Habitat Protection and Restoration Committee Meeting August 11, 2021:

Development of Generic Essential Fish Habitat (EFH) Amendment

Background: What is EFH?

- Sustainable Fisheries Act 1996
- What is essential fish habitat (EFH)
  - "*those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity*"
- Generic EFH Amendment 3 completed 2004
- 5-year reviews completed in 2010 & 2016
- Defining EFH is one of several considerations
  - See Background: 5-year review letters

SERO Recommendations from 2016 5-year review

- Update habitat protection policy
- Identify and prioritize research needs
- Amend Council's FMPs with updated habitat information as soon as possible in consideration of other Council priorities and timelines

Why identify and describe EFH?

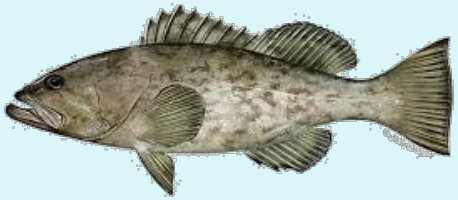
- **EFH descriptions are used to inform the consultation process; who needs a consultation?**
  - A federal agency has authorized, funded, or undertaken part or all of a proposed activity
  - The action will "adversely" affect EFH. An adverse effect includes direct or indirect physical, chemical, or biological alterations.
  - If a federal agency determines that an action will not adversely affect EFH, and NOAA Fisheries agrees, no consultation is required.

Gulf Council's upcoming tasks

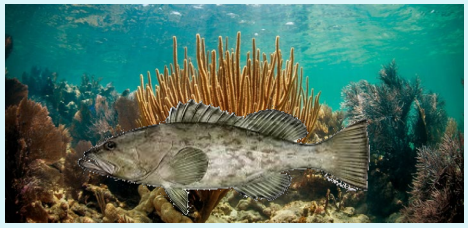
- Council must identify and describe EFH for all managed species by life stage: *egg, larvae and post larvae, early and late juvenile, adult, and spawning adults*
- Required to complete 5 year review
  - Next due in 2021
- 5-year review needs development as does an updated generic EFH amendment
- Combine two efforts
  - Goal of completion by 2022

Method and Policy Considerations

Habitat and life stage tables
(current method)



Species presence



Species presence/absence and habitat model

Established method
Quick progress
Broad

Limited species
Longer timeline
More refined

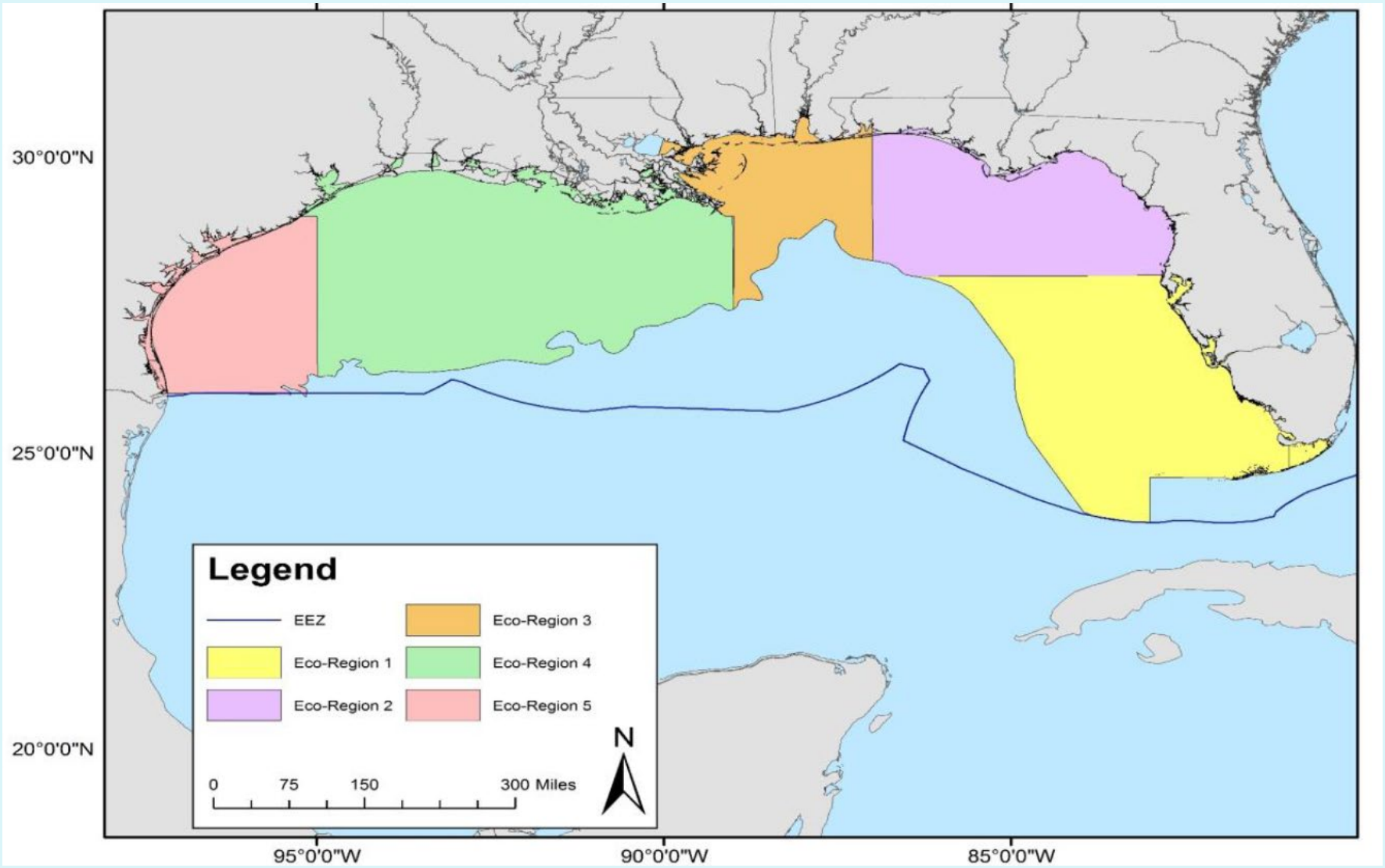
How is EFH currently described for Gulf managed species?

- Habitat use as reported in scientific literature
- Benthic habitat characteristics as mapped in the NOAA GOM Data Atlas
  - Twelve categories
- Gulf divided into 5 ecoregions and 3 depth zones

Habitat and life history tables

Eco-region Name	Bounds	NOAA Stat Grids
1. South Florida	Florida Keys to Tarpon Springs	1-5
2. North Florida	Tarpon Springs to Pensacola Bay	6-9
3. East Louisiana, Mississippi and Alabama	Pensacola Bay to the Mississippi Delta	10-12
4. East Texas and West Louisiana	Mississippi Delta to Freeport, Texas	13-18
5. West Texas	Freeport, Texas to the Mexican border	19-21

