IMPROVING FISHERIES CONSERVATION AND MANAGEMENT IN THE EASTERN GULF OF MEXICO

RESULTS FROM FIVE YEARS OF INVESTMENT
IN FISHERIES MONITORING AND TECHNOLOGY • 2020

Red snapper

NFWF

Prepared in conjunction with Florida Fish and Wildlife Research Institute,
Alabama Department of Conservation and Natural Resources, Marine Resources Division
and Mississippi Department of Marine Resources

Fisheries scientists empty the contents of a trawl off the coast of Alabama. | Credit: ADCNR/AMRD

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A creolefish swims behind a spotted scorpionfish in the Gulf of Mexico. | Credit: NOAA

A scientist extracts otoliths and other parts from yellowtail snapper off the coast of Florida. | Credit: FWC/FWRI

EXECUTIVE SUMMARY

The Deepwater Horizon Oil Spill resulted in an unprecedented injury to fishes in the Gulf of Mexico. It was estimated that trillions of larval fishes died from exposure to oil and dispersants, resulting in a significant loss (DWH Trustees 2016). In 2013, as part of the settlement to resolve certain criminal charges against BP and Transocean, $2.544 billion was directed to be paid to the National Fish and Wildlife Foundation (NFWF) to conduct or fund projects that remedy harm or reduce the risk of future harm to Gulf Coast natural resources of a type injured by the spill. NFWF subsequently established the Gulf Environmental Benefit Fund (GEBF) to identify, fund, and administer these projects. Several Gulf States were particularly interested in utilizing the GEBF to restore fishes impacted by the spill. Because fishing pressure is one of the most powerful drivers of fish populations, improving the responsiveness and accuracy of management tools could have a meaningful impact on fishes in the Gulf of Mexico.

The Gulf States Marine Fisheries Commission, in partnership with State resource agencies and NOAA, developed a proposal for Gulf-wide fisheries monitoring in the aftermath of the Deepwater Horizon oil spill, which formed the basis for fisheries monitoring work funded by GEBF in the eastern Gulf. Starting in 2013, NFWF's GEBF provided a total of $45.5 million to the states of Florida, Alabama, and Mississippi to enhance fishery independent and dependent monitoring and, in so doing, improve management decisions that are expected to restore fishes.

As these projects neared their completion in 2019, NFWF and representatives from Florida, Alabama and Mississippi reviewed project results, discussed successes, and explored opportunities to maintain and support these efforts into the future. A Steering Committee consisting of representatives from the three eastern Gulf States worked with NFWF to convene a workshop in December of 2019 to review project outcomes and discuss next steps with managers and fisheries scientists from NOAA, the States of Louisiana and Texas, and the Gulf States Marine Fisheries Commission. This report captures the findings and recommendations of that workshop.

Steering Committee members include:

- **Kevin Anson**, Alabama Department of Conservation and Natural Resources, Marine Resources Division (MRD)
- **Sean Powers**, University of South Alabama/ Dauphin Island Sea Lab (USA / (DISL)
- **Luiz Barbieri**, Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute (FWRI)
- **Ted Switzer,** Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute
- **Paul Mickle**, Mississippi Department of Marine Resources (MDMR)
- **Robert Leaf**, University of Southern Mississippi (USM)

Data, methodologies, and tools developed as a part of these efforts have promoted sustainable fisheries by informing stock assessments and providing a data driven framework for rapid decision making between stock assessments. Data collected as a part of these projects have already made substantial contributions to four completed federal stock assessments (gray snapper, red snapper, red grouper, and vermilion snapper) and similar use of the data is expected to continue in stock assessments for years to come. Tools developed and implemented as a part of these projects (e.g. Florida's Gulf Reef Fish Survey, Alabama's Snapper Check, and Mississippi's Tails 'n Scales) have allowed each state to more accurately estimate recreational fisheries catch and effort, improving their management of fishing season lengths. These projects have also provided status and trends for southern flounder in coastal Alabama and red grouper in Florida, enabling fisheries managers to respond to previously unknown species declines and evaluate the impacts of disasters like red tides.

These projects have made important advancements in fisheries science and substantially improved recent stock assessments (Table 1), but further improvements could increase the long-term impact of these data. These projects have contributed greatly to advancing video-based abundance surveys in the Gulf, with an FWRI-NOAA led survey (the combined video survey) becoming a key part of Gulf stock assessments. Computer automated video analysis could ultimately reduce the cost and increase the timeliness of video data, as video analysis is a time intensive process. All survey types examined (mapping, video, hook and line) would benefit from standardization efforts (calibrations, building consistent protocols) and by improving systems to store and share data.

Key aspects of these monitoring programs have secured long-term funding, but some important efforts could expire without additional funding. Long-term funding has been secured for the FWRI video survey, Florida's recreational fisheries survey (State Reef Fish Survey), Alabama's fishery independent surveys (partially funded), and Alabama's recreational fishing effort survey (Snapper Check). Mississippi will continue sampling through 2020 utilizing funds provided through the NFWF GEBF, and the State's efforts to secure long-term funding are ongoing. Notably, some abundance surveys that have proved useful for stock assessment have not secured long-term (or future) funding. The end of funding for these monitoring programs may preclude their use in future stock assessments and could complicate future stock assessment models.

These monitoring projects were a substantial effort that significantly advanced Gulf of Mexico fisheries management. Recommendations identified at the workshop provide an opportunity to further advance fisheries management science to ensure a robust and sustainable future for these important natural resources.

BACKGROUND

In 2013, the Gulf Environmental Benefit Fund (GEBF) was established to fund projects that remedy harm or reduce the risk of future harm to the types of natural resources of the Gulf of Mexico that were impacted by the Deepwater Horizon oil spill of 2010. GEBF has funded many projects to conserve and enhance coastal habitats, restore beach and dune habitats, protect habitat important to coastal bird species, assess and restore fish populations, and increase the capacity of marine mammal and sea turtle stranding networks.

GEBF awarded approximately $45.5 million to the states of Alabama, Florida and Mississippi for projects to address critical gaps in reef fish science to improve the states' ability to assess and manage fishery resources. These five-year awards were for projects to enhance fishery monitoring to address information needs of vital importance to support science-based fishery management.

The purpose of these investments in eastern Gulf of Mexico reef fish monitoring was to support activities that supplement ongoing state and federal monitoring of fish and habitat resources. Ultimately, these investments would benefit fishes by equipping fishery scientists and managers with better tools and data to sustainably manage these ecologically and economically important natural resources. The goal of these projects was to demonstrate the benefits of enhanced monitoring

Table 1: Stock assessments for which GEBF data have been used or submitted for inclusion in the model. The status notes whether work on the assessment is complete or ongoing and the terminal year is the last year of data collection that was used in the assessment. Life history typically included age, growth, size, and reproduction data. GEBF data used notes the data used in stock assessment models for SEDARs where the status is complete, submitted data where status is ongoing, and data planned for submission for gag (SEDAR 72) and where the status is to be determined.

Number	Species	Status	Terminal Year	GEBF Data Used
1	gray snapper (SEDAR 2018a)	Complete	2015	Combined video survey, summer groundfish survey, recreational discards by size class, life history
2	red snapper (SEDAR 2018b)	Complete	2016	Recreational discards by size class, life history
3	red grouper (SEDAR 2019)	Complete	2017	Combined video survey, repetitive timed drop, summer groundfish survey, recreational discards by size class, life history
4	vermilion snapper (SEDAR 2020a)	Complete	2017	Combined video survey, summer groundfish survey, recreational discards by size class
5	scamp (SEDAR 2020b)	Ongoing	2017	Combined video survey, recreational discards by size class, life history
6	greater amberjack (Thompson et al. 2020)	Ongoing	2018	Combined video survey, recreational discards by size class, life history
7	gag	Ongoing	2019	Combined video survey, polyhaline seagrass survey, recreational discards by size class, life history
8	red snapper	Begin 2021	TBD	Combined video survey, vertical long line, recreational discards by size class, recreational landings from calibrated state surveys, life history
9	gray snapper	Begin 2021	TBD	Combined video survey, summer groundfish survey, polyhaline seagrass survey, recreational discards by size class, life history

and to facilitate improvements to reef fish monitoring programs in the eastern Gulf of Mexico states. While states consulted with one another, monitoring programs were designed to accommodate unique conditions in each state, reflecting the great diversity and variability of fish resources, habitats, and fishing practices from Key West, Florida to Bay St. Louis, Mississippi.

