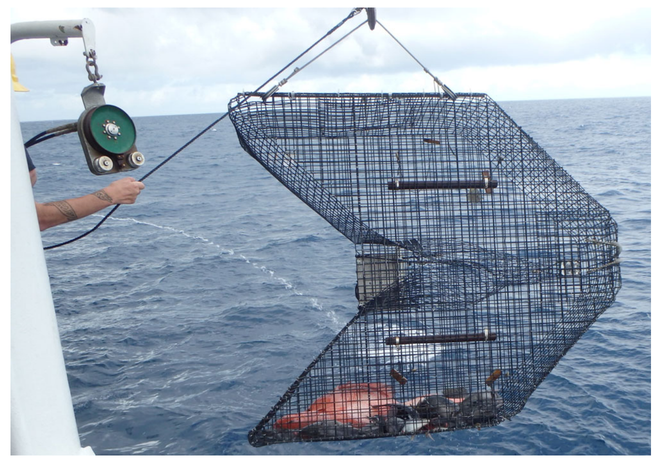
Approach:

1) Integrate red snapper density estimates from multiple survey methods to jointly estimate red snapper abundance at three spatial scales: i) survey site, ii) grid cell (25 km^2), and iii) study area (~100 x 10^3 km^2)

2) Habitat suitability to be informed from study video data, fishery-dependent data, and informed priors from previous studies and recent mapping

3) Separate observation models to account for different detection probabilities and effective sampling area of ROV, traps, and cameras mounted to traps





Bayesian Hierarchical Integrated Modeling: Potential Challenges

Challenge	Data	Approach	Citations
Convert counts to density	Video (counts), Chevron (counts), ROV (density)	Integrated Abundance Model, estimate effective sampling area from newly-collected data and prior information	Pacifici et al. (2017), Hostetter et al. (2019), Bacheler et al. (2021), Garner et al. (2021)
Spatial variation in abundance	Spatial covariates, two levels of spatial resolution, ROV surveys of uncharacterized habitat	Abundance modeled as a function of spatial covariates and random effects	Pacifici et al. (2019)
Detection varies by survey method	Spatially and temporally replicated video counts, overlapping ROV and video surveys	ROV and trap data jointly analyzed, N-mixture type detection process for video counts, informative priors	Shertzer et al. (2016), Hostetter et al. (2019), Kazyak et al. (2020)
Spatial sampling	SERFS and ROV	Study design simulation, account for effort and preferential sampling	Pacifici et al. (2016), Coggins et al. (2014)

Red Snapper Reaction to Trap-Camera or ROV

Vol. 517: 1–14, 2014
doi: 10.3354/meps11094
MARINE ECOLOGY PROGRESS SERIES
Mar Ecol Prog Ser
Published December 15

FEATURE ARTICLE

FREE ACCESS

Environmental conditions and habitat characteristics influence trap and video detection probabilities for reef fish species

Nathan M. Bacheler[1,*], David J. Berrane[1], Warren A. Mitchell[1], Christina M. Schobernd[1], Zebulon H. Schobernd[1], Bradford Z. Teer[1], Joseph C. Ballenger[2]

[1]National Marine Fisheries Service, Southeast Fisheries Science Center, 101 Pivers Island Road, Beaufort, NC 28516, USA
[2]Marine Resources Research Institute, South Carolina Department of Natural Resources, 217 Fort Johnson Road, Charleston, SC 29412, USA

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Canadian Science Publishing

ARTICLE

Fine-scale behavior of red snapper (*Lutjanus campechanus*) around bait: approach distances, bait plume dynamics, and effective fishing area

Nathan M. Bacheler, Brendan J. Runde, Kyle W. Shertzer, Jeffrey A. Buckel, and Paul J. Rudershausen

Fisheries Research 246 (2022) 106155

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

ELSEVIER

Check for updates

A multidisciplinary approach to estimating red snapper, *Lutjanus campechanus*, behavioral response to mobile camera and sonar sampling gears

Steven B. Garner[a,*], Robert Ahrens[a], Kevin M. Boswell[b], Matthew D. Campbell[c], Daniel Correa[b], Joseph H. Tarnecki[a], William F. Patterson III[a]

[a] University of Florida, Fisheries and Aquatic Sciences, 7922 NW 71st St, Gainesville, FL 32653, USA
[b] Florida International University, Biological Sciences, Biscayne Bay Campus, 3000 NE 151st St, North Miami, FL 33181, USA
[c] National Marine Fisheries Service, Southeast Fisheries Science Center, Mississippi Laboratories, 3209 Frederic St, Pascagoula, MS 39567, USA

PLOS ONE

Check for updates

OPEN ACCESS

Citation: Garner SB, Olsen AM, Caillouet R, Campbell MD, Patterson WF, III (2021) Estimating reef fish size distributions with a mini remotely operated vehicle-integrated stereo camera system. PLoS ONE 16(3): e0247985. https://doi.org/10.1371/journal.pone.0247985

Editor: Hudson Tercio Pinheiro, California Academy of Sciences, UNITED STATES

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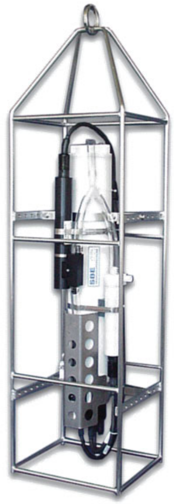
RESEARCH ARTICLE

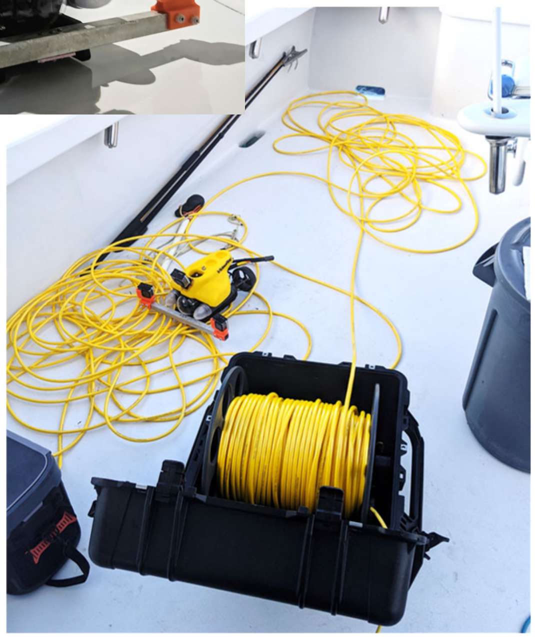
Estimating reef fish size distributions with a mini remotely operated vehicle-integrated stereo camera system

Steven B. Garner[1*], Aaron M. Olsen[2], Ryan Caillouet[3], Matthew D. Campbell[3], William F. Patterson, III[1]