Habitat and life history tables

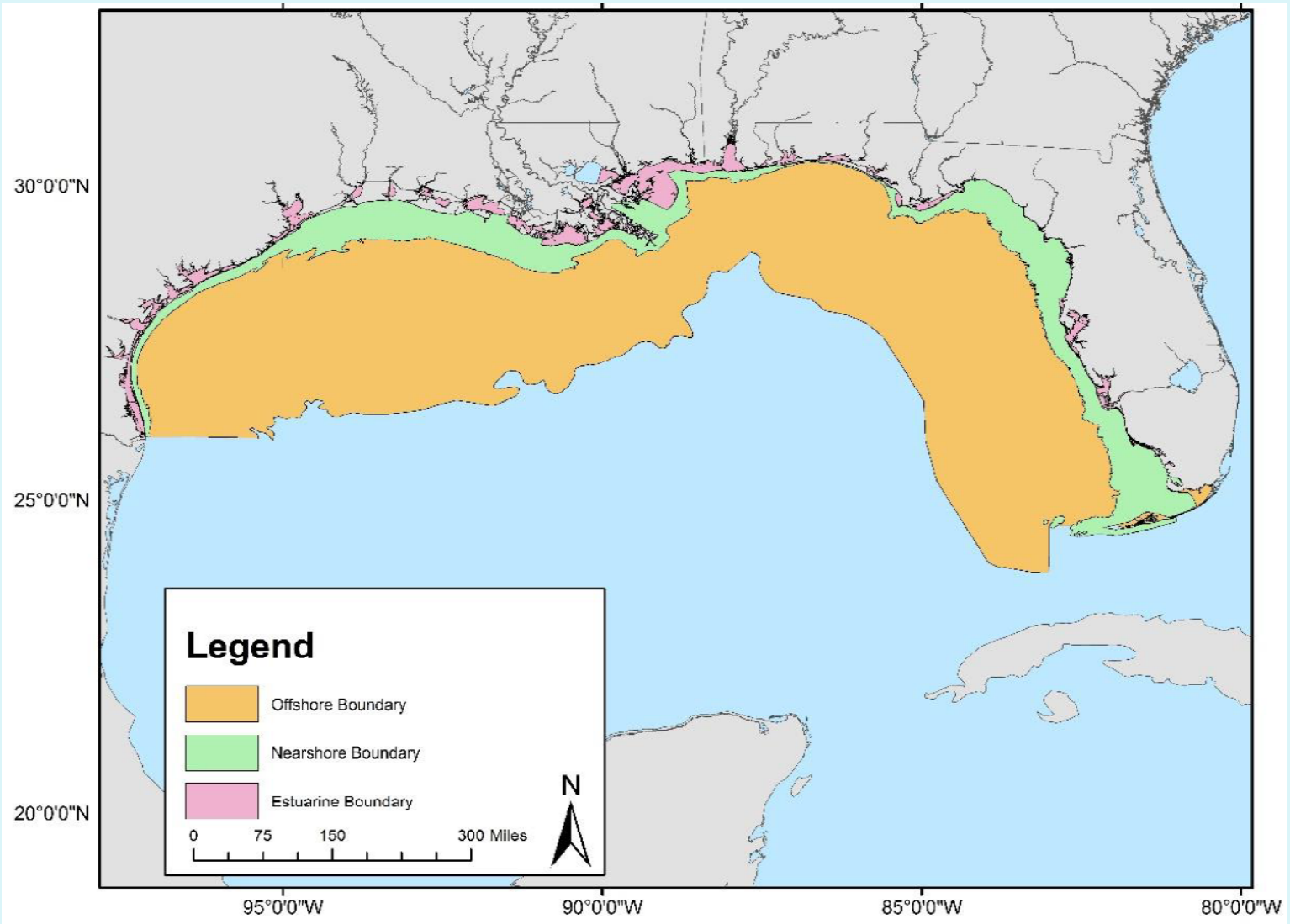


Habitat and life history tables

Habitat Type	Related Terms
Submerged Aquatic Vegetation (SAV)	Seagrasses, benthic algae
Mangroves	
Drifting algae	*Sargassum*
Emergent marshes	Tidal wetlands, salt marshes, tidal creeks, rives/streams
Sand/shell bottoms	Sand
Soft bottoms	Mud, clay, silt
Hard bottoms	Hard bottoms, live hard bottoms, low-relief irregular bottoms, high-relief irregular bottoms
Oyster reefs	
Banks/shoals	
Reefs	Reefs, reef halos, patch reefs, deep reefs
Shelf edge/slope	Shelf edge, shelf slope
Water Column Associated (WCA)	Pelagic, planktonic, coastal pelagic

Note: low-relief irregular bottoms include low ledges, caves, crevices, and burrows; high-relief irregular bottoms include high ledges & cliffs, boulders, and pinnacles.

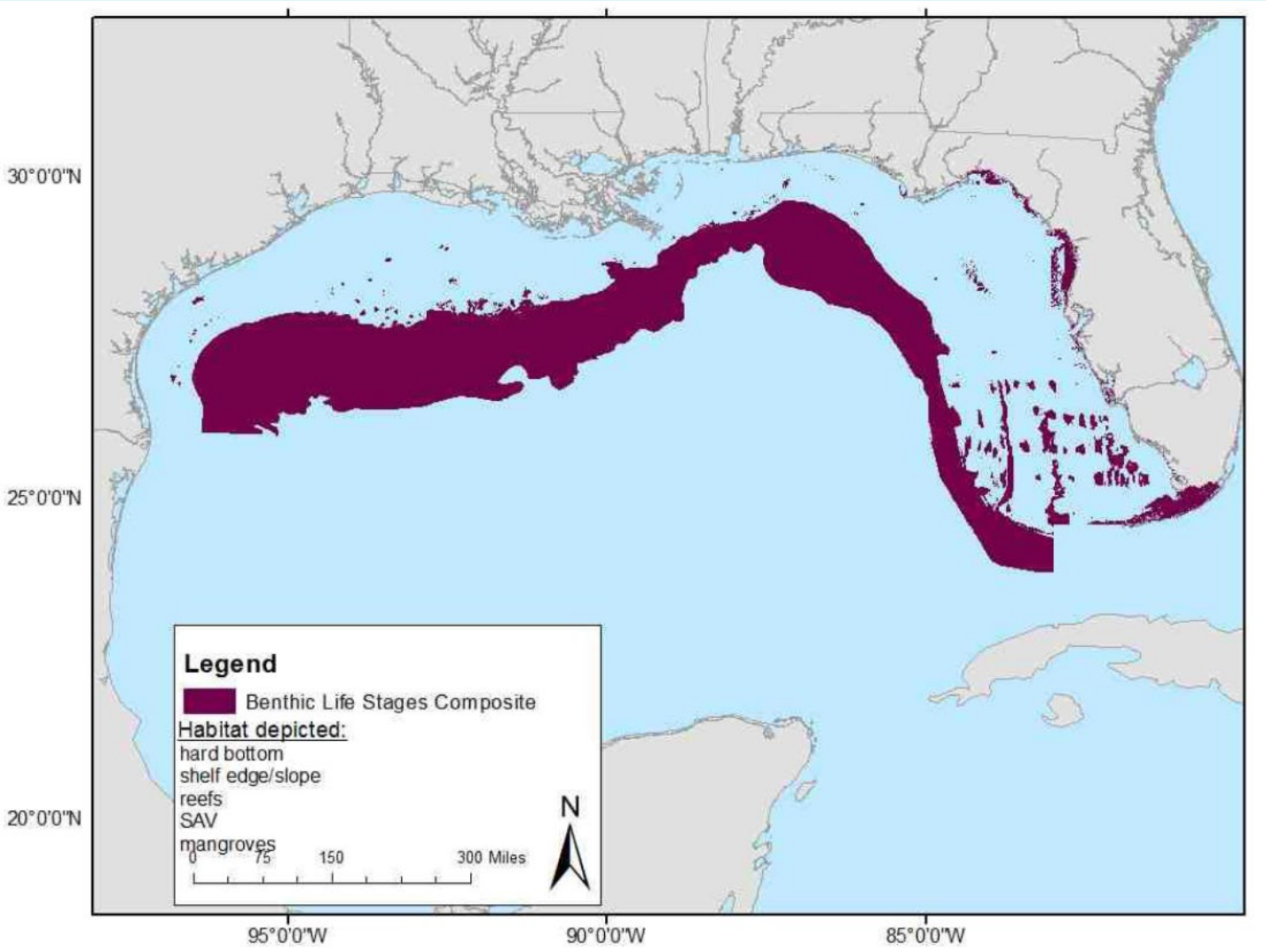
Habitat and life history tables



Habitat and life history tables

Life stage	Eco-region	Habitat Zone	Habitat Type	Season	Temp (°C)	Depth (m)	Prey	Predators	Mortality	Growth
eggs[4,5,7,9, 13,19,24]	ER-1, ER-2	offshore	WCA	Dec-Apr		***50-120***				hatch in 45h at 21°C
larvae[13, 19, 21, 24, 31]	ER-1, ER-2	offshore	WCA	early spring		***50-120***				pelagic larval duration = 29-52 d
postlarvae[10, 13, 21, 31]	ER-1, ER-2	offshore	WCA			***50-120***				pelagic larval duration = 29-52 d
early juveniles[1, 2, 3, 6, 7, 13, 21, 23, 24, 28, 32]	ER-1, ER-2	estuarine, nearshore	SAV, mangroves	late spring-early fall	22-32	0-12	crustaceans (amphipods, copepods, grass shrimp)		minimal while in SAV	rapid during association with SAV
late juveniles[2, 3, 7, 11, 13, 15, 21, 23, 24, 26, 28, 32]	ER-1, ER-2	estuarine, nearshore, offshore	SAV, hard bottom, reefs, mangroves	recruit to reefs offshore in fall	22-32	1-50	decapod crustaceans and fish	cannibalistic, larger fishes	recreational fishery, shrimp fishery bycatch	
adults[2, 6, 9, 13, 15, 16, 18, 20, 22, 23, 24, 29, 34, 35]	ER-1, ER-2, ER-3, ER-4, ER-5	nearshore, offshore	hard bottom, reefs	year-round	14-24	13-100	fish, crustaceans, cephalopods	sharks	sudden low temps, fishing mortality; M = 0.1342	L_{inf} = 1277.95 mm FL, k = 0.1342, t_0 = -0.6687, max. age = 31 yrs
spawning adults[2, 4, 8, 9, 13, 14, 18, 19, 25, 27, 30]	ER-1, ER-2, ER-3, ER-4, ER-5	offshore	shelf edge/slope, hard bottom	Dec-May peak: Feb-Mar	21-30	50-120			spawning aggregations vulnerable to fishery	

Habitat and life history tables: Gag grouper (all life stages)



Habitat and life history tables

	Pros	Cons
Method	• Established in Gulf • Data updated in 2016 review	• Data Atlas outdated • More refined methods available
Policy	• SAFMC, CFMC, WPFMC • Quickly updated • Works for most species	• Very broad • Indirect linkages for species and habitat

What draft options look like

Alternative 1: No Action – Retain current description and identification of essential fish habitat (EFH) for Gulf of Mexico (Gulf) Fishery Management Plans as outlined in EFH Generic Amendment 3.

Alternative 2: Continue to use methods of habitat mapping and life history association tables to describe and identify EFH. Update habitat mapping data from the National Oceanic and Atmospheric Administration (NOAA) Atlas to a more contemporary source. Update species life history and habitat attribute tables to include primary research and technical literature sources through 2020. This alternative could be used for any and all managed species.

FI data available by species for other modeling methods: Grüss *et al.* 2018

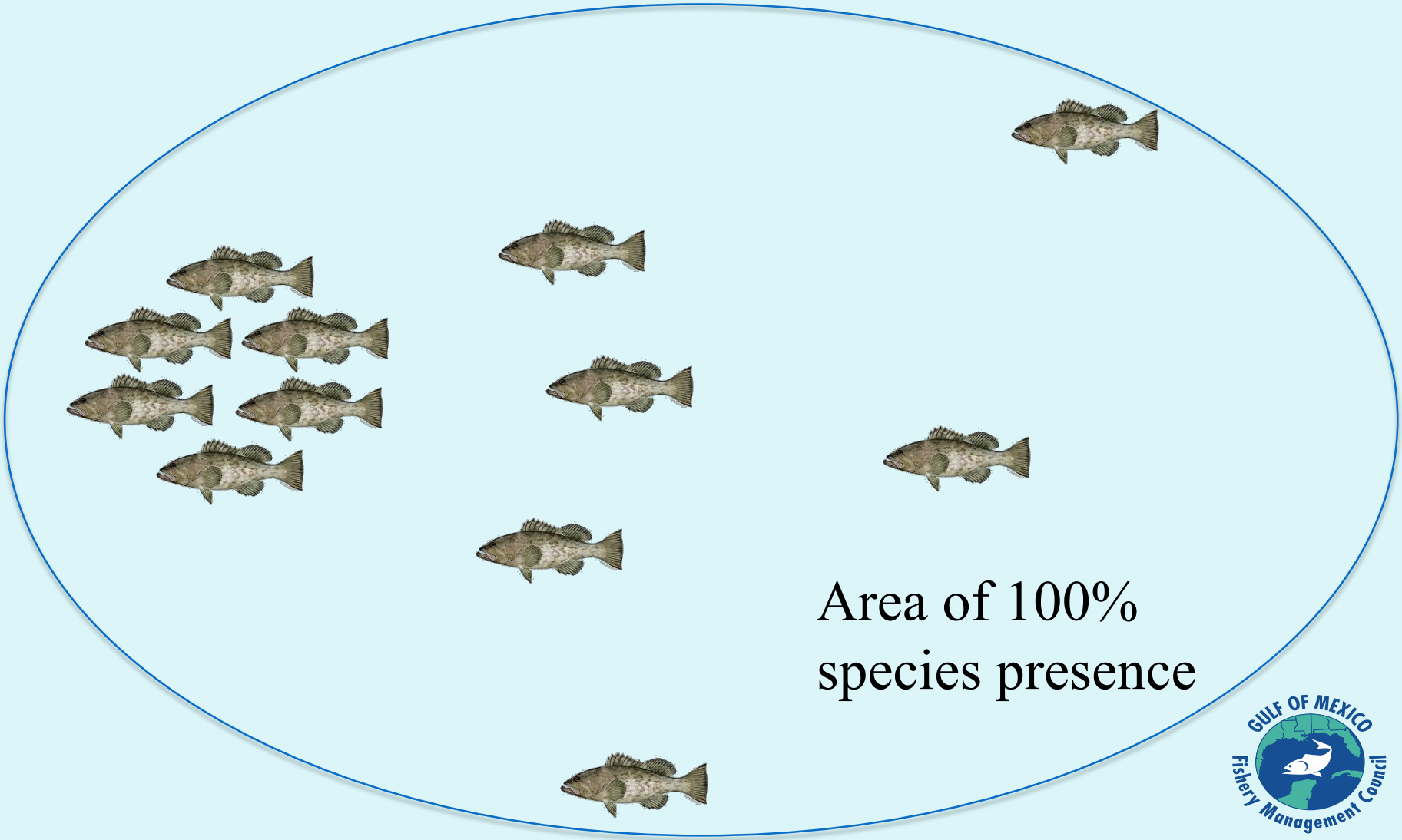
FMP	Aggregated life-stage data	Have life stage data
Reef fish	• Black grouper • Goliath grouper • Vermillion snapper • Yellowedge grouper • Deepwater grouper • Shallow water grouper • Tilefish	• Gag grouper • Red grouper • Red snapper
Shrimp		• White • Brown • Pink
CMP	• King mackerel • Cobia	• Spanish mackerel

Data sources and methods

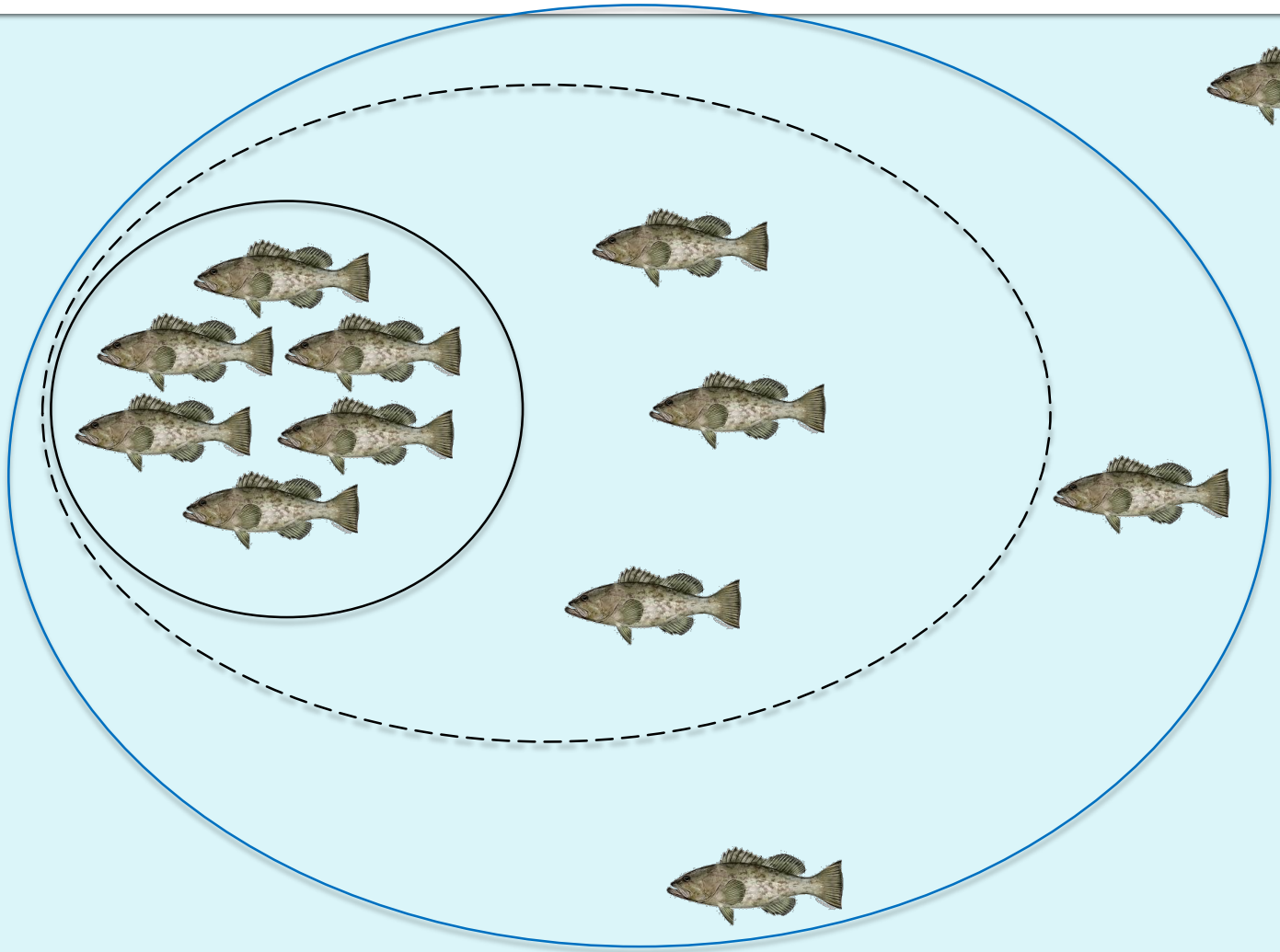
- **Data source (Grüss *et al*. 2018)**
  - 27 fishery independent data sets
  - 7 fishery dependent data sets
  - 2000-2016
  - Video, trawl, seine, vertical line, longline, gillnet, various observer programs