As these projects neared completion in 2019, NFWF and representatives from Florida, Alabama and Mississippi discussed project successes and how to maintain and support these efforts into the future. The state representatives recommended NFWF host a workshop, guided by a steering committee of the three eastern Gulf States, to identify long-term strategies for implementing a coordinated monitoring program. While GEBF projects took place in the eastern Gulf of Mexico, the steering committee invited Louisiana and Texas participation to ensure discussion of issues of Gulf-wide interest. This group met in December 2019 and included representatives from all five Gulf States, the National Oceanic and Atmospheric Administration (NOAA), and the Gulf States Marine Fisheries Commission (see attendance list in the Appendix). Workshop participants shared their priorities, described project successes, pinpointed ongoing challenges and needs, and identified opportunities for greater collaboration. The purpose of this report is to capture the major findings and recommendations discussed at the workshop.

Figure 1: Example of catch from a vertical long line deployed off Alabama's coast. Left, A scientist holds a mutton snapper captured off the coast of Florida. | Credit: FWC/FWRI

SUMMARY OF STATE ACCOMPLISHMENTS

With support from GEBF, Florida, Alabama, and Mississippi addressed many facets of monitoring fish and habitat resources including both fishery independent (e.g. sampling that does not rely on commercial or recreational fishing) and dependent (e.g. landings and effort) monitoring. The states tailored monitoring programs to provide the most useful information to improve the management of marine fishery resources. All three states conducted vertical longline sampling (VLL; Figure 1) and developed and implemented tools to monitor and forecast recreational red snapper landings. The three distinct efforts were coordinated across the states through venues such as the Gulf of Mexico Fishery Management Council (GMFMC), the Gulf States Marine Fisheries Commission (GSMFC), and the National Marine Fisheries Service (NMFS).

Over a five-year period, which concluded in 2019, the Alabama Department of Conservation and Natural Resources Marine Resources Division, in partnership with the Dauphin Island Sea Lab/University of South Alabama, used GEBF funding to conduct the following monitoring activities:

- Reef fish surveys for species distribution, abundance, size and age composition, reproductive characteristics, and feeding ecology. This work was conducted using standardized hook gears (vertical longline, bottom longline), offshore trawls, and remotely operated vehicles.
- Trawl surveys in nearshore waters to characterize the distribution and abundance of juvenile red snapper, which do not generally occupy high-relief reef habitats where adults are found
- Application of side scan sonar to better characterize the distribution and abundance of different benthic habitats
- Use of fishery observers to characterize recreational discards
- Implementation of a large-scale tagging program to characterize fishing pressure in different areas off Alabama's coast.

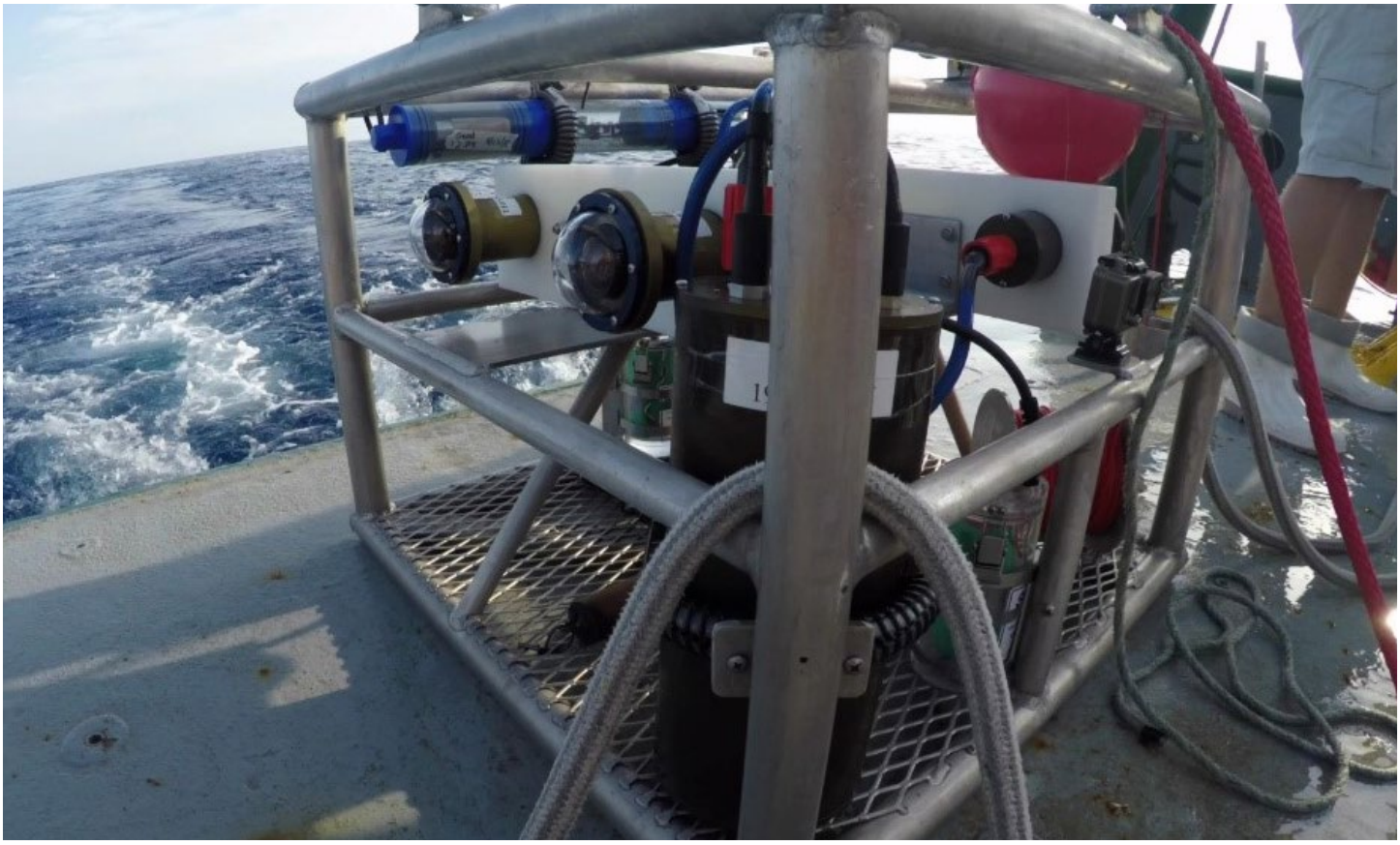


Figure 2: Video array used to estimate abundances and sizes of fishes off Florida's coast. This array design is comparable to the one used by NMFS in the Gulf of Mexico. | Credit: FWC/FWRI

- Implementation of Snapper Check, a tool used to estimate and forecast recreational catch of red snapper in the state and federal waters off Alabama's coast

In Florida, GEBF funding was used for two projects. First, the Florida Fish and Wildlife Conservation Commission's (FWC) Fish and Wildlife Research Institute (FWRI) has completed five years of monitoring, which concluded in 2019, as follows:

- Reef fish surveys for species distribution, abundance, size and age composition, reproductive characteristics, and feeding ecology. This work was conducted using standardized hook gears (vertical longline and timed repetitive drops), offshore trawls, stationary underwater cameras (Figure 2), and chevron traps (discontinued after year 2).

