Spatial Analyses of Commercial and Recreational Catch (2019) Compared to Biomass Derived from the “Great Red Snapper Count”

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Objectives

1) assign recreational catch and effort in space

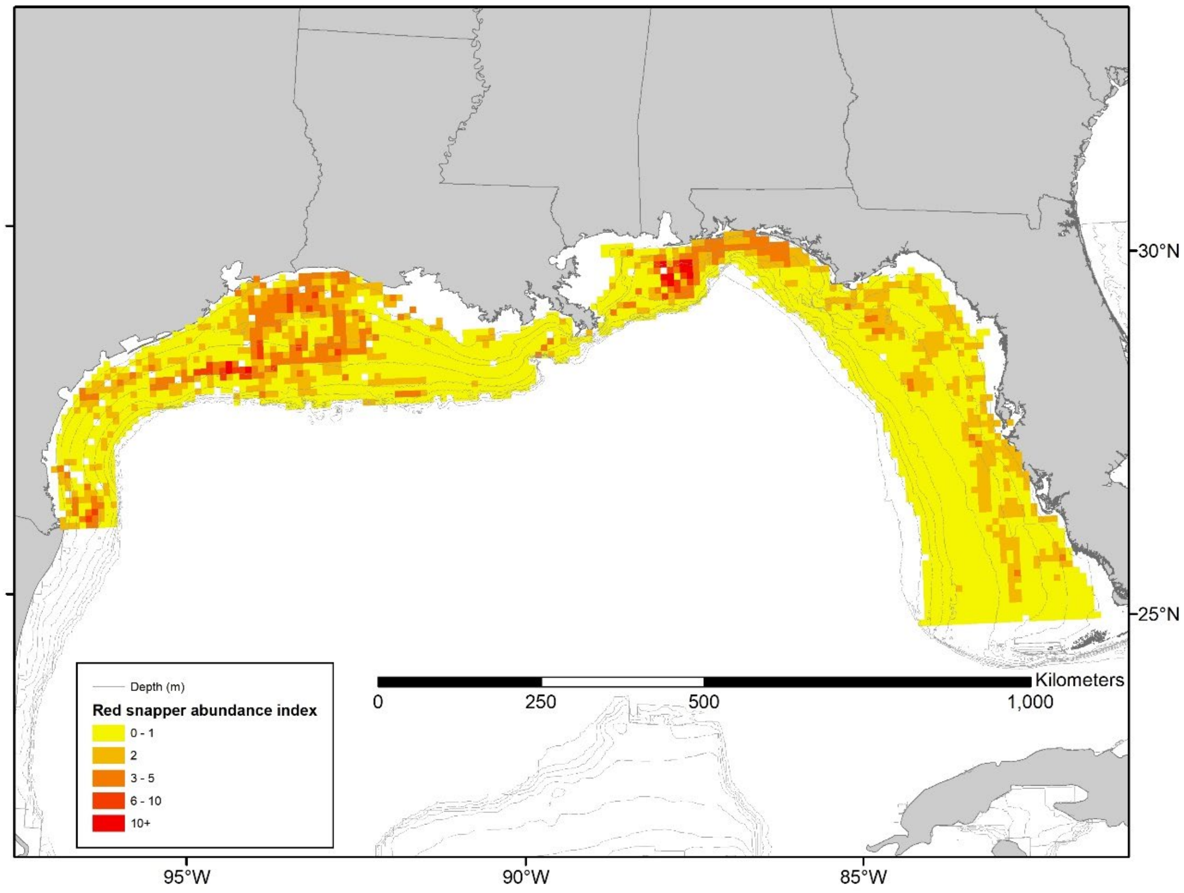
1) sum commercial and recreational landings spatially

1) overlay extractions with estimates of biomass from the “Great Red Snapper Count” (GRSC)

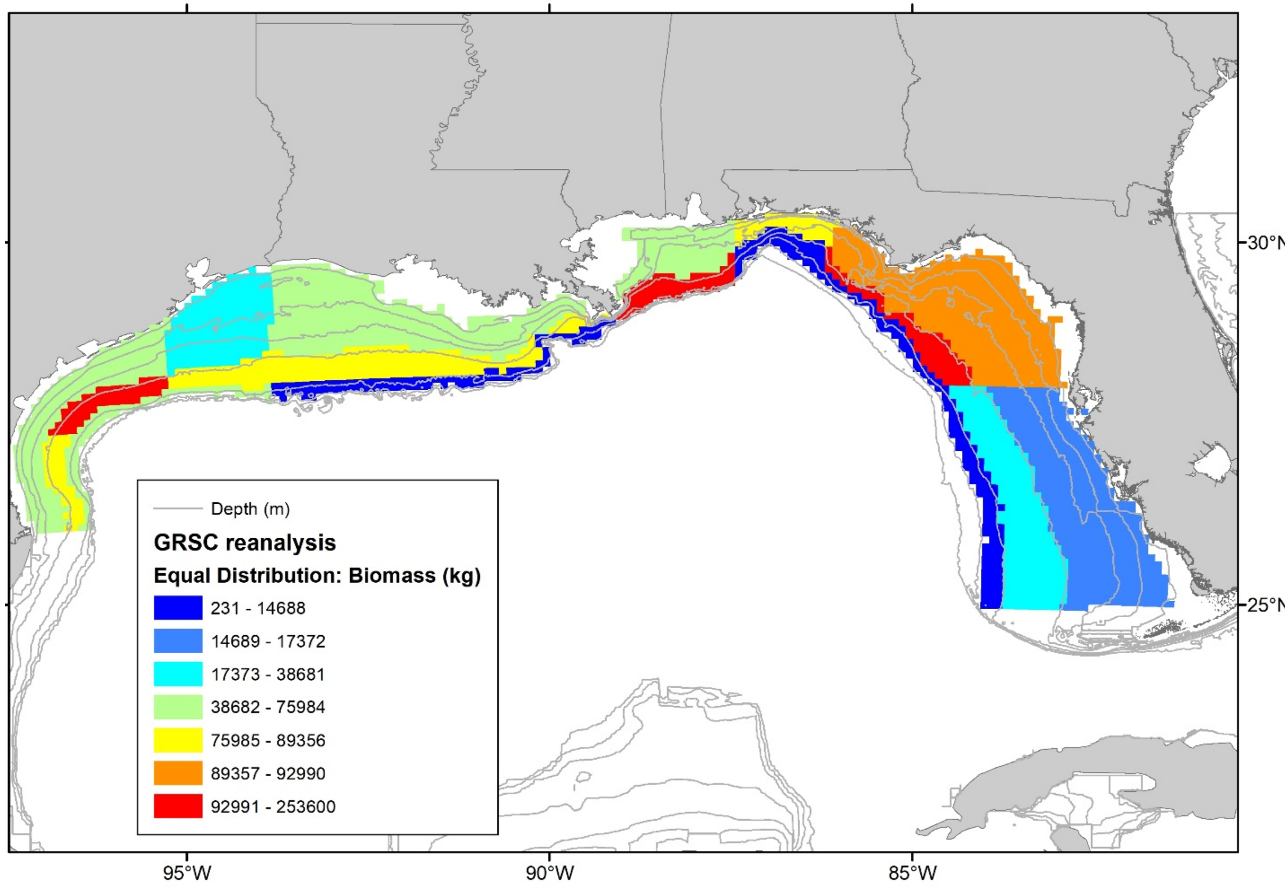
1) calculate exploitation (catch/abundance) rates from three scenarios of fishery yield.

1) Assuming the recent spatial footprint of fishing, identify if it supports the assumptions about fishable biomass:
   all structure, all structure + 10 or +15% UCB

