Generalized Additive Model Analysis: Summary of approach and highlights of results

Closed Area Technical Team/Groundfish PDT meeting
April 4, 2013

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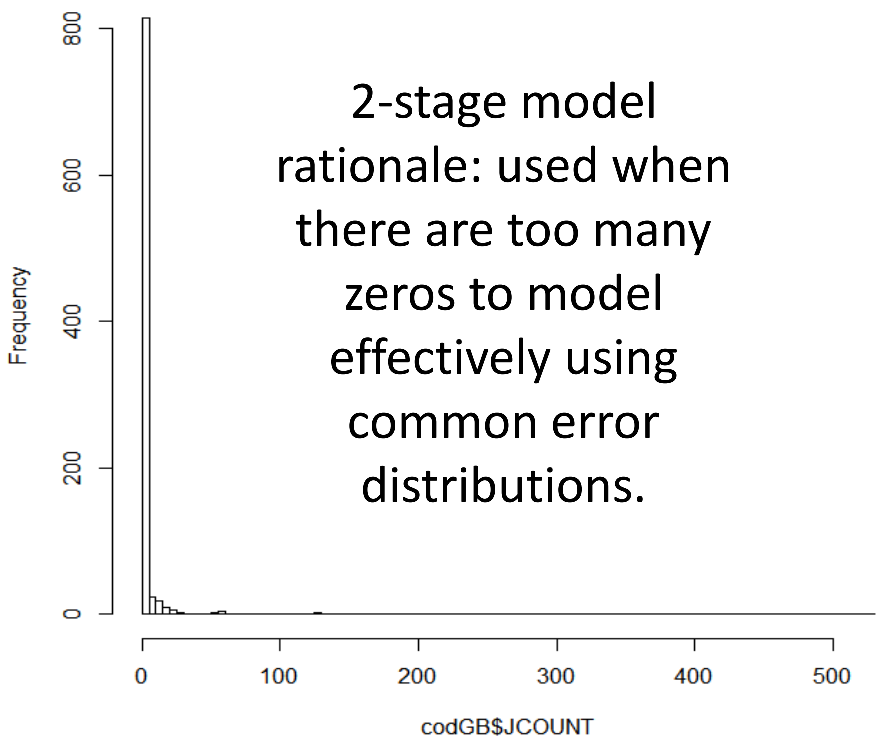
Presented by Michelle Bachman, NEFMC staff

Purpose: Estimate habitat association parameters for juvenile cod (GB and GOM) and yellowtail flounder (GB) using generalized additive models



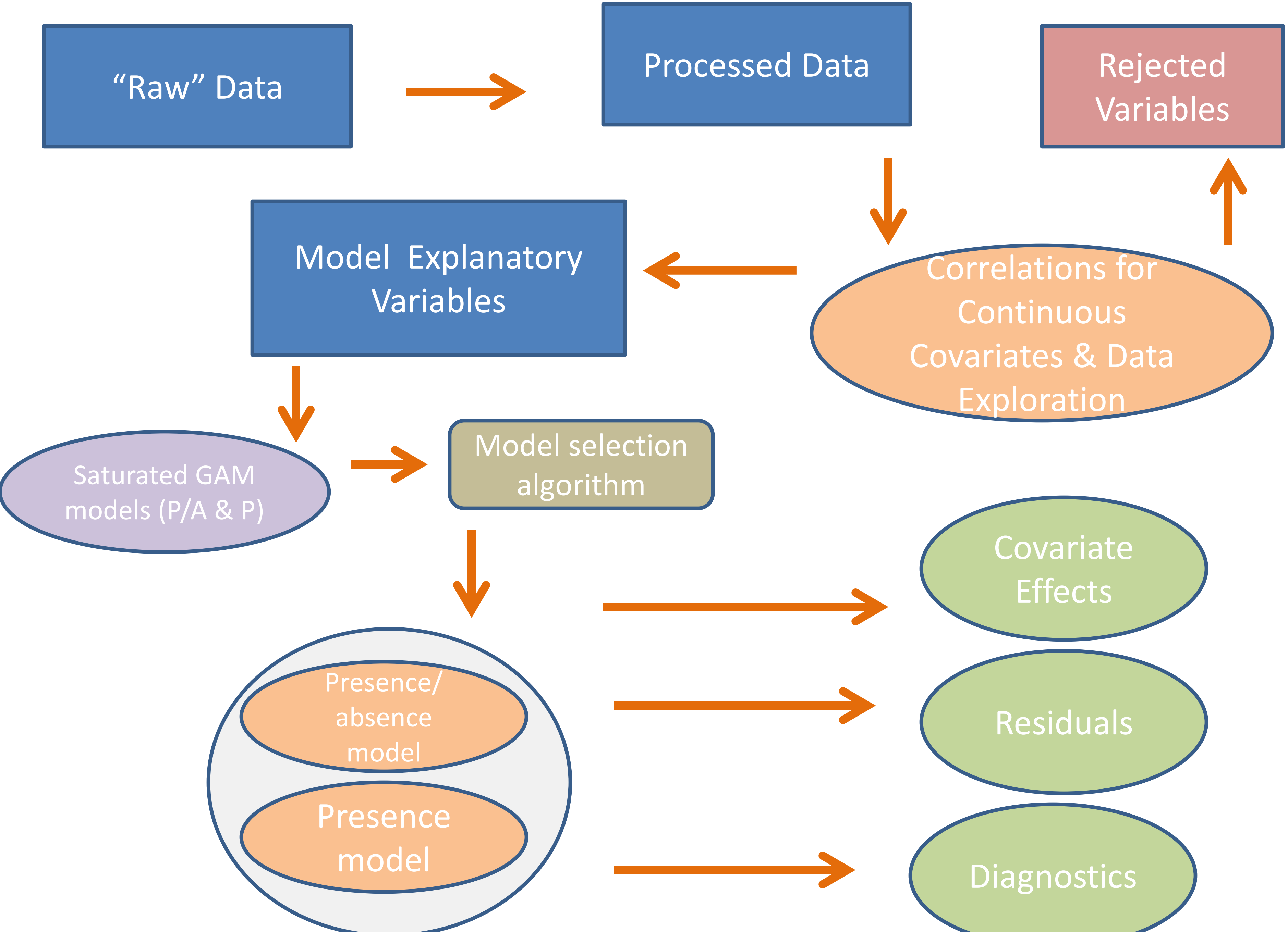
2-stage model rationale: used when there are too many zeros to model effectively using common error distributions.