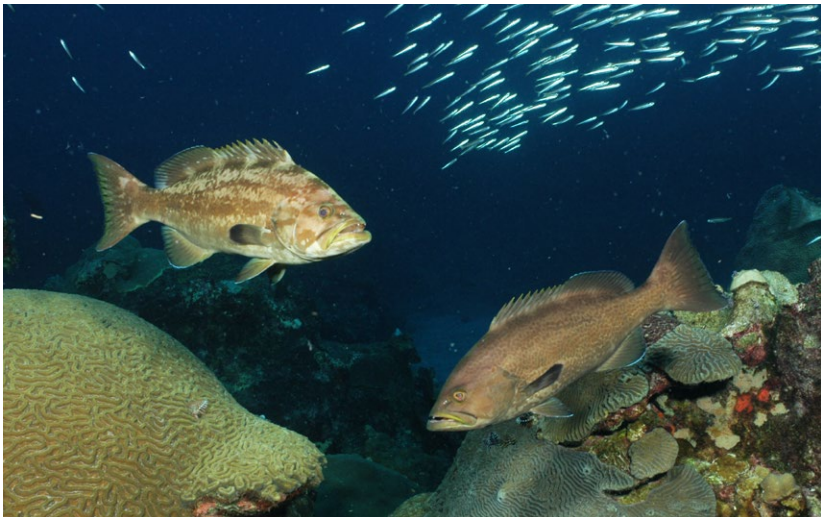
- Trawl and seine sampling in shallow and nearshore areas for fish and invertebrates. This work targeted juvenile reef fishes that use seagrasses as a transitional habitat before their migration to reef habitats.

- Application of hydro acoustics and side scan sonar (Figure 3) to better characterize the biomass of fishes sampled with stationary cameras and the distribution and abundance of different benthic habitats, respectively.

- Use of fishery observers to characterize recreational discards.

- Implementation of the Gulf Reef Fish Survey, a tool used to estimate and forecast recreational catch and effort of 10 species of reef fishes, including red snapper, red grouper, gag grouper, and gray triggerfish, in the State and Federal waters off Florida's coast.

Second, the University of South Florida used towed video arrays to map benthic habitat in the West Florida Shelf area. The primary objective of this work was to map important reef habitats that could be considered for additional protections under the Magnuson-Stevens Fishery Conservation and Management Act. Most waters in the Gulf are considered Essential Fish Habitat, and the fisheries management community has a strong interest in identifying areas that require additional



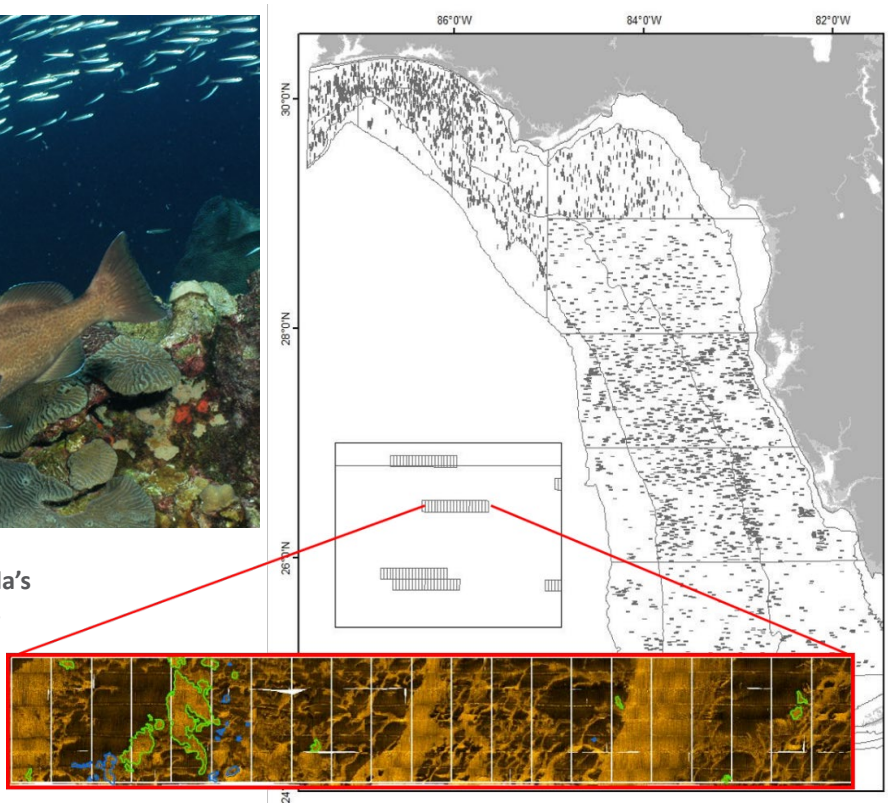


Figure 3: **Area covered by side scan sonar off Florida's coast from 2014-2019. The colored image towards the bottom of the figure shows an example of side scan sonar imagery that is used to characterize habitat types. | Credit: FWC/FWRI**
Above: Yellowmouth grouper over a hermatypic reef in the Gulf of Mexico | Credit: NOAA

protection (e.g. Habitat Area of Particular Concern). GEBF funding was used to conduct:

- Multi-beam acoustic surveys to characterize the distribution and abundance of various habitat types. Survey equipment also included towed cameras that were used to relate fish abundances to different habitat types.
- Development of technologies to use machine learning for estimating fish abundances and habitat types. This technology could ultimately advance automated processing of underwater video for a variety of programs, including FWRI and NMFS, which would greatly decrease the cost and processing time associated with sampling protocols.

The Mississippi Department of Environmental Quality, in partnership with the Mississippi Department of Marine Resources and the University of Southern Mississippi, has completed four of five years of monitoring funded by GEBF, with 2020 serving as the final year of sampling. This includes:

- Reef fish surveys for species distribution, abundance, size and age composition, reproductive characteristics, and feeding ecology. This work was conducted using vertical longline.
- Extensive water quality sampling to better characterize the distribution and drivers of hypoxia off Mississippi's Coast.
- Use of fishery observers to characterize recreational discards in the federal for-hire fleet.
- Implementation of Tails n' Scales, a tool used to estimate and forecast recreational catch of red snapper in the state and federal waters off Mississippi's coast.

While they did not receive GEBF funding to support fishery monitoring, the States of Louisiana and Texas attended the workshop and shared information about their respective monitoring programs and their perspectives on the future of offshore fisheries monitoring in the Gulf. Tables 2-4 include a comprehensive list of different monitoring programs throughout the Gulf of Mexico. The Southeast Area Monitoring and Assessment Program (SEAMAP) provides the only source of long-term offshore monitoring data in the western Gulf.

Table 2: Offshore habitat mapping programs in the Gulf utilized by fisheries managers. Time series highlighted in red were funded by GEBF following the kickoff of these projects (2014 in Florida, 2015 in Alabama, and 2016 in Mississippi); other funding sources were sometimes used to support these sampling programs before and after GEBF projects ended.

	FL	MS	AL	LA	TX	NMFS
			-Multibeam-			
Lead	USF	MDMR	MRD	NA	NA	NMFS
Time Series Length	2014-2021	2015-2016	2020	NA	NA	Long Term, Ongoing
Seasonality	Year Round	Winter	Year Round	NA	NA	Year Round
			-Side scan-			
Lead	FWRI	MDMR	MRD/USA	LDWF Artificial Reef Program	TPWD	SEFSC
Time Series Length	2010-present	2013-2017	2011-2021	Unknown	2010-present	2008-present
Seasonality	Year Round, Opportunistic	Variable	Summer	Variable	Variable	Year Round

Table 3: Offshore hook and line sampling programs in the Gulf utilized by fisheries managers. Time series highlighted in red were funded by GEBF following the kickoff of these projects (2014 in Florida, 2015 in Alabama, and 2016 in Mississippi); other funding sources were sometimes used to support these sampling programs before and after GEBF projects ended. Superscript numbers following the time series length correspond to the stock assessments in Table 1 where GEBF-funded data were used.

	FL	MS	AL	LA	TX	NMFS
			-Vertical Longline-			
Lead	FWRI	MDMR/GCRL	MRD/USA	LDWF	TPWD	SEFSC
Time Series Length	2014 - 2018[8]	2016-present[8]	2012-present[8]	2011-present	2014-present	2008-present
Seasonality	May - October	March-October	March-October	March-October	May-October	Spring
			-Bottom Longline-			
Lead	USF	GCRL	MRD/USA	LDWF	TPWD	SEFSC
Time Series Length	2011-2018	2007-2019	2006-present	2011-present	2007-present	1990-present
Seasonality	NA	March-September	March-October	March-October	April-October	Summer-Fall
			-Repetitive Timed Drop-			
Lead	FWRI	NA	NA	NA	NA	NA
Time Series Length	2014 - 2018[3]	NA	NA	NA	NA	NA
Seasonality	May - October	NA	NA	NA	NA	NA

Table 4: Offshore underwater video-based monitoring programs in the Gulf utilized by fisheries managers. Time series highlighted in red were funded by GEBF following the kickoff of these projects (2014 in Florida, 2015 in Alabama, and 2016 in Mississippi); other funding sources were sometimes used to support these sampling programs before and after GEBF projects ended. Superscript numbers following the time series length correspond to the stock assessments in Table 1 where GEBF-funded data were used. VLL-mounted cameras are used for different purposes for each lead organization (estimating depredation, habitat type, etc.).

	FL	**MS**	**AL**	**LA**	**TX**	**NMFS**
			-Remotely Operated Vehicle-			
Lead	USF	NA	MRD/USA	LDWF	NA	NOS, ONMS
Time Series Length	2014-2021	NA	2011-present	2012-2017	NA	Unknown
Seasonality	Year Round	NA	March-October	Variable	NA	Variable
			-Baited Remote Underwater Video-			
Lead	FWRI	NA	NA	NA	NA	SEFSC
Time Series Length	2008-present[1,3-9]	NA	NA	NA	NA	1992-Present
Seasonality	May - October	NA	NA	NA	NA	Variable
			-Vertical Long Line-Mounted Cameras-			
Lead	FWRI	MDMR/GCRL	MRD/USA	LDWF	NA	NA
Time Series Length	2014 - 2018[8]	2016-2019	2011-present	2015-present	NA	NA
Seasonality	May - October	Year Round	March-October	July-Oct	NA	NA

Red snapper and lionfish swim near a submerged chicken coop off the Florida Panhandle| Credit: FWC/FWRI

BENEFITS OF MONITORING

Enhanced fisheries monitoring contributed to the effective conservation and management of fishes by ensuring managers had access to timely, more complete and accurate information to support management decisions. These investments conserved fishes through two primary avenues: contributing to stock assessments and providing a basis for robust data-driven decision making outside the stock assessment process.

INFORMING STOCK ASSESSMENT

Stock assessment models for fishes in the Gulf of Mexico are developed and reviewed through the Southeast Data, Assessment and Review (SEDAR) process. Assessment models utilize large quantities and diverse types of data to analyze the status and trends of fish populations. These models are critical for helping fisheries managers establish sustainable catch limits and evaluate stock status. In the Gulf of Mexico, assessment models have relied heavily on fishery dependent data because these data streams often constitute the longest time series of available data. The fisheries management community has long pushed for greater incorporation of fishery independent data because it is difficult to parse out whether changes in fishery dependent data products (e.g., indices of relative abundance) are driven by changes in the fish population, fishing pressure, or management (e.g., fishing regulations). SEAMAP is the primary source of long-term fishery independent data in the Gulf, but budgetary constraints [approximately $1.9 million for the entire Gulf in FY19 (SEAMAP Subcommittee 2019)] have acted as a barrier to augmenting collection of fishery independent data for stock assessment.

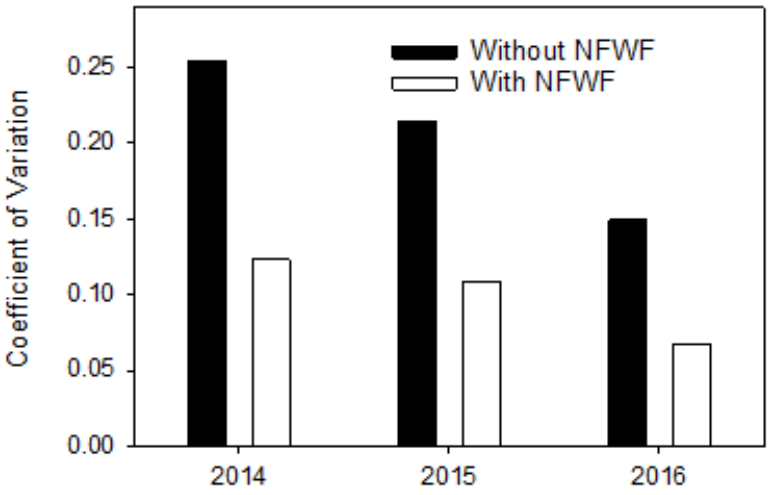


Figure 4: Red grouper relative abundance coefficients of variation (a measure of uncertainty) for the FWRI-NMFS combined video survey with and without GEBF funded sampling. Note that uncertainty is decreasing over time, but GEBF funding has resulted in drastic reductions to uncertainty due to improved modeling approaches and additional data collection. | Credit: FWC/FWRI

Fishery independent data collected as a part of these projects have already been utilized in four completed SEDARs and will likely be used in future Gulf reef fish SEDARs (Table 1). The SEDAR 61 red grouper assessment (SEDAR 2019) incorporated a large amount of data from the FWRI-led monitoring program, including life history data (size/age structure, age and growth, reproduction), discard mortality, and abundance data from both the repetitive timed drop survey (hook and line), and the FWRI video survey. The red grouper assessment placed a large emphasis on the FWRI video survey, which was combined with the SEAMAP Reef Fish and NMFS Panama City video surveys for the purposes of the analysis. With GEBF funding, FWRI has significantly expanded video work, which has resulted in large reductions to the uncertainty of population estimates generated from analyses of survey data, including a ~50 percent reduction in uncertainty for red grouper (Figure 4). The SEDAR 61 red grouper assessment report took note of these successes, attributing "major advances" in data streams as the reason for revising many model inputs (SEDAR 2019). It is noteworthy that this new approach of combining and integrating video data has become the standard approach for recent reef fish stock assessments.

Many of these monitoring efforts were funded with a specific goal of contributing and improving the red snapper stock assessment. The SEDAR 52 red snapper assessment (SEDAR 2018b) used life history and recreational discard data that were collected at the very beginning of these monitoring projects (prior to 2017). While including more sampling methodologies may have broadened our understanding of red snapper size-class structure (Figure 5 and see Powers et al. 2018a), SEDAR (2018b) notes that these new data only resulted in a minor update from the previous assessment. Relative abundance data were not included in the SEDAR 52 red snapper assessment, which included data from 2016 and earlier, because the data streams associated with these projects had just been established, and time series were of insufficient length (2018b). It is expected that data collected as a part of these projects will play a larger role in the upcoming red snapper research track stock assessment, which is scheduled to begin in 2021 (schedule available at http://sedarweb.org/), as all data streams will be fully established at that point.

