ESTIMATION OF TOTAL RED SNAPPER ABUNDANCE IN LOUISIANA AND ADJACENT FEDERAL WATERS

A Study for

State of Louisiana
Louisiana Department of Wildlife and Fisheries

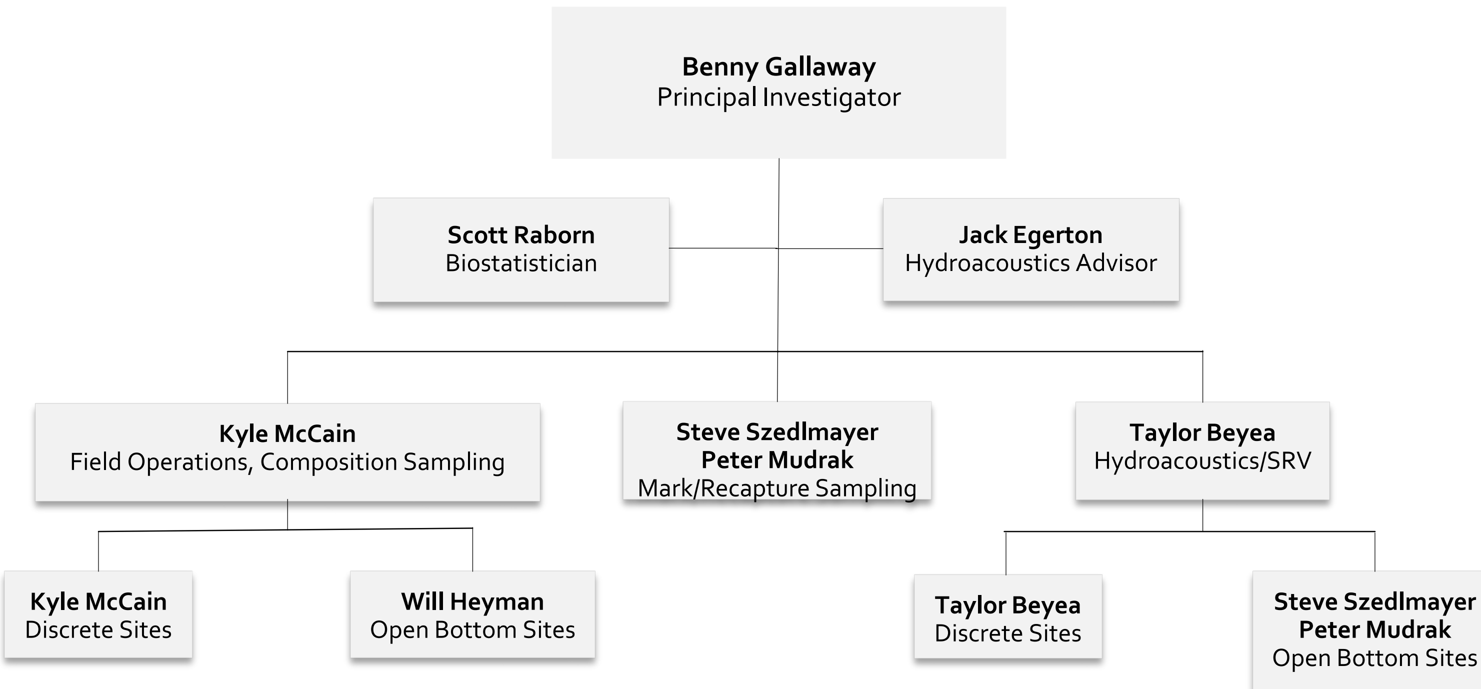
By

LGL Ecological Research Associates, Inc.

INTRODUCTION

- On 1 November 2019, the Louisiana Department of Wildlife and Fisheries (LDWF) entered into a Contract (Purchase Order No. 2000461788) with LGL Ecological Research Associates, Inc. (LGL) to estimate total Red Snapper abundance in Louisiana waters.
- The specific objectives of the study were to:
  - Determine species composition at 106 sampling sites at predetermined locations in the Gulf of Mexico per approved sampling methodology.
  - Conduct hydroacoustic, Submersible Rotating Video (SRV), and biological sampling for finfish at 106 sampling sites at predetermined locations in the Gulf of Mexico offshore Louisiana.
  - Conduct water column surveys at 106 sampling sites at predetermined locations in the Gulf of Mexico offshore Louisiana.
  - Conduct a mark/recapture study at a subset of six sites (1 platform and 1 artificial reef site in each of three regions). Of importance, the study was required to be compatible with "Great Red Snapper Count" (Stunz et al. 2021).

ORGANIZATIONAL CHART



ACKNOWLEDGEMENTS

Funding for this study was provided by Louisiana Department of Wildlife and Fisheries (LDWF) through Contract with LGL Ecological Research Associates, Inc. (LGL) (Purchase Order No. 2000461788). We especially acknowledge Dr. Steve Szedlmayer and Dr. Pete Mudrak, Auburn University for completing hydroacoustic surveys on uncharacterized bottom and for mark/recapture work on reefed and standing platforms.

The results of this study are based on data gathered at 100% of the 106 intended sampling sites during summer 2020, despite a historic hurricane season and various restrictions from COVID-19. Our success is due in large part to our trusted captains (clockwise from top left): Jamie Gaspard, Hans Guindon, Mike Jennings, Buddy Guindon, Scott Hickman, and Bill Butler.

INTRODUCTION (CONTINUED)

- The study was believed necessary when it was learned that unforeseen circumstances had curtailed the plan for sampling in Louisiana.
- Stunz et al. (2021a) developed an ad hoc estimate for Louisiana based largely on sampling in waters adjacent to Louisiana in Texas.
- However, it was determined that sampling directly in Louisiana waters was needed and the LDWF contract was subsequently let to LGL to sample the 106 pre-selected sites in 2020.
- The sites had been selected by LDWF following extensive collaboration with researchers throughout the Gulf of Mexico states.

INTRODUCTION (CONTINUED)

- Some milestones in the project included:
  - A proof-of-concept study conducted in March and April 2020 and reported in May 2018 to finalize final field sampling and logistic plans prior to conducting field studies.
  - All 106 sites were successfully sampled over the period 18 May 2020- 6 September 2020, despite COVID and a bad hurricane season.
  - Sample and data analyses occurred from September 2020-June 2021.

INTRODUCTION (CONTINUED)

- The original "Great Red Snapper Count" (Stunz et al. 2021a) was first released on 3 March 2021 followed by a revised report released on 15 March 2021.
- This report was reviewed by the Science and Statistical Committee (SSC) of the Gulf of Mexico Fishery Management Council (GMFMC) and by outside reviewers during 30 March through 2 April (2021).
- We did not receive the final revision of this report(Stunz et al 2021b) published in August 2021 until early September of 2021, so we relied mainly on the draft report.
- However, we did modify our report in critical areas based on the final GRSC study published in August 2021.

INTRODUCTION (CONTINUED)

- Our Draft Final Report was submitted to LDWF on 2 June 2021 and the corresponding Data Report was submitted on hard drive on 11 June 2021.
- The Draft Final Report was sent out for outside Peer Review shortly after submittal was reviewed by two external reviewers and one internal reviewer.
- Comments were received from External Reviewer 1 on 10 and 16 August 2021; from External Reviewer 2 on 25 August 2021 and from the internal LDWF Reviewer 3 on 29 August 2021.
- Our responses to Reviewer Comments were submitted to LDWF and the SSC on 9 September 2021.
- The revised report was submitted to LDWF and the SSC on 13 September 2021.

GENERAL REVIEWER COMMENTS, AND OUR RESPONSES

LGL ECOLOGICAL RESEARCH ASSOCIATES, INC.

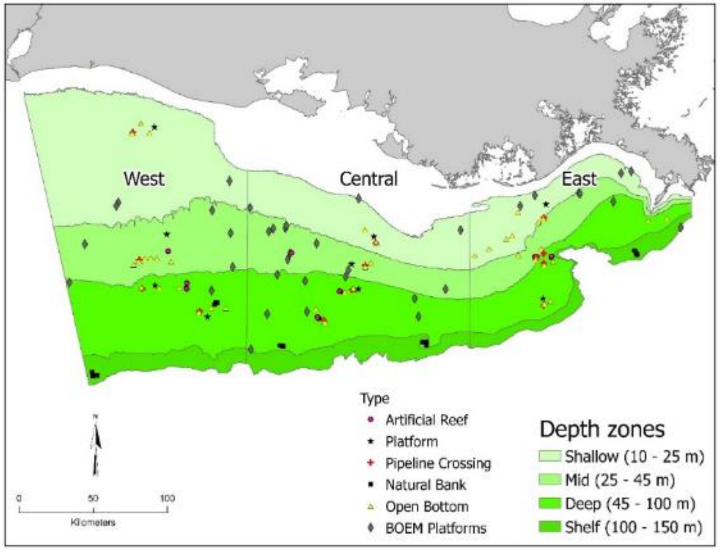
INTRODUCTION (CONTINUED)

- Below we first describe our Study Area (the Louisiana State Red Snapper Management Area) and provide a characterization of the major types of habitats represented within the area.
- We then describe the 106 designated sampling sites that were located within the area.
- Next we will describe our field sampling strategies for each habitat which were divided into discrete sites (artificial reefs, petroleum platforms, pipeline crossings) and Natural Banks and Uncharacterized Bottoms (UCB).
- The field methods section is followed by descriptions of Data and Statistical Analyses followed by Results and a Summary and Conclusion Section.

Study Area and Habitats

STUDY AREA AND HABITATS

- The Louisiana Red Snapper Management Area (the Study Area) was divided into three regions (West, Central, and East) each of which was divided into four depth zones (Shallow, 10- to 25- m deep; Mid-depth, 25- to 45- m deep; Deep, 45- m to 100- m deep and Shelf, 100- to 150- m deep).



- The Deep and Shelf Zones were later combined as a single zone.

STUDY AREA AND HABITATS (CONTINUED)

- As noted, the 106 sites were sampled in summer and fall of 2020 and data for 37 petroleum platforms that were present in the study area and sampled as part of the Bureau of Ocean Energy Management's study (Gallaway et al. 2020) were also included in the analyses.
- Before describing our specific sampling sites, we will first provide an overall background for Red Snapper habitats found in the Study Area.

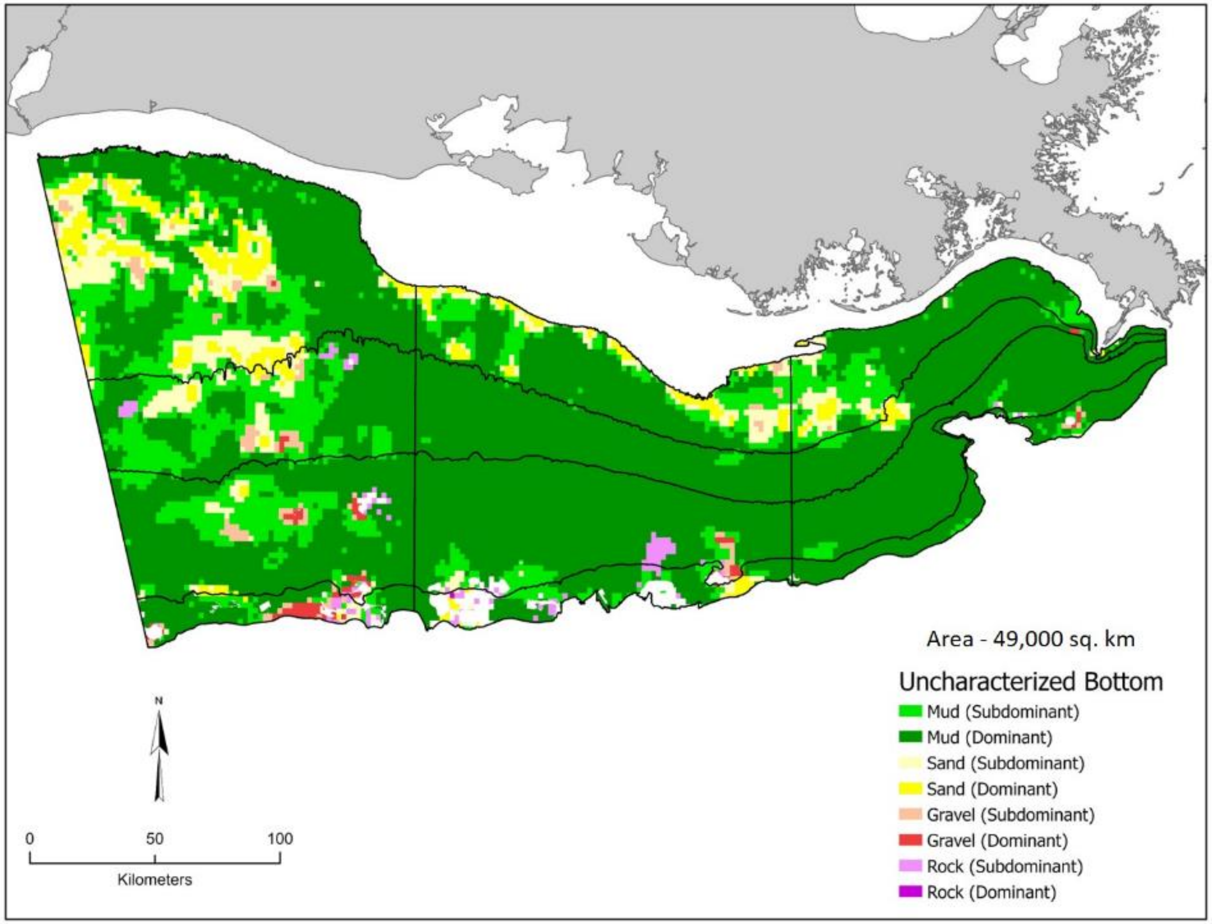
HABITAT AREAS AND DISCRETE STRUCTURES

- Areal coverage of all discrete and UCB habitats within each region and depth zone was determined using GIS.
- We used an Albers Conic Projection with North American Datum of 1983 (NAD83).
- This projection is centered at 91.5° W, 28.0 ° N on the area offshore of Western Louisiana and encompasses the Study Area.
- This served to reduce distortion when calculating areal coverage of bottom habitats.

HABITAT AREAS AND DISCRETE STRUCTURES (CONTINUED)

- The extent of UCB habitat was estimated from the usSEABED bottom sediment database (Buczkowski 2006).
- This is a gridded database that estimates percent coverage of bottom sediment (rock, mud, sand and gravel) within each grid cell (2.22 km by 1.96 km).
- We considered UCB as being those grid cells that had less than 66% rock.

UNCHARACTERIZED BOTTOM



UNCHARACTERIZED BOTTOM (CONTINUED)

- As shown in the previous slide, the Louisiana Study Area was dominated by mud substrates with much lessor amounts sand and gravel substrate, except in the West Shallow zone.
- We calculated the total area of UCM in Louisiana to have been on the order of 49,000 km^2 and this compares favorably to the GRSC estimate of 53,052 km^2-- the difference is less than 10%.
- For our analyses, we deleted the shelf area which was not sampled:

Name	Zone_ID	Area_km^2	Num Sites Uncharacterized Bottom	Area sampled _km^2	Percent sampled
West Shallow	1	10,267.60	3	12.94	0.13
West Mid	2	5,297.20	6	25.87	0.49
West Deep	3	5,892.60	6	25.87	0.44
Central Shallow	5	4,407.10	2	8.62	0.20
Central Mid	6	3,760.00	2	8.62	0.23
Central Deep	7	6,043.10	4	17.25	0.29
East Shallow	9	3,058.40	7	30.18	0.99
East Mid	10	2,326.70	3	12.94	0.56
East Deep	11	3,853.00	6	25.87	0.67
West Shelf	4	1,269.70	0	0.00	0
Central Shelf	8	1,468.30	0	0.00	0
East Shelf	12	1,359.50	0	0.00	0
Total - Shallow, Mid,Deep		**44,905.70**	**39**	**168.17**	**0.3745%**

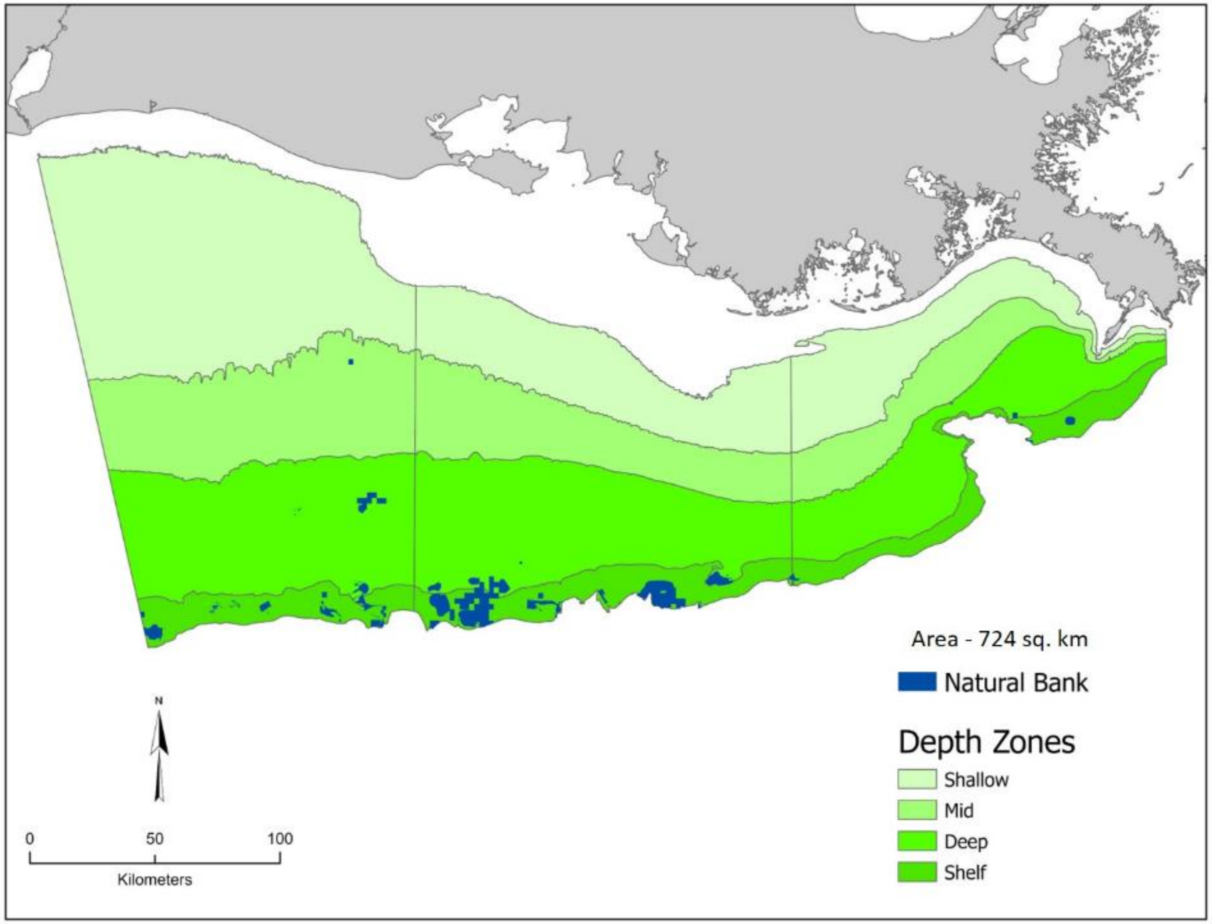
NATURAL BANK HABITAT

- Natural Bank Habitat was estimated using a natural bank coverage obtained from the Gulf States Marine Fisheries Commission in combination with areas from the usSEABED dataset having > 66% rock coverage.
- A summary of our estimate of Natural Bank Habitat and area sampled shows a total of ~724 km^2 of Natural Bank Habitat offshore Western Louisiana.

Natural Bank Area (km^2)	
Natural Bank Region	**Total**
West Mid/Deep (Sonnier)	45.85 (0.48)
West Shelf/Deep (Bright)	133.97 (0.48)
Central East Deep/Shelf	544.42 (1.44)
Total	**724.25 (2.4)**
% Sampled = 0.33	

- Our estimate of 724 km^2 compares closely to the GRSC estimate of 821 km^2, only about 12% different.

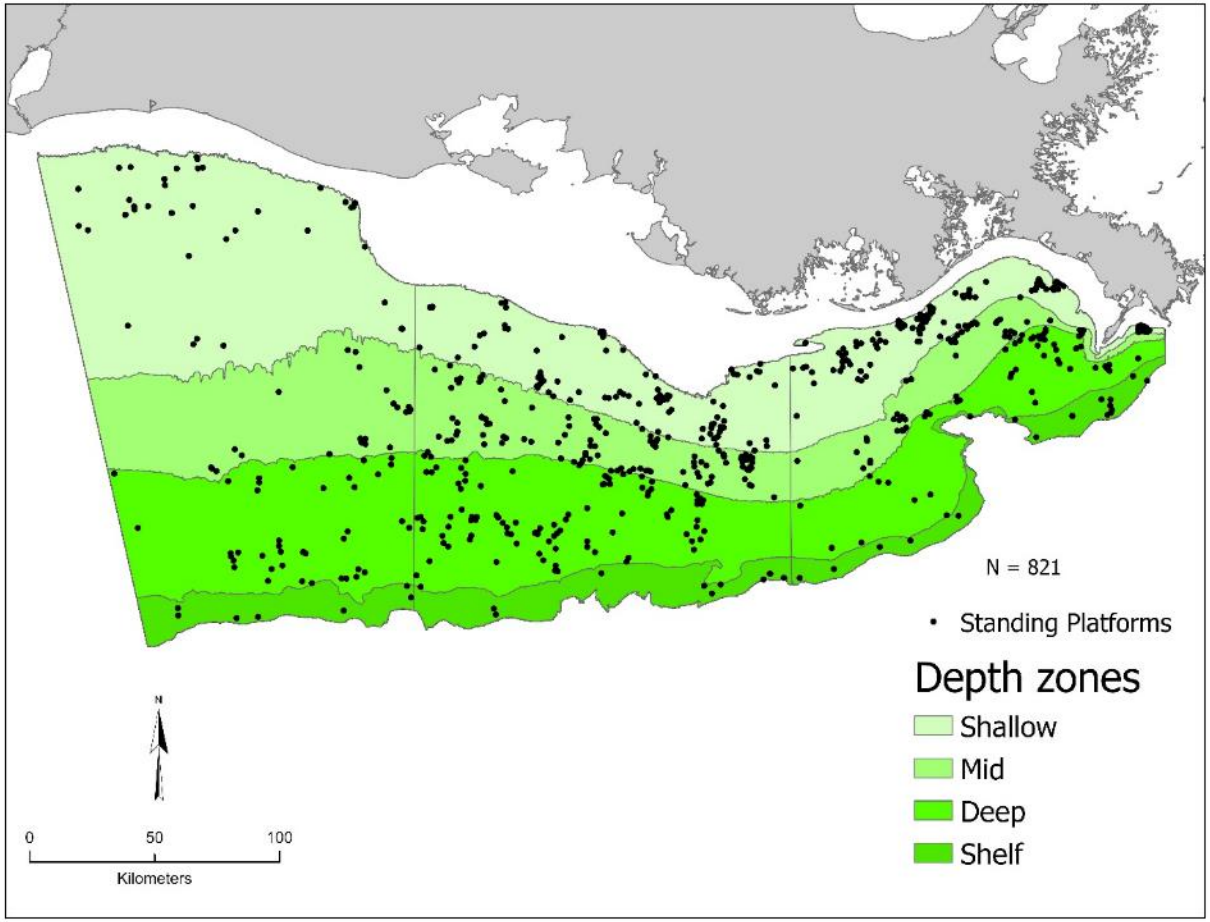
NATURAL BANK DEPTH ZONES



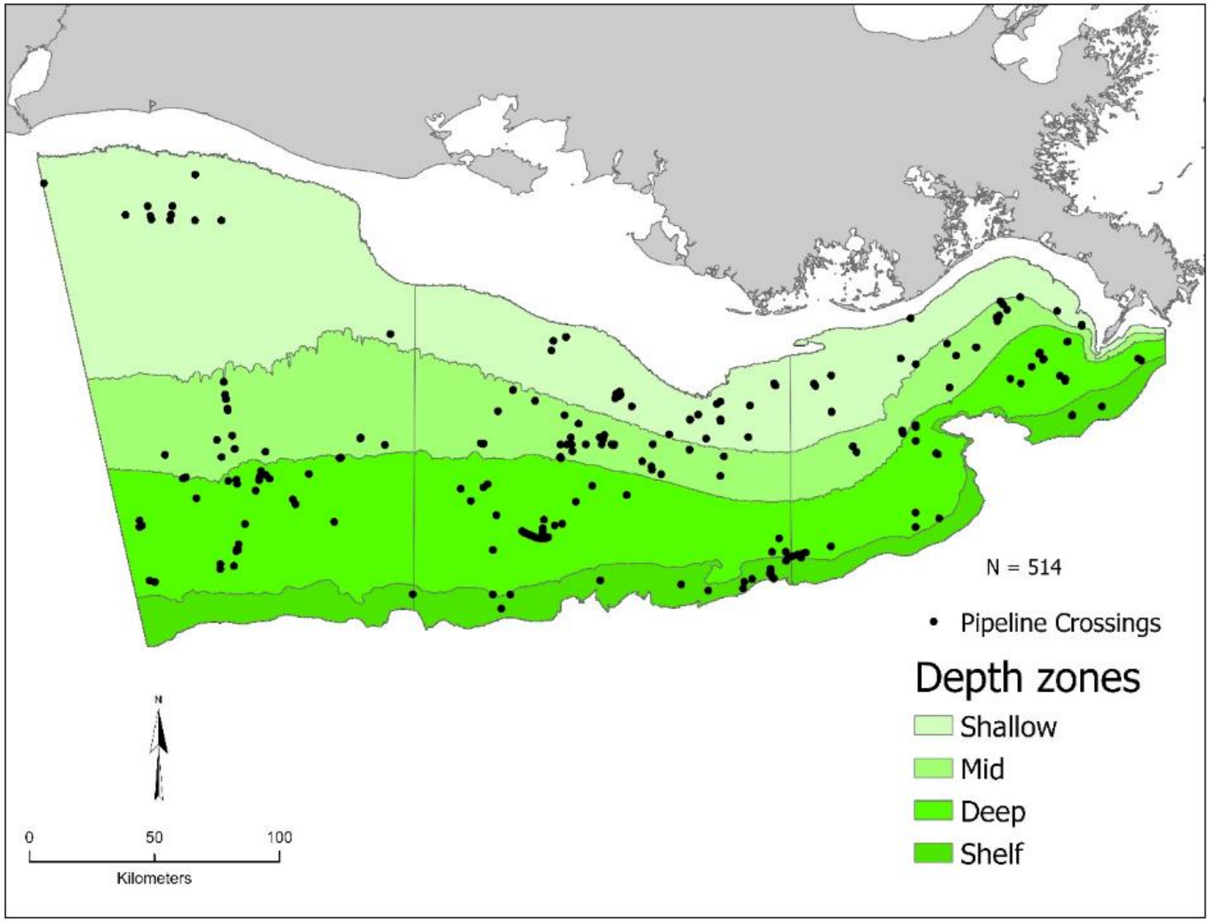
ARTIFICIAL REEF HABITAT

- We included three types of large Artificial Reefs in our analyses, namely standing platforms (821 in place in 2020), Pipeline Crossings where each of the pipes was greater than 20" in diameter (514) and reefed platforms (442).
- Collectively, these total 1,777 discrete habitats and our estimates are almost identical to the latest GRSC estimate of 1,771 Artificial Reefs offshore West Louisiana.
- The following maps show platforms and pipeline crossings occur across all regions and depths, whereas reefed platforms occur mainly in the mid- and deep depth zones.

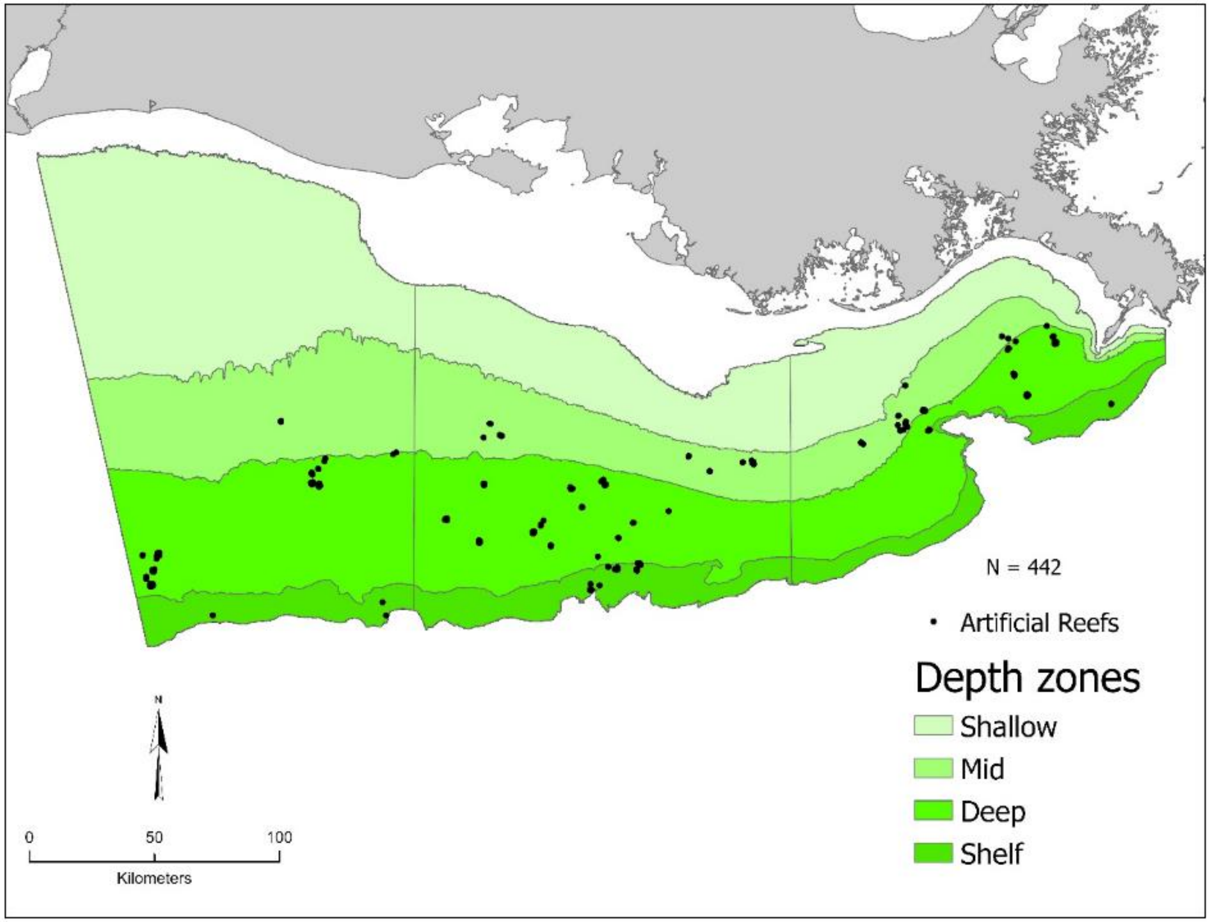
STANDING PLATFORMS DEPTH ZONES



PIPELINE CROSSINGS DEPTH ZONES



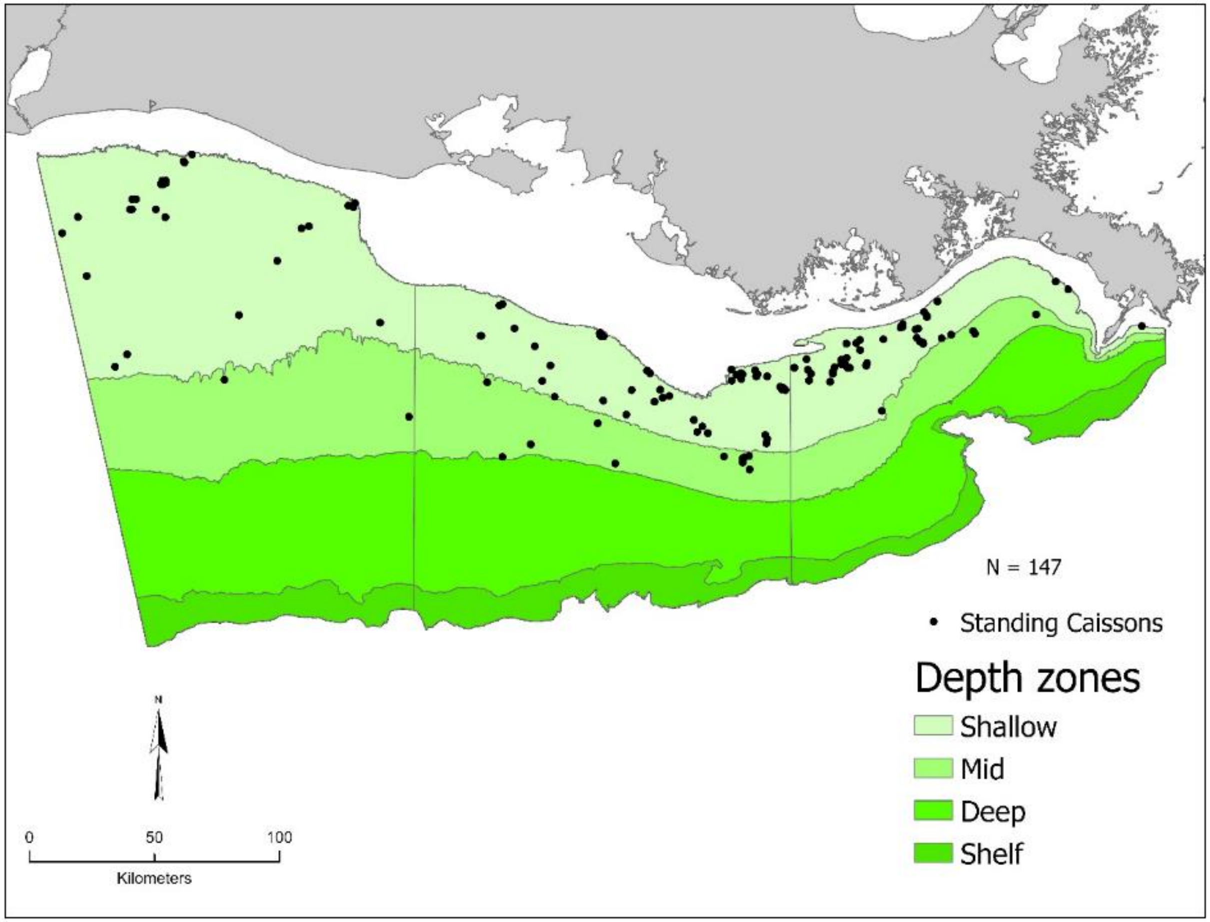
ARTICIAL REEFS DEPTH ZONES



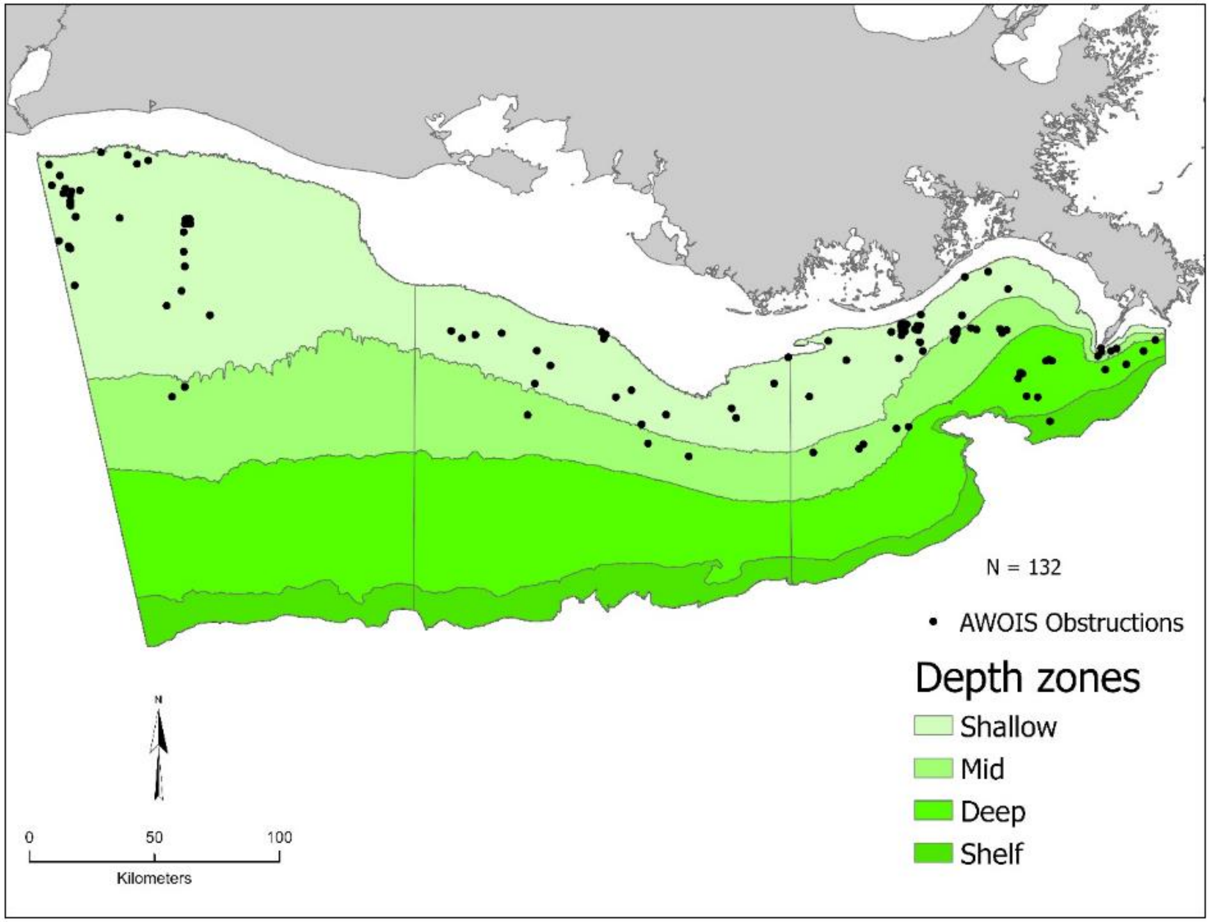
SMALL ARTIFICIAL REEFS

- In addition to the above, small caissons (147), documented obstructions (132) and wrecks (56) were also present. These were not sampled or included in our analyses but the impact of not including these is considered small.
- As shown by the following maps, most of these habitats are restricted to shallow- and mid depths.

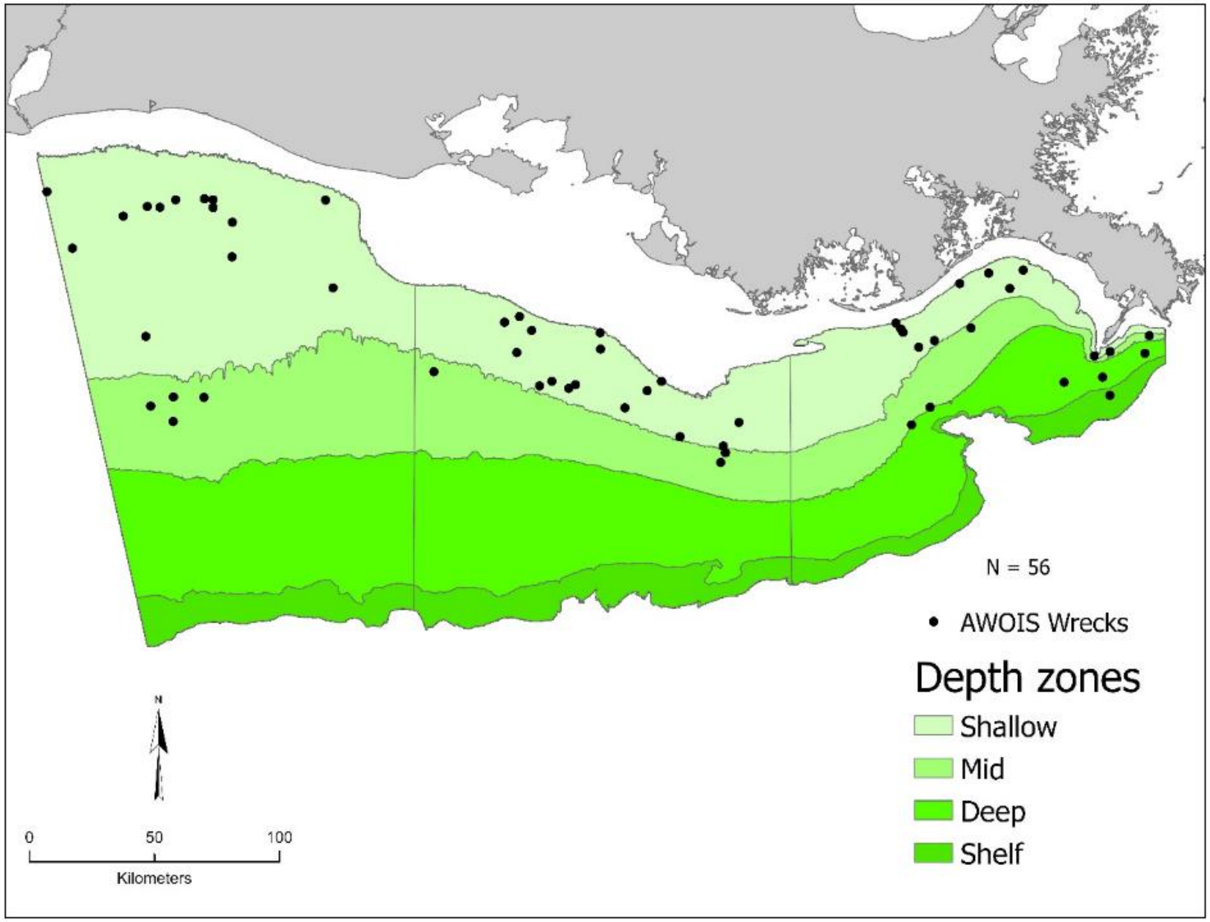
STANDING CAISSONS DEPTH ZONES



AWOIS OBSTRUCTIONS DEPTH ZONES



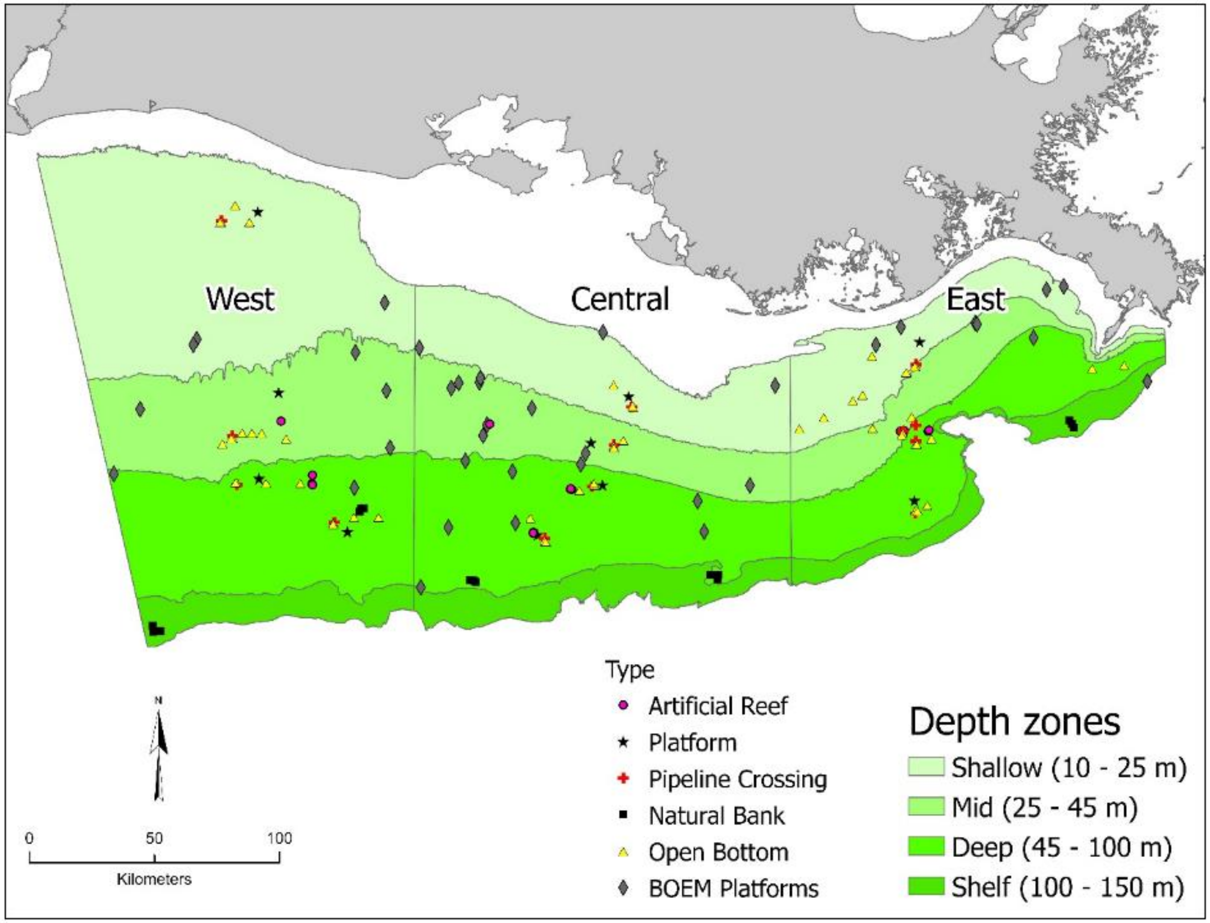
AWOIS WRECKS DEPTH ZONES



SAMPLING SITES

- Of the 106 total sampling sites, 37 were located in the West Region, 33 were in the Central Region and 36 were in the East Region.
- Of these, 55 were discrete reef sites whereas 51 were UCB sites. The UCB surveys included only 39 unique sites but paired sampling was performed at 12 sites (with and without pipelines).
- Note that the UCB hydroacoustic surveys were conducted by Auburn University and alternative site numbers (1-39) were assigned for internal tracking purposes. Appendix 1 of our report provides a key for relating Auburn numbers to the original LDWF site numbers.
- Our samples for UCB habitat did not include any taken from the shelf zone which constitutes about 8% of the total sampled area.

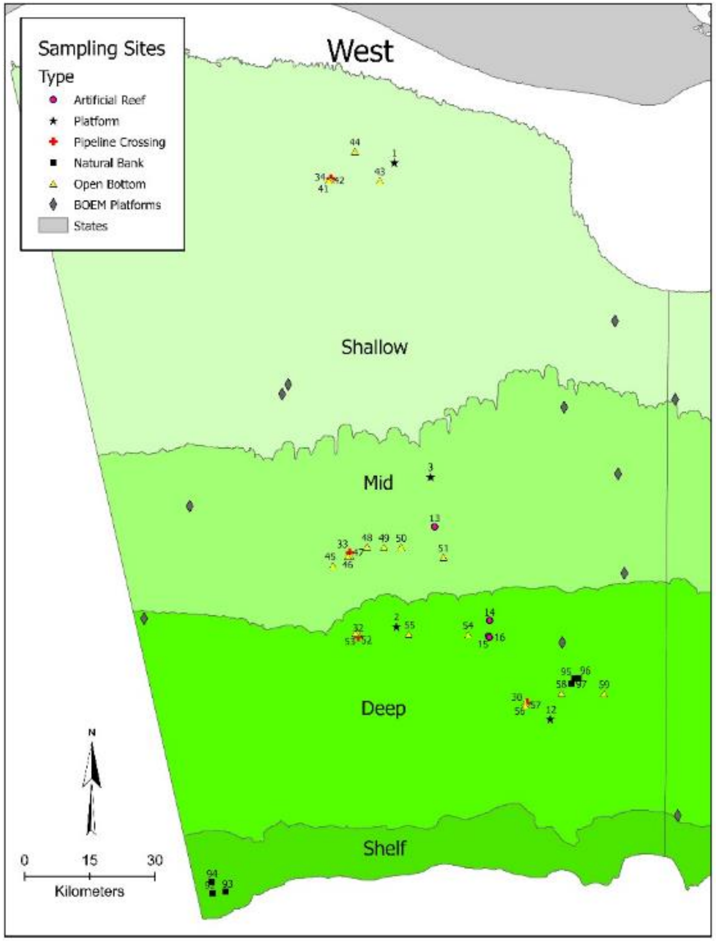
SAMPLING SITE MAP



WEST REGION (37 SITES)

Site_num	Latitude	Longitude	Site type	Sample type	Type	region	depthzone	Name	Zone_ID	Preliminary Schedule
1	29.406851	-92.896044	Platform	Site appropriate hook and line	Platform	West	Shallow	West Shallow	1	March - April
34	29.372924	-93.045991	Pipeline Crossing	Site appropriate hook and line	Pipeline Crossing	West	Shallow	West Shallow	1	March - April
41	29.368515	-93.046051	Open Bottom	Trammel or Longline	Open Bottom	West	Shallow	West Shallow	1	March - April
42	29.368466	-93.051362	Open Bottom	Trammel or Longline	Open Bottom	West	Shallow	West Shallow	1	March - April
43	29.370352	-92.929575	Open Bottom	Trammel or Longline	Open Bottom	West	Shallow	West Shallow	1	March - April
44	29.430211	-92.989713	Open Bottom	Trammel or Longline	Open Bottom	West	Shallow	West Shallow	1	March - April
3	28.634438	-92.771399	Platform	Site appropriate hook and line	Platform	West	Mid	West Mid	2	April - May
13	28.65235	-92.7915	Artificial Reef	Site appropriate hook and line	Artificial Reef	West	Mid	West Mid	2	April - May
33	28.596853	-92.99014	Pipeline Crossing	Site appropriate hook and line	Pipeline Crossing	West	Mid	West Mid	2	April - May
45	28.57022	-93.029661	Open Bottom	Trammel or Longline	Open Bottom	West	Mid	West Mid	2	April - May
46	28.589748	-92.988716	Open Bottom	Trammel or Longline	Open Bottom	West	Mid	West Mid	2	April - May
47	28.589641	-92.994673	Open Bottom	Trammel or Longline	Open Bottom	West	Mid	West Mid	2	April - May
48	28.610547	-92.949974	Open Bottom	Trammel or Longline	Open Bottom	West	Mid	West Mid	2	April - May
49	28.610443	-92.909674	Open Bottom	Trammel or Longline	Open Bottom	West	Mid	West Mid	2	April - May
50	28.610264	-92.869659	Open Bottom	Trammel or Longline	Open Bottom	West	Mid	West Mid	2	April - May
51	28.590587	-92.769783	Open Bottom	Trammel or Longline	Open Bottom	West	Mid	West Mid	2	April - May
2	28.452056	-92.925103	Platform	Site appropriate hook and line	Platform	West	Deep	West Deep	3	May - June
12	28.255541	-92.515615	Platform	Site appropriate hook and line	Platform	West	Deep	West Deep	3	May - June
14	28.458817	-92.660217	Artificial Reef	Site appropriate hook and line	Artificial Reef	West	Deep	West Deep	3	May - June
15	28.427067	-92.662517	Artificial Reef	Site appropriate hook and line	Artificial Reef	West	Deep	West Deep	3	May - June
16	28.424167	-92.66005	Artificial Reef	Site appropriate hook and line	Artificial Reef	West	Deep	West Deep	3	May - June
30	28.289362	-92.569871	Pipeline Crossing	Site appropriate hook and line	Pipeline Crossing	West	Deep	West Deep	3	May - June
32	28.422298	-92.968512	Pipeline Crossing	Site appropriate hook and line	Pipeline Crossing	West	Deep	West Deep	3	May - June
52	28.430524	-92.969579	Open Bottom	Trammel or Longline	Open Bottom	West	Deep	West Deep	3	May - June
53	28.430501	-92.974722	Open Bottom	Trammel or Longline	Open Bottom	West	Deep	West Deep	3	May - June
54	28.429728	-92.709545	Open Bottom	Trammel or Longline	Open Bottom	West	Deep	West Deep	3	May - June
55	28.430198	-92.850249	Open Bottom	Trammel or Longline	Open Bottom	West	Deep	West Deep	3	May - June
56	28.289941	-92.574727	Open Bottom	Trammel or Longline	Open Bottom	West	Deep	West Deep	3	May - June
57	28.284417	-92.574667	Open Bottom	Trammel or Longline	Open Bottom	West	Deep	West Deep	3	May - June
58	28.309715	-92.48989	Open Bottom	Trammel or Longline	Open Bottom	West	Deep	West Deep	3	May - June
59	28.310103	-92.389851	Open Bottom	Trammel or Longline	Open Bottom	West	Deep	West Deep	3	May - June
95	28.340833	-92.459444	Sonnier bank	Site appropriate hook and line	Natural Bank	West	Deep	West Deep	3	May - June
96	28.340833	-92.459444	Sonnier bank	Site appropriate hook and line	Natural Bank	West	Deep	West Deep	3	May - June
97	28.340833	-92.459444	Sonnier bank	Site appropriate hook and line	Natural Bank	West	Deep	West Deep	3	May - June
92	27.886389	-93.301389	Bright bank	Site appropriate hook and line	Natural Bank	West	Shelf	West Shelf	4	May - June
93	27.886389	-93.301389	Bright bank	Site appropriate hook and line	Natural Bank	West	Shelf	West Shelf	4	May - June
94	27.886389	-93.301389	Bright bank	Site appropriate hook and line	Natural Bank	West	Shelf	West Shelf	4	May - June