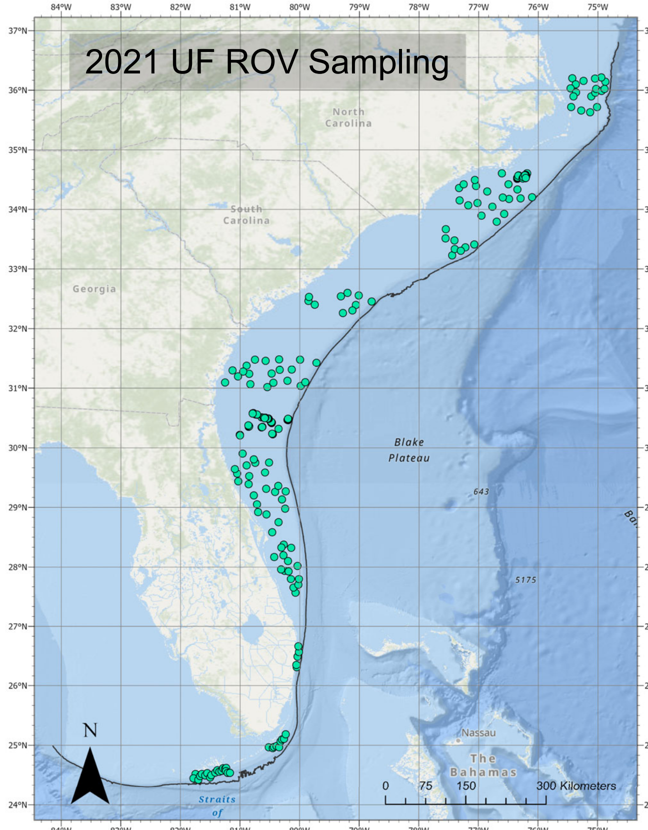
1 Fisheries and Aquatic Sciences, University of Florida, Gainesville, Florida, United States of America, **2** Department of Ecology and Evolutionary Biology, Brown University, Providence, Rhode Island, United States of America, **3** Mississippi Laboratories, Southeast Fisheries Science Center, National Marine Fisheries Service, Pascagoula, Mississippi, United States of America

