

A close-up photograph of a Red Snapper's head, focusing on its large, dark eye. The fish's scales are a vibrant reddish-orange color, and the eye is surrounded by a lighter, fleshy ring. The background is dark and out of focus.

“The Great Red Snapper Count”

Estimating the absolute abundance of Red Snapper
in the U.S. Gulf of Mexico.

What is the problem/goal?

- Absolute abundance estimate leads to most informed mgmt.

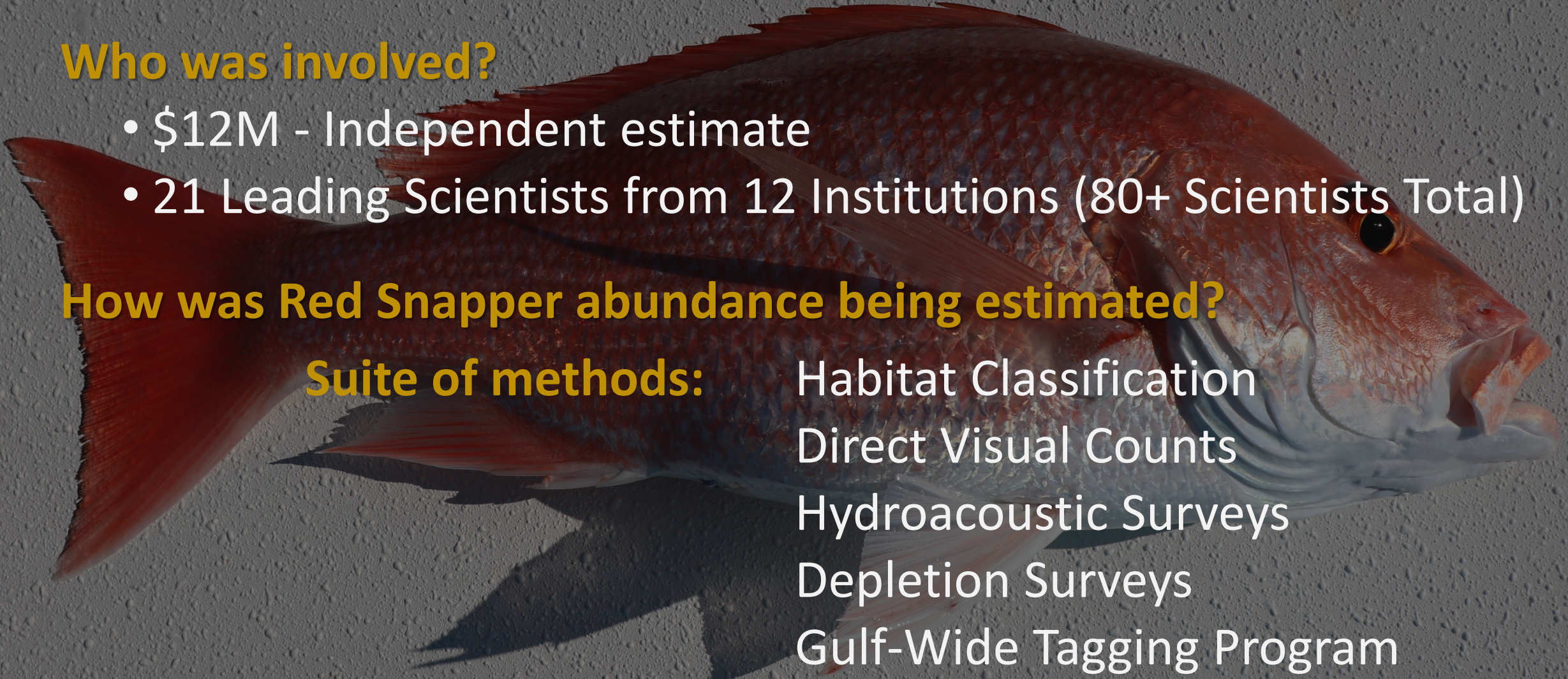
Who was involved?

- \$12M - Independent estimate
- 21 Leading Scientists from 12 Institutions (80+ Scientists Total)

How was Red Snapper abundance being estimated?

Suite of methods:

Habitat Classification
Direct Visual Counts
Hydroacoustic Surveys
Depletion Surveys
Gulf-Wide Tagging Program



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Participating Institutions



History

- **Planning Meetings/Workshops**
- **Consisted of a Two-Phase RFP Process:**

Phase I - 6 Proposals (\$100K ea.) to develop designs

- **Coalescing of desirable aspects and design framework**
- **Somewhat unconventional**

Phase II – Implement designs for an abundance estimate

Phase II

Red Snapper Abundance Estimate in the U.S. Gulf of Mexico

Key Points:

- Explicitly detailed: scope, goals, objectives, and general sampling methodologies
- Specified:
 - General statistical analyses
 - Target CVs
 - Geographic scope
 - Habitat types to assess
 - Depth ranges
 - Tagging study requirement
 - Requirement for comprehensive stakeholder engagement
 - No genetic-based methods and only archiving of samples

External and SSC Review - Update

During Spring 2021 Report Reviewed by External Experts and SSC

Key Points:

- Very valuable process. Details are captured in the report and response letter.
- Recommendation on design and analyses greatly improved report.
- Team has worked diligently to reanalyze and address each of these suggestions.
- Specifically:
 - Explicitly describing the stratified random sampling design;
 - Capturing as much additional variability as possible (including adding 'variance buffer');
 - Improving estimators, calibrations, and modification of post-strata based on suggestions;
 - Re-evaluating the contribution Uncharacterized Bottom;
 - Developed an alternate estimator of variance to capture additional uncertainty;
 - Developed an alternate estimator to reduce bias.

Tagging and Exploitation Studies



Catalano (AU)



**Thousands of fish
tagged Gulf-wide**



**Archived genetic
samples**

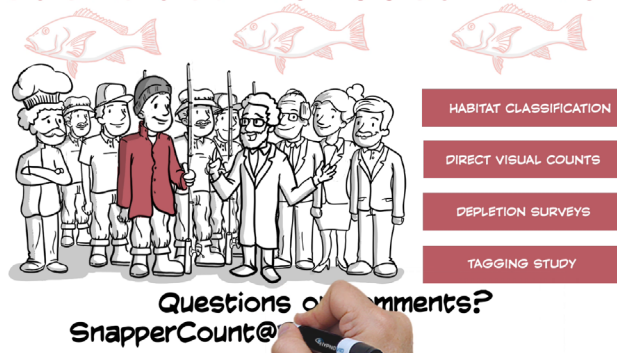


**Angler
Engagement**

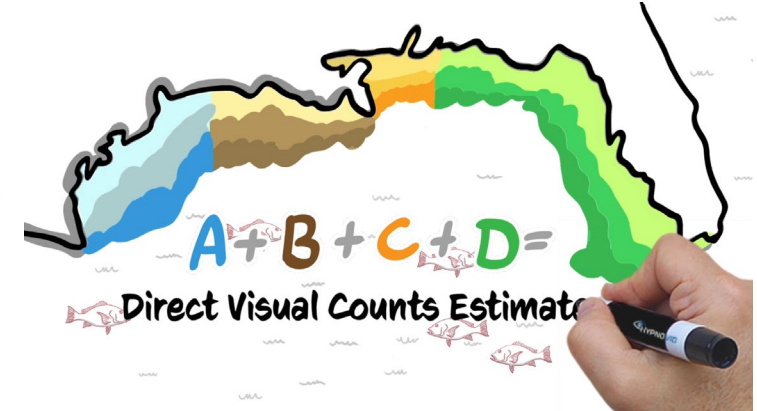
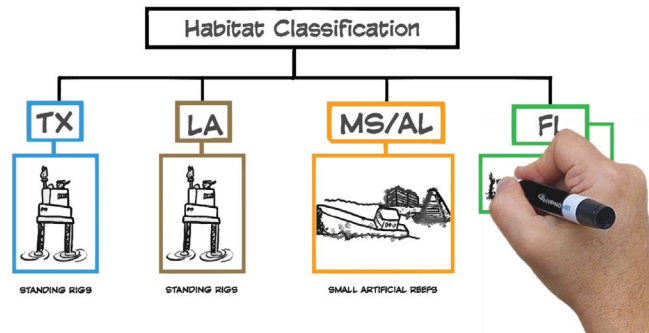


Extensive Stakeholder Engagement

GREAT RED SNAPPER COUNT



GREAT RED SNAPPER COUNT



The Great Red Snapper Count PROJECT OVERVIEW

This project overview describes the Great Red Snapper Count, which is a two-year research project to estimate the abundance of red snapper in the U.S. Gulf of Mexico.