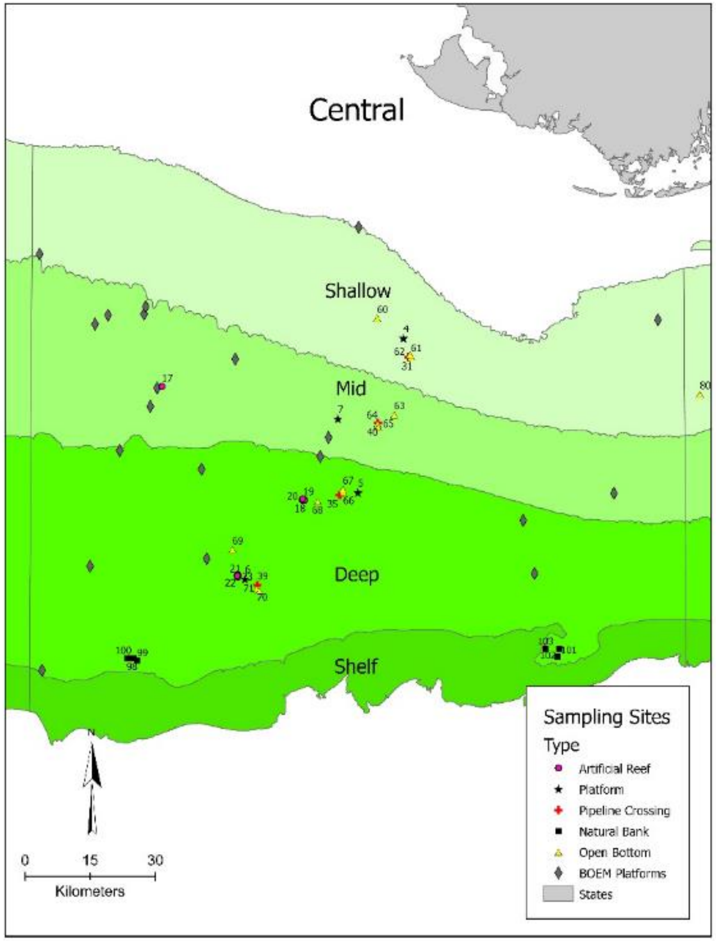
WEST SAMPLING SITES



CENTRAL REGION (33 SITES)

Site_num	Latitude	Longitude	Site type	Sample type	Type	region	depthzone	Name	Zone_ID	Preliminary Schedule
4	28.747864	-91.367972	Platform	Site appropriate hook and line	Platform	Central	Shallow	Central Shallow	5	June - July
31	28.709506	-91.355535	Pipeline Crossing	Site appropriate hook and line	Pipeline Crossing	Central	Shallow	Central Shallow	5	June - July
60	28.790073	-91.429786	Open Bottom	Trammel or Longline	Open Bottom	Central	Shallow	Central Shallow	5	June - July
61	28.709894	-91.350221	Open Bottom	Trammel or Longline	Open Bottom	Central	Shallow	Central Shallow	5	June - July
62	28.71497	-91.352645	Open Bottom	Trammel or Longline	Open Bottom	Central	Shallow	Central Shallow	5	June - July
7	28.580784	-91.522373	Platform	Site appropriate hook and line	Platform	Central	Mid	Central Mid	6	June - July
17	28.6473	-91.936867	Artificial Reef	Site appropriate hook and line	Artificial Reef	Central	Mid	Central Mid	6	June - July
40	28.572994	-91.428114	Pipeline Crossing	Site appropriate hook and line	Pipeline Crossing	Central	Mid	Central Mid	6	June - July
63	28.590226	-91.389678	Open Bottom	Trammel or Longline	Open Bottom	Central	Mid	Central Mid	6	June - July
64	28.571074	-91.429147	Open Bottom	Trammel or Longline	Open Bottom	Central	Mid	Central Mid	6	June - July
65	28.563853	-91.428247	Open Bottom	Trammel or Longline	Open Bottom	Central	Mid	Central Mid	6	June - July
5	28.415161	-91.613131	Platform	Site appropriate hook and line	Platform	Central	Deep	Central Deep	7	June - July
6	28.248197	-91.740532	Platform	Site appropriate hook and line	Platform	Central	Deep	Central Deep	7	June - July
18	28.412817	-91.606433	Artificial Reef	Site appropriate hook and line	Artificial Reef	Central	Deep	Central Deep	7	June - July
19	28.412583	-91.601067	Artificial Reef	Site appropriate hook and line	Artificial Reef	Central	Deep	Central Deep	7	June - July
20	28.415067	-91.60525	Artificial Reef	Site appropriate hook and line	Artificial Reef	Central	Deep	Central Deep	7	June - July
21	28.252517	-91.757183	Artificial Reef	Site appropriate hook and line	Artificial Reef	Central	Deep	Central Deep	7	June - July
22	28.257433	-91.7575	Artificial Reef	Site appropriate hook and line	Artificial Reef	Central	Deep	Central Deep	7	June - July
23	28.2553	-91.7585	Artificial Reef	Site appropriate hook and line	Artificial Reef	Central	Deep	Central Deep	7	June - July
35	28.422934	-91.517873	Pipeline Crossing	Site appropriate hook and line	Pipeline Crossing	Central	Deep	Central Deep	7	June - July
39	28.235995	-91.711222	Pipeline Crossing	Site appropriate hook and line	Pipeline Crossing	Central	Deep	Central Deep	7	June - July
66	28.429789	-91.50974	Open Bottom	Trammel or Longline	Open Bottom	Central	Deep	Central Deep	7	June - July
67	28.435034	-91.510698	Open Bottom	Trammel or Longline	Open Bottom	Central	Deep	Central Deep	7	June - July
68	28.409966	-91.56994	Open Bottom	Trammel or Longline	Open Bottom	Central	Deep	Central Deep	7	June - July
69	28.310126	-91.770028	Open Bottom	Trammel or Longline	Open Bottom	Central	Deep	Central Deep	7	July - August
70	28.228586	-91.712486	Open Bottom	Trammel or Longline	Open Bottom	Central	Deep	Central Deep	7	July - August
71	28.224233	-91.706819	Open Bottom	Trammel or Longline	Open Bottom	Central	Deep	Central Deep	7	July - August
98	28.0825	-92.000556	Alderdice bank	Site appropriate hook and line	Natural Bank	Central	Deep	Central Deep	7	July - August
99	28.0825	-92.000556	Alderdice bank	Site appropriate hook and line	Natural Bank	Central	Deep	Central Deep	7	July - August
100	28.0825	-92.000556	Alderdice bank	Site appropriate hook and line	Natural Bank	Central	Deep	Central Deep	7	July - August
101	28.086667	-91.007222	Ewing bank	Site appropriate hook and line	Natural Bank	Central	Deep	Central Deep	7	July - August
102	28.086667	-91.007222	Ewing bank	Site appropriate hook and line	Natural Bank	Central	Deep	Central Deep	7	July - August
103	28.086667	-91.007222	Ewing bank	Site appropriate hook and line	Natural Bank	Central	Deep	Central Deep	7	July - August

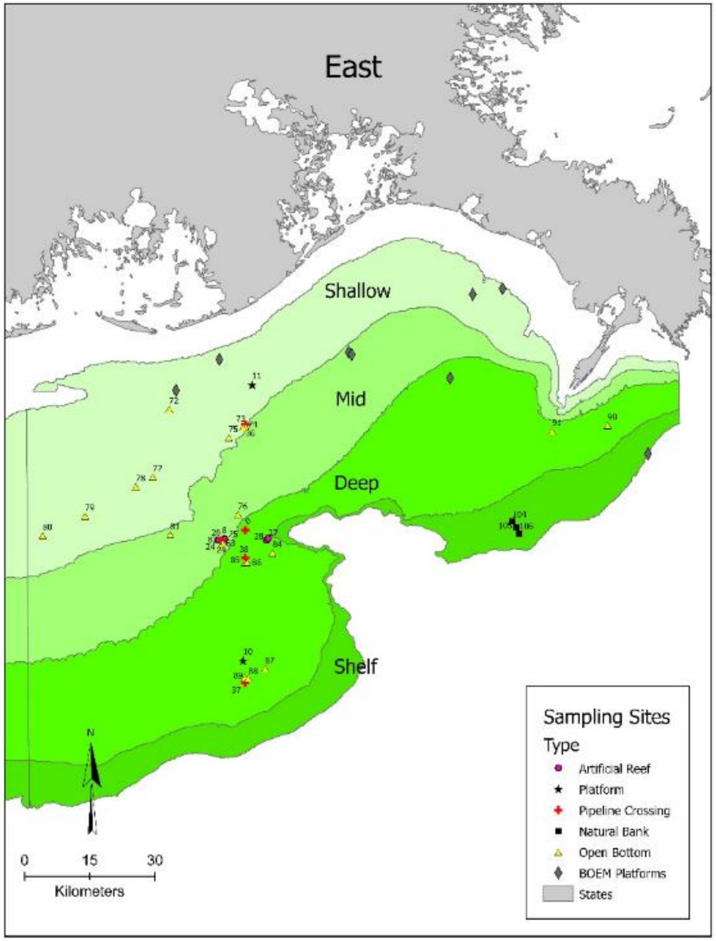
CENTRAL SAMPLING SITES



EAST REGION (36 SITES)

Site_num	Latitude	Longitude	Site type	Sample type	Type	region	depthzone	Name	Zone_ID	Preliminary Schedule
11	28.938154	-90.173564	Platform	Site appropriate hook and line	Platform	East	Shallow	East Shallow	9	July - August
36	28.856417	-90.190258	Pipeline Crossing	Site appropriate hook and line	Pipeline Crossing	East	Shallow	East Shallow	9	July - August
72	28.890083	-90.369979	Open Bottom	Trammel or Longline	Open Bottom	East	Shallow	East Shallow	9	July - August
73	28.851754	-90.190362	Open Bottom	Trammel or Longline	Open Bottom	East	Shallow	East Shallow	9	July - August
74	28.850503	-90.196183	Open Bottom	Trammel or Longline	Open Bottom	East	Shallow	East Shallow	9	July - August
75	28.830084	-90.230048	Open Bottom	Trammel or Longline	Open Bottom	East	Shallow	East Shallow	9	July - August
77	28.749947	-90.409725	Open Bottom	Trammel or Longline	Open Bottom	East	Shallow	East Shallow	9	July - August
78	28.729624	-90.450372	Open Bottom	Trammel or Longline	Open Bottom	East	Shallow	East Shallow	9	July - August
79	28.66991	-90.570649	Open Bottom	Trammel or Longline	Open Bottom	East	Shallow	East Shallow	9	July - August
80	28.630147	-90.670299	Open Bottom	Trammel or Longline	Open Bottom	East	Shallow	East Shallow	9	July - August
8	28.618102	-90.242191	Platform	Site appropriate hook and line	Platform	East	Mid	East Mid	10	July - August
24	28.617017	-90.256667	Artificial Reef	Site appropriate hook and line	Artificial Reef	East	Mid	East Mid	10	July - August
25	28.619583	-90.243267	Artificial Reef	Site appropriate hook and line	Artificial Reef	East	Mid	East Mid	10	July - August
26	28.619383	-90.2432	Artificial Reef	Site appropriate hook and line	Artificial Reef	East	Mid	East Mid	10	July - August
29	28.615382	-90.248006	Pipeline Crossing	Site appropriate hook and line	Pipeline Crossing	East	Mid	East Mid	10	July - August
76	28.670075	-90.209932	Open Bottom	Trammel or Longline	Open Bottom	East	Mid	East Mid	10	August - September
81	28.630169	-90.370072	Open Bottom	Trammel or Longline	Open Bottom	East	Mid	East Mid	10	August - September
82	28.611727	-90.247085	Open Bottom	Trammel or Longline	Open Bottom	East	Mid	East Mid	10	August - September
83	28.604154	-90.25125	Open Bottom	Trammel or Longline	Open Bottom	East	Mid	East Mid	10	August - September
9	28.570007	-90.172903	Platform	Site appropriate hook and line	Platform	East	Deep	East Deep	11	August - September
10	28.366093	-90.201843	Platform	Site appropriate hook and line	Platform	East	Deep	East Deep	11	August - September
27	28.61545	-90.14325	Artificial Reef	Site appropriate hook and line	Artificial Reef	East	Deep	East Deep	11	August - September
28	28.619467	-90.1394	Artificial Reef	Site appropriate hook and line	Artificial Reef	East	Deep	East Deep	11	August - September
37	28.320538	-90.198326	Pipeline Crossing	Site appropriate hook and line	Pipeline Crossing	East	Deep	East Deep	11	August - September
38	28.579346	-90.194461	Pipeline Crossing	Site appropriate hook and line	Pipeline Crossing	East	Deep	East Deep	11	August - September
84	28.590131	-90.1298	Open Bottom	Trammel or Longline	Open Bottom	East	Deep	East Deep	11	August - September
85	28.570487	-90.19453	Open Bottom	Trammel or Longline	Open Bottom	East	Deep	East Deep	11	August - September
86	28.57044	-90.190081	Open Bottom	Trammel or Longline	Open Bottom	East	Deep	East Deep	11	August - September
87	28.347647	-90.150624	Open Bottom	Trammel or Longline	Open Bottom	East	Deep	East Deep	11	September - October
88	28.331062	-90.198177	Open Bottom	Trammel or Longline	Open Bottom	East	Deep	East Deep	11	September - October
89	28.33063	-90.190188	Open Bottom	Trammel or Longline	Open Bottom	East	Deep	East Deep	11	September - October
90	28.844233	-89.3365	Open Bottom	Trammel or Longline	Open Bottom	East	Deep	East Deep	11	September - October
91	28.83445	-89.4674	Open Bottom	Trammel or Longline	Open Bottom	East	Deep	East Deep	11	September - October
104	28.6475	-89.564722	Sackett bank	Site appropriate hook and line	Natural Bank	East	Shelf	East Shelf	12	September - October
105	28.6475	-89.564722	Sackett bank	Site appropriate hook and line	Natural Bank	East	Shelf	East Shelf	12	September - October
106	28.6475	-89.564722	Sackett bank	Site appropriate hook and line	Natural Bank	East	Shelf	East Shelf	12	September - October

EAST SAMPLING SITES



Sampling Methods

Hydroacoustic: Jack Egerton
Other: Benny J. Gallaway

HYDROACOUSTIC METHODS OVERVIEW

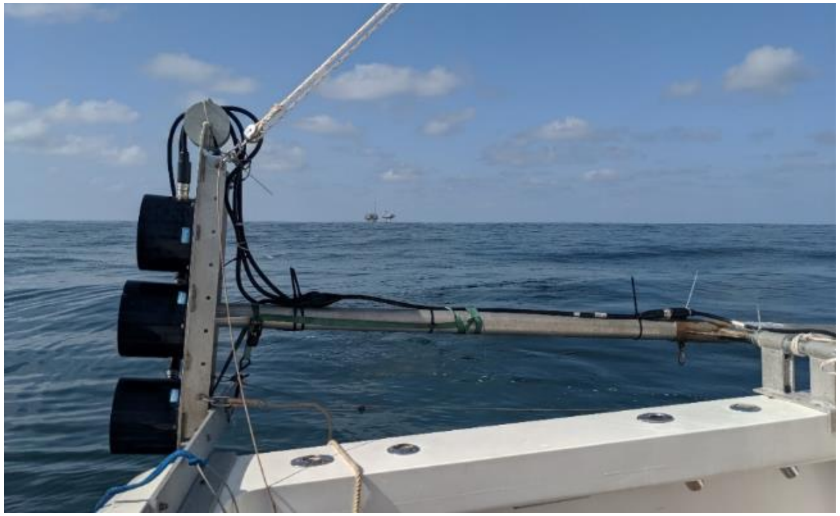
- Field methods
- Calibration
- The echogram
- Data processing overview
- Multifrequency analysis overview
- Dataflow in Echoview
- Noise removal
- Decibel differencing
- Single targets and Multiple echoes
- Target Strength (TS)
- Fish Density
- Bait school removal
- Geographic Analyses and fish abundance calculations
- Application of SRV data
- Comparisons with GRSC

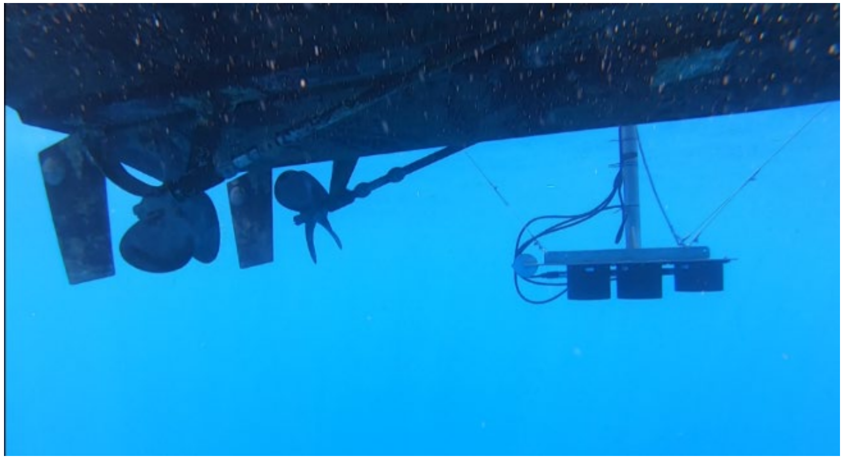
HYDROACOUSTIC METHODS

- BioSonics DTX Hydroacoustic echosounder deployed on collaborating fishing vessels.
- Pole mounted.
- Standard calibration procedures conducted on every trip.
- YSI EXO Sonde

MULTI-FREQUENCY TECHNIQUES

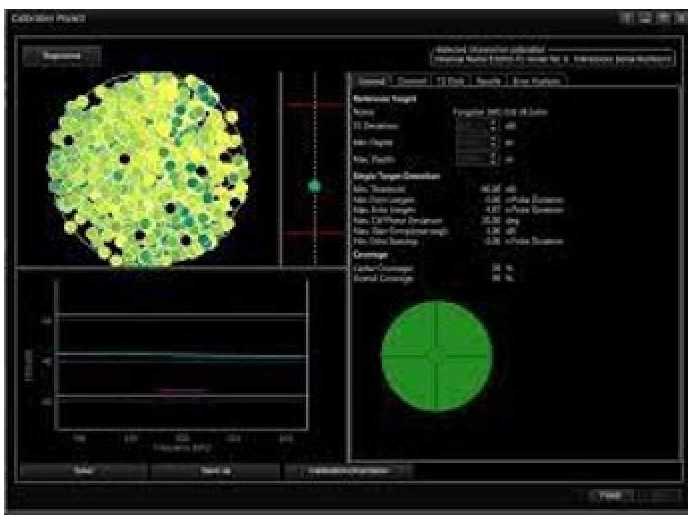
- 3 transducers with distinct frequencies
  - 38 kHz
  - 70 kHz
  - 120 kHz

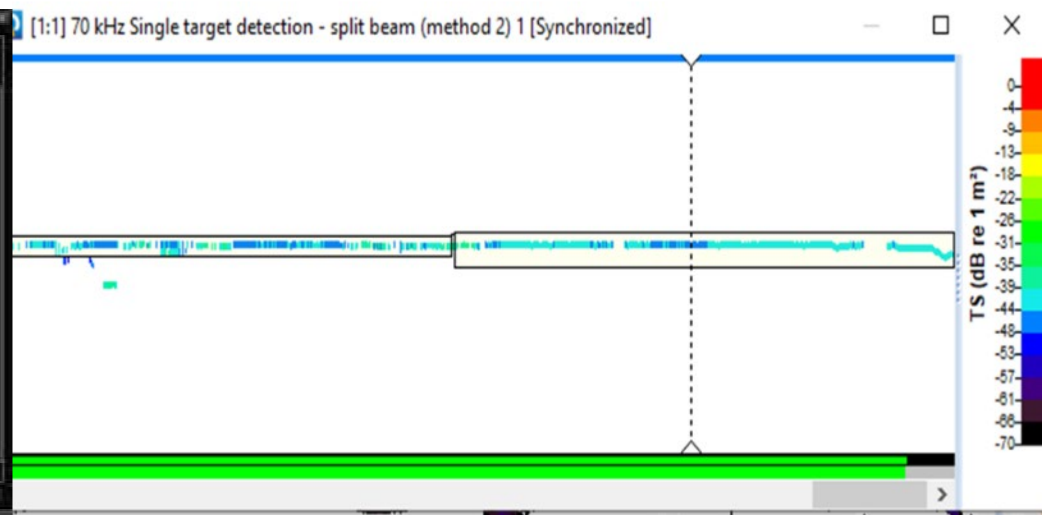




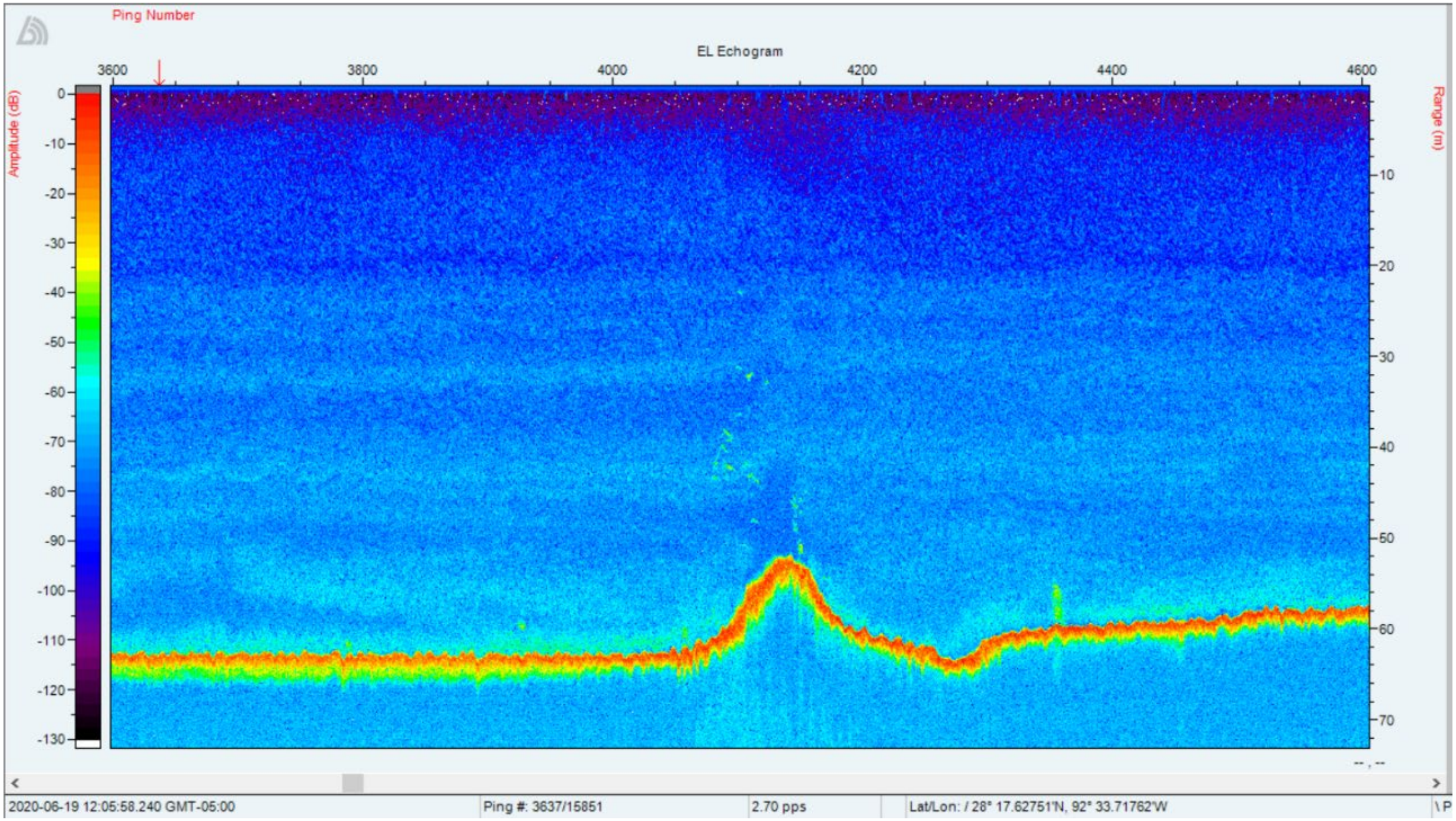
CALIBRATION

- Tungsten carbide standard spheres (following Foote et al., 1987)
- Environmental Data
- Calibration Software
- Processed in Echoview





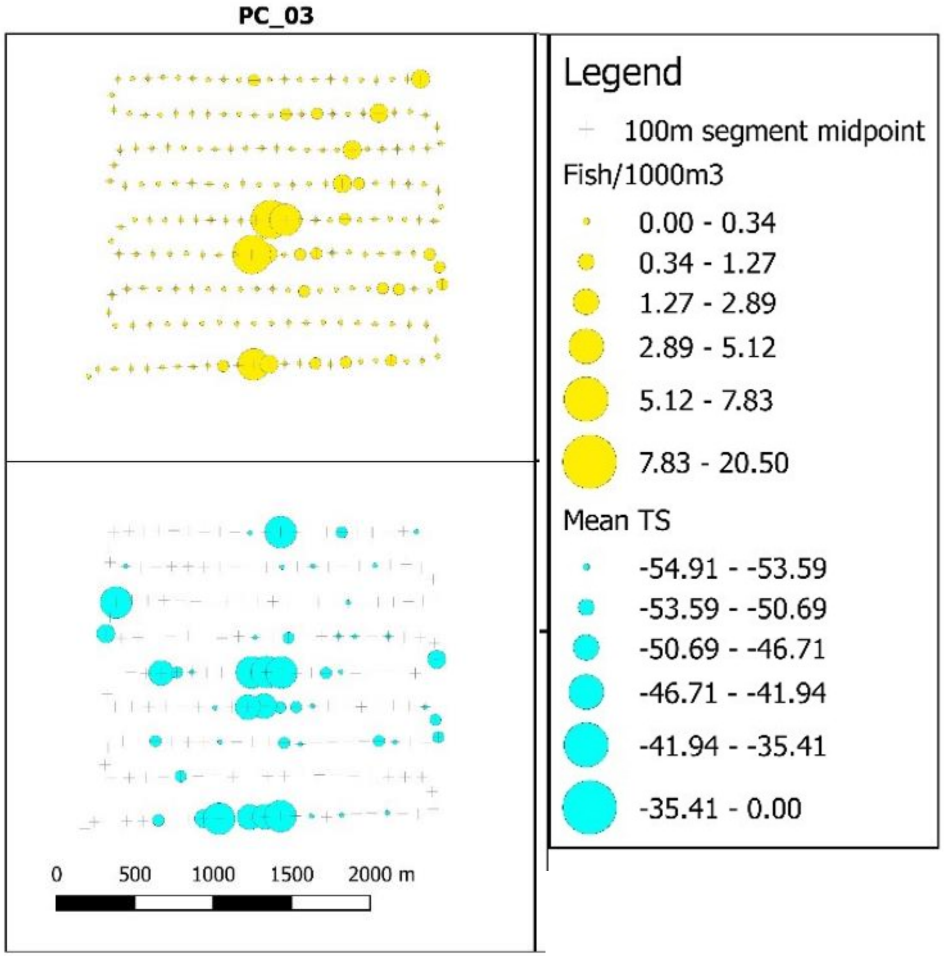
RAW DATA ECHOGRAM



UCB Site A13

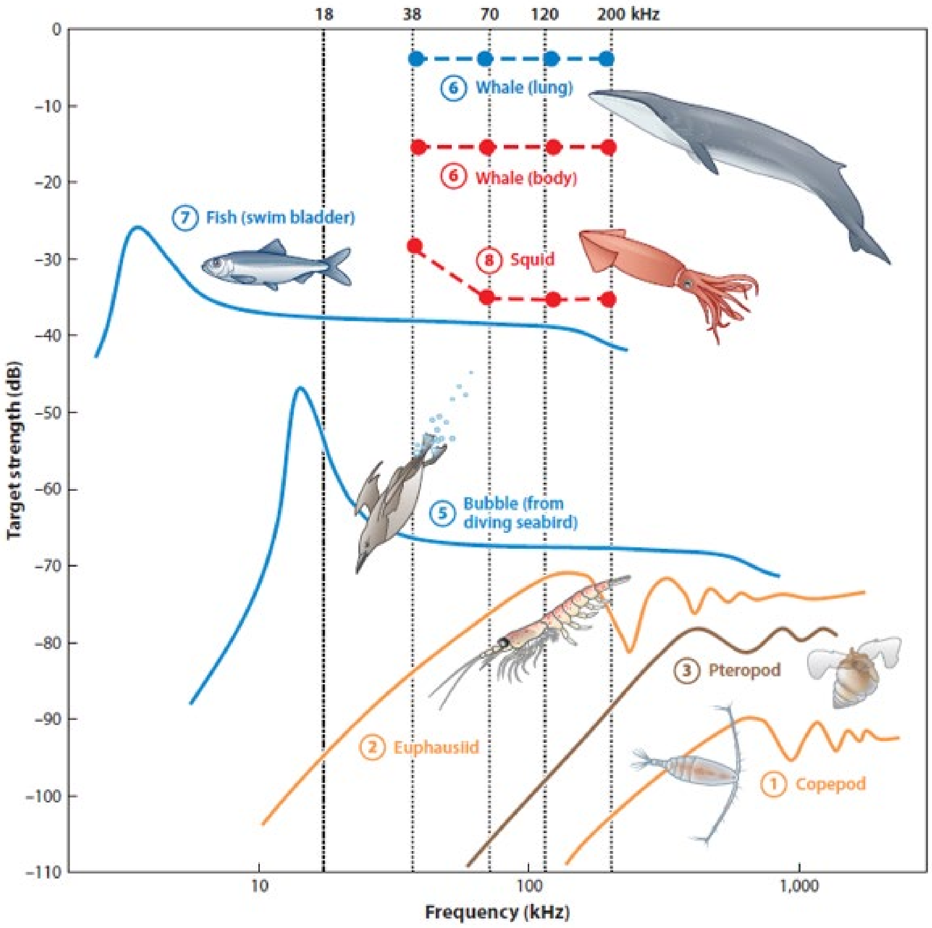
HYDROACOUSTIC DATA PROCESSING

- Raw data processed in **Echoview v11** software.
- Data filtered for swimbladdered fish and to remove noise.
- Used echo integration method – total biomass (Sv) scaled by mean Target Strength (single fish signals in situ).
- Data exported as fish density in 20m analysis cells per 10m vertical layer.



