

Greater Amberjack (*Seriola dumerili*)

Exploring Unexplained Variability in the Stock-Recruitment Relationship Estimates in the Gulf of Mexico

Wednesday, April 14, 2021

Presented to:

Gulf of Mexico Fisheries Management Council



Presented by:

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University of South Florida, College of Marine Science



Study Scope and Objectives

- To investigate variability within the Greater Amberjack (*Seriola dumerili*) stock's **recruitment deviations** over time
- Relate recruitment variability to **ecological considerations** in the Gulf of Mexico large marine ecosystem (Gulf LME)
 - **Multiscale** analyses over space and time
 - Explicitly account for **temporal autocorrelation**
 - Focus on *Sargassum* macroalgae as habitat
 - Focus on **Ecosystem Status Report** (ESR) indicators for Gulf LME
- Identify **leading indicators** to inform formal assessment modeling and interim efforts

Data Sources & Model Parameterizations

Constrained Analysis Framework

PREDICTOR
INDICATORS

X

Anthropogenic,
Climate, Habitat,
Sargassum, Ecological

Effect ?

ONE WAY

RESPONSE
INDICATOR

Y

Greater Amberjack
Recruitment
Deviations

Hypothesized to affect
things we care about

Things we care about

Constrained Analysis Framework

PREDICTOR
INDICATORS

X

Anthropogenic,
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ONE WAY

RESPONSE
INDICATOR

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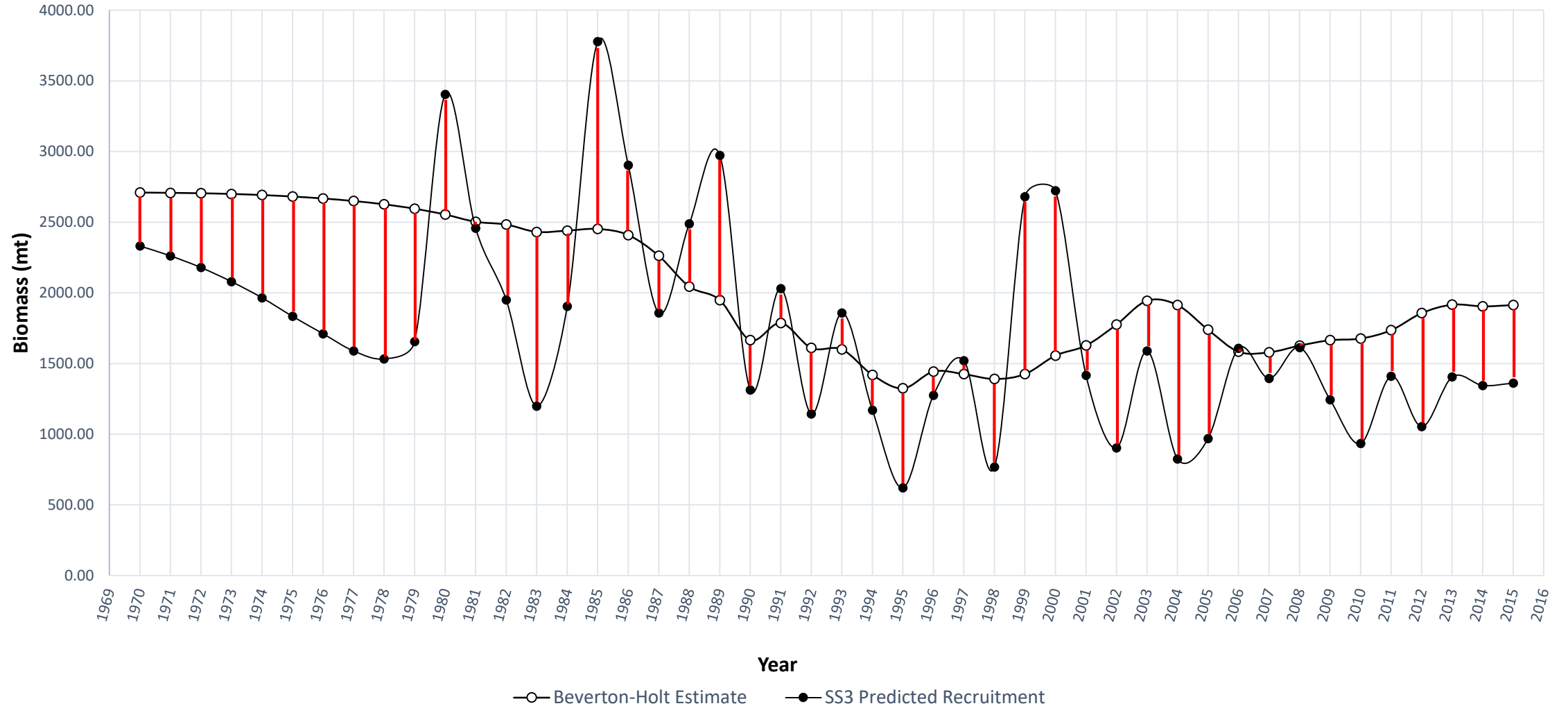
Greater Amberjack
Recruitment
Deviations