Why is this study important?

- Red snapper comprise an economically valuable and culturally relevant fishery in the Gulf of Mexico.
- The stock is currently under a rebuilding plan.
- Although the red snapper fishery is showing signs of recovery, anglers are frustrated by restrictions, such as shortened seasons.
- Stakeholders collectively desire a healthy, well-managed red snapper stock.
- A lack of abundance data hinders the best possible stock management.

Who is funding the study?

- Congress made the money in funding available for research projects designed to independently estimate red snapper abundance.
- After a competitive review process, Mississippi-Alabama Sea Grant awarded the \$10 million for a 2-year (2017-2019) project.

What is the goal of the study?

The central objective of this study is to independently separately from NOAA fisheries estimate the abundance of red snapper in the U.S. Gulf of Mexico.

Who is involved in the study?

A well-integrated, multidisciplinary team of investigators, which includes leading fisheries experts from the Gulf region and beyond, is leading the project.

Questions or comments? Contact the project team at snappercount@hatterseaninstitute.org. For more information, visit snappercount.org.

The Great Red Snapper Count - PROJECT OVERVIEW

How will scientists develop the abundance estimate?

Scientists will use a suite of methods, including habitat classification, direct visual counts, depletion surveys, and a tagging study, across the entire U.S. Gulf of Mexico.

What are the expected outcomes of the study?

- Legislators and fishery managers will review the abundance estimate from this project and use it to make more informed management decisions.
- This will lead to:
 - Calibration of the current stock assessment
 - Increased confidence in the status of the stock
 - Maximum fishery access for stakeholders

How will scientists collect fish count data from the video footage?

Scientists use remotely operated vehicles (ROVs) to collect video footage to conduct direct visual counts and estimate the number of fish inhabiting artificial reef. This is a highly technical task that requires specialized equipment and expertise.

How will scientists collect fish count data from the video footage?

The videos from the two types of cameras will be transferred to laboratory computers and analyzed.

- First, scientists will count the number of red snapper in each ROV and towed camera videos.
- Then, these counts will be converted to density estimates, which will yield abundance estimates.
- It is areas with poor visibility or very large structures, the towed camera (snapper) will be used with ROV surveys to confirm red snapper abundance estimates.

How will scientists collect fish count data from the video footage?

At an ROV, the towed camera shows gear snapper along the Gulf of Mexico. At an ROV, the towed camera shows gear snapper along the Gulf of Mexico. At an ROV, the towed camera shows gear snapper along the Gulf of Mexico.

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The Great Red Snapper Count HABITAT CLASSIFICATION

This fact sheet describes the habitat classification phase of the Great Red Snapper Count, which is a two-year research project to estimate the abundance of red snapper in the U.S. Gulf of Mexico.

Where do red snapper live in the U.S. Gulf of Mexico?

- Red snapper are distributed across a variety of habitats.
- The snapper counts primarily of sand and mud, along with natural reefs, these areas provide habitat for red snapper.
- Concentrated areas of artificial structures also serve as red snapper habitat.
- The coverage of sediments, natural reefs, and artificial structures differs drastically across the Gulf.

What types of artificial structures exist in the Gulf?

- Large oil and gas platforms are common in the western Gulf.
- Smaller structures include transport cages, pens, military tanks, piers, car bodies, and others are deliberately placed on the seafloor to create fish habitat.

Questions or comments? Contact the project team at snappercount@hatterseaninstitute.org. For more information, visit snappercount.org.

The Great Red Snapper Count - HABITAT CLASSIFICATION

What is habitat classification?

Habitat classification is "Phase 1" of the Great Red Snapper Count.

- This phase involves determining where each of the various habitat types exist across the Gulf.

