

Eye on the Gulf - Electronic Monitoring: An Emerging Technology and Platform for Science in the Gulf of Mexico Snapper Grouper Fishery

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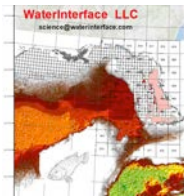
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Gulf of Mexico Fisheries Management Council
Galveston, TX

October 21, 2019



<https://mote.org/research/program/fisheries-ecology-and-enhancement/electronic-monitoring-project>

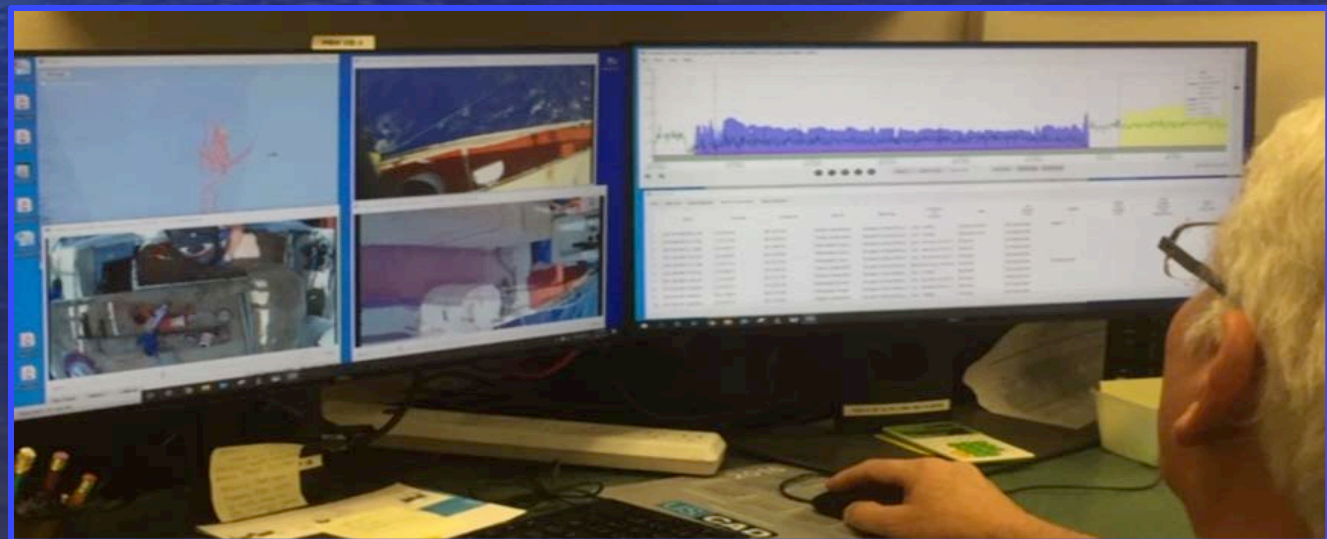
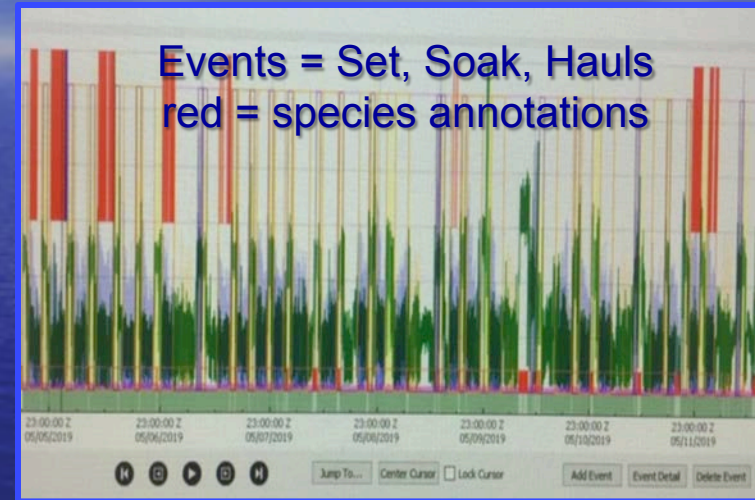
MOTE.ORG

What is Electronic Monitoring (EM)?

Integrated onboard system – video cameras, GPS, and sensors designed to provide permanent documentation of fishing operations, vessel movements, speed, and location.



Vessel tracks



A close-up photograph of a red snapper fish, showing its head, eye, and scales. The fish is reddish-orange with a white underbelly. The background is a dark blue, textured surface, likely water.

Why Is the Application of EM Important for Management of the GOM Snapper Grouper Fishery?

1. Limited resources (\$\$\$\$) for observer coverage.
~2% of the vessels covered by observers /yr.
2. Limited reporting of bycatch and discards by fishers.

NMFS Management Goal

(Electronic Monitoring & Reporting SE Region Implementation Plan, Feb. 26, 2016).

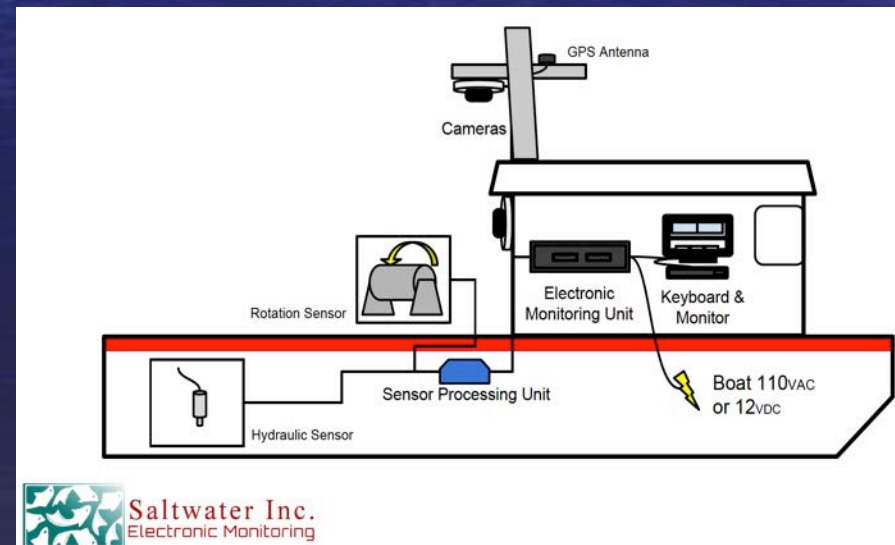
- ★ Implement Electronic Methods to Improve Data Collection, Accuracy and Timeliness.

CFEMM Objectives

- Advance EM as a fishery-dependent data collection tool to provide industry and management with permanent documentation:
 - catch and bycatch
 - interactions with protected species
- ★ Fishers request – “document increasing incidental shark bycatch and gear and targeted catch depredation.”
- Increase regional capacity-building for EM – industry, management, and science partnerships.
- Link EM trip data with corresponding observer, dealer, and/or dockside biological sampling records.



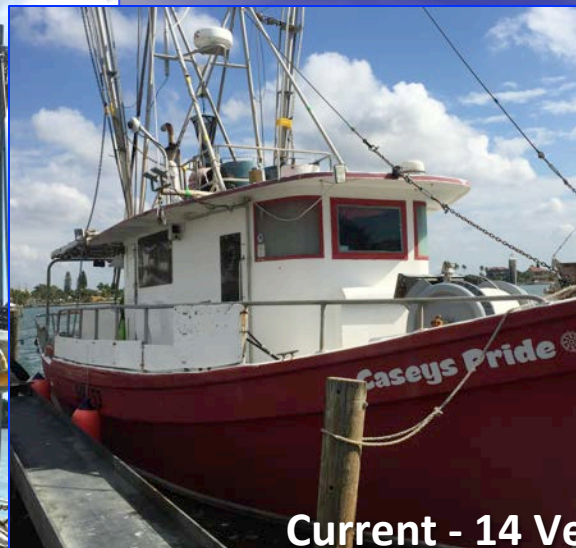
Fishery-
Dependent
Monitoring
Complement



