EXPLOSIVE REMOVAL OF STRUCTURES: FISHERIES IMPACT ASSESSMENT

Presented By
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LGL Ecological Research Associates, Inc.

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Acknowledgements

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Environmental Studies Program
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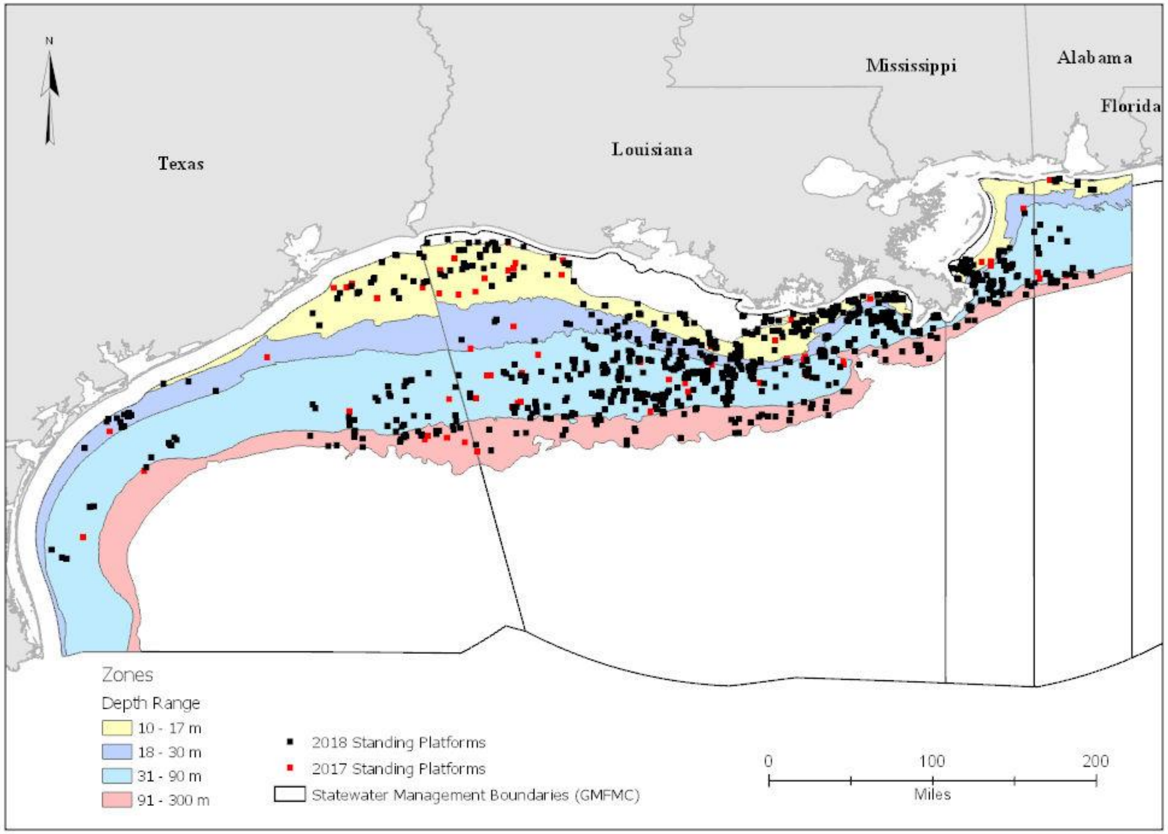
Introduction

- In 2016, the Bureau of Ocean Energy Management (BOEM), perceived a need for an updated estimate of potential impacts to Gulf of Mexico Fisheries due to OCE explosive decommissioning of offshore oil and gas platforms.

- On June 15, 2016, the Bureau of Safety and Environmental Enforcement (BSEE) on behalf of BOEM, issued a contract to LGL Ecological Research Associates, Inc. to address this need.

- The study's focus is the federal waters of the Gulf of Mexico, western and Central Planning Areas, from the limit of state waters to a water depth of 300 m.

Standing Platforms by State Red Snapper Management Areas



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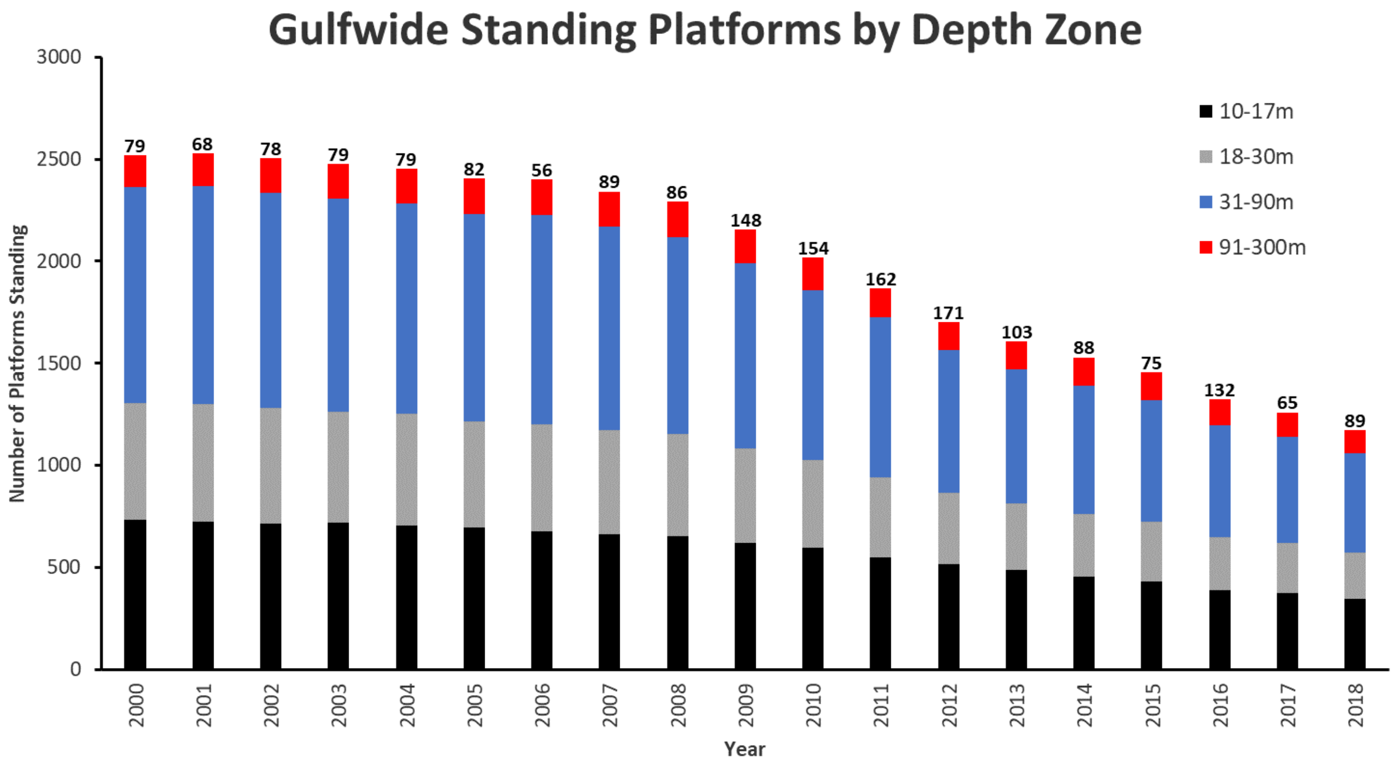
Depth Zone (m)	2017 Total	TX	LA	MS	AL
10 - 17	374	30	297	39	8
18 - 30	247	26	198	20	3
31 - 90	520	50	386	67	17
91 - 300	119	31	66	13	9
	1,260	137	947 (75%)	139	37

Depth Zone (m)	2018 Total	TX	LA	MS	AL
10 - 17	346	26	275	39	6
18 - 30	229	23	186	17	3
31 - 90	484	47	356	66	15
91 - 300	112	26	65	13	8
	1,171	122	882 (75%)	135	32

Platform Removals : Gulf-wide



BOEM Study Objectives

- Characterize the relative abundance and distribution of commercially and/or recreationally-valuable, federally-managed fish species within the lethal blast radius of explosive severance charges used during decommissioning of fixed OCS platforms;

- Develop a technique to estimate or model species-specific mortality of managed fish species due to explosive severance activities, incorporating factors such as severance methods and environmental variables;

- Compare study results with mortality estimates currently used in fisheries management plans or recent stock assessments. Quantify resulting differences in abundance or population estimates and determine if, and at what rate of explosive severance operations impact populations;

- Develop recommendations that minimize impacts to fish and fisheries to guide BOEM and (BSEE) in authorizing decommissioning activities.

Research Team

- The team assembled to conduct this research includes:
  - Benny J. Gallaway, Ph.D.
    Program Manager
    LGL Ecological Research Associates, Inc.
  - Brad Erisman, Ph.D.
    Hydroacoustics P.I.
    University of Texas Marine Science Institute
  - Stephen T. Szedlymayer Ph.D.
    Acoustic Tagging and Telemetry P.I.
    Auburn University
  - Katherine Kim, Ph.D.
    Shock Wave Propagation and Mortality P.I.
    Greeneridge Sciences, Inc.
  - Scott W. Raborn Ph.D.
    Data Manager, Analyst
    LGL Ecological Research Associates, Inc.
  - William Gazey
    Stock Assessment P.I.
    Gazey Research Associates
  - Scott Hickman
    Logistics Coordinator
    Charter Fishermans Association

Captain Mike Jennings
President
Charter Fishermans
Association

Chris Taylor
Hydroacoustic Expert
National Ocean Service
Beaufort Labs

Scientific Peer Review Team

- All work conducted in this project is subjected to External Scientific Peer Review

- The Peer Reviewers are:

  Gregg Gitschlag, MSc
  NOAA Fisheries Galveston
  Platform Removals

  Dr. John Walter
  NOAA Fisheries, SEFSC
  Stock Assessment

  Dr. Edward Chesney
  LUMCON
  Platform Ecology

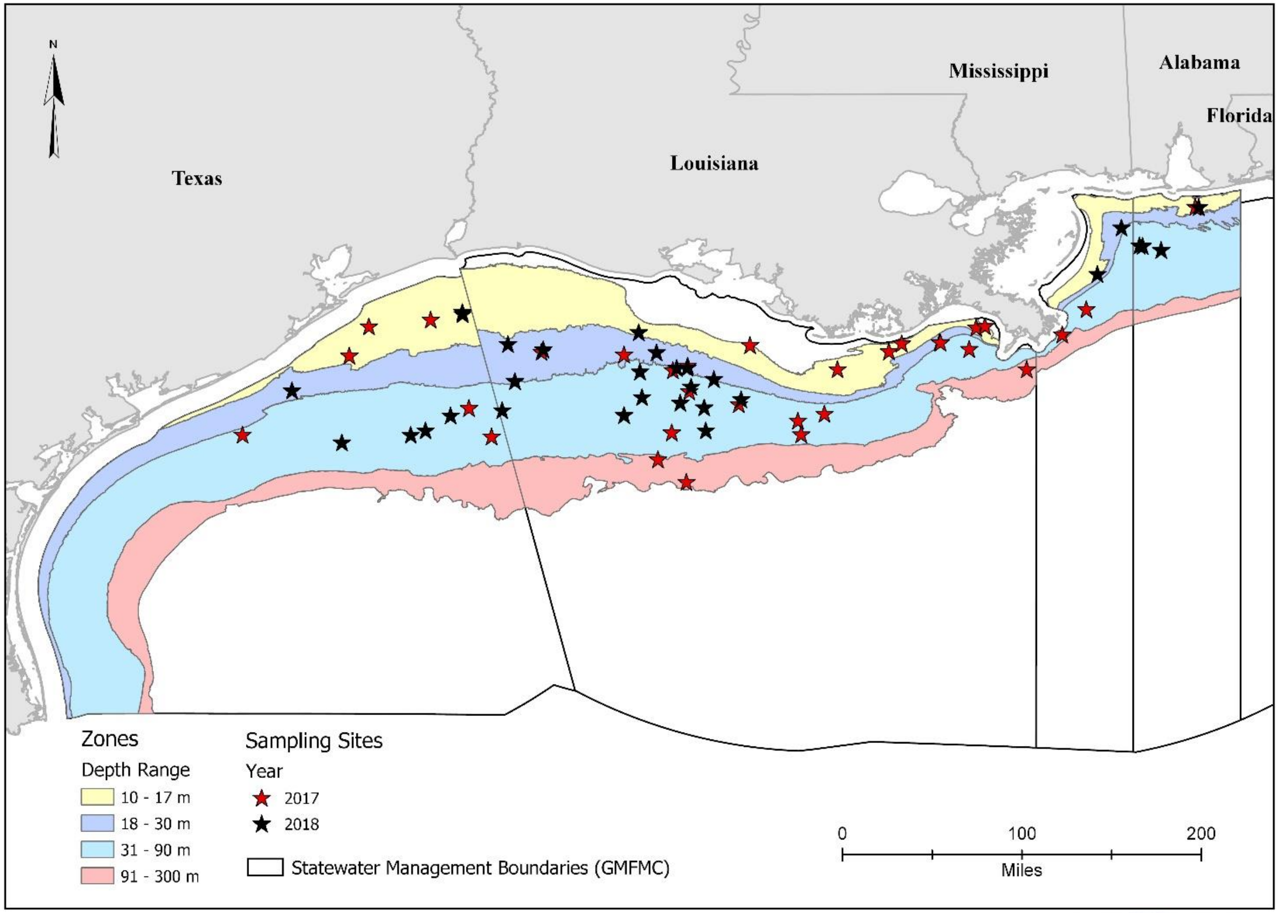
Study Approach

- The first task was to conduct a synthesis of current literature regarding the distribution of federally-managed fish species on or around GOM OCS structures and the expected mortality that these species might experience as a result of underwater detonations.
- This document also provided the basis for finalizing our preliminary field sampling design.
- The field studies were restricted to the May-October period of 2017 and 2018.
- A total of 30 platforms were planned to be sampled each year.

Study Species

Common name	Scientific name	Observed on Platforms	With Stock Assessments	Chosen for Impact Analysis
Almaco jack	*Seriola rivoliana*	Almaco jack		
Banded rudderfish	*Seriola zonata*	Banded rudderfish		
Black grouper	*Mycteroperca bonaci*			
Blackfin snapper	*Lutjanus buccanella*			
Bluefish	*Pomatomus saltatrix*	Bluefish		
Blueline tilefish	*Caulolatilus microps*			
Cero	*Scomberomorus regalis*			
Cobia	*Rachycentron canadum*	Cobia	Cobia	Cobia
Cubera snapper	*Lutjanus cyanopterus*			
Dolphinfish	*Coryphaena hippurus*	Dolphinfish		
Gag	*Mycteroperca microlepis*	Gag	Gag	
Goldface tilefish	*Caulolatilus chrysops*			
Goliath grouper	*Epinephelus itajara*	Goliath grouper		
Gray snapper	*Lutjanus griseus*	Gray snapper		
Gray triggerfish	*Balistes capriscus*	Gray triggerfish	Gray triggerfish	Gray triggerfish
Greater amberjack	Seriola dumerili	Greater amberjack	Greater amberjac	Greater amberjack
Hogfish	*Lachnolaimus maximus*	Hogfish		
King mackerel	*Scomberomorus cavalla*	King mackerel	King mackerel	
Lane snapper	Lutjanus synagris	Lane snapper		
Lesser amberjack	*Seriola fasciata*	Lesser amberjack		
Little tunny	*Euthynnus alletteratus*	Little tunny		
Mutton snapper	*Lutjanus analis*			
Queen snapper	*Etelis oculatus*			
Red drum	*Sciaenops ocellatus*	Red drum		
Red grouper	*Epinephelus morio*	Red grouper		
Red snapper	*Lutjanus campechanus*	Red snapper	Red snapper	Red snapper
Scamp	*Mycteroperca phenax*	Scamp		
Silk snapper	Lutjanus vivanus	Silk snapper		
Snowy grouper	Hyporthodus niveatus			
Spanish mackerel	*Scomberomorus maculatus*	Spanish mackerel	Spanish mackerel	
Speckled hind	*Epinephelus drummondhayi*			
Tilefish	*Lopholatilus chamaeleonticeps*			
Vermilion snapper	*Rhomboplites aurorubens*	Vermilion snapper	Vermilion snappe	Vermilion snapper
Warsaw grouper	*Hyporthodus nigritus*			
Wenchman	*Pristipomoides aquilonaris*	Wenchman		
Yellowedge grouper	*Hyporthodus flavolimbatus*			
Yellowfin grouper	*Mycteroperca venenosa*	Yellowfin grouper		
Yellowmouth grouper	*Mycteroperca interstitialis*			
Yellowtail snapper	*Ocyurus chrysurus*	Yellowtail snapper	Yellowtail snapper	
n = 39	n = 39	n = 25	n = 9	n = 5

Study Sites



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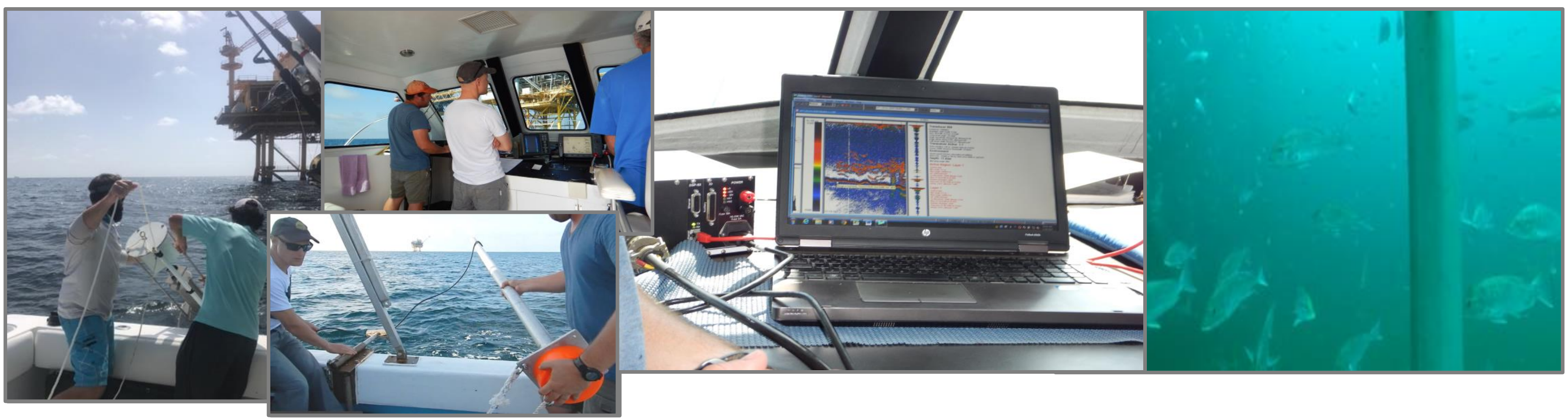
Study Approach

- Hydroacoustic Surveys and Submersible Rotating Video Cameras (SRVs) were used to estimate the total numbers of fish present, and the species composition of fish at all 60 sites.



Study Approach (continued)

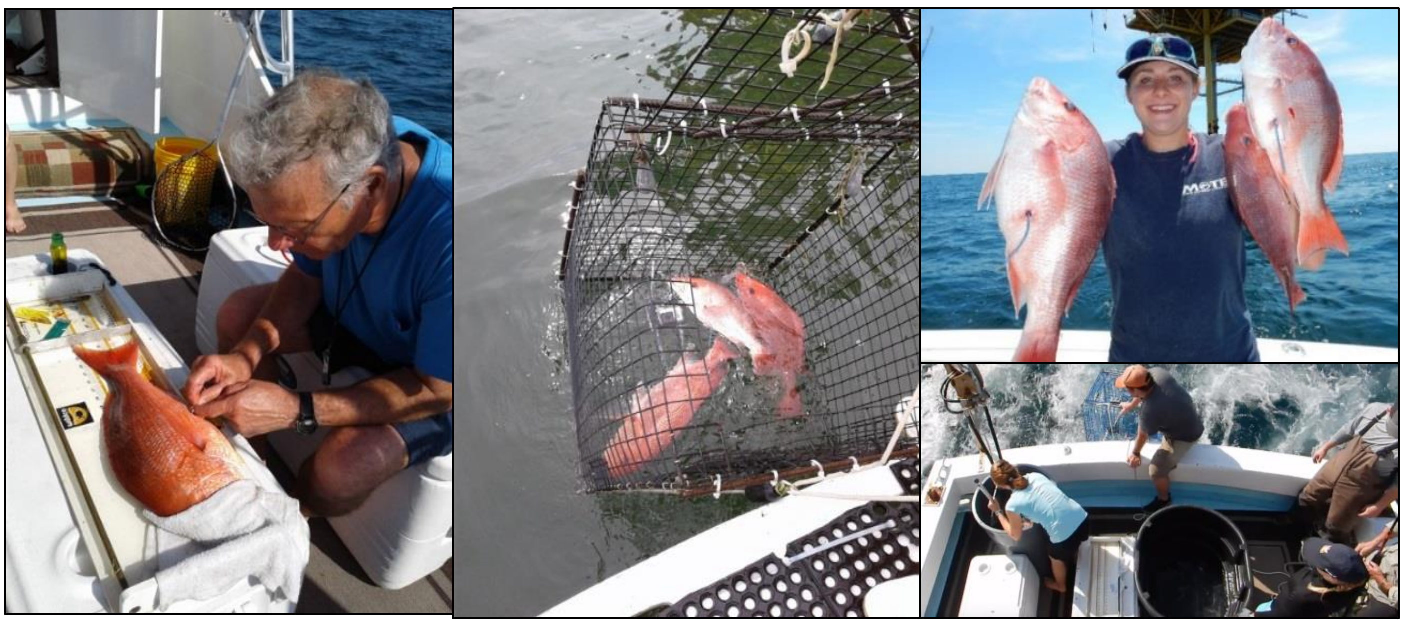
- Hook and line sampling was conducted at all 60 sites, also supplemented by SRV surveys. Fish were identified to species and sex, weighed, measured and the otoliths are extracted.

Study Approach (continued)

- Dockside processing was done on the same day that the samples were collected.

Study Approach (continued)

- At a subset of 10 of these platforms, experimental mark/recapture studies were conducted to obtain independent population estimates for Red Snapper.



Study Approach (continued)

- Acoustic telemetry studies were conducted at a subset of 7 (3 in 2017 and 4 in 2018) platforms to determine site fidelity.

- Vertical profiles of temperature, salinity, dissolved oxygen and turbidity were taken synoptically with each sampling event.

Analytical Methods

- As described in our recent Draft Final Report (Gallaway et al. 2019)*, **Assemblage Structure** and **Total Fish Abundance** were modeled separately using the SRV and hydroacoustic data, respectively.
- For each bottom depth zone and vertical water layer combination, predictions from both models were combined to provide species abundance levels with confidence intervals.
- Species abundances were predicted for what we term an "average platform" within each depth zone. Given the variabilities in things like substrate type, water properties, platform complexity etc., one could argue that an average platform does not exist.
- While our estimates may not apply to any single platform within a depth zone, we argue that our average platform estimates yield unbiased expanded abundances when multiplied by the total number of platforms within a given depth zone because they were based on random samples spanning the total ranges of the observed variables.
- Detailed methods are available in the referenced report and will not be addressed in this summary presentation.

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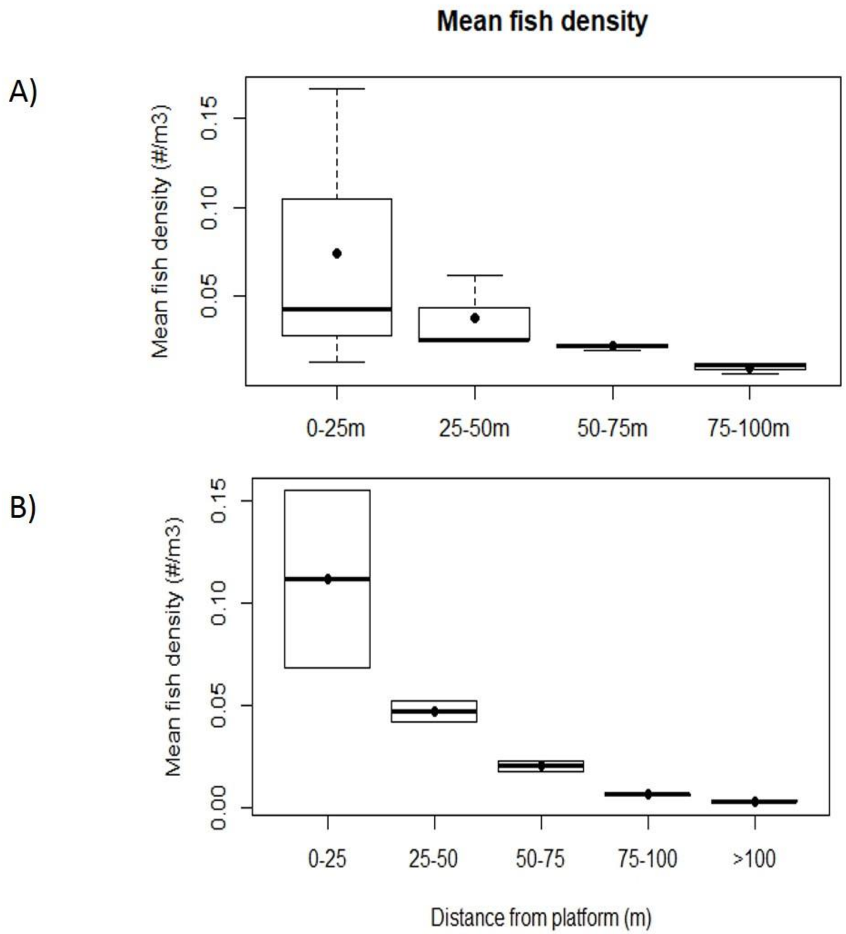
* Gallaway, B.J., S. Raborn, K. McCain, T. Beyea, and S. Dufault. (2019). Explosive Removal of Structures: Fisheries Impact Assessment. Report from LGL to the Bureau of Ocean Energy Management, New Orleans. 134 p.

Platform Fish

Model estimates of the abundance of fish at the “average platform” in the four depth zones defined in this study. In contrast to the modeled estimates not all species were observed at each site. The species actually observed at platforms in each depth zone are designated with an asterisk. Observed species comprised from 97 to 99% at each site.

		Depth zone (m)							
Common Name	Scientific Name	10 - 17		18 - 30		31 - 90		91 - 300	
Almaco Jack	*Seriola rivoliana*	5 (1-25)		16 (8-32)	*	129 (90-183)	*	111 (-)	*
Angelfish sp.	*Pomacanthidae* sp.	0.4 (0-5)		2 (1-6)	*	47 (18-122)	*	0.7 (0-3)	
Atlantic Bumper	*Chloroscombrus chrysurus*	4,362 (1105-17216	*	6,227 (3507-11054)	*	841 (585-1210)	*	324 (171-612)	
Atlantic Moonfish	*Selene setapinnis*	19 (4-82)		514 (261-1011)	*	97 (68-138)	*	23 (11-47)	
Atlantic Spadefish	*Chaetodipterus faber*	1,815 (463-7117)	*	926 (457-1876)	*	481 (323-716)	*	60 (31-115)	
Bar Jack	*Carangoides ruber*	1 (0-9)		4 (2-10)		13 (7-24)	*	178 (42-745)	*
Bermuda Chub	*Kyphosus sectatrix*	39 (8-179)		162 (89-293)	*	838 (545-1288)	*	1,405 (521-3787)	*
Black Jack	*Caranx lugubris*	0.1 (0-4)		0.2 (0-2)		0.1 (0-1)		23 (10-55)	*
Blue Runner	*Caranx chrysos*	622 (152-2539)	*	1,712 (956-3063)	*	3,971 (2805-5622)	*	691 (343-1390)	*
Bluefish	*Pomatomus saltatrix*	2 (0-14)		4 (2-9)	*	0.6 (0-1)		0.6 (0-2)	
Butterflyfish sp.	*Chaetodontidae* sp.	0.1 (0-3)		0.4 (0-2)		8 (-)	*	0.2 (0-2)	
Cobia	*Rachycentron canadum*	57 (14-230)	*	13 (6-26)	*	24 (16-36)	*	1.4 (0-5)	
Crevalle Jack	*Caranx hippos*	16 (3-76)		148 (83-263)	*	326 (234-456)	*	2,074 (941-4571)	*
Dog Snapper	*Lutjanus jocu*	0.2 (0-5)		0.1 (0-1)		0.5 (0-2)	*	0.05 (0-1)	
Filefish sp.	*Monacanthidae* sp.	- (-)		- (-)		0.2 (0-1)	*	- (-)	
Gray Snapper	*Lutjanus griseus*	137 (35-528)	*	400 (255-710)	*	491 (345-698)	*	37 (19-70)	
Gray Triggerfish	*Balistes capriscus*	1.3 (0-11)		13 (6-26)	*	63 (40-101)	*	2 (1-6)	
Great Barracuda	*Sphyraena barracuda*	4 (1-24)		27 (14-51)	*	75 (50-113)	*	478 (206-1107)	*
Greater Amberjack	*Seriola dumerili*	14 (3-60)		32 (17-59)	*	487 (176-1347)	*	587 (313-1099)	*
Grouper sp.	*Epinephelinae* sp.	0.2 (0-5)		0.7 (0-3)		16 (-)	*	0.3 (0-2)	
Guaguanche	*Sphyraena guachancho*	3 (0-19)		32 (17-60)	*	22 (14-33)	*	2 (1-8)	
Gulf Menhaden	*Brevoortia patronus*	67 (17-266)		2,876 (1642-5039)	*	169 (120-239)		105 (56-197)	
Horse-eye Jack	*Caranx latus*	3 (1-20)		19 (10-37)	*	86 (56-133)	*	416 (187-925)	*
King Mackerel	*Scomberomorous cavalla*	4 (1-23)		81 (45-146)	*	38 (26-57)	*	5 (2-12)	
Leatherjack	*Oligoplites saurus*	26 (6-106)		105 (59-187)		706 (475-1051)	*	45 (23-86)	
Lookdown	*Selene vomer*	3 (1-16)		26 (14-50)	*	107 (72-159)	*	8 (5-13)	
Ocean Triggerfish	*Canthidermis sufflamen*	0.6 (0-9)		1 (0-4)		10 (5-17)	*	20 (10-42)	*
Rainbow Runner	*Elagatis bipinnulata*	13 (3-67)		266 (133-529)	*	53 (36-78)	*	405 (178-924)	*
Red Drum	*Sciaenops ocellatus*	0.1 (0-2)		4 (1-13)	*	0.2 (-)		0.2 (-)	
Red Snapper	*Lutjanus campechanus*	359 (94-1367)	*	1,015 (541-1904)	*	2,980 (875-10152)	*	133 (72-246)	*
Sheepshead	*Archosargus probatocephalus*	0.3 (0-3)		19 (9-39)	*	6 (-)	*	1 (-)	
Spanish Hogfish	*Bodianus rufus*	0.1 (0-2)		0.3 (0-1)		2 (-)	*	0.1 (0-1)	
Spanish Mackerel	*Scomberomorous maculatus*	0.2 (0-6)		- (-)	*	0.1 (0-1)	*	- (-)	
Unidentified Fish		142 (39-520)	*	250 (140-446)	*	276 (196-389)	*	13,090 (5363-31952)	*
Vermilion Snapper	*Rhomboplites aurorubens*	45 (11-180)		118 (67-210)		3,506 (428-28743)	*	57 (30-109)	
Yellow Jack	*Carangoides bartholomaei*	0.8 (0-11)		0.9 (0-3)	*	7 (4-13)	*	0.5 (0-3)	
Total		7,764 (1975-30517)		15,014 (8593-26234)		15,877 (6349-39700)		20,284 (10169-40459)	
Total Taxa Verified by SRV Observation		7		26		32		13	
Total Number Verified by SRV Observation		7,494		14,784		15,707		19,611	
Percent of Model Abundance Verified by SRV		96.5		98.5		98.9		96.7	

Abundance by Proximity to Platform

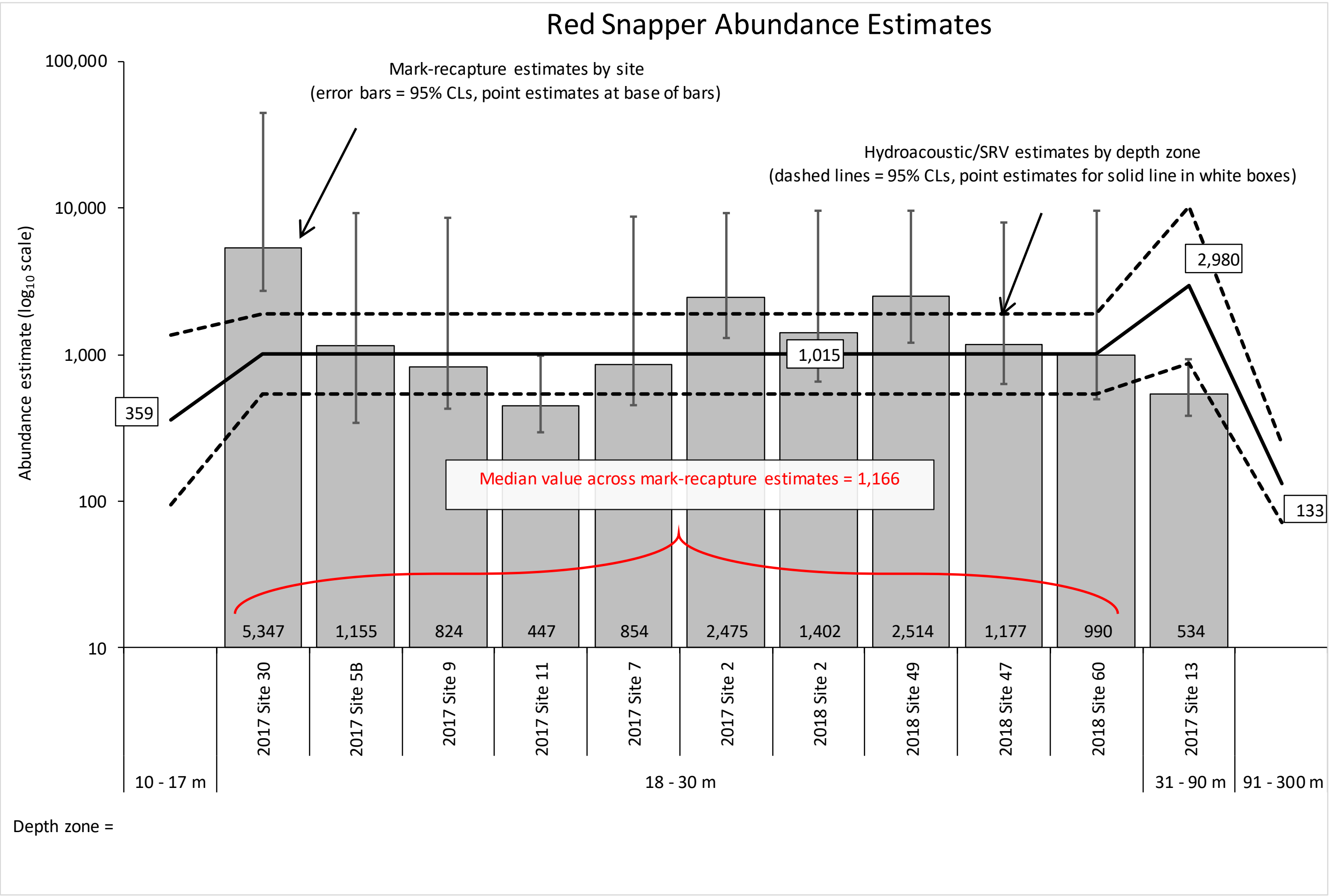


Platform Reef Fish

- Platforms harbored significant reef resources including Red Snapper, Vermilion Snapper, Greater Amberjack, Cobia and other species.

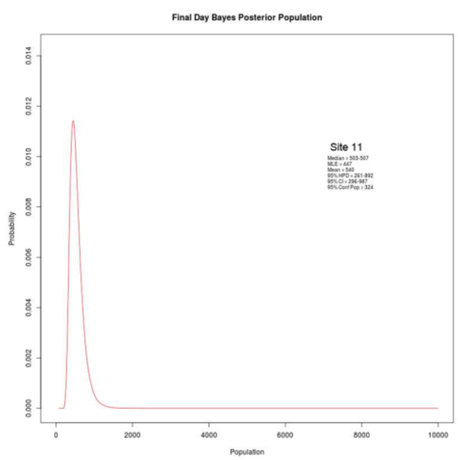
Red Snapper

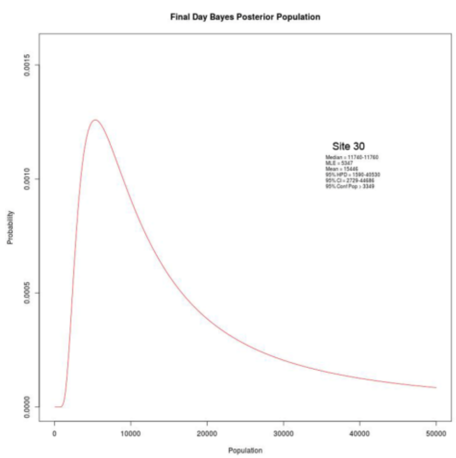
Comparison of Red Snapper Population Estimates by Mark-Recapture to Hydroacoustic/SRV Estimates



Mark Recapture Population Estimates Following Gazey and Staley (1986)

- Population estimates were made using a Bayesian approach following Gazey and Staley (1986).
- This approach provides a Maximum Likelihood Estimate, mean and median estimates along with a probability estimate for each population size:
- Examples are provided for Site 11 (low population size) and for Site 30 (high population size).

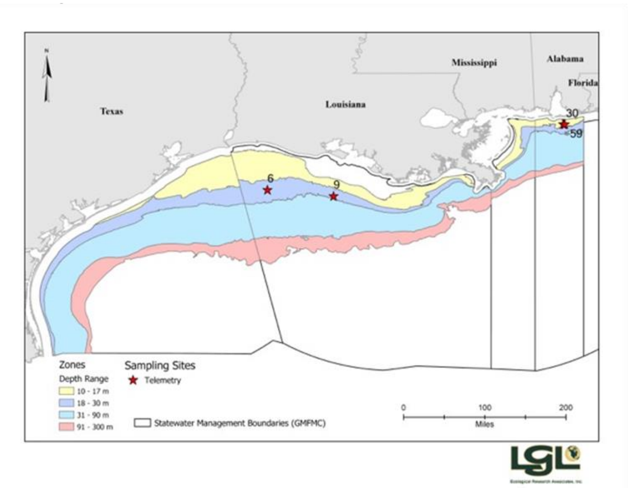




* Gazey, W. and M.J. Staley. 1986. Population estimates from mark-recapture experiments using a sequential bayes algorithm. Ecology 67(4): 941-951.

Red Snapper Acoustic Telemetry Studies

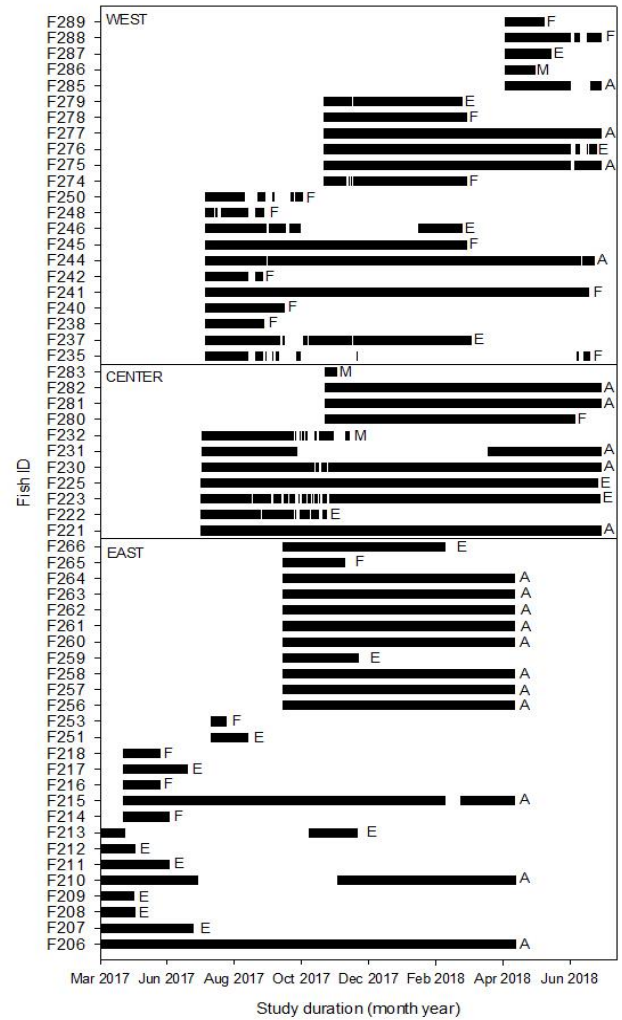
- A total of 71 Red Snapper were tagged and released at sites 6, 9 and 30 (all in the 18- m to 30- m depth zone).



- After tagging, six days were allowed for "tagging recovery"; after 6 days 59 fish survived and were tracked for extended periods.

Red Snapper Acoustic Telemetry Studies (continued)

- A total of 11 of the 59 fish (19%) permanently emigrated following residences at the sites of 33 to 385 days after tagging.
- Some 24 fish exhibited homing behavior, leaving and returning to the sites following absences of 3 to 184 days.
- In figure on right, black bars = active on platform. Letters represent final status of fish. A = Active at end of study. E = Emigrant at end of study. M = Natural mortality. F = Fishing mortality.

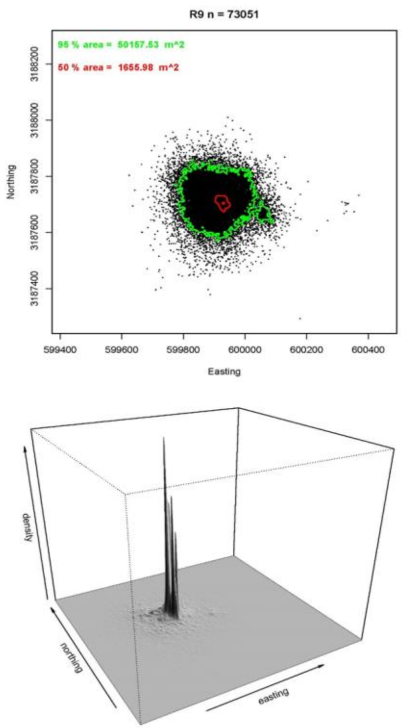


Red Snapper Acoustic Telemetry Studies (continued)

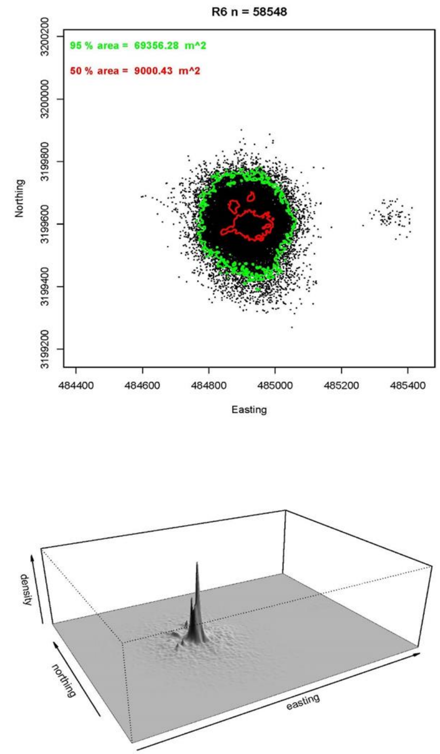
- The fish typically remained in close proximity to the platform (mean distance from platforms was 28.2 m ± 33.9 m, n=59).
- 10% of the 879,299 recorded positions were under the platforms; 84% were within 95 m of the platform perimeters and 6% were more than 95 m from the platform perimeters.

Red Snapper Acoustic Telemetry Studies (continued)

- The distributions were clumped closely associated with the structures; e.g.:



Red Snapper positions (dots) and Kernel density estimates (KDE) from all fish at site 9 in 2017. Red = 50% (KDE) and green = 95% (KDE).



Red Snapper positions (dots) and Kernel density estimated (KDE) from all fish at site 6 in 2017. Red = 50% (KDE) and green = 95% (KDE).

Red Snapper Acoustic Telemetry Studies (continued)

- A known fate model in the "MARK" program (White 2014)* was used to estimate mortalities (F, M, Z).
- Overall, mortalities at the shallow-water (17- to 30- m deep) platforms suggested high fishing and total mortality, and low natural mortality.

  F = 0.75 (95% CI: 0.35 – 1.36)

  M = 0.06 (95% CI: 0.01 – 0.22)

  Z = 0.81 (95% CI: 0.36 – 1.58)
- Red Snapper at shallow water sites are heavily fished as evidenced by the data and observations of fishing at these sites during the study.

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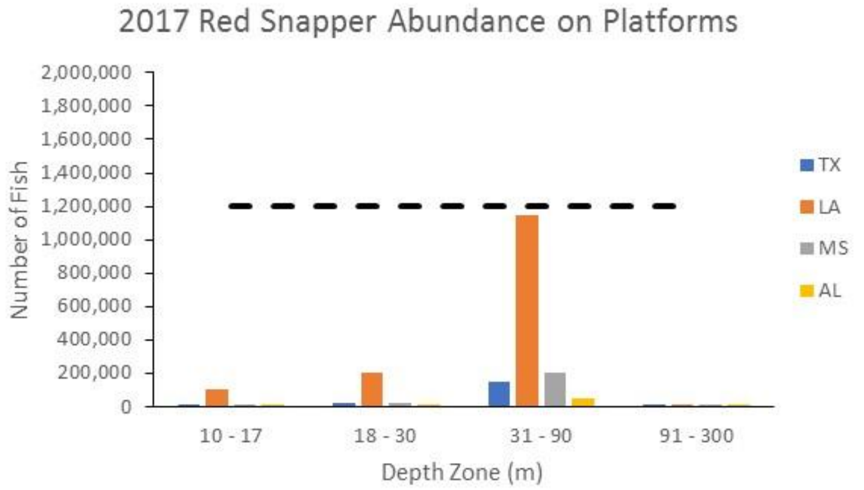
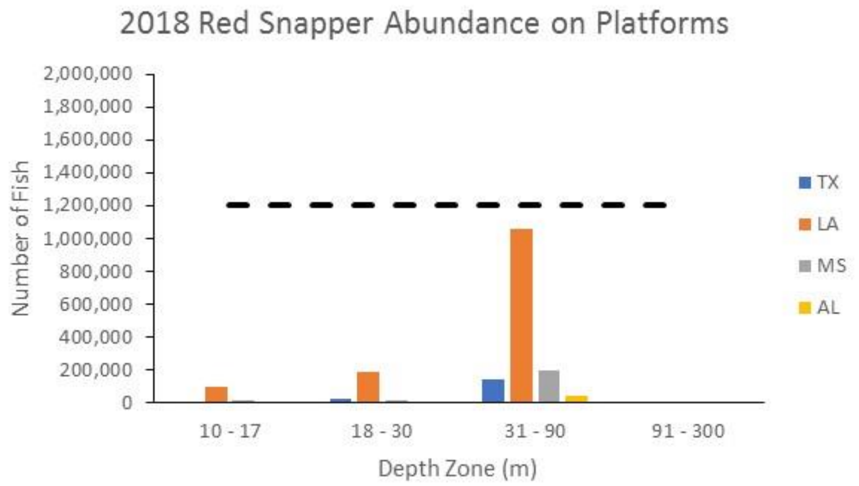
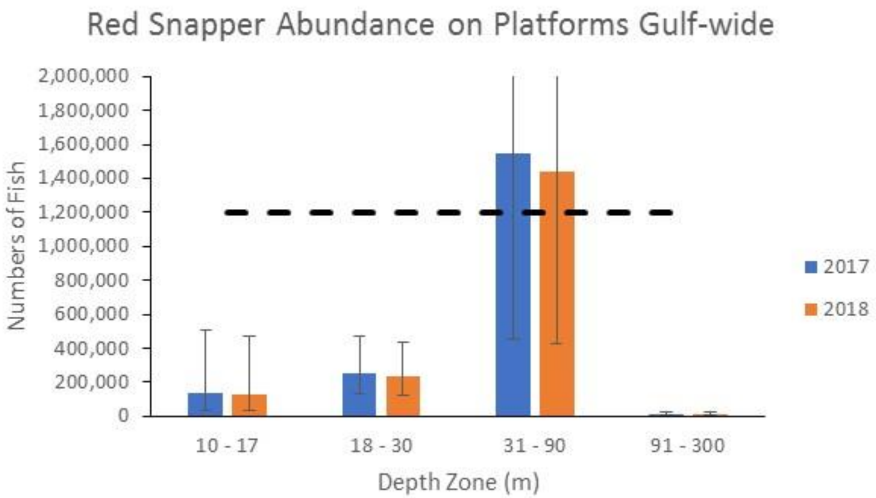
* White, G.C. 2014. Introduction to Program Mark. Werner College of Natural Resources, Colorado State University. http://sites.warnercnr.colostate.edu.gwhite/introduction-program-mark/#1495486638963-0093a6d7-86al. Last visited 24 May 2019.

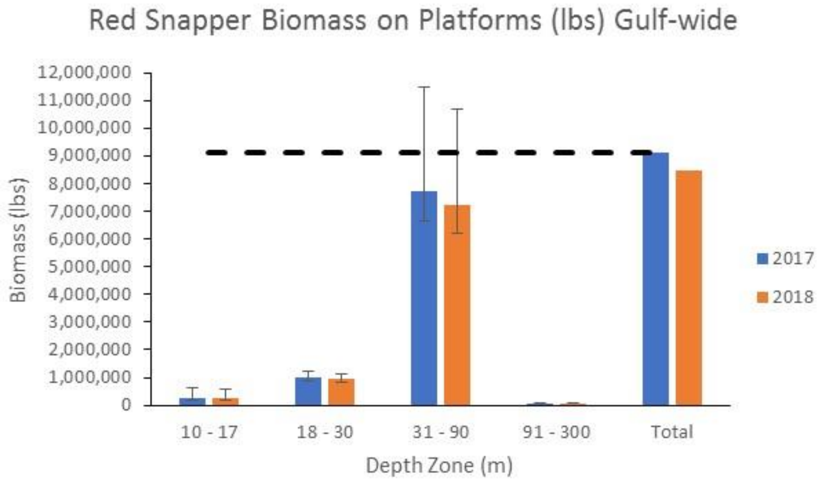
Red Snapper Abundance on Platforms by State and Depth Zone



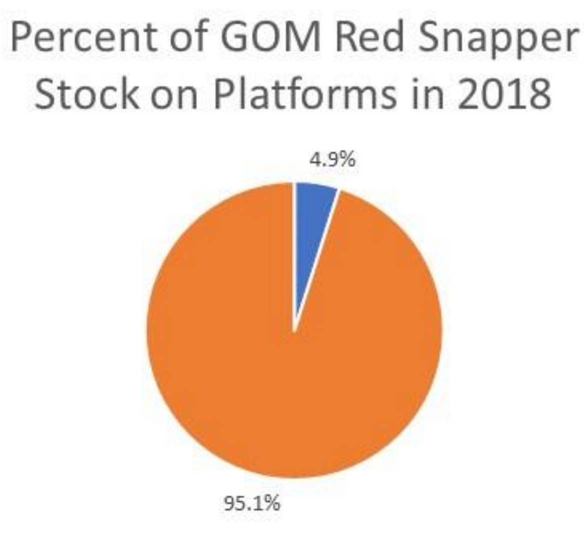


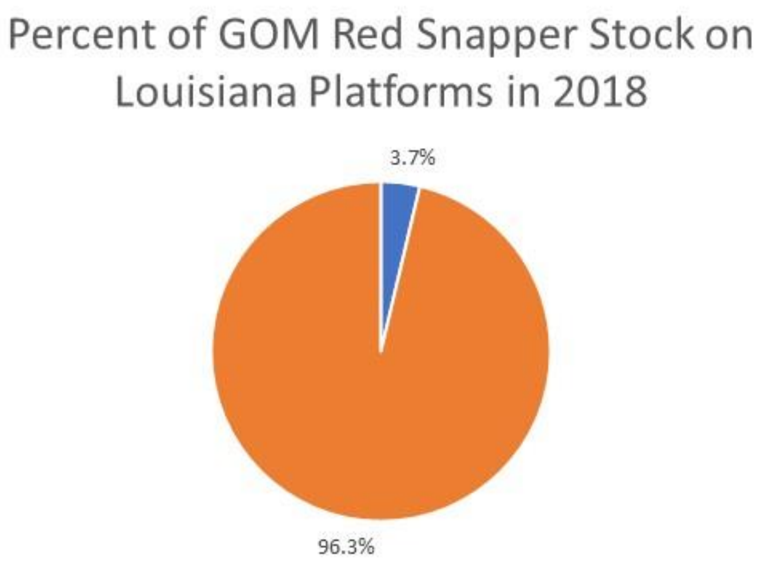
Red Snapper Abundance and Biomass on Platforms





Red Snapper Abundance on Platforms: 2018 Percent Total Gulf Stock





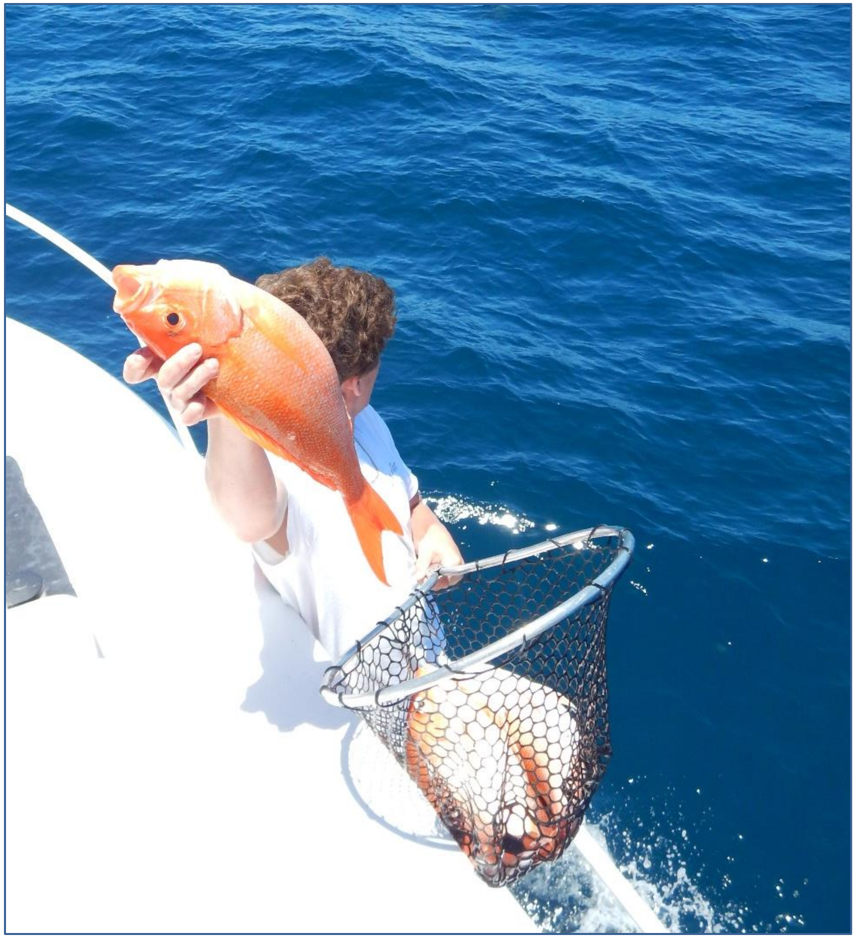
4.9% stocks occurred on platforms.

3.7% stocks occurred on platforms.

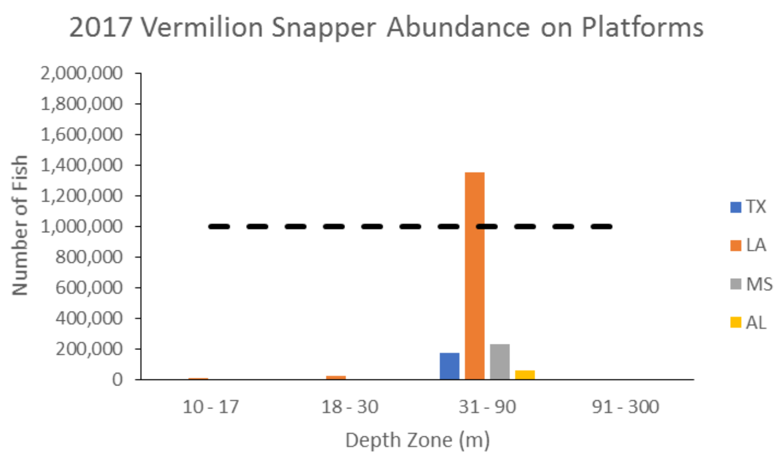
Shallow Water Platforms are also Important

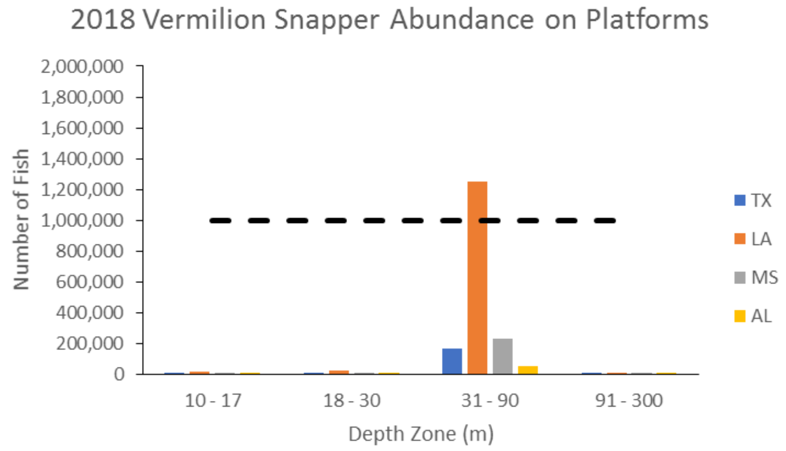
- As an aside, Ed Chesney and David Reeves have shown shallow platforms offshore western Louisiana are important habitats for age 0 and age 1 Red Snapper.

Vermilion Snapper

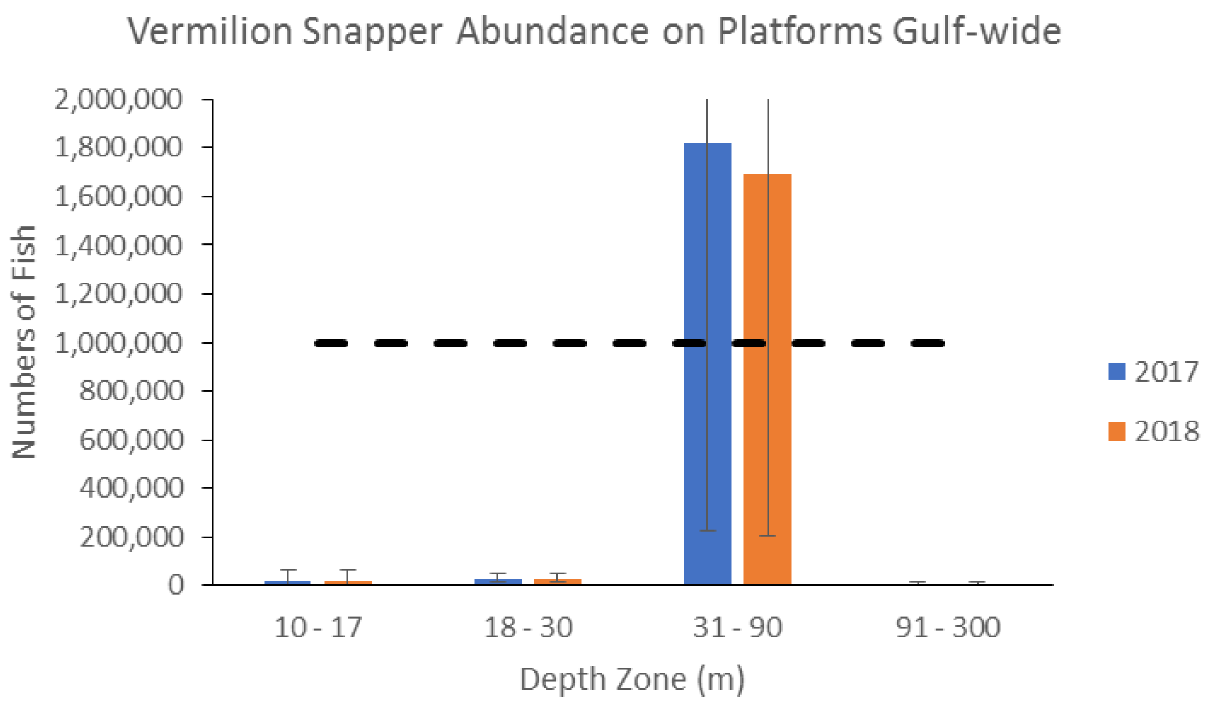


Vermilion Abundance on Platforms by State and Depth Zone

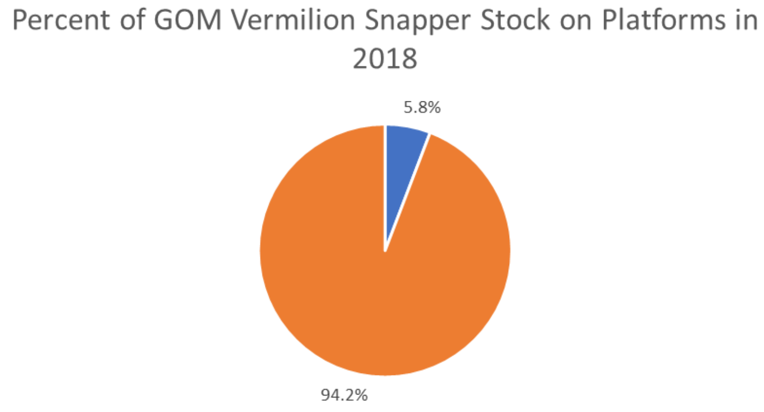


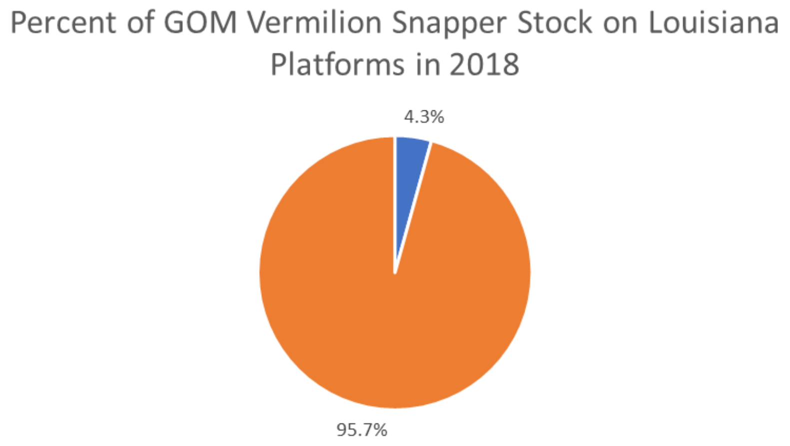


Vermilion Abundance on Platforms



Vermilion Abundance on Platforms : 2018 Percent Total Gulf Stock



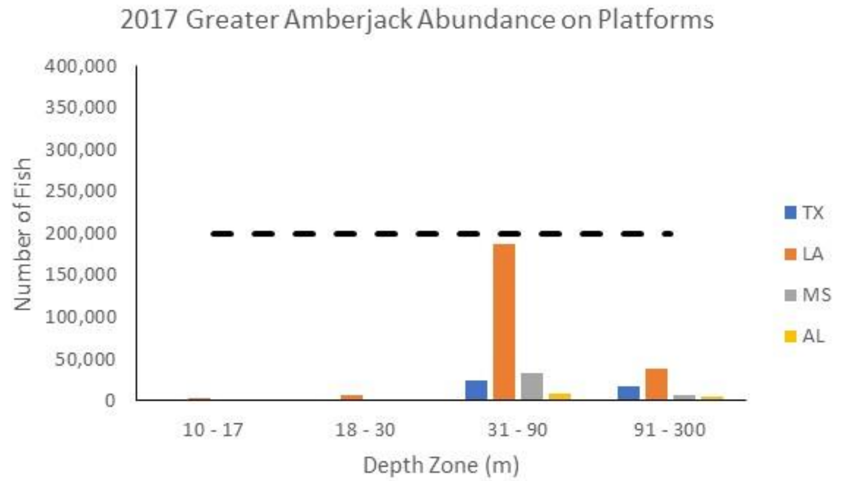


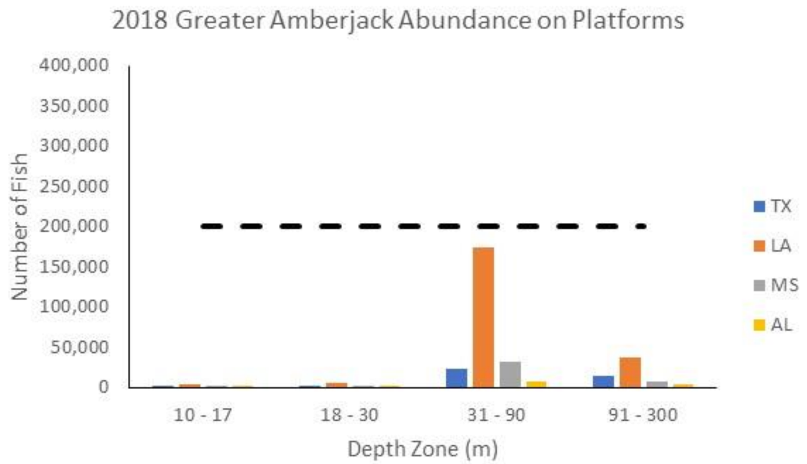
5.8% stocks occurred on platforms.

4.3% stocks occurred on platforms.

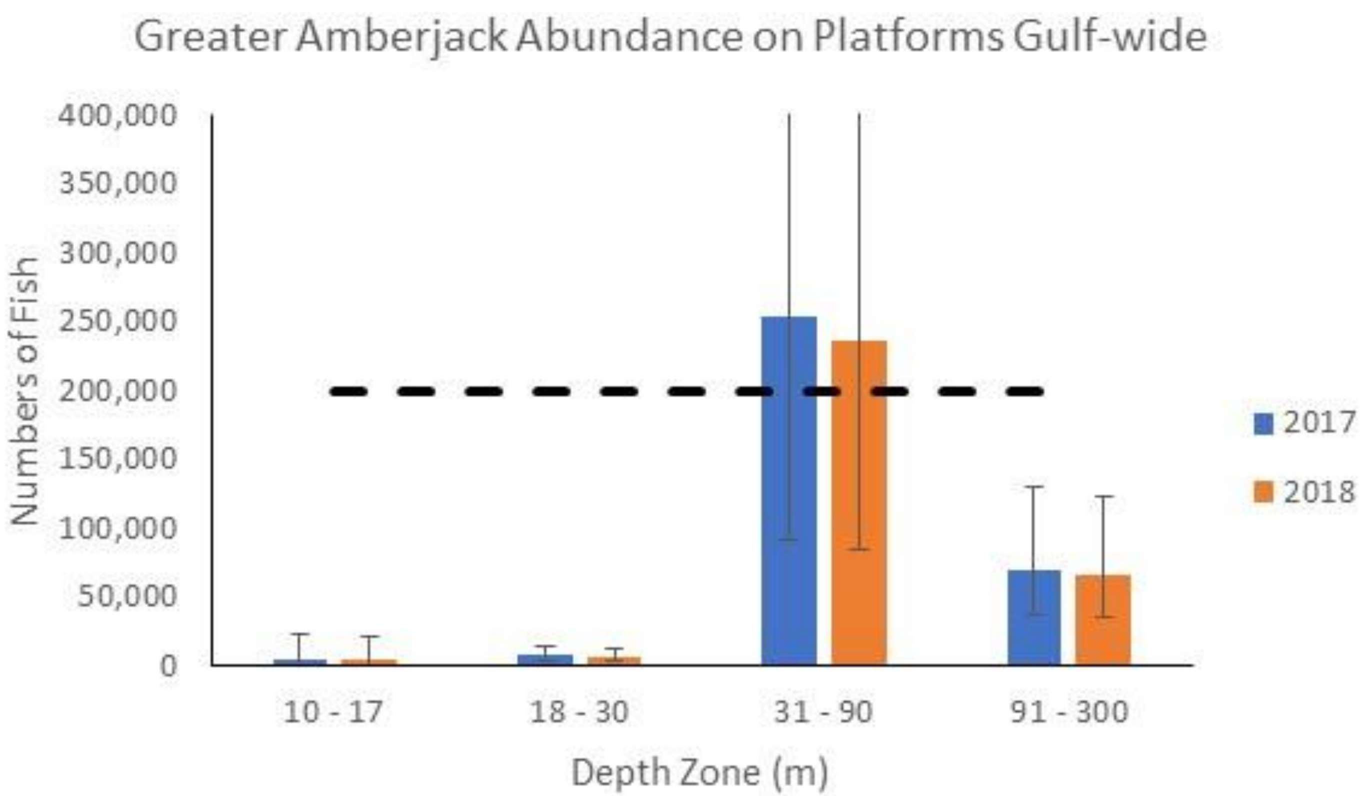
Greater Amberjack

Greater Amberjack Abundance on Platforms by State and Depth Zone

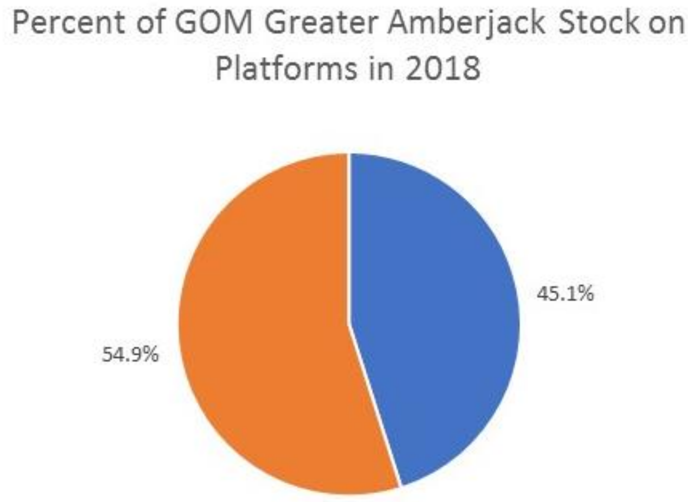


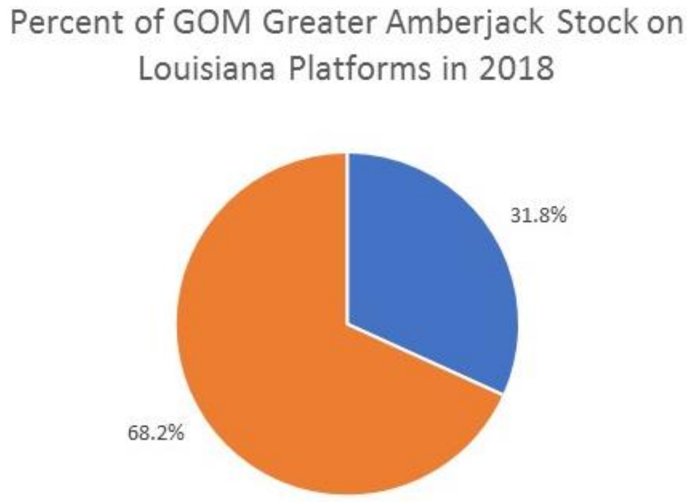


Greater Amberjack Abundance on Platforms



Greater Amberjack Abundance on Platforms : 2018 Percent Total Gulf Stock



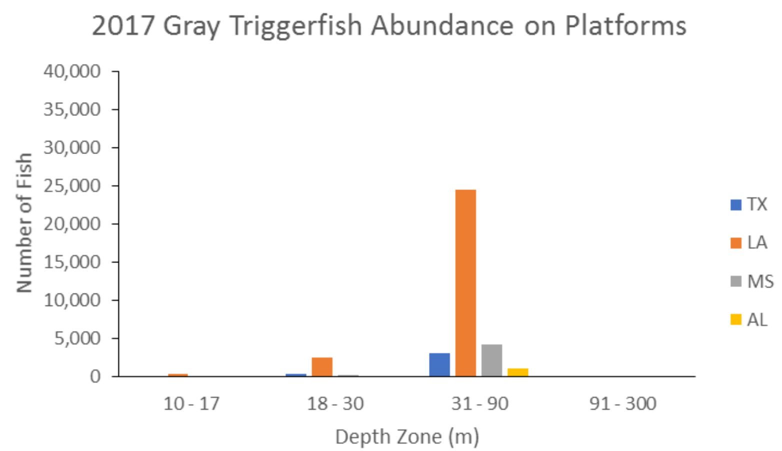


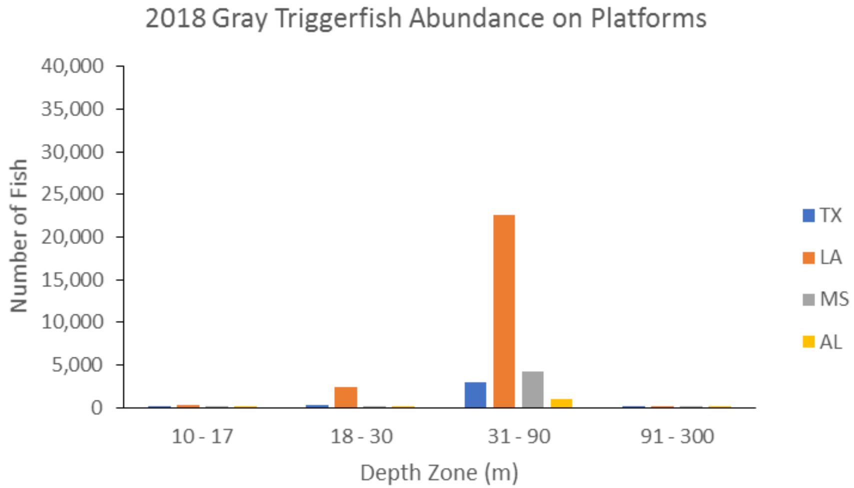
45.1% stocks occurred on platforms.

31.8% stocks occurred on platforms.

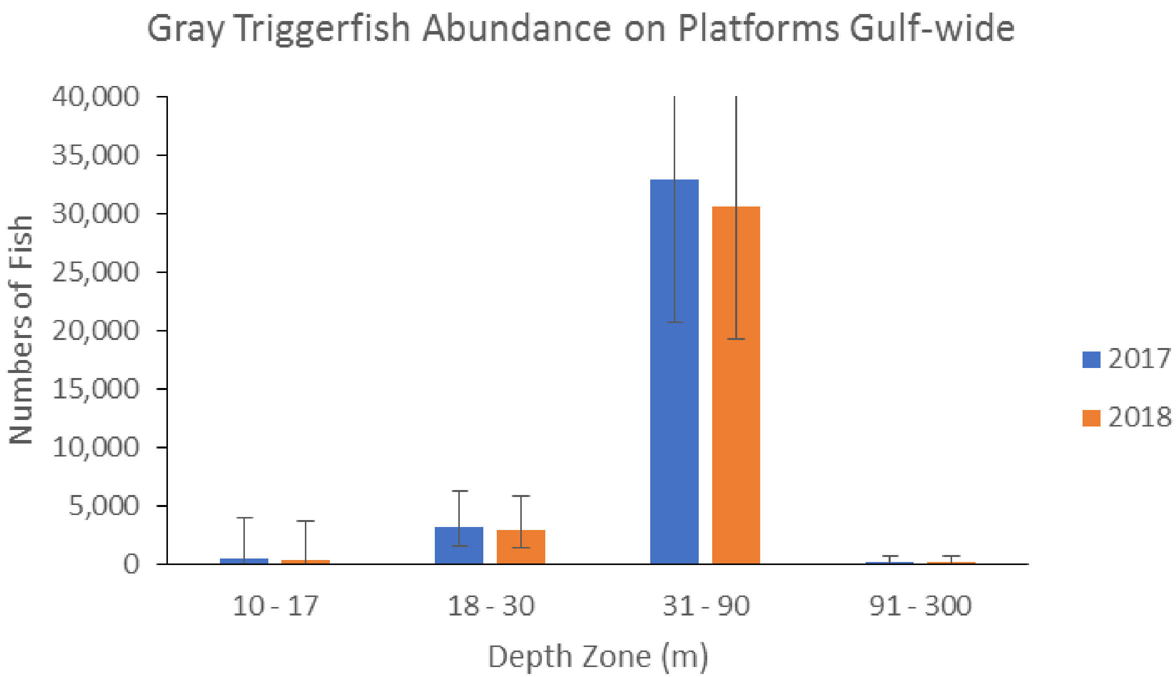
Gray TriggerFish

Gray TriggerFish Abundance on Platforms by State and Depth Zone



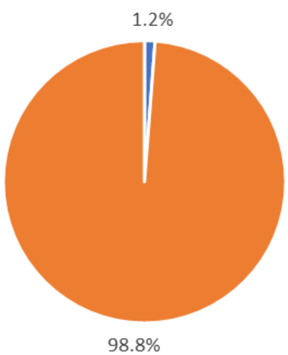


Gray TriggerFish Abundance on Platforms

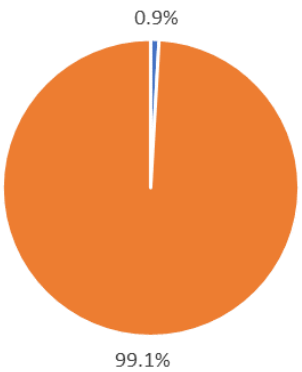


Gray TriggerFish Abundance on Platforms : 2018 Percent Total Gulf Stock

Percent of GOM Gray Triggerfish Stock on Platforms in 2018



Percent of GOM Gray Triggerfish Stock on Louisiana Platforms in 2018

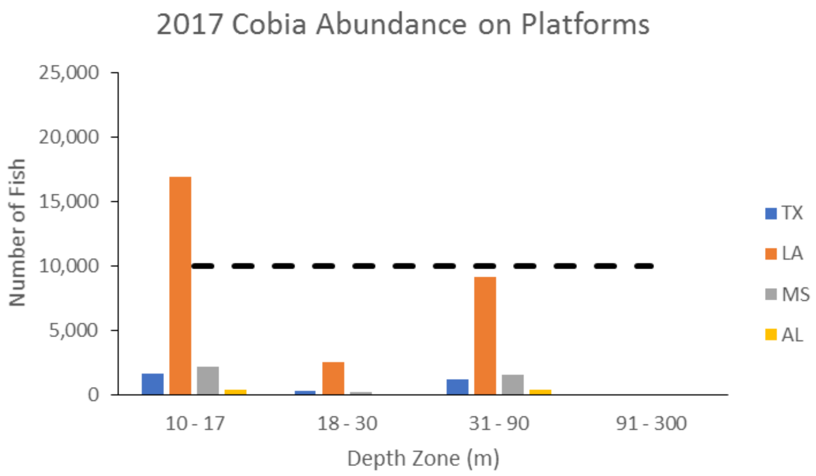


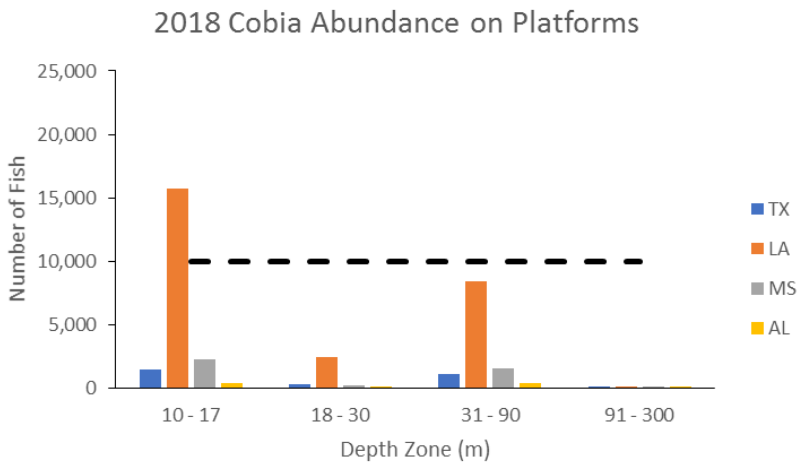
1.2% stocks occurred on platforms.

0.9% stocks occurred on platforms.

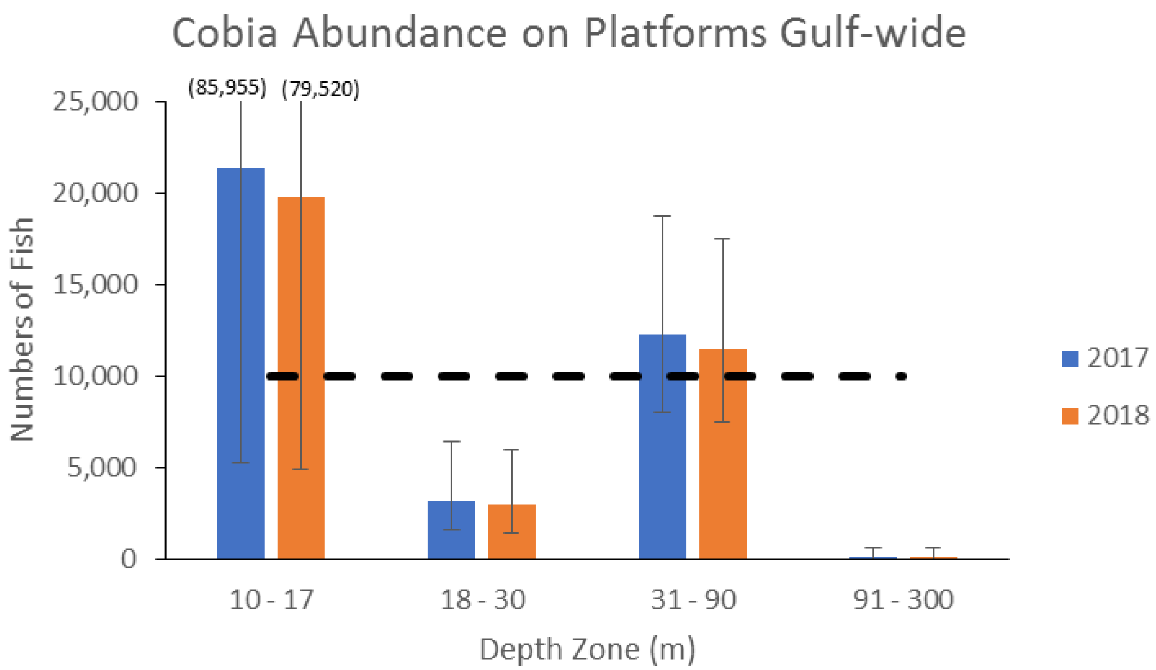
Cobia

Cobia Abundance on Platforms by State and Depth Zone





Cobia Abundance on Platforms



Cobia Abundance on Platforms : 2018 Percent Total Gulf Stock

Percent of GOM Cobia Stock on Platforms in 2018

Percent of GOM Cobia Stock on Louisiana Platforms in 2018

8.1% stocks occurred on platforms.

6.3% stocks occurred on platforms.

AN ASSESSMENT OF THE EFFECTS OF EXPLOSIVE REMOVAL OF OFFSHORE OIL AND GAS PLATFORMS

by

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Assessment Approach

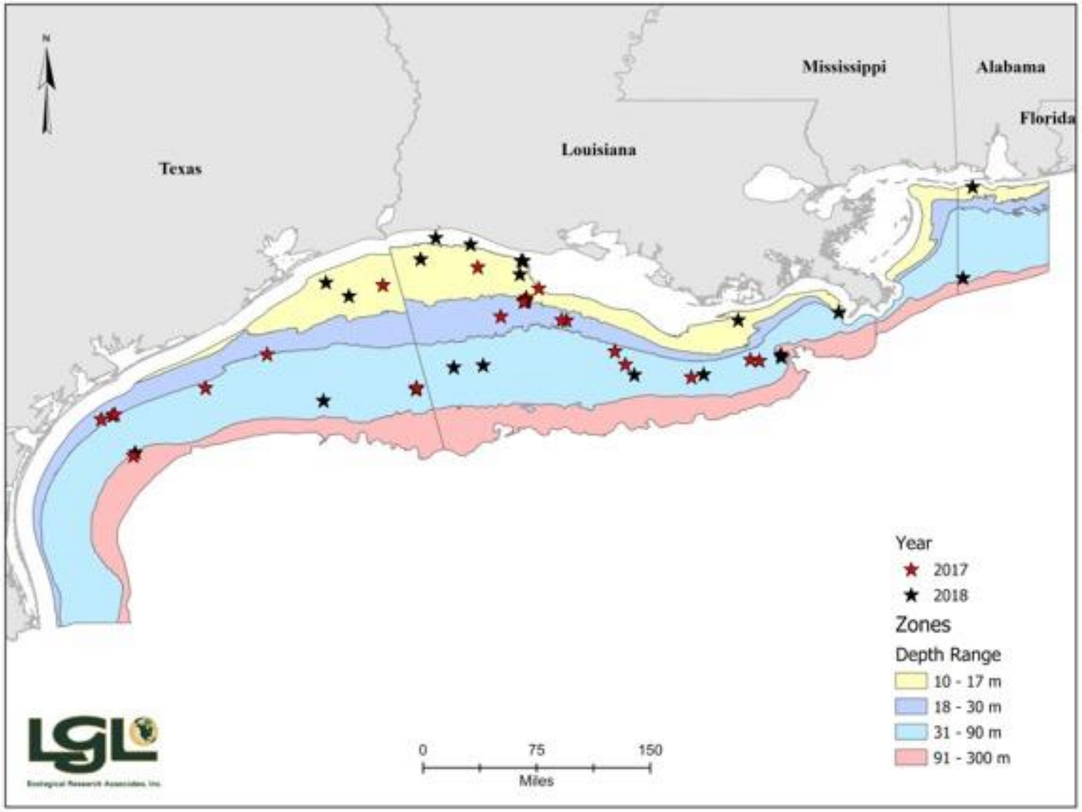
- Our assessment of effects were based on three scenarios:

1) The effects of the actual explosive removals of 47 platforms over our 2017-2018 study period;

In 2017 and 2018, 329 explosions were used to sever 319 pipes at 47 platforms in water depths ranging from 10 m to 93 m. These 47 platforms were divided into four depth zone categories as follows:

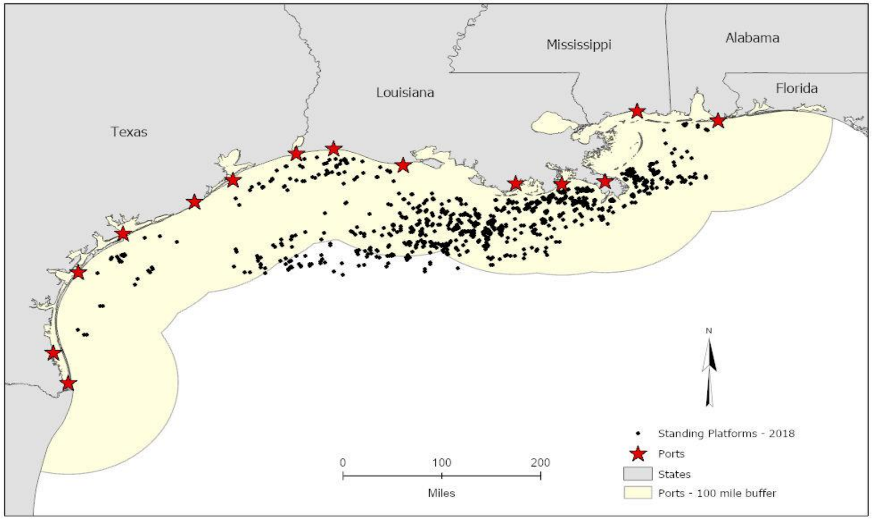
Depth Zone	Water Depth	2017	2018	Number of Platforms
A	10-17 m	3	11	14
B	18-30 m	12	1	13
C	31-90 m	8	10	18
D	91-300 m	1	1	2

Assessment Approach (continued)



Assessment Approach (continued)

2) The effects that would occur if all the remaining platforms in the study area were removed in a single year; and



The location of the 1,171 standing platforms in the Gulf of Mexico in 2018. The red stars represent major fishing ports and the yellow polygon represents a 100-mile radius from each major port. A total of 1,115 platforms were located within 100-m of each port.

Ecological Research Associates, Inc.

3) The effects of removing all the remaining platforms within a 100-mile radius of the major fishing ports.

Assessment Approach (continued)

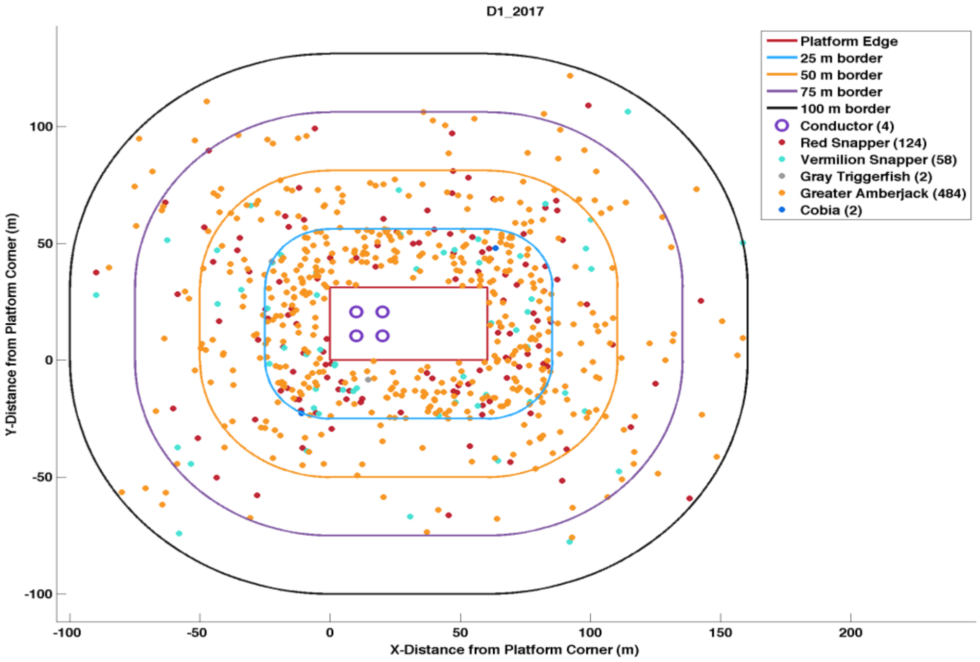
- Data on the abundance of fishes were binned with respect to horizontal distance from the platform and vertical depth below the water surface.
- Due to abundance being binned into four depth zones, most platforms were actually shallower than the deepest bin for the prescribed depth zone.
- All fish in bins shallower than each platforms water depth were placed and the remaining fish were then placed in the deepest bin available.
- The exact number of fish and their locations were randomly selected 10,000 times to ensure representative distributions.

Acoustic Modeling Results

- For this report, over 100,000 simulated fish were placed around 47 platforms removed in 2017 and 2018 and mortality ranges were calculated for 329 explosions.
- Based on the “more conservative” inputs (229 dB, smaller inner pipes, soft clay) every fish was exposed to a lethal peak pressure at all 47 sites.
- There was limited survival using the “less conservative” inputs (234 dB, large inner pipes, stiff clay) applied to the deepest depth range.

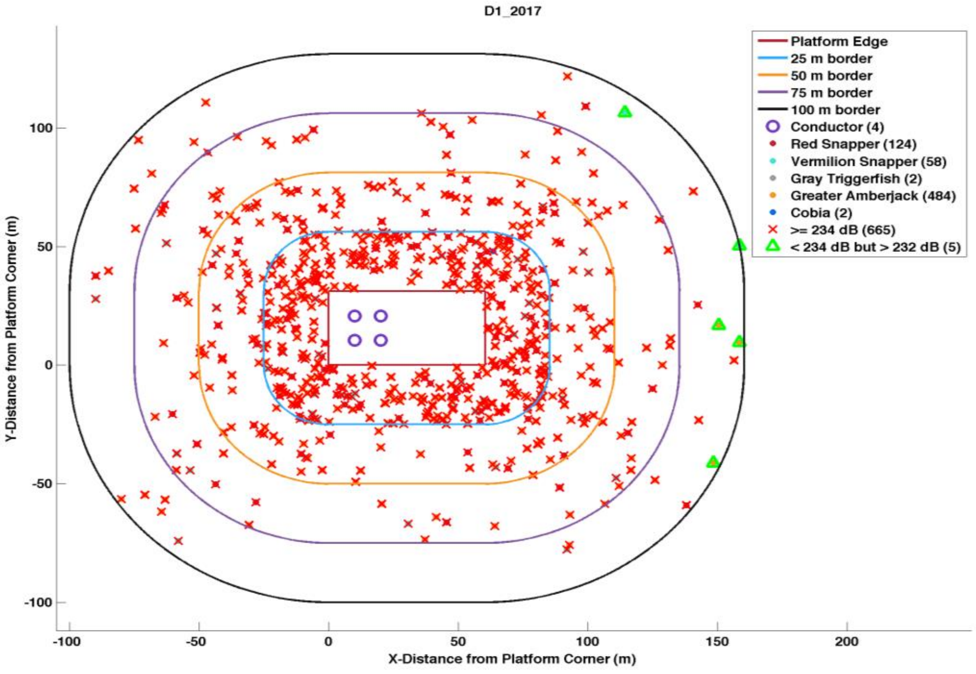
Acoustic Modeling Results (continued)

- One iteration of fish placement at platform D1_2017 in 91-m deep water is shown.
- Four conductors were exploded at this site on 3 July 2017.