- **Methods considered**
  - Non-parametric kernel density estimator using a nearest neighbor approach (presence only)
  - Boosted regression tree model (presence/absence + habitat)

Presence only



Presence only



50% occurrence
(solid black line)

75% occurrence
(dashed black line)

95% occurrence
(solid blue line)

GULF OF MEXICO
Fishery Management Council

Presence only

- List of locational points

$$Z^n = \{z_i = (x_i, y_i) | \; i = 1, \ldots, n\}$$

- Generate list of 'local' convex hulls using (k-1) nearest neighbor algorithm

$$L_o = \{(z_i, c^k_i, a_i,) | \; i = 1, \ldots, n\}$$

- Reorder areas (a1 < a2 < a3 etc.) and define unions ($C^k_i, \cup^i_{j=1} c^k_j$) to create list of 'extent' convex hulls

$$L_e = \{z_i, c^k_i, a_i, C^k_i, A_i, N_i) | i = 1, \ldots, n\}$$

Presence only

- Percentile of points within utilization density

$$0 < p_1 < p_2 < \ldots < p_m = 100$$

- Construct corresponding nested set of regions with each areas

$$\{C^k_{ip1}, C^k_{ip2}, \ldots, C^k_{ipm-1}, C^k_{i100}\}$$
$$\{A^k_{ip1}, A^k_{ip2}, \ldots, A^k_{ipm-1}, A^k_{i100}\}$$

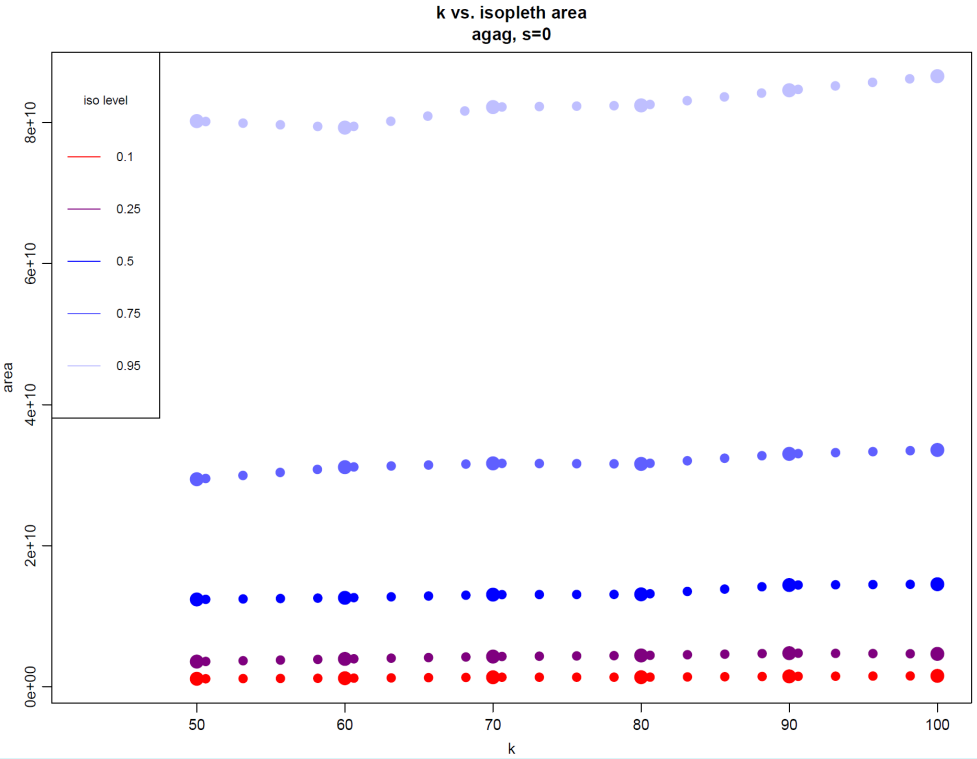
- Calculate utilization density

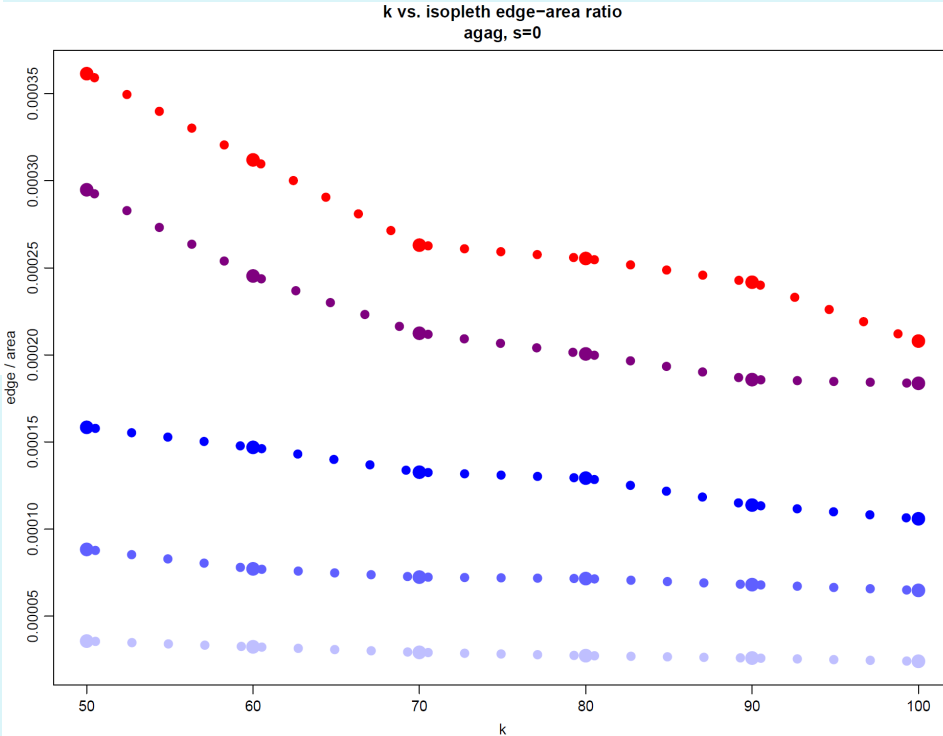
$$d^k_{pi} = (A^k_{ipi} - A^k_{ipi-1})/\, n(p_i - p_{i-1}),\ i=1,\ldots,m$$