Remotely Operated Vehicle Sampling Across the US Atlantic Shelf

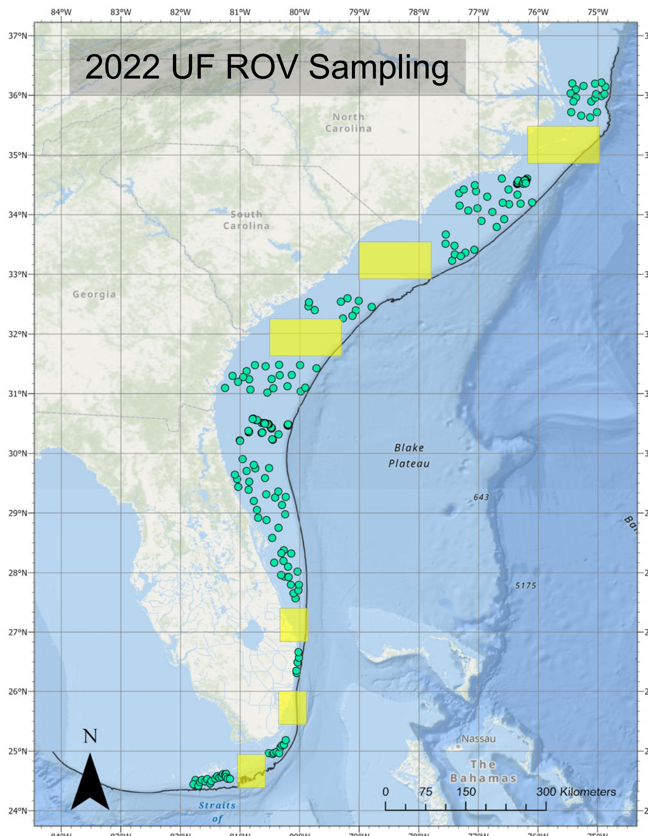


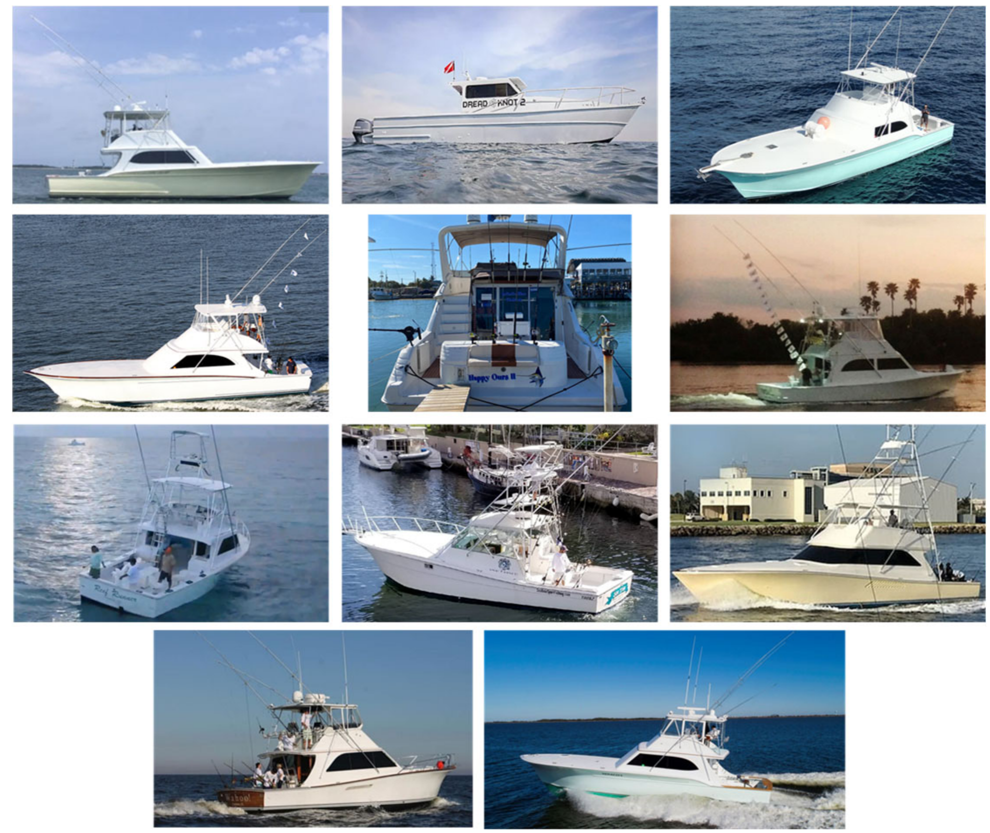


Remotely Operated Vehicle Surveys

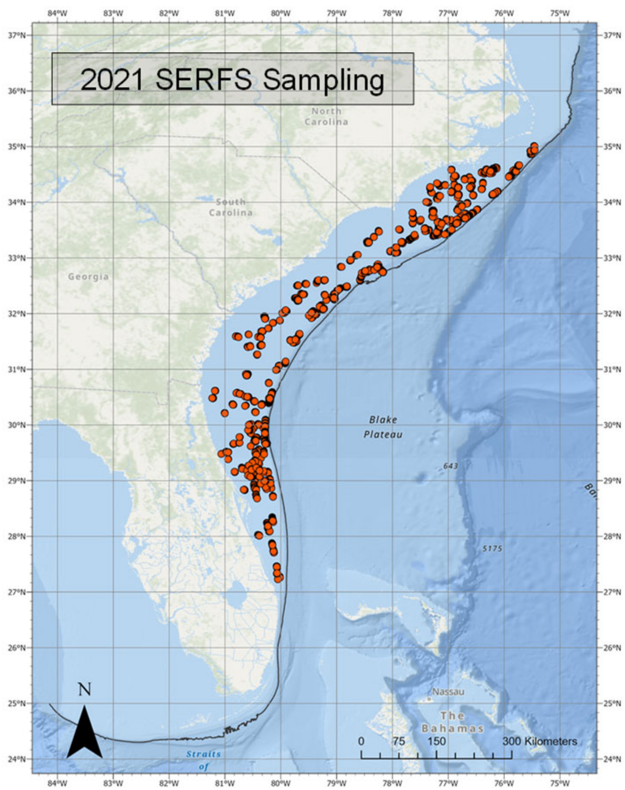


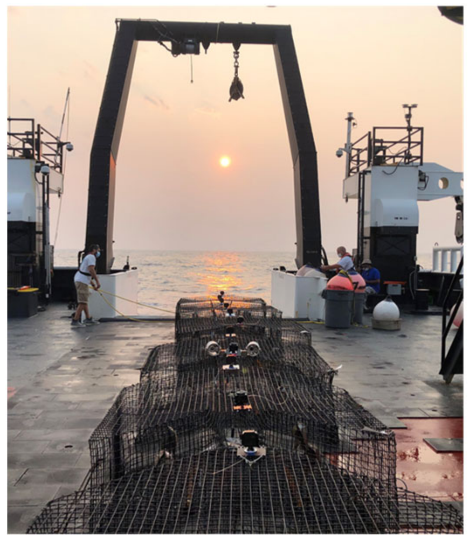
Remotely Operated Vehicle Surveys

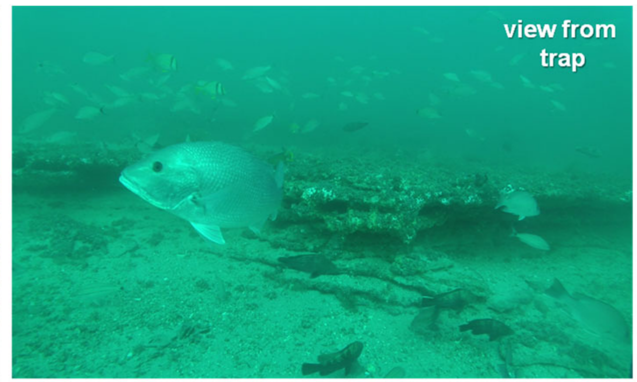


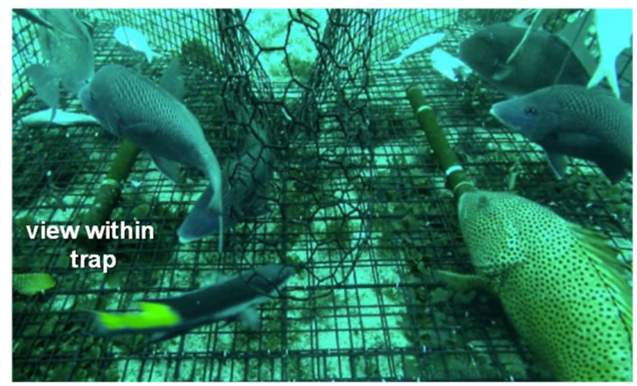


SERFS (MARMAP and SEFIS)Trap-Camera Sampling









Fishermen Interviews

Objectives:

1) To increase knowledge of hard bottom habitat distribution in the US Atlantic from NC to FL

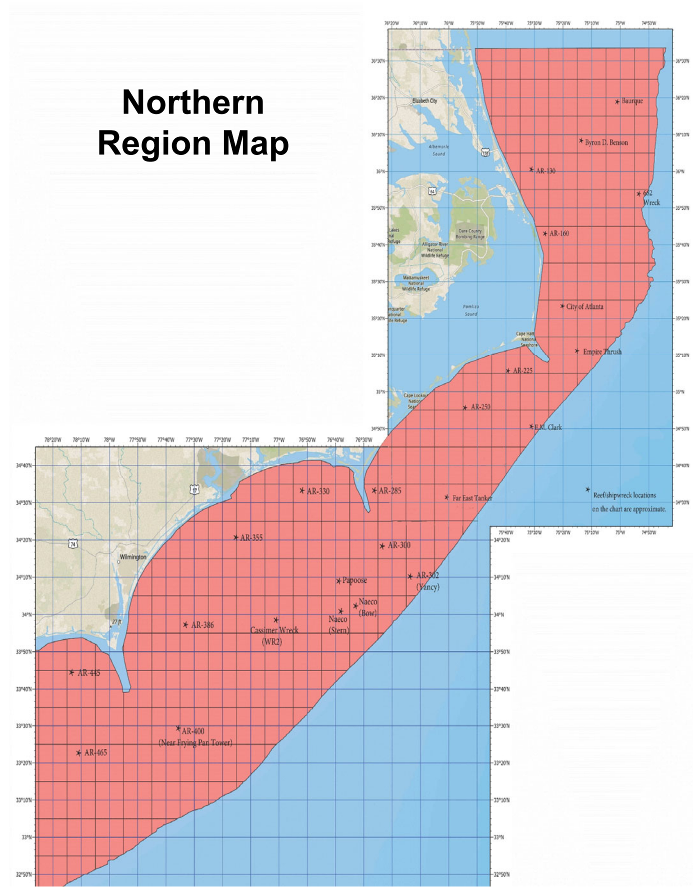
2) To estimate the spatial distribution of fishing effort and relative catch rates of commercial red snapper fishermen

Approach:

1) Intended to be in-person interviews; complicated by Covid-19

2) Contact fishermen and mail questionnaires with region-specific maps for them to indicate:
   a) where reef habitat exists in their fishing area
   b) where their fishing effort occurs
   c) relative catch rates of red snapper in the region

3) To date, 5 of 32 fishermen have completed questionnaires and maps



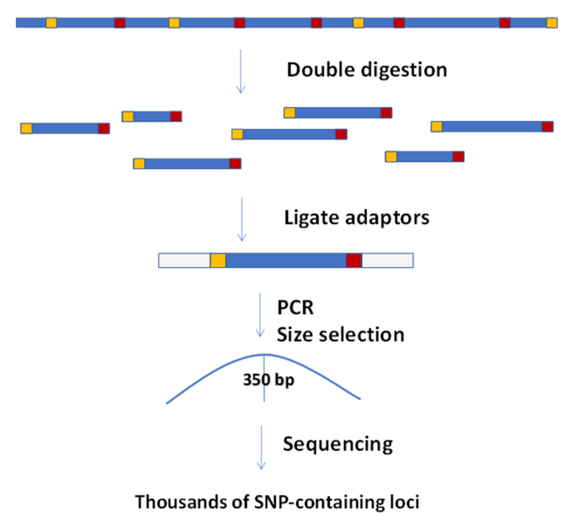
Northern Region Map

Close-Kin Mark-Recapture

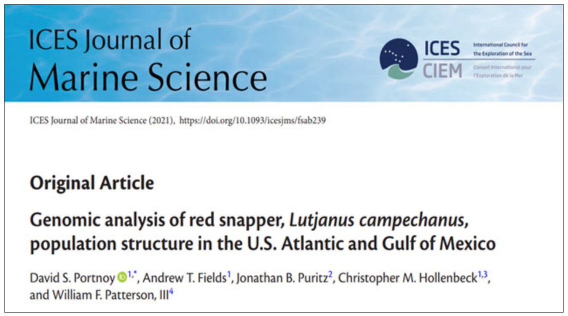
Objectives:
1) To estimate red snapper population size in US Atlantic
2) To estimate red snapper genetic population structure

Approach:
1) Fin clip sampling of Atlantic red snapper; up to 5k per year for 3 years
2) Development of genotyping in the thousands (GT-seq) panels to allow high through-put sequencing of 400 microhaplotypes (SNP-containing loci)
3) Sequencing of fin clip samples and population size estimation with CKMR model

Reduced representation genomics



A Priori Information: Red Snapper Genome and Population Dynamics


ICES Journal of Marine Science

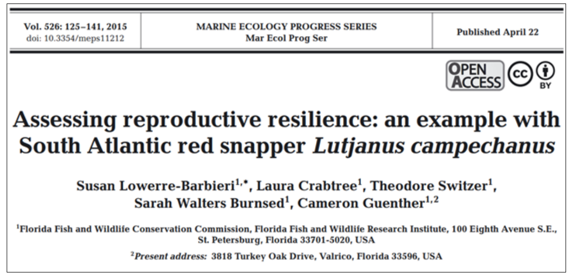
ICES CIEM

ICES Journal of Marine Science (2021), https://doi.org/10.1093/icesjms/fsab239

Original Article

Genomic analysis of red snapper, *Lutjanus campechanus*, population structure in the U.S. Atlantic and Gulf of Mexico