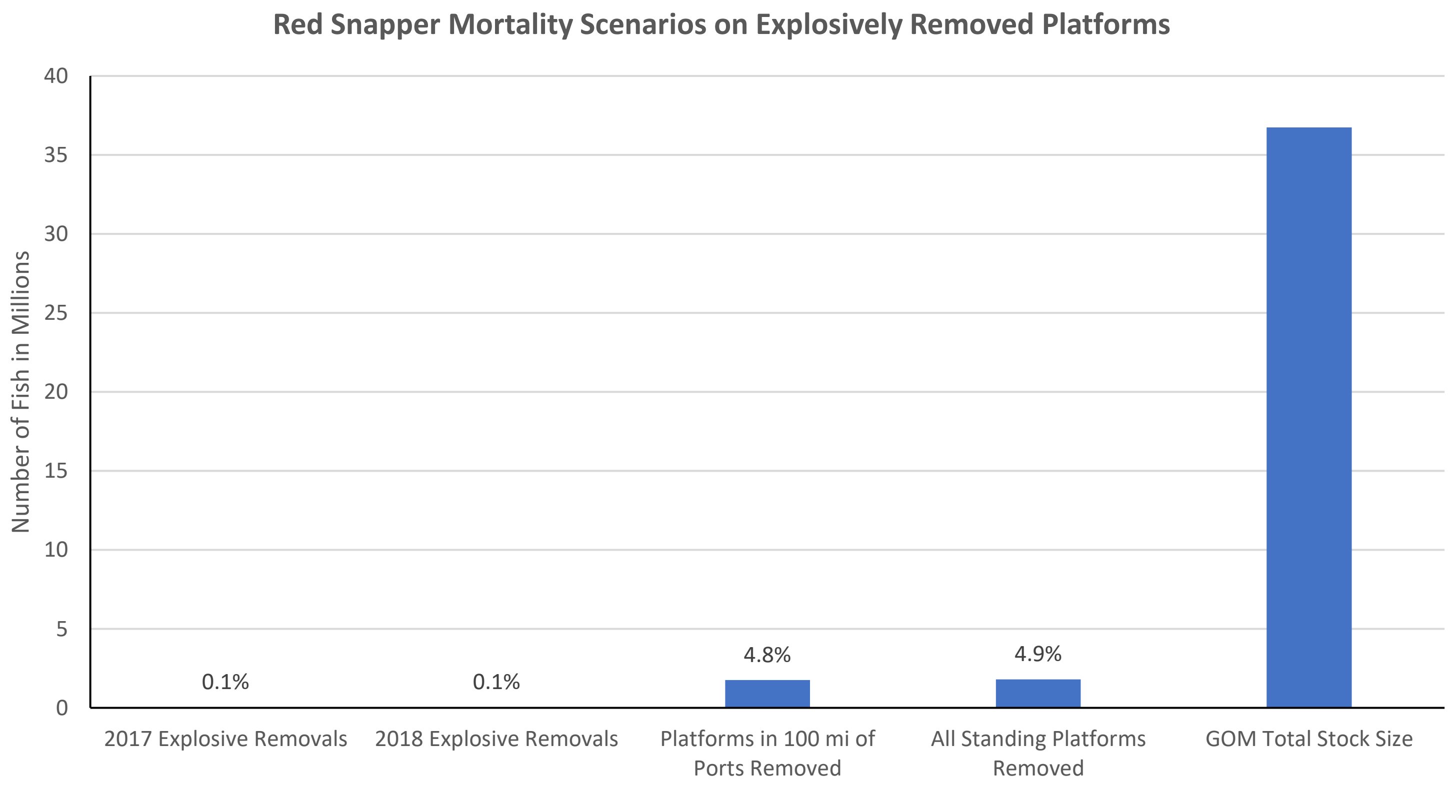


Acoustic Modeling Results (continued)

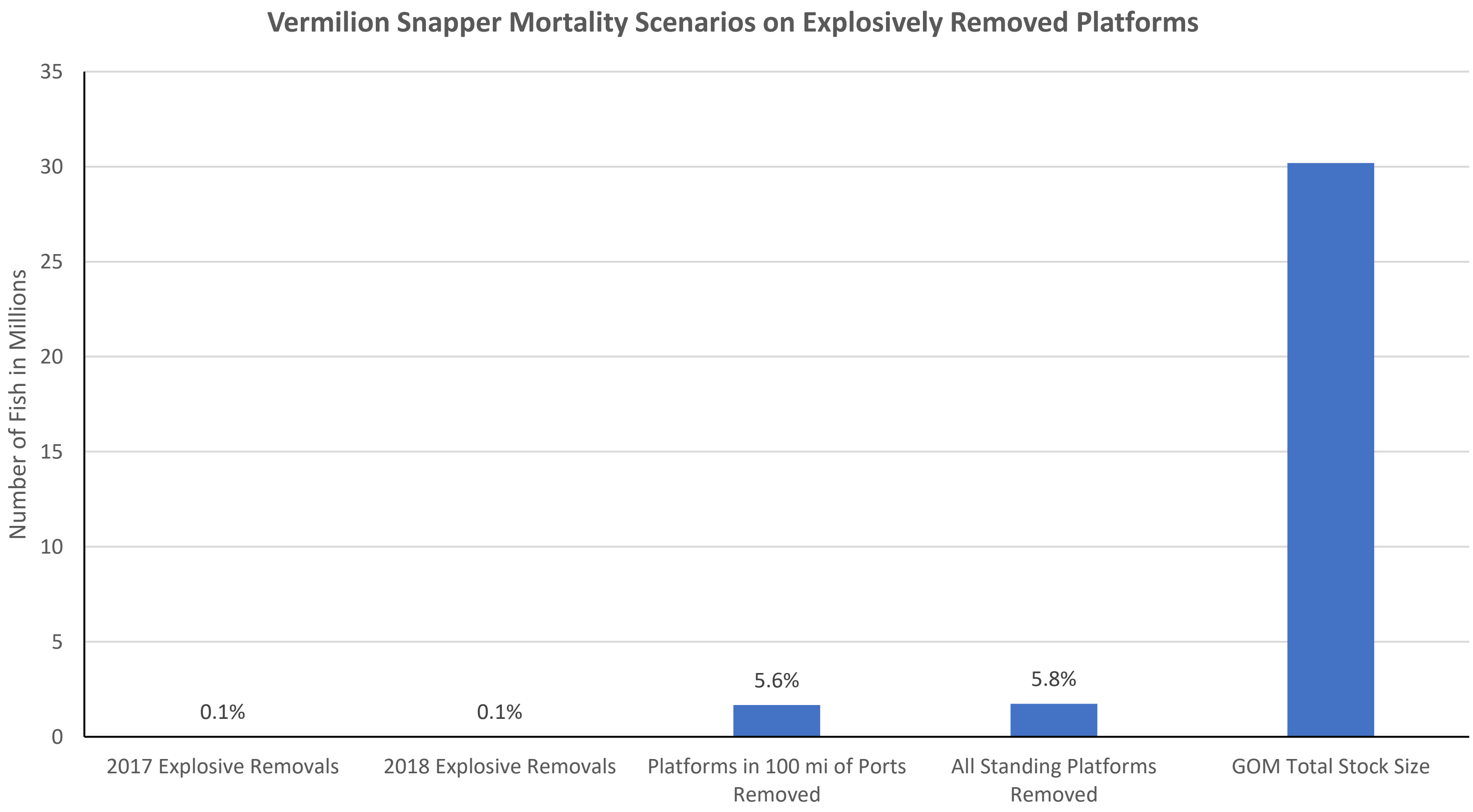
- These explosions were estimated to kill 665 of the 670 fish placed in this single iteration of the 10,000 model runs.
- Basically, even at deep water sites, fish survival is nil at distances less than 157 meters from the explosions.



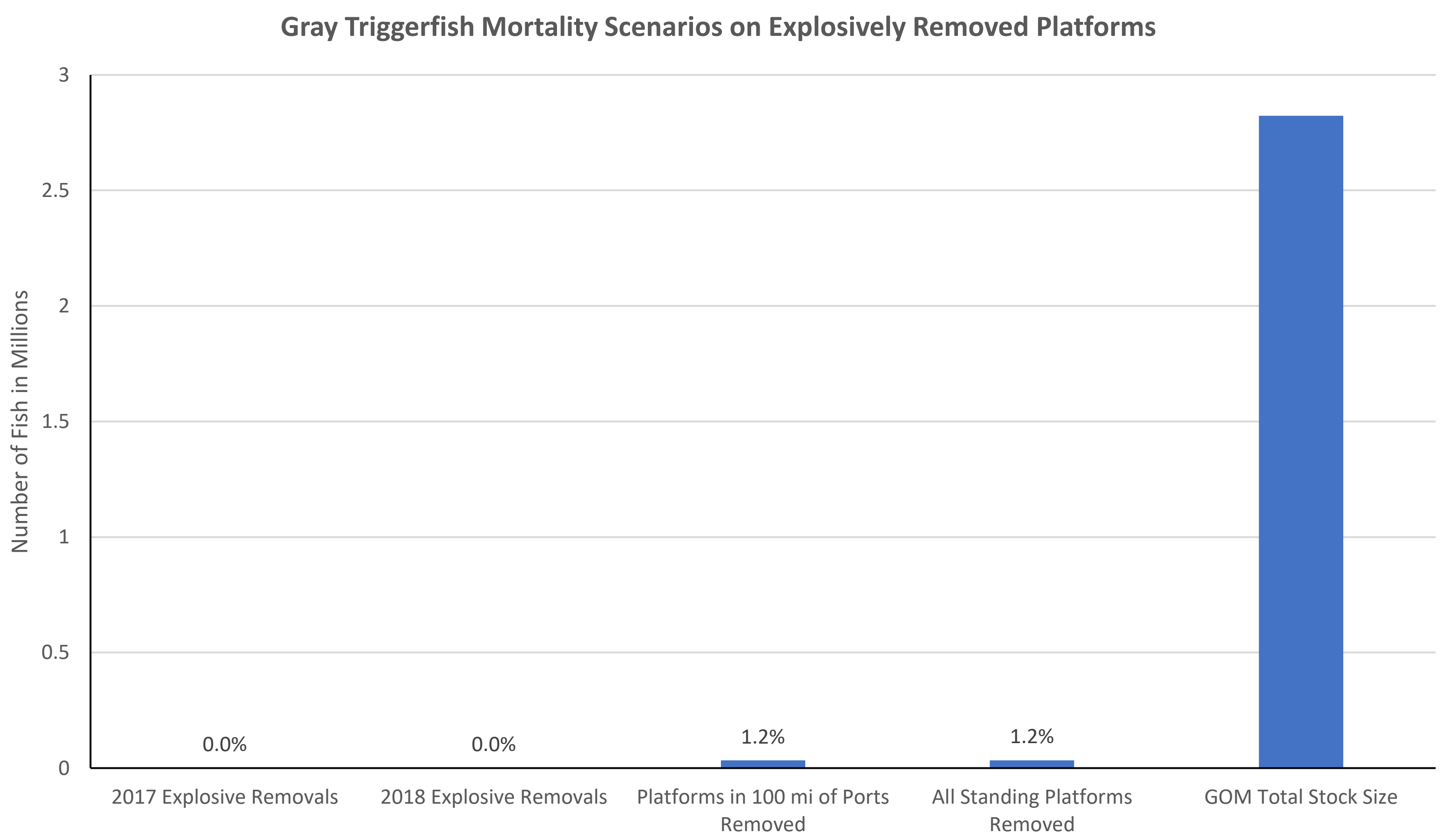
Results: Red Snapper



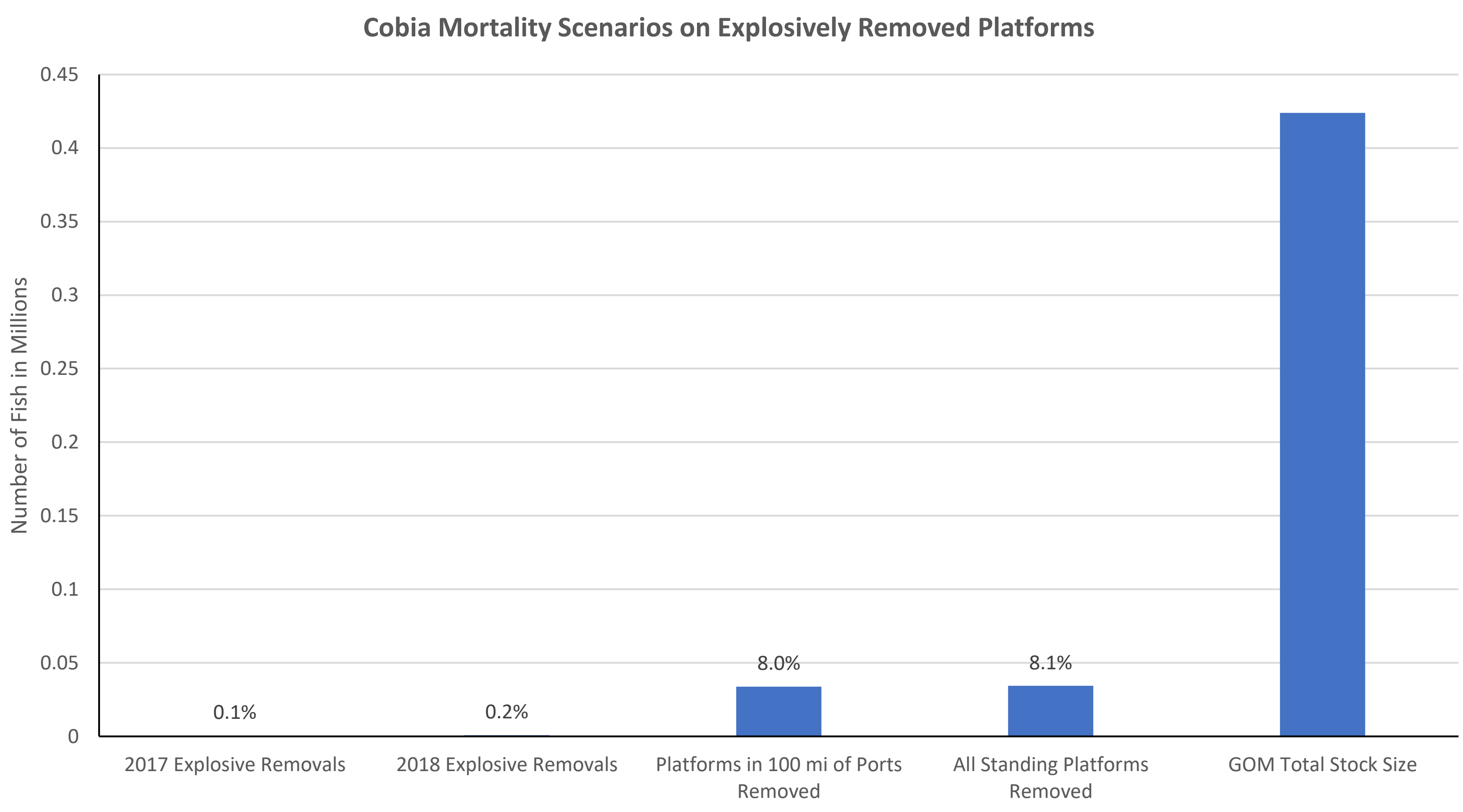
Results: Vermilion Snapper



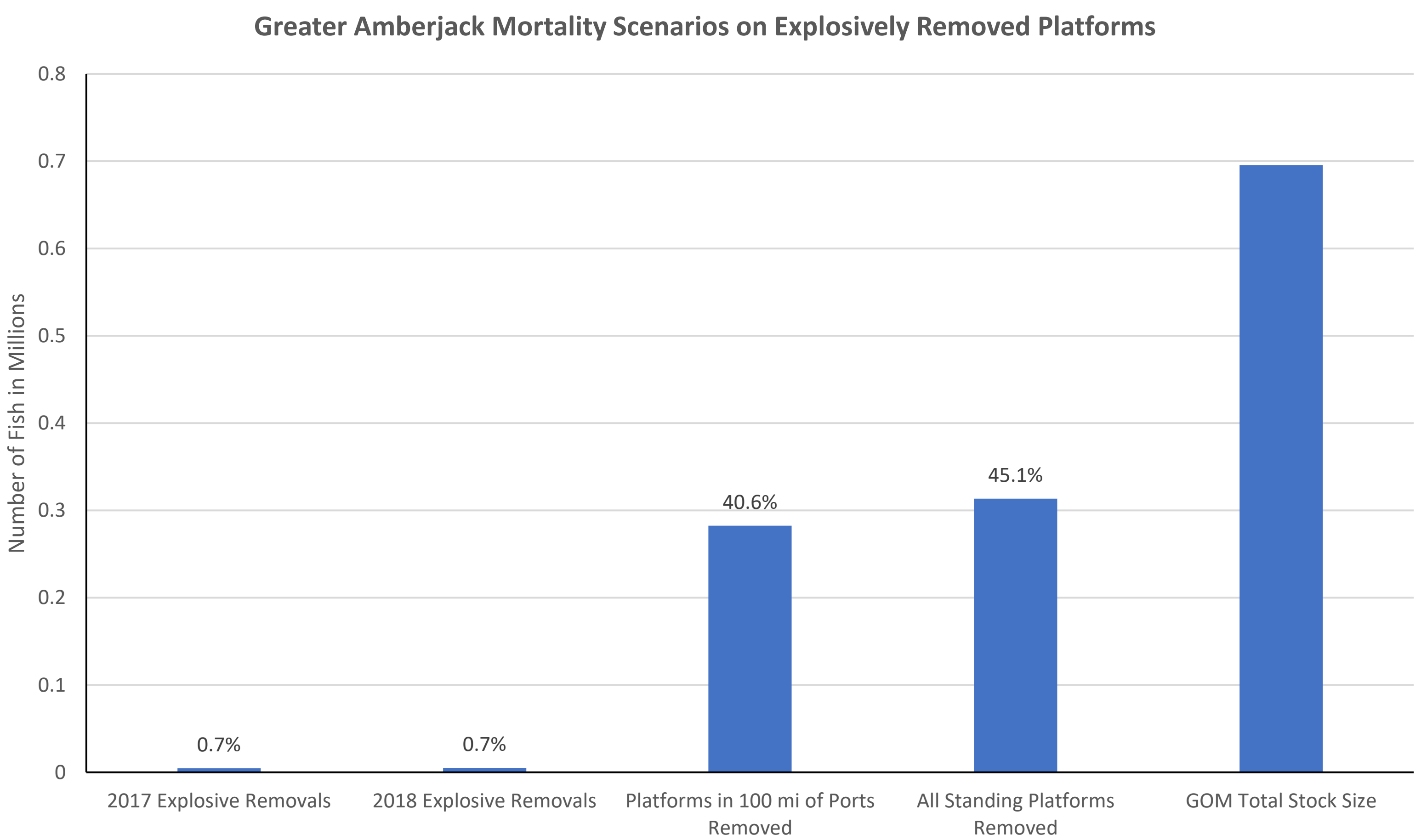
Results: Gray Triggerfish



Results: Cobia



Results: Greater Amberjack

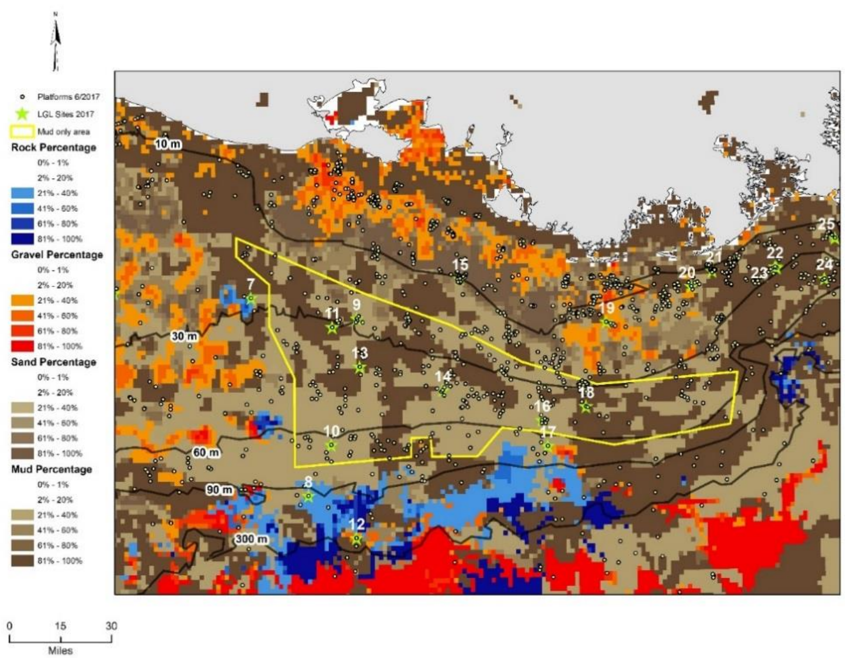


Results: Local Stakeholders

- Offshore petroleum platforms are targeted by local fishermen, especially the recreational sector of the western Gulf.
- Platform removals in the western Gulf in 2018 killed the equivalent of 35% of the Red Snapper total landings taken by the commercial and recreational fisheries in 2016, the most recent year for which landings were available.
- These removals equated to about 16% of the Red Snapper Allowable Catch Limits (ACL) for Louisiana and about 7% of the Texas ACLs.
- Platform removals can effect local stakeholders by reducing catch limits.

Results: Habitats

- In some areas of the Gulf (e.g. western Louisiana), mud bottom substrates appear to predominate; and, aside from offshore petroleum platforms, little reef habitat is evident.

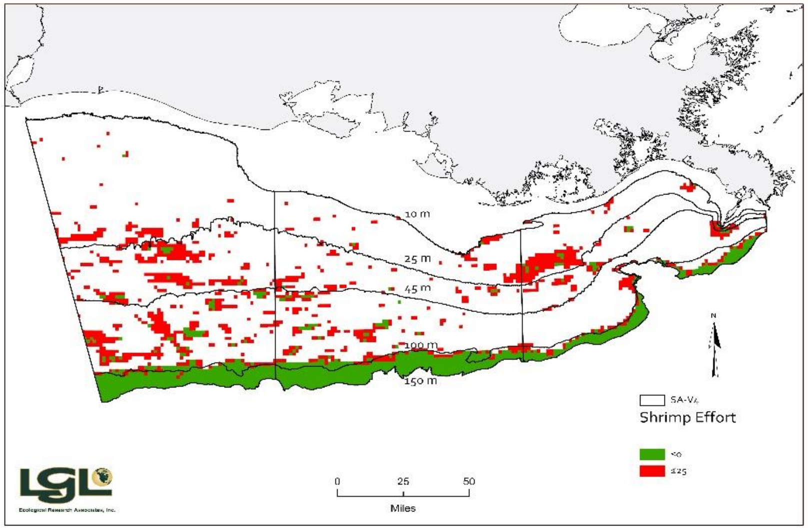


Results: Habitats (continued)

- In western Louisiana, known hard- substrate habitats include 866 platforms, 327 slate-permitted, large artificial reefs and 13 or so discrete or named banks.
- Platforms thus constitute about 72% of the known, discrete habitats in this zone and their removal would likely have significant impacts on local fisheries.

Results: Habitats (continued)

- However, there may be more reef habitat offshore western Louisiana than has been characterized or charted.
- Based on shrimp trawling data, the potential distribution of uncharted reef habitat may be more extensive than realized.



Results: Local Stakeholder Impacts

- Platform removals likely impact local stakeholders, especially in Louisiana.
- In western Louisiana, Red Snapper losses due to explosive removals in 2018 constituted on the order of 16% of the Allowable Catch Limit (ACL) for the private recreational sector of the fishery.
- If the losses were subtracted from the private recreational sector ACL, fewer fish would be available and the allowable take would be reached sooner, thereby shortening the season.
- Mitigation credit might be considered if platforms were removed using non-explosive methods.

Conclusions

- An array of recreationally and commercially valuable, federally-managed reef fish species aggregate to varying degrees around offshore oil and gas platforms.
- On a gulfwide basis, these aggregations typically represent small fractions of the overall stocks.
- However, there appears to be at least one potential exception. On the order of 45% of the Greater Amberjack stock is associated with offshore oil and gas platforms, mainly platforms offshore Western Louisiana. Few, if any, fish that aggregate around platforms survive explosive platform removal.
- Platform removals are likely having, and will likely have, significant adverse impacts on local fisheries, especially those offshore Louisiana and Mississippi.
- In these specific areas, a case can be made that platforms serve to increase reef fish productivity as opposed to merely aggregating the fish due to the apparent absence of other suitable habitats.
- However, evidence is presented that there may be more reef habitat in these areas than is currently recognized.

Questions

Additional Material

Additional Material - Hydroacoustics

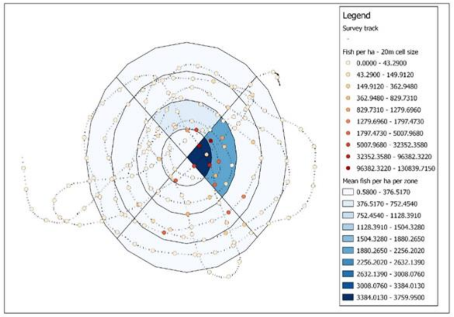
Hydroacoustic Surveys and Analyses

- Simrad EK80 Split Beam Echosounder with a 120 KH2 transducer was used for the hydroacoustic surveys.
- The Echosounder transducer was pole-mounted over the starboard side of the vessel with a transducer face 1 m under the water surface.

- The Echosounder was calibrated using standard methods and a tungsten carbide sphere.
- At each site, the physical properties at the entire water column were collected using an EXO3 data sonde (Turbidity, Temperature, Conductivity, Salinity, Total Dissolved Solids, Dissolved Oxygen, Depth).

Hydroacoustic Surveys and Analyses

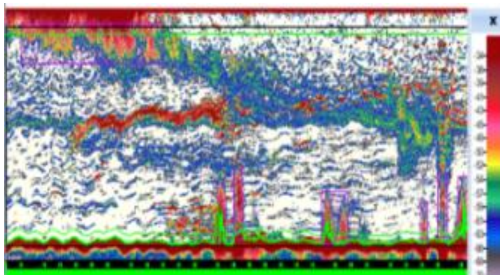
- The hydroacoustics survey track followed a spiral pattern commencing as close to the platform as possible and then approximately 20 m further out on each pass out to a distance of 100 m.
- Additional transects toward and from the platforms (and under walkways connecting platforms) were conducted perpendicular to the spiral transects.



- The survey area at each single platform site was a 31,400 m^2.
- When a site consisted of multiple, joined platforms, it was necessary to survey within a 200 m radius to encompass all the joined structures.
- The sample area to total area ratio exceeded the minimum 6:1 ratio (Aglen 1989) at all sites (our ratios ranged from about 13:1 to 30:1).

Hydroacoustic Surveys and Analyses

- Acoustic data were analyzed in 20- m long by 10- m deep cells.
- Fish Density was calculated via eco integration (Sv/Ts) where Sv is the backscattering coefficient per volume of water and Ts is the target strength from individual fish (mean of all fish targets)



- Threshold values were set for Sv (-56 db) and Ts (-50 db) to discern fish from other biological or particulate material (see report for details).

Hydroacoustic Surveys and Analyses

- Ultimately, following a series of complicated processing steps, (calculation of mean target strength based on single targets on a overall basis, adjusting for water depth and the spreading of sound with depth, adjusting for multiple echo etc.) fish density (fish/m^3) was established by depth & distance from platform:

Table 3-8A		Red Drum				Red Snapper			
		Sciaenops ocellatus				*Lutjanus campechanus*			
		Depth Zone (m)				Depth Zone (m)			
Layer	Layer Depth (m)	10 - 17	18 - 30	31 - 90	91 - 300	10 - 17	18 - 30	31 - 90	91 - 300
1	3 - 12	0.06	0.23	0.00	0.00	257.17	210.39	76.83	11.06
2	13 - 22	0.02	1.36	0.05	0.02	101.78	489.54	575.34	20.80
3	23 - 32		2.50	0.06	0.02		315.34	767.97	26.97
4	33 - 42			0.02	0.03			424.51	24.74
5	43 - 52			0.02	0.03			282.14	17.40
6	53 - 62			0.02	0.02			487.79	10.49
7	63 - 72			0.01	0.01			365.26	6.04
8	73 - 82				0.01				3.61
9	83 - 92				0.01				2.40
10	93 - 102				0.01				1.87
11	103 - 112				0.01				1.69
12	113 - 122				0.01				1.60
13	123 - 132				0.01				1.43
14	133 - 142				0.01				1.10
15	143 - 152				0.01				0.72
16	153 - 162				0.01				0.46
17	163 - 172				0.01				0.34
18	173 - 182				0.01				0.34
Total		0.08	4.09	0.18	0.24	358.95	1015.28	2979.85	133.06

Table 3-5A		Gray Triggerfish				Great Barracuda			
		Balistes capriscus				*Sphyraena barracuda*			
		Depth Zone (m)				Depth Zone (m)			
Layer	Layer Depth (m)	10 - 17	18 - 30	31 - 90	91 - 300	10 - 17	18 - 30	31 - 90	91 - 300
1	3 - 12	0.95	4.19	3.79	0.22	3.31	15.06	26.26	170.47
2	13 - 22	0.35	6.16	20.59	0.39	0.61	10.12	37.84	152.74
3	23 - 32		2.50	19.87	0.47		1.87	9.71	94.26
4	33 - 42			7.95	0.39			1.03	41.18
5	43 - 52			3.82	0.26			0.13	13.79
6	53 - 62			4.79	0.15			0.05	3.96
7	63 - 72			2.60	0.08			0.00	1.08
8	73 - 82				0.04				0.31
9	83 - 92				0.03				0.10
10	93 - 102				0.02				0.04
11	103 - 112				0.02				0.01
12	113 - 122				0.02				0.01
13	123 - 132				0.01				0.00
14	133 - 142				0.01				0.00
15	143 - 152				0.01				0.00
16	153 - 162				0.00				0.00
17	163 - 172				0.00				0.00
18	173 - 182				0.00				0.00
Total		1.30	12.85	63.41	2.11	3.92	27.05	75.02	477.94

Table 3-8B		Sheepshead				Spanish Hogfish			
		Archosargus probatocephalus				*Bodianus rufus*			
		Depth Zone (m)				Depth Zone (m)			
Layer	Layer Depth (m)	10 - 17	18 - 30	31 - 90	91 - 300	10 - 17	18 - 30	31 - 90	91 - 300
1	3 - 12	0.18	3.80	0.08	0.07	0.06	0.08	0.11	0.00
2	13 - 22	0.09	9.27	0.69	0.14	0.02	0.11	0.58	0.02
3	23 - 32		6.28	1.14	0.19		0.06	0.66	0.02
4	33 - 42			0.79	0.20			0.29	0.02
5	43 - 52			0.65	0.15			0.16	0.01
6	53 - 62			1.39	0.10			0.23	0.01
7	63 - 72			1.29	0.06			0.14	0.00
8	73 - 82				0.04				0.00
9	83 - 92				0.03				0.00
10	93 - 102				0.03				0.00
11	103 - 112				0.03				0.00
12	113 - 122				0.02				0.00
13	123 - 132				0.03				0.00
14	133 - 142				0.02				0.00
15	143 - 152				0.02				0.00
16	153 - 162				0.01				0.00
17	163 - 172				0.01				0.00
18	173 - 182				0.01				0.00
Total		0.27	19.35	6.03	1.18	0.08	0.25	2.17	0.08

Table 3-5B		Greater Amberjack				Grouper sp.			
		Seriola dumerili				*Epinephelinae* sp.			
		Depth Zone (m)				Depth Zone (m)			
Layer	Layer Depth (m)	10 - 17	18 - 30	31 - 90	91 - 300	10 - 17	18 - 30	31 - 90	91 - 300
1	3 - 12	9.70	16.14	15.39	31.36	0.18	0.31	0.36	0.05
2	13 - 22	4.28	13.00	107.58	65.77	0.06	0.28	2.87	0.07
3	23 - 32		2.88	134.07	95.03		0.08	3.92	0.06
4	33 - 42			69.21	97.19			2.22	0.07
5	43 - 52			42.96	76.21			1.51	0.04
6	53 - 62			69.36	51.25			2.69	0.02
7	63 - 72			48.50	32.88			2.07	0.01
8	73 - 82				21.91				0.01
9	83 - 92				16.24				0.00
10	93 - 102				14.15				0.00
11	103 - 112				14.21				0.00
12	113 - 122				14.96				0.00
13	123 - 132				14.95				0.00
14	133 - 142				12.85				0.00
15	143 - 152				9.35				0.00
16	153 - 162				6.66				0.00
17	163 - 172				5.47				0.00
18	173 - 182				6.09				0.00
Total		13.97	32.02	487.07	586.51	0.23	0.67	15.63	0.33

- These data will be used to determine mortality from explosive removals using Underwater Calculator, Version 1.

Hydroacoustic Surveys – SRV Surveys

- The SRV surveys used the following protocol:
  - The SRV camera was lowered at each site in a location close to the platform where safe positioning was possible (normally down current). The echosounder was used to avoid areas where the camera could become entangled with the platform legs.
  - 5 minutes of footage was recorded at each 10m depth strata at prescribed depths at all sites e.g. 3m, 8m, 13m, 23m, etc.
  - When significant aggregations of fish were present in areas away from where the vessel was tied up, efforts were made to drop the SRV amongst them. Occasionally this was difficult due to strong currents moving the camera off location.
  - The elapsed time of the drops at each depth were recorded on every occasion.
- The maximum number of each species seen in a single frame of the video record for each depth layer were used to obtain species composition percentages.
- These percentages were applied to the hydroacoustic abundance data for that site and depth layer.

Assemblage Structure and Total Fish Abundance Models

- **Assemblage Structure** can be characterized as a nominal multinominal distribution which we have developed using a generalized logit/ink function:

$$log_e\left[\frac{Pr(y=j|x_i)}{Pr(y=k|x_i)}\right] = \alpha_{jk} + x_i\beta_{jk} \qquad (1)$$

where, all j^{th} nominal species categories were referenced to a particular species category k (we used the most numerically dominant species for k), x_i=the vector of fixed effects explanatory variables for the i^{th} sample, and α_{jk} and β_{jk} were parameters specific to the j^{th} category and referenced to k. Hence, we modeled the log odds of a fish in the *Assemblage Structure* being in the j^{th} category rather than being in the reference category, k, and allowed this relationship to change with the explanatory variables. The likelihood (l_i) for each i^{th} observation was given as:

$$l_i = \sum_{j=1}^{J} y_{ij}\, log_e(\lambda_{ij}) \qquad (2)$$

where, J=total number of species in the analysis, y_{ij}=observed number of individuals in the j^{th} species and i^{th} sample, and λ_{ij}=the predicted number of individuals in the j^{th} species and i^{th} sample. Fixed effect variables included the categorical variable *DepthZone* (10-17 m, 18-30 m, 31-90 m, or 91-300 m), and the covariates *Layer* (vertical depth bands 3-12 m [labeled as 1], 13-22 m [labeled as 2], etc.), temperature and dissolved oxygen (*DO*). These last two covariates were included as extraneous/nuisance variables to reduce noise and confounding influences; furthermore, they were converted to standard normal deviates (z-scores) within each *DepthZone-Layer* combination before analysis. *Layer* was entered as a covariate to allow change in *Assemblage Structure* along the vertical depth gradient. Ignoring subscripts and parameters for the right side of the equation, fixed effects for the final model were specified as follows:

$$\lambda_{ij} = DepthZone|Layer + Temperature + DissolvedOxygen \qquad (3)$$

where the operator "|" indicates an interaction of two or more terms and all of the corresponding main effects. We attempted to let the intercept and covariates *Temperature* and *DO* vary randomly across subjects defined with the categorical variable Site nested within each *Year-DepthZone* combination. Model convergence could not be achieved with this specification so Site could not be modelled as a random variable. Thus all effects remained fixed. This specification formed a generalized linear model (GLM) for which we estimated parameters with the GLIMMIX procedure in the statistical software SAS 9.4 TS Level 1M5 (SAS Institute, Inc., 2016).

Assemblage Structure and Total Fish Abundance Models

- **Total Fish Abundance** observations from the hydroacoustic surveys were assumed to be from a lognormal distribution which we modeled with the log link function.

$$log_e(TFA_i) = \alpha + x_i\beta + z_i b \quad (4)$$

where, TFA_i=predicted total fish abundance for the i^{th} sample, α = the intercept, x_i=the vector of fixed effects explanatory variables for the i^{th} sample, β= their corresponding vector of coefficients, and Z_i and b = the random effects and coefficients. The likelihood (l_i) for each i^{th} observation was given as:

$$l_i = -\frac{1}{2}\left[\frac{log\{y_i\}-\mu_i}{\sigma_i^2} + log\{\sigma_i^2\} + log\{2\pi\}\right] \quad (5)$$

where y_i = observed total fish abundance for the i^{th} sample, μ_i and σ_i^2 are the respective predicted mean and variance parameters for the loge transformed observations, and π=the constant pi. The same fixed effects variables were used as was described above for modeling *Assemblage Structure*. However, as the pattern of fish abundance throughout the water column did not appear to be linear, the term *Layer* was fit using a cubic B-spline (*splLAYER*) with three equally spaced knots positioned between the minimum and maximum values. Ignoring subscripts and parameters for the right side of the equation, fixed effects for the final model were specified as follows:

$$\mu_i = DepthZone|splLAYER + Temperature + DissolvedOxygen \quad (6)$$

The intercept and covariates *Temperature* and *DO* were allowed to vary randomly across subjects defined with the categorical variable *Site* nested within each *Year-DepthZone* combination. This specification formed a generalized nonlinear mixed model (GNLMM) whose parameters were also estimated with the GLIMMIX Procedure in SAS.

Assemblage Structure and Total Fish Abundance Models

- Species Abundances and Associated Variance Propagation

Abundance of each species was predicted by *Layer* for an average platform within each *Depth Zone* as the product of their predicted proportions from the *Assemblage Structure* model output and the predicted total fish abundance from the *TFA* model output. The arithmetic variance of *TFA* was given by the method of moments estimator:

$$Var[TFA] = e^{2\mu+\sigma^2}\left(e^{\sigma^2} - 1\right) \quad (7)$$

Variances from *TFA* and *Assemblage Structure* were then combined using Goodman's (1960) variance of products estimator:

$$Var[\lambda * TFA] = \lambda^2 Var[TFA] + TFA^2 Var[\lambda] - Var[TFA] * Var[\lambda] \quad (8)$$

Model Diagnostics and Type III p-values for the generalized models of TFA and Assemblage structure

- Type III p-values from the GNLM of hydroacoustic estimates of total fish abundance (*TFA*). spl = the *Layer* spline, and *zTemp* and *zDO* refer to temperature and dissolved oxygen, respectively, standardized to their z-scores within each *Depth Zone-Layer* combination.

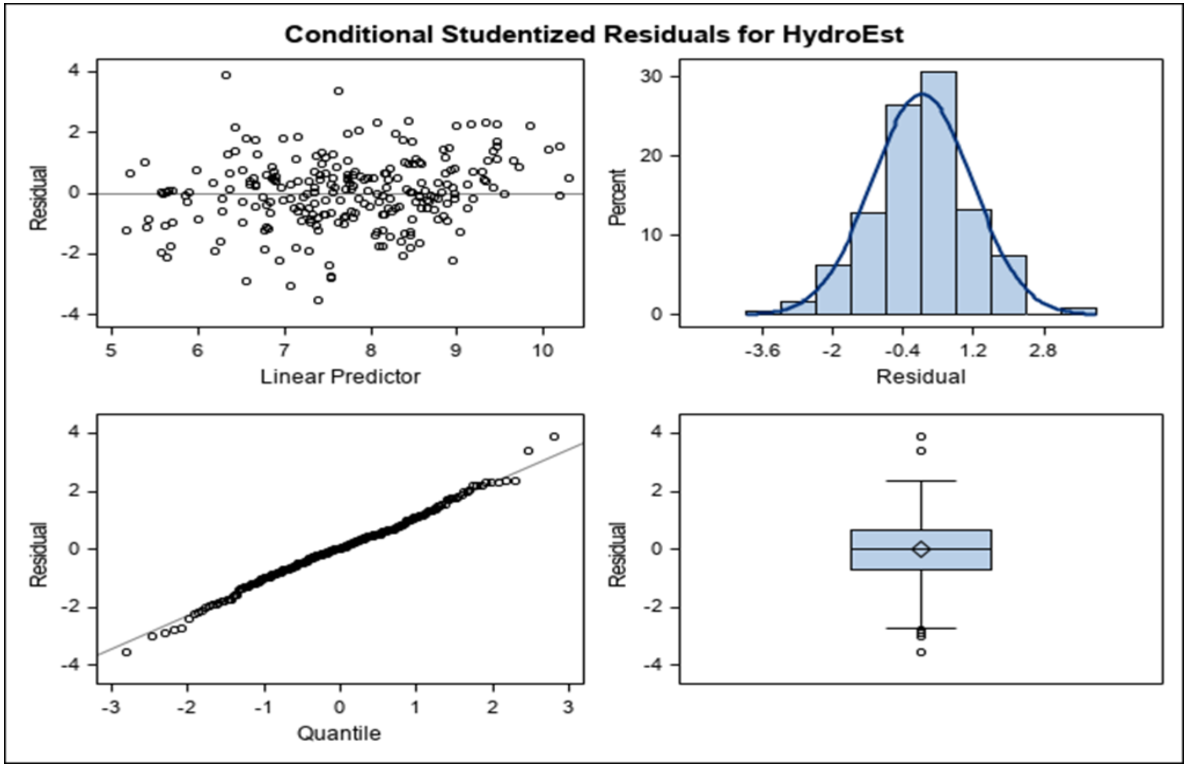
Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
DepthZone	3	227	1.00	0.3956
spl	6	227	2.03	0.0622
spl*DepthZone	7	227	2.37	0.0236
zTemp	1	227	1.12	0.2900
zDO	1	227	3.05	0.0821

- Covariance parameters from the GNLM of hydroacoustic estimates of total fish abundance (TFA). *zTemp* and *zDO* refer to temperature and dissolved oxygen, respectively, standardized to their z-scores within each *Depth Zone-Layer* combination.