Presence only

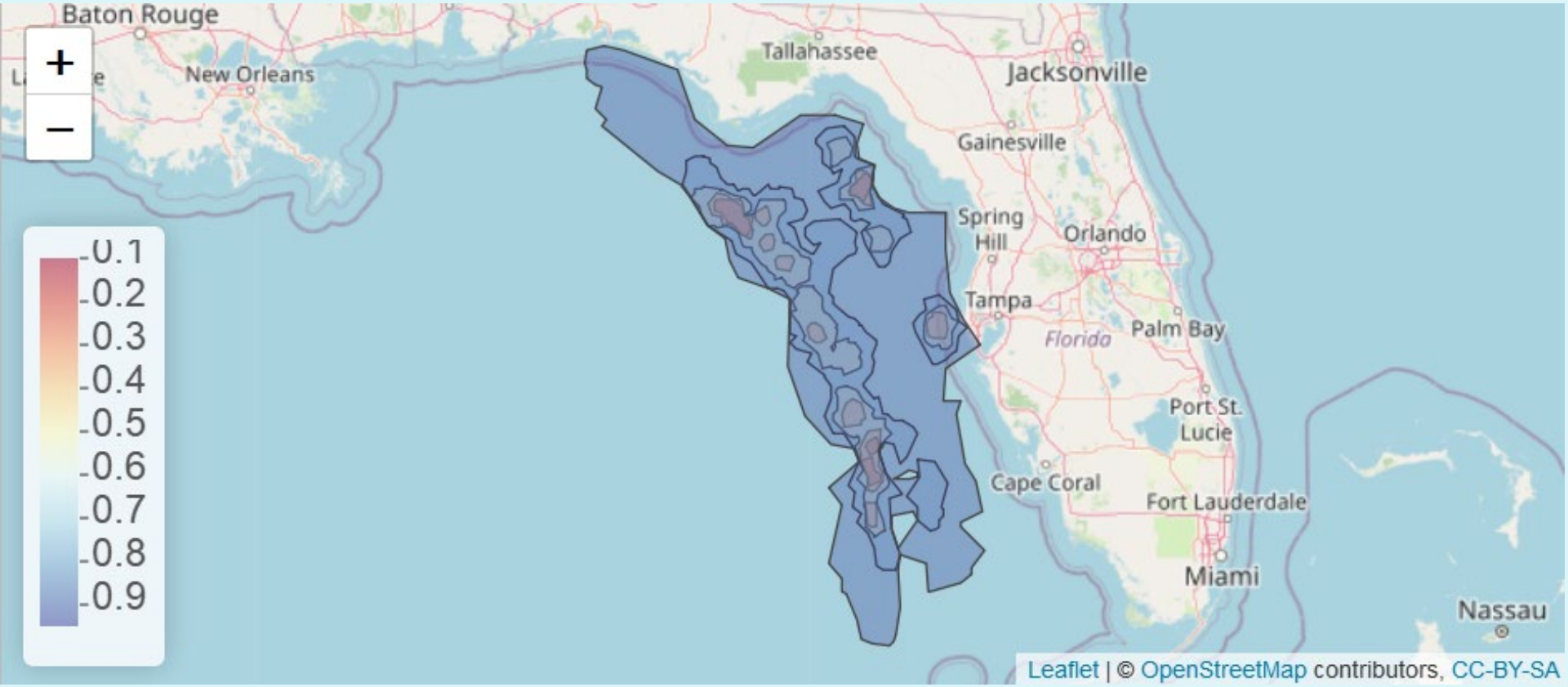
- Analysis performed using R statistical software
  - (T-LoCoH package)
- Apply smoothing parameter
  - k-method; finds the k^{th} nearest neighbor
- Examine isopleth area curves and isopleth edge:area curves for each k value

Presence only

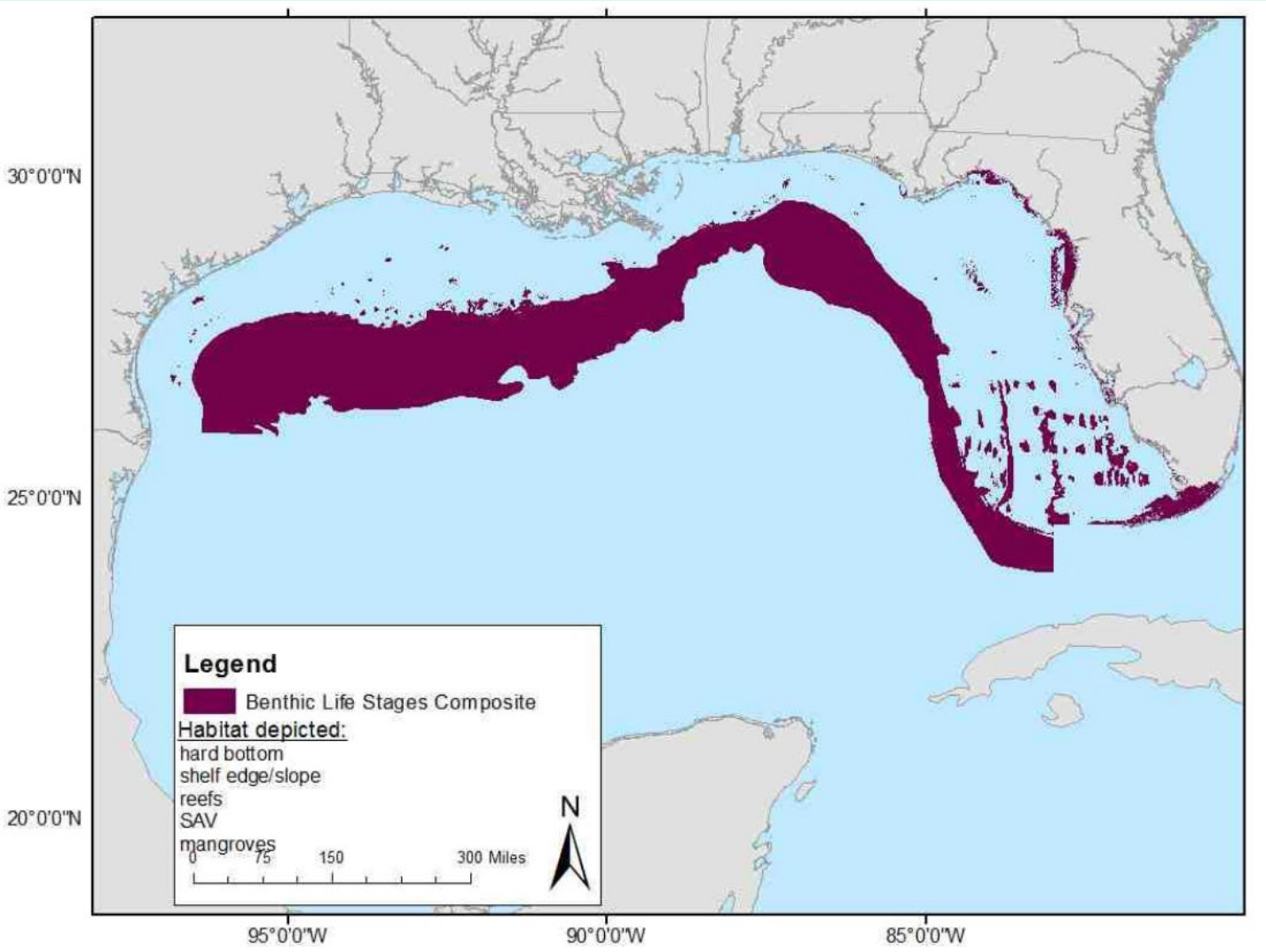




Presence only: Adult Gag grouper



Habitat and life history tables: Gag grouper (all life stages)



Presence only

	Pros	Cons
Method	• Simple model • Data: fishery independent	• Data not available for all species/ life stages
Policy	• NEFMC, MAFMC, HMS • Better refine EFH • Used to inform HAPCs	• More actions • Species:habitat linkage tradeoff

What draft options look like

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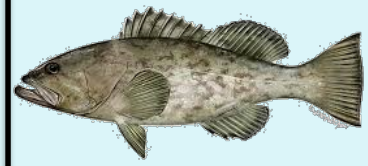
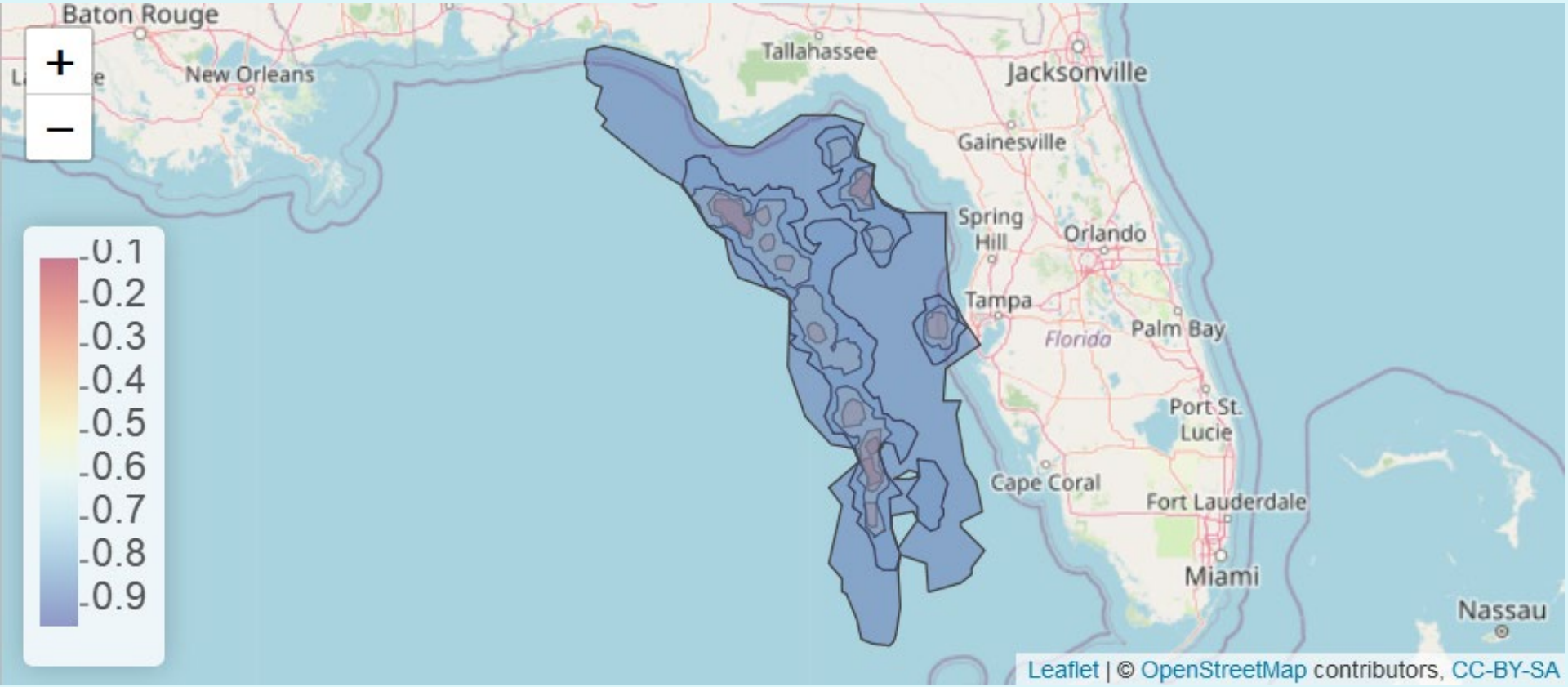