David S. Portnoy[1,*], Andrew T. Fields[1], Jonathan B. Puritz[2], Christopher M. Hollenbeck[1,3], and William F. Patterson, III[4]


Vol. 526: 125–141, 2015 doi: 10.3354/meps11212 | MARINE ECOLOGY PROGRESS SERIES Mar Ecol Prog Ser | Published April 22

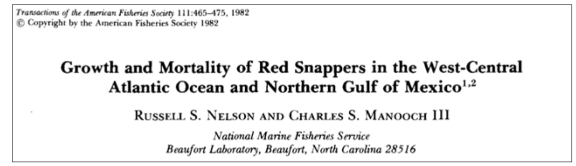
OPEN ACCESS

Assessing reproductive resilience: an example with South Atlantic red snapper *Lutjanus campechanus*

Susan Lowerre-Barbieri[1,*], Laura Crabtree[1], Theodore Switzer[1], Sarah Walters Burnsed[1], Cameron Guenther[1,2]

[1]Florida Fish and Wildlife Conservation Commission, Florida Fish and Wildlife Research Institute, 100 Eighth Avenue S.E., St. Petersburg, Florida 33701-5020, USA

[2]*Present address:* 3818 Turkey Oak Drive, Valrico, Florida 33596, USA


Transactions of the American Fisheries Society 111:465–475, 1982
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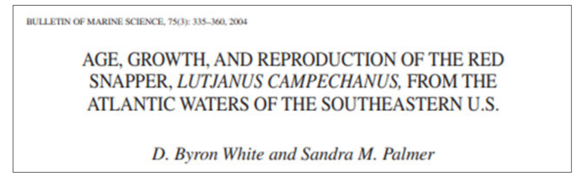
Growth and Mortality of Red Snappers in the West-Central Atlantic Ocean and Northern Gulf of Mexico[1,2]

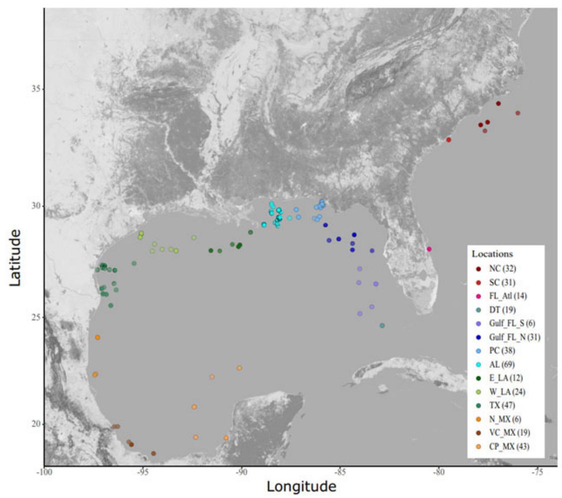
Russell S. Nelson and Charles S. Manooch III

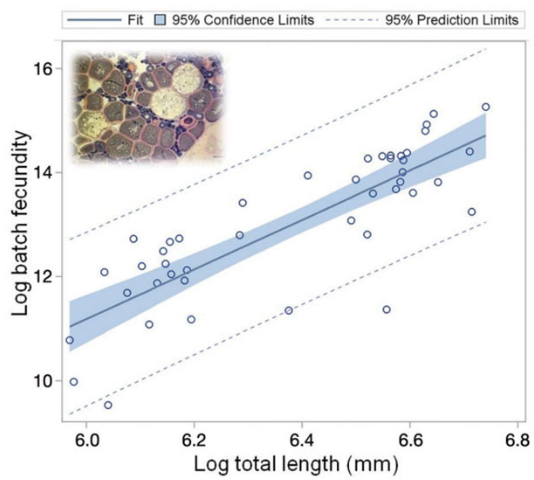
National Marine Fisheries Service
Beaufort Laboratory, Beaufort, North Carolina 28516

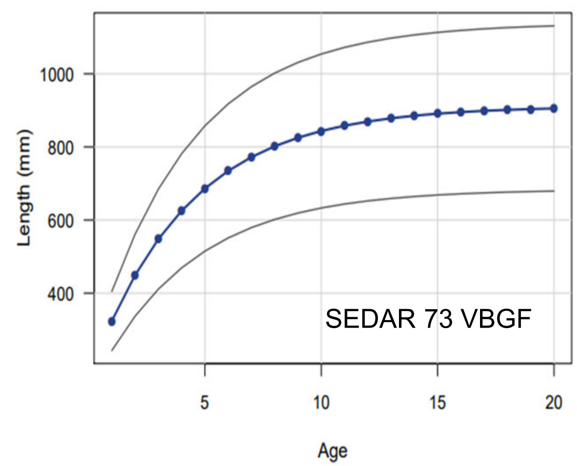

BULLETIN OF MARINE SCIENCE, 75(3): 335–360, 2004

AGE, GROWTH, AND REPRODUCTION OF THE RED SNAPPER, *LUTJANUS CAMPECHANUS*, FROM THE ATLANTIC WATERS OF THE SOUTHEASTERN U.S.