Covariance Parameter Estimates							
				Estimated Likelihood 95% Confidence Bounds			
				Lower		Upper	
Cov Parm	Subject	Estimate	Standard Error	Bound	Pr > Chisq	Bound	Pr > Chisq
Intercept	Site(Year*DepthZone)	0.4653	0.2095	0.2389	0.0500	0.8490	0.0500
zTemp	Site(Year*DepthZone)	0.03182	0.2299	0	0.7066	0.3175	0.0500
zDO	Site(Year*DepthZone)	0.4444	0.4166	0.1337	0.0500	0.9967	0.0500
Residual		0.9428	0.1842	0.7633	0.0500	1.1776	0.0500

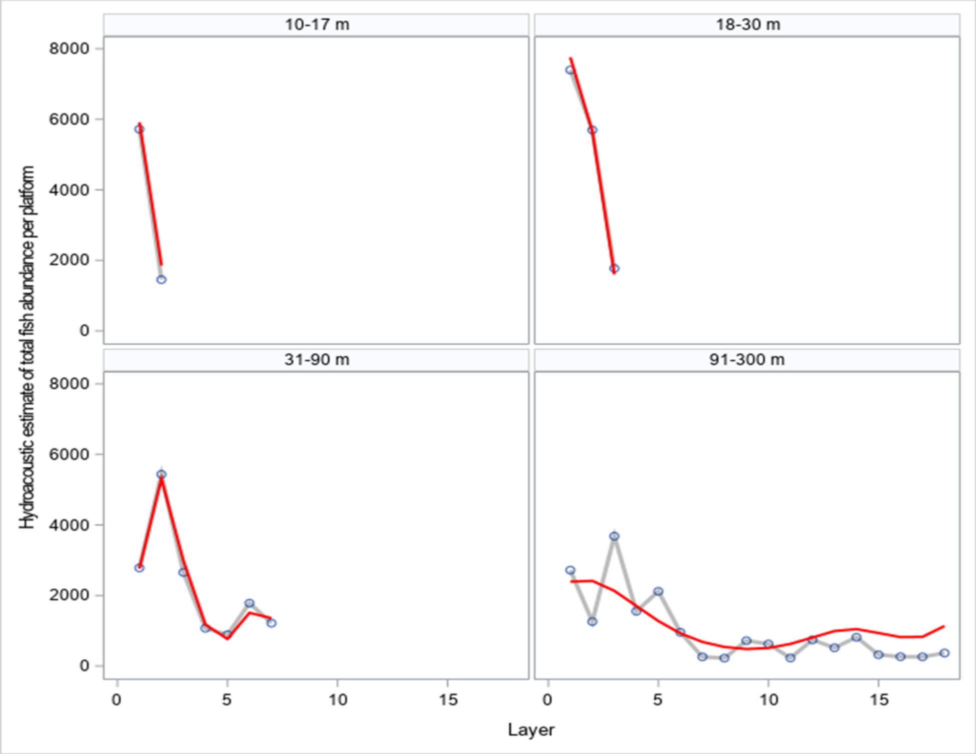
Model Diagnostics and Type III p-values for the generalized models of TFA and Assemblage structure

- Residual panel from the GNLM of hydroacoustic estimates of total fish abundance (*TFA*).



Model Diagnostics and Type III p-values for the generalized models of TFA and Assemblage structure

- Averaged observed versus predicted values for each *Depth Zone-Layer* combination from the GNLM of hydroacoustic estimates of total fish abundance (*TFA*).



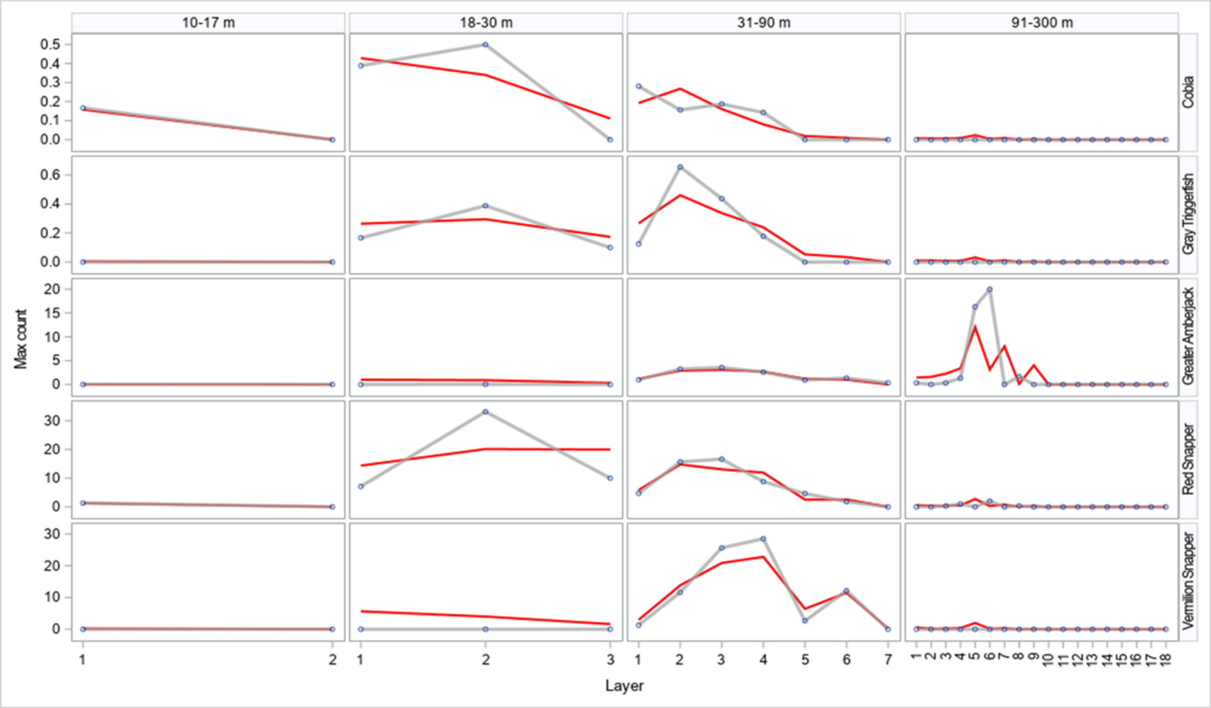
Model Diagnostics and Type III p-values for the generalized models of TFA and Assemblage structure

- Type III p-values from the GLM of *SRV* max count estimates for the five federally managed species selected for this study. *zTemp* and *zDO* refer to temperature and dissolved oxygen, respectively, standardized to their z-scores within each *Depth Zone-Layer* combination.

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
DepthZone	70	37940	35.87	<.0001
Layer	35	37940	34.15	<.0001
Layer*DepthZone	70	37940	15.00	<.0001
zTemp	35	37940	101.50	<.0001
zDO	35	37940	43.54	<.0001

Model Diagnostics and Type III p-values for the generalized models of TFA and Assemblage structure

- Averaged observed versus predicted values for each *Depth Zone-Layer* combination from the GLM of SRV max count estimates for the five federally managed species selected for this study. Note: axis scales differ for species and *Depth Zones*.



Acoustic Modeling Acknowledgements

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Environmental Studies Program
Contract M16PC00005

Introduction

- The overarching goal of the "Explosive Removal of Structures: Fisheries Impact Assessment" study is to estimate potential impacts to commercial and recreational fish and fisheries resulting from Gulf of Mexico (GOM) explosive severance decommissioning activities on the Outer Continental Shelf (OCS).
- An acoustic model-based approach combined with measurements of the relative abundance and distribution of commercially and/or recreationally valuable federally-managed fish species was used to estimate mortality of managed fish species due to the explosive severance of the offshore structures.

Introduction (continued)

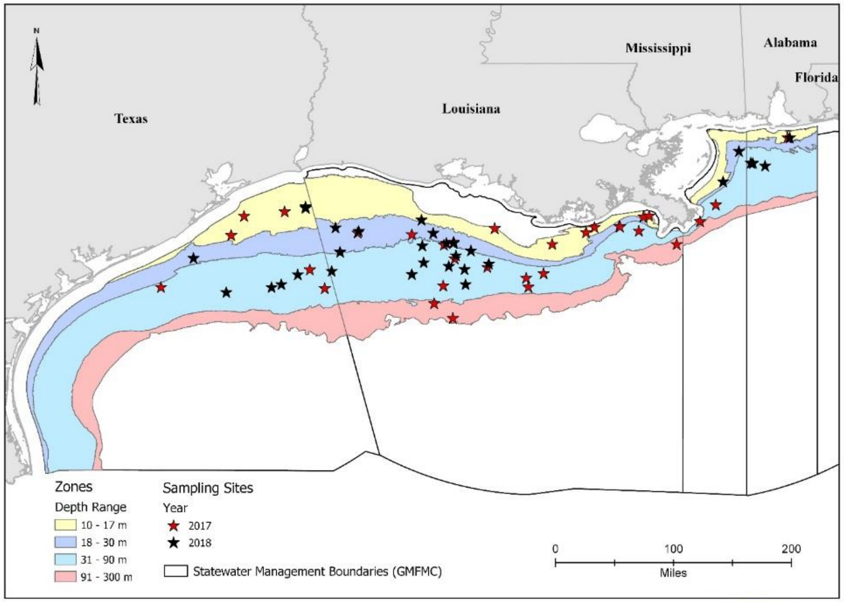
- Below, we first provide a characterization of the fish assemblages and their abundance patterns at offshore oil and gas platforms.
- Next, we describe the acoustic models that were used for the analyses and the assessment scenarios that were selected.
- Lastly, we provide the results that were obtained and an assessment of the effects.

Fish Distribution and Abundance at Platforms

- The relative abundance and distribution of federally-managed fish species around offshore platforms were determined from an intensive 2-year field study (LGL 2019).
- The LGL (2019) study area included federal waters in the Central and Western Planning Areas from the limit of State Waters to a water depth of 300 m.
- Based on a comprehensive literature synthesis at the start of the project LGL selected five federally-managed species for impact analysis:
  - Red Snapper (*Lutjanus campechanus*),
  - Vermilion Snapper (*Rhomboplites aurorubens*),
  - Gray Triggerfish (*Balistes capriscus*),
  - Greater Amberjack (*Seriola dumerili*), and
  - Cobia (*Rachycentron canadum*).

Fish Distribution and Abundance at Platforms (continued)

- Sampling was conducted at 30 platforms during summer 2017 and 32 platforms during summer 2018. Study sites were selected based on a stratified random design using region and depth as the basis for strata.



Platform Fish

Model estimates of the abundance of fish at the “average platform” in the four depth zones defined in this study. In contrast to the modeled estimates not all species were observed at each site. The species actually observed at platforms in each depth zone are designated with an asterisk. Observed species comprised from 97 to 99% at each site.

		Depth zone (m)											
Common Name	Scientific Name	10 - 17			18 - 30			31 - 90			91 - 300		
Almaco Jack	*Seriola rivoliana*	5	(1-25)		16	(8-32)	*	129	(90-183)	*	111	(-)	*
Angelfish sp.	*Pomacanthidae* sp.	0.4	(0-5)		2	(1-6)	*	47	(18-122)	*	0.7	(0-3)	
Atlantic Bumper	*Chloroscombrus chrysurus*	4,362	(1105-17216	*	6,227	(3507-11054)	*	841	(585-1210)	*	324	(171-612)	
Atlantic Moonfish	*Selene setapinnis*	19	(4-82)		514	(261-1011)	*	97	(68-138)	*	23	(11-47)	
Atlantic Spadefish	*Chaetodipterus faber*	1,815	(463-7117)	*	926	(457-1876)	*	481	(323-716)	*	60	(31-115)	
Bar Jack	*Carangoides ruber*	1	(0-9)		4	(2-10)		13	(7-24)	*	178	(42-745)	*
Bermuda Chub	*Kyphosus sectatrix*	39	(8-179)		162	(89-293)	*	838	(545-1288)	*	1,405	(521-3787)	*
Black Jack	*Caranx lugubris*	0.1	(0-4)		0.2	(0-2)		0.1	(0-1)		23	(10-55)	*
Blue Runner	*Caranx chrysos*	622	(152-2539)	*	1,712	(956-3063)	*	3,971	(2805-5622)	*	691	(343-1390)	*
Bluefish	*Pomatomus saltatrix*	2	(0-14)		4	(2-9)	*	0.6	(0-1)		0.6	(0-2)	
Butterflyfish sp.	*Chaetodontidae* sp.	0.1	(0-3)		0.4	(0-2)		8	(-)	*	0.2	(0-2)	
Cobia	*Rachycentron canadum*	57	(14-230)	*	13	(6-26)	*	24	(16-36)	*	1.4	(0-5)	
Crevalle Jack	*Caranx hippos*	16	(3-76)		148	(83-263)	*	326	(234-456)	*	2,074	(941-4571)	*
Dog Snapper	*Lutjanus jocu*	0.2	(0-5)		0.1	(0-1)		0.5	(0-2)	*	0.05	(0-1)	
Filefish sp.	*Monacanthidae* sp.	-	(-)		-	(-)		0.2	(0-1)	*	-	(-)	
Gray Snapper	*Lutjanus griseus*	137	(35-528)	*	400	(255-710)	*	491	(345-698)	*	37	(19-70)	
Gray Triggerfish	*Balistes capriscus*	1.3	(0-11)		13	(6-26)	*	63	(40-101)	*	2	(1-6)	
Great Barracuda	*Sphyraena barracuda*	4	(1-24)		27	(14-51)	*	75	(50-113)	*	478	(206-1107)	*
Greater Amberjack	*Seriola dumerili*	14	(3-60)		32	(17-59)	*	487	(176-1347)	*	587	(313-1099)	*
Grouper sp.	*Epinephelinae* sp.	0.2	(0-5)		0.7	(0-3)		16	(-)	*	0.3	(0-2)	
Guaguanche	*Sphyraena guachancho*	3	(0-19)		32	(17-60)	*	22	(14-33)	*	2	(1-8)	
Gulf Menhaden	*Brevoortia patronus*	67	(17-266)		2,876	(1642-5039)	*	169	(120-239)		105	(56-197)	
Horse-eye Jack	*Caranx latus*	3	(1-20)		19	(10-37)	*	86	(56-133)	*	416	(187-925)	*
King Mackerel	*Scomberomorous cavalla*	4	(1-23)		81	(45-146)	*	38	(26-57)	*	5	(2-12)	
Leatherjack	*Oligoplites saurus*	26	(6-106)		105	(59-187)		706	(475-1051)	*	45	(23-86)	
Lookdown	*Selene vomer*	3	(1-16)		26	(14-50)	*	107	(72-159)	*	8	(5-13)	
Ocean Triggerfish	*Canthidermis sufflamen*	0.6	(0-9)		1	(0-4)		10	(5-17)	*	20	(10-42)	*
Rainbow Runner	*Elagatis bipinnulata*	13	(3-67)		266	(133-529)	*	53	(36-78)	*	405	(178-924)	*
Red Drum	*Sciaenops ocellatus*	0.1	(0-2)		4	(1-13)	*	0.2	(-)		0.2	(-)	
Red Snapper	*Lutjanus campechanus*	359	(94-1367)	*	1,015	(541-1904)	*	2,980	(875-10152)	*	133	(72-246)	*
Sheepshead	*Archosargus probatocephalus*	0.3	(0-3)		19	(9-39)	*	6	(-)	*	1	(-)	
Spanish Hogfish	*Bodianus rufus*	0.1	(0-2)		0.3	(0-1)		2	(-)	*	0.1	(0-1)	
Spanish Mackerel	*Scomberomorous maculatus*	0.2	(0-6)		-	(-)	*	0.1	(0-1)	*	-	(-)	
Unidentified Fish		142	(39-520)	*	250	(140-446)	*	276	(196-389)	*	13,090	(5363-31952)	*
Vermilion Snapper	*Rhomboplites aurorubens*	45	(11-180)		118	(67-210)		3,506	(428-28743)	*	57	(30-109)	
Yellow Jack	*Carangoides bartholomaei*	0.8	(0-11)		0.9	(0-3)	*	7	(4-13)	*	0.5	(0-3)	
Total		7,764 (1975-30517)			15,014 (8593-26234)			15,877 (6349-39700)			20,284 (10169-40459)		
Total Taxa Verified by SRV Observation		7			26			32			13		
Total Number Verified by SRV Observation		7,494			14,784			15,707			19,611		
Percent of Model Abundance Verified by SRV		96.5			98.5			98.9			96.7		

Platform Fish (continued)

- The point estimates of the abundance of federally-managed species by depth zone is shown:

Depth Zone	Red Snapper	Vermilion Snapper	Gray Triggerfish	Greater Amberjack	Cobia	TOTAL
A	359	44.7	1.3	14	57.1	476
B	1015.3	118.4	12.8	32	13	1191.6
C	2979.9	3506.2	63.4	487.1	23.7	7060.2
D	133.1	57	2.1	586.5	1.4	780

- Red and Vermilion Snapper were the most abundant of the federally-managed species.

Acoustic Modeling

- The UnderWater Calculator version 1, herein referred to as simply the UWC, was the underwater acoustic shock propagation model utilized for this study.
- User input to the UWC includes detonation charge specifications (explosive type and weight), pile specifications (diameter and wall thickness), source (charge) depth, and receiver (e.g., fish) depth.
- In addition, the UWC offers three bottom boundary conditions to be specified by the user: water (free space), soft clay, and stiff clay.

Acoustic Modeling (continued)

- In its forward calculation, UWC estimates underwater shock wave parameters such a peak pressure, impulse, and energy flux density for a user-specified source-to-receiver slant range.

- In its backward or inverse calculation, UWC estimates the slant range from the explosive charge to a user-specified energy flux density or peak pressure value.

- In this study, received peak sound pressure level (SPL_{peak}) from 229 to 234 dB re 1 µPa were adopted as alternative threshold levels for mortality.

Acoustic Modeling (continued)

- For each pipe explosion, the inverse calculation was performed twice: once to calculate a narrow range of mortal injury using the most conservative model input values and a second time for a wider range of potential mortal injury using the least conservative values.

Variable	Narrow Range (Less Conservative)	Wide Range (More Conservative)
Sediment Type	Stiff Clay	Soft Clay
Pipe Option	Large Internal Pipes	Small Internal Pipes
SPL_{peak}	234 dB re 1 µPa	229 dB re 1 µPa

- The range of each randomly placed fish to each explosion was calculated and the count of lethal exposures tallied.

- Minimum and maximum exposure levels, as well as the total number of exposures (most sites involved multiple explosions), were recorded for any fish located farther than the defined lethal range based on the UWC forward calculation.