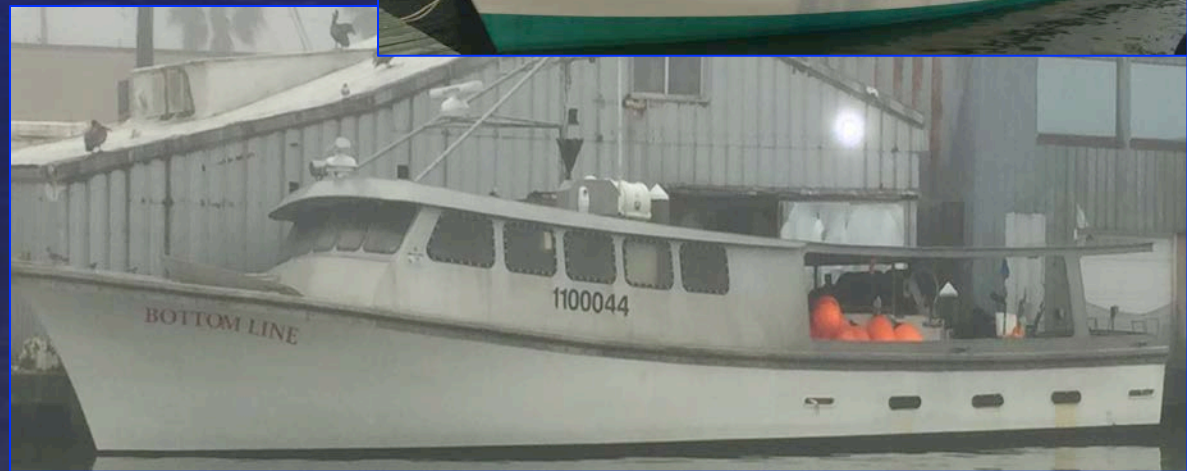
MML Gulf of Mexico EM Projects

- Ocean Conservancy - National Fish & Wildlife Foundation (NFWF – Innovation Fund)
 - NFWF Innovation Fund
 - ★Environmental Defense Fund
 - NOAA/NMFS
 - Cooperative Research Project (**current**) – Eastern GOM
 - Bycatch Reduction Engineering Project (**current**) – Eastern GOM
 - NFWF EM Gulf-Wide (**current**) - FL,TX
- ★NMFS – proprietary to non-proprietary “open source software”
Archipelago Marine Research (AMR) → Saltwater Inc. (SI)





Current - 14 Vessels
Bottom Longline and Vertical Line
Bradenton, FL
Madeira Beach, FL
Redington Beach, FL
Galveston, TX





Electronic Monitoring Unit



No Audio



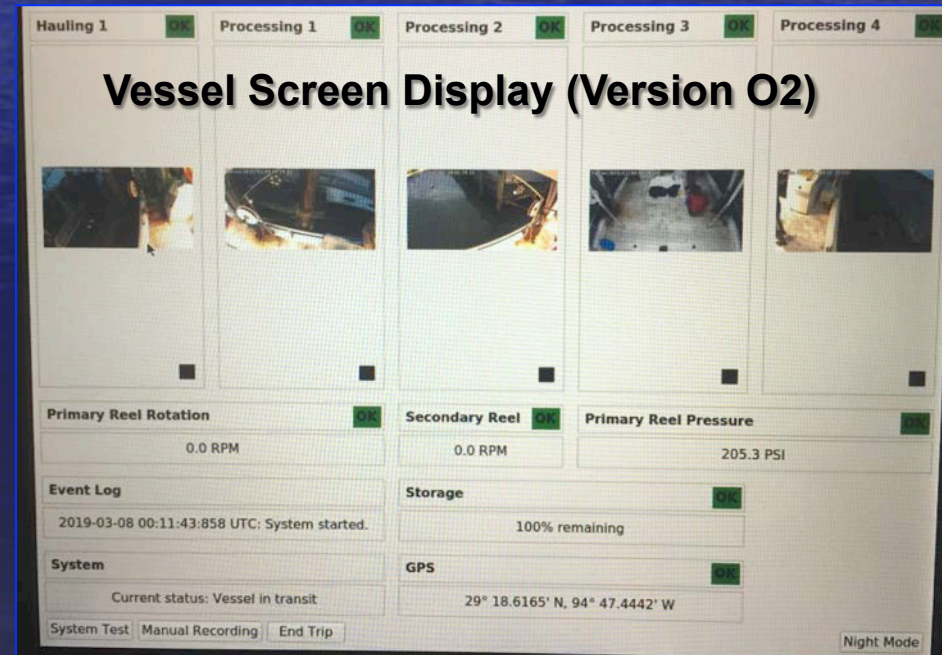
Electronic Monitoring Unit Processor and Monitor

Saltwater Inc. (SI) Unit Components

- Processor (Linux™ software)
- 2 encrypted 1tb hard drives
- GPS
- 3-5 IP cameras (3.6mm) w/LED's (can use up to 8) – activated during events
- hydraulic sensor
- rotation sensor(s)
- monitor
- waterproof keyboard w/mouse



Camera Placement

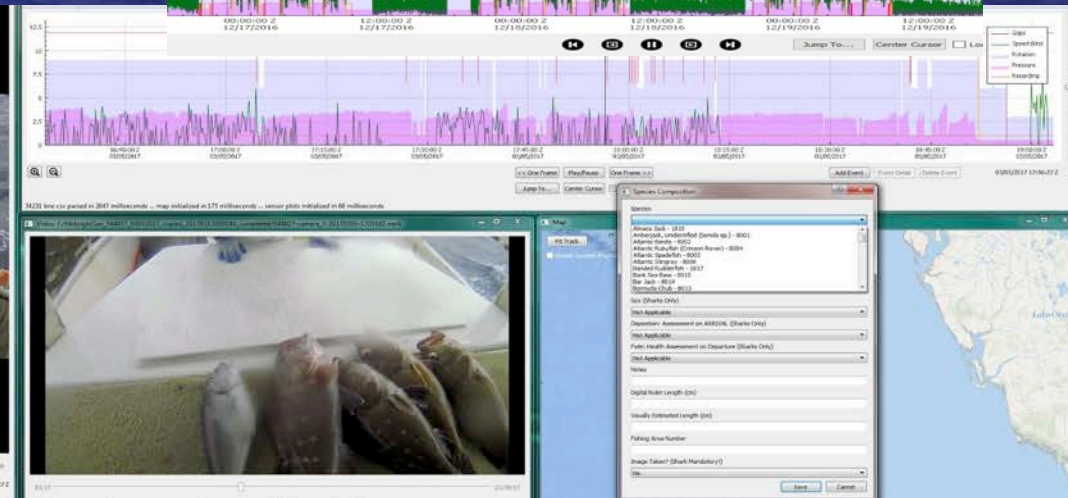
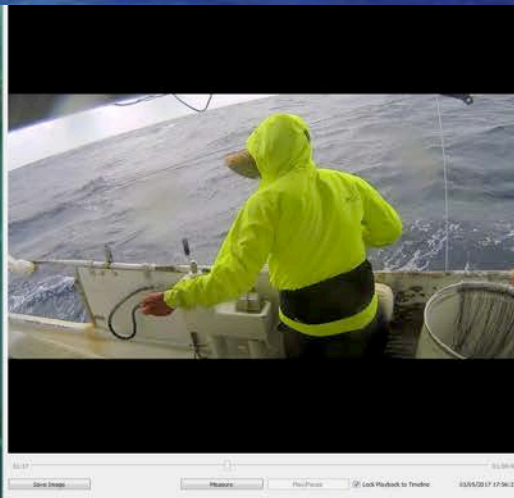
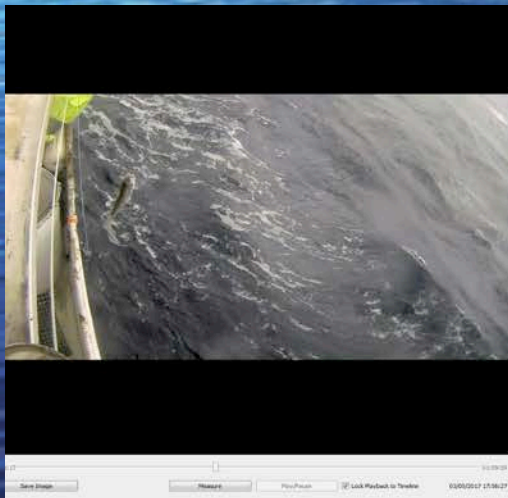
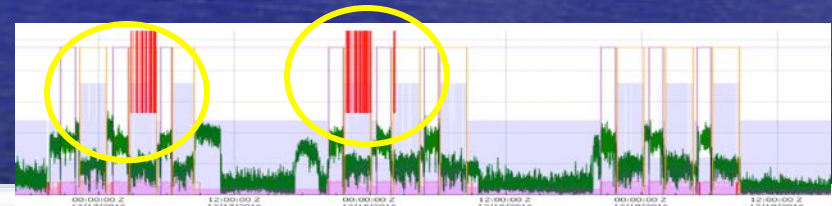