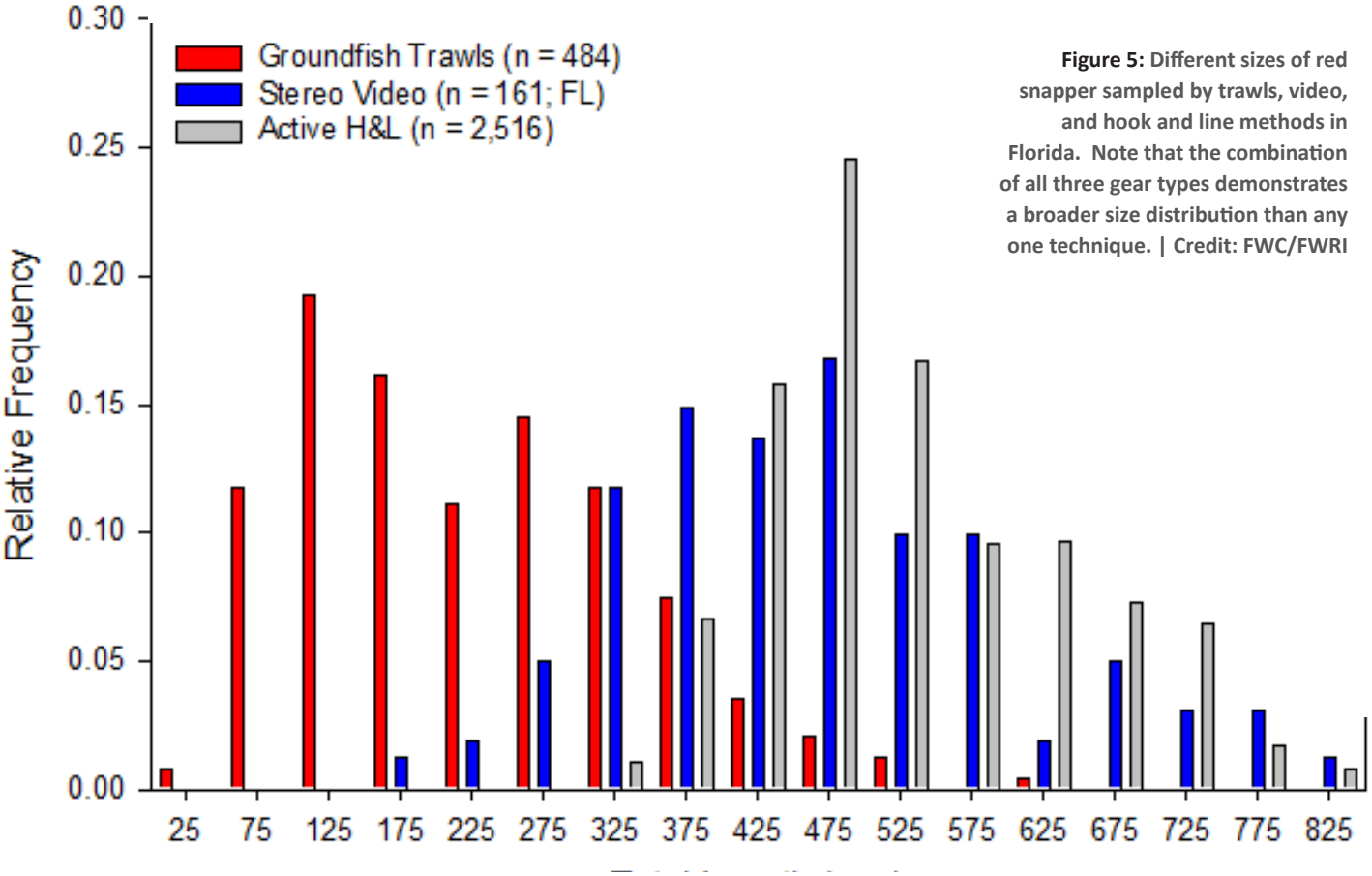


Figure 5: Different sizes of red snapper sampled by trawls, video, and hook and line methods in Florida. Note that the combination of all three gear types demonstrates a broader size distribution than any one technique. | Credit: FWC/FWRI

In addition to improved data streams that contributed to federal stock assessment (SEDAR 52), Alabama's project created capacity that allowed for a southern flounder stock assessment in Alabama's coastal waters. Anglers and fisheries managers alike have suspected a decline in southern flounder in Alabama's coastal waters. Increased capacity associated with this project allowed Alabama to perform a stock assessment, which corroborated this observed decline (Powers et al. 2018b). The state responded by increasing the minimum size of southern flounder from 12 to 14 inches, reducing the bag limit by 50 percent, and closing fishing when adult southern flounder migrate from inshore waters to offshore waters during November (Rainer 2019). Increasing the size limit alone will leave approximately 38 percent (>50,000 individuals) more fish in the water every year, ensuring this important resource is available for future generations of Alabamians.

PROVIDING A DATA-DRIVEN FRAMEWORK TO MAKE RAPID MANAGEMENT DECISIONS

Fisheries managers are tasked with making management decisions that affect the conservation of marine fishes. These decisions include adjusting season lengths in response to changes in fishing pressure, and unfortunately, often in response to environmental disaster. Over the last five years, these projects have provided managers with a data-driven framework when making these difficult decisions.

Tools implemented to monitor recreational effort and catch of reef fishes in the eastern Gulf have furthered the conservation of red snapper. These three tools [Gulf Reef Fish Survey (FL), Snapper Check (AL), and Tails n' Scales (MS)] are marked improvements on their predecessors in terms of reduced uncertainty and the timeliness of the data. The utility of increased timeliness of the data has already been demonstrated in Alabama. Exceptionally good weather during the summer of 2018 provided more offshore fishing opportunity than anticipated, and consequentially, forecasts using in-season data from Snapper Check indicated recreational catch would exceed sustainable levels if the fishery had remained open for the remainder of the original announced season. The state responded by reducing the season by more than 50 percent to remain within their recreational catch limit of 984,211 pounds (the recreational fishery exceeded its allocation by 2,007 pounds). It is notable that Alabama has also extended the 2019 red snapper fishing season when Snapper Check data were used to forecast that catch would not reach the limit by season close. These adjustments demonstrate to the public that decisions are being made objectively based upon the best available science.

Red snapper, lionfish, and a school of juvenile vermilion snapper off the coast of Florida. | Credit: FWC/FWRI

During the Deepwater Horizon oil spill, managers struggled with a lack of baseline data in determining real or potential injuries to reef fish populations. These projects were designed, in part, to ensure baseline data are available in the unfortunate event of another disastrous environmental event. To that end, fishery independent data from several of these projects were used to support fisheries management in response to the 2018 red tide in southwest Florida. Red tide is known to have population-level impacts on gag and red grouper (SEDAR 2014, SEDAR 2019), and analyses indicated that the 2018 red tide had a large impact on red grouper in particular. (GMFMC 2019). NMFS ultimately reduced the catch allowed in both 2019 and 2020 by approximately 60 percent (4.78 million pounds/year) to account for concerning declines in landings in recent years as well as the anticipated loss of red grouper associated with this disaster (NOAA 2019). The reduction was based on analysis of past red tides, but the FWRI repetitive timed drop and video survey provided important supporting evidence for deeming this a severe mortality event (Figure 6).

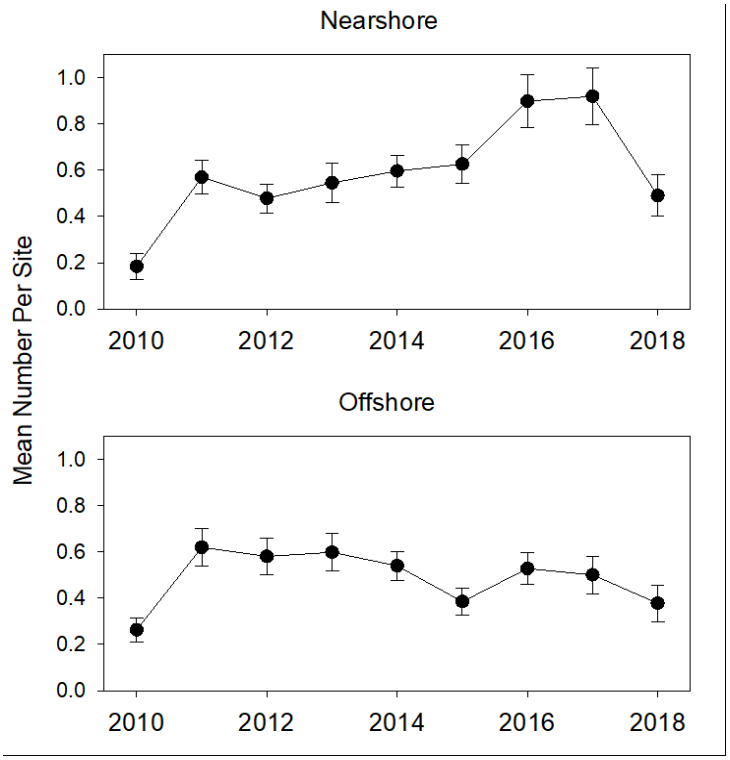


Figure 6: Video-Based relative abundance estimates of red grouper in the nearshore and offshore zones of Florida. Note the steep drop in nearshore abundance during 2018. Nearshore waters were those most severely affected by red tide. | Credit: FWC/FWRI