How did scientists approach the habitat classification process?

- U.S. Gulf waters were separated into four regions: Texas, Louisiana, Mississippi-Alabama, and Florida.
- Each region was divided into three depth zones, creating 12 unique sections.

What did scientists learn from this process?

- Scientists calculated the amount of the U.S. Gulf sea floor that is covered by sand, mud, and natural reefs.
- Scientists also determined the quantity of existing artificial reef structures.

Why is this information useful?

- Based on the distribution and number of different habitat types, scientists developed a sampling approach, or "gear types," to use in the Great Red Snapper Count.
- This will allow the best possible estimate of red snapper abundance across each section of the U.S. Gulf of Mexico.

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The Great Red Snapper Count DIRECT VISUAL COUNTS

This fact sheet describes the direct visual counts phase of the Great Red Snapper Count, which is a two-year research project to estimate the abundance of red snapper in the U.S. Gulf of Mexico.

Where will scientists count red snapper?

Counts will be performed across the U.S. Gulf of Mexico at various habitat types (see the more details, see our "Habitat Classification" video and fact sheet).

What types of equipment will scientists use onboard research vessels?

- Scientists will use two types of camera equipment: remotely operated vehicles (ROVs) and towed cameras.
- An ROV is deployed from a stationary vessel and driven by an operator in a specific platform, much like the operation of a remote-controlled car.
- A towed camera is pulled behind a research vessel at a constant speed and altitude above the seafloor, along a predetermined path.
- Both camera types will record video footage to be analyzed later.

Questions or comments? Contact the project team at snappercount@hatterseaninstitute.org. For more information, visit snappercount.org.

The Great Red Snapper Count - DIRECT VISUAL COUNTS

Why do scientists need to use two different types of equipment?

- ROVs are best for surveying discrete artificial and natural habitats.
- Towed cameras are best for surveying large expanses of sand and mud bottom.

How will scientists collect fish count data from the video footage?

The videos from the two types of cameras will be transferred to laboratory computers and analyzed.

- First, scientists will count the number of red snapper in each ROV and towed camera videos.
- Then, these counts will be converted to density estimates, which will yield abundance estimates.
- It is areas with poor visibility or very large structures, the towed camera (snapper) will be used with ROV surveys to confirm red snapper abundance estimates.