Alternative 3: Use a non-parametric kernel density estimate (KDE) approach using various fishery independent sources outlined from Grüss et al. 2018 to describe and identify EFH. This alternative could only be used to describe and identify EFH for species listed in table on slide 14.

Presence only: Adult Gag grouper



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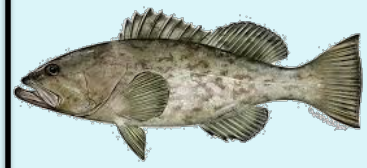

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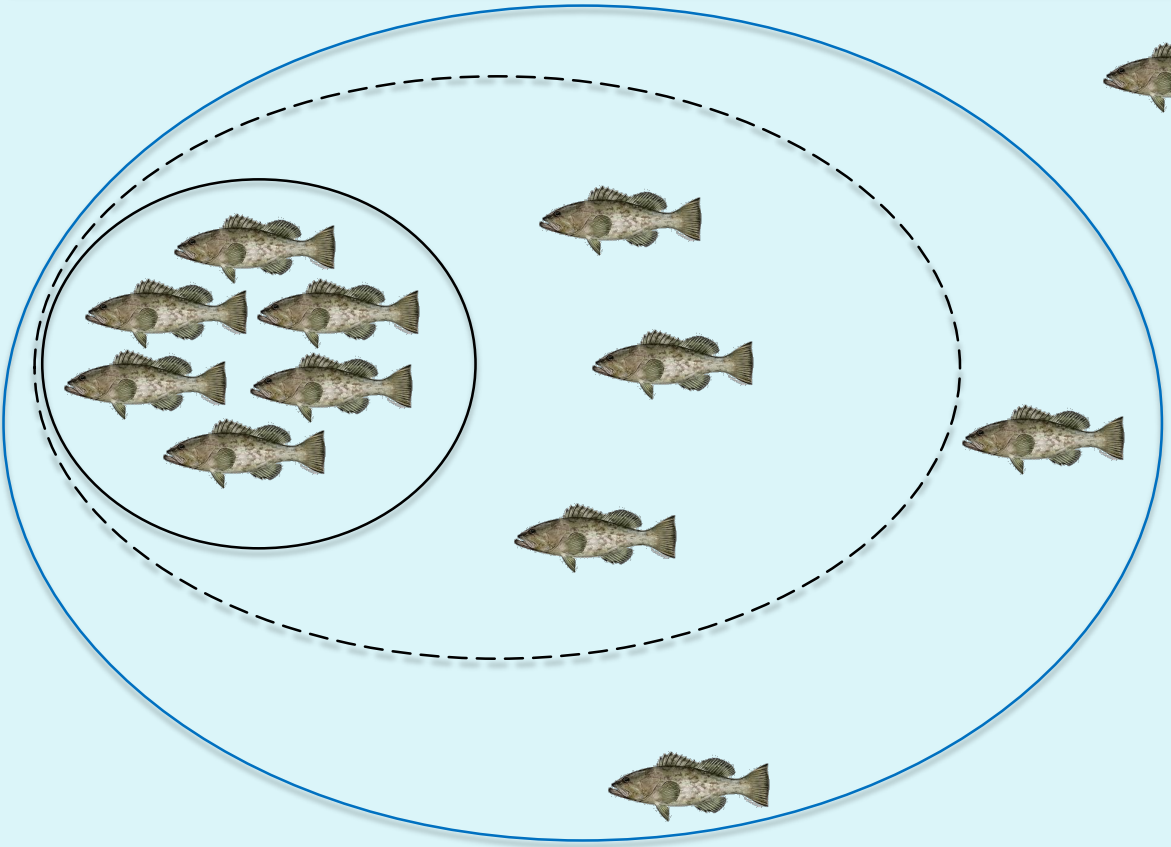


Option 3A: 50% KDE (solid black line)

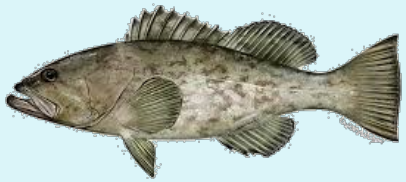
Option 3B: 75% KDE (dashed black line)

Option 3C: 95% KDE (solid blue line)

Presence/absence and habitat model

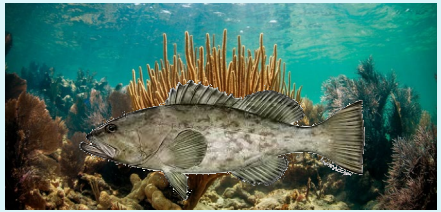
SAMPLING EVENT

Present



Absent

Model output



Presence/absence and habitat model

Boosted regression trees: model overview

- Regression model approach but objective is not to identify "best" model
- Instead, recursive bifurcations (trees) are constructed to identify regions that have most homogenous response to predictors
- Regression model where each term is a tree
- Model can fit a variety of response types
  - Presence/absence observations and data set best suited for fitting a binomial distribution for EFH analysis
- gbm package in R statistical software

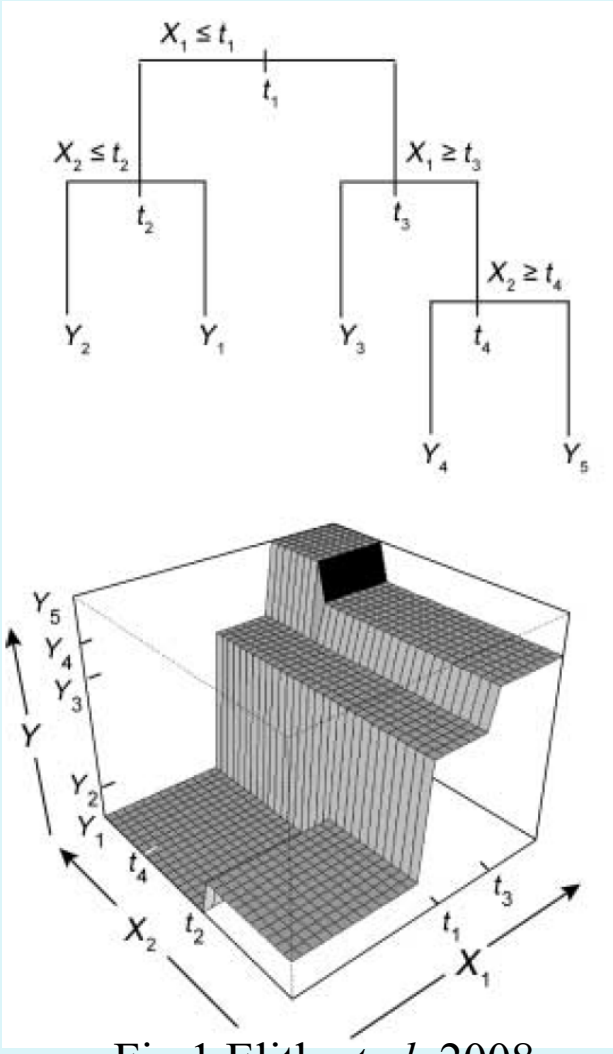


Fig 1 Elith *et al*. 2008

Presence/absence and habitat model

Boosted regression trees: purpose of "boosting"