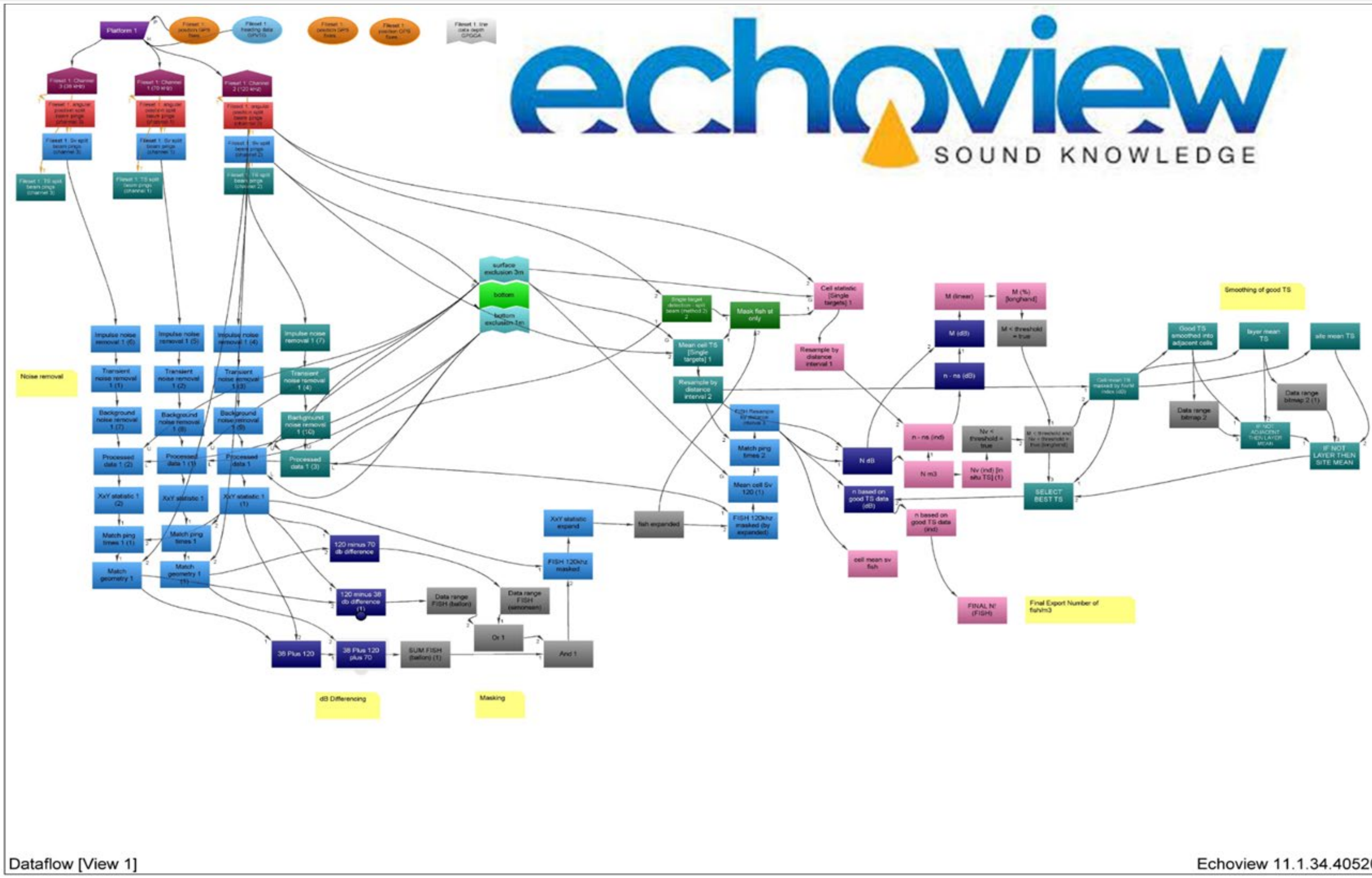
MULTI-FREQUENCY TECHNIQUES

- Different frequencies produce different target strength responses, depending on the target type.
- Allows filtering of types of organisms (i.e. Swimbladdered fish vs non-swimbladdered organisms and plankton).
- Focused observation and analysis on target species assemblage (reef fish) and excluded sharks and non-target species which could possibly confound results.

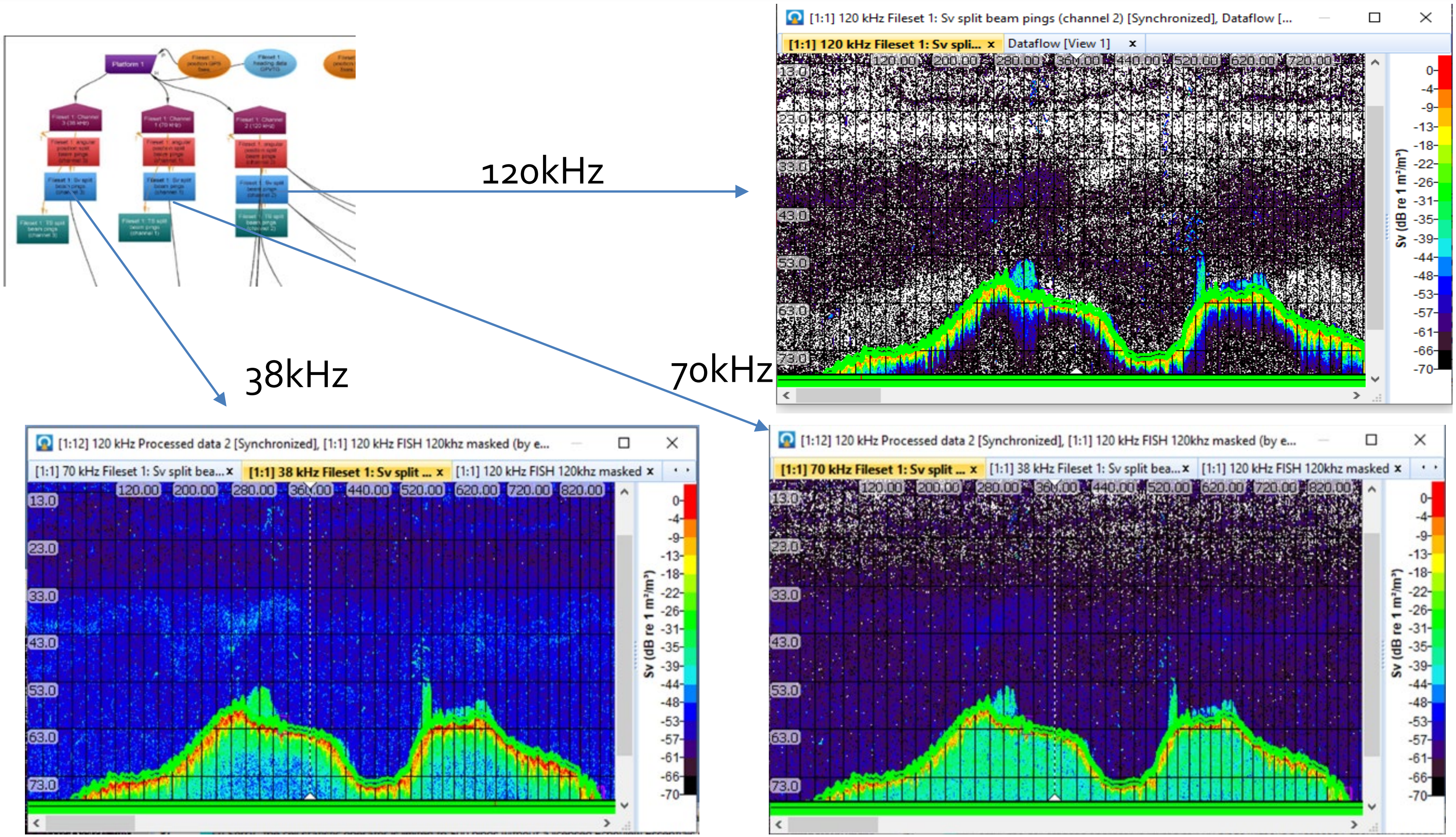


Reproduced from: Benoit-Bird, KJ and Lawson, GL. 2016. Ecological Insights from Pelagic Habitats Acquired Using Active Acoustic Techniques. Annual Review of Marine Science 8:1, 463-490.

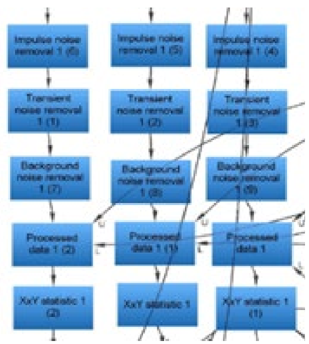
HYDROACOUSTIC ANALYSES NOT SIMPLE



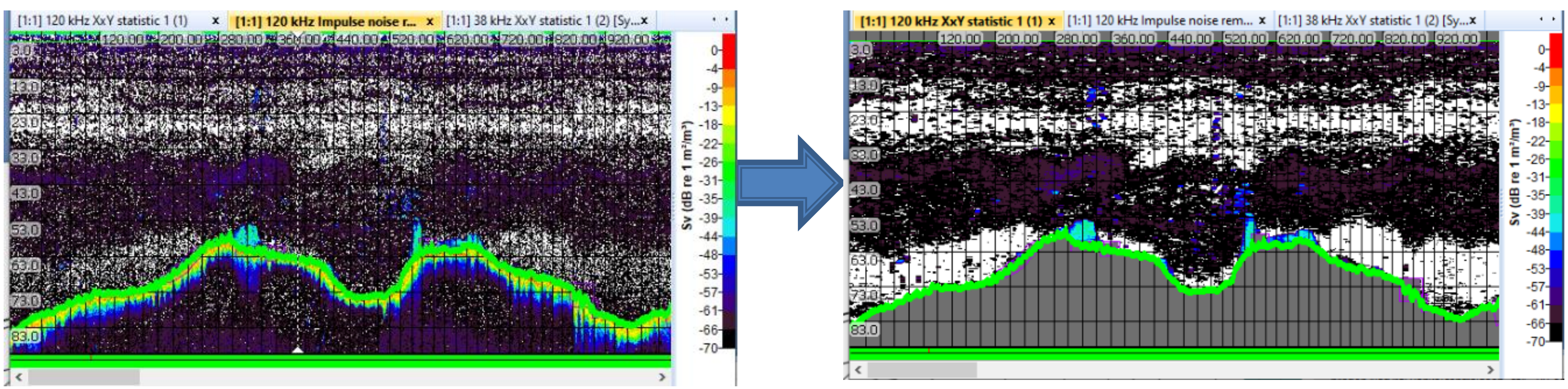
DATA PROCESSING



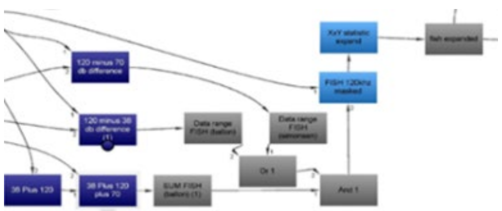
NOISE REMOVAL AND DATA PREPARATION



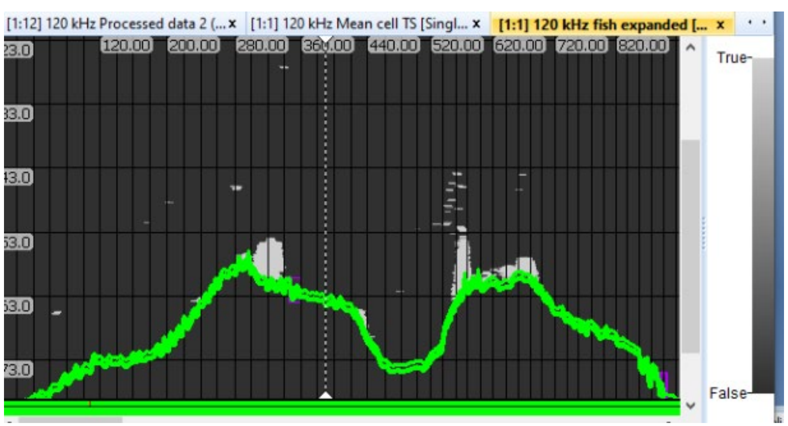
- 1. The impulse noise (IN) removal filter removes sound spikes
- 2. Then transient noise (TN) removal was applied following Ryan et al, (2015).
- 3. Finally, a Background noise (BN) filter was used, this operator estimates the background-noise level and subtracts it from the value of each sample (De Robertis and Higginbottom, 2007).
- 4. Remaining noise (etc.) removed "by eye".
- 5. Smoothing (Korneliussen et al. 2009) and data removal below seabed and 3 m surface exclusion.

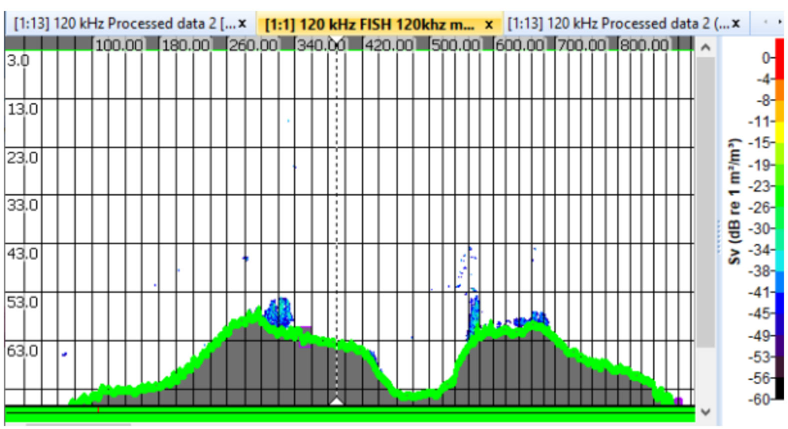


DECIBEL DIFFERENCING



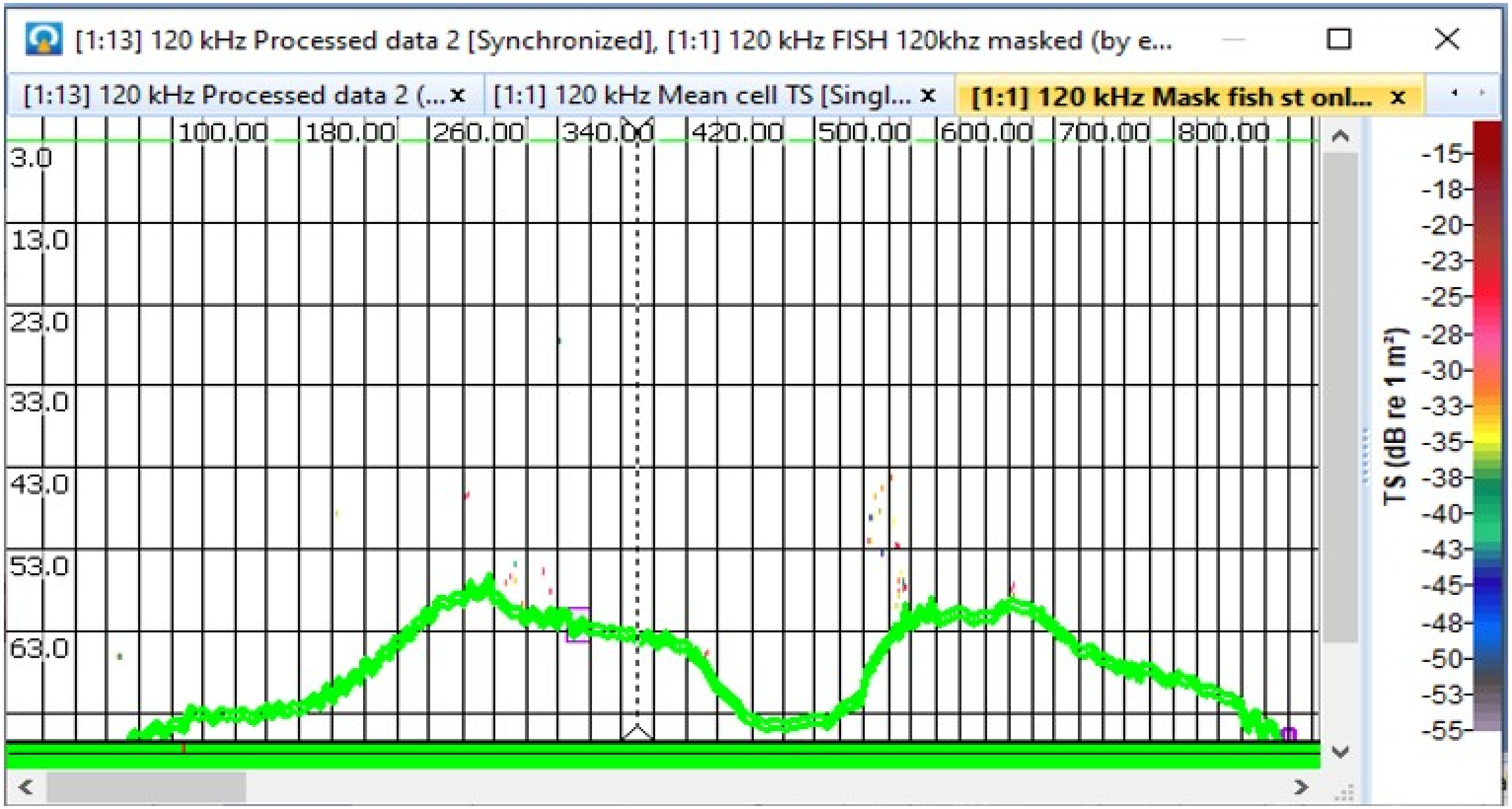
- Sv 120kHz- 70kHz data had to be between -15 and 1. following Reynolds et al. (2018) and Simonsen (2013)
- Sv 120kHz-38kHz <3dB was used to apportion also swimbladdered fish following Ballon et al. (2011) and Lezama-Ochoa et al. (2011)
- 120+70+38<-170dB. This summation assists in determining fishes of interest as it retains only those that exist on all frequencies (Fernandes 2009, Ballon et al. 2011).
- Sv -50dB threshold





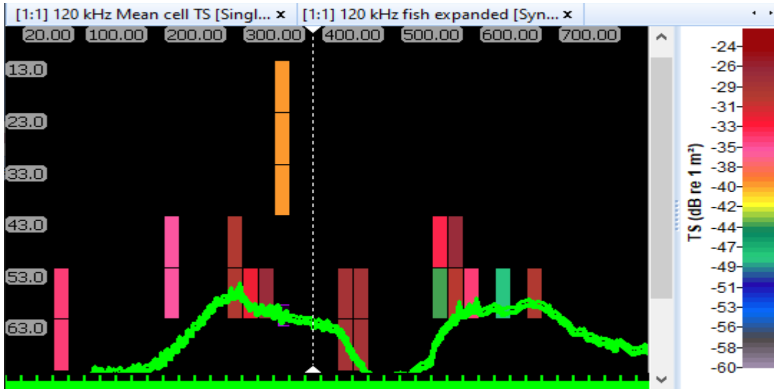
SINGLE TARGETS

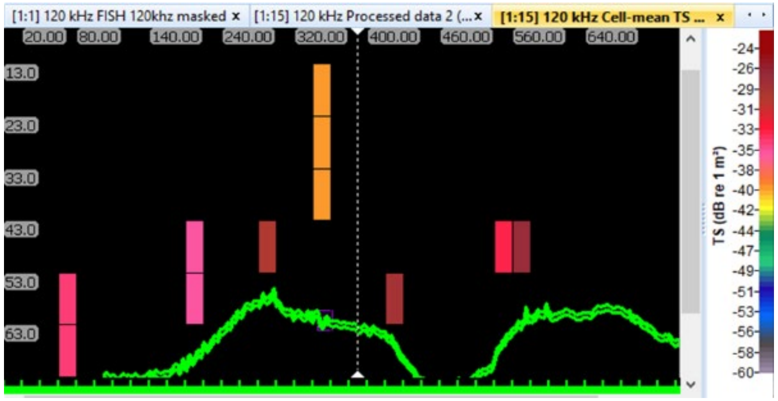
- Mask from the decibel differencing also used to mask TS data.
- TS threshold of -50 dB



TARGET STRENGTH (TS)

- Resultant from single targets.
- But also have to be filtered to remove "multiple echoes" (Sawada et al. 1993)
- Nv index (Nv<0.1)
- M % of multiple echoes (<70%)
- Not accounting for these can cause TS to be overestimated, resulting in an underestimation of fish density (Kocovsky et al. 2013).