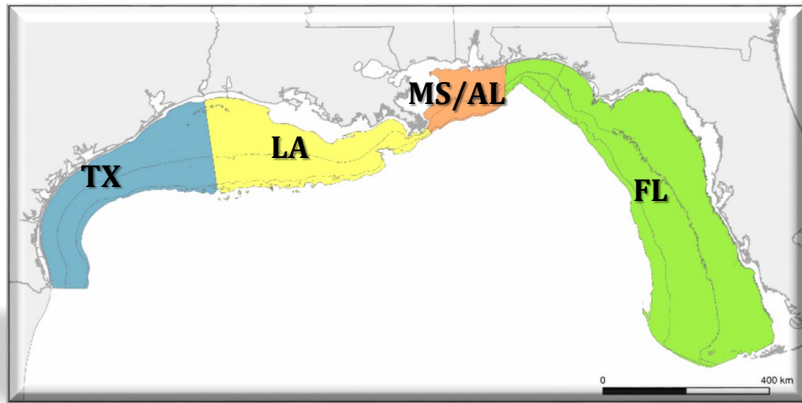
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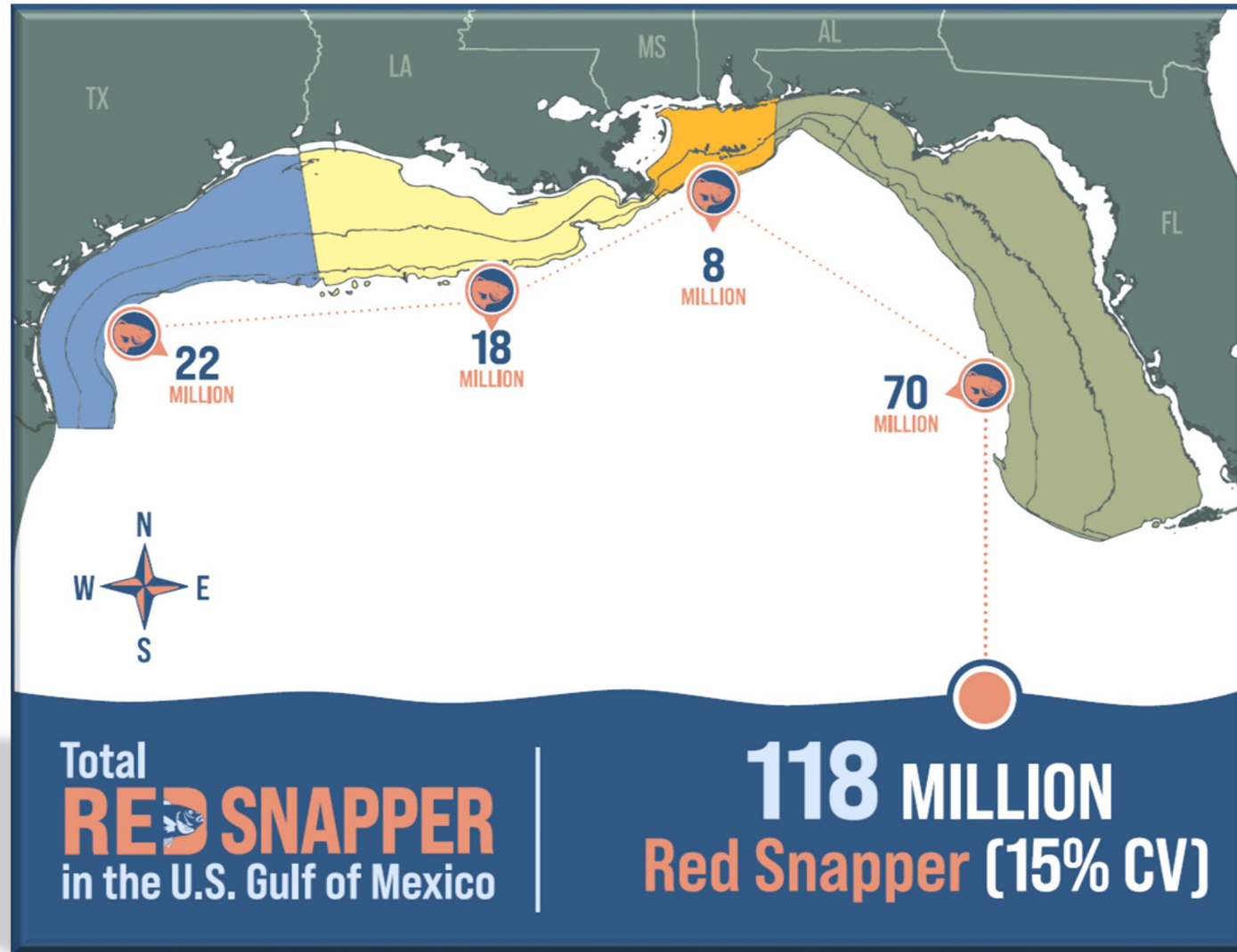
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www.snappercount.org

Estimate and Analysis



- **Two Independent Estimates (relatively low CVs)**
- **Converged with ~ 6 % difference (~ 7M Fish)**



NOAA 2018 Stock Assessment (SEDAR 52): 36 M









State /Region	Habitat Type	Estimated Abundance
 Texas	Natural	7,000,000
	Artificial	<1,000,000
	Uncharacterized Bottom	14,000,000
	 State Total	22,000,000
 Louisiana	Natural	4,000,000
	Artificial	4,000,000
	Uncharacterized Bottom	10,000,000
	 State Total	18,000,000
 Mississippi & Alabama	Natural	4,000,000
	Artificial	1,000,000
	Uncharacterized Bottom	3,000,000
	 State Total	8,000,000
 Florida	Natural & Uncharacterized Bottom	70,000,000
	Artificial	<1,000,000
	 State Total	70,000,000
Total RED SNAPPER in the U.S. Gulf of Mexico		118 MILLION [15% CV]

Table 5. Absolute abundance estimates for each state/region broken into the three habitat strata: Natural hard bottom, Artificial Reef, and Uncharacterized bottom, and pipeline estimates for the entire Gulf. Estimates of area coverage for natural and uncharacterized bottom, and number of structures for artificial reefs plus mean density per area or structure. SE = standard error; CV = coefficient of variation.