Procedure:

(1) Build a model for the data that is presence absence (set all abundances to a value of 1)

(2) Build a second model that describes the presence-only data (i.e. discard the zeros) – here used log(Juv. count) as response

(3) Overall predictions can be made by multiplying the probability of presence from model (1) by the predicted abundance from model (2)


"Raw" Data
Processed Data
Rejected Variables
Model Explanatory Variables
Correlations for Continuous Covariates & Data Exploration
Saturated GAM models (P/A & P)
Model selection algorithm
Covariate Effects
Presence/ absence model
Residuals
Presence model
Diagnostics

Notes on the interpretation of the models

(1) In general, the data we have leave much variance unexplained. Still, this does not discount the importance of individual model terms that were found to be important

(2) Model-output spline smooths represent essentially the standardized effect of each variable on the response. While this represents different information than a simple plot of the variable against the response, if these two validate each other this increases confidence in the relationship

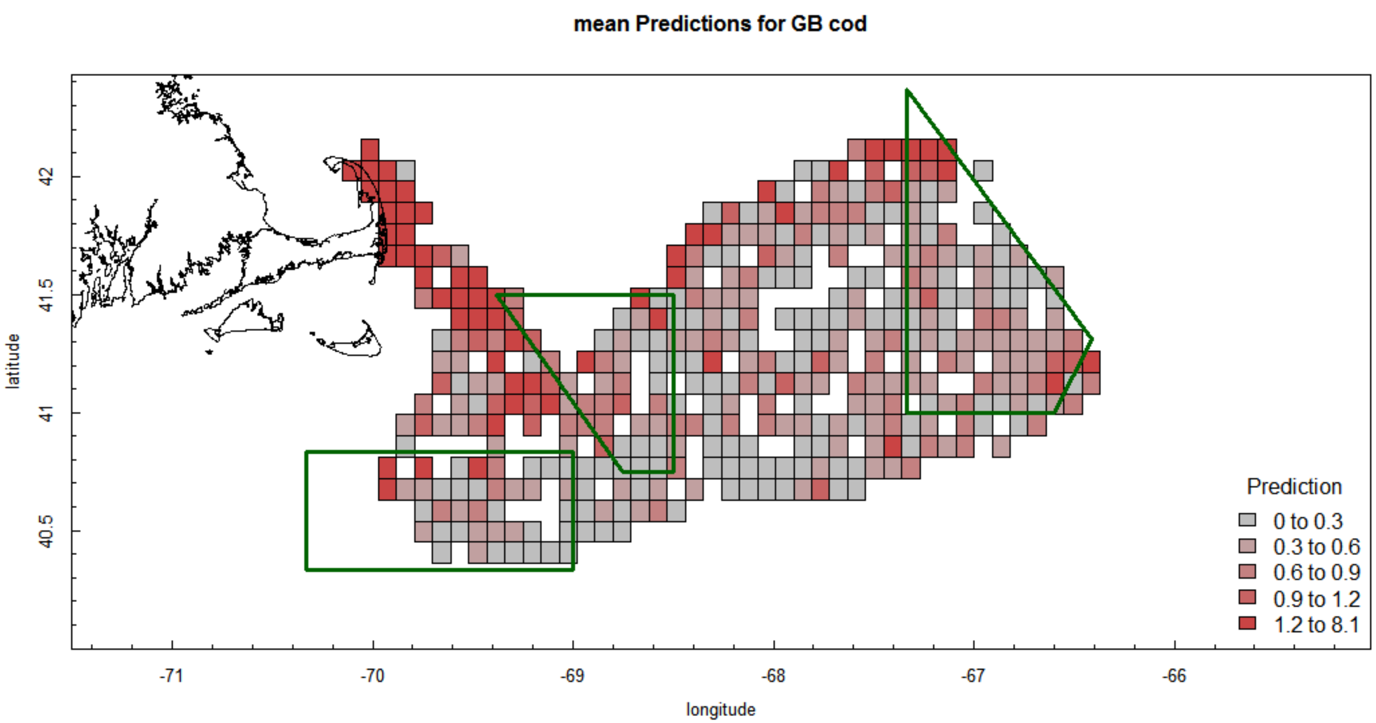
(3) Some model diagnostics render the model questionable in terms of predictions, but again this does not discount the importance of individual terms that are found to be significant (though in this case the relationship should be further verified)

Georges Bank cod

The general saturated model for Georges Bank cod was:

$$\hat{J} = SEA + PC + SBF + SD + s(SC) + s(STR) + s(T) + s(Z) + s(D)$$

Where SEA is season, PC is purpose code (survey type), SBF is seabed form, SD is dominant sediment type, SC is sediment coarseness, STR is shear stress, T is temperature, Z is zenith angle at tow-time, and D is depth. $\hat{J}$, the expected value of the response, was zero or one for the presence-absence model and the logged measured juvenile abundance for the conditional presence model.



Final variables in GB cod presence/absence model – explained 31.8% deviance, reasonable diagnostics

Variable	**Direction of relationship**
Purpose code	
Season	Fewer cod in spring
Sediment coarseness	Positive linear relationship
Shear stress (marginal)	Expected abundance decreased with increasing shear stress between values of 1 and 3
Zenith (marginal)	Slightly positive linear effect, indicates increase in catches at night
Temperature	Bottom temperature to have a highly negative almost linear effect
Depth	Depth to have a positive effect between approximately 5 to 35 meters and then a strong negative effect between depths of about 35 to 80 meters

Final variables in GB cod conditional presence model – 6.1% of deviance, mixed diagnostics

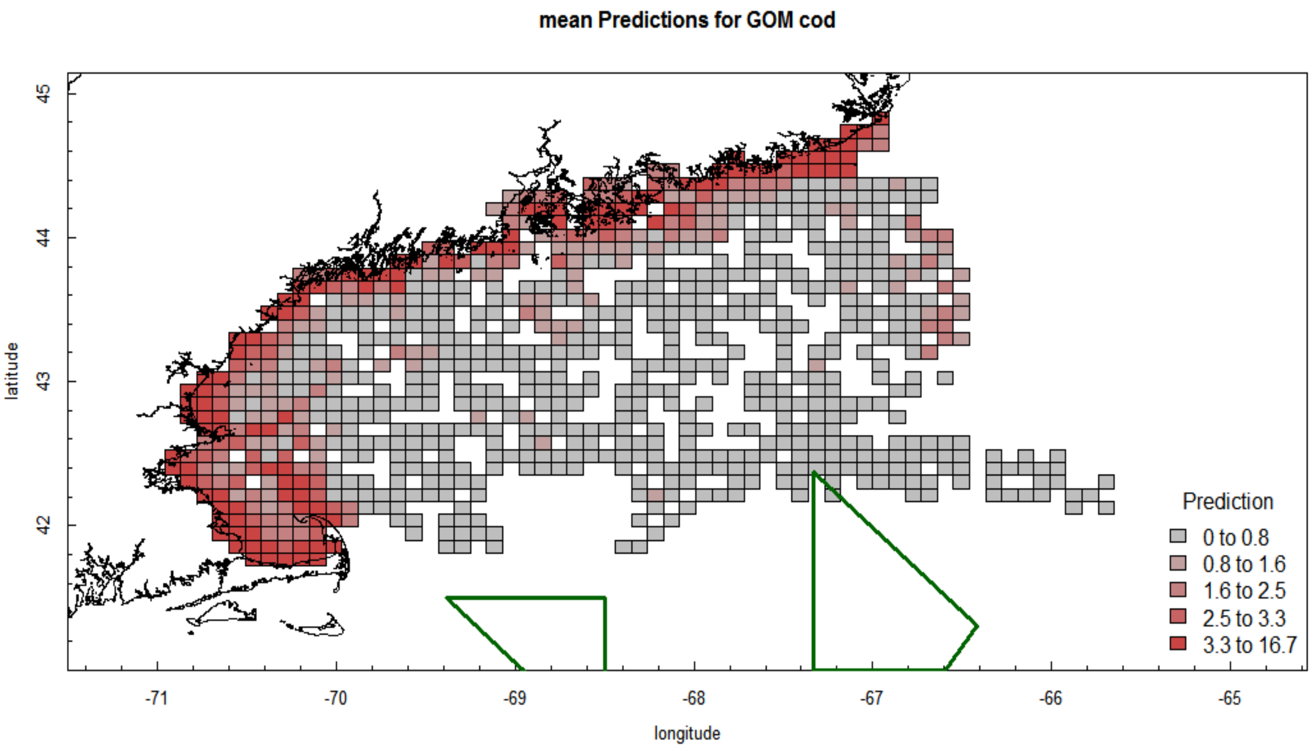
Variable	**Direction of relationship**
Shear stress (marginal)	Negative and linear, so expected abundance decreased with increasing shear stress, but the residuals show much scatter around the trend line

Gulf of Maine cod

The general saturated model for Gulf of Maine cod was:

$$\hat{J} = SEA + PC + SBF + SED + s(T) + s(Z) + s(D)$$

Where SEA is season, PC is purpose code (survey type), SBF is seabed form, SED is sediment type, T is temperature, Z is zenith angle at tow-time, and D is depth. $\hat{J}$, the expected value of the response, was zero or one for the presence-absence model and the logged measured juvenile abundance for the count model.



Final variables in GOM cod presence/absence model – explained 20.7% deviance, mixed diagnostics

Variable	Direction of relationship
Sediment type	Mud had a very negative effect and the smallest and extra-large sand categories also had a negative effect though they were weaker.
Seabed form	The “high flat” and “high slope” seabed form categories had a strong positive effect.
Temperature	Highly significant, negative effect on abundance. Temperature effect shows a sharp decline at values less than about five, followed by a more gradual decline between 5 and 11 degrees, then a steeper decline again at temperatures higher than 11 (though there is relatively less data at these higher temperatures)
Depth	Highly significant, negative effect on abundance. On average, abundance is highest at depths between approximately 0 and 80 meters, then declines rapidly after that.

Final variables in GOM cod conditional presence model – 11.3% of deviance, mixed diagnostics

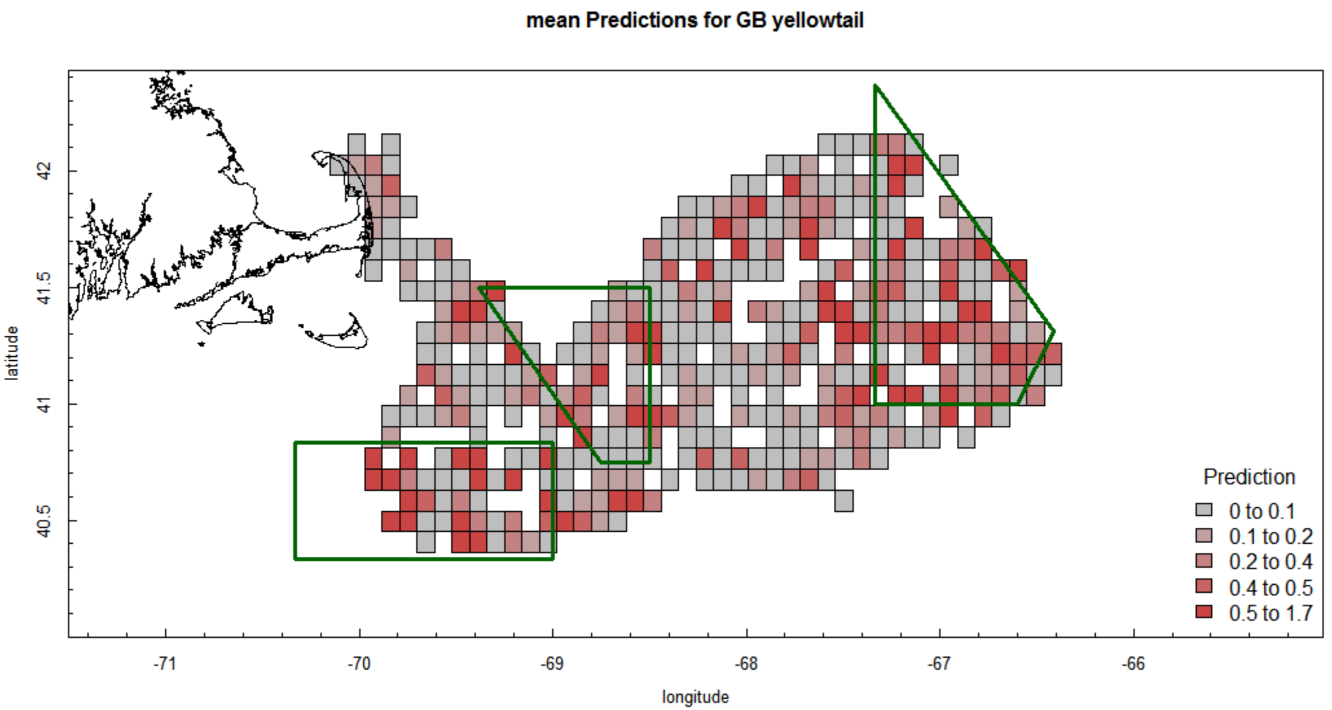
Variable	Direction of relationship
Purpose code	
Season	Spring had a highly significant, positive effect.
Sediment type	Mud had a negative effect on measured juvenile abundance, while large sand had a positive, marginally significant effect
Zenith	Significant effect but relationship unclear
Temperature	Abundance increased slightly with temperature from 0 to 10 degrees, then showed a marked decline, though there were only very few data points above 10 degrees.
Depth	The depth effect was slightly negative and linear.

Georges Bank yellowtail flounder

The general saturated model for Georges Bank yellowtail was:

$$\hat{J} = SEA + PC + SBF + SD + s(SC) + s(STR) + s(T) + s(Z) + s(D)$$

Where SEA is season, PC is purpose code (survey type), SBF is seabed form, SD is dominant sediment type, SC is sediment coarseness, STR is shear stress, T is temperature, Z is zenith angle at tow-time, and D is depth. $\hat{J}$, the expected value of the response, was zero or one for the presence-absence model and the logged measured juvenile abundance for the conditional presence model.



GB yellowtail presence/absence – explained 23.3% deviance, poor diagnostics

Variable	**Direction of relationship**
Purpose code	
Season	Many more yellowtail in spring
Seabed form (marginal)	More yellowtail on high flats
Sediment coarseness (marginal)	Significant term but spline relationship questionable. Sediment coarseness increased slightly across values less than about 2.2 and decreased slightly at values larger than about 2.5 but these effects were small.
Zenith angle	Had a highly significant, positive, almost linear effect indicating that more yellowtail are caught at night
Depth (marginal)	Significant term but spline relationship questionable. Estimated abundance increased slightly with depth until about 85 meters, after which it declined.

GB yellowtail conditional presence – 52.9% of deviance, reasonable diagnostics

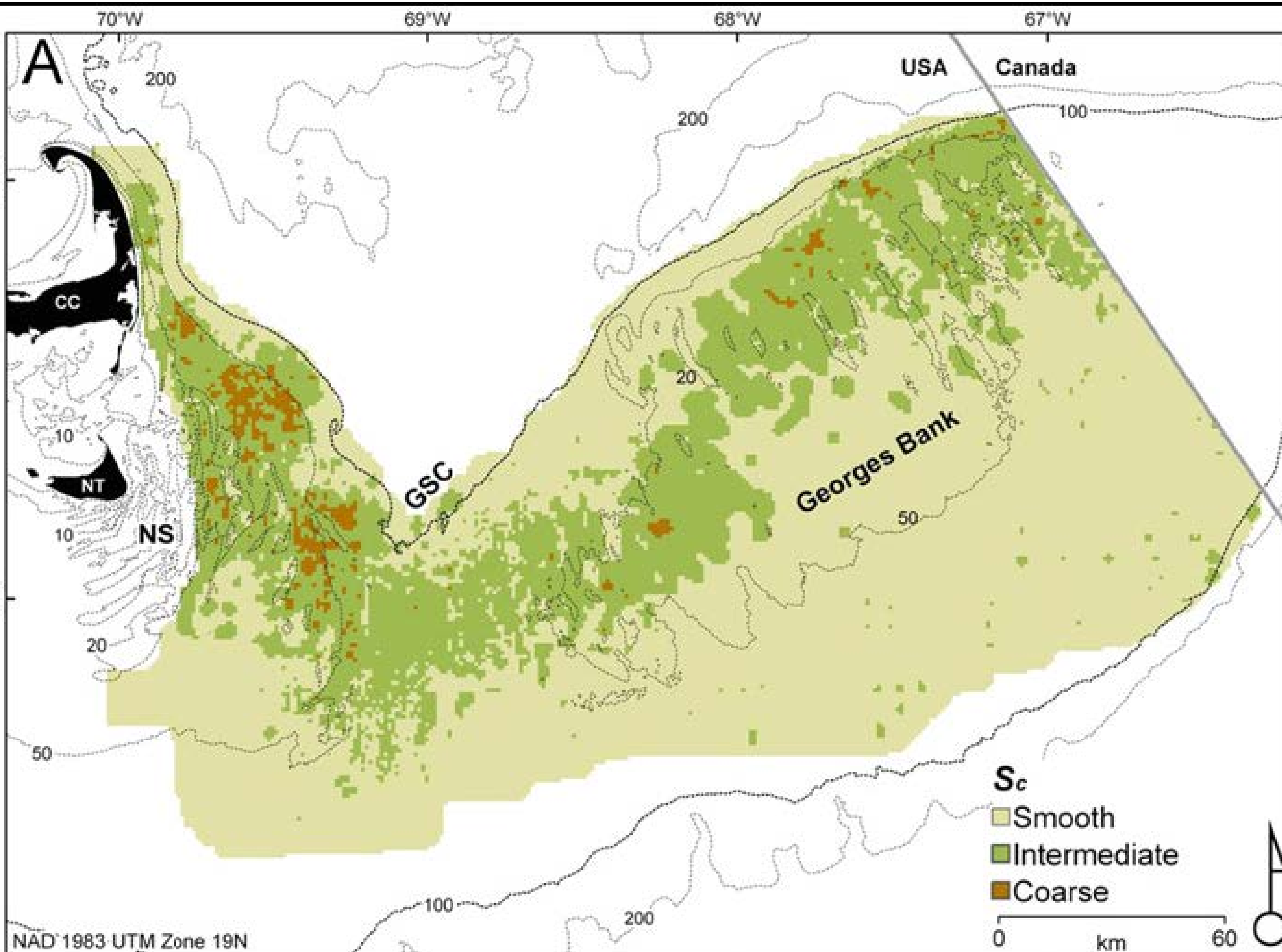
Variable	**Direction of relationship**
Purpose code	
Sediment coarseness (marginal)	Complicated spline relationship
Temperature (marginal)	The temperature effect was positive between 4 and 7 degrees where most of the data lay, and then declined at higher values.
Depth	The depth effect was negative and linear

Table 2: Summary of parameter effects for all models. +/++ = positive/very positive effect; -/-- = negative/very negative; ~ = complicated spline relationship; 0 = significant term but spline relationship questionable. Dominant sediment not significant for GB cod or GB YTF, so not shown.

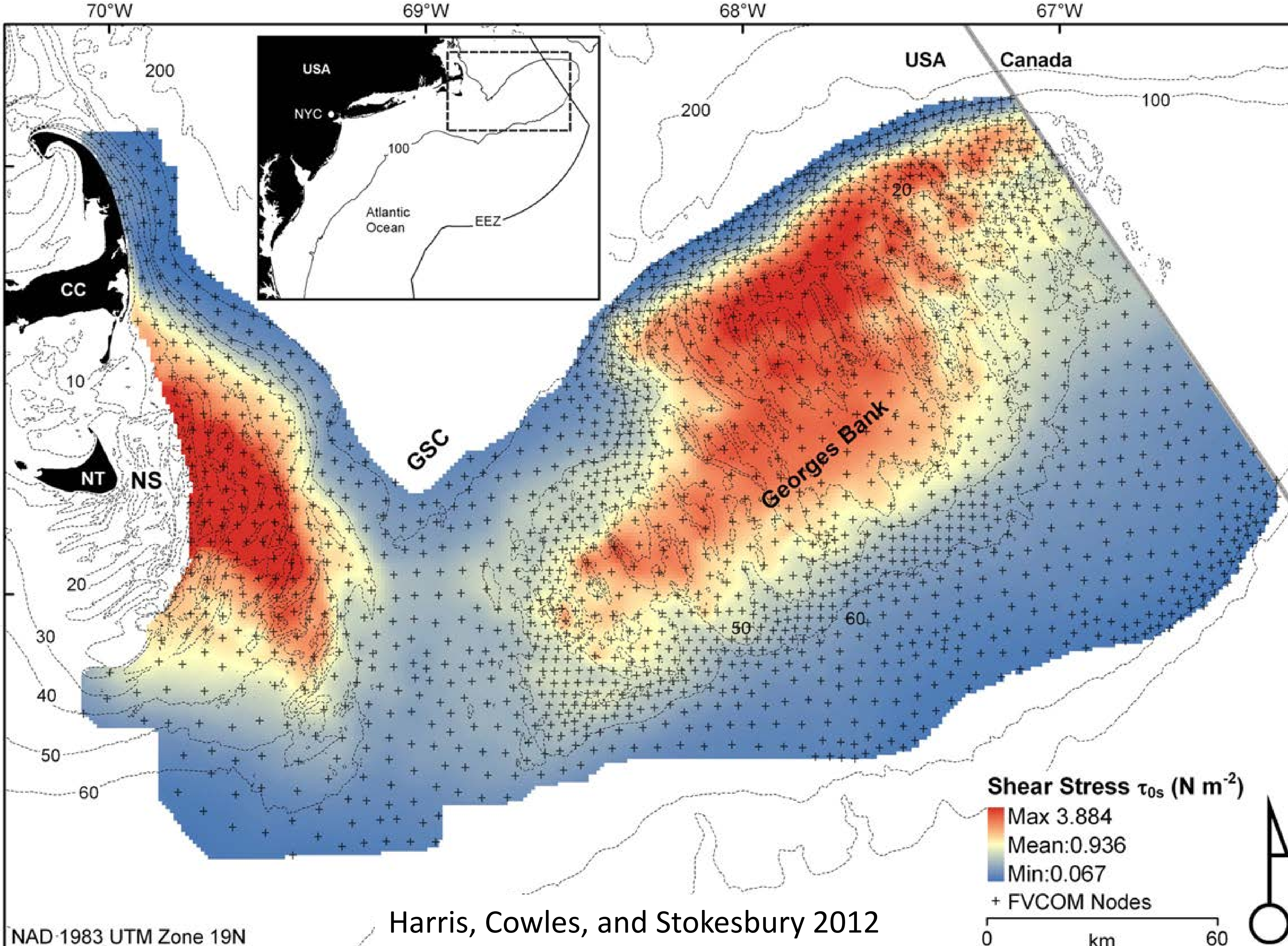
Variable	(Relative to)	GB Cod		GOM Cod		GB Yellowtail	
		P/A	P	P/A	P	P/A	P
DEPTH		— —		— —	—	0	— —
TEMPERATURE		— —		— —	~		~
ZENITH		+			0	+ +	
Sed Coarseness		+ +		NA		0	~
Shear Stress		—	—	NA			
Season – Spring	Fall	— —			+ +	+ +	
SB Form – High Flat	Depression			+ +		+	
SB Form – High Slope	Depression			+ +			
SB Form – Low Slope	Depression						
SB Form – Mid Flat	Depression						
SB Form – Side Slope	Depression						
Sediment – SandXL	Gravel	NA		—			NA
Sediment – SandLarge	Gravel	NA			+		NA
Sediment – SandMed	Gravel	NA					NA
Sediment – SandSmall	Gravel	NA		—			NA
Sediment – Silt/Mud	Gravel	NA		— —	—		NA