MONITORING LANDSCAPE AND RECOMMENDATIONS FOR THE FUTURE

FISHERY INDEPENDENT MONITORING

Tables 2-4 (pages 9-10) summarize recent fishery independent monitoring efforts in the Gulf of Mexico. These tables are organized by theme: characterizing benthic habitats (Table 2), monitoring abundances and sizes of fishes using underwater video surveys (Table 3), and monitoring abundances and life history (age, growth, reproduction, diet) using traditional hook and line techniques (Table 4). These tables clearly demonstrate that sampling efforts varied state-by-state and that GEBF funding has played a large role in getting these efforts out to sea.

Habitat mapping has become a cornerstone of fishery independent monitoring in recent years by guiding the design of sampling efforts. This focus, in large part, is driven by a desire to incorporate habitat characteristics into statistical analyses (e.g., indices of relative abundance) and, ultimately, stock assessment. The availability of habitat can have population-level impacts on fishes by influencing their survival, growth, and reproduction. Thus, inclusion of habitat in the stock assessment process can help reduce uncertainty.

While knowledge of benthic habitats in the Gulf has improved drastically since the Deepwater Horizon Oil Spill, additional work is needed to improve the compatibility and accessibility of these data (Table 5).

RECOMMENDATION: IMPROVE DATA ACCESSIBILITY. Mapping data are housed in a variety of external and internal repositories, making it difficult for those individuals who need this information to understand what is available and how to access it. Enhanced data availability could be accomplished through setting clear metadata standards and establishing a centralized repository for fishery scientists, managers, and other researchers. It may be appropriate to restrict access to these databases to protect locations of sensitive habitats and unpublished artificial reefs.

RECOMMENDATION: PROVIDE FOR BETTER STANDARDIZATION OF DATA ACROSS INSTITUTIONS. Discrepancies exist in how habitat types are classified during data analysis. Different organizations use different habitat classification procedures (e.g. FWRI uses ~30 different habitat classifications, whereas USF only uses two), constraining the comparability of data. Additional work is needed to evaluate these various techniques and to determine how best to integrate classifications from multiple programs and promote greater compatibility. Lastly, a calibration study is needed for multi-beam and side scan sonar to determine if these methods could be used jointly.

Underwater video surveys have transformed fisheries management, but techniques vary widely across programs. Stereo-baited remote underwater video (S-BRUV) is the most widely used video method for surveying reef fishes. A standardized S-BRUV protocol is used by the State of Florida (FWRI) and NMFS, which involves attaching cameras to a sturdy metal frame that is left on the seafloor for about one hour. USF also utilizes a towed camera array to characterize fish abundances on the West Florida Shelf. However, these surveys differ from randomized fishery independent surveys, as they are targeted at mapping hard bottom habitats and characterizing associated fish assemblages. The State of Alabama uses a remotely operated vehicle (ROV) to conduct video survey transects on and around reefs to survey fishes. Use of underwater video surveys in Mississippi, Louisiana, and Texas is considerably more difficult because of poor visibility associated with river outflows and muddy bottoms in this part of the Gulf. Nevertheless, these methods have been successfully used off Louisiana in surveys following the Deepwater Horizon Oil Spill and as a part of many academic studies off the coasts of Mississippi, Louisiana, and Texas.

Additional work is required to increase the usability of video surveys in fisheries management, with the ultimate goal of incorporating video surveys into federal stock assessment models.

RECOMMENDATION: CONDUCT A CALIBRATION STUDY TO EVALUATE THE COMPATIBILITY OF THE FWRI VIDEO SURVEY AND ALABAMA'S ROV SURVEY. FWRI's video survey and Alabama's ROV survey were used (along with data from other surveys) to estimate lengths for the SEDAR 52 red snapper stock assessment (SEDAR 2018b). Differences in these two techniques present challenges for using these separate surveys to jointly estimate abundance. This type of joint abundance estimation will require a calibration study where both methods are compared across a range of environmental and habitat conditions. FWRI and USF have already made some progress towards calibrating the S-BRUV and USF's towed video array. Because of the similarity between the USF's towed video array and Alabama's ROV survey, this initial progress towards calibrating the two methods may provide a framework for calibrating the S-BRUV and Alabama's ROV.

Table 5: List of this report's recommendations and progress towards meeting those recommendations at the time of publication.

Recommendation	Progress to Date
- FISHERY INDEPENDENT DATA –	
Improve data accessibility	Not started
Provide for better standardization of data across institutions	Not started
Conduct a calibration study to evaluate the compatability of the FWRI video survey and Alabama's ROV survey	Not started
Develop machine learning techniques to automate the analysis of video data	Ongoing NMFS-FWRI led effort
Invest in experimental video-like technologies that can be used in low visibility environments	Ongoing, but primarily led by academic researchers
-FISHERY DEPENDENT DATA-	
Calibrate state-based tools to estimate recreational catch with the historic Marine Recreational Information Program (MRIP) statistics	Ongoing GMFMC led effort
Build upon successes of the recreational fishing at-sea observer programs by evaluating the possibility of jointly submitting data from the eastern Gulf for inclusion in SEDARs	Not started
Identify a long-term funding source for the recreational fishing at-sea observer program	Ongoing priority for FWRI, but no path forward has been identified
-SYNTHESIS-	
Create funding opportunities that support the compilation and synthesis of these data to address questions relevant to fisheries management.	Not started

RECOMMENDATION: DEVELOP MACHINE LEARNING TECHNIQUES TO AUTOMATE THE ANALYSIS OF VIDEO DATA. Video survey methods are also constrained by the amount of time and level of effort required to analyze video. To date, these analyses have mostly been performed by people who "read" the video and record fish lengths, abundances, and habitat characteristics. NMFS and the University of South Florida have made recent advances in automating these analyses. Automating video processing will decrease the analysis time, allow for the computation of multiple abundance indices, make data rapidly available for management decisions, and will likely decrease high analysis costs associated with these survey methods. Automation of image analysis will also allow for the analysis of all cameras from an individual sample (historically, only one camera per sample is analyzed for fish relative abundances) and will increase the feasibility of using 360 degree camera arrays, which have been hampered by long processing times.

RECOMMENDATION: INVEST IN EXPERIMENTAL VIDEO-LIKE TECHNOLOGIES THAT CAN BE USED IN LOW VISIBILITY ENVIRONMENTS. Equipment such as imaging sonar that converts sound echoes into digital images may facilitate surveying fishes in all types of visibility conditions. However, these technologies are still in development and it is currently not possible to make species-level fish identifications using these sonar imaging techniques, limiting their current utility for monitoring fish abundance.

Hook and line methodologies, especially VLL, have been a mainstay of fishery independent monitoring. VLL and Bottom Longline (BLL) have been historically implemented through SEAMAP's partnerships with the Gulf States. These projects resulted in drastic increases in VLL and BLL sampling. The repetitive timed drop survey (RTD) was an experimental method tested by FWRI. RTD proved to be extremely valuable, especially for the SEDAR 61 red grouper stock assessment (SEDAR 2019). However, FWRI elected to discontinue this survey after 2018 and to rely on video surveys for abundance estimates. VLL and BLL are known to have sampling biases towards certain species and sizes of fishes, but they provide important data on life history (age, growth, reproduction, diet) that cannot be derived from other survey methods, such as video surveys. These programs vary by footprint, timeline, and station distribution; however, sampling techniques have been well coordinated through SEAMAP.

FISHERY DEPENDENT MONITORING

The three fishery dependent monitoring programs implemented in Florida, Alabama, and Mississippi have been some of the most impactful investments made as a part of these projects. As discussed in section 3c, tools used for estimating recreational catch (Gulf Reef Fish Survey, Snapper Check, Scales n' Tails) have driven fisheries management decision-making regarding bag limits and season lengths. However, additional work is needed to facilitate their application to federal stock assessments.

RECOMMENDATION: CALIBRATE STATE-BASED TOOLS TO ESTIMATE RECREATIONAL CATCH WITH THE HISTORIC MARINE RECREATIONAL INFORMATION PROGRAM (MRIP) STATISTICS. The designs underlying all three of these tools have been certified by the MRIP, but there is an outstanding need to calibrate these surveys against MRIP's national survey. Calibration of these surveys is ongoing and will continue in 2020.

RECOMMENDATION: BUILD UPON SUCCESSES OF THE RECREATIONAL FISHING AT-SEA OBSERVER PROGRAMS BY EVALUATING THE POSSIBILITY OF JOINTLY SUBMITTING DATA FROM THE EASTERN GULF FOR INCLUSION IN SEDARS. Techniques for collecting observer-based estimates of discard mortality and size composition of discarded fish have been well coordinated, as the programs in Alabama and Mississippi were modeled on Florida's program. Florida's estimates of discard mortality have been included in ten federal Gulf of Mexico stock assessments. Because of the similarity in programs across the three eastern Gulf States, it may be possible to combine the outputs from these three programs into a single dataset for the eastern Gulf.

RECOMMENDATION: IDENTIFY A LONG-TERM FUNDING SOURCE FOR THE RECREATIONAL FISHING AT-SEA OBSERVER PROGRAM. FWRI's at sea observer program has been supported on short-term funding for over ten years. Given the widely recognized value of these data, which are the sole source of characterizing the sizes of fish discarded by the recreational fishery, securing long-term funding for recreational observer programs should be a priority.

SYNTHESIZING EXISTING DATA TO ANSWER IMPORTANT QUESTIONS FOR FISHERIES MANAGEMENT

Fisheries managers readily incorporated data produced by these projects into the fisheries management process; however, the data collected as a part of these expanded fisheries monitoring programs provide a unique opportunity to use an integrative (cross-program) approach to answer questions of critical importance to fisheries managers. For example, the expanded collection of growth, reproduction, and diet data on natural and artificial reefs across the eastern Gulf could likely provide fresh insights on the use of artificial reefs as a fisheries management tool. These data could also be used to model the distribution and abundance of various habitat types and better understand the drivers of fish assemblages in the Gulf.

RECOMMENDATION: CREATE FUNDING OPPORTUNITIES THAT SUPPORT THE COMPILATION AND SYNTHESIS OF THESE DATA TO ADDRESS QUESTIONS RELEVANT TO FISHERIES MANAGEMENT.

A scientist deploys a vertical long line off the coast of Florida. | Credit: FWC/FWRI

CONCLUSIONS

Restoration of marine fishes is an ambitious task. While ocean-scale ecological processes that influence fish populations are unlikely to be influenced by local actions, ensuring sustainable fishing practices is achievable. This was the rationale for using GEBF funds to equip fisheries managers with better tools and data.

These projects show that investments in fisheries monitoring are an effective way of restoring and conserving marine fishes. These monitoring programs have contributed positively to every major Gulf reef fish stock assessment since the beginning of these investments. These investments furthered stock assessment by improving the quality of model inputs, and the conservation impacts can be seen in the management actions that take place after the stock assessment. For example, GEBF-funded tools and data have driven the decision-making behind mid-season adjustments of fishing seasons to promote sustainable catch and adjusting catch limits to account for the catastrophic 2018 Red Tide in southwest Florida. These investments have also given fisheries managers increased flexibility with implementing stock assessments and updates. The SEDAR 62 gray triggerfish stock assessment was scheduled for completion in the Spring of 2020, but unfortunately was canceled and recommended for a more intensive "research track" assessment to resolve issues associated with data inputs and assessment model configuration. In the meantime, the GMFMC noted they would base management recommendations, in part, upon annual interim analyses, which will be based on gray triggerfish relative abundance using the combined FWRI-NMFS video survey (GMFMC 2020).

The greatest benefits of these data may be in the future. All three states invested in enhanced collection of diet information because they are critical for implementing ecosystem and multi-species stock assessments. These data have helped improve ecosystem models and our understanding of trophodynamics and the productivity of managed and non-managed species. While managers are not ready to implement these advanced stock assessment models at this time, these data could ultimately

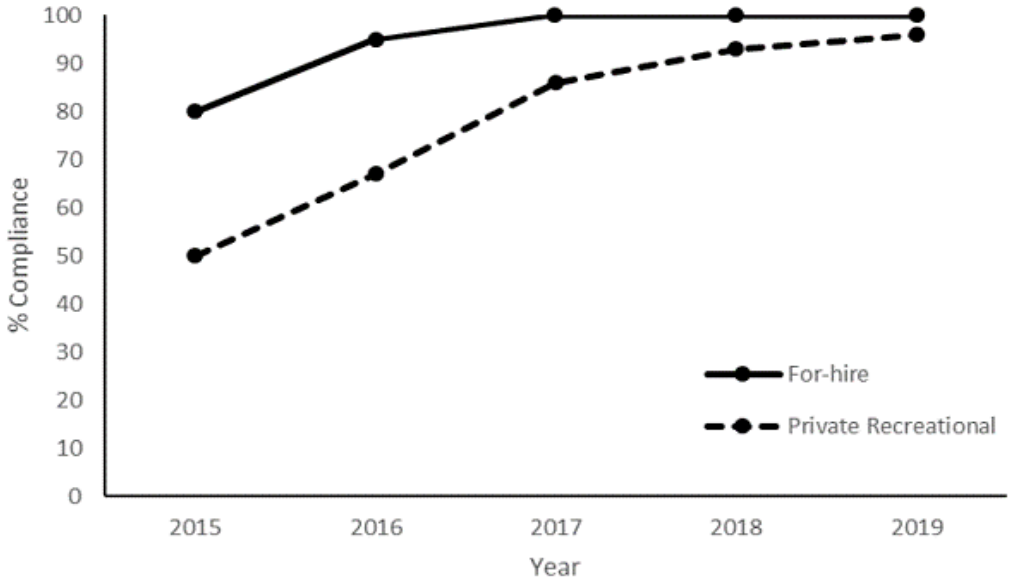


Figure 7: Percentage of intercepted anglers in compliance with offshore fishing regulations in Mississippi waters. Taken from "Office of Marine Fisheries. 2019. Mississippi Recreational Red Snapper Season 2019. Pp.1-7."

serve as a cornerstone of future stock assessments. Despite the widely recognized value of these data, these programs have not secured long-term funding.

Long-term funding has been secured for many aspects of these programs. The impact of FWRI's video survey on stock assessment and fisheries management resulted in a team of FWRI and NMFS scientists securing up to 10-years of competitive funding (NOAA RESTORE Act Science Program) to implement a joint survey at a Gulf-wide scale (https://restoreactscienceprogram.noaa.gov/projects/reef-fish-survey). The State of Florida has decided to use state appropriations to fund an expansion of the Gulf Reef Fish Survey that covers the State's Gulf and Atlantic coasts (Florida Reef Fish Survey). The State of Alabama introduced a Saltwater Reef Fish Endorsement in 2020 that will provide limited funding for their VLL, ROV and/or Snapper Check activities. While no long-term funding has been identified to support Mississippi's expanded fisheries monitoring efforts, the State's project is funded with GEBF dollars through the 2020 sampling season.