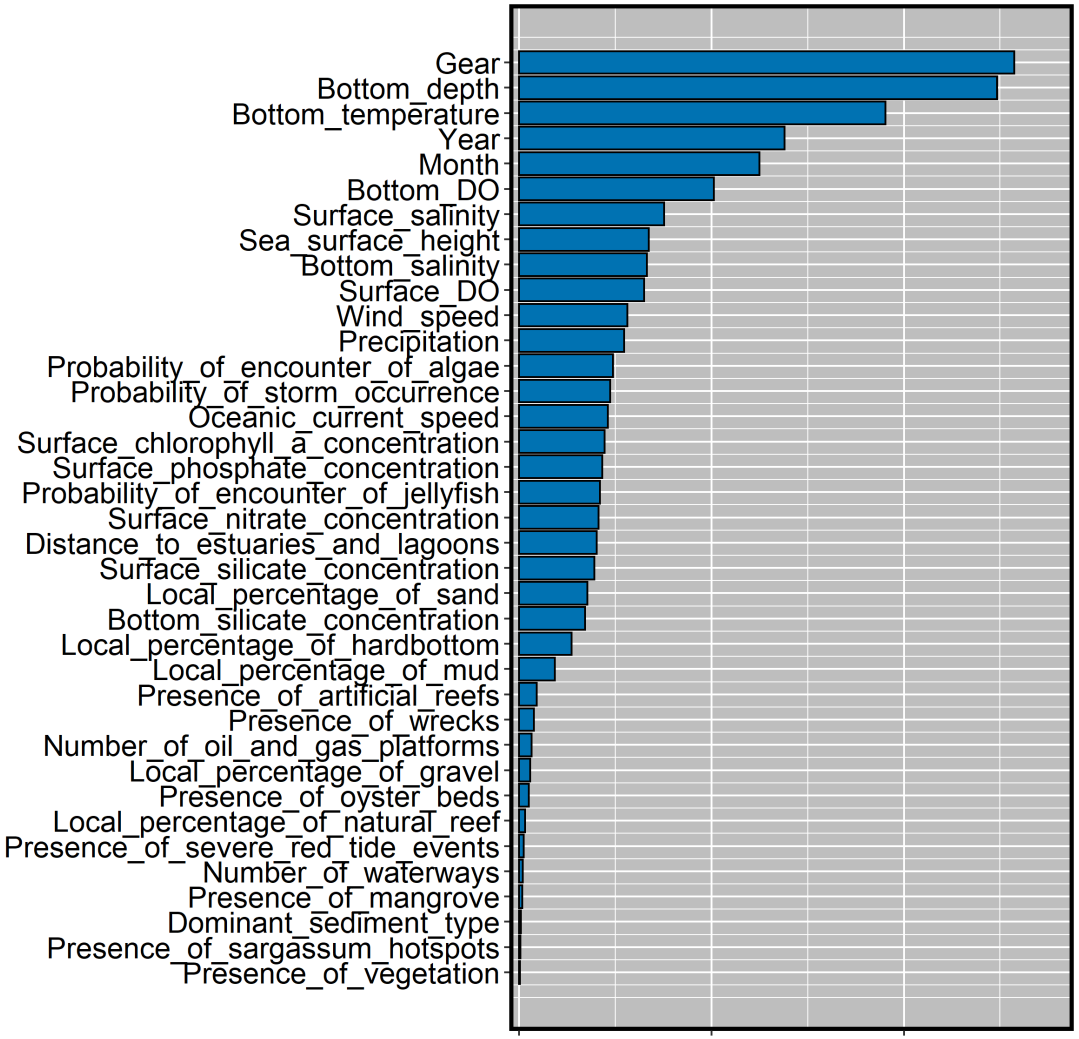
- Stage-wise optimization is focused on quantifying the variation in the response that is not so far explained by the model (i.e. residuals)
- Boosting incorporates stochasticity in model using random subsets to reduce overfitting and improve predictive performance
- Sequential model-fitting builds from knowledge of previously fitted trees to focus on more convoluted observations which are difficult to predict
  - This effects the learning rate and tree complexity
- Allows for straight forward prediction but still requires considerable thought in interpretation

Data sources

- **Data source (Grüss *et al*. 2018)**
  - 209 original inputs; reduced using Spearman Correlation

- **Covariate inputs (39; environmental variables are bottom measurements)**
  - Year: *2000-2016*
  - Gear: *Trawl, seine, longline, gillnet*
  - Distance from shore and distance from coastal rivers
  - Dissolved oxygen (fall and winter)
  - Salinity (by season and month)
  - Temperature (by season and month)
  - Nitrate concentration (season)
  - Phosphate concentration (Fall, Summer, Winter)
  - Silicate concentration (Fall and Winter)

Presence/absence and habitat model: Adult gag grouper



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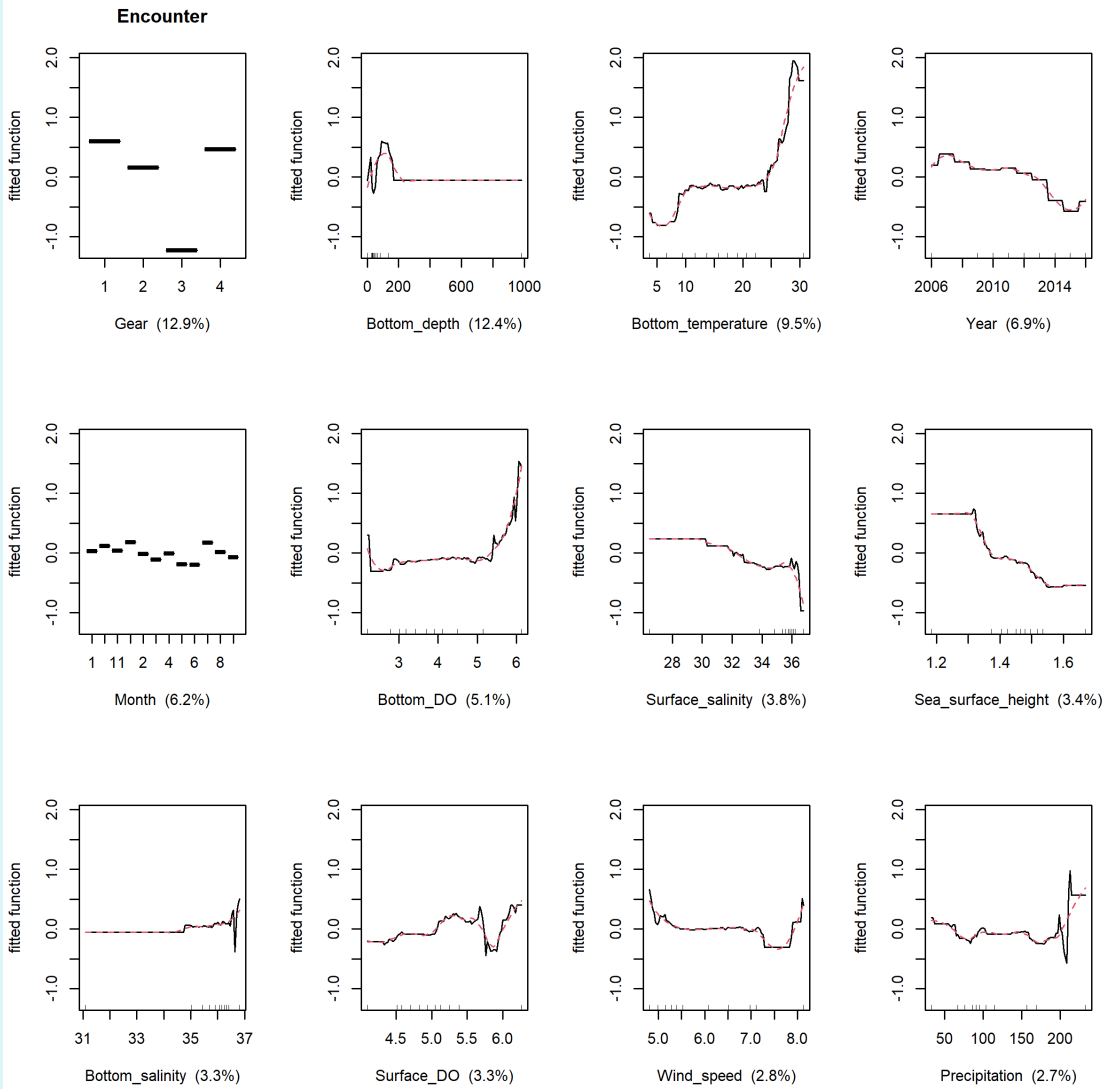

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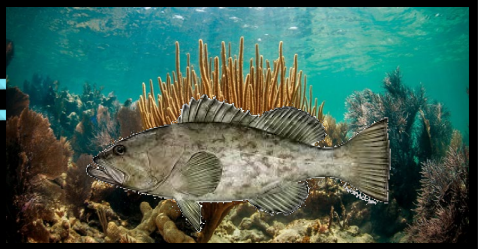

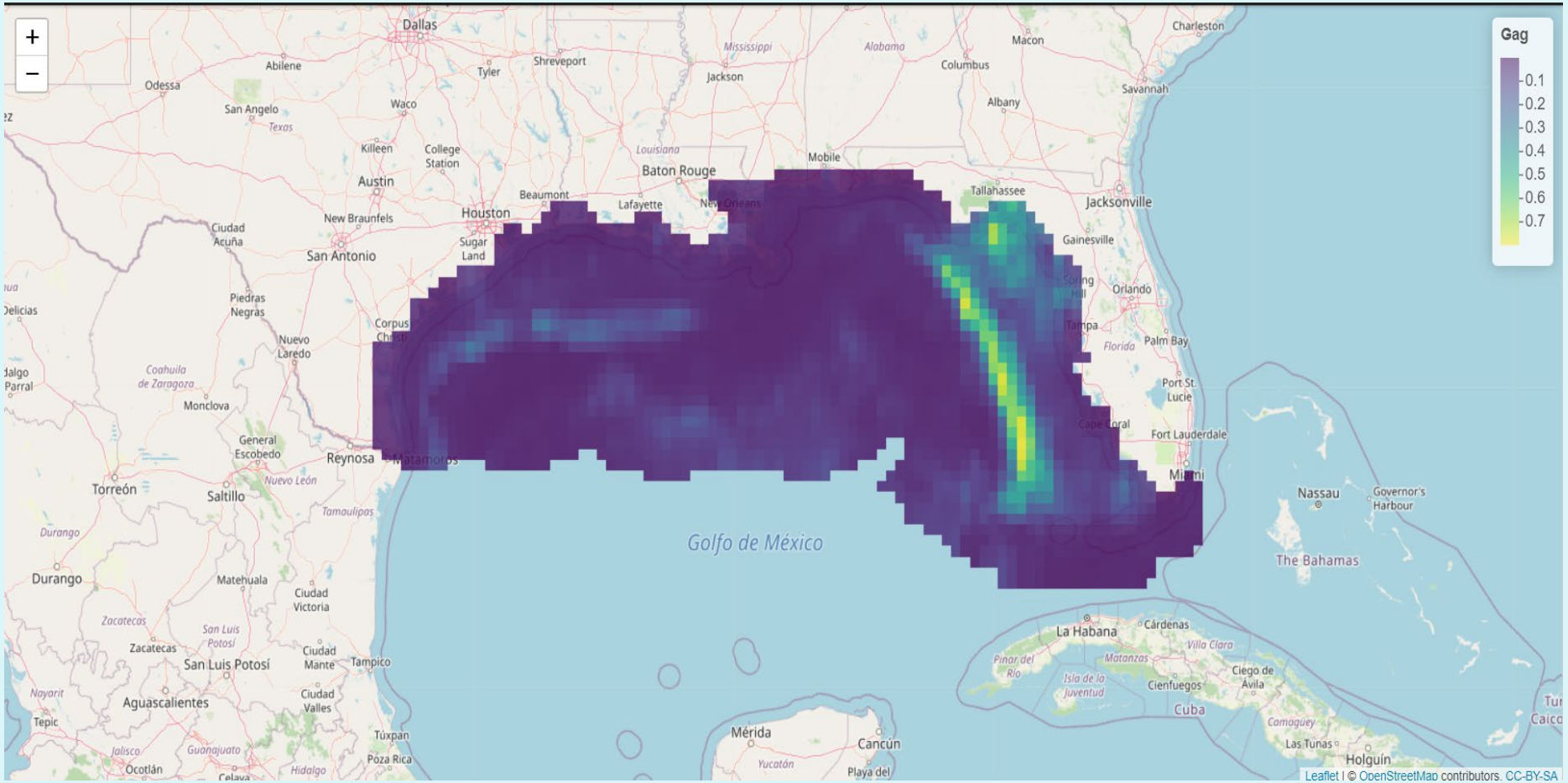

Presence and habitat model

	Pros	Cons
Method	• Very refined • Data: fishery independent	• Data not available for all species/ life stages • Complex model
Policy	• NPFMC, PFMC • Directly links species and habitat • Used to inform HAPCs	• Few species • Complex document

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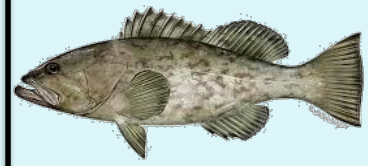
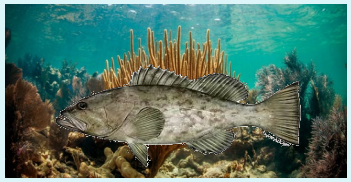


Alternative 3: Use a non-parametric kernel density estimate (KDE) approach using various fishery independent sources outlined from Grüss et al. 2018 to describe and identify EFH. This alternative could only be used to describe and identify EFH for species listed in table on slide 14.

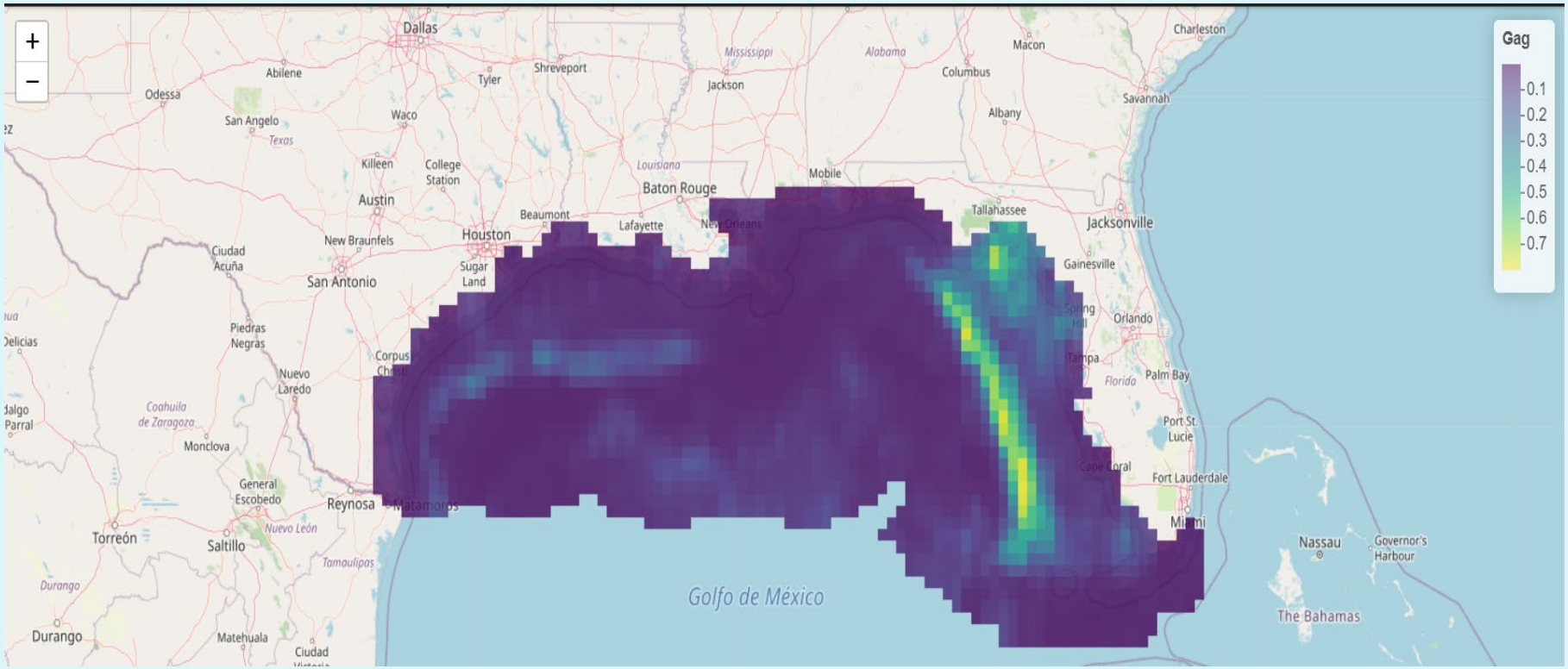


Alternative 4: Use a boosted regression tree (BRT) modeling approach using various fishery independent sources outlined from Grüss et al. 2018 to describe and identify EFH. This alternative could only be used to describe and identify EFH for species listed in table on slide 14.

What draft options look like

Alternative 4: Use a boosted regression tree (BRT) modeling approach using various fishery independent sources outlined from Grüss et al. 2018 to describe and identify EFH. This alternative could only be used to describe and identify EFH for species listed in table on slide 14.

Option 4A: 30% BRT **Option 4B:** 50% BRT **Option 4C:** 95% BRT



Proposed discussion topics

- Standardized method versus piecemeal approach?
- Other data layer sources? (i.e. *Sargassum* maps)
- Timeline considerations
  - Document needs to be completed by early 2022

Questions?