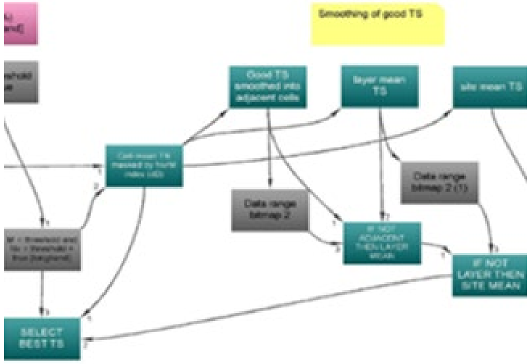


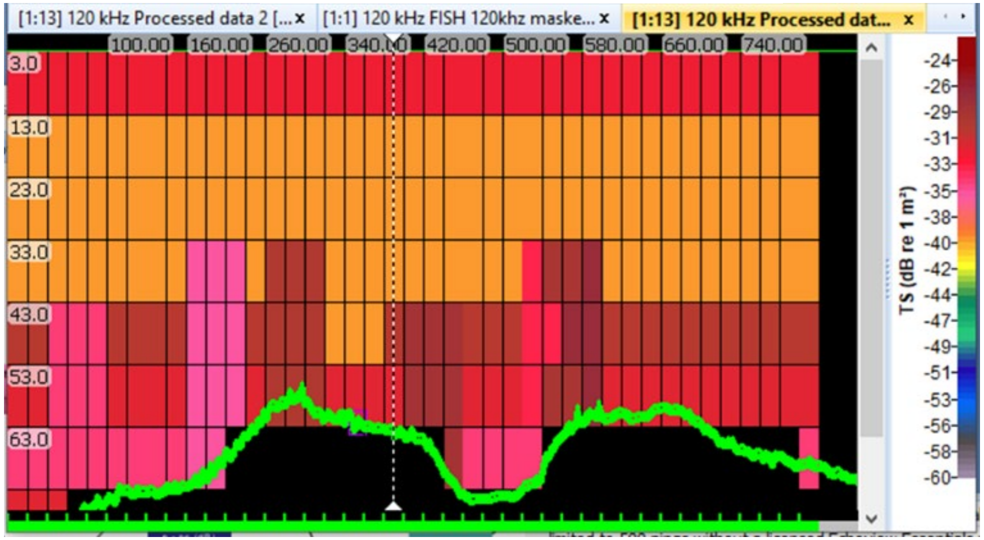


SMOOTHING OF TS

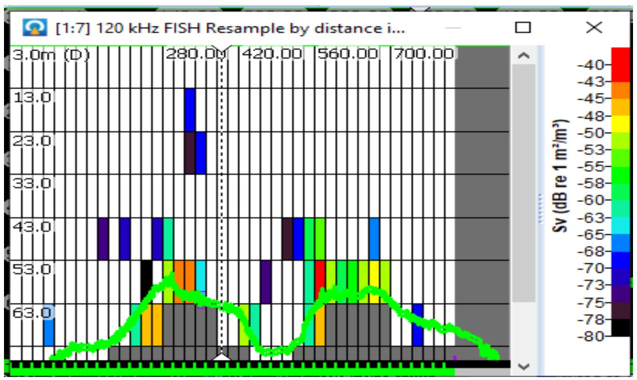
- Order of preference:

1. TS from the same cell
2. TS from adjacent cell
3. Mean TS from layer
4. Mean TS from site





FISH DENSITY (N)



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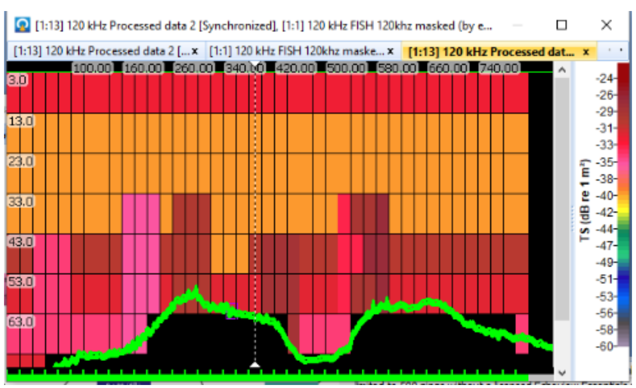

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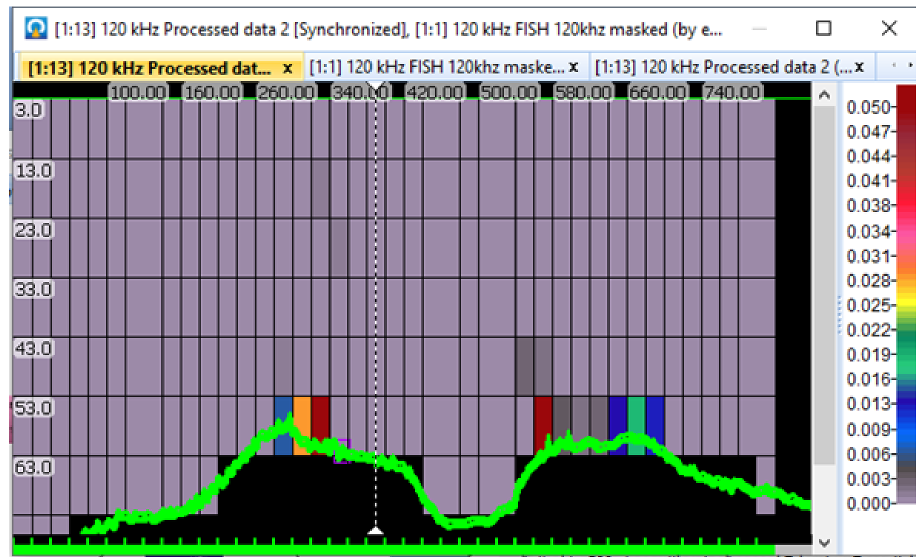
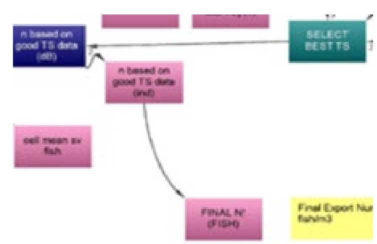
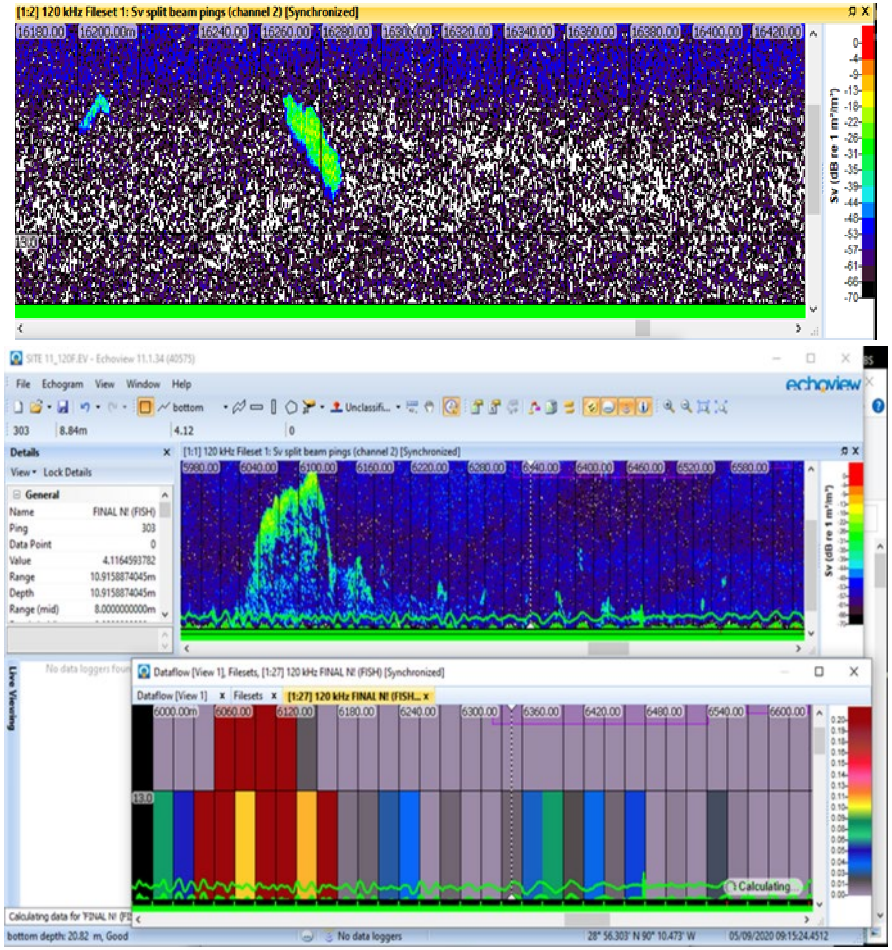
- Number of fish/m^3 per each acoustic 20 m x 10 m cell





BAIT SCHOOL REMOVAL

- Result in very high densities that could skew abundance, hence were removed.
- These were defined as having a dense monotone look, often in a spherical nature, and when individual fish within them could not be discerned.



HABITAT TYPE SURVEY METHODS

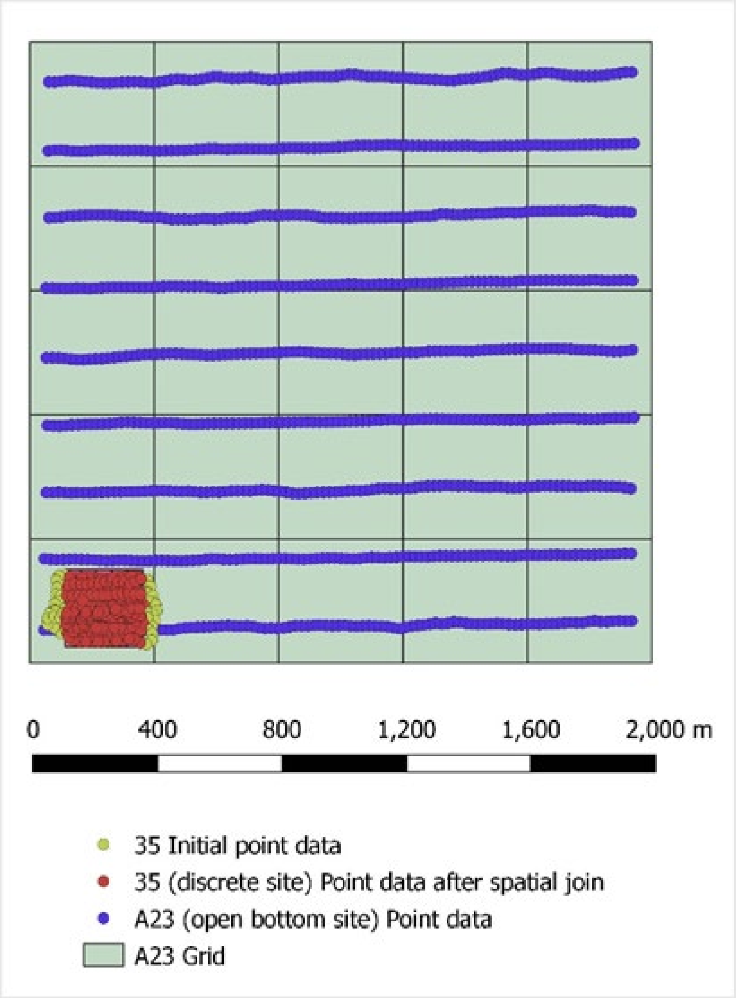
Habitat Type	Number of Transects	Sampling Area Dimensions	Area Sampled (m^2)	Aglen Ratio (>6 required)	Grid Cell Size (m^2)
Platform	11*	250 m x 250 m	62,500	11	50 m x 50 m
Artificial Reef	11	250 m x 250 m	62,500	11	50 m x 50 m
Pipeline Crossing	11	250 m x 250 m	62,500	11	50 m x 50 m
Natural Bank	11	500 m x 500 m	250,000	11	100 m x 100 m
Uncharacterized Bottom	9	2000 m x 2000 m	4,000,000	10	400 m x 400 m

*Additional spiral transects conducted in order to maneuver around standing structures

FISH ABUNDANCE CALCULATIONS

- Final density values/m^3 per analysis cell calculated through the division of Sv by the best available *in situ* TS.
- Exported to spreadsheet.
- Converted to density /m^2 through multiplication of acoustic cell thickness, and blank cells dealt with.
- Exported to QGIS.
- Spatial join to provide values in each grid cell.
- Exported back to Excel and abundance gained through density /m^2 x area of analysis grid.
- Finally, all data input into pivot table to provide mean density and abundance values per grid cell for every depth layer.

QGIS



GRSC HYDROACOUSTIC COMPARISON

- Similar techniques overall.
  - Both studies calculated fish density, then converted to abundance using the volume of water investigated.
  - Proportioned abundance using camera data and the MaxN metric.
  - Primarily used Echo Integration methods and in situ Target Strength measurements.
    - GRSC combined Echo Counting methods at times (e.g. when fish were more dispersed at a site).

GRSC HYDROACOUSTIC COMPARISON

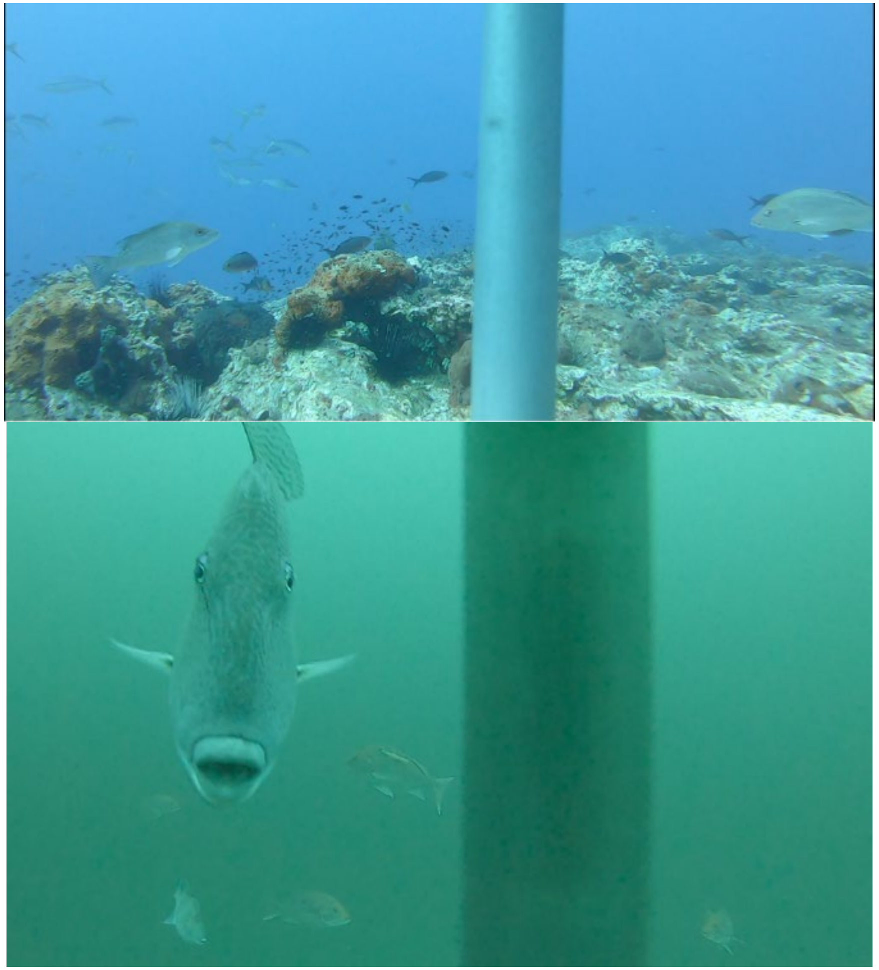
- Differences
  - GRSC used different methods in each region within the study.
    - LGL mostly similar to methods used in FL, different from methods in TX (4 frequencies in FL, 1 frequency in TX)
      - FL multi-frequency analysis used echogram summation to filter organism types. LGL used a combination of echogram summation and decibel differencing (subtraction) to filter swimbladdered fish, based on previous literature.
    - Decibel thresholds for Target Strength were the same between LGL and FL, but Sv thresholds used in FL were lower. TX thresholds were less conservative.
  - GRSC used a kriging interpolation to analyze final densities, as opposed to grid analysis.

SUBMERSIBLE ROTATING VIDEO (SRV)

- Discrete Sites
  - Dropped near structure
  - 5 minutes (>10 rotations 360˚) recorded every 10 m layer of water column at predetermined depths to match hydroacoustic data.
- Target drops
  - Opportunistically dropped to capture fish assemblages and points of interest on Discrete and UCB Sites.

SRV ANALYSIS

- Identified all fish to lowest possible taxon.
- Recorded relative abundance of each species using MaxN (maximum number of a species in any single frame).
- Recorded for every 10m depth layer.

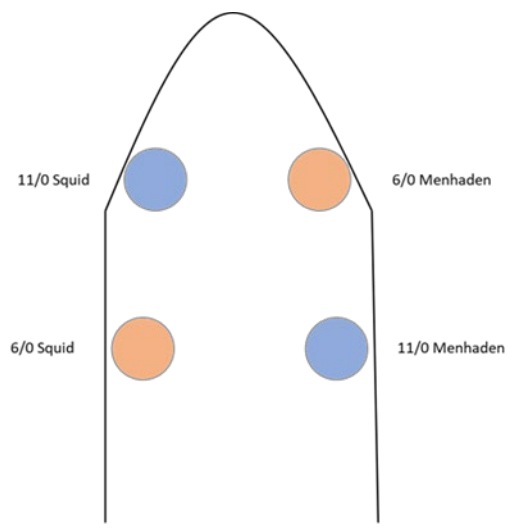


SRV ANALYSIS

- Relative species abundances were converted to composition percentages to apportion hydroacoustic abundances.
  - Proportions applied to fish abundances at each 10m depth layer.


VERTICAL HOOK-AND-LINE SAMPLING FOR LENGTH, WEIGHT, SEX AND AGE COMPOSITION

- Vertical hook-and-line sampling was conducted at each discrete habitat included in the study (platforms, artificial reefs, pipeline crossings, Natural Banks.
- Sampling gear consisted of two hook sizes (6.0, 11.0) and two bait types (squid and menhaden) allowing for 4 bait-hook combinations.
- Only one bait-hook combination was fished on an individual pole, and each bait-hook combination was fished an equal amount of time at each site.
- As fish were caught and brought on board, they were placed corresponding shrimp baskets indicating which combination of bait-hook type had been used.



VERTICAL HOOK-AND-LINE SAMPLING

- Large fish were not rare, especially at pipeline crossings and artificial reef sites.

VERTICAL HOOK-AND-LINE SAMPLING FOR LENGTH, WEIGHT, SEX AND AGE COMPOSITION

- Fish were returned to dock for processing on the same day, typically late in day or at night.

- All specimens were weighed, measured, sexed; and for Red Snapper otoliths were extracted, cleaned and stored in a labeled envelope.

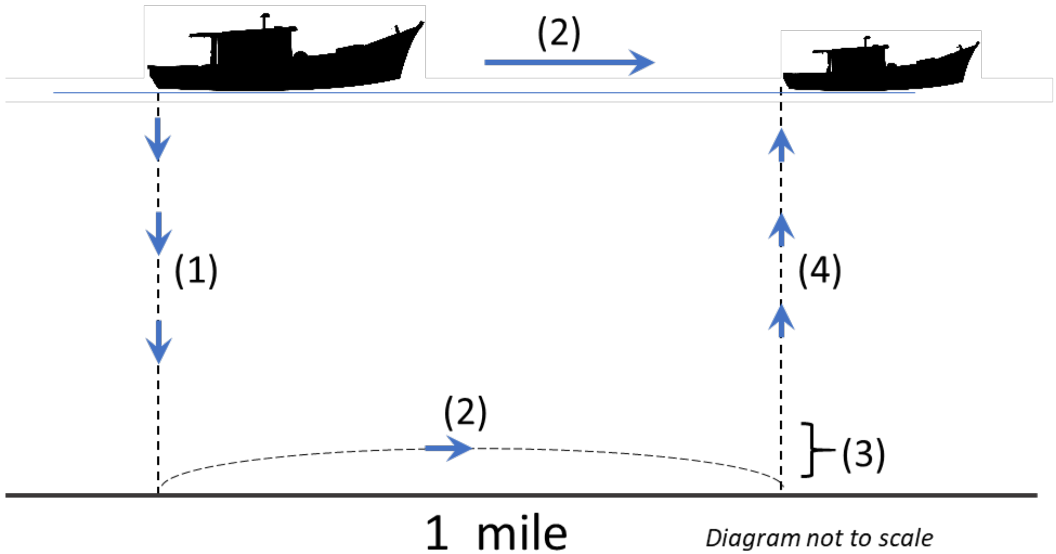
VERTICAL HOOK-AND-LINE SAMPLING

- Once fish were processed, they were stored on ice and transported to charity organizations.

MARK RECAPTURE METHODS

- Conducted mark/recapture studies at six (6) sites (3 platforms and 3 artificial reefs).
- One set of experiments performed in each of the 3 regions in the mid-depth zone of each.
- Double tagged dorsally; fish were caged released.

TOWED UNDERWATER VIDEO METHODS



(1) Vertical deployment
(2) Towing at 3 – 5 knots;
    no additional scope
    camera position arc
(3) Filming 0 – 10 m above the bottom
(4) Vertical retrieval

UNDERWATER VIDEO TOW SLED DETAIL

Side view

Front view

Video Camera: GoPro Hero 7 Black

- ISOTTA Housing (rated to 200 m)
- 1440 resolution, 60 fps, 4x3 Wide, no zoom
- HyperSmooth video stabilization
- Field of View: 94.4° Vertical 122.6° Horizontal

TOWED UNDERWATER VIDEO METHOD DETAIL

Notes: Sled was towed without adding additional scope to avoid bottom snags while capturing the focal depth area at between 0 and 10 m above the bottom, depending on water depth and water clarity.

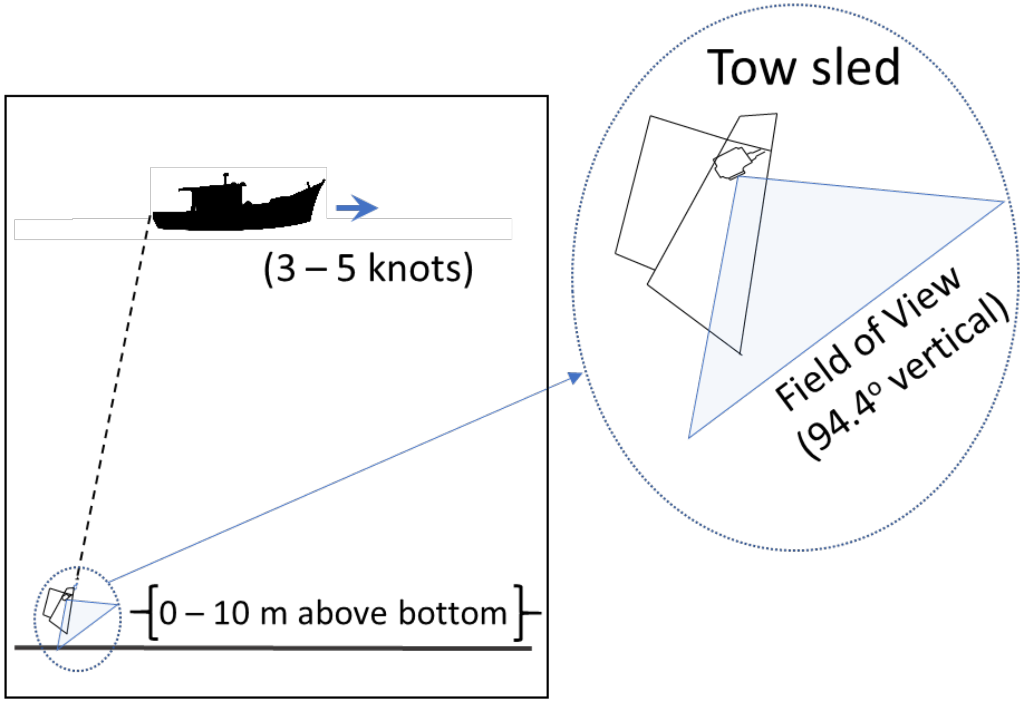
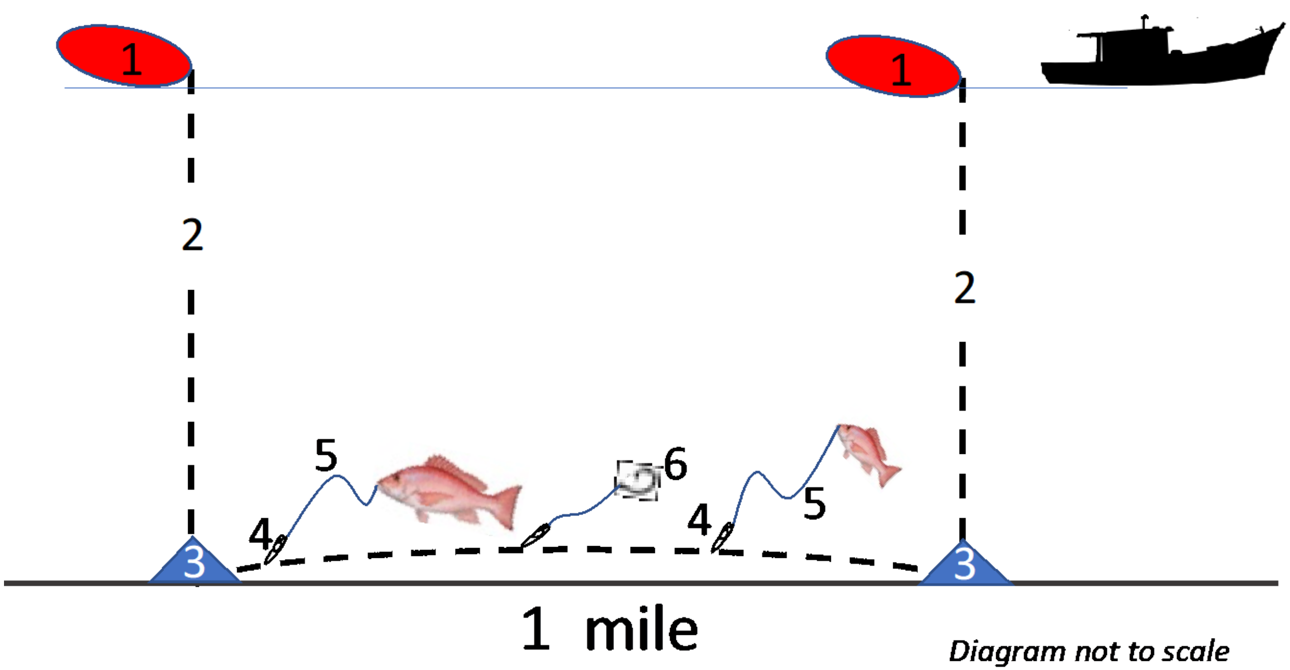


Diagram not to scale

BOTTOM LONGLINE METHODS

- 1 mile of longline with weights and floats at each end.
- 1400 lb. test monofilament mainline.
- 3 ft. gangions of 80 lb. test.
- 74 hooks baited with squid.
- alternating 6/0 and 11/0 circle hooks.

BOTTOM LONGLINE METHODS



1. Buoy
2. Mainline (1400 lb. test)
3. Weight (20 – 40 lbs.)
4. snap clip
5. gangion (3 ft. 80 lb. test)
6. Circle hook (11/0 and 6/0)

ALSO LOTS OF BIG RED SNAPPER OVER UNCHARACTERIZED BOTTOM

- 183 Red Snapper used for composition sampling.
- Ages ranged 2 - 25 years (average of 8.6 years).
- Mean weight: 9.4 lbs.
- Max weight 18.4 lbs.
- Mean length of 25.57 inches (64.9 mm).

DOCKSIDE CATCH COMPOSITION MEASUREMENTS - LONGLINE

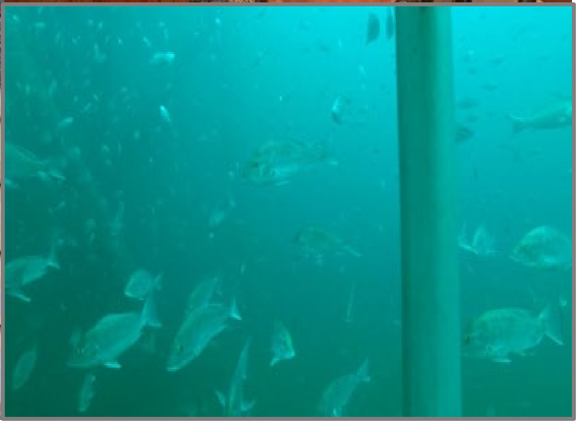
FATE OF CAPTURED FISH

Red Snapper were carefully iced from capture through processing after which they were donated to charities.

LABORATORY ANALYSES

LABORATORY ANALYSES

- Most of the laboratory time was devoted to analyzing videotapes of fish within habitat type and analyzing ootilths to determine Red Snapper age.



Statistical Modeling to Estimate Red Snapper Abundance

(Scott Raborn)

RESPONSE OF INTEREST

- Ultimately, Red Snapper abundance was determined for a given stratum based on the product of three estimates:
  - Total fish density (TFD) sampled with hydroacoustics
  - Proportion of TFD that were Red Snapper (PropRS) sampled with SRV
  - Area or number of structures for the entire stratum estimated from appropriate databases as described above.