CFEMM In-House Components

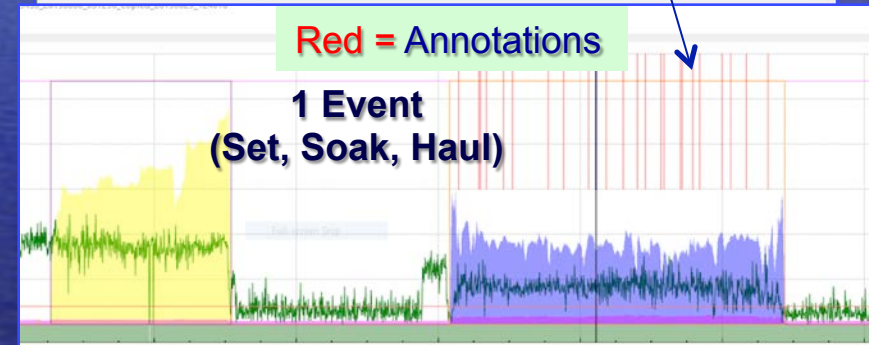
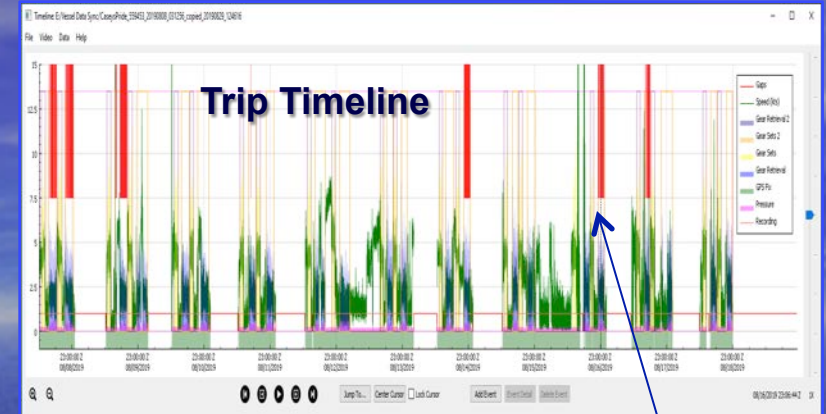
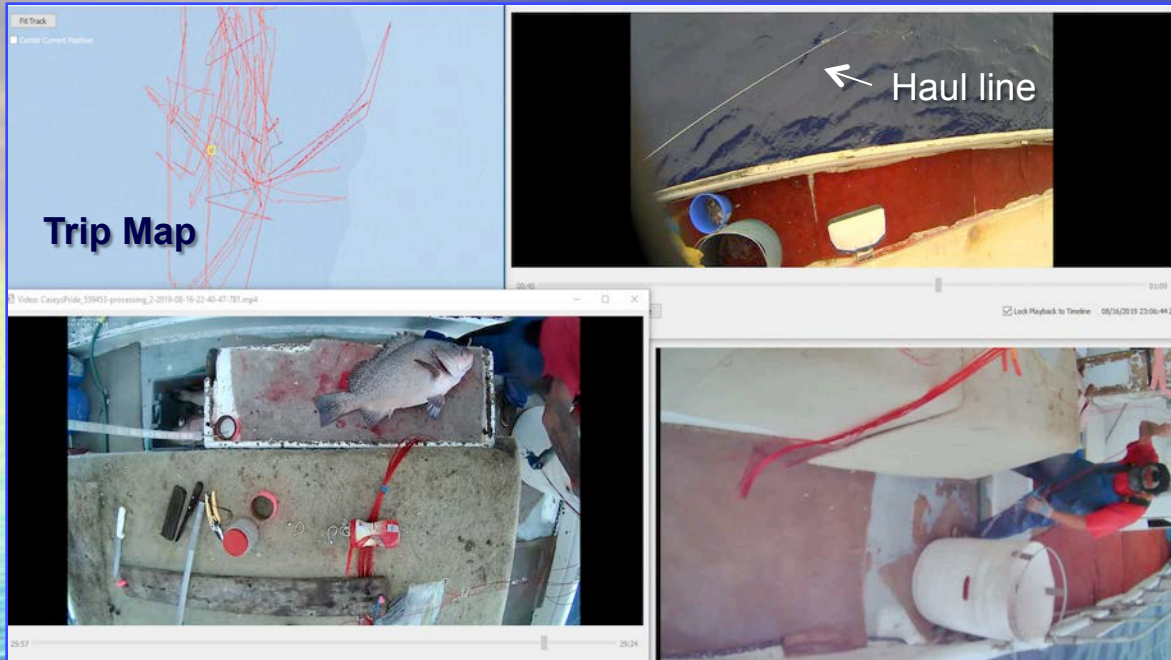
- Track:
 - vessel status
 - hard drive processing (includes person hrs for each task)
- Pre-process hard drives for review – Linux™ to Windows™
- Review video imagery and annotate species
- ★ Review 25% complete events (set, soak, haul)/trip random number generated
- Video & data storage – dedicated EM server, Network Attached Storage (NAS)
- Quality control – series of time point checks
- Data processing and aggregation – use of “R” statistical software
- Data analysis – Waterinterface LLC. & CFEMM



Events



Trip Review



Species Composition

Species: Yellowedge Grouper

Handling: Brought on Board (Retained/Discarded)

Condition on Arrival: Live - Stomach and/or Eyes Protruding

Fate: Retained

Sex (Sharks Only): Not Applicable

Notes:

Digital Ruler Length (cm):

Shark Length Estimate (Shark Mandatory!):

Shark Q/A Required?: No

Save Cancel

Trip

Gear Set

Gear Retrieval

Species Composition

Open Comment

Species Annotations

	Time	Latitude	Longitude	Species	Handling	Condition on Arrival	Fate	Sex (Sharks Only)	Notes	Digital Ruler Length (cm)	Shark Length Estimate (Shark Mandatory!)	Shark Q/A Required?
197	2019-08-16T22:52:55Z	25 36.985 N	84 11.353 W	Yellowedge Grouper	Brought on Board (Retain...	Dead on Arrival - Damag...	Discarded - Dead	Not Applicable				No
198	2019-08-16T23:03:32Z	25 37.307 N	84 11.203 W	Yellowedge Grouper	Brought on Board (Retain...	Live - Stomach and/or E...	Retained	Not Applicable				No
199	2019-08-16T23:06:43Z	25 37.406 N	84 11.161 W	Speckled Hind	Brought on Board (Retain...	Live - Healthy	Retained	Not Applicable				No
200	2019-08-16T23:11:02Z	25 37.545 N	84 11.094 W	Bluefin Tilefish	Brought on Board (Retain...	Live - Healthy	Retained	Not Applicable				No
201	2019-08-16T23:18:10Z	25 37.781 N	84 10.993 W	Yellowedge Grouper	Brought on Board (Retain...	Live - Stomach and/or E...	Retained	Not Applicable				No
202	2019-08-16T23:24:05Z	25 37.976 N	84 10.916 W	Yellowedge Grouper	Brought on Board (Retain...	Live - Stomach and/or E...	Retained	Not Applicable				No
203	2019-08-16T23:27:20Z	25 38.087 N	84 10.803 W	Yellowedge Grouper	Brought on Board (Retain...	Live - Stomach and/or E...	Retained	Not Applicable				No
204	2019-08-16T23:34:04Z	25 38.310 N	84 10.784 W	Moray Eel, Unidentified	Brought on Board (Retain...	Live - Healthy	Retained as Bait	Not Applicable				No
205	2019-08-16T23:35:20Z	25 38.353 N	84 10.768 W	Speckled Hind	Brought on Board (Retain...	Live - Healthy	Retained	Not Applicable				No
206	2019-08-16T23:42:22Z	25 38.578 N	84 10.692 W	Yellowedge Grouper	Brought on Board (Retain...	Live - Stomach and/or E...	Retained	Not Applicable				No

Application of EM – Document Shark Bycatch

Reported by Fishers

↑ Increasing incidental shark interactions =
depredation of targeted catch and gear

Document – species, location, size, sex, capture and release disposition, targeted catch and gear damage



Atlantic Sharpnose



Big Eye Thresher



Tiger Shark (juvenile)