State/Region	Habitat Type	Total Area (km ²) or Structures	Number of Samples (<i>n</i>)	Area Sampled (km ²)	Mean Density (100m ²) or by Structure	Number	SE	CV (%)
TX	Natural	1,570	36	6.13	0.45	7,037,443	2,537,014	36
	Artificial	4,348	49			417,761	88,469	21
	<i>Large</i>	941	45		362	340,905	79,287	23
	<i>Small</i>	3,460	4		22	76,855	39,246	51
	Uncharacterized Bottom	57,535	140	6.26	0.03	14,569,830	6,663,776	46
	Total		225			22,025,035	7,130,931	32
LA	Natural	821	22	<i>n/a</i>	0.47	3,852,652	1,671,470	43
	Artificial	1,771	42		2174	3,849,325	576,234	15
	Uncharacterized Bottom	53,052	87	3.61	0.02	9,729,387	5,699,448	59
	Total		151			17,431,364	5,967,375	34
AL&MS	Natural	211	32	0.013	1.78	3,751,988	752,467	20
	Artificial	9,410	128		160	1,509,625	167,506	11
	Uncharacterized Bottom	18,500	3	0.74	0.02	3,199,472	1,625,263	51
	Total		163			8,461,085	1,798,817	21
FL	Natural & Uncharacterized	143,538	748	0.61	0.05	69,918,949	14,349,384	21
	Artificial	7,763	79		16	127,560	21,088	17
	Total		832			70,046,509	16,789,232	24
Pipelines (Gulf-wide)		26,686 linear km	27	0.49	0.02	507,661	218,961	43
Gulf of Mexico						118,471,654	17,194,438	15

Table 7.

State/Region	Habitat Type	Area (km ²) or Structures	Number of Samples (n)	Mean Density (100m ²) or by Structure	Number	SE	CV (%)	Conservative CV(%)	Estimator
TX	Natural	1,570	36		5,218,915	1,390,733	27	44	
	Deep	209	11	0.09	178,682	70,111	39	65	$\hat{t}_{y,r}$
	Mid	953	22	0.35	3,381,753	955,545	28	47	$\hat{t}_{y,r}$
	Shallow	409	3	0.41	1,658,480	1,008,046	61	101	$\hat{t}_{y,r}$
	Artificial	12,010	31		706,327	191,728	27	45	
	Pyramids	10,902	13	11	125,300	80,777	64	107	$\hat{t}_{y,r(pyr)}$
	Non-Pyramids	1,108	18	524	581,027	173,881	30	50	$\hat{t}_{y,mpu}$
	Uncharacterized Bottom	57,535	140		10,332,018	3,449,733	33	33	
	Deep	4,034	4	0.002	71,460	38,584	54	90	$\hat{t}_{y,r}$
	Mid-North	8,765	39	0.015	747,705	512,361	69	93	$\hat{t}_{y,r}$
	Mid-Central	6,450	22	0.033	2,159,374	2,014,526	93	69	$\hat{t}_{y,r}$
	Mid-South	6,503	16	0.005	340,824	205,910	60	60	$\hat{t}_{y,r}$
	Shallow- North	17,036	36	0.014	2,335,968	1,426,726	61	65	$\hat{t}_{y,r}$
	Shallow- Central	8,951	15	0.038	3,367,881	2,183,282	65	61	$\hat{t}_{y,r}$
	Shallow- South	5,797	8	0.023	1,308,806	856,547	65	65	$\hat{t}_{y,r}$
	Total		198		16,257,260	3,724,454	23	26	
LA	Natural	821	22		3,683,745	958,570	26	43	
	Deep	105	6	0.14	151,361	51,731	34	57	$\hat{t}_{y,sub}$
	Mid & Shallow	716	16	0.49	3,532,384	957,173	27	45	$\hat{t}_{y,sub}$
	Artificial	1,771	42		3,849,325	1,341,617	35	58	
	Deep	93	7	710	66,046	38,272	58	96	$\hat{t}_{y,mpu}$
	Mid	602	29	1,399	842,219	363,261	43	72	$\hat{t}_{y,mpu}$
	Shallow	1,076	6	2,733	2,941,060	1,290,935	44	73	$\hat{t}_{y,mpu}$
	Uncharacterized Bottom	53,052	65		11,043,973	4,024,820	36	45	
	Deep	5,348	3	0.01	406,320	387,513	95	159	$\hat{t}_{y,sub}$
	Mid	19,077	11	0.02	3,756,598	2,715,533	72	120	$\hat{t}_{y,sub}$
	Shallow	28,627	51	0.02	6,881,055	2,945,317	43	71	$\hat{t}_{y,sub}$
	Total		129		18,577,043	4,349,479	23	39	
AL/MS	Natural	211	32	1.78	3,751,988	752,467	20	20	
	Artificial	9,410	128	160	1,509,625	167,506	11	11	
	Uncharacterized Bottom	18,500	3	0.02	4,425,687	1,730,961	39	39	$\hat{t}_{y,r}$
	Total		163		9,687,300	1,894,859	20	20	
FL	Natural & Uncharacterized	143,538	748		66,121,747	13,296,205	20	20	
	NW Region- Deep	1,662	26	0.01	92,360	92,214	100	100	$\hat{t}_{y,r}$
	NW Region- Mid	2,060	29	0.004	85,274	85,757	101	101	$\hat{t}_{y,r}$
	NW Region- Shallow	3,553	52	0.05	1,859,201	1,298,879	70	70	$\hat{t}_{y,r}$
	Mid Region- Deep	3,759	4	-	-	-		N/A	$\hat{t}_{y,r}$
	Mid Region- Mid	12,113	20	0.12	15,114,169	8,521,792	56	56	$\hat{t}_{y,r}$
	Mid Region- Shallow	33,977	425	0.11	37,891,216	9,203,445	24	24	$\hat{t}_{y,r}$
	Southern Region- Deep	12,189	25	-	-	-		N/A	$\hat{t}_{y,r}$
	Southern Region- Mid	37,043	37	0.01	3,510,529	2,532,121	72	72	$\hat{t}_{y,r}$
	Southern Region- Shallow	37,180	130	0.02	7,568,998	3,368,997	45	45	$\hat{t}_{y,r}$
	Artificial	7,763	84	16	123,377	20,016	16	16	$\hat{t}_{y,mpu}$
	Total		832		66,245,124	13,296,220	20	20	
Pipelines (Gulf-wide)			27	0.02	546,988	358,761	64	64	$\hat{t}_{y,r}$
Gulf of Mexico					111,313,716				
TX, MS, AL, FL					92,736,673	13,942,031	15	14	
Louisiana*					18,577,043	4,349,479	23	39	

Uncharacterized bottom

Texas

- Mean and SD of fish density was calculated across random start point acoustic transects for mid and shallow depths.
- RS density was estimated as fish density times the region specific mean proportion RS.
- Variance combined uncertainty across transects as well as in the proportion.
- Mean and SD of RS density for the deep depth was calculated using transects from randomly selected locations using CBASS visual counts.

Louisiana

- Mean and SD of fish density was calculated across random start point acoustic transects for mid and shallow depths.
- RS density was estimated as fish density times the region specific mean proportion RS.
- Variance combined uncertainty across transects as well as in the proportion.
- Mean and SD of RS density for the deep depth was calculated using transects from randomly selected locations using CBASS visual counts.

Mississippi / Alabama

- Mean and SD of RS density for the all depths was calculated using transects from randomly selected locations using CBASS visual counts.

Florida

- Mean and SD of RS density for 3 regions and all depths was calculated from randomly selected ROV visual transects.

Hardbottom

Texas

- Mean and SD of RS density was calculated across random start point hydroacoustic transects with paired species composition for areas of know hardbottom.

Louisiana

- Mean and SD of RS density was calculated across random start point hydroacoustic transects with paired species composition for areas of know hardbottom.
- Data was imputed based on Texas observations.