VARIABLES DEFINING STRATA

- Strata were defined by combinations of the following three categorical variables:
  - Region (East, Central, and West)
  - Depth Zone (10-25 m, 25-45 m, and 45-150 m)
  - Habitat type:
    - Natural (Natural Banks and Uncharacterized Bottom)
    - Manmade (Artificial reefs, Standing Platforms, and Pipeline Crossings)

VARIABLES DEFINING STRATA (CONT.)

- A fourth variable, Vertical Depth Band, although ordinal in nature, was ultimately treated as a continuous variable.
  - For each site, the distance from the center of each depth band to the bottom was estimated and used as a covariate term.

APPROACHES TO ESTIMATING TOTAL RED SNAPPER ABUNDANCE

- In the Mean Site Abundance approach, site-specific estimates were made before extrapolation.
  - TFD and PropRS were multiplied at the site-specific level
  - All sites within a defined stratum were averaged before being extrapolated to the entire stratum area or number of structures
- In the Modeling Approach, TFD and PropRS were estimated separately for each stratum before being combined and extrapolated.

PROBLEMS WITH SITE-SPECIFIC ESTIMATION APPROACH

- Sampling error magnification
- For example:
  - Let’s say we accurately estimated TFD (or abundance in this case) to be 2,000 fish; unknowingly, half were Red Snapper and half were Atlantic Bumper.
  - But the SRV only recorded 10 fish, nine of which were Atlantic Bumper.
  - The Red Snapper estimate would then be biased low (i.e., 200 instead of 1,000).
- A large apportionment error weighted by a large TFD for a single site would likely result in a spurious conclusion for a given stratum when averaged in with the other respective sites.

ADVANTAGES OF OUR MODELING APPROACH

- We argue that the better approach was to use the categorical variables defining the strata along with pertinent environmental covariates in separate statistical models that predicted TFD and PropRS.
- Outputs from these models were then multiplied to predict Red Snapper density (or abundance) for each stratum.
- Random errors in PropRS estimates had a greater chance of canceling each other across sites before being multiplied by TFD.

FINAL MODEL SPECIFICATION FOR PROP RS

$$Prop\ Red\ Snapper = Region + zTemp + HabitatType|\ s(zDistFrom\ Bottom)$$

- Covariates Temperature and Distance from Bottom were standardized to z-scores
- The operator "|" indicates an interaction of two terms with all the corresponding main effects.
- s() indicates a thin plate smoothing spline was used to relax the linear assumption.
- Thus, we specified a generalized additive model (GAM) for the binomial response, *PropRS.*
- Parameterized with the gam function in the mgcv Package for R.

FINAL MODEL SPECIFICATION FOR TFD

$$TFD = zDO + zTemp + HabitatType|\ s(zDistFromBottom) + Region|s(zDistFromBottom) + DepthZone|\ s(zDistFromBottom)$$

- Same fixed effect variables considered as for PropRS.
- Salinity was dropped from consideration due to collinearity with Temperature and DO.
- Volume of water sampled at each site-depth band combination was entered as an offset.
- The intercept was allowed to vary randomly across sites.
- Thus, we specified a generalized additive mixed model (GAMM) for the response, *TFD*, whose units were fish per m^3.
- TFD was assumed to follow the tweedie exponential family distribution with variance given by the mean to the power *p* (estimated to be ~1.7).

COMBINING MODEL OUTPUTS

- For each Region-Depth Zone-Habitat Type-Vertical Depth Band combination, PropRS and TFD were predicted.
- All covariates were held at their observed averages within each stratum.
- RS density (Red Snapper per m^3) was estimated as the product of PropRS and TFD.

VARIANCE PROPAGATION

- The arithmetic variance of TFD was given by the method of moments estimator:

$$Var[TFD] = e^{2\mu+\sigma^2}\left(e^{\sigma^2} - 1\right)$$

- Goodman's (1960) variance of products estimator:

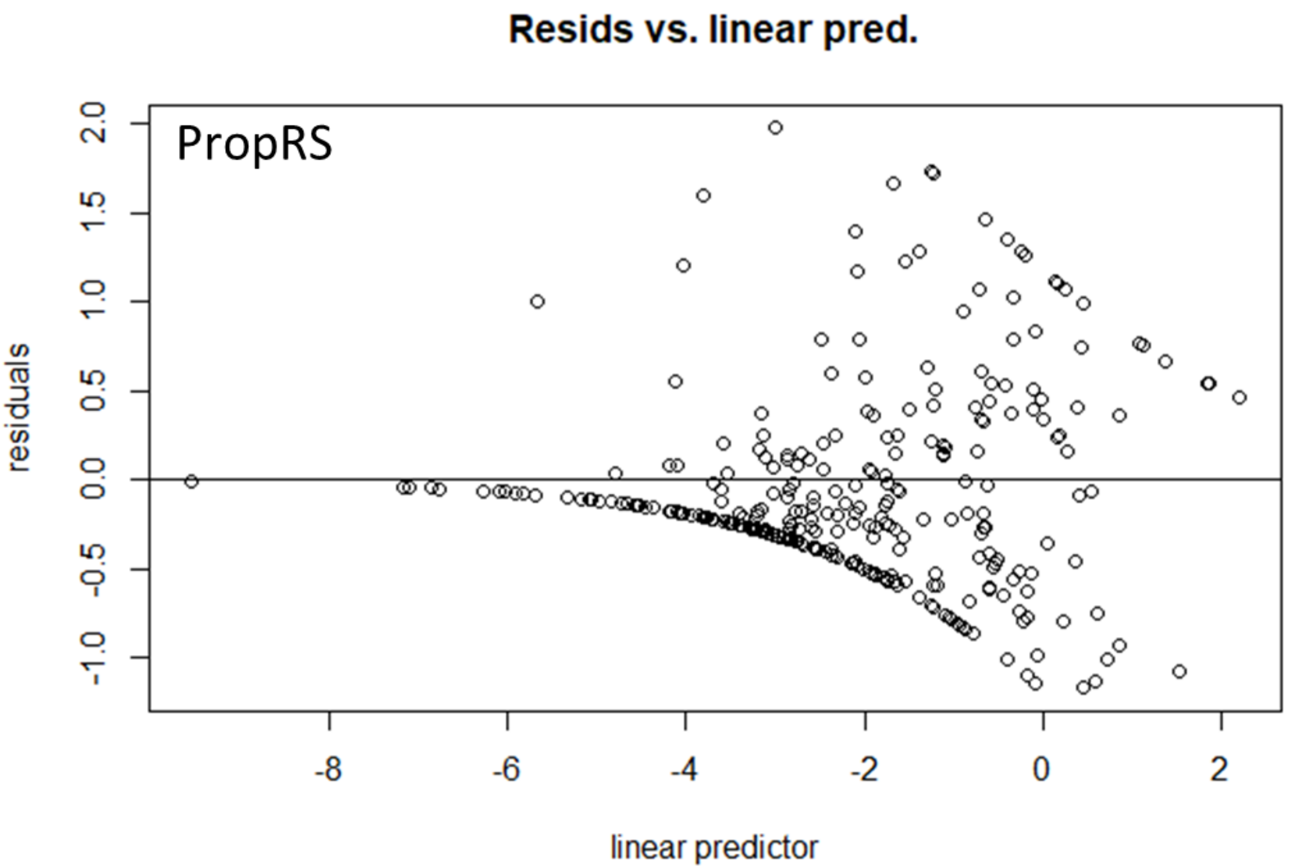
$$Var[PropRS * TFD]$$
$$= PropRS^2 Var[TFD] + TFD^2 Var[PropRS] - Var[TFD] * Var[PropRS]$$

- TFD and PropRS were not correlated; thus, their covariance was ignored.

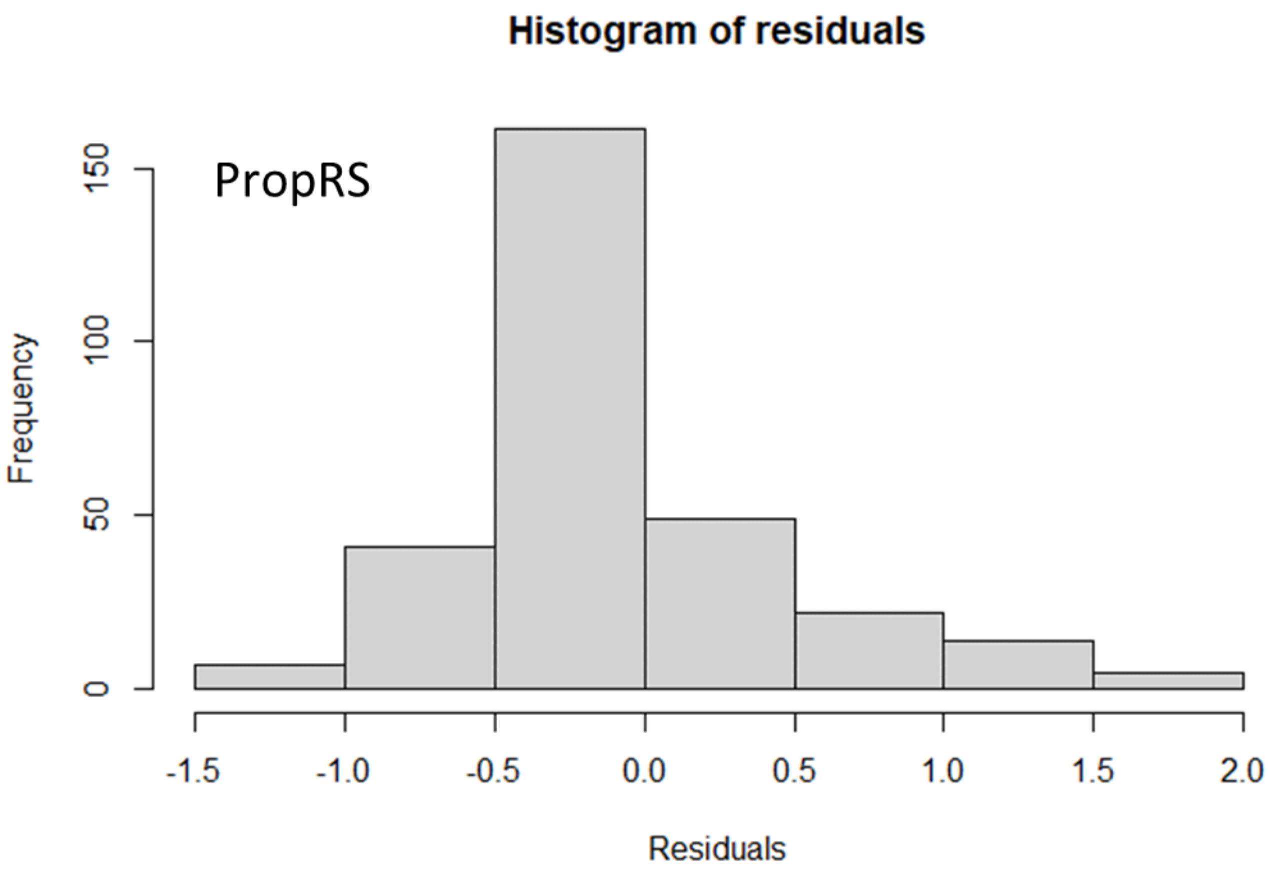
EXTRAPOLATING RED SNAPPER DENSITY TO OVERALL ABUNDANCE

- Red snapper per m^3 was converted to per m^2 based on the average width of each vertical depth band for each stratum combination with variances expanded accordingly.
- Total abundances for Natural Banks and Uncharacterized Bottom were then determined using the total areas of these habitats as multipliers for their respective estimated densities.
- For Standing Platforms, Artificial reefs, and Pipeline Crossings the predicted number of Red Snapper per structure was multiplied by the total number of structures.
  - Red Snapper per structure was estimated by assuming the average area covered at a sampling site subsumed all Red Snapper present at a typical site.
  - These areas were 62,500 m^2 for Artificial Reefs and Pipeline Crossings and 42,000 m^2 for Platforms (equates to a sampling radius of about 115 m from the center).