The end of these investments will carry some unfortunate consequences for fisheries management in the Gulf of Mexico. The end of abundance surveys that have proved useful for stock assessment (e.g. FWRI's RTD survey) will likely preclude their use in future stock assessments. This is especially true for the red snapper stock assessment, which historically includes a rich assortment of abundance indices. The end of these investments could also mark the terminus of Florida's discard size data collected by the At-Sea Observer Program for the recreational fishery. These are often the only source of information available to determine the sizes of fish discarded, which is important when estimating retention within stock assessment models. The end of GEBF support for this data collection leaves the future of this data stream in doubt and could increase model uncertainty by requiring more assumptions regarding discard mortality and retention.

While Mississippi has another year of available funding, the end of funding for the State's program could also have important consequences. Tails n' Scales has enabled Mississippi to manage recreational red snapper catch under GMFMC's Amendment 50. It has also resulted in extraordinary improvements in compliance with recreational fishing rules (~50 percent compliance in 2015 and >90 percent compliance in 2019, Figure 7). A transition away from using Tails n' Scales could result in more conservative (shorter) season lengths that may undo some of the goodwill Mississippi fisheries managers have earned from fishermen. Lastly, VLL sampling off Mississippi's coast occurs in an area that was not historically sampled by SEAMAP, so the expansion of this program represents the only fishery independent monitoring of its kind happening off Mississippi's coast.

These monitoring projects were a substantial effort that advanced Gulf of Mexico fisheries management. Further advances are needed to support more complex stock assessment models (e.g. multi-species assessments) and ecosystem-based fisheries management. Our hope is that future investments will continue to advance fisheries management science and understanding and ensure a robust and sustainable future for these important natural resources.

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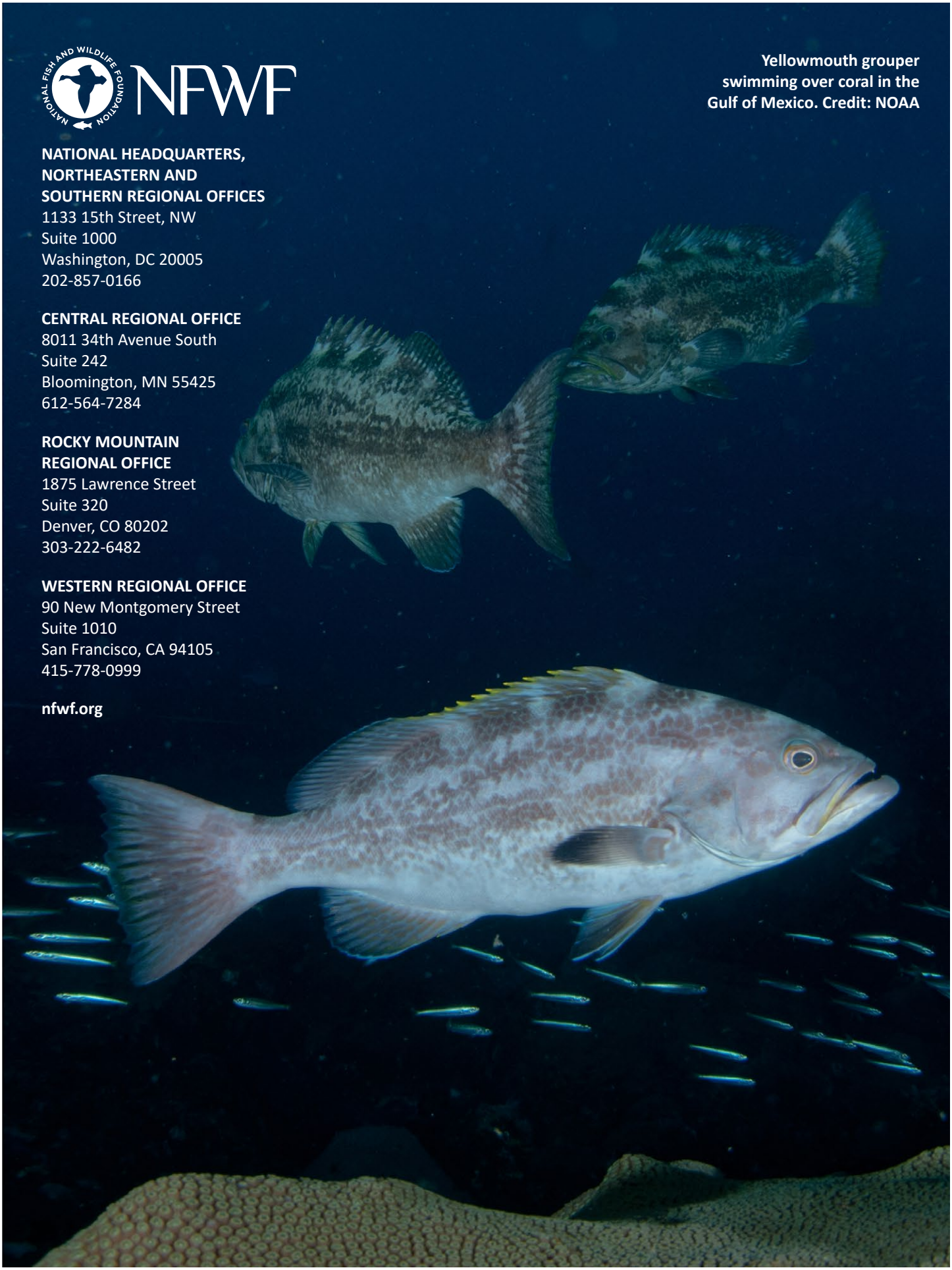
DECEMBER 2019 WORKSHOP ATTENDANCE LIST

STATE	NAME	ORGANIZATION
Alabama	Kevin Anson	Alabama Department of Conservation and Natural Resources, Marine Resources Division
Alabama	Sean Powers	University of South Alabama/ Dauphin Island Sea Lab
Alabama	John Mareska	Alabama Department of Conservation and Natural Resources, Marine Resources Division
Florida	Ted Switzer	Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute
Florida	Beverly Sauls	Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute
Florida	Sean Keenan	Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute
Florida	Kevin Thompson	Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute
Florida	Steve Murawski	University of South Florida
Louisiana	Brett Falterman	Louisiana Department of Wildlife and Fisheries
Louisiana	Jason Adriance	Louisiana Department of Wildlife and Fisheries
Mississippi	Paul Mickle	Mississippi Department of Marine Resources
Mississippi	Trevor Moncrief	Mississippi Department of Marine Resources
Mississippi	Jill Hendon	University of Southern Mississippi, Gulf Coast Research Laboratory
Mississippi	Marcus Drymon	Mississippi State University, Coastal Research and Extension Center
Texas	James Tolan	Texas Parks and Wildlife Department
Texas	Mark Fisher	Texas Parks and Wildlife Department
NA	Roy Crabtree	NOAA National Marine Fisheries Service
NA	Andy Strelcheck	NOAA National Marine Fisheries Service
NA	Jamie Reinhardt	NOAA National Marine Fisheries Service
NA	Skyler Sagarese	NOAA National Marine Fisheries Service
NA	Matthew Campbell	NOAA National Marine Fisheries Service
NA	Jeff Rester	Gulf States Marine Fisheries Commission
NA	Mike Sharp	National Fish and Wildlife Foundation
NA	Erika Feller	National Fish and Wildlife Foundation
NA	David Reeves	National Fish and Wildlife Foundation
NA	Elizabeth Gullett	National Fish and Wildlife Foundation
NA	George LaPointe	George LaPointe Consulting

Fishing vessel and oil rig
in the Gulf of Mexico



Yellowmouth grouper swimming over coral in the Gulf of Mexico. Credit: NOAA

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