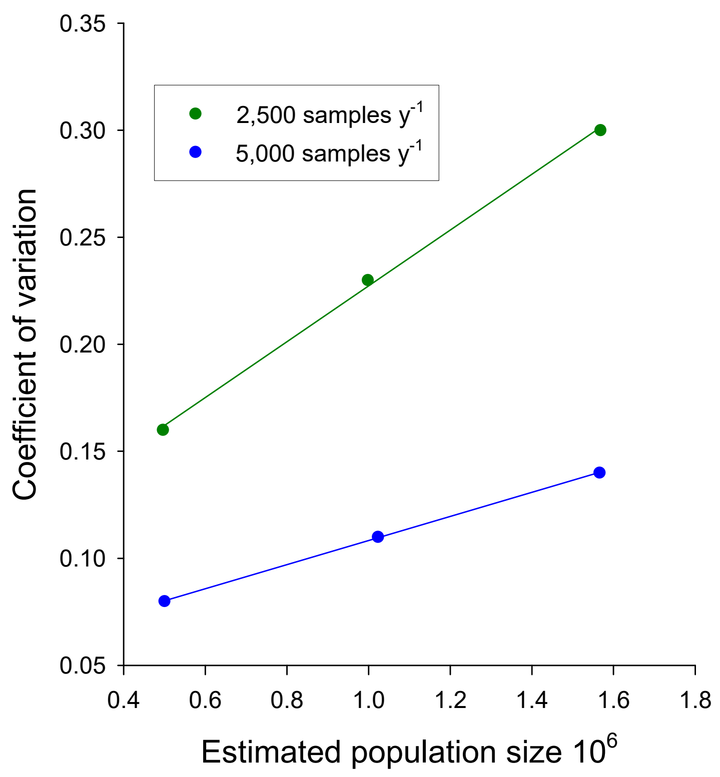
D. Byron White and Sandra M. Palmer







Fin Clip Sampling



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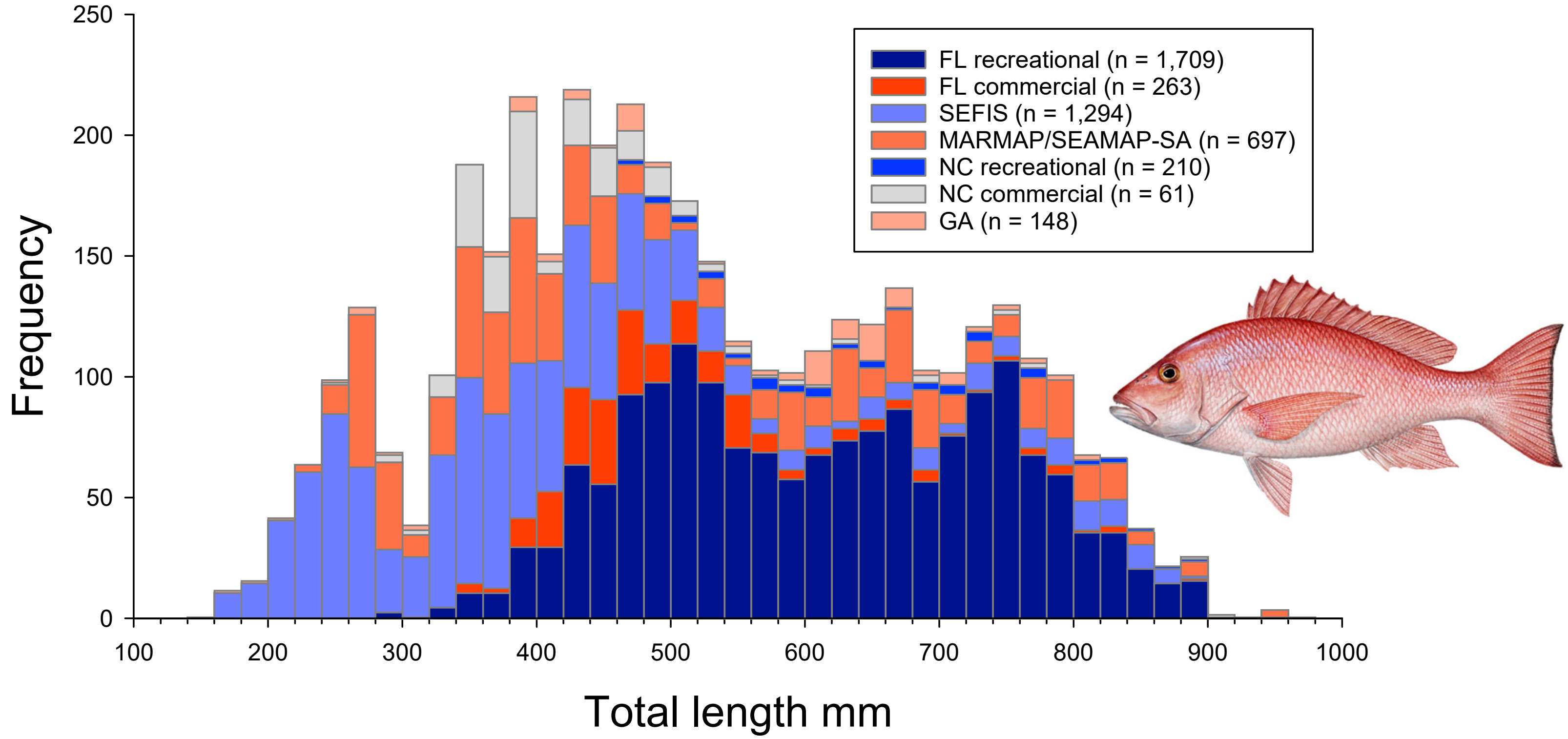
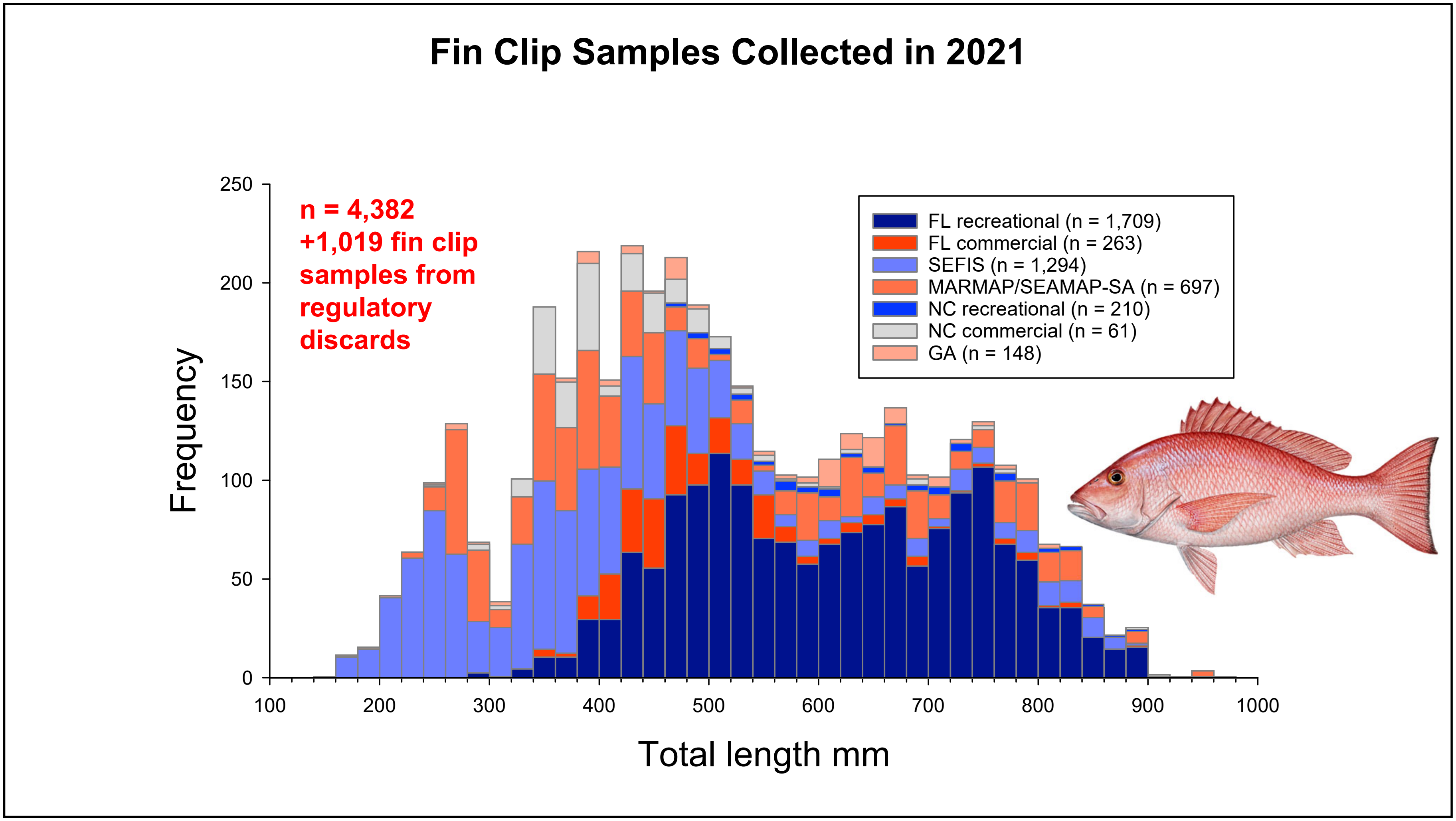
Fin Clip Samples Collected in 2021




Fin Clip Samples Collected in 2021
n = 4,382
+1,019 fin clip
samples from
regulatory
discards
FL recreational (n = 1,709)
FL commercial (n = 263)
SEFIS (n = 1,294)
MARMAP/SEAMAP-SA (n = 697)
NC recreational (n = 210)
NC commercial (n = 61)
GA (n = 148)
Frequency
0
50
100
150
200
250
100
200
300
400
500
600
700
800
900
1000
Total length mm