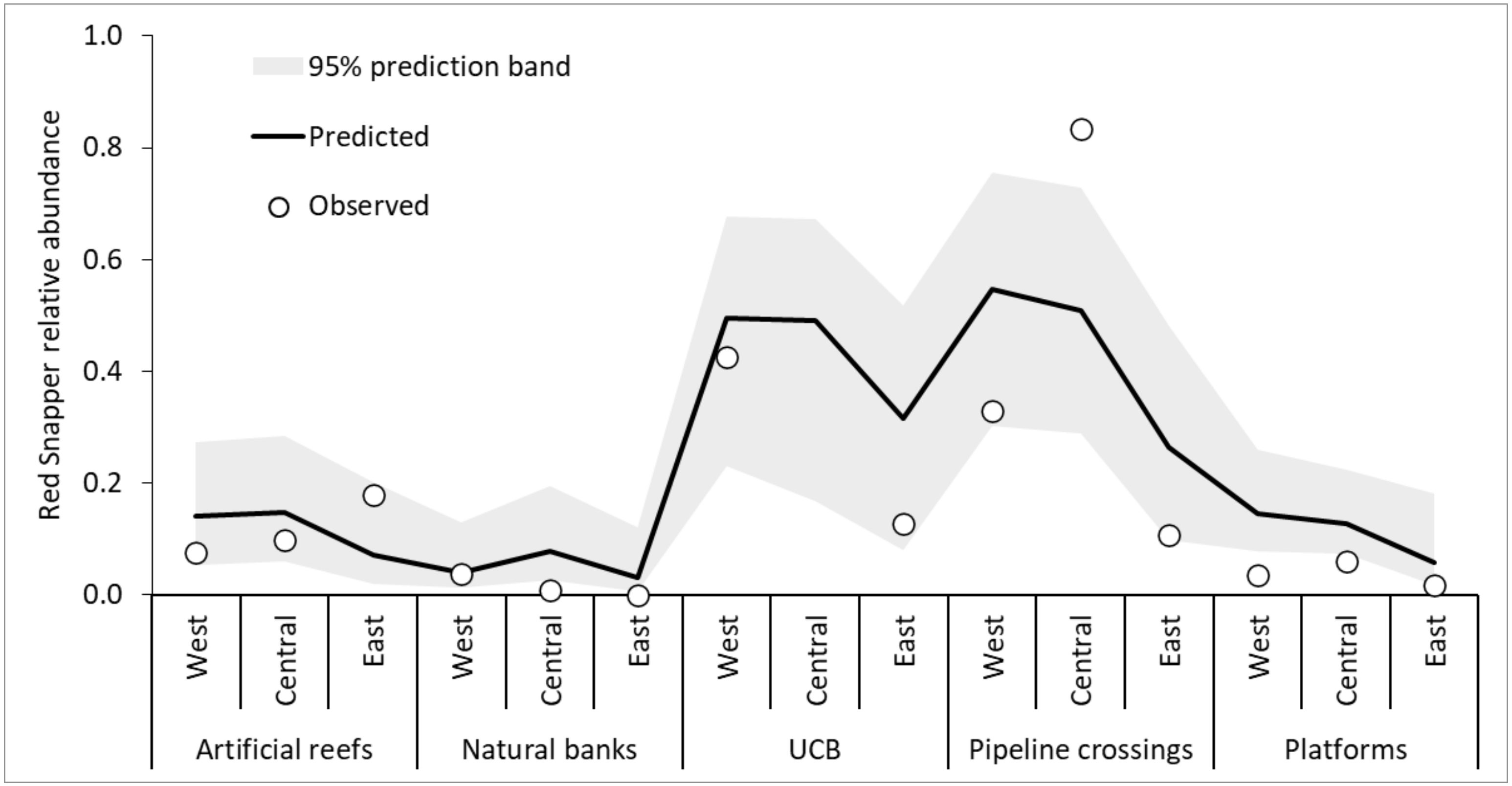
MODEL DIAGNOSTICS—PROP RS



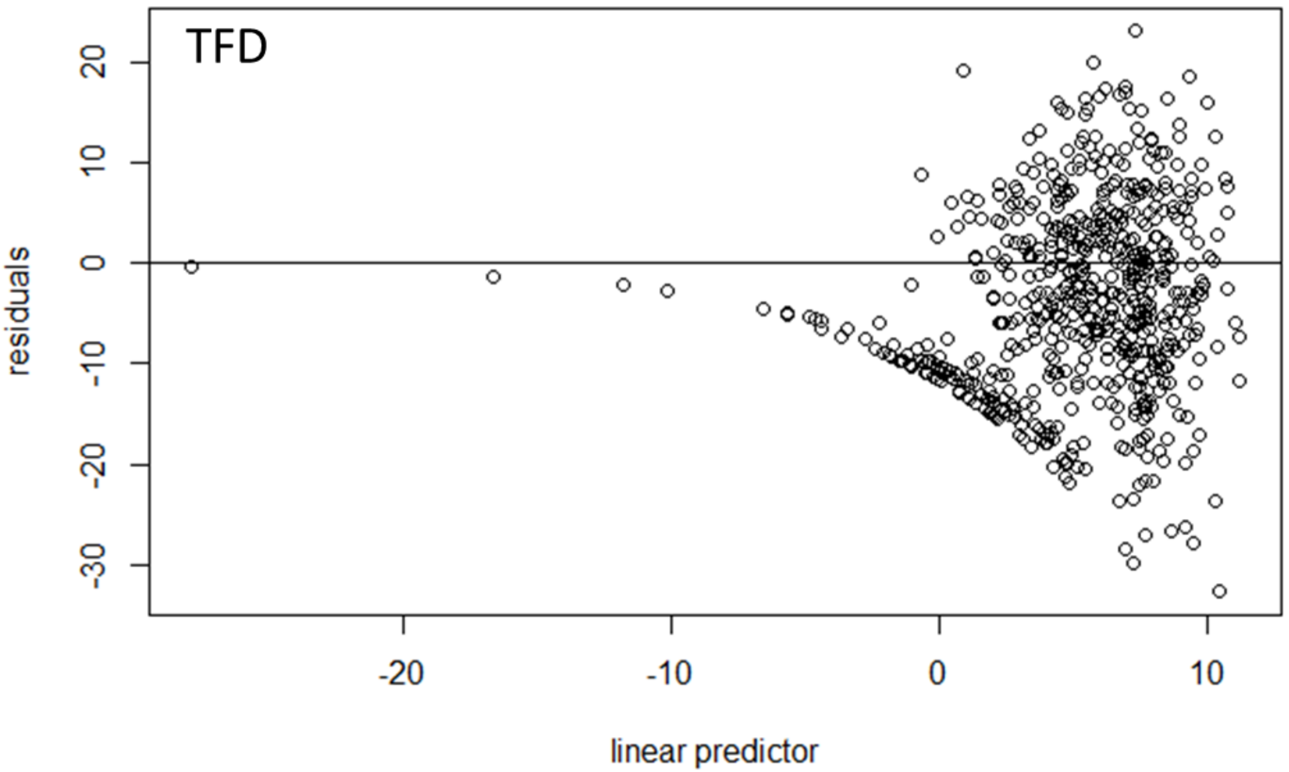
MODEL DIAGNOSTICS—PROP RS



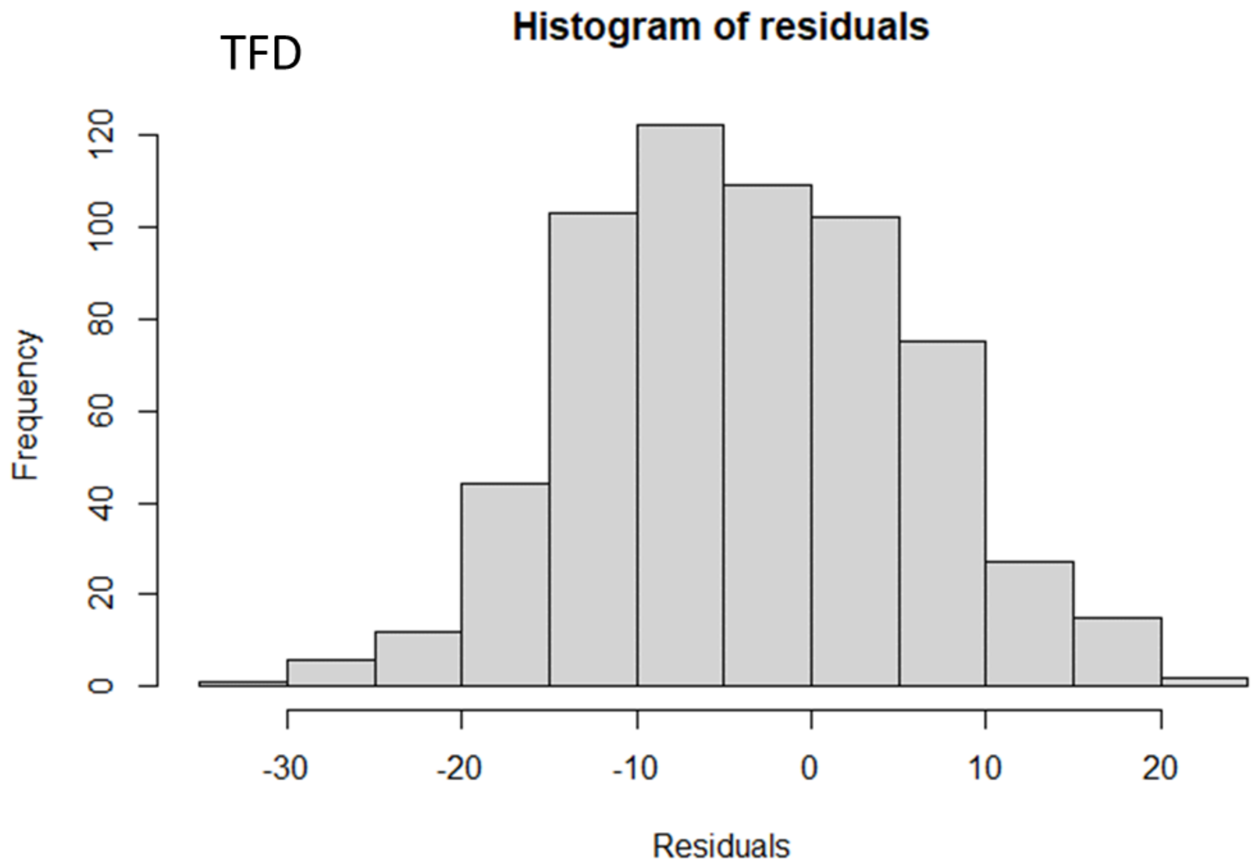
MODEL DIAGNOSTICS—PROP RS



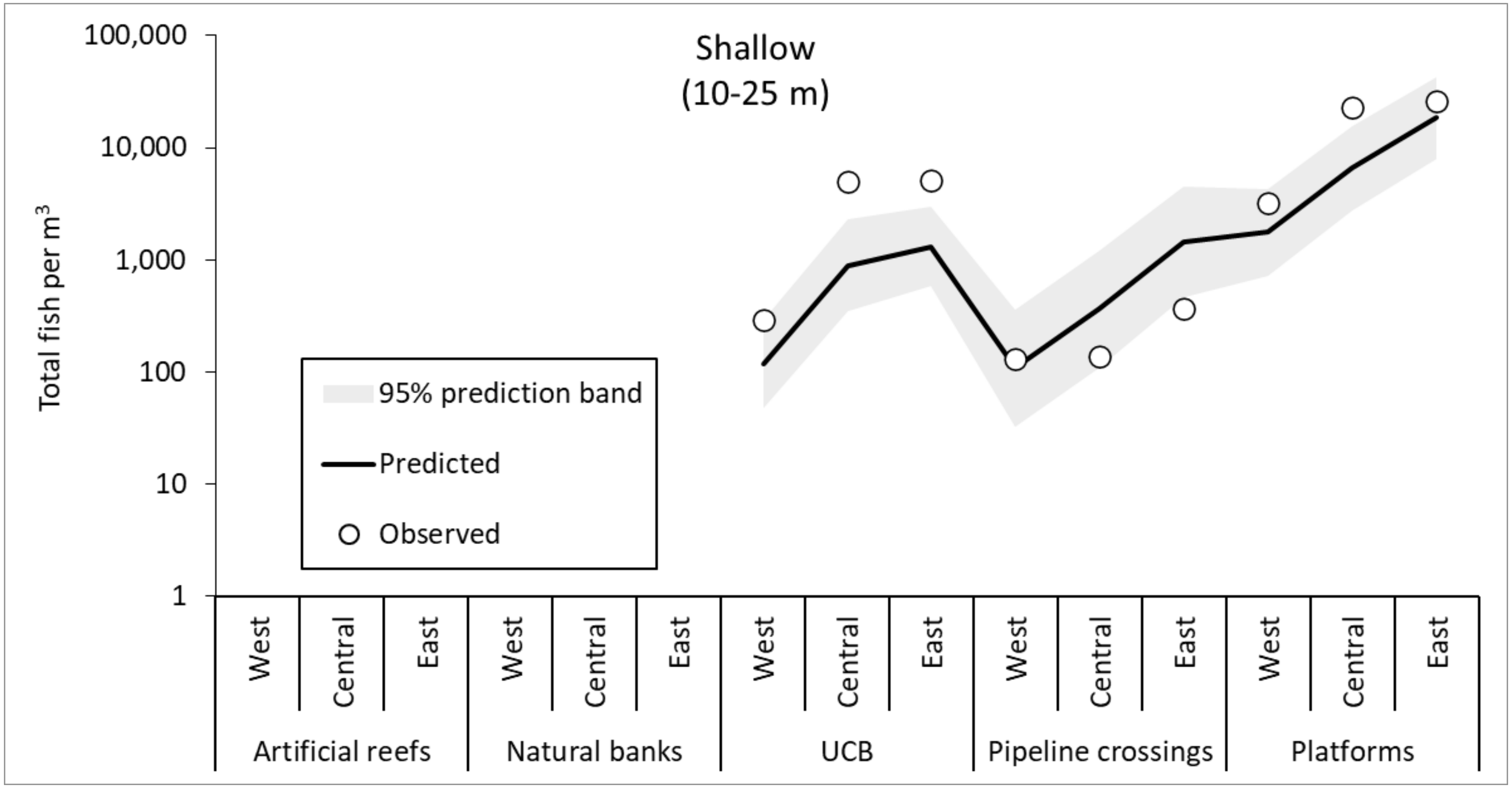
MODEL DIAGNOSTICS—TFD



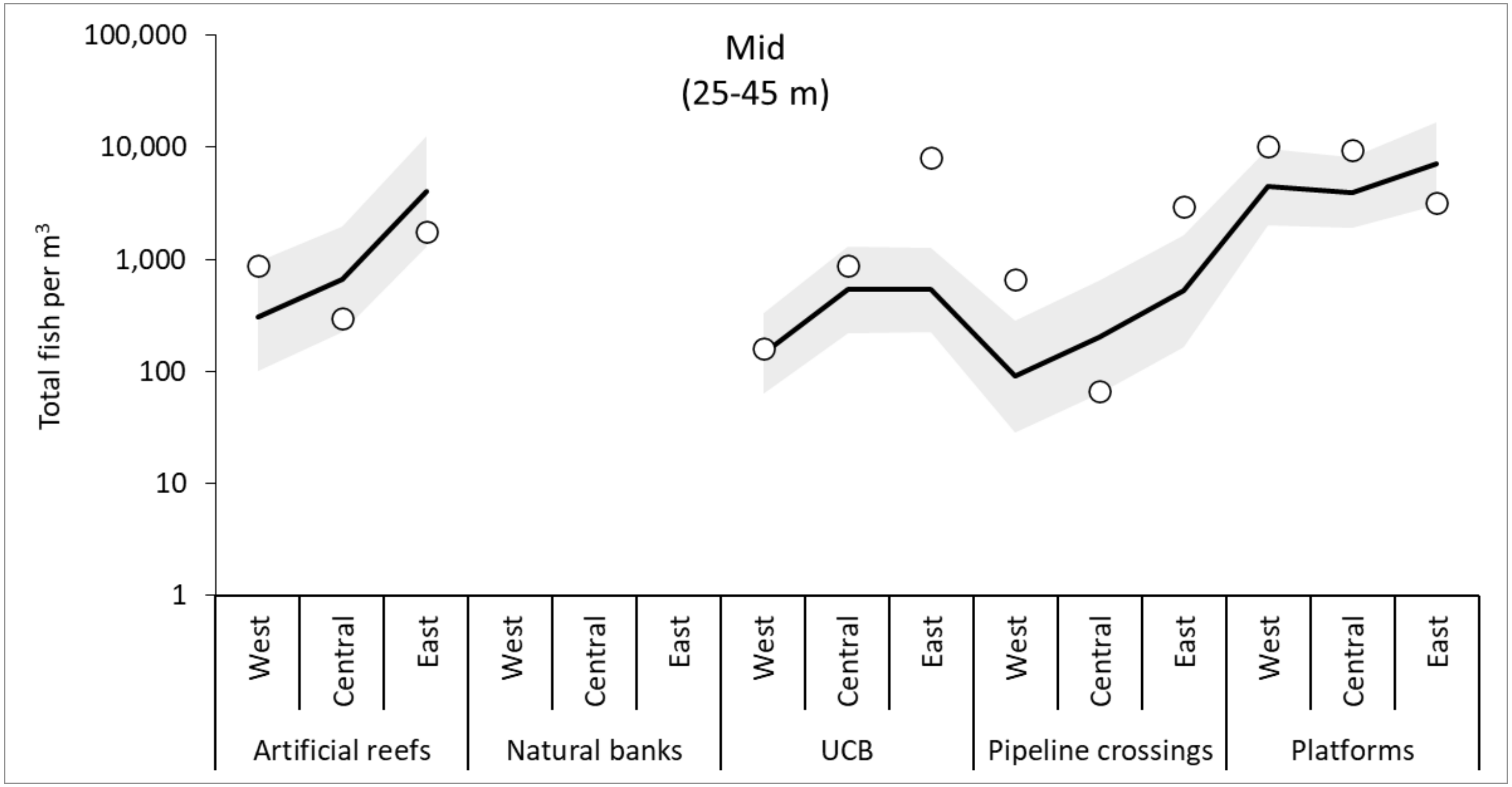
MODEL DIAGNOSTICS—TFD



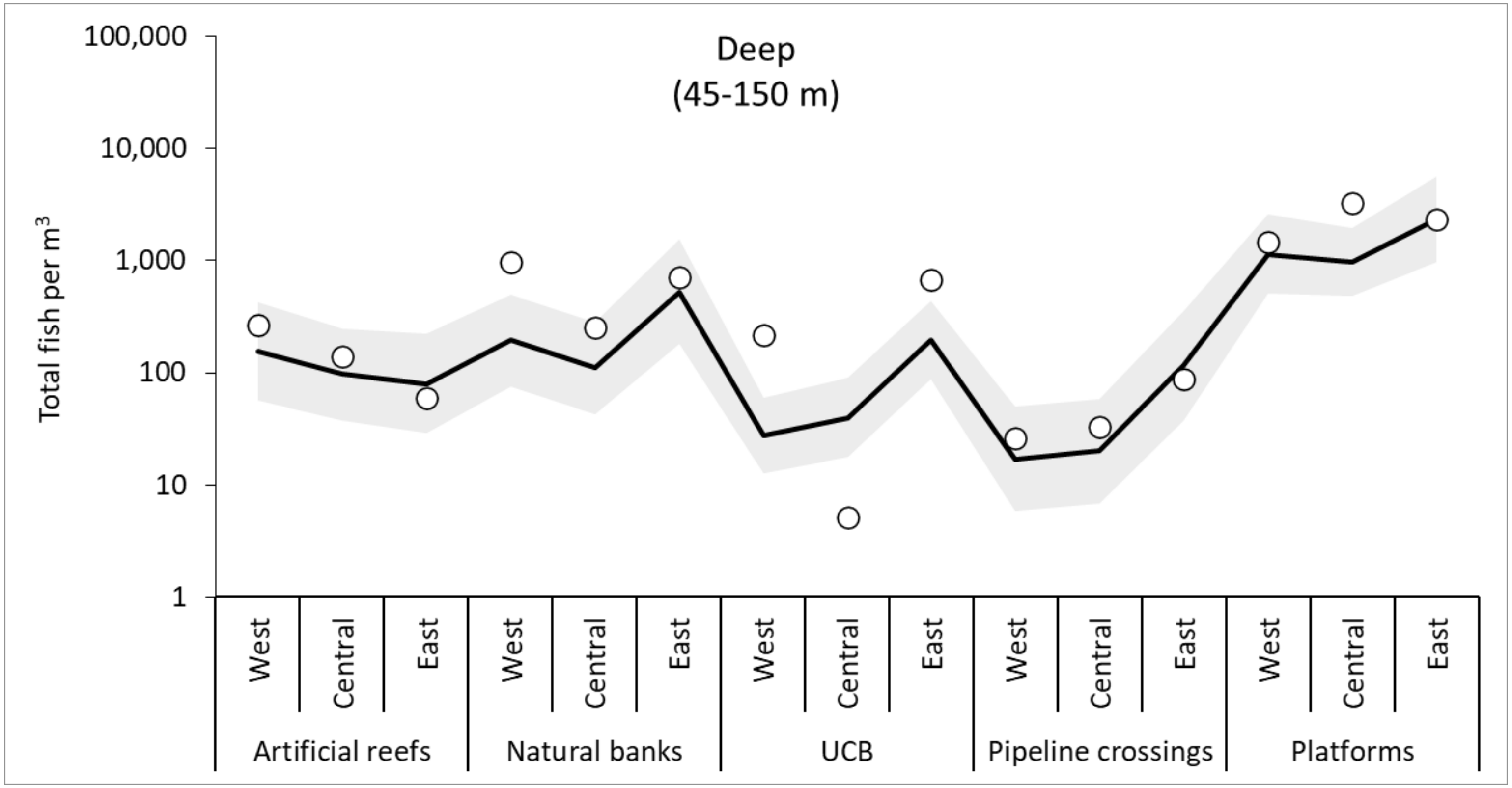
MODEL DIAGNOSTICS—TFD



MODEL DIAGNOSTICS—TFD



MODEL DIAGNOSTICS—TFD



MARK RECAPTURE METHODS

- We used the Gazey and Staly (1986) approach for estimating population size from the mark recapture data given our small sample sizes.
- Traditional mark/recapture analyses yield population estimates with substantial negative bias and overly large confidence intervals if the number of animals marked and examined falls too low.
- To address these problems, Gazey and Staley (1986) cast mark/recapture experiments in a Bayesian framework using a "noninformative" discrete uniform improper prior distribution.
- A sequential Bayes computational algorithm is provided which estimates the probability of a population size given the data.
- Inferences can be made directly since the end product completely describes the uncertainty of the population size given the data.

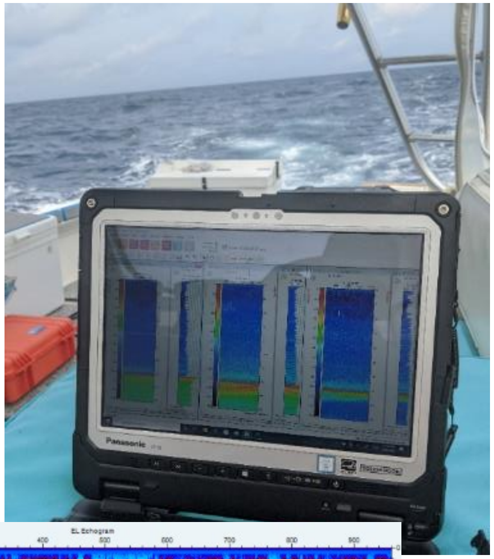
RESULTS

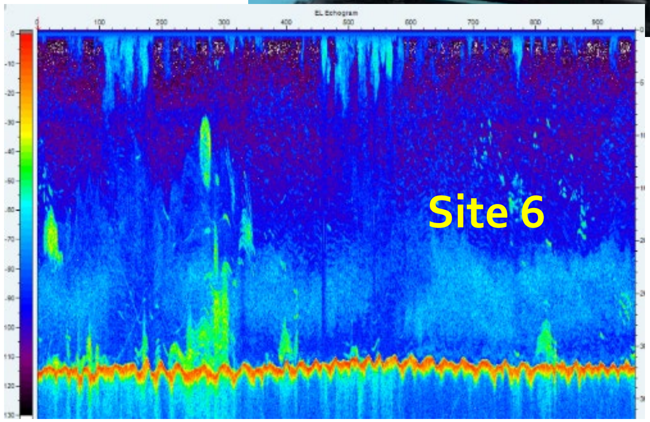
RESULTS

- Overall, we encountered 88 unique species across all sampling approaches and habitats.
- At discrete sites, we viewed 60 species on the SRV and collected 29 species using vertical hook-and-line sampling.
- At UCB sites, only 6 species were documented using the towed video camera but another 19 species were documented in the SRV drops taken over bottom features occurring in UCB.
- A total of 21 species were documented using bottom longlines over UCB.

DISCRETE SITE HYDROACOUSTIC/SRV SAMPLING SUMMARY

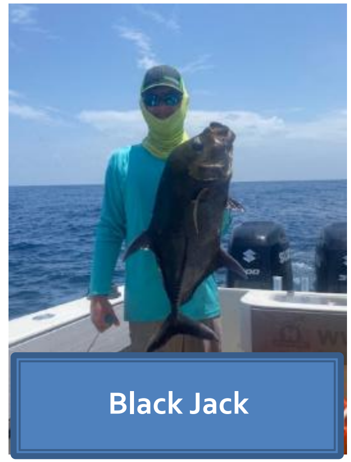
- 55 Sites
  - 192.5 km of hydroacoustic transects
  - 72 SRV surveys
    - 39,014 fish counted
    - 2,813 Red Snapper counted





DIVERSITY OF SPECIES FROM VERTICAL LINES

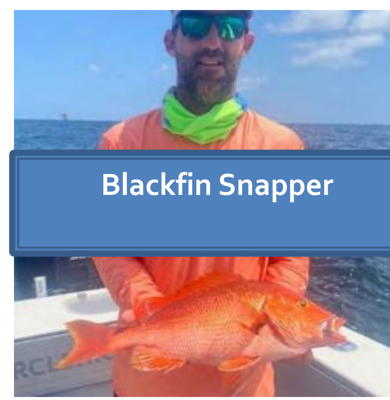

Greater Amberjack


Black Jack


Scamp

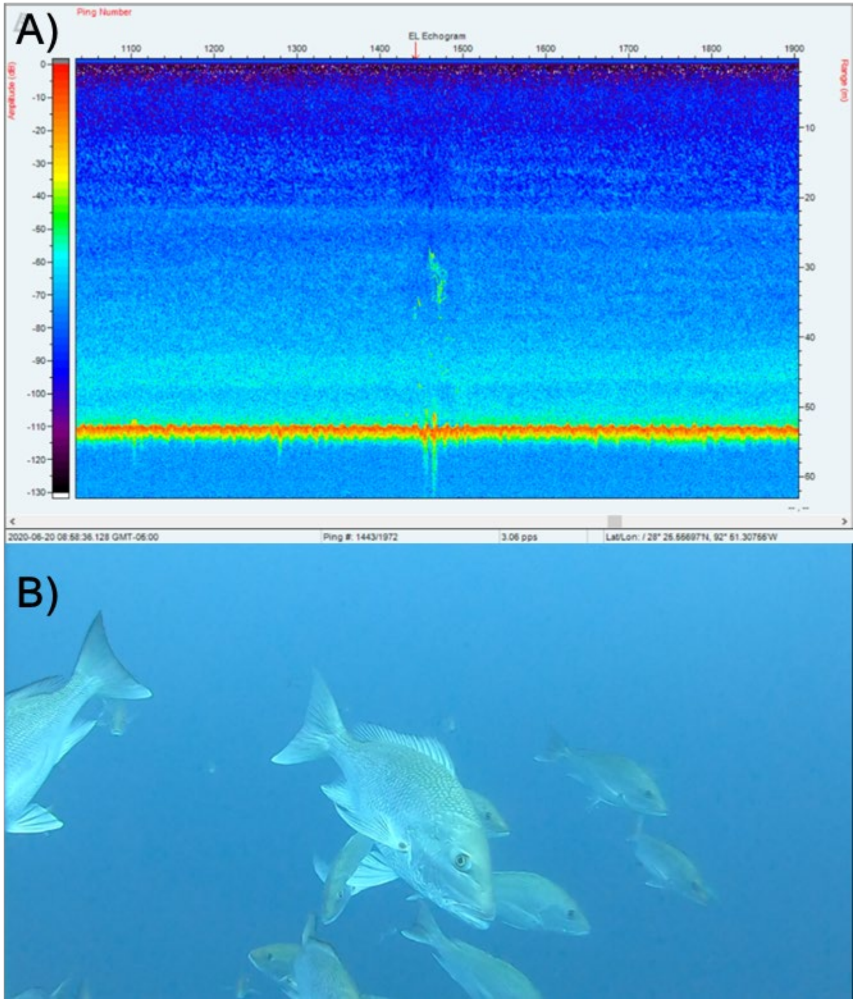

Porgy


Gray Triggerfish


Blackfin Snapper

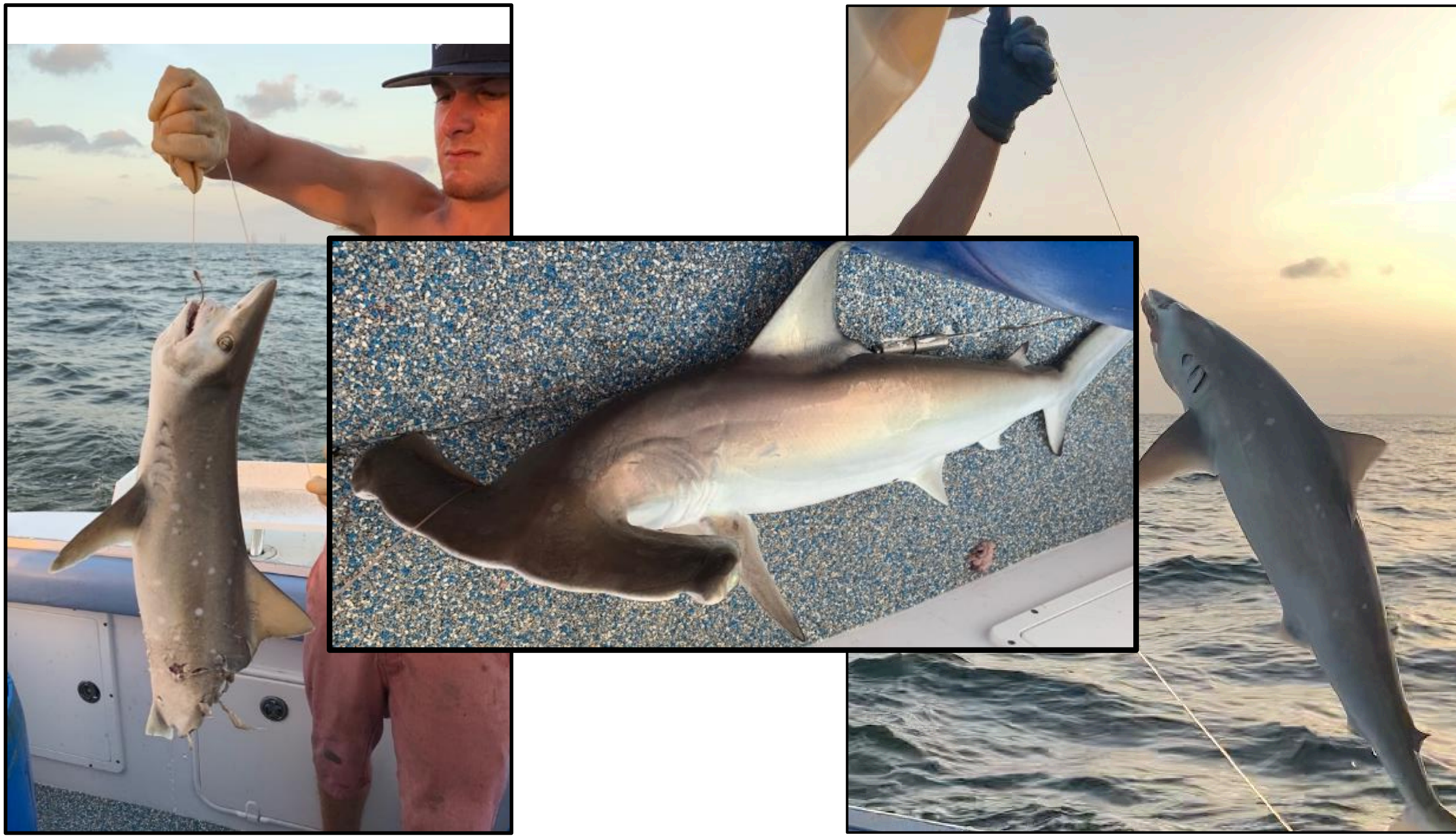
UCB TOWED VIDEO AND LONGLINE SAMPLING SUMMARY

- 51 sites (39 unique)
  - 702 km of hydroacoustic transects
  - 49 km of towed video transets
- Towed video surveys
  - 3,239 fish counted over small features of which 1,433 were Red Snapper
  - In contrast, towed video surveys on UCB without features yielded observations of just 101 fish of which only 11 were Red Snapper.



DIVERSITY OF SPECIES FROM LONGLINES

LOTS OF SHARKS ON LONGLINES

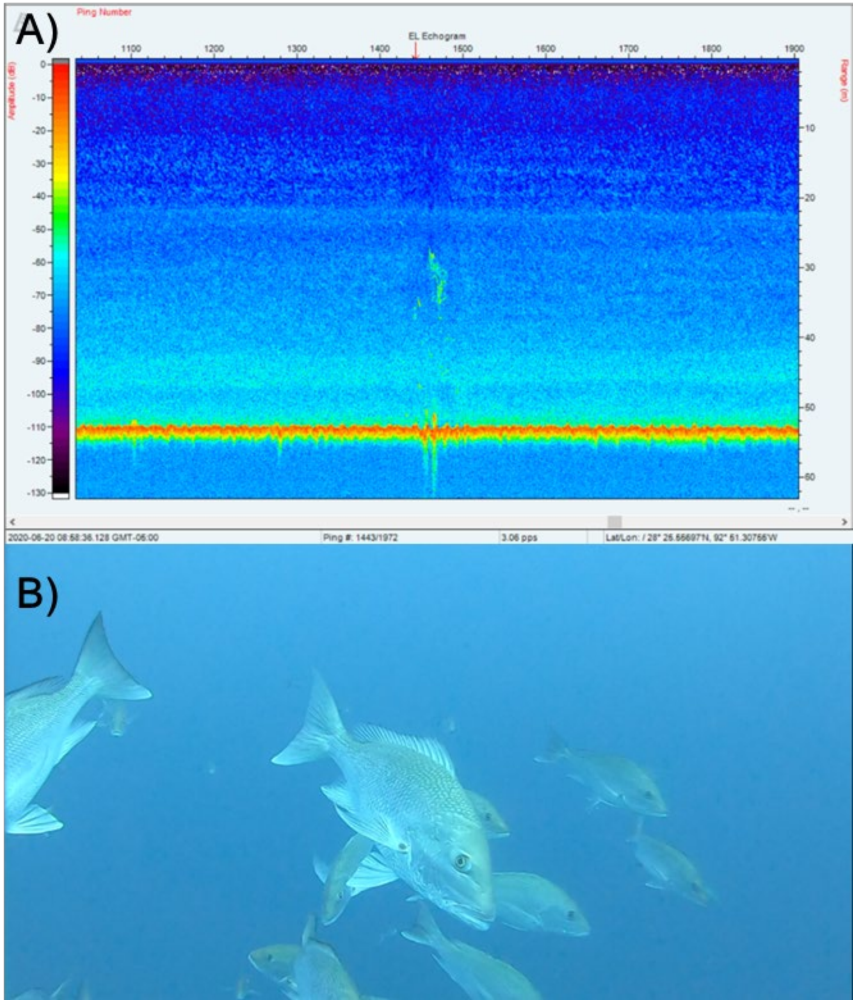


ESTIMATED ABUNDANCE OF RED SNAPPER IN LOUISIANA

- As shown by Table 9 (p.61) of our report, our model results suggested that the total abundance of Red Snapper offshore Louisiana during the Summer of 2020 was 6,027,890 fish (95% CI: 4,665,675-7,787,825.
- The SE was 791,199 with a corresponding CV of 13.1%.
- Most of the Red Snapper occurred over UCB (63% or 3,782,532 fish); followed by standing platforms (22%; 1,328,714 fish); Natural Banks (10%; 621,133 fish); pipeline crossings (3%, 195,778 fish) and artificial reefs (2%, 99,733 fish).

RED SNAPPER AT UCB HABITAT IN LOUISIANA

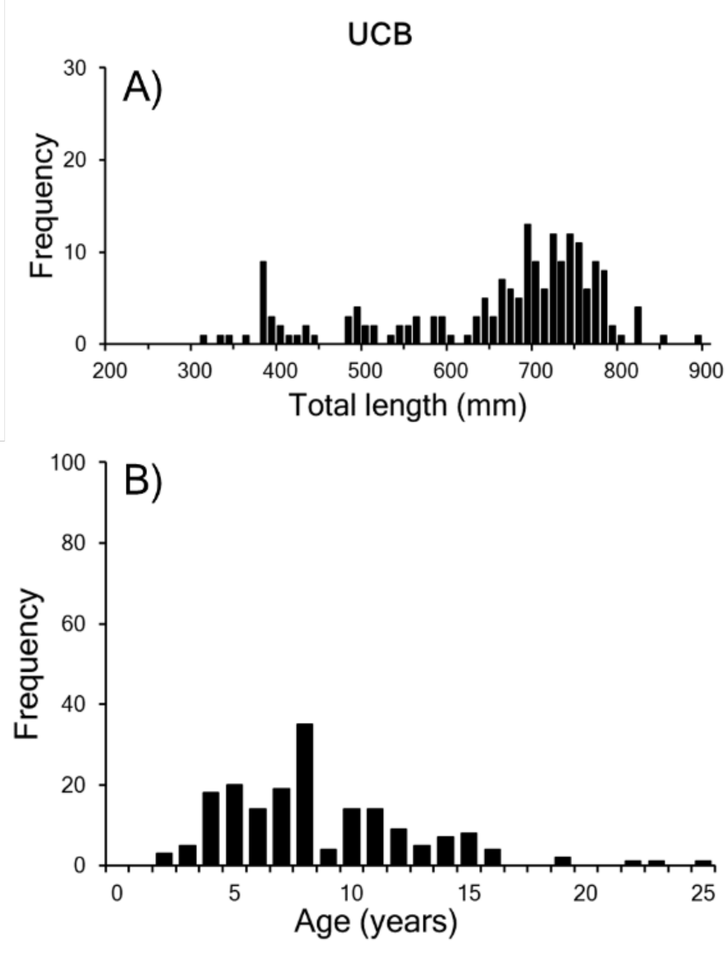
- Red Snapper were not uniformly distributed across UCB but were primarily associated with small bottom features of relief within this habitat.
- Red Snapper over UCB habitat in the West Region were much less abundant (736,867 fish) than observed in the Central (1,518,772 fish) and East Regions (1,526,893 fish).



RED SNAPPER SIZE/AGE AT UCB HABITAT IN LOUISIANA

- Red Snapper over UCB habitats were typically larger (610-888 mm TL) and older fish (ages 6-25) than seen elsewhere.

- Many of these fish were observed to have had fully developed gonads and many showed signs of imminent spawning.

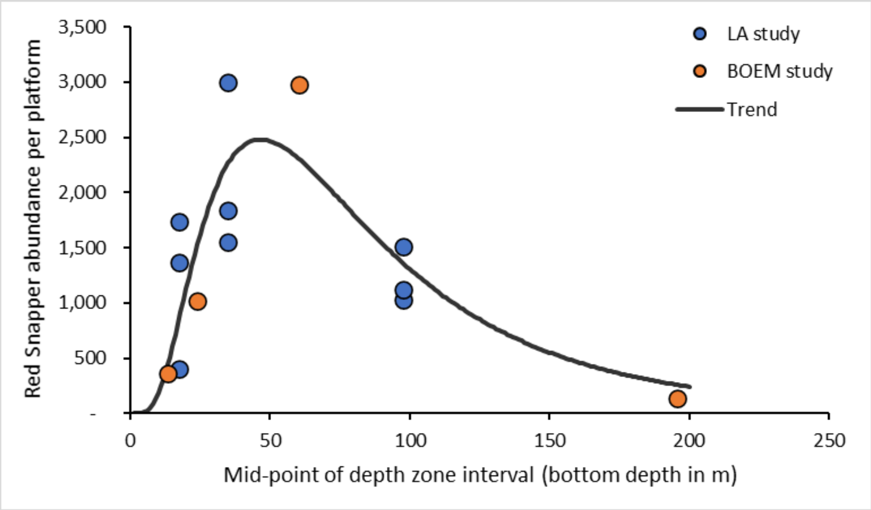


UNEXPLOITED BREEDING STOCK?

Notes: Female Red Snapper from the mid depth eastern zone.
Many of the snappers from this area had fully developed gonads and many showed signs imminent spawning.