Karnauskas et al spatial mapping

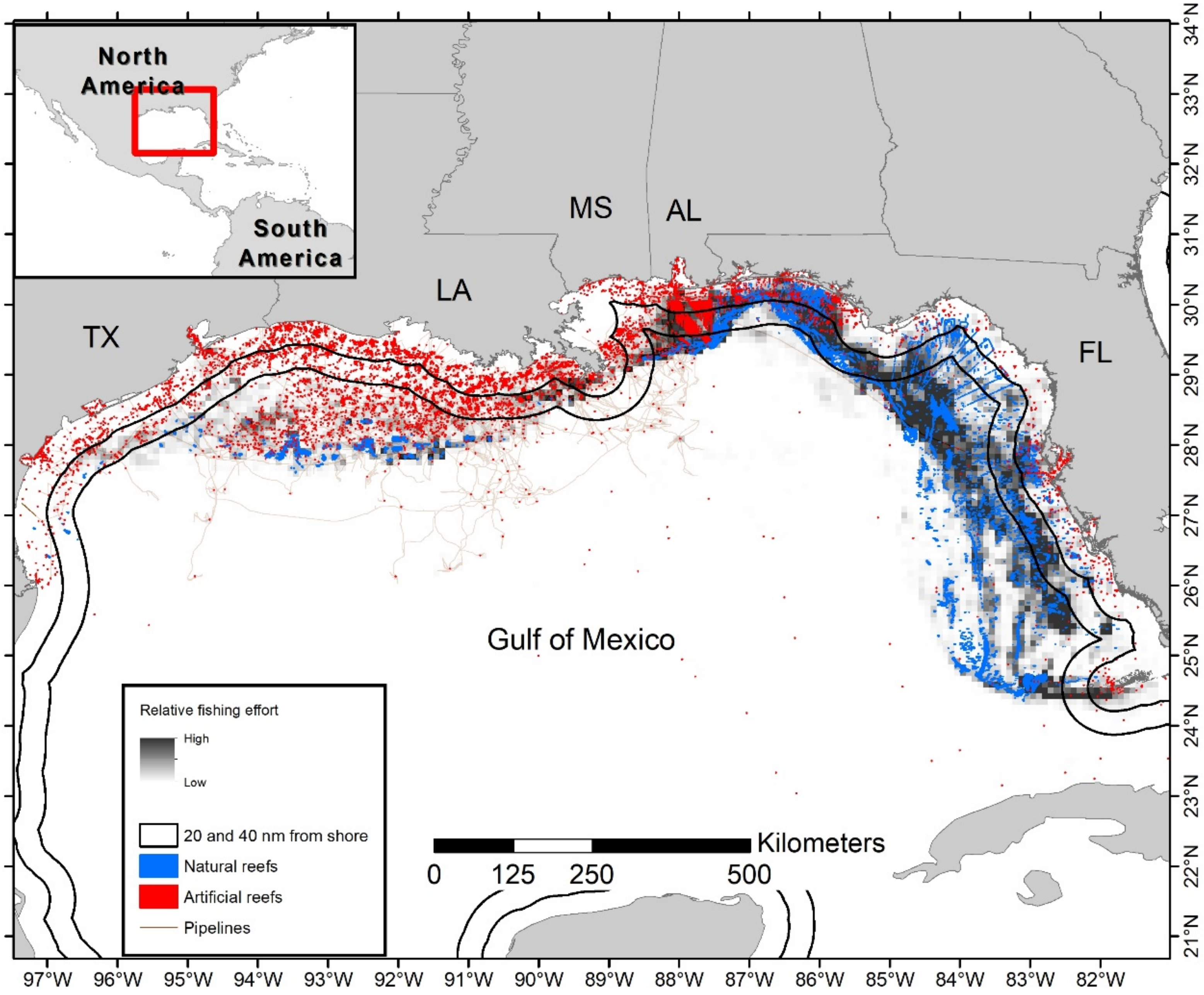


GRSC spatial mapping

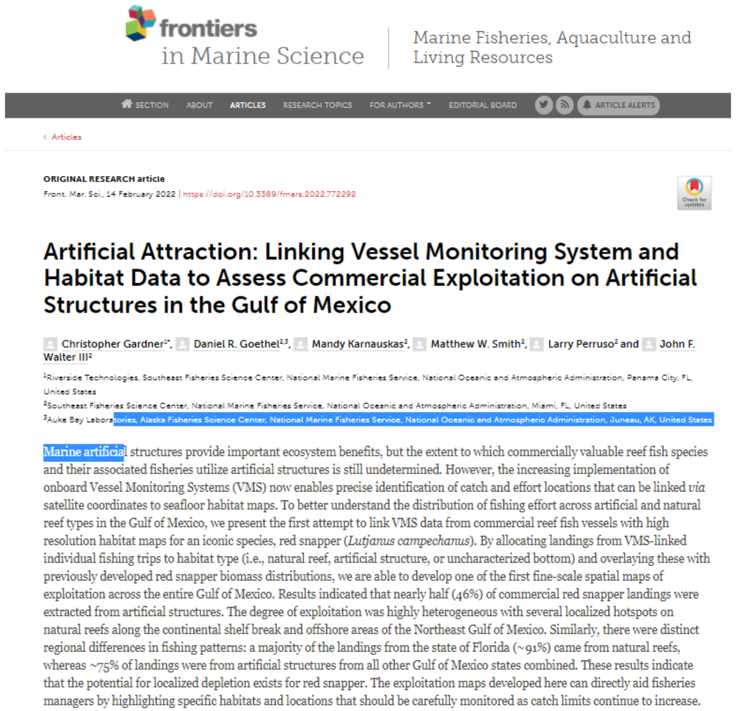


Mandy Karnauskas, John F. Walter III, Matthew D. Campbell, Adam G. Pollack, J. Marcus Drymon & Sean Powers (2017) Red Snapper Distribution on Natural Habitats and Artificial Structures in the Northern Gulf of Mexico, Marine and Coastal Fisheries, 9:1, 50-67.

Estimating commercial reef fish (vertical line) effort



- Vessel Monitoring System (VMS)
  - Algorithms outlined in O'Farrell et al. to predict fishing and steaming.
  - Restricted to GOM vertical line fishery
    - ~96% of commercial RS landings (SERO 2020)
- Merged in GIS w/structure (Natural or artificial (reef, platform, wreck or pipeline)



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Artificial Attraction: Linking Vessel Monitoring System and Habitat Data to Assess Commercial Exploitation on Artificial Structures in the Gulf of Mexico

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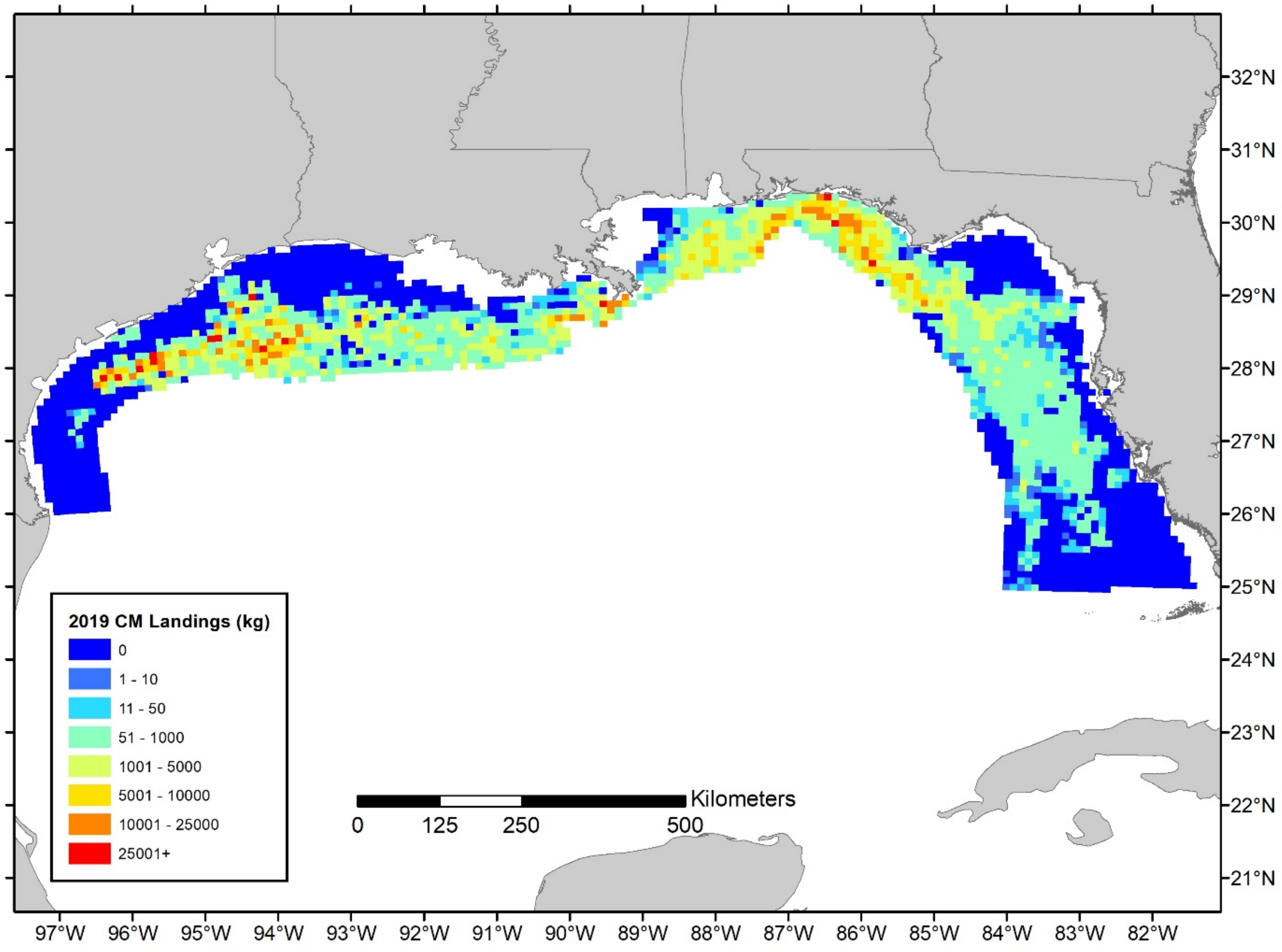
Marine artificial structures provide important ecosystem benefits, but the extent to which commercially valuable reef fish species and their associated fisheries utilize artificial structures is still undetermined. However, the increasing implementation of onboard Vessel Monitoring Systems (VMS) now enables precise identification of catch and effort locations that can be linked *via* satellite coordinates to seafloor habitat maps. To better understand the distribution of fishing effort across artificial and natural reef types in the Gulf of Mexico, we present the first attempt to link VMS data from commercial reef fish vessels with high resolution habitat maps for an iconic species, red snapper (*Lutjanus campechanus*). By allocating landings from VMS-linked individual fishing trips to habitat type (i.e., natural reef, artificial structure, or uncharacterized bottom) and overlaying these with previously developed red snapper biomass distributions, we are able to develop one of the first fine-scale spatial maps of exploitation across the entire Gulf of Mexico. Results indicated that nearly half (46%) of commercial red snapper landings were extracted from artificial structures. The degree of exploitation was highly heterogeneous with several localized hotspots on natural reefs along the continental shelf break and offshore areas of the Northeast Gulf of Mexico. Similarly, there were distinct regional differences in fishing patterns: a majority of the landings from the state of Florida (~91%) came from natural reefs, whereas ~75% of landings were from artificial structures from all other Gulf of Mexico states combined. These results indicate that the potential for localized depletion exists for red snapper. The exploitation maps developed here can directly aid fisheries managers by highlighting specific habitats and locations that should be carefully monitored as catch limits continue to increase.

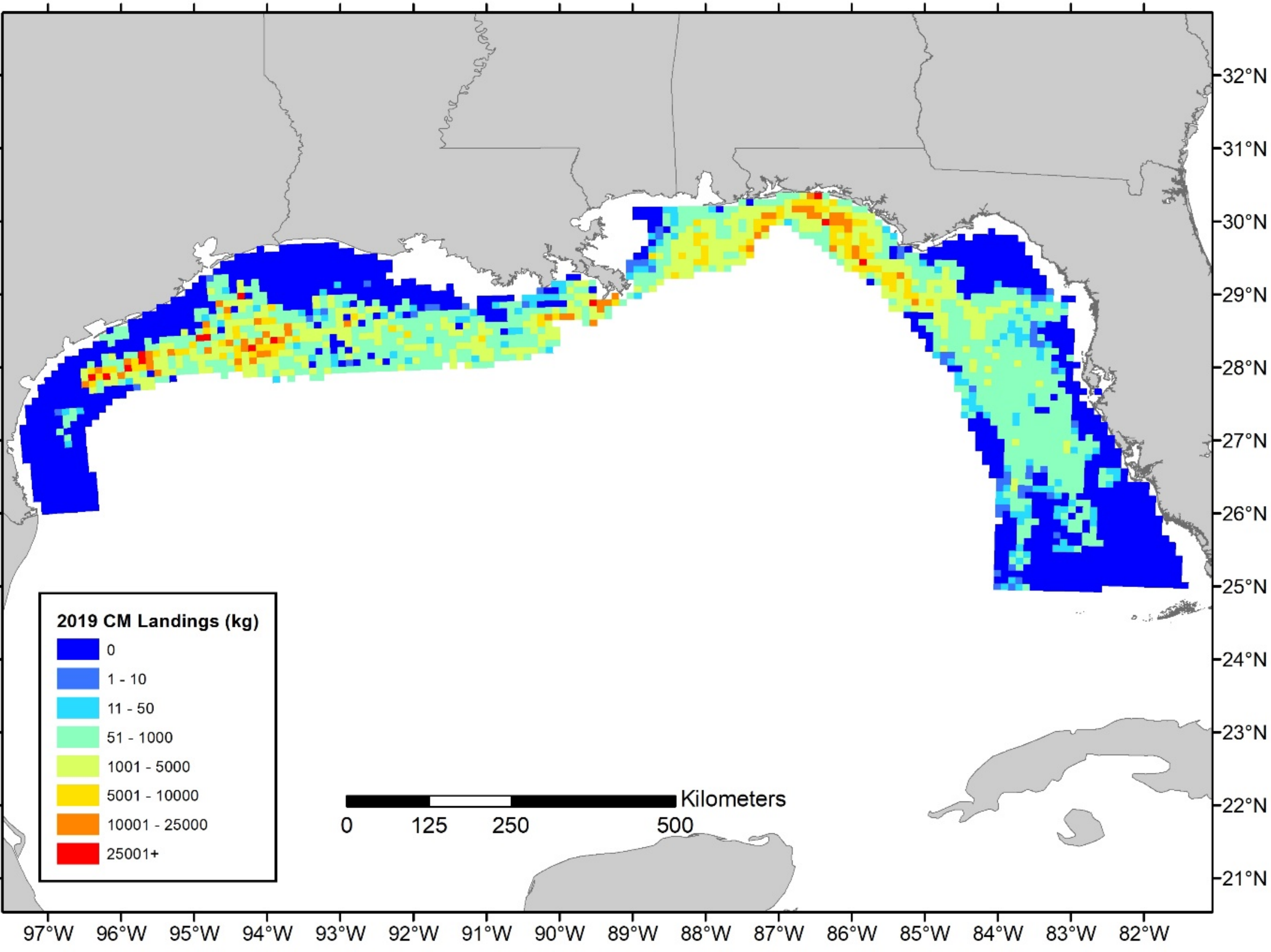
Estimating commercial red snapper catch in space



- Matched VMS data (proportion of habitat fished) with dockside Trip Interview Program (TIP) landings
- Calculated trip level CPUE, applied to individual fishing points in 10x10 km blocks.
- Landings estimated by proportion of trip per block

From Gardner et al. 2022

Spatially explicit landings (Commercial only)



From Gardner et al. 2022

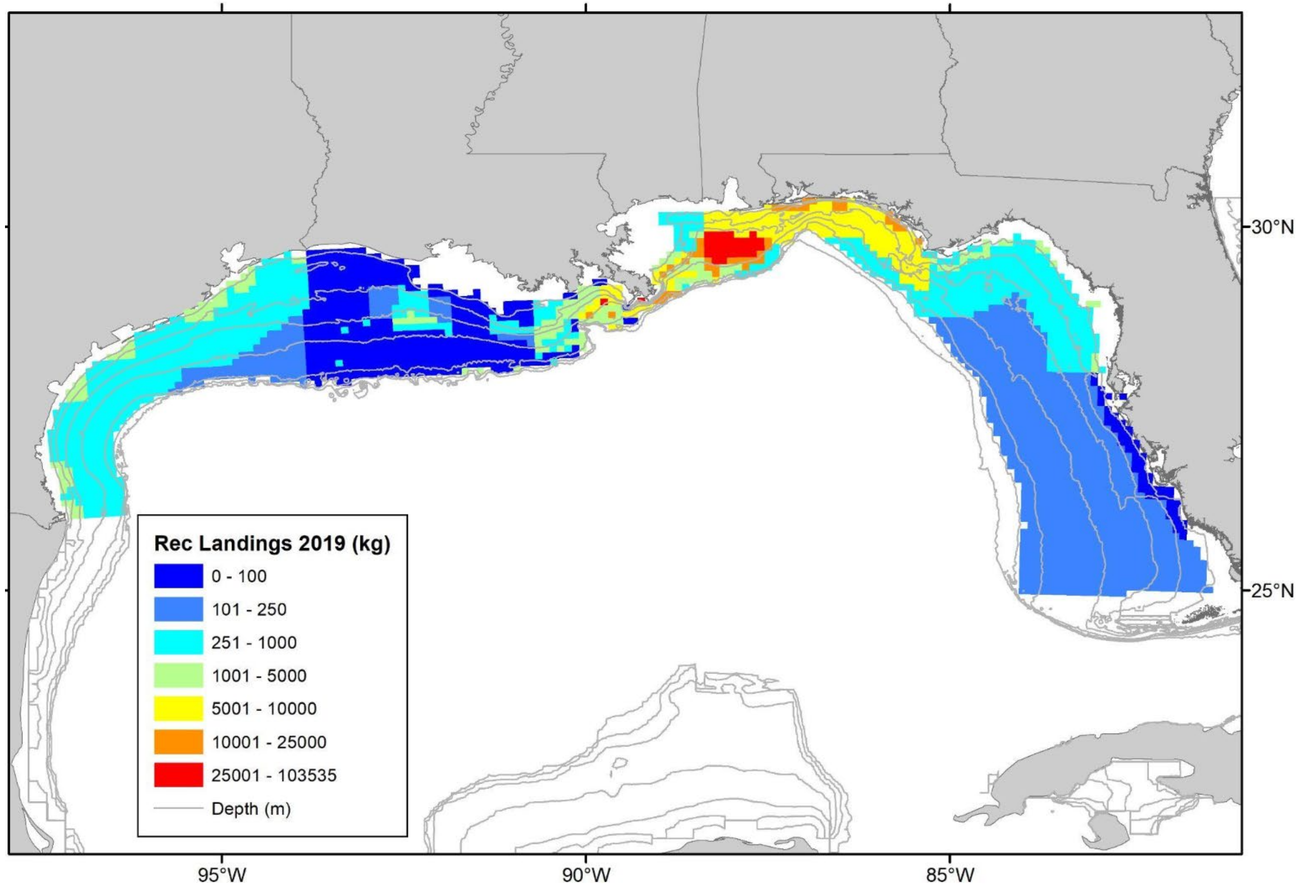
Table 2. Annual Gulf wide estimates of red snapper proportion of landings by structure (NR=Natural reef, AS=Artificial Structure, UNK=Unknown) along with mean proportion (across all years) of catch per habitat from the VMS-TIP linked trips (x± 95% CI are provided in parenthesis). Values are provided for the VMS-TIP non-extrapolated data set along with the VMS-TIP extrapolated data set (i.e., columns starting with 'Ext_'; see text for a full description of the methods used to derive both sets of values).

Year	NR	AS	UNK	Ext_NR	Ext_AS
2011	0.29	0.17	0.54	0.69	0.31
2012	0.21	0.24	0.55	0.54	0.46
2018	0.19	0.3	0.51	0.5	0.5
2019	0.19	0.28	0.53	0.51	0.49
Mean	0.22±0.07	0.25±0.09	0.53±0.03	0.54±0.14	0.46±0.14

Spatial allocation of recreational catch

- FL:
  - Observer data (charter) and State Reef Fish Survey dockside interviews (private boats)
  - Treated as two fleets and allocated by catch/region as well then combined by proportion of REC catch, divided into FL Panhandle, Cape San Blas to 28° N latitude (mid-FL) and S of 28° (S FL).
  - Data were collected on ~2500 private trips accounting for ~22000 red snapper caught and ~4000 retained. Observers on for-hire vessels collected data from~1750 trips accounting for ~26000 red snapper.
- AL/MS
  - AL reported depth, MD ssed same depth structure as reported in Snapper Check (J. Mareska, AL DCNR pers. Comm.).
  - Reporting mandatory for rec anglers AL and includes time fishing, depth, fish landed & discarded (Outdoor Alabama, 2022).
  - ~62,000 red snapper targeted trips 2016-2018 landing 631,000 fish. Data partitioned by proportion of total landings per depth strata then applied to 2019 reported landings (NOAA Fisheries 2021).
- LA
  - Louisiana recreational spatial landings were derived from voluntary dockside interviews collected between 2018-2021 by the Louisiana Department of Wildlife and Fisheries in which information was gathered from approximately 2400 private and charter trips.
  - Data included depth, target species, BOEM grid location and natural or artificial habitat (J. Adriance, LDWF, pers. comm).
- TX
  - data analyzed collected between 2017-2020 as part of voluntary self-reporting app (isnapper Harte Research Institute, 2022), which fishers reported locations, number of fishermen and total red snapper landed.
  - ~800 fishing trips landing ~7000 red snapper. Catch allocated by dist.from port to 10x10 km blocks meeting those criteria.

Figure 2: 2019 estimated recreational landings (kg per 10 x 10km block). Estimated from individual state reporting programs.



Older, much improved with additional data from Louisiana

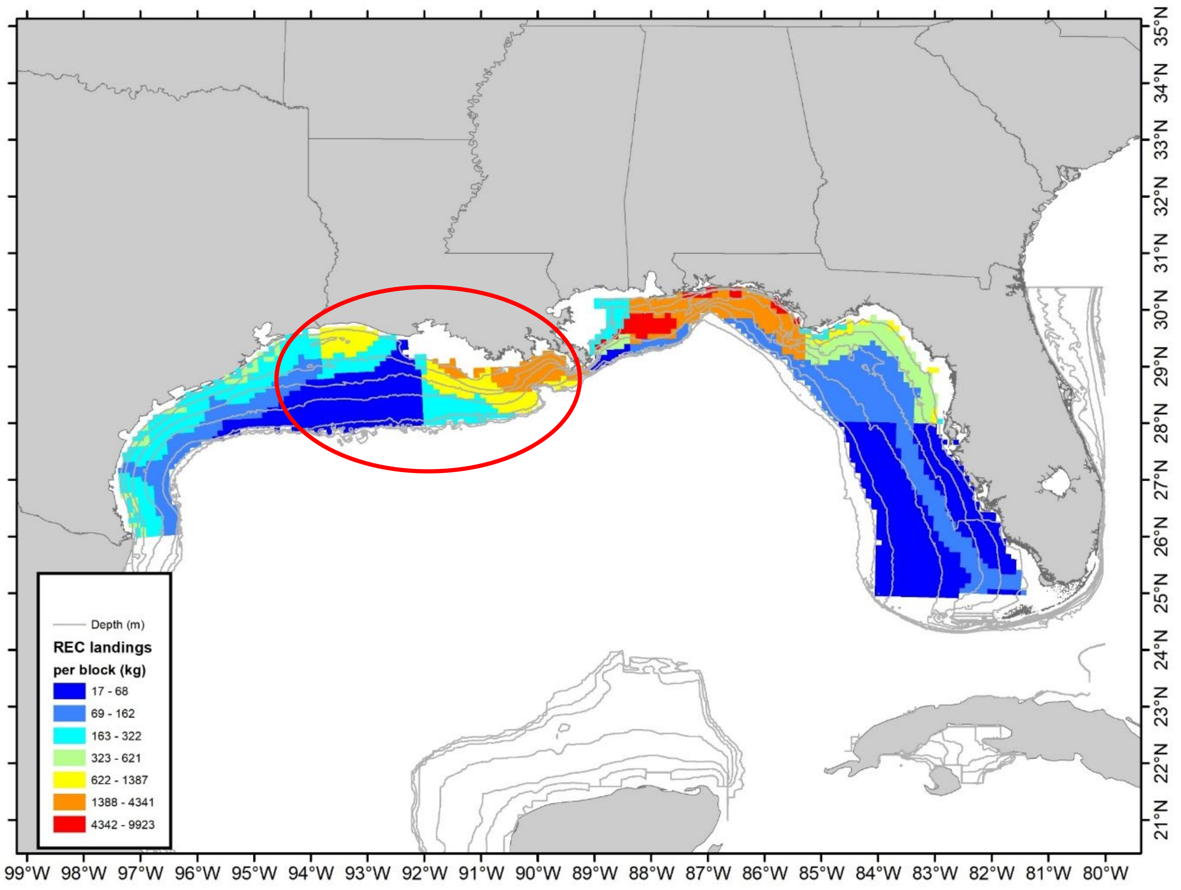
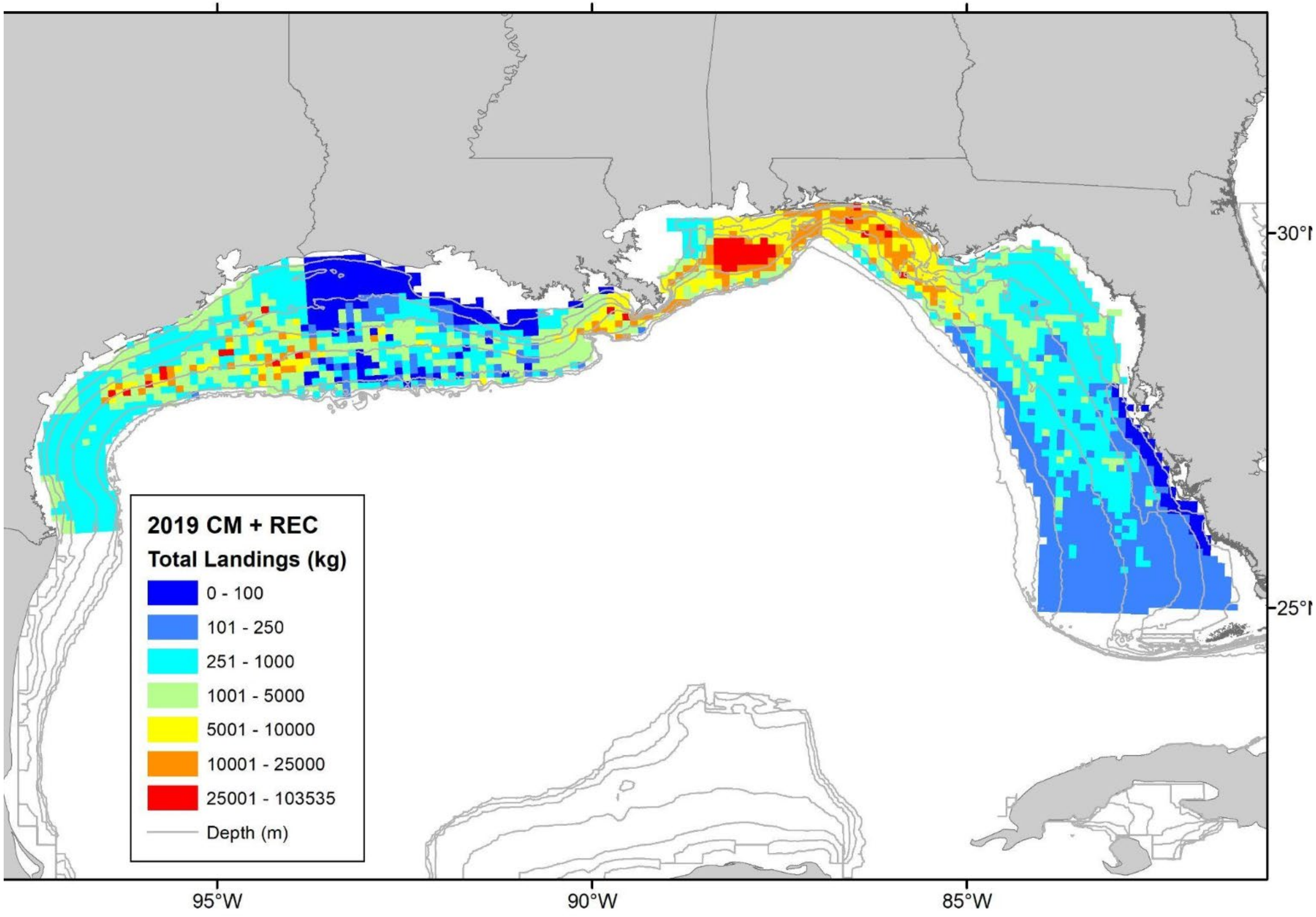


Figure 3: 2019 commercial and estimated recreational landings (kg per 10 x 10km block).



Biomass distributions- assumptions 1 and 2 (GRSC by state, but Karnauskas within state)

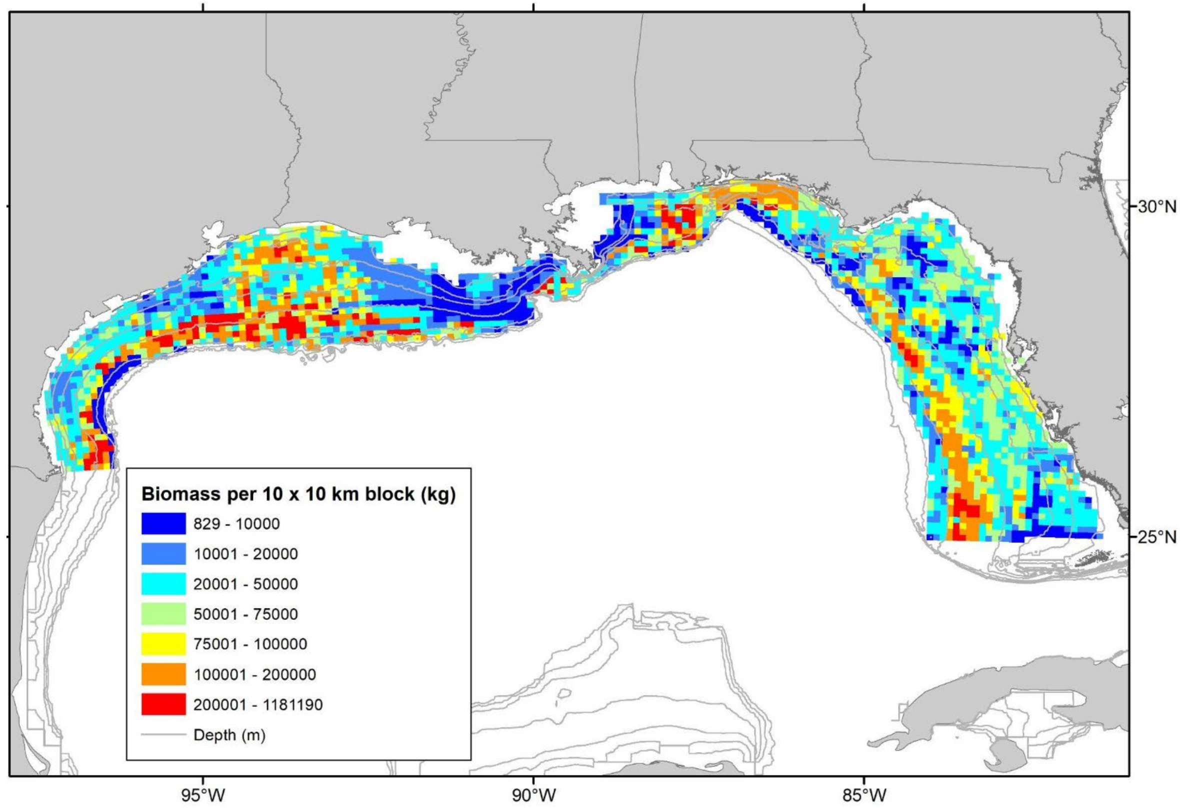


Figure 5: Biomass distribution of 96.7 million red snapper according to state scaled Karnauskas et al. 2017 distribution.

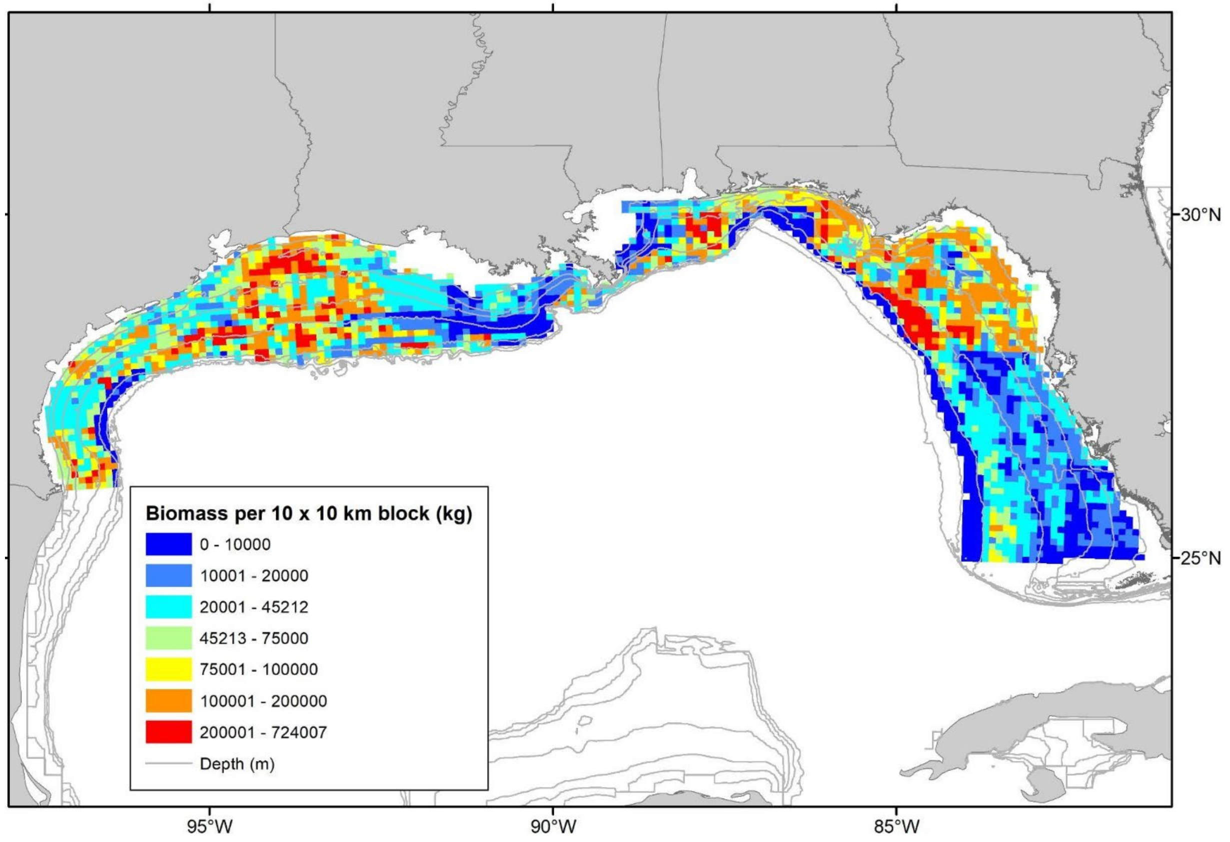


Figure 6: Biomass distribution of 96.7 million red snapper according to state, region, and depth scaled values of the GRSC to Karnauskas et al. 2017.

Biomass distributions- assumptions 3 and 4 (post-stratifications)

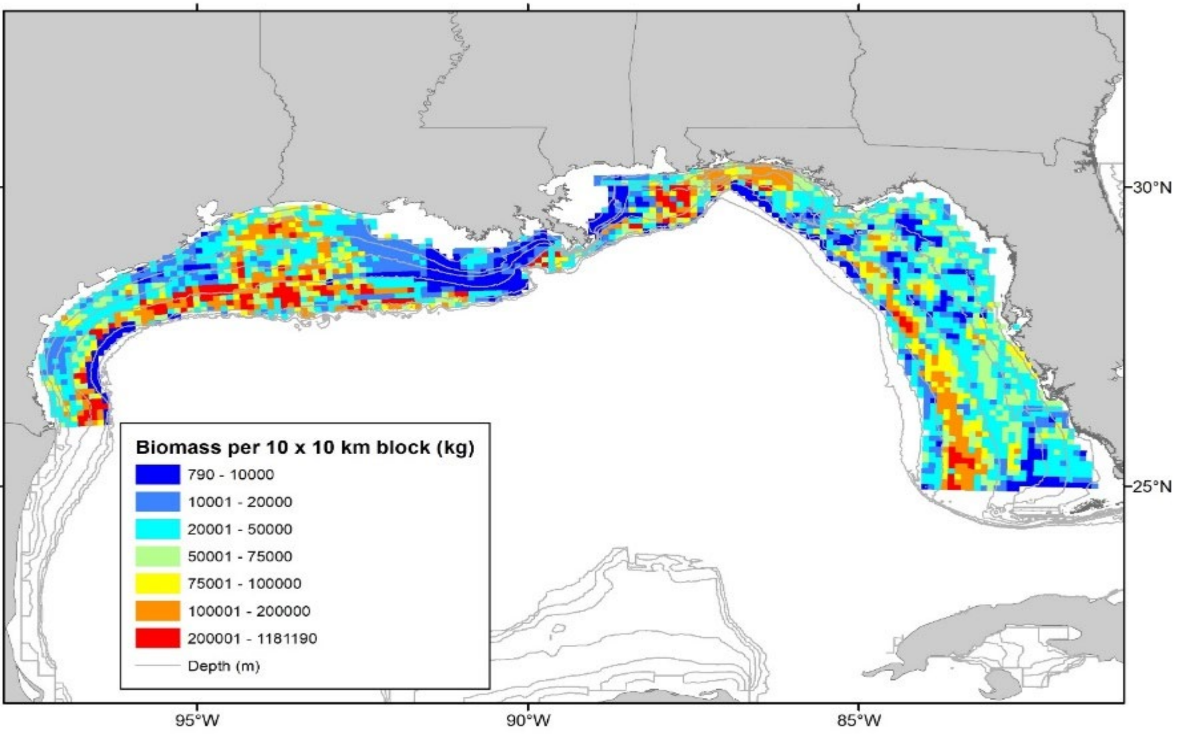


Figure 7: Biomass distribution of the post-stratified GRSC numbers (94.3 M) according to state scaled Karnauskas et al. 2017 distribution.

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Note influence of depth here

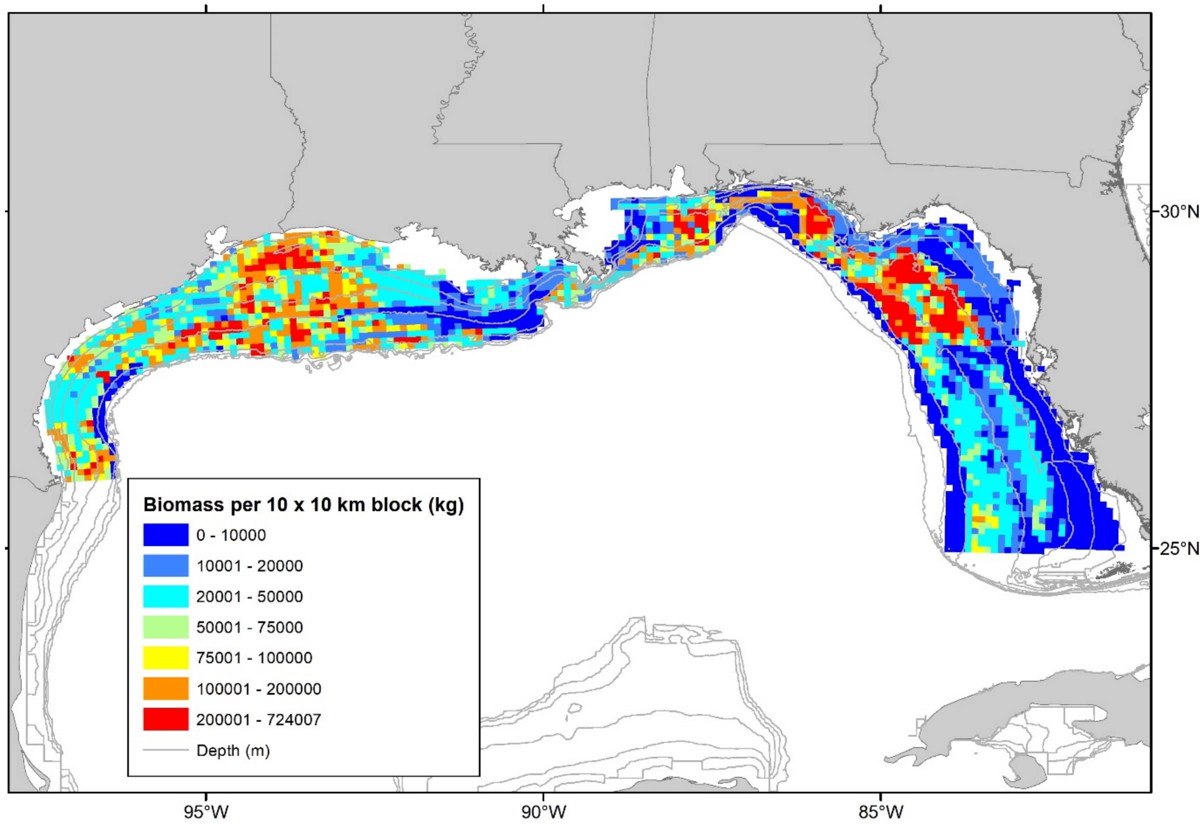


Figure 8: Biomass distribution of the post-stratified GRSC numbers (94.3 M) according to state, region, and depth scaled values of the GRSC to Karnauskas et al. 2017.

Catch Analysis 1:
96.7 M fish
Post-stratification=no

Catch Analysis II:
94.3 M fish
Post-stratification=yes

Karnauskas et al. 2017
State distribution to GRSC #'s

Karnauskas et al. 2017
State/region/depth distribution to GRSC #'s

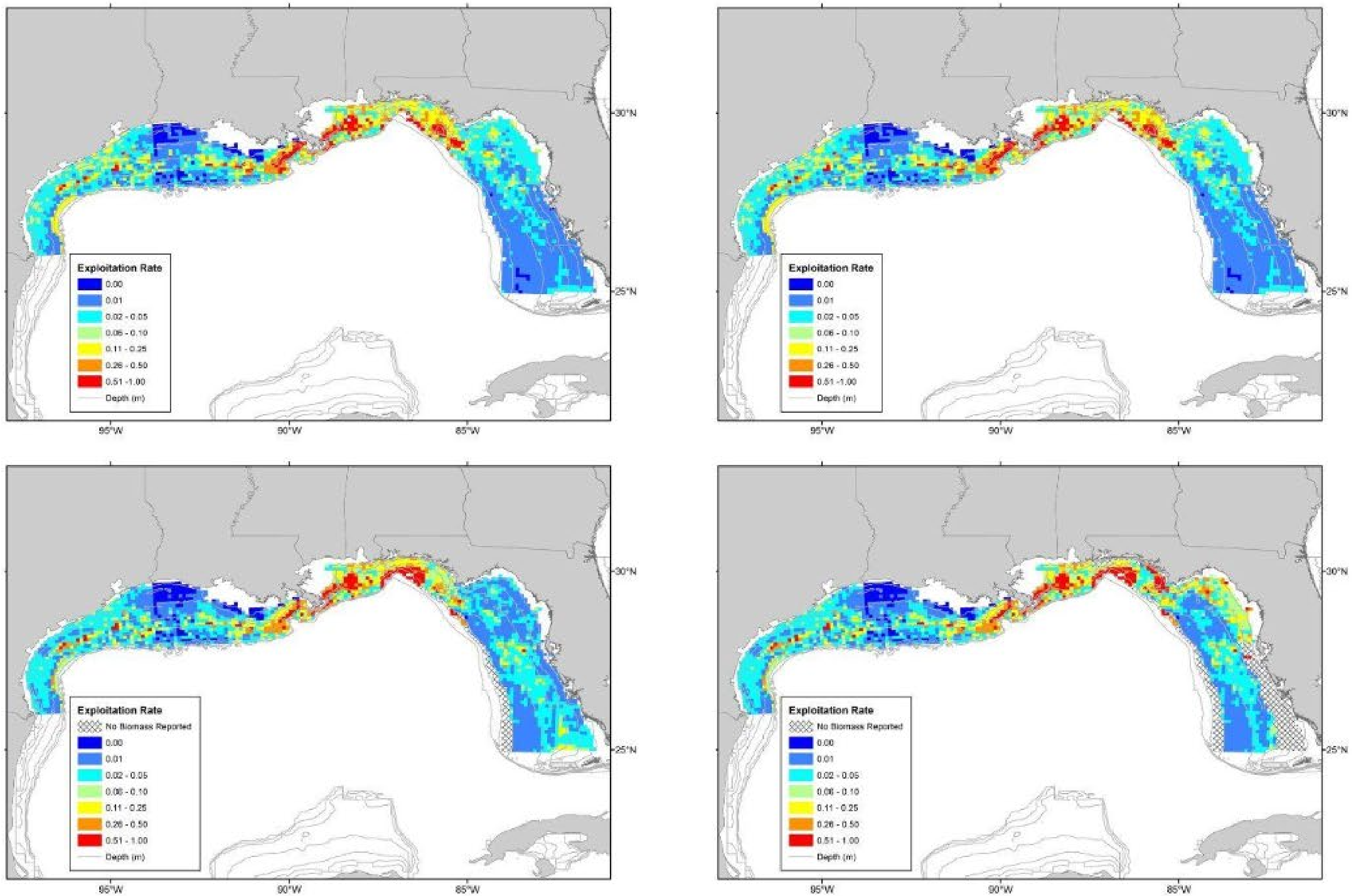


Figure 9: 2019 exploitation rates for commercial and recreational catches combined. Analysis is presented for two distributions and two levels of biomass.

Catch Analysis 1:
96.7 M fish
Post-stratification=no

Catch Analysis II:
94.3 M fish
Post-stratification=yes

Karnauskas et al. 2017
State distribution to GRSC #'s

Karnauskas et al. 2017
State/region/depth distribution to GRSC #'s

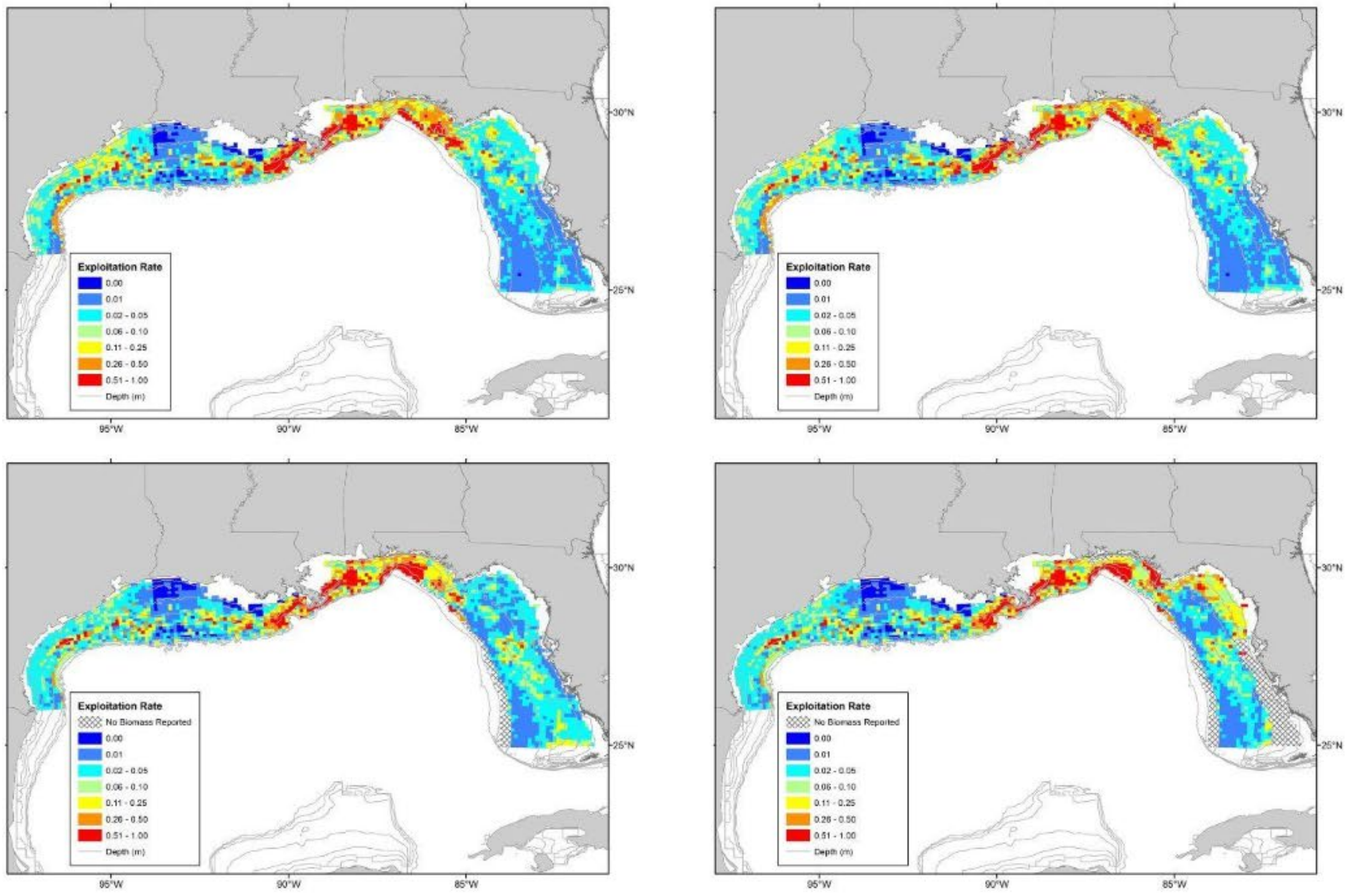


Figure 13: Exploitation rates based "All Structure + 15% UCB" yield estimate of 23.41 million pounds. Catch analysis is presented for two distributions and two levels of biomass.

Table 1: Proportion biomass available to the fishery at or above each level of exploitation per each of the distributions explored.

Biomass available to fishery

Exploitation rate	96M Karnauskas	96M GRSC	ReDist94m Karnauskas	ReDist94m GRSC
0.001	0.84	0.885	0.843	0.862
0.005	0.574	0.635	0.579	0.579
0.01	0.454	0.451	0.459	0.436
0.025	0.277	0.271	0.28	0.27
0.05	0.17	0.161	0.172	0.154
0.1	0.095	0.085	0.098	0.081

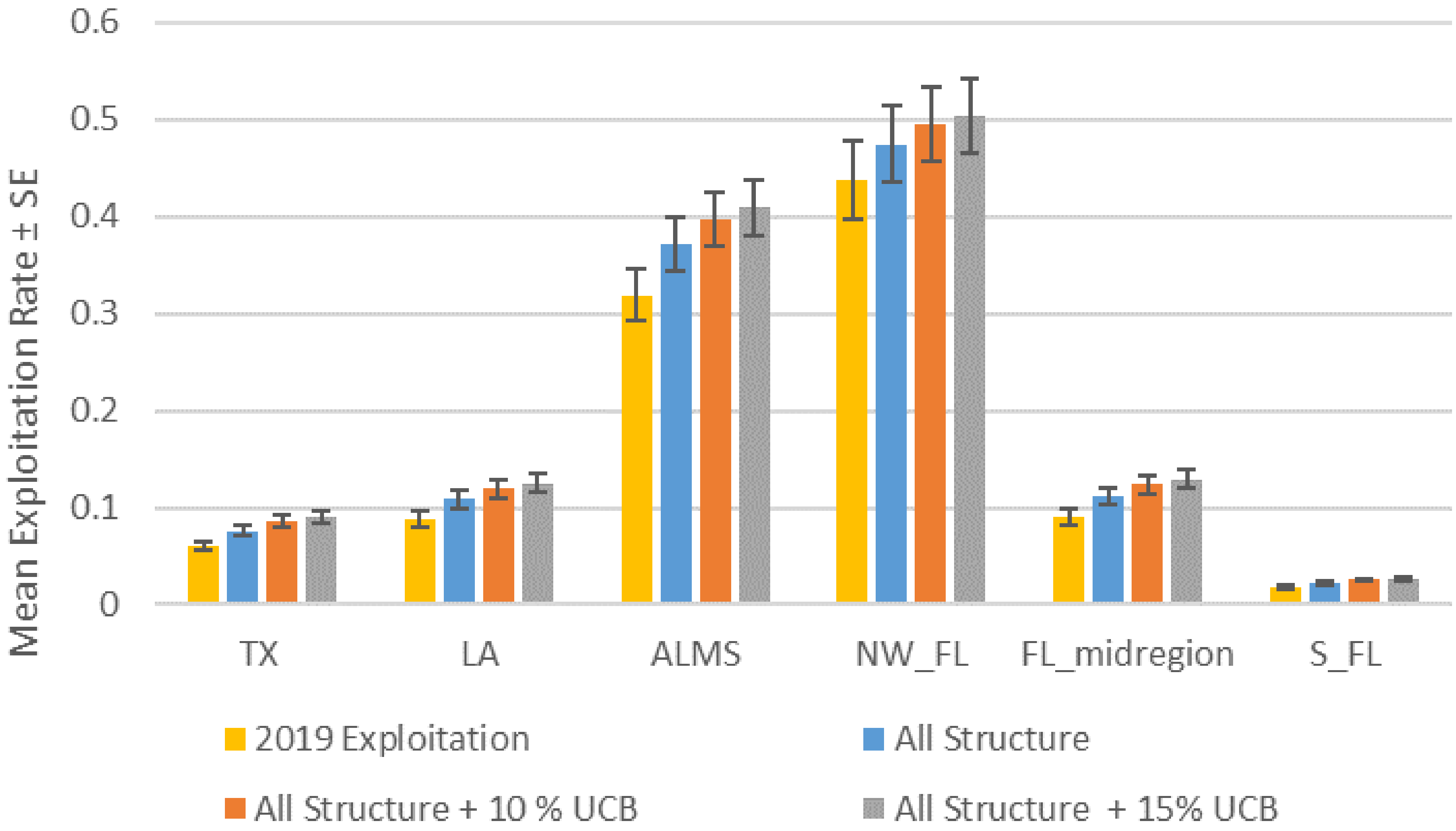
Large fraction of biomass gets very low exploitation, based in 2019 'footprint' of catch

Table 6: Overall population exploitation rates per each distribution and SEDAR52 estimates set to each distribution.

	96M Karnauskas	96M GRSC	ReDist94M Karnauskas	ReDist94M GRSC
SEDAR52 exploitation rate	0.153	0.148	0.153	0.171
All structure	0.105	0.102	0.107	0.121
All structure + 10% UCB	0.115	0.111	0.117	0.132
All structure + 15% UCB	0.120	0.116	0.122	0.137

Basic message is that if one assumed a similar effort footprint of fishing, or similarly, the same effort but higher biomass, what would the resulting population exploitation rates be for different total catch estimates.

Figure 14. Exploitation rates by region according to four different catch scenarios: baseline 2019 exploitation rates (see Figure 9), All structure, All Structure + 10% UCB and All Structure + 15% UCB averaged across the four spatial biomass allocation scenarios outlined in Figures 5-8.



However, exploitation not equal across Gulf; NW_FL and AL/MS experience higher exploitation and would experience increases relative to other regions, if spatial allocation of effort did not shift.

We use SEDAR 52 biomass estimates with a terminal year of 2016 divided by 2019 catch, so the exploitation rates (in yellow) should be taken as relative and approximate.

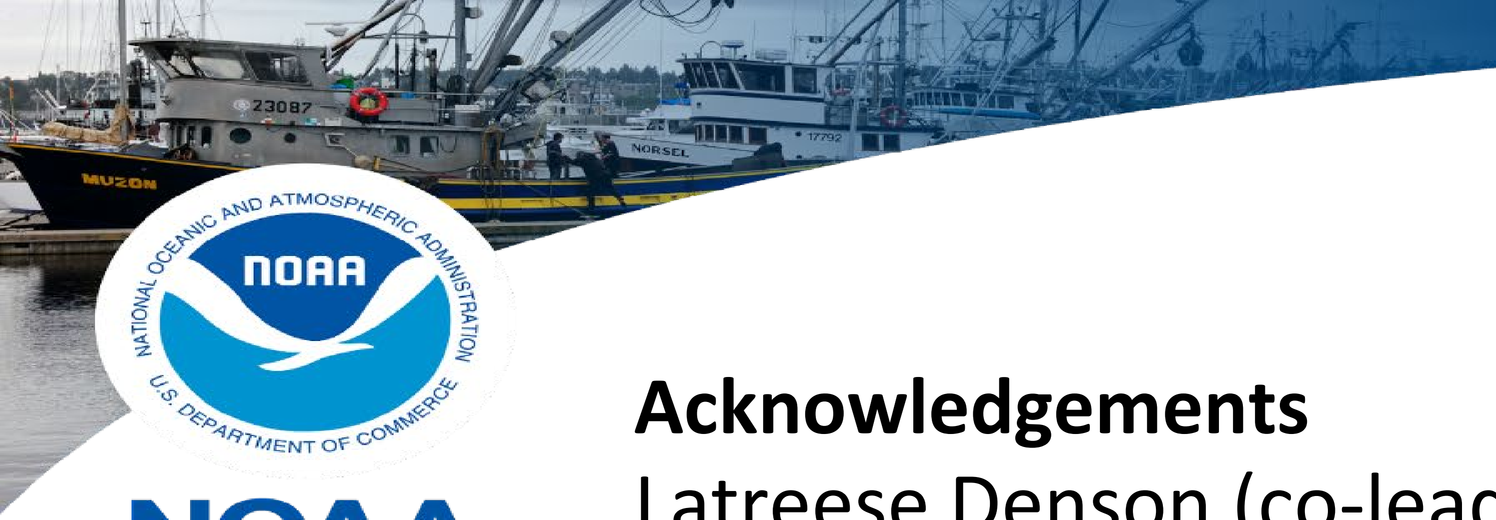
Conclusions

- majority of biomass in the UCB is very lightly exploited according to recent (2019) spatial pattern of fishing effort

- 'all structure' alone underestimates existing footprint, indicating that some fraction of UCB is currently fished.

- Assuming similar pattern of spatial exploitation as in 2019 supports some fraction of UCB for allocation of available biomass for catch advice

- However, exploitation not equal across Gulf; NW_FL and AL/MS experience higher exploitation and would experience increases in exploitation relative to other regions, if the spatial allocation of effort did not shift.



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References

Gardner, C., D.R. Goethel, M. Karnauskas, M. Smith, L. Perruso, and J.F. Walter III. 2022. Artificial Attraction: Using Vessel Monitoring System and Habitat Mapping Data to Compare Gulf of Mexico Red Snapper Commercial Fishery Removals Among Artificial and Natural Reefs. Frontiers in Marine Science. 9:772292. doi: 10.3389/fmars.2022.77292

Goethel, Daniel & Smith, Matthew. 2018. SEDAR 52 Red Snapper Stock Status Summary. SEDAR52, North Charleston, SC. 434 pp.

Karnauskas, Mandy, John F. Walter III, Matthew D. Campbell, Adam G. Pollack, J. Marcus Drymon & Sean Powers. 2017. Red Snapper Distribution on Natural Habitats and Artificial Structures in the Northern Gulf of Mexico. Marine and Coastal Fisheries, 9:1, 50-67,Doi: 10.1080/19425120.2016.1255684

O'Farrell, S., Sanchirico, J. N., Chollett, I., Cockrell, M., Murawski, S. A., Watson, J. T., Haynie, A., Strelcheck, A., and Perruso, L. 2017. Improving detection of short-duration fishing behavior in vessel tracks by feature engineering of training data. – ICES Journal of Marine Science. 74: 1428–1436.

Reynolds, E. M. 2015. Fish biomass and community structure around standing and toppled oil and gas platforms in the northern Gulf of Mexico using hydroacoustic and video surveys. Master's thesis. Louisiana State University, Baton Rouge.

SERO (Southeast Regional Office). 2020. Gulf of Mexico Red Snapper Individual Fishing Quota Report (2019 update). National Marine Fisheries Service, Southeast Regional Office. https://portal.southeast.fisheries.noaa.gov/reports/cs/2019_RS_AnnualReport_SEROFinal.pdf

Stunz, G. W., W. F. Patterson III, S. P. Powers, J. H. Cowan, Jr., J. R. Rooker, R. A. Ahrens, K. Boswell, L. Carleton, M. Catalano, J. M. Drymon, J. Hoenig, R. Leaf, V. Lecours, S. Murawski, D. Portnoy, E. Saillant, L. S. Stokes., and R. J. D. Wells. 2021. Estimating the Absolute Abundance of Age-2+ Red Snapper (Lutjanus campechanus) in the U.S. Gulf of Mexico. Mississippi-Alabama Sea Grant Consortium, NOAA Sea Grant. 439 p.