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Things we care about

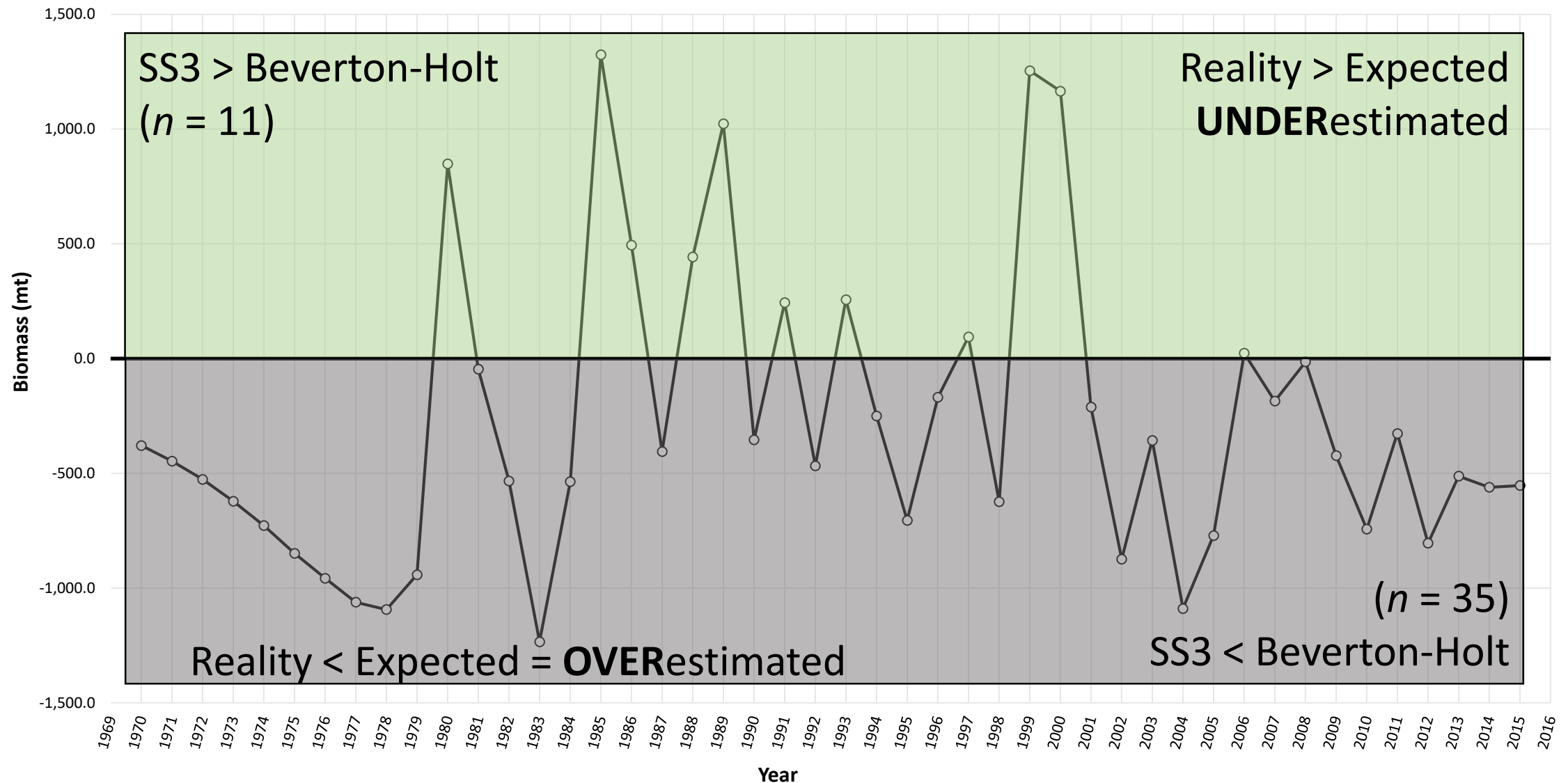
Greater Amberjack Recruitment Deviations

Greater Amberjack Stock Recruