Habitat Suitability and Restoration Potential in Estuaries: Integrating Monitoring and Land Cover Data Using EMAP Probabilistic Survey Methods

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What's the problem?

Many ecologically and economically important fish and shellfish species are dependent upon estuarine habitats during some life stage, BUT…

Very few numeric water quality criteria are in place to protect aquatic life use in estuaries, SO…

How do we avoid "death by a thousand cuts" when habitat loss and alterations are concerned?

We can assess estuarine habitats at multiple scales…

- to estimate habitat suitability for estuarine populations;
- to evaluate "death by a thousand cuts; "
- and to target restoration for specific habitat types.

Estuarine Habitat Assessment Recipe…

You will need (tools):

1 Habitat Suitablity Index (HSI) Model
1 State-level probabilistic survey design for estuaries

Ingredients (Data):

WQ and sediment characteristic data from a probablistic survey (EMAP-NCA)

DO	*Salinity*	*Grain Size*
Temperature	*pH*	*Sediment TOC*

Land Cover Data (NWI)

Open water	*grassy wetlands*
SAV	*sandy shoreline*

Stir (calculate)

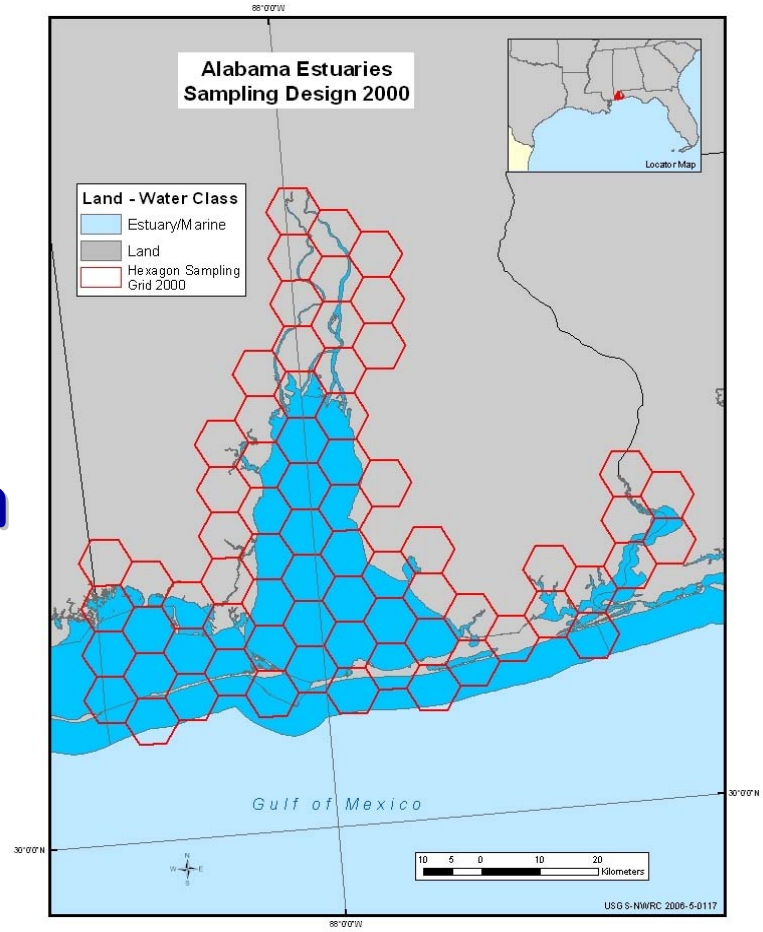
Use WQ, sediment, and LC data to calculate HSI values.

Bake (Analyze)

Use the Cumulative Distribution Function (CDF) to estimate the areal extent of habitat condition

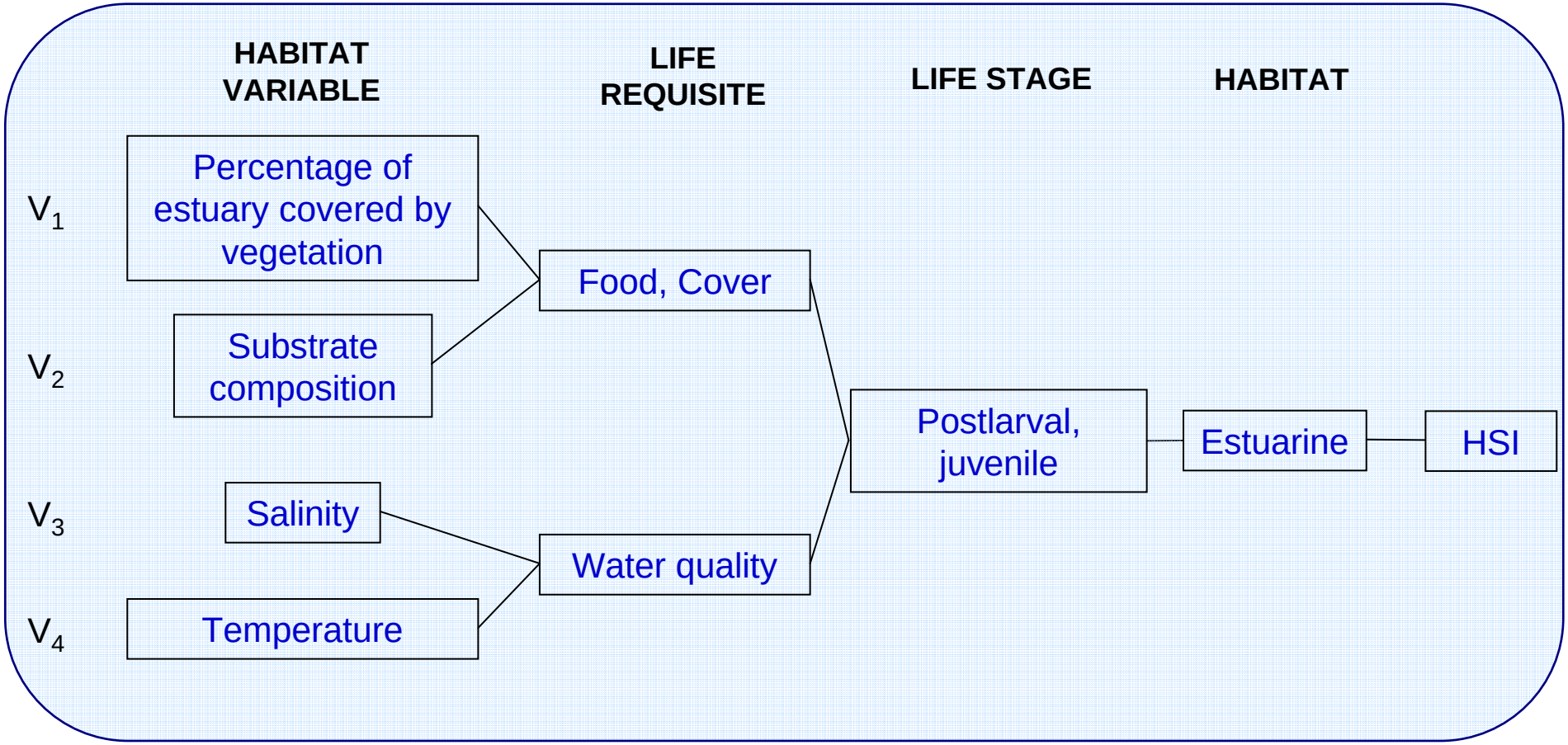
What's the Assessment Unit?

Using a grid design for a state-level probabilistic survey, the smallest assessment unit within an estuary is the "polygon."

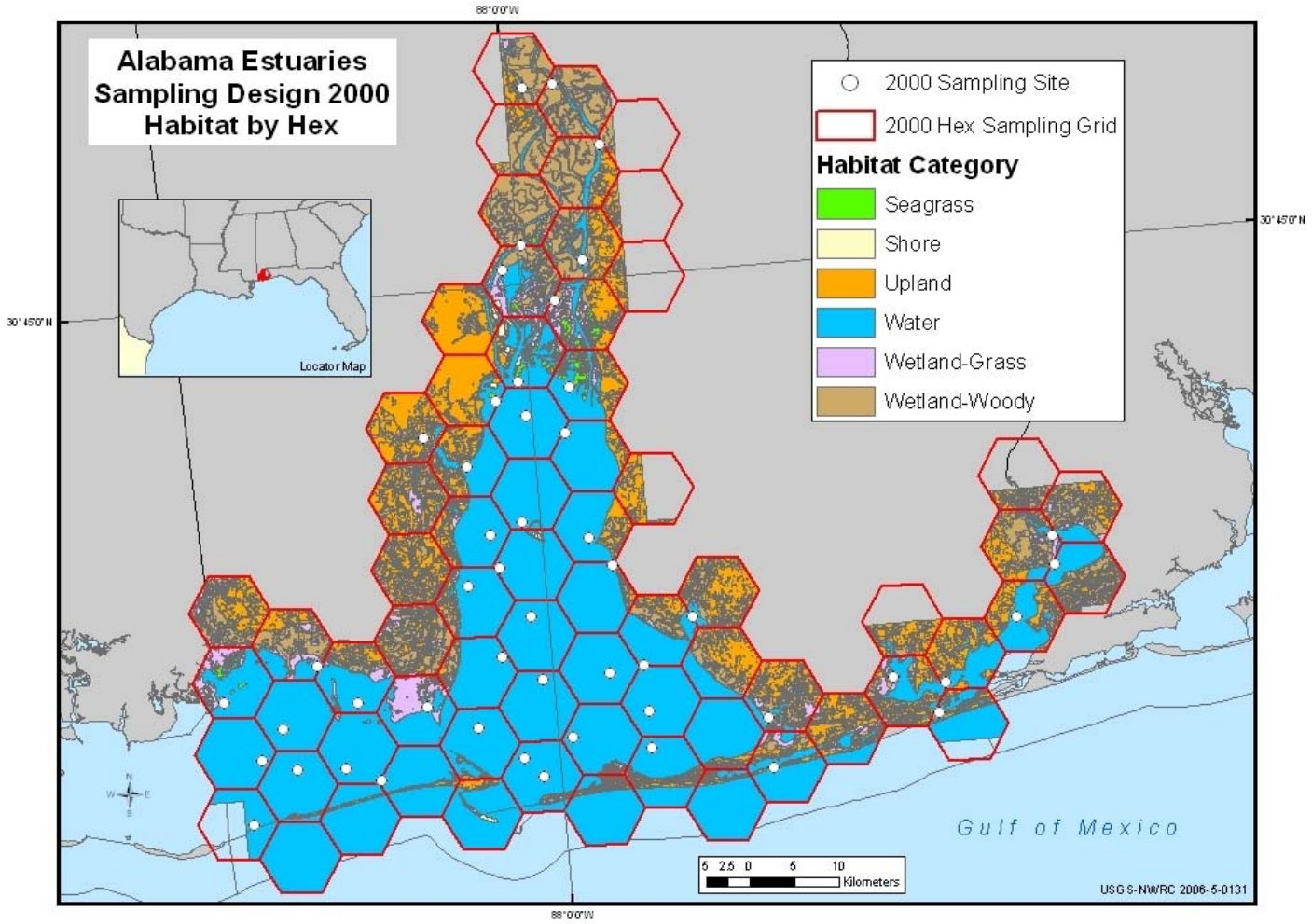


NCA State-levelSurvey Design for Alabama Estuaries

U.S. Fish & Wildlife Service Habitat Suitability Index (HSI) Models: Northern Gulf of Mexico Brown Shrimp

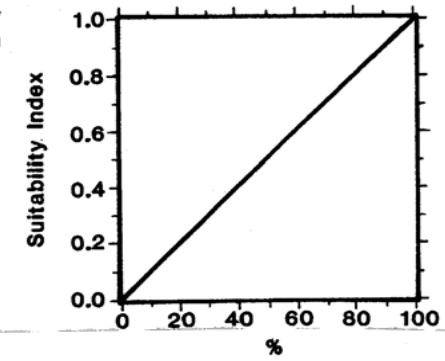


Land cover Data Used to Calculate the Area of Each Habitat Category Within Each Polygon



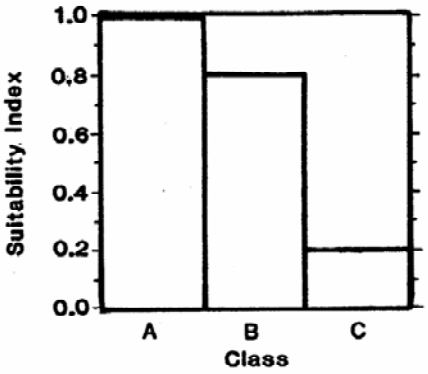
Habitat Suitability Graphs

V_1 Percentage of estuary covered by vegetation (marsh and seagrass).

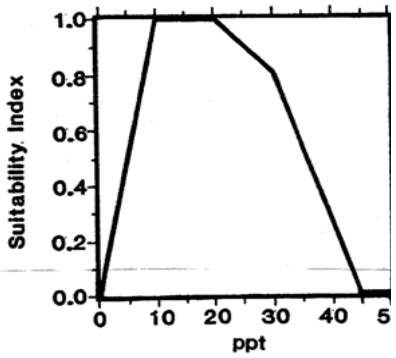


V_2 Substrate composition --

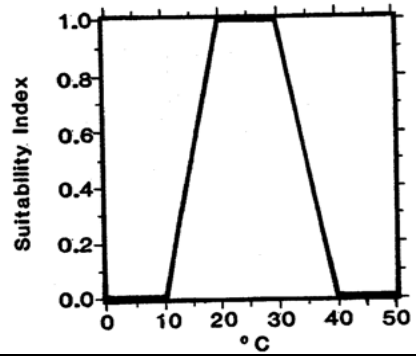
1) Soft bottom -- peaty silts, organic muds with decaying vegetation and organic material.
2) Muddy sands, fine sands.
3) Coarse or hard bottom -- sands, shell, gravel with little or no organic material.



V_3 Mean salinity



V_4 Mean water temperature



Turner, R. E. and M. S. Brody. 1983. Habitat suitability index models: Northern Gulf of Mexico brown shrimp and white shrimp. U.S. Fish & Wildlife Service FWS/OBS-82/10.54: 24p.

Suitability Index (SI) values for each variable (V_x) were determined from the graphs and used to calculate the food and cover (*FC*) and water quality (*WQ*) components of the HSI for each polygon:

$$FC^{*} = (SI^{2}_{V1} \times SI_{V2})^{1/3}$$

$$WQ = (SI_{V3} \times SI_{V4})^{1/2}$$

*At stations where SAV was not expected to occur naturally, the FC variable was calculated as $(SIV2)^{1/3}$

The HSI value is equal to the FC or WQ component value; whichever is lowest

Example data from Mobile Bay, AL

sta_name	SIV1	SIV2	SIV3	SIV4	SIV1_2	(SIV1_2*SIV2)	FC	(SIV3*SIV4)	WQ	HSI
AL00-0001	0.2	0.6	0.3	1.0	0.06	0.034	0.3	0.3	0.5	0.3
AL00-0002	0.1	0.4	0.6	1.0	0.01	0.004	0.2	0.6	0.8	0.2
AL00-0003	0.0	1.0	0.7	1.0	0.00	0.000	1.0	0.7	0.8	0.8
AL00-0004	0.2	0.8	0.3	1.0	0.02	0.020	0.3	0.3	0.5	0.3

Polygon scale (site) assessment

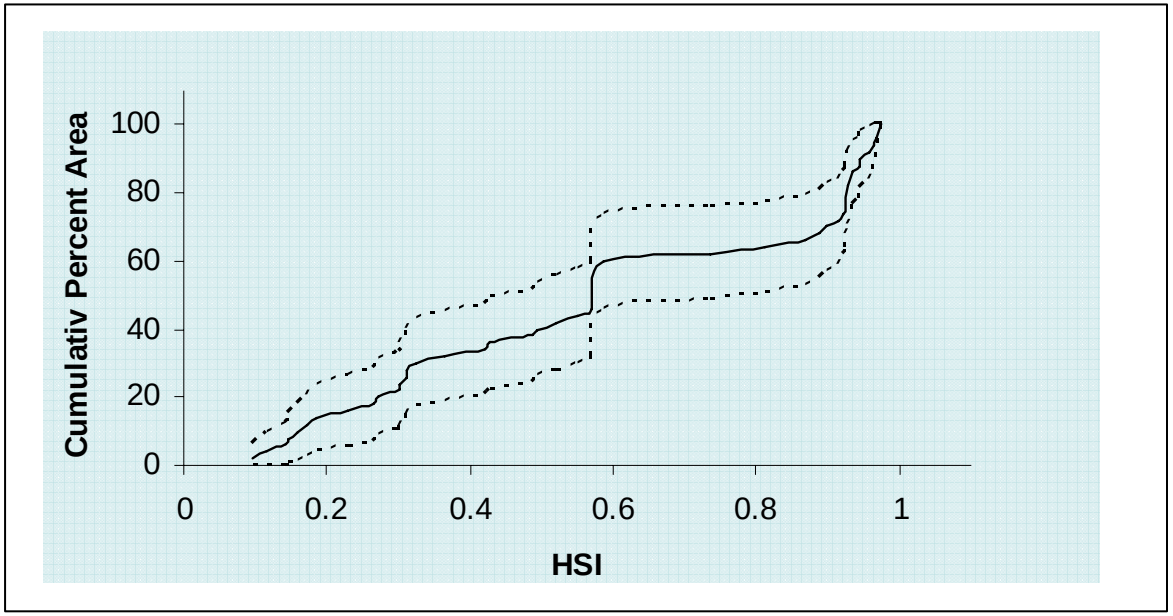
Assigning a Habitat Score

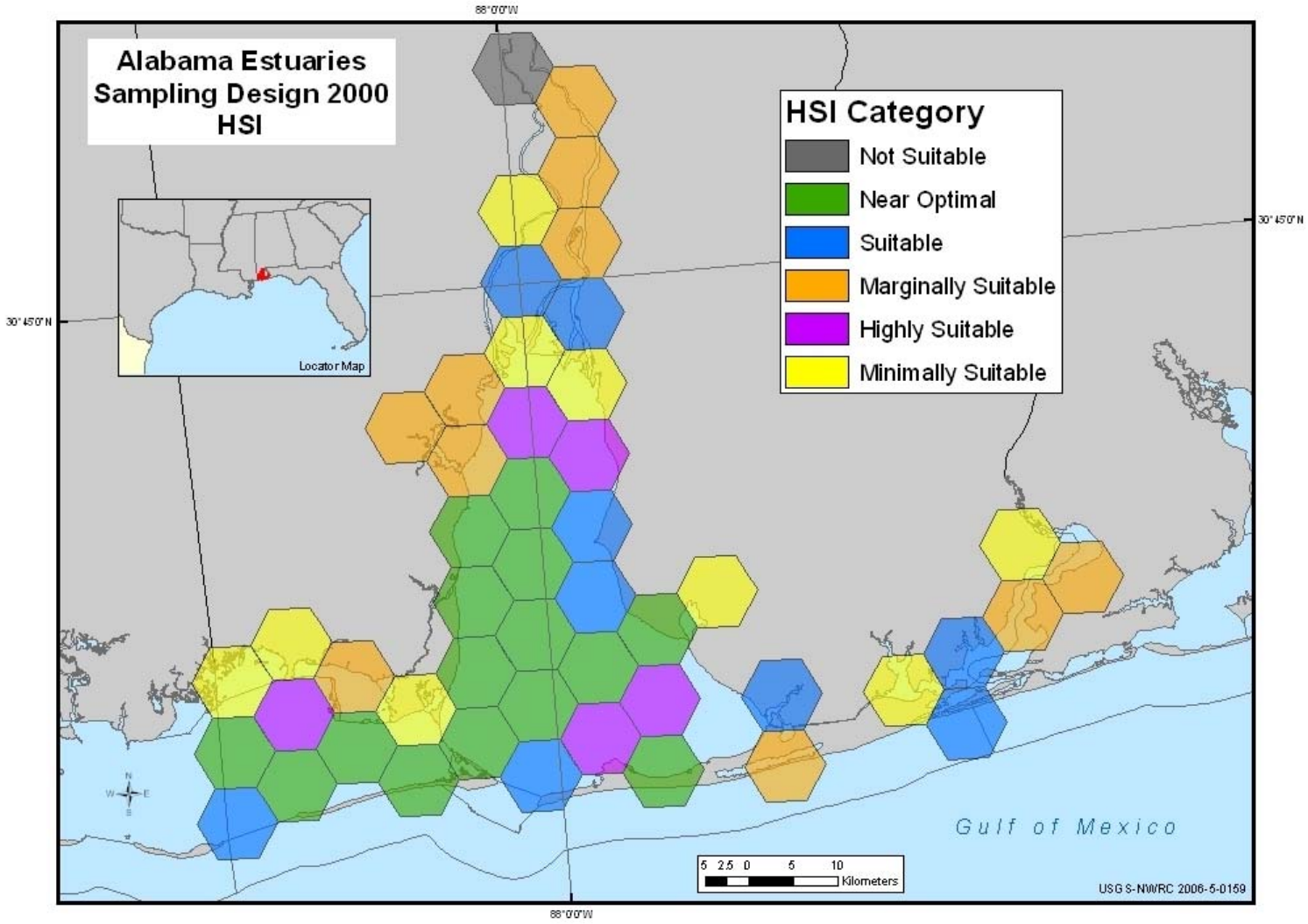
The HSI were given a condition description according to the following threshold values:

Calculated HSI	Habitat Assessment
< 0.1	Not suitable
0.1-0.3	Marginally suitable
>0.3-0.5	Minimally suitable
0.5-0.7	Suitable
>0.7-0.9	Highly suitable
>0.9	Near Optimal

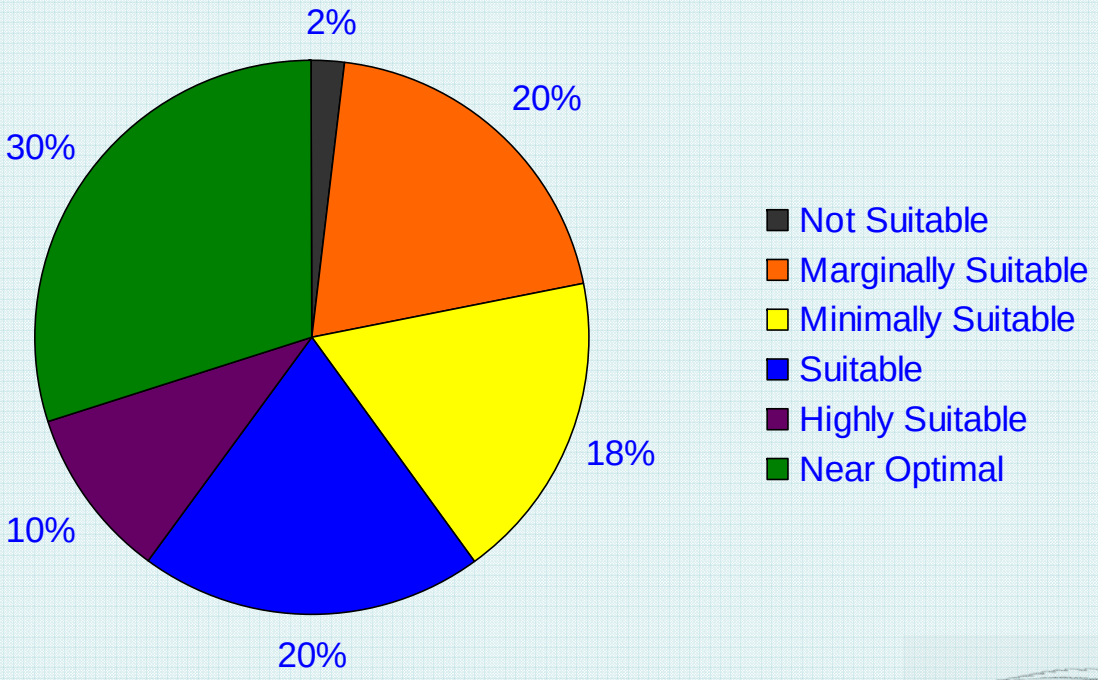
Since the survey data were collected using a random probabilistic survey design-

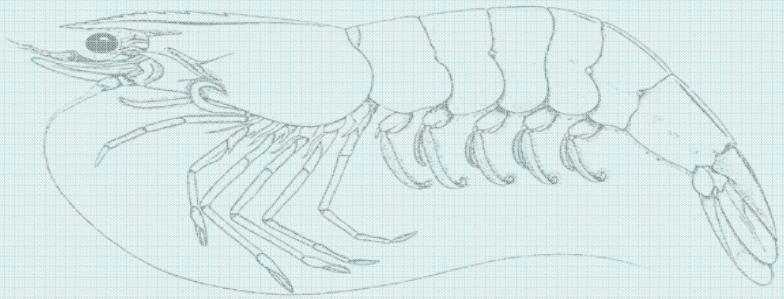
The cumulative distribution function (CDF) can be used to estimate the areal extent of habitat suitability based on these ranges.




Alabama Estuaries
Sampling Design 2000
HSI
HSI Category
Not Suitable
Near Optimal
Suitable
Marginally Suitable
Highly Suitable
Minimally Suitable
Locator Map
88°0'0"W
30° 45'0"N
Gulf of Mexico
5 2.5 0 5 10
Kilometers
USGS-NWRC 2006-5-0159

The estimated areal extent of habitat suitability for brown shrimp in Mobile Bay, AL

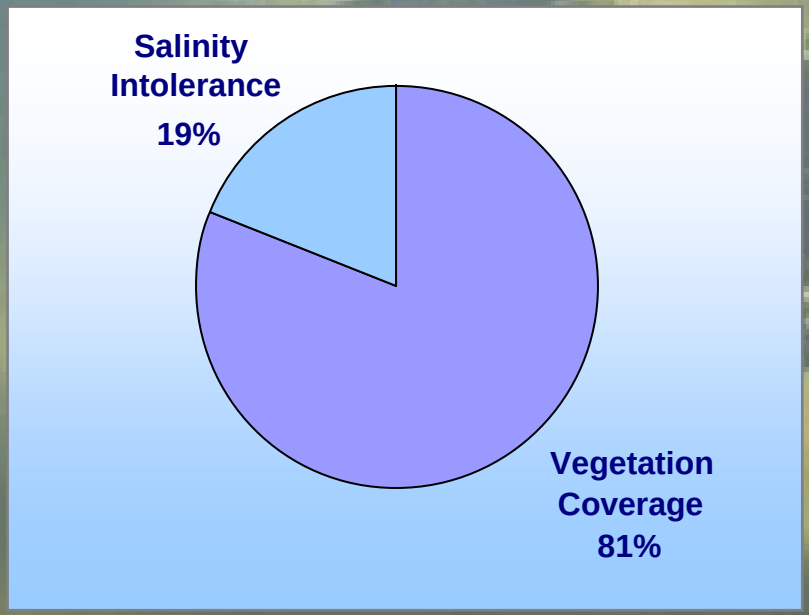




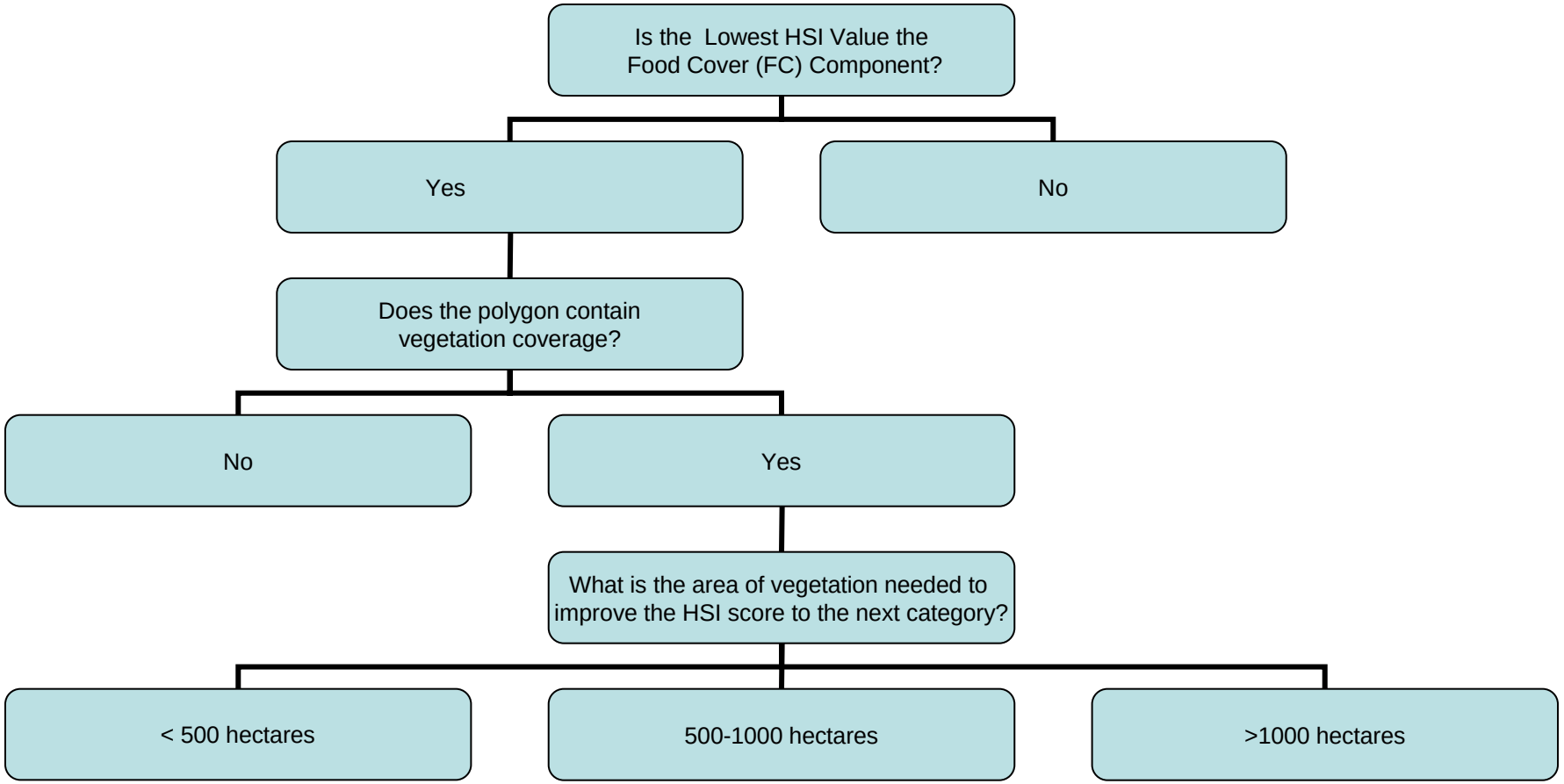
You wanna put that dock where?

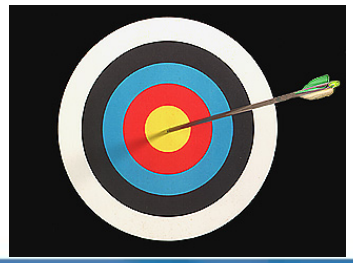
- Knowing the areal extent of habitat suitability for a given species helps support decisions to protect habitat
- Reducing vegetation coverage in a polygon will decrease the food cover value of the area and could decrease the quality of habitat
- On the other hand, where habitat is not suitable, can it get any worse?

Habitat Suitability scores less than 'suitable' (minimally, marginally or not suitable) were broken down into the components contributing to the condition



Where habitat condition is less than suitable…





Candidate hexagons were targeted for vegetation restoration, based on the following:

Habitat Condition:

not suitable
marginally suitable
minimally suitable
suitable
highly suitable
near optimal

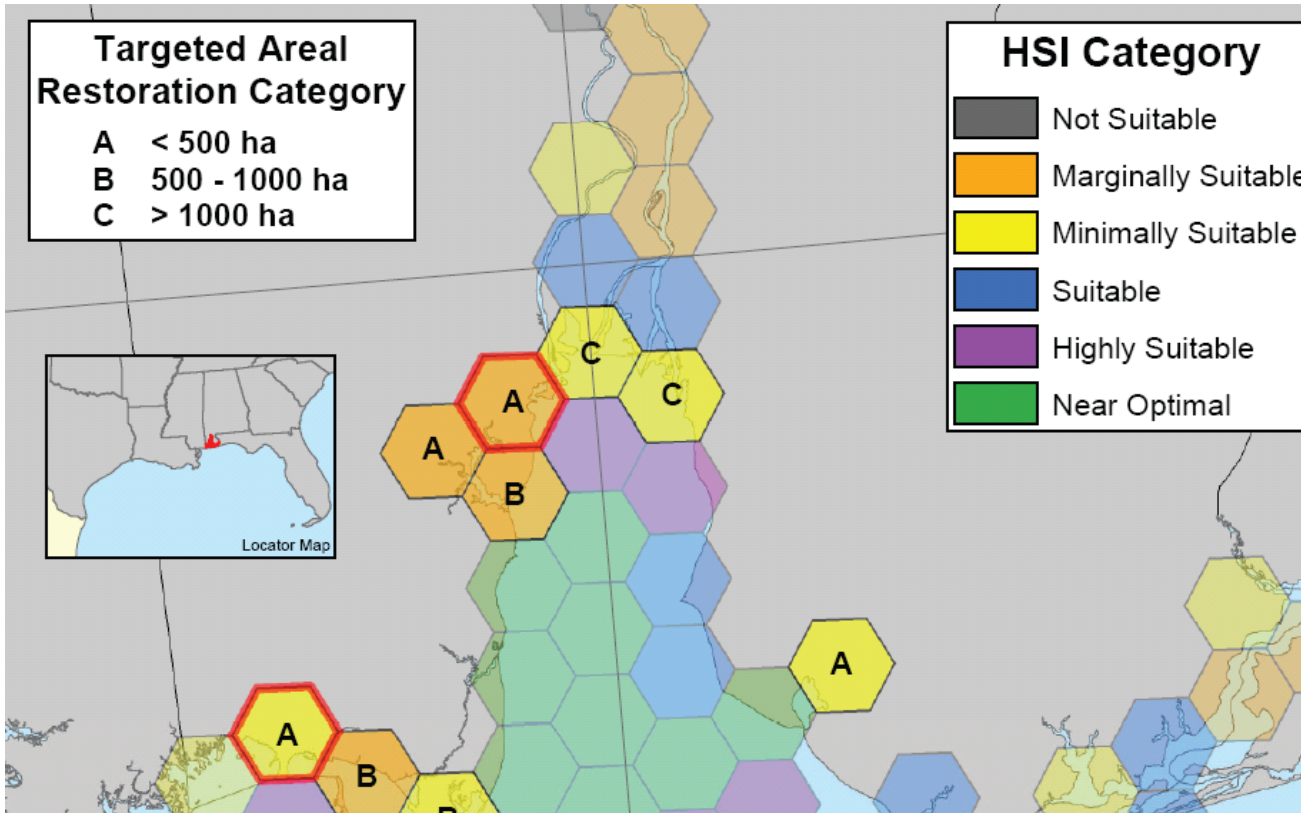
Specific physical parameters:

salinity
temperature
grain size
depth
vegetation coverage

Areal extent of restored vegetation needed to improve the polygon's HSI score to the next category.

The two hexagons outlined in red were identified as having both existing SAV and requiring < 500 ha of restored vegetation to improve the HSI score.

Areas with existing vegetation are more likely to support SAV restoration efforts; therefore the areas within these two hexagons are candidates for targeted SAV restoration to improve brown shrimp habitat suitability.

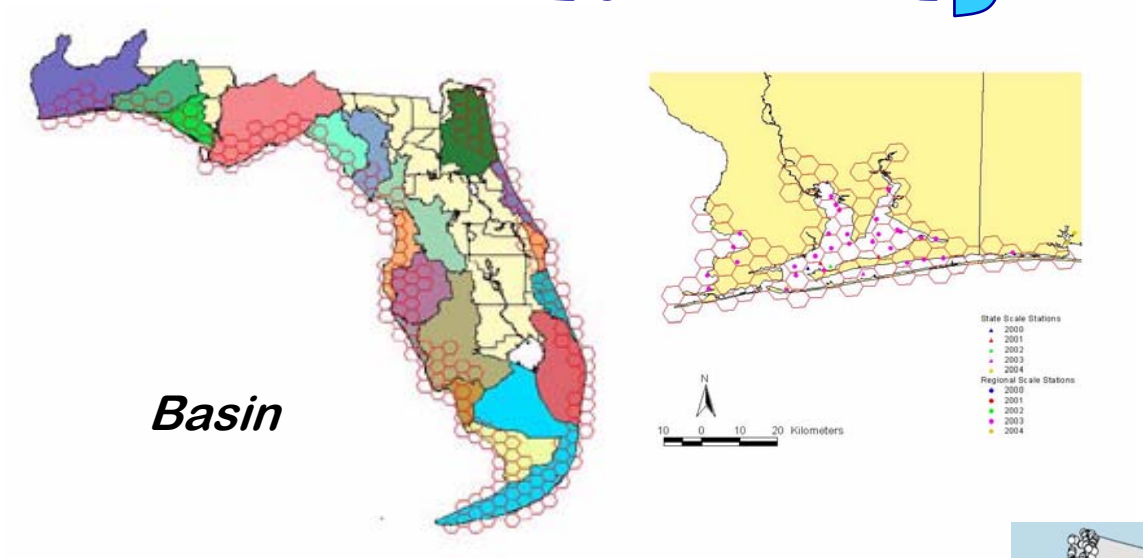


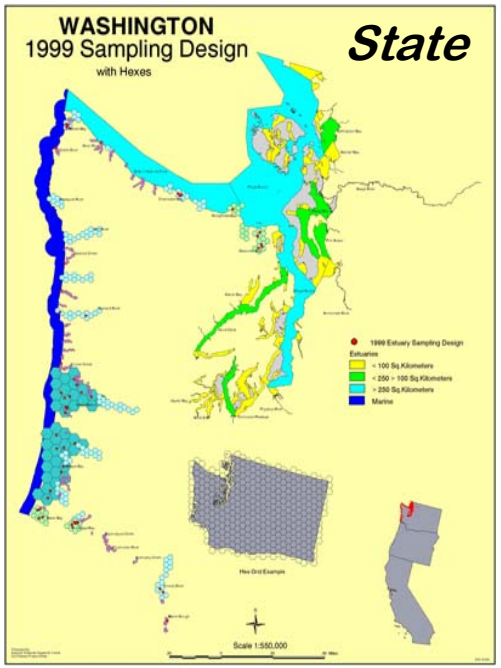
Data Availability

Data for this approach is available for all the nation's estuarine resources

(thanks NCA and NWI)

Scalability





Multiple scales

Versatility

This approach can be applied using generic HSI models like the FWS or more refined models developed for individual systems. Either way, the result is an estimated proportion of habitat in a given condition.

The approach could be used as a screening tool to answer management questions such as:

- What areas could be restored to improve habitat quality
- How does this restoration contribute to the areal percentage of suitable habitat within an estuary? Region?
- and maybe later… Has restoration improved habitat condition?