Methylomic Ageing of Red Snapper from Fin Clip Samples

Canadian Science Publishing

RAPID COMMUNICATION

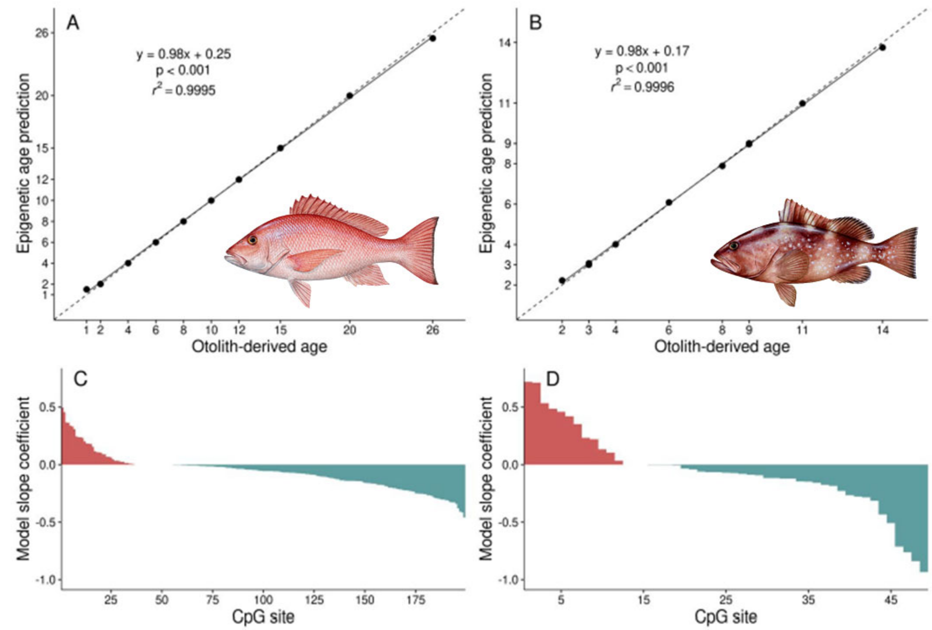
Novel epigenetic age estimation in wild-caught Gulf of Mexico reef fishes

D. Nick Weber, Andrew T. Fields, William F. Patterson III, Beverly K. Barnett, Christopher M. Hollenbeck, and David S. Portnoy

Abstract: Cutting-edge DNA methylation-based epigenetic aging techniques were applied to Gulf of Mexico northern red snapper (*Lutjanus campechanus*; n = 10; 1–26 years old) and red grouper (*Epinephelus morio*; n = 10; 2–14 years old). Bisulfite-converted restriction site-associated DNA sequencing was used to identify CpG sites (cytosines followed by guanines) that exhibit age-correlated DNA methylation, and species-specific epigenetic clocks developed from hundreds of CpG sites in each species showed strong agreement between predicted and otolith-derived age ($r^2 > 0.99$ for both species). Results suggest epigenetic age estimation could provide an accurate and efficient approach to mass-aging fishes in a non-invasive manner.

Résumé : Des méthodes épigénétiques de pointe de détermination de l'âge reposant sur la méthylation de l'ADN ont été appliquées au vivaneau campèche (*Lutjanus campechanus*; n = 10; 1–26 ans) et au mérou rouge (*Epinephelus morio*; n = 10; 2–14 ans). Le séquençage avec conversion au bisulfite d'ADN associé à des sites de restriction a été utilisé pour cerner des sites CpG (cytosines suivies de guanines) qui présentent une méthylation de l'ADN corrélée à l'âge, et des horloges épigénétiques propres à l'espèce développées à partir de centaines de sites CpG de chaque espèce ont révélé de fortes concordances entre les âges prédits et les âges obtenus par analyse d'otolites ($r^2 > 0,99$ pour les deux espèces). Les résultats donnent à penser que l'estimation épigénétique de l'âge pourrait constituer une approche non invasive exacte et efficiente de détermination des âges de quantités massives de poissons.

Canadian Journal of Fisheries and Aquatic Sciences, 79(1):1-5



Recent Funding:

1) S-K funds to expand red snapper and red grouper work
2) MARFIN to develop epigenetic clocks for gray triggerfish and gag, as well as test for general application of clocks to other SEUS reef fishes

Integrating Pop Estimates into Assessment and Management: GOM Example

Key differences in approaches:

1) In GOM study, optical methods utilized in all regions, but exclusively in FL; a depletion method utilized off AL and MS, sonar and towed camera rig utilized off TX and LA

2) Random forest model (RFM) predicted high, median, and low probability of encountering red snapper via analysis of numerous fishery-independent and -dependent data sets

3) Stratified random design implemented based on RFM (but only followed in FL) to produce pop estimate with CV ≤ 0.3

4) No attempt made in the GOM study to integrate red snapper pop estimate into assessment, or otherwise reconcile differences, until after study completion

Integrating Pop Estimates into Assessment and Management: GOM Example

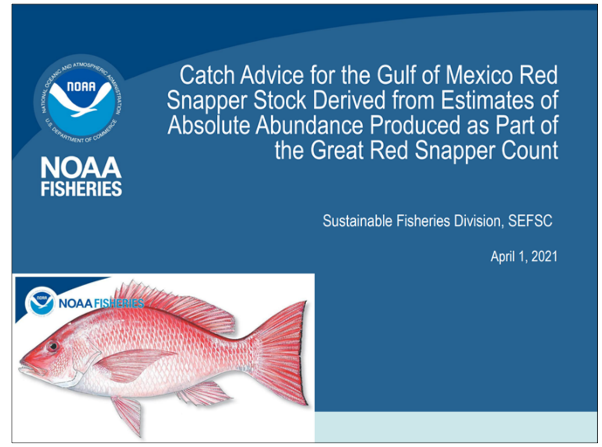
1) Great Red Snapper Count (GRSC) results presented to Gulf SSC in March 2021 after CIE review

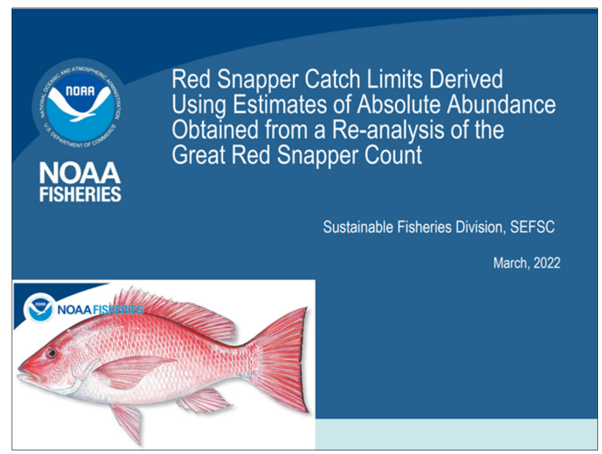
2) Interim assessment (IA) approach proposed by SEFSC based on scaling assessment projections with GRSC pop estimate

3) 2021 OFL estimated (3-year average) by Gulf SSC as 25.6 MP assuming 13% of Gulf uncharacterized bottom (UCB) was targeted by the red snapper fishery

4) 2021 ABC set at 15.4 MP based on IA results scaled to GRSC pop estimate, but informed by updated bottom longline index through 2020

5) 2022 OFL estimated as 18.91 MP based on ensemble approach of Monte Carlo simulations assuming 0-15% of UCB habitat was targeted by the fishery and taking a 5-year average of OFL projections; ABC = 16.31 MP based on OFL PDF and a P* value of 0.3





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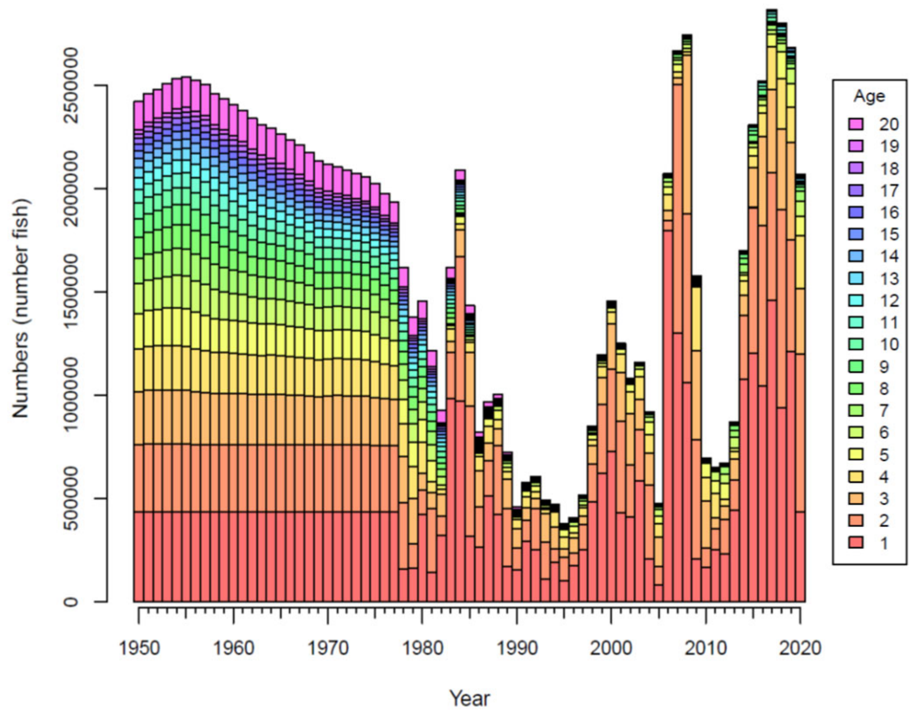
Integrating Pop Estimates into Assessment and Management: SA Plan

1) Evaluate two assessment approaches:
   A. Scale the current assessment model to the externally derived abundance estimates (with error)
   B. Integrate new data and methodology into the assessment model

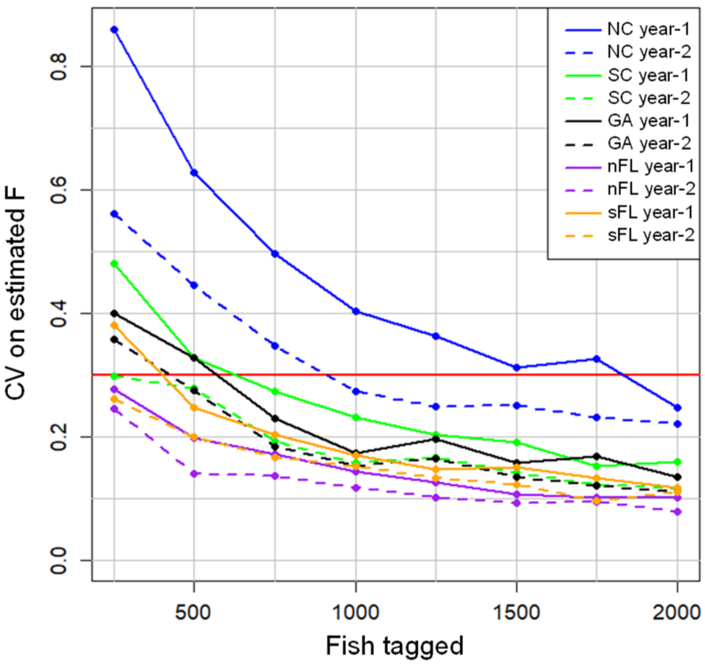
2) Planning for a post-doc to work with Kyle Shertzer at NOAA Fisheries-Beaufort Laboratory

3) Incorporate estimates into next Research Track Assessment, scheduled to start in 2024

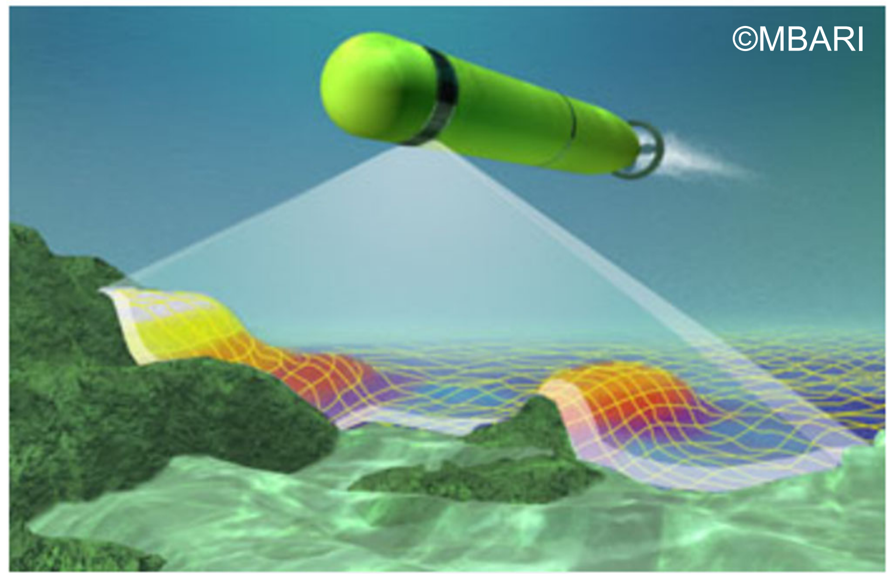


Potential Future Funding

Conventional Tagging Study

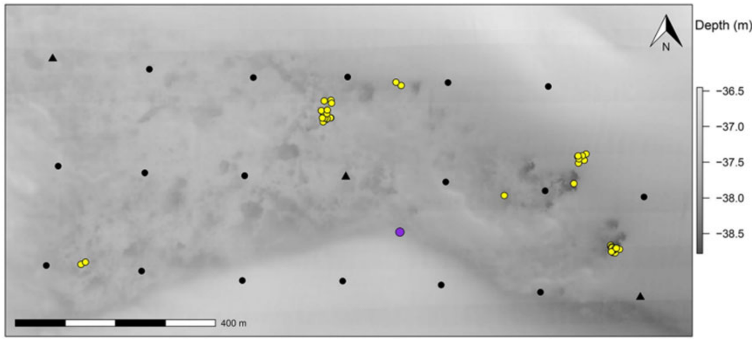


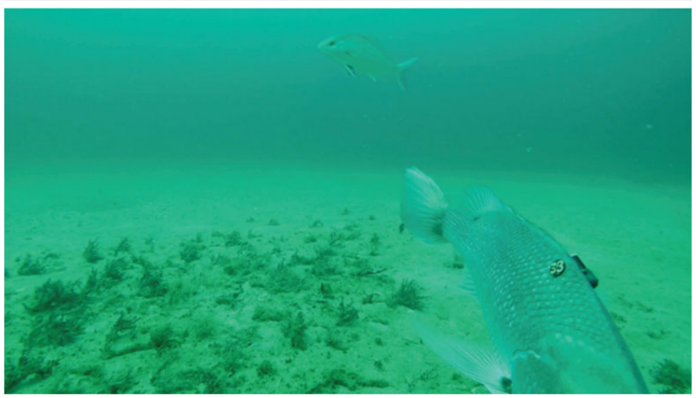
Habitat Surveys with AUVs



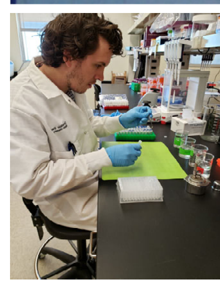
Potential Future Funding

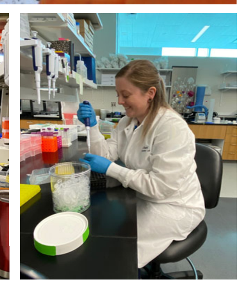
3D Telemetry: Gear Calibration and Estimating M



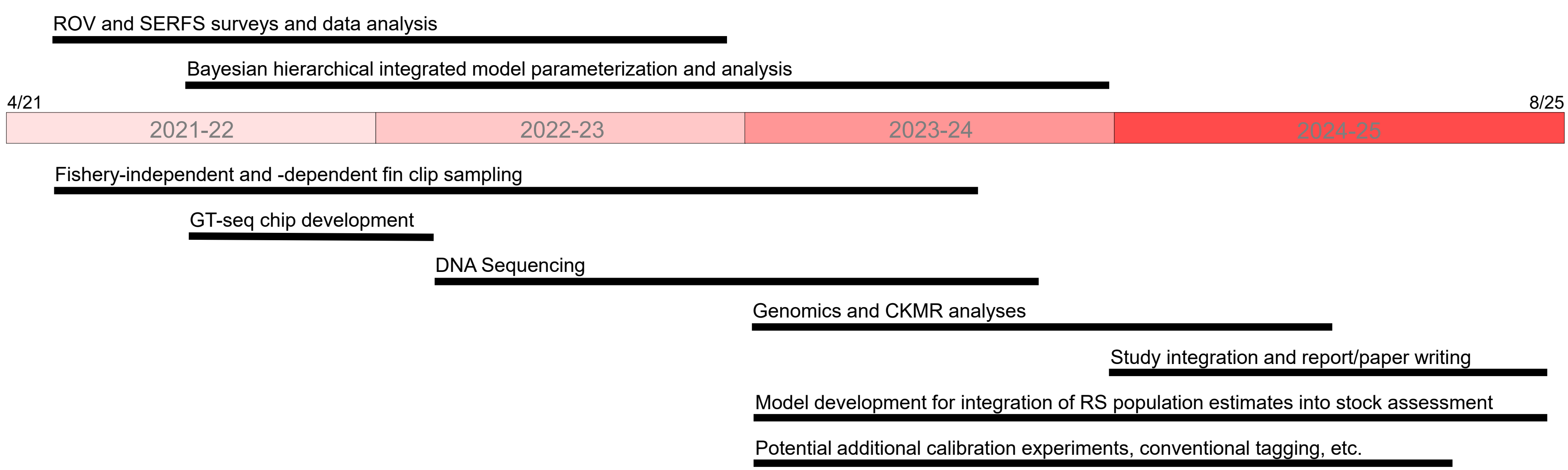


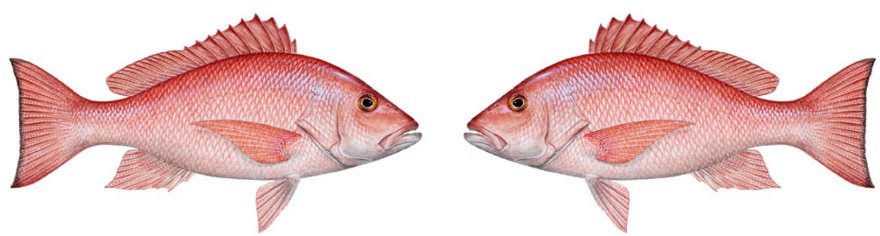
Red Snapper Sex-Identifying Genomics





Timeline of Study Components





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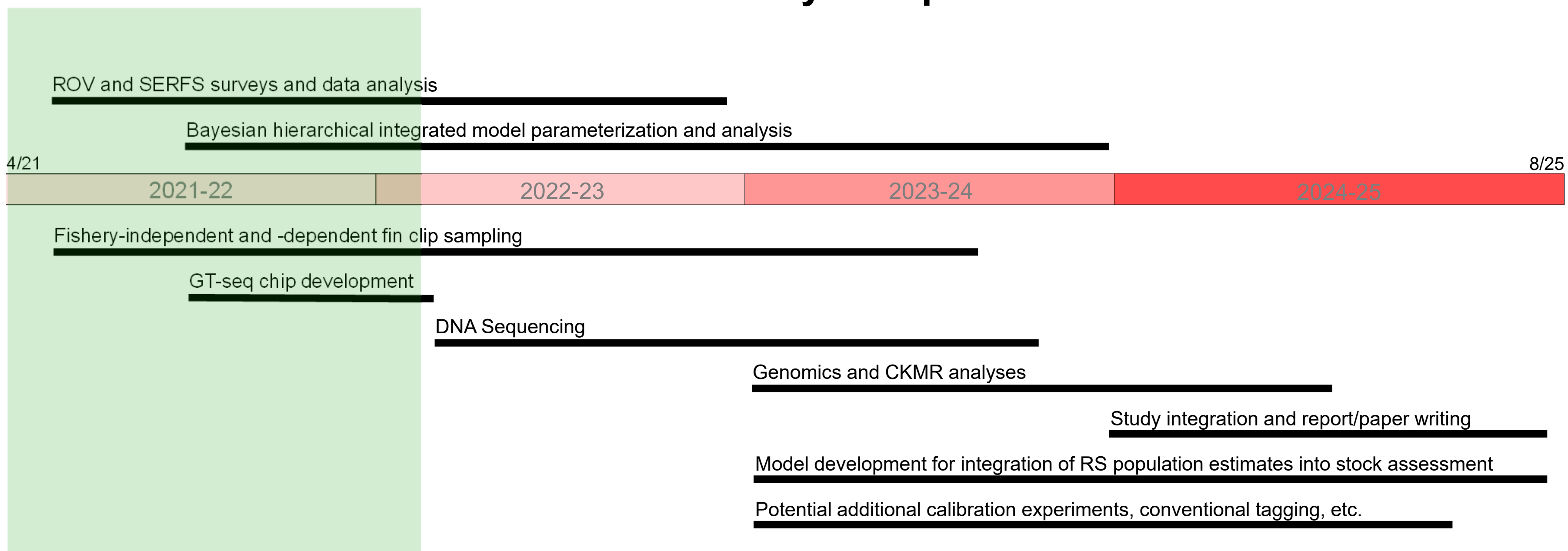
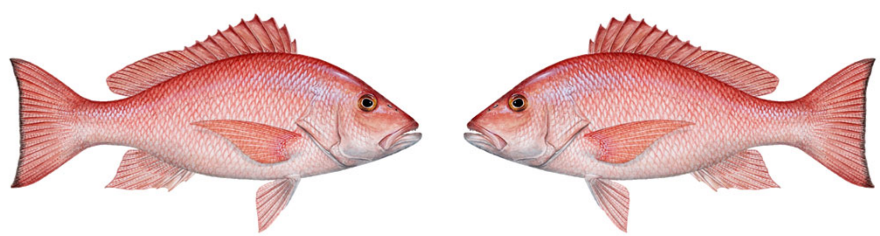
Timeline of Study Components





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South Carolina Sea Grant
Technical Review Committee
Susan Lovelace
Susannah Sheldon
Graham Gaines
Ryan Bradley
Tracey Smart
Dominique Lazarre
Jessica Carroll
Chris Bradshaw
Elizabeth Hunt
Fishery Observers
Port Agents

Paul Conn
Drew Demaree
Hans Kraaz
Jayme Stephenson
Joey Rivenbark
Josh Livingston
Mike Millroy
Paul Johnson
Robert Johnson
Robert Williams
Tom Baer
Wade Fickling
Fishermen Interviewees