Summary of results

- The habitat variables that (qualitatively) proved most important in determining the distribution of the juvenile groundfish stocks we examined were depth and bottom temperature and both had generally negative effects on abundance (i.e. abundance decreased with increasing depth or temperature). Season, sediment, and the shape of the seabed were also important, but the particular effects were not as consistent across the stocks (and in the case of sediment could not be compared across all three). Zenith angle was also an important standardizing variable in some cases.
- Juvenile cod on Georges Bank were predicted to occur mostly off Cape Cod, in the Great South Channel, and along the northern edge of Georges. In the Gulf of Maine the region of highest expected catch was in Massachusetts Bay, and elsewhere the model predicted the highest abundances along the Maine coast. High predictions for Georges Bank yellowtail were scattered, though they were more common on the southeast part of Georges and in the Nantucket Lightship area.

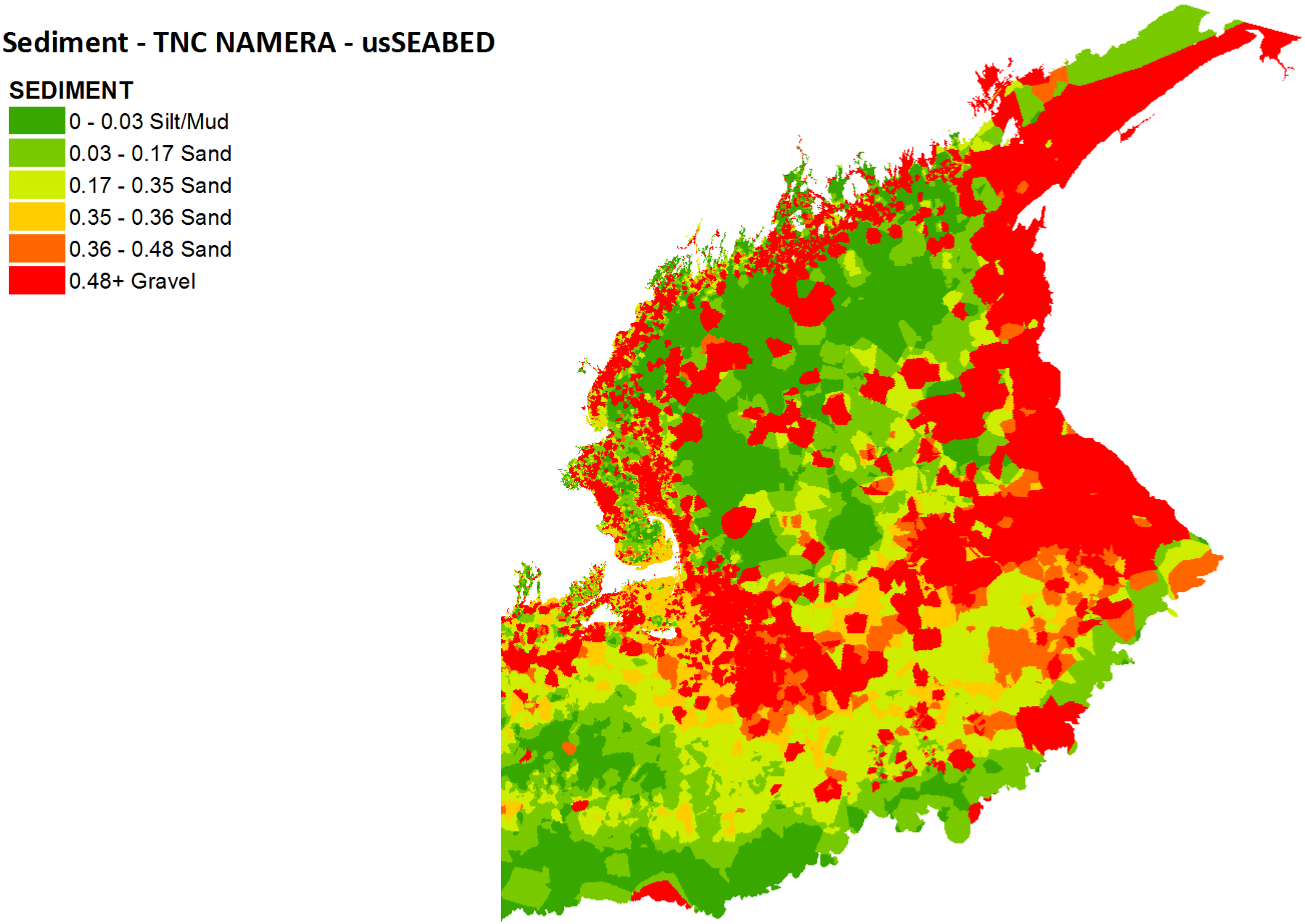


Harris and Stokesbury 2010

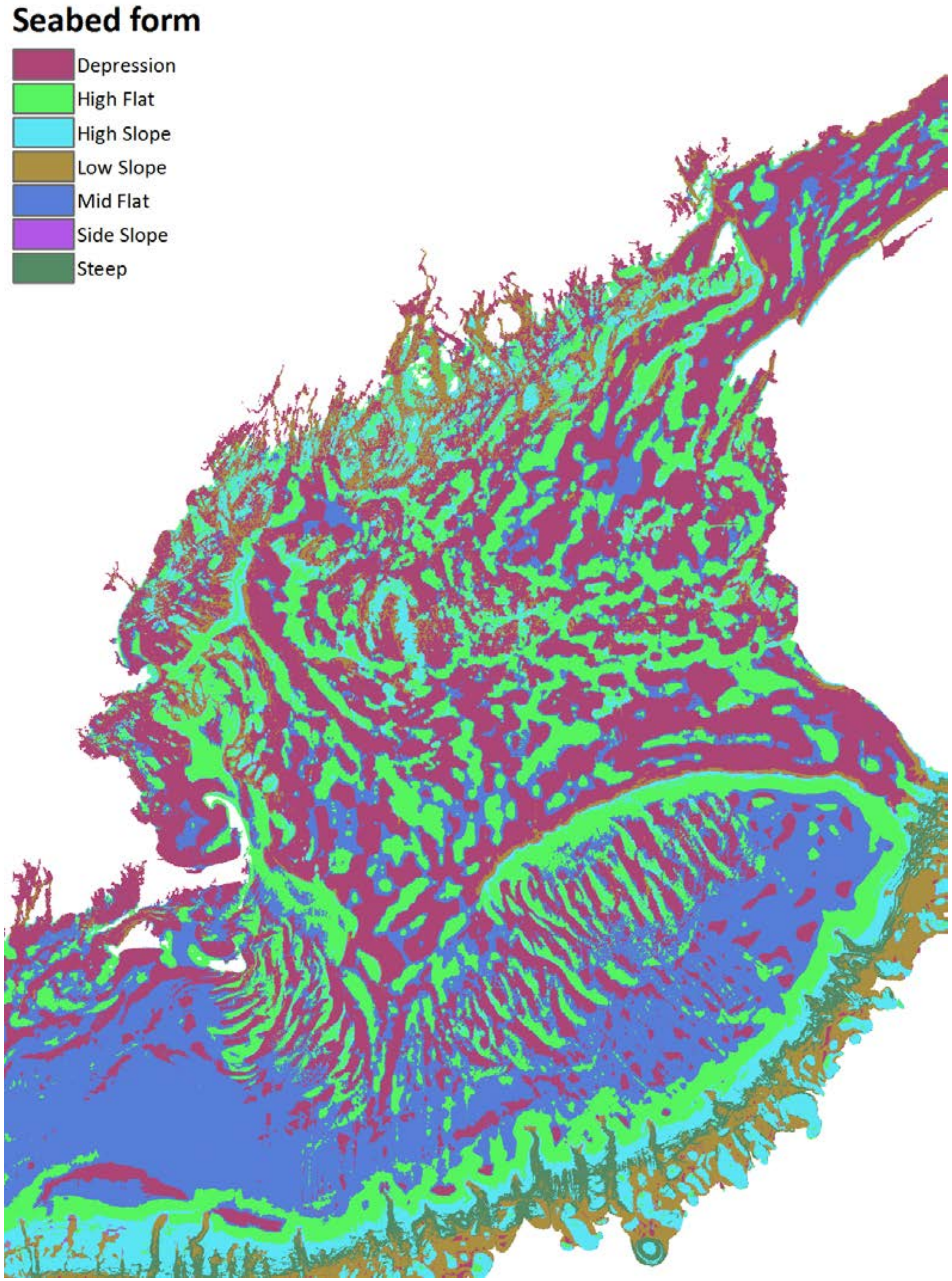


Harris, Cowles, and Stokesbury 2012

Sediment - TNC NAMERA - usSEABED



The Nature Conservancy's Northeast Marine Ecoregional Assessment



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