Night Shark



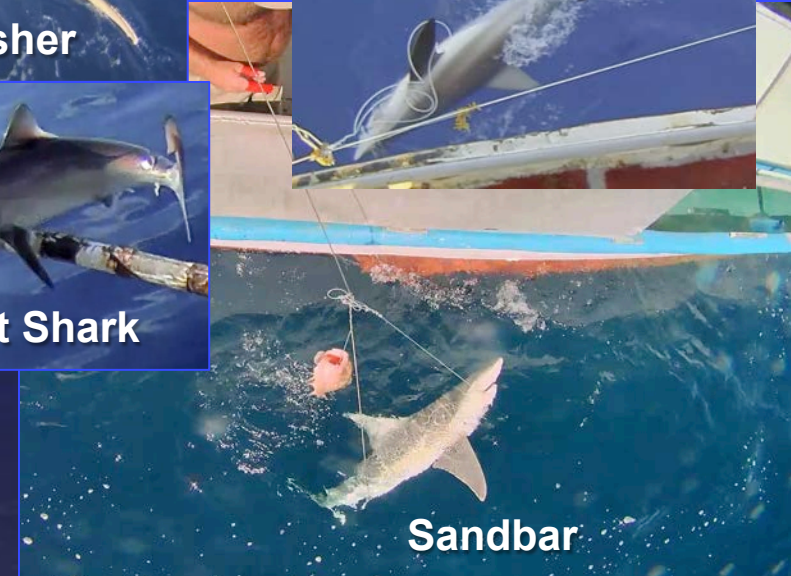
Dusky



Great White



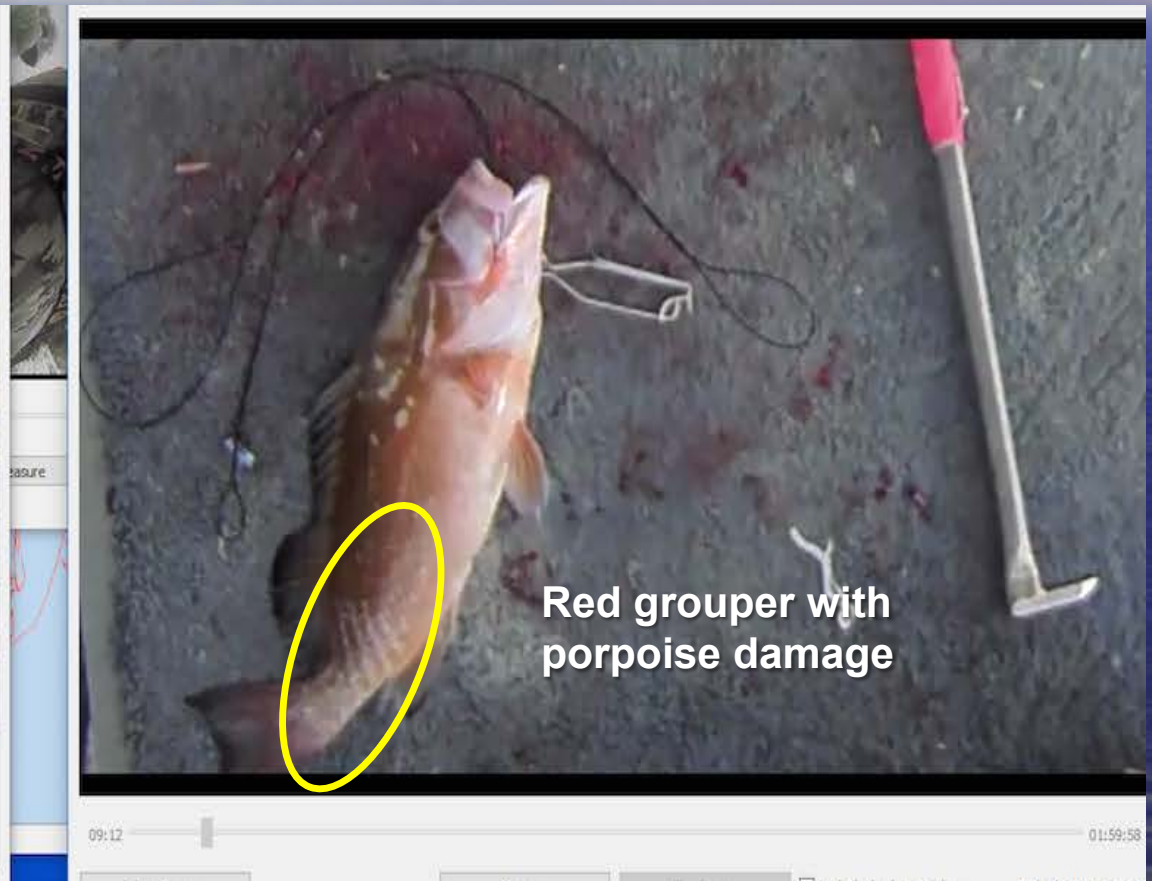
Scalloped Hammerhead



Sandbar

Application of EM – Document Incidental Marine Mammal Encounters

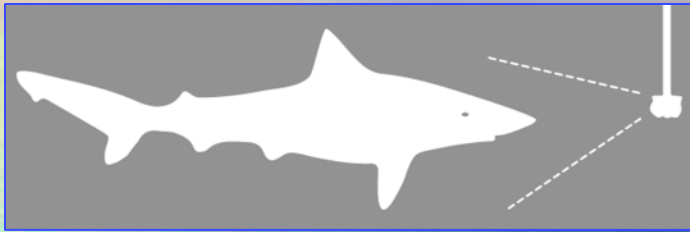
Note: 09/12/2016 - 06/06/2019 = 4 loggerhead sea turtles (1-2016, 2-2017, 1-2018) in >38,000 events. 6 sea birds. 0 other marine mammals.



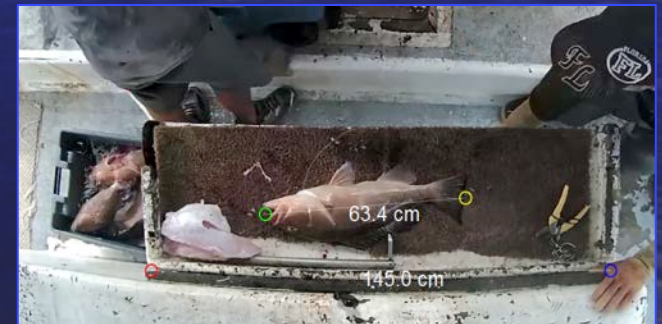
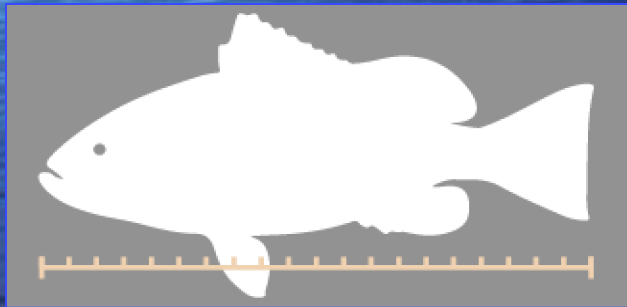
Pilot Studies

Improving Technology Integration and Data Collection

1. **Underwater Camera Systems (UCAM's)** - integrate into onboard SI EM Systems – document cut-offs of large sharks.



2. **SI “Digital Ruler”** - application in SI EM reviewer software – remotely “measure” fish, enhance EM data with accurate catch measurements. Evaluate w/NMFS observer and FWC TIP data.

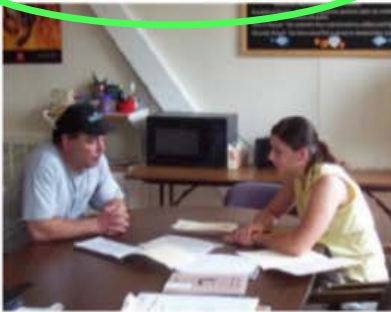


Commercial Fisheries Data Collection

On-Board
Observers

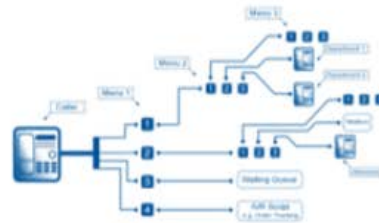


Dealer Reports;
Dockside Sampling



VTR
(logbook)

Vessel Trip Report
IVR



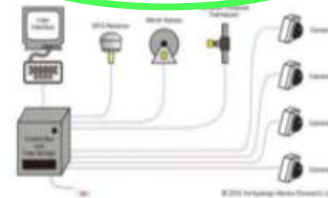
Interactive Voice Report

VMS



Vessel Monitoring System

On-Board
Electronic Monitoring



Documenting Linkages for Data Integration

Correlate project EM data with identifiers to other fishery data:

- Observer
- Dealer
- TIP [dockside sampling] for management to augment currently available datasets.

EM Trip Workflow No. / Dockside Sampling (TIP) Identification No. / Dealer Reference No. / Observer Trip Reference No.
Includes trip start and end dates recorded for each.

Presentation Data

6 BLL Vessels – WFS

- Sept. 2016 – May 2019 = ~ 636 sea days
- ~ 537 annotated set-haul events (~2,148 hauls total)
- ~ 30,416 individuals = 152 species
- ~ sharks 4.22% of total catch, caught in 100% of trips, in 54% of set haul events

Total Effort (Hook-Hrs)	84,762,075.89
Total Individual Fish CPUE x 1000	11,530.57
Mean Retained : Discard Ratio (1:0)	0.583363472
Total Soak Time (Decimal Hrs)	113,016.10
Fish Retained : Discard (N:%)	17743 : 12674 / 58.34 : 41.66
Mean Catch Landed Per Set Haul Event	18.03

Most Frequently Annotated Species - West Florida Shelf (WFS)

Bottom Longline (BLL) vessels (09/2016 through 05/2019)

(→ sharks)