Mississippi / Alabama

- Mean and SD of RS density was calculated across random selected features using camera MaxN counts and a fixed area surveyed.

Florida

- Not separated out given the nature of the bottom in Florida

Texas

- Mean and SD of RS density was calculated across random hydroacoustic surveys of a structure with paired species composition for platform structures and clusters of smaller structures.

Louisiana

- Mean and SD of RS density was calculated across random hydroacoustic surveys of a structure with paired species composition for platform structures and clusters of smaller structures.
- Data was imputed based on Texas observations.

Mississippi / Alabama

- Mean and SD of RS density was calculated for each depth across random selected sites.
- To obtain total numbers per depth category, RS density was combined with stratified estimated of the total number of structures within each depth.
- Uncertainties from both estimates were combined.

Florida

- Mean and SD of RS density per structure for each depth was calculated from randomly selected ROV visual point counts.

Pipelines

Texas

- Mean and SD of RS density was calculated across transects from random selected pipeline arcs from the BOEM database.

Louisiana

- Mean and SD of RS density was calculated across transects from random selected pipeline arcs from the BOEM database.

Mississippi / Alabama

- Mean and SD of RS density was calculated across transects from random selected pipeline arcs from the BOEM database.

Florida

- Mean and SD of RS density was calculated across transects from random selected pipeline arcs from the BOEM database.

Revised estimation – Dr. Lynne Stokes

- In the secondary analysis, revisions were made in each state estimate:
 - FL: Post-strata were eliminated
 - MS/AL: variance was adjusted to account for estimation of AR population size
 - TX: Variance estimate was increased to include variance component due to calibration in UCB stratum; post-strata were added to UCB due to separate calibration factors; error in identifying transects was corrected, resulting in fewer transects in UCB.
 - LA: TX changes affected LA estimate, since much of LA data was imputed.
- Some changes increased estimate/SE and some decreased them.
- Total abundance was reduced by ~ 4.9 million and CV was nearly unchanged.

Calibration variance component for UCB in TX

- For TX UCB, Mid & Shallow, calibration factors for C, N, and S were estimated from independent experimental data (say \hat{p}_h , $h = C, N, S$), where p represents the proportion of fish (u) that are RS (y).
 - Estimate of calibration factor is sample mean: $\hat{p}_h = \frac{\sum_{j=1}^r \hat{p}_{hj}}{r}$
- Then $\hat{t}_{h,y} = t_{h,x} \times \frac{\sum_{i=1}^{n_h} \hat{p}_h u_{hi}}{\sum_{i=1}^n x_{hi}} = t_{h,x} \frac{\sum_{i=1}^{n_h} u_{hi}}{\sum_{i=1}^n x_{hi}} \times \hat{p}_h = \hat{t}_{hu,r} \times \hat{p}_h$
- An unbiased estimate of the variance of a product of two independent random variables has a closed form (Goodman 1962). This estimator was used for the variance for all Mid&Shallow UCB strata.

Other TX strata using calibration

- Natural bottom also used a calibration method, but the data on which the calibration was based was not readily available to me.
- To compensate, I used a “worst case scenario” approach to examine the effect.
 - I calculated the multiplicative increase in variance of RS abundance estimate (efficiency) due to calibration for each of the six post-strata of the UCB in Texas.
 - They ranged from 1.01 to 2.77.
 - I applied the maximum value to remaining post-strata using calibration in TX and LA.
 - This increased the variances as shown in Table 7 of report.

A close-up photograph of a fish's head, showing a large, dark eye with a prominent pupil and iris. The fish has reddish-brown scales and a slightly open mouth. The background is a textured, light-colored surface.

Key Takeaways:

- Report had undergone a very rigorous peer-review process.
- Fully met the concerns of the external review team and SSC.
- Estimate is conservative and likely underestimates abundance.
- Visual/detectability constraints generally lead to underestimate.
- Habitat types are not known with certainty – improved mapping.
- Known populations occur outside of defined study area.

Acknowledgements



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- **Dr. LaDon Swann**
 - **Loretta Leist**
 - **Devaney Cheramie**