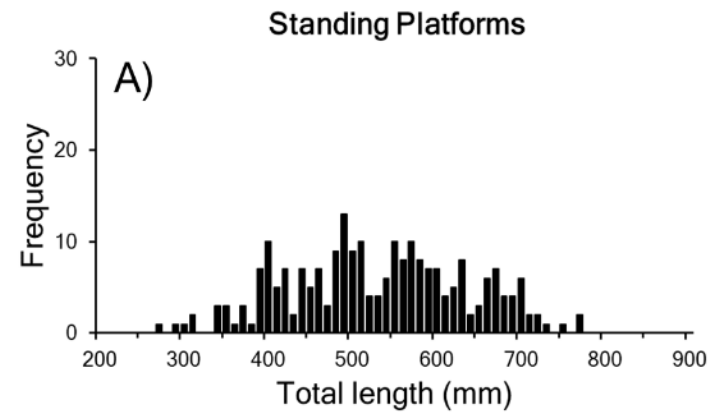
RED SNAPPER AT PLATFORM HABITAT IN LOUISIANA

- Some 1,328,714 Red Snapper (22% of the total population) were estimated to be present on the 821 offshore platforms present offshore Louisiana in the summer of 2020. This compares to 1,353 Red Snapper estimated to occur of 882 platforms present in the same area in 2018 (Gallaway et al. *in press*, the "BOEM Study").
- Both studies observed abundance differences by depth with maximum abundance being about 3,000 fish/platforms in the mid-depth range.

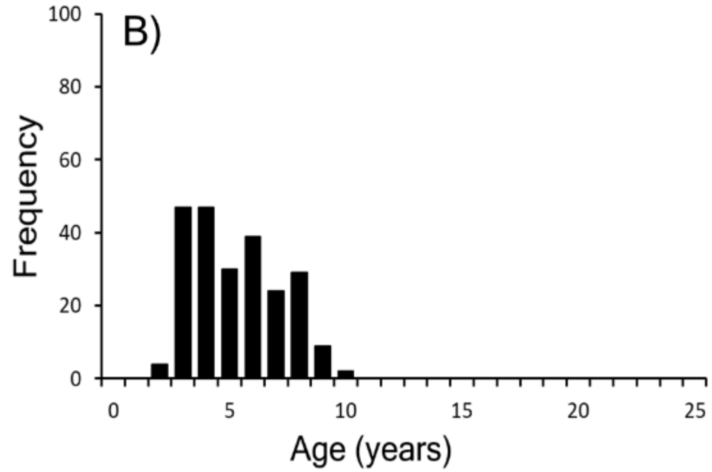


SIZE/AGE RED SNAPPER AT LOUISIANA PLATFORMS

- Red Snapper on platforms were characterized by a wide size range (270 mm TL to 770 mm TL) and most fish were between 3 and 8 years in age.



- The total biomass of Red Snapper at platforms in 2020 was 6,722,541 lbs. This compares to a recent recreational fishing quota for the study area of 784,332 lbs.

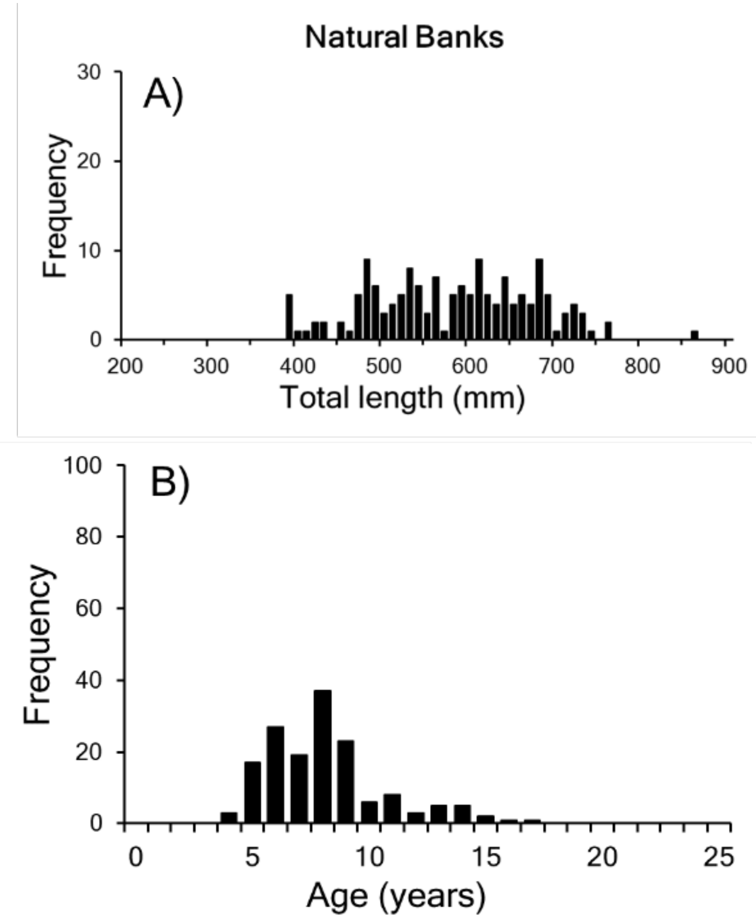


RED SNAPPER AT NATURAL BANK HABITAT IN LOUISIANA

- An estimated 621,133 Red Snapper occurred on Natural Banks and this represented 10% of the total abundance.
- As shown by Table 9 in our report, the observed regional densities were not markedly different (766 to 876 fish/km^2); the main difference was related to an area of habitat available within region (West=180 km^2; Central=1,521 km^2; East=23 km^2).
- Given these observations, a total 456,500 Red Snapper occurred on Natural Banks in the Central Region; 146,820 were present on Western Natural Banks and only 17,812 occurred on Eastern Natural Banks.

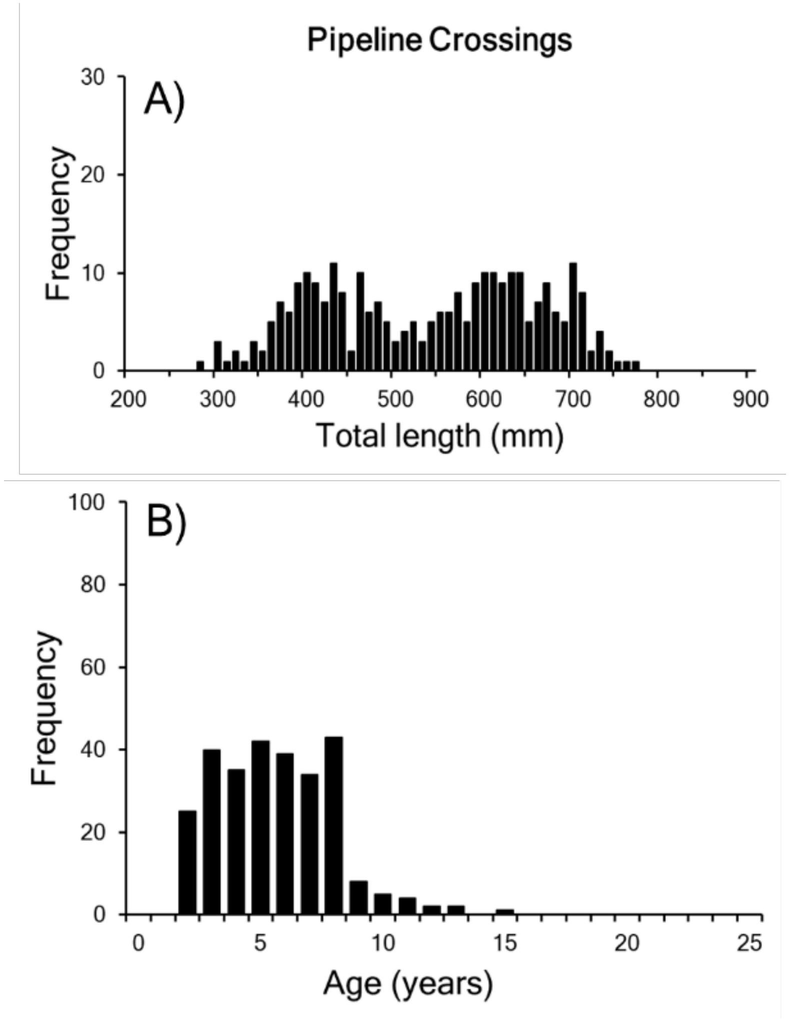
SIZE/AGE OF RED SNAPPER ON LOUISIANA NATURAL BANKS

- Red Snapper at Louisiana Natural Banks within the study area typically included large fish with most between 470 mm and 690 mm TL and from 5 to 9 years in age.
- Red Snapper biomass on Natural Banks within the study area was estimated to be on the order 3,745,866 lbs.



ABUNDANCE OF RED SNAPPER AT PIPELINE CROSSINGS

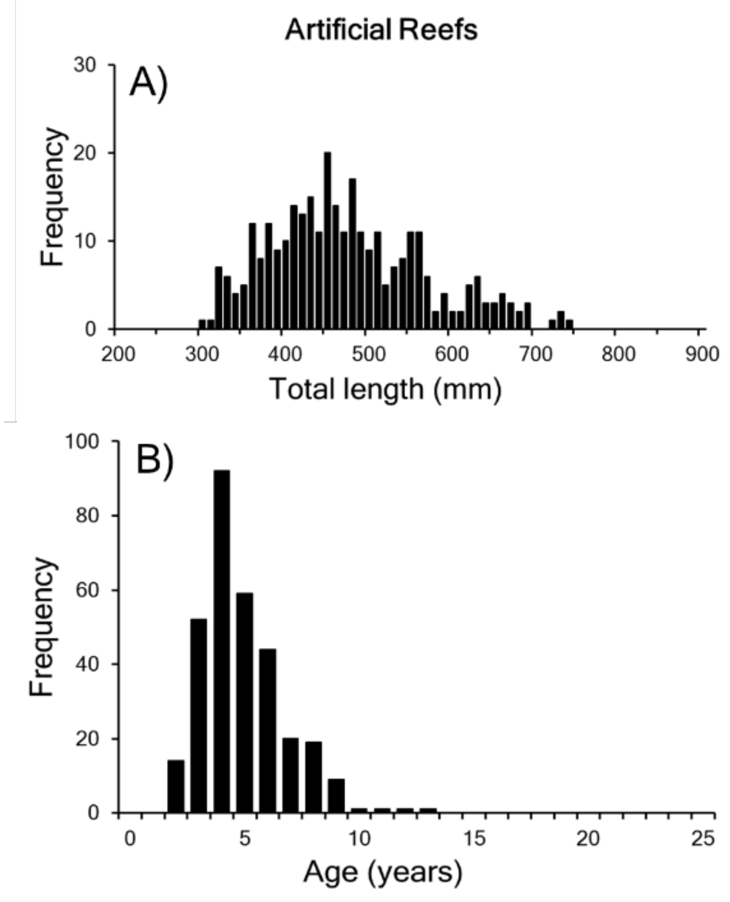
- A total of 195,778 Red Snapper having an associated biomass of 1,069,318 lbs. were estimated to occur at 514 crossing of large (>20" in diameter) pipelines.
- These fish exhibited a broad size range (270-770 mm TL) with most being between 2 and 8 years of age.



ABUNDANCE OF RED SNAPPER AT LOUISIANA ARTIFICIAL REEFS

- A total of 99,733 Red Snapper with a total of 359,241 lbs. were estimated to occur on Louisiana artificial reefs during the summer of 2020.

- A broad range of sizes were observed at these habitats (300- to 750- mm TL) and most of the fish were between 3 and 6 years in age.



PLATFORM POPULATION ESTIMATES VS SITE SPECIFIC AND MODELED ESTIMATES

- Our population estimates were characterized by small sample sizes (as expected).

Region	Site	Habitat	Depth Zone	Numbers Mark	Numbers Recapture	Numbers Tags
West	3	Platform	MID	30	117	2
West	13	Artificial Reef	MID	45	45	3
Central	7	Platform	MID	28	89	4
Central	17	Artificial Reef	MID	31	81	4
East	8	Platform	MID	4	35	0
East	26	Artificial Reef	MID	16	58	1

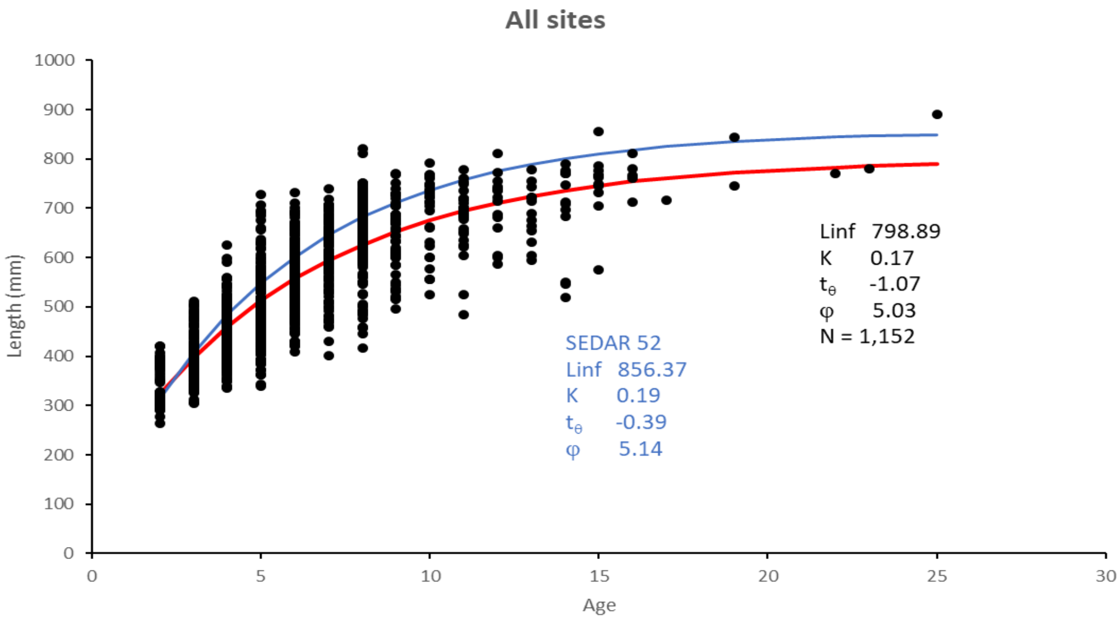
- The MLE estimate for West Platform Site 3 was **1,740** Red Snapper as compared to 2,734 estimated using Mean Site Abundance approach. However, the model estimate typical for platforms in this region and depth zone was **1,838** Red Snapper.
- The MLE estimate for Central Platform Site 7 was **608** Red Snapper compared to 1,491 fish based on the Mean Site Abundance approach. The model estimate for this region and depth zone was **430** Red Snapper.

PLATFORM POPULATION ESTIMATES VS SITE SPECIFIC AND MODELED ESTIMATES (CONTINUED)

- The population estimates for an individual artificial reef in the mid-depth zone in the Louisiana study area was estimated to be about 1,491 Red Snapper based on the mean count estimates.
- This estimate contrasts with the population estimates ranging from **608** to **902** fish and the modeled estimates ranging from **261** to **908** fish.

AGE AND GROWTH OF RED SNAPPER OFFSHORE WESTERN LOUISIANA

- We collected length, weight and age data from over a 1,000 Red Snapper offshore Louisiana and will address most of these data at a later time.
- For now, suffice to say, that our growth perimeter estimates were lower than those reported in SEDAR 52 (2018):



COMPARISON OF THIS STUDY TO THE GRSC

- A summary of our estimates of Red Snapper abundance and biomass (lbs.) by habitat type and/or area is summarized.

	Habitat Type	Area (km$^{2\,1}$)/Count	Abundance	Biomass
1)	**Natural Bank**	724 km^2	621,133	3,745,866
2)	**Uncharacterized Bottom**	49,003 km^2	3,782,532	35,450,492
3)	**Artificial Reefs**	1,777	1,624,225	8,181,819
	Platforms	821	1,328,714	6,753,260
	Artificial Reefs	442	99,733	359,241
	Pipeline Crossings	514	195,778	1,069,318
	TOTALS		6,027,890	47,378,177

- Stunz et al. (2021b), The GRSC provide a corresponding estimate of 17,431,364

Habitat Type	Area (km^2/count) Structures	Mean Density	Total
1) Natural	821	0.47	3,852,652
2) Artificial	1,771	2,174	3,849,325
3) Uncharacterized Bottom	53,052	0.02	9,729,387
			17,431,364

- This is about 3 times larger than our estimate.

COMPARISON OF THIS STUDY TO THE GRSC (CONTINUED)

- The differences seem largely related to catch rates rather than differences in area of habitat or number of habitats:

Habitat	Study	Area (km^2)	Catch Rate	Total
Natural Bank	Stunz	821 (x 1.13)	4,693/km^2 (x 5.5)	3,852,652 (x 6.2)
	LGL	724	858/km^2	621,123
Artificial Reef	Stunz	* 1,771 (x 0.99)	2,174/reef (x 2.4)	3,849,325 (x 2.4)
	LGL	* 1,777	914/reef	
UCB	Stunz	53,052 (x 1.08)	183/km^2 (x 2.3)	9,729,387 (x 2.6)
	LGL	49,003	77/km^2	3,782,532

* Number of reefs; numbers in parentheses are Stunz estimates divided by LGL estimates.

- The area or count of habitats are similar between the two studies.
- However, the catch rates of Stunz et al. (2021b) are from 2.3 to 5.5 times higher than the corresponding LGL estimate and the total estimates ranged from 2.4 to 6.2 times higher.

COMPARISON OF THIS STUDY TO THE GRSC (CONTINUED)

- The observed differences in catch rates could be attributed to a number of factors; but as one reviewer stated,

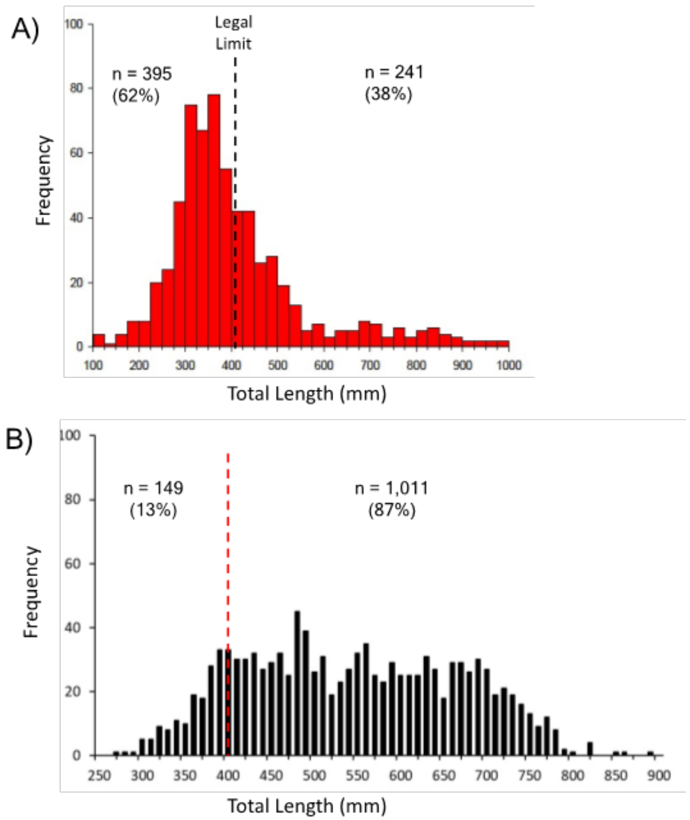
  "However, since the Louisiana estimates in LGL are based solely on sampling in Louisiana and adjacent Federal Waters, whereas Stunz et al. used extrapolated samples from outside that area, this provides some *prima fascia* support for using the LGL results in support of management".

- The other external reviewer noted:

  " I am very much more comfortable with the LGL estimate of 6 million Red Snapper off the Louisiana coast then I am with the GRSC estimate of 26-28 million Red Snapper… Then again, the GRSC had very little data from the waters off Louisiana… I suspect both estimates would converge in Louisiana over several more years".

COMPARISON OF THIS STUDY TO THE GRSC (CONTINUED)

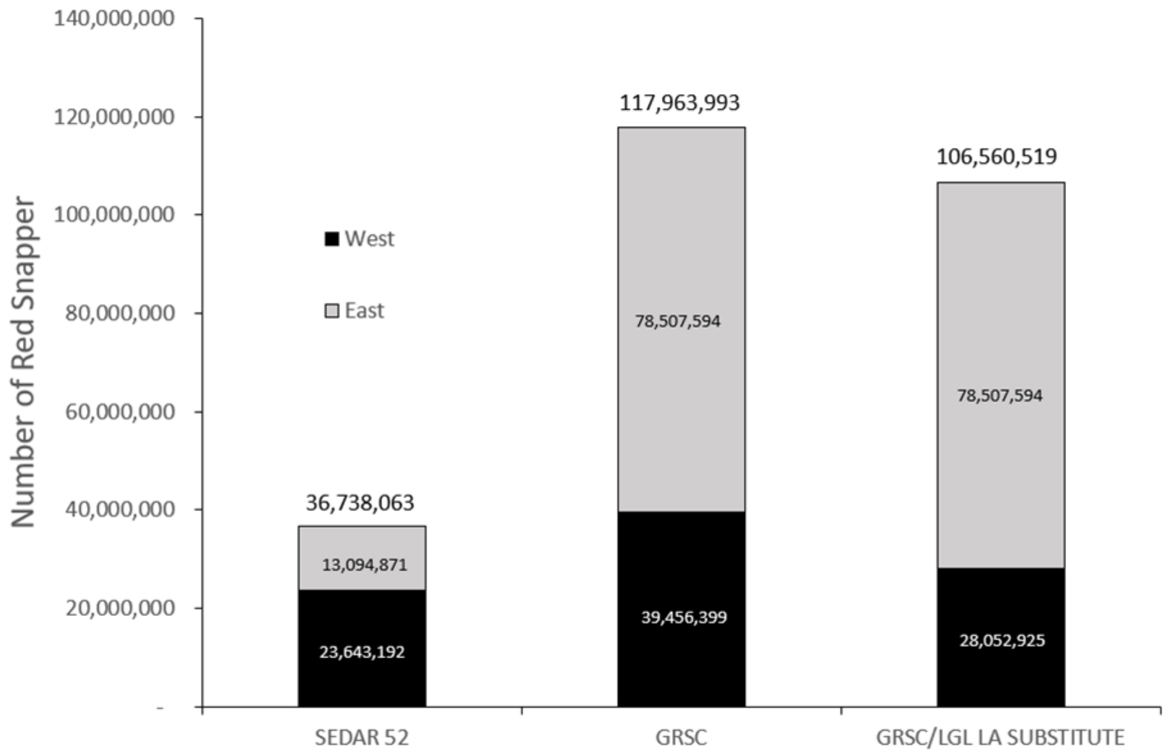
- The size differences for Red Snapper in the Eastern Gulf differ greatly from the Western Gulf (Louisiana). In Florida, most of the Red Snapper are small; 62% of the fish appear to be below the legal size limit of 16 in. In Louisiana, a wide size range was evident in 2020 with 87% of the fish being above the legal size limit.



IMPACT ON STOCK STATUS

- The Stunz et al. (2021b) estimate of the absolute abundance of Red Snapper in the Gulf of Mexico was estimated to have been about 118 million fish in 2019 as compared to about 36,738,063 fish estimated to be present by the SEDAR 52 Stock Assessment (SEDAR 2018).
- SEDAR 52 estimated that 23,643,192 age 2+ Red Snapper were present in the Western Gulf (Texas and Louisiana) as compared to 39,456,399 estimated to be present in the Western Gulf by Stunz et al. (2021b). The new estimate for the West Gulf was about 1.7 times as high as suggested by SEDAR 52.
- For the East Gulf, Stunz et al. (2021b) estimated 78,507,594 Red Snapper were present, nearly 6 times as many as estimated for the Eastern Gulf by SEDAR 52 (13,094,871):
- However, if our Louisiana estimates, are combined with the Texas estimates from Stunz et al. (2021), the overall estimate, of Red Snapper in the Western Gulf was very close to the SEDAR 52 estimate. The SEDAR 52 estimate for the West Gulf was 23,643,192 and the modified Stunz et al. (2021b) estimate plus this study estimate was 28,052,925 fish.

IMPACT ON STOCK STATUS (CONTINUED)



Red Snapper population estimates for the Red Snapper in the Gulf of Mexico based on the SEDAR 52 Red Snapper stock assessment, Stunz et al. (2021b) and this study.

SUMMARY AND CONCLUSIONS

- Overall, the study area was estimated to contain on the order of 6.0 million Red Snapper having an associated total biomass of over 47 million pounds. About 63% (3,782,532 fish) of the population was estimated to occur in association with UCB habitat, and about 27% (1,624,225 fish) occurred at artificial reefs. Only about 10% (621,133 fish) of the Red Snapper population in the study area occurred on natural banks.
- Our estimate (6 million fish) while lower than the estimated 18 million Red Snapper extrapolated to occur in the study area by Stunz et al. (2021b) suggests a healthy stock is present. Despite our estimate that the Red Snapper population of the study area was only about 6.0 million fish, the biomass was high (>47 million pounds) due to the abundance of relatively large, old fish. For context, the most recent recreational fishing quota for Louisiana was about 784,332 lbs. or about 1.7% of the total Red Snapper stock size in the study area.
- The Red Snapper in the Gulf of Mexico are divided into West Gulf and East Gulf stocks. The West Gulf stock includes our Louisiana study area plus Texas and the East Gulf stock includes Louisiana east of the mouth of the Mississippi River, Mississippi, Alabama and Florida.
- We combined our Louisiana estimate with the Stunz et al. (2021) Texas estimate to obtain a total West Gulf stock size of 28,052,925 Red Snapper. This compares closely to the most recent Red Snapper stock assessment (SEDAR 52) that estimated that the West Gulf stock contains 23,643,192 Red Snapper.

SUMMARY AND CONCLUSIONS (CONTINUED)

- The size distribution for Red Snapper in Western Louisiana, reported herein, differs greatly from the size distribution reported for the Eastern Gulf (Florida) by Stunz et al. (2021a,b). In Florida most of the Red Snapper are small; i.e., 62% of the measured fish appeared to be below the minimum size limit of 16 in. In Louisiana, a wide size/age range was evident in 2020, with 87% of the measured fish being above the minimum size limit.
- Offshore oil and gas platforms appear to be the most heavily fished habitat in our study area. In 2020, this habitat had a standing stock of about 1.3 million Red Snapper with an associated biomass of 6.7 million pounds. The average weight of Red Snapper at platforms was about 5 lbs., and the average length of the fish was about 21 in, well over the minimum size limit.
- Of importance, over 63% of the total population of Red Snapper in West Louisiana occurred over UCB habitat. In these habitats, the Red Snapper present were generally larger than elsewhere, averaging about 26 in. in total length, 9.4 lbs. in weight and about 9 years in age. Because Red Snapper are widely distributed over large areas of UCB, fishing pressure is likely reduced compared to more dense aggregations over habitats with structure in charted locations. Thus, UCB habitats have, in essence, served as **de facto** “Marine Protected Areas”.
- Overall, the Louisiana Red Snapper stock appears to be in excellent condition and is experiencing very low levels of recreational fishery mortality. The recreational fishing quota is only about 1.7% of the total stock biomass.

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