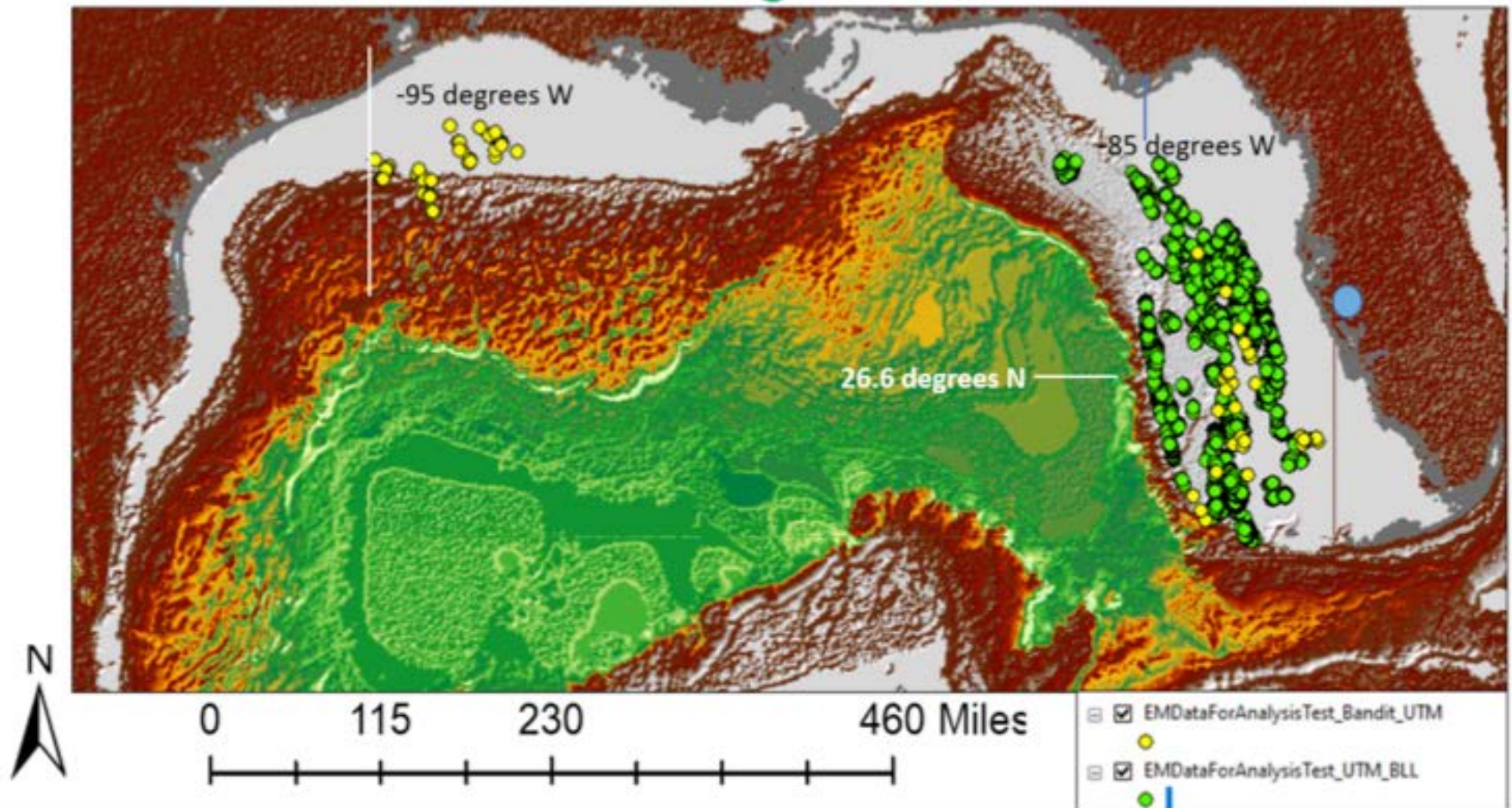
Common Name	Total Catch	Rel.Freq.	Rel.Freq. (%)	Cum.Freq.	Cum.Rel.Freq.
Red Grouper	19099	0.6281	62.81	23123	0.7604
Red Snapper	3377	0.1111	11.11	26646	0.8763
Yellowedge Grouper	1366	0.0449	4.49	30387	0.9993
Scamp	579	0.019	1.9	27500	0.9043
Gag Grouper	478	0.0157	1.57	2164	0.0712
Blueline Tilefish	470	0.0155	1.55	994	0.0327
Mutton Snapper	382	0.0126	1.26	3841	0.1263
Jolthead Porgy	340	0.0112	1.12	2937	0.0966
→ Sharpnose Shark	323	0.0106	1.06	27883	0.9169
Snowy Grouper	317	0.0104	1.04	28351	0.9323
→ Dogfish, Spiny (Cuban)	271	0.0089	0.89	1465	0.0482
Tilefish, Golden/Great Northern	201	0.0066	0.66	28797	0.947
Eel, Unidentified	179	0.0059	0.59	1673	0.055
→ Blacknose Shark	177	0.0058	0.58	524	0.0172
Moray Eel, Unidentified	177	0.0058	0.58	3459	0.1137
Red Porgy	146	0.0048	0.48	23269	0.7652
Gray Triggerfish	138	0.0045	0.45	2436	0.0801
Remora (all)	137	0.0045	0.45	26783	0.8808
Gray (Mangrove) Snapper	131	0.0043	0.43	2298	0.0756
Lane Snapper	128	0.0042	0.42	3098	0.1019

Example of EM Documented Fishing Locations

● Mote Marine Laboratory

● Vertical Line Fishing Locations to Date

● Bottom Longline Fishing Locations to Date



**CFEMM
West FL Shelf and
Northwestern GOM
Datasets
09/2016 – 05/2019**

WFS

85.0 degrees W

26.6 degrees N

Recently Processed
VL Annotation Data

NW

-95 degrees W

26.6 degrees N

85.0 |

WFS

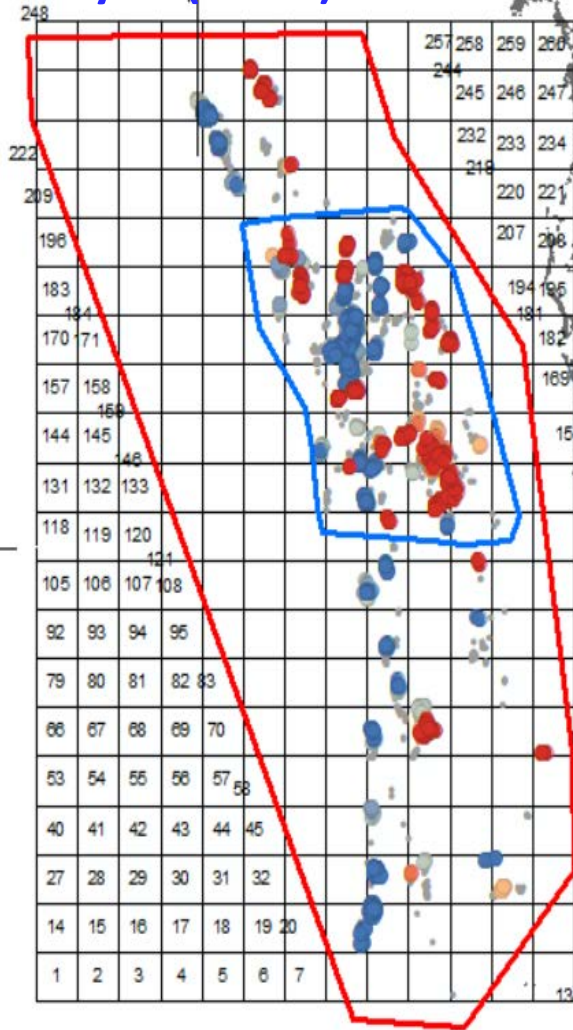
Area of
Intense
Fishing Effort =
19.68% of WFS
fishing area
produced 60.94%
of the WFS BLL catch

26.6

West Florida Shelf
BLL and VL Fishing Area

Optimized Hotspot Coldspot Analysis (CPUE)

26.6 degrees N

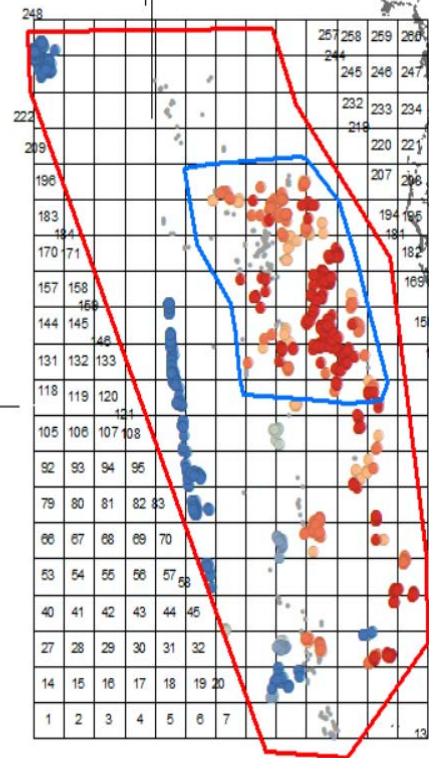


Red Snappers

RS_HS_CPUE_IND_1000

- Gi_Bin
- Cold Spot - 99% Confidence
- Cold Spot - 95% Confidence
- Cold Spot - 90% Confidence
- Not Significant
- Hot Spot - 90% Confidence
- Hot Spot - 95% Confidence
- Hot Spot - 99% Confidence

-85 degrees W



Sharks

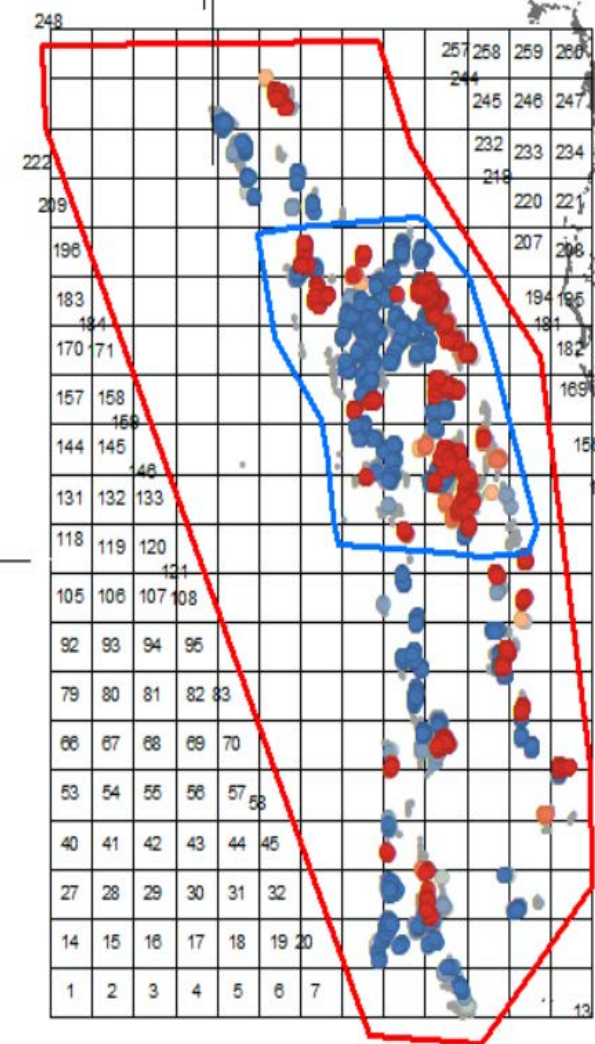
SHARK_HS_CPUE_IND_1000

- Gi_Bin
- Cold Spot - 99% Confidence
- Cold Spot - 95% Confidence
- Cold Spot - 90% Confidence
- Not Significant
- Hot Spot - 90% Confidence
- Hot Spot - 95% Confidence
- Hot Spot - 99% Confidence

RG_HS_CPUE_IND_1000

- Gi_Bin
- Cold Spot - 99% Confidence
- Cold Spot - 95% Confidence
- Cold Spot - 90% Confidence
- Not Significant
- Hot Spot - 90% Confidence
- Hot Spot - 95% Confidence
- Hot Spot - 99% Confidence

-85 degrees W



Red Groupers

Condition At-vessel Arrival All Fish	Frequency	Rel.Freq.	Rel.Freq. (%)	Cum.Freq.	Cum.Rel.Freq.
Dead on Arrival - Damaged	268	0.0088	0.88	268	0.0088
Dead on Arrival - Undamaged	754	0.0248	2.48	1022	0.0336
Live - Damaged	57	0.0019	0.19	1079	0.0355
Live - Healthy	16977	0.5583	55.83	18056	0.5938
Live - Stomach and/or Eyes Protruding	12176	0.4004	40.04	30232	0.9942
Unknown Condition	177	0.0058	0.58	30409	1
Condition At-vessel Arrival Sharks	Frequency	Rel.Freq.	Rel.Freq. (%)	Cum.Freq.	Cum.Rel.Freq.
Dead on Arrival - Damaged	2	0.0016	0.16	2	0.0016
Dead on Arrival - Undamaged	51	0.0397	3.97	53	0.0412
Live - Damaged	1	0.0008	0.08	54	0.042
Live - Healthy	1223	0.951	95.1	1277	0.993
Unknown Condition	9	0.007	0.7	1286	1

Arrival Condition and Final Disposition of All Fish and Specifically Sharks

At-Vessel Arrival Condition

Disposition All Fish	Frequency	Rel.Freq.	Rel.Freq. (%)	Cum.Freq.	Cum.Rel.Freq.
Discarded - Dead	747	0.0246	2.46	747	0.0246
Discarded - Live and Damaged (Not Vented)	102	0.0034	0.34	849	0.0279
Discarded - Live and Damaged (Vented)	90	0.003	0.3	939	0.0309
Discarded - Live and Healthy (Not Vented)	3777	0.1242	12.42	4716	0.1551
Discarded - Live and Healthy (Vented)	7792	0.2562	25.62	12508	0.4113
Discarded - Unknown	160	0.0053	0.53	12668	0.4166
Fish vented prior to release	1	0	0	12669	0.4166
Retained	16835	0.5536	55.36	29504	0.9702
Retained as Bait	767	0.0252	2.52	30271	0.9955
Unknown Fate	138	0.0045	0.45	30409	1
			0		
Disposition Sharks	Frequency	Rel.Freq.	Rel.Freq. (%)	Cum.Freq.	Cum.Rel.Freq.
Discarded - Dead	57	0.0443	4.43	57	0.0443
Discarded - Live and Damaged (Not Vented)	21	0.0163	1.63	78	0.0607
Discarded - Live and Healthy (Not Vented)	1186	0.9222	92.22	1264	0.9829
Discarded - Unknown	8	0.0062	0.62	1272	0.9891
Retained as Bait	2	0.0016	0.16	1274	0.9907
Unknown Fate	12	0.0093	0.93	1286	1

Final Disposition

Frequency Summary for Discarded and Retained Fish

(6 BLL vessels fishing the WFS, September 2016 - May 2019)

Species (Common Name)	Discarded (n / %)	Retained (n / %)	Total (n / %)	Percent of Total Catch (%)
**Red Grouper	9682 37.85%	9417 36.81%	19099 74.66%	62.79
**Red Snapper	867 3.39%	2510 9.81%	3377 13.20%	11.1
**Blueline Tilefish	93 0.36%	377 1.47%	470 1.84%	1.55
**Scamp	24 0.09%	555 2.17%	579 2.26%	1.9
**Golden Tilefish	24 0.09%	177 0.69%	201 0.79%	0.66
**Yellowedge Grouper	16 0.06%	1350 5.28%	1366 5.34%	4.49
**Gag Grouper	13 0.05%	465 1.82%	478 1.87%	1.57
**Sand Tilefish	2 0.01%	11 0.04%	13 0.05%	1.57
Column Total	10721 41.91%	14862 58.09%	25583 100.00%	84.10%

**These fish comprise 84.10 % of total catch

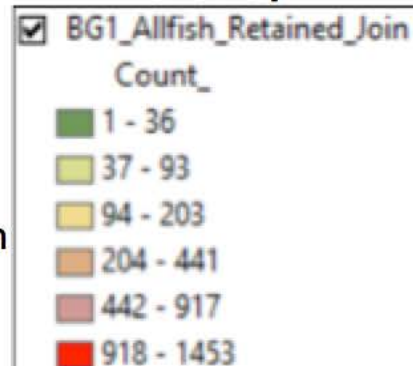
*Percent of these 8 species

Geographic Frequency Locations of Retained Fish, **All Species**, for BLL, WFS, 6 Vessels, Summarized in 15 min X 15 min Grids

**Intensively
fished area**

“Count” is the number
of grids with retained fish;
“Mean” is the mean number
of retained fish per grid
(N=104). Grid cells = Histogram
bins.

Grid Key



Statistics of BG1_Allfish_Retained_Join

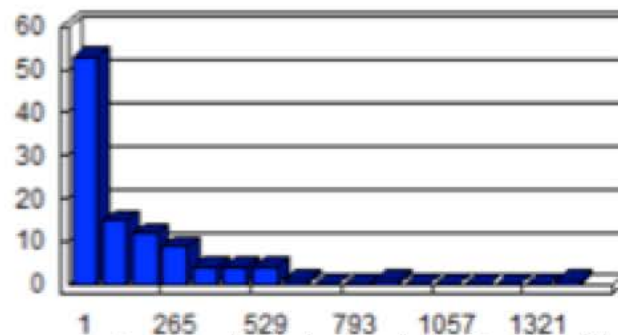
Field

Count_

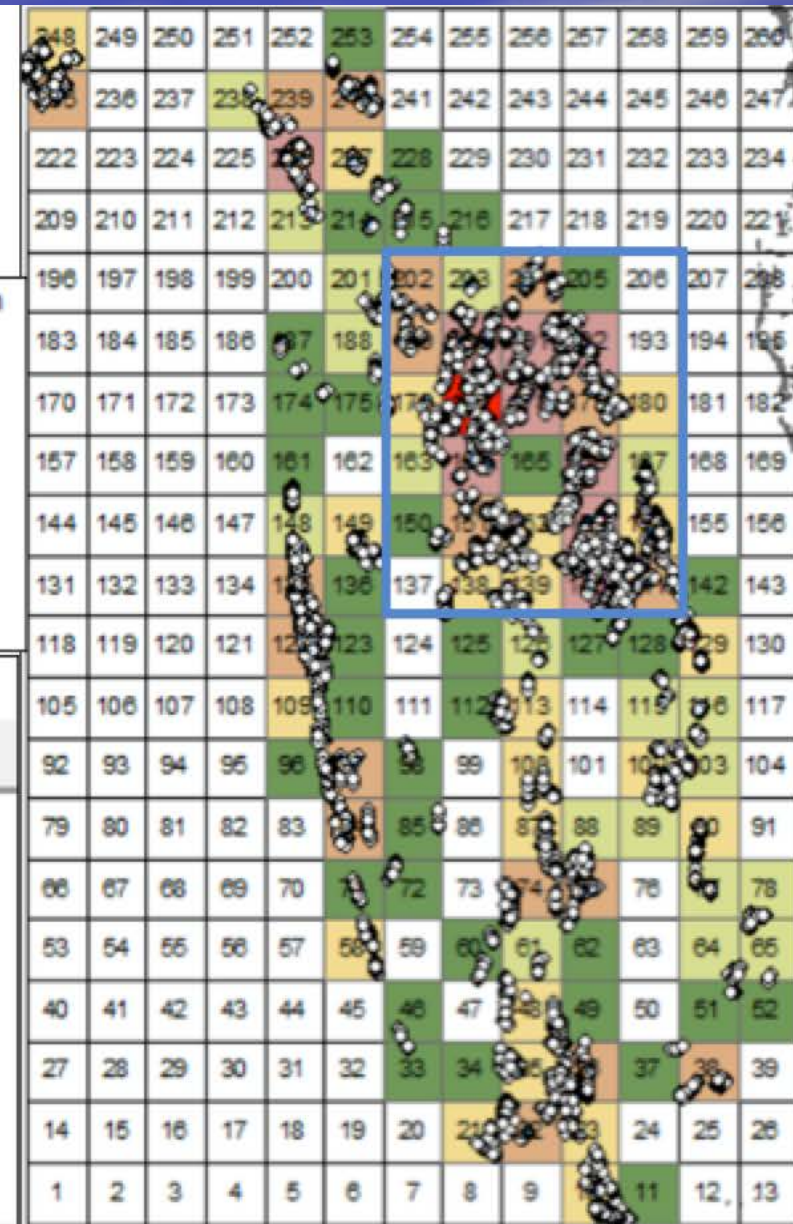
Statistics:

Count: 104
Minimum: 1
Maximum: 1453
Sum: 17740
Mean: 170.576923
Standard Deviation: 216.536047
Nulls: 156

Frequency Distribution



Retained Fish in 15 min X 15 min Grid

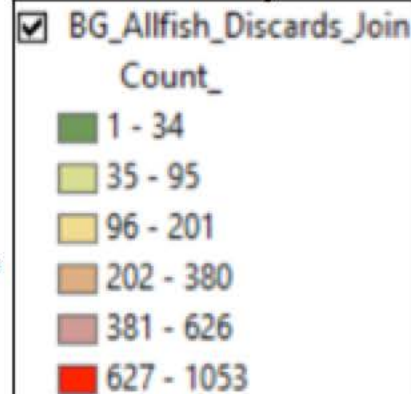


Geographic Frequency Locations of Discarded Fish, All Species, for BLL, WFS, 6 Vessels, Summarized in 15 min X 15 min Grids

Intensively fished area

"Count" is the number of grids with discarded fish; "Mean" is the mean number of discarded fish per grid (N=100). Grid cells = Histogram bins.

Grid Key



Selection Statistics of BG_Allfish_Discards_Join

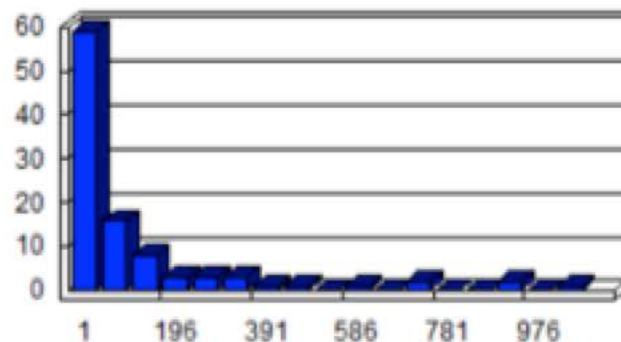
Field

Count_

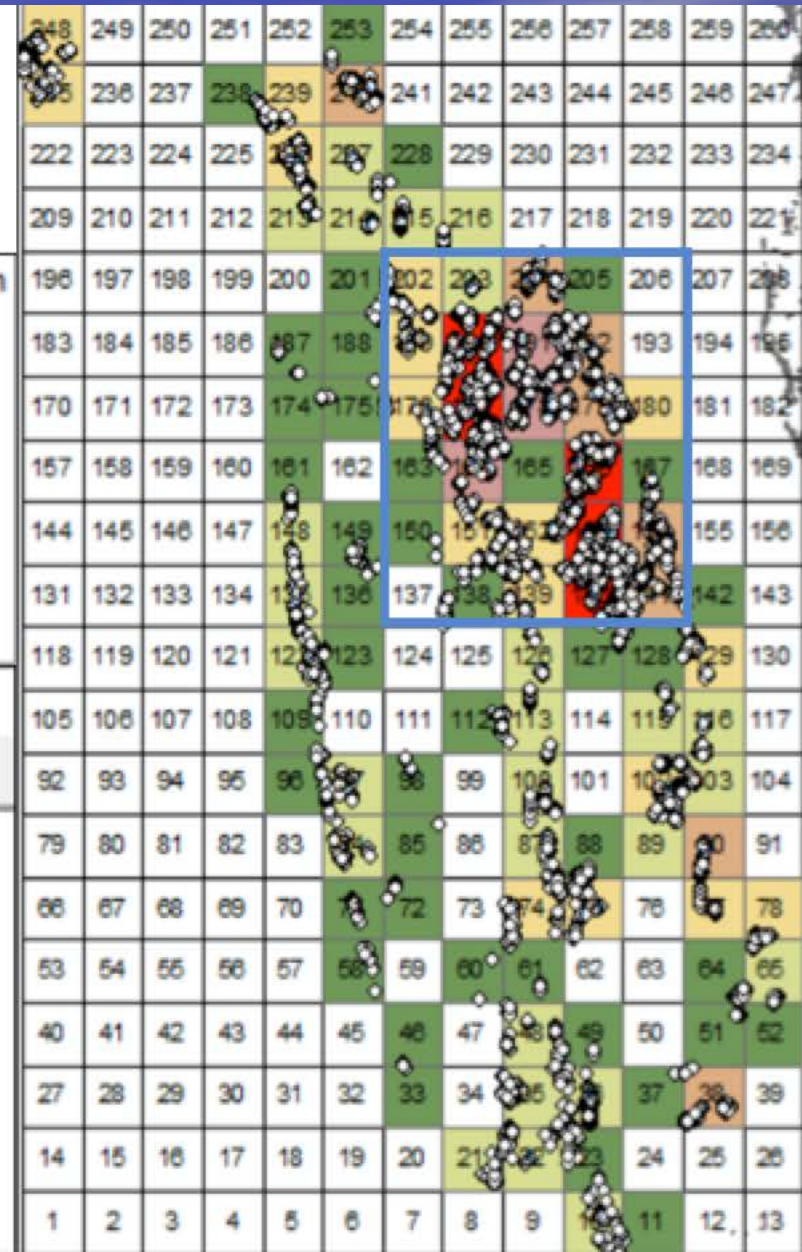
Statistics:

Count: 100
Minimum: 1
Maximum: 1053
Sum: 12668
Mean: 126.68
Standard Deviation: 206.615192
Nulls: 0

Frequency Distribution



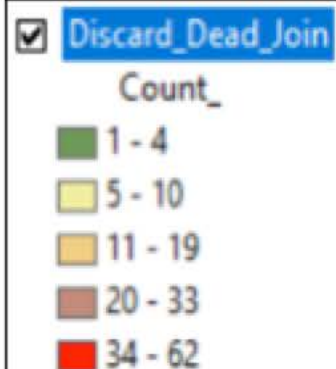
Discarded Fish in 15 min X 15 min Grid



Geographic Location Count for Discarded Dead, **All Species**, for BLL, WFS, 6 Vessels, Summarized in 15 min X 15 min Grids

**Intensively
fished area**

“Count” is the number of grids
with discarded dead fish;
“Mean” is the mean number
of discarded dead fish per grid
(N=80). Grid cells = Histogram
bins.



Statistics of BG1_DEAD

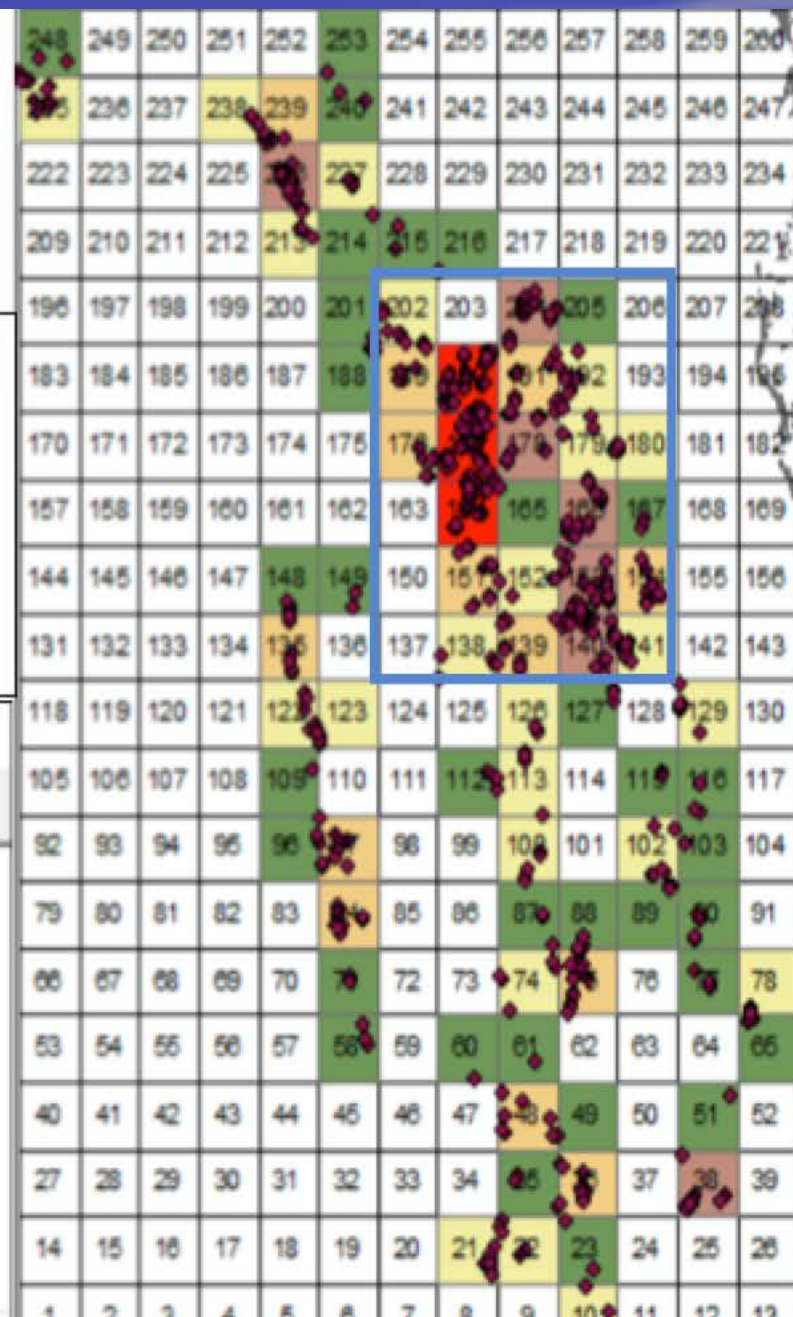
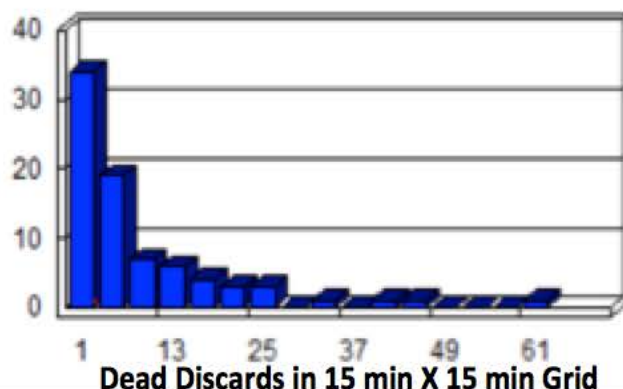
Field

Count_

Statistics:

Count: 80
Minimum: 1
Maximum: 62
Sum: 749
Mean: 9.3625
Standard Deviation: 10.860759
Nulls: 180

Frequency Distribution



Mote Marine Lab - GOM Reef Fish EM Logbook-Longline				Date: mm/dd/yr
Vessel:	Trip Start Date (mm/dd):			Discard Condition Codes: 1. All discards dead 2. The majority were dead 3. All discards alive 4. Majority of discards alive 5. Kept but not sold (eaten/bait) 6. Unable to determine Discard Reason Codes: A - Regulations B - Market conditions.
Skipper:	Trip End Date (mm/dd):			
Vessel No.:	Set:	Haul:	Set Start Time:	
Operator No.:	Start Lat:	Start Lat:	Set End Time:	
No. of Crew:	Start Long:	Start Long:	Haul Start Time:	
Phone No.:	End Lat:	End Lat:	Haul End Time:	
Line Length:	End Long:	End Long:	Event No.:	Signature:
Area:				

Species		Retained Catch		Discarded Catch				Sub-legal (Y/N)
		Number	Est. Total Weight (lbs)	Number	Est. Total Weight (lbs)	Condition	Reason	
S N A P P E R	Vermillion							
	Red							
	Gray (Mangrove)							
	Mutton							
	Yellowtail							
G R O U P P E R S	Lane							
	Yellowfin							
	Red							
	Gag							
	Black							
	Yellowmouth							
	Scamp							
	Rock Hind							
	Red Hind							
	Misty							
	Snowy							
	Yellowedge							
	Warsaw							
	Speckled Hind							
Jolthead Porgy								
Red Porgy								
Grun (Margate)								
Greater Amberjack								
Tilefish								
Triggerfish								
Cobia (Lemonfish)								
S H A R K S	Dusky							
	Tiger							
	Blacktip							
	Atlantic Sharpnose							
	Lemon							
	Sandtiger							
	Great Hammerhead							
	Scalloped Hammerhead							
S	Sandbar							
	Smoothhound Dogfish							
OTHER:								
OTHER:								
OTHER:								
Comments:								
Date Received: Entered By:								

Vessel Data Log Forms

Results (2016 - 2019):

Vessels – 3 reporting WFS

Hauls – 1,758

Caught – 55,287 individuals

Species - Finfish =54, Sharks =6

Retained – 33,990 (61.4%)

Discarded – 21,297 (38.5%)

92% Finfish Discards listed as sublegal

<1% Discards recorded as mortalities

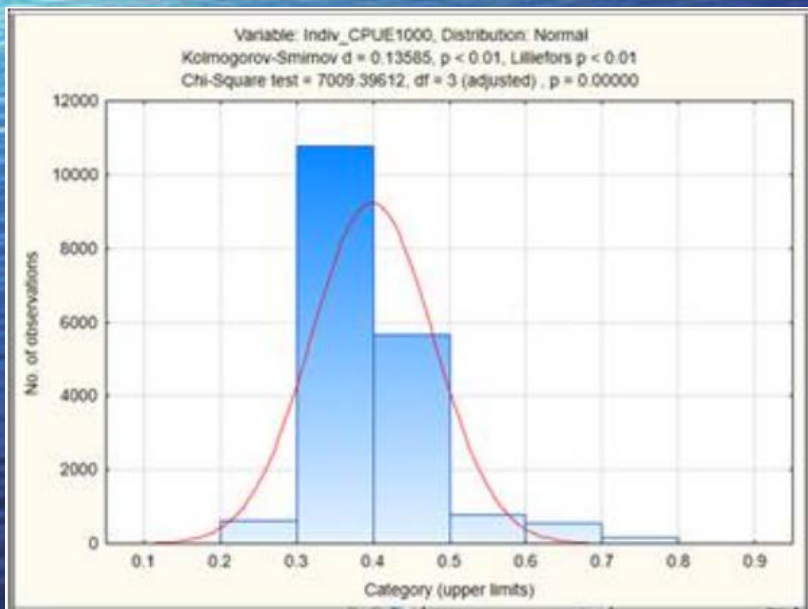
In Progress - EM Data Modeling

Objective: Understand and model the EM aspects of the fishery

- fitting Generalized Additive Models (GAMs) and Generalized Linear Models (GLMs) with appropriate distribution functions, link functions, and smoothing parameters.

Note in this study –

- response variables (discards & morbidity counts [binomial distributions], & CPUE [non-normal continuous distributions]) are heteroscedastic and non-independent.
- explanatory variables (e.g. time, moon phase name, sediment type...) are unbalanced.



A typical non-normal CPUE distribution

It Takes a Fleet – Science, Industry and Management for a Sustainable Gulf Snapper Grouper Fishery - Thank You

- ✧ NOAA-NMFS
- ✧ National Fish and Wildlife Foundation
- ✧ Environmental Defense Fund
- ✧ Ocean Conservancy
- ✧ MML Center for Shark Research
- ✧ Florida Fish and Wildlife Research Institute
- ✧ Waterinterface LLC.
- ✧ Saltwater Inc.
- ✧ Gulf States Marine Fisheries Commission
- ✧ Gulf of Mexico Fisheries Management Council

Special Thank You – *NMFS scientific advisors Elizabeth Scott-Denton, Ph.D. and Jessica Stephen, Ph.D.*

- ✧ Vessel Owners, Captains, and Crew
- ✧ GOM Reef Fish Shareholders' Alliance
- ✧ Wild Seafood
- ✧ Save-On Seafood
- ✧ Snug Harbor Boatworks
- ✧ Fishbusterz Seafood
- ✧ Get Reel Fisheries, LLC.
- ✧ Blenker Boatworks and Marina
- ✧ Cortez Ice
- ✧ Hubbard's Marina
- ✧ Katie's Seafood
- ✧ Sub-Aqua Imaging
- ✧ SeaSucker LLC.
- ✧ Randy Baker Hydraulics
- ✧ Lewis Woods Welding
- ✧ Roland Car Enterprises



Invaluable Fisheries EM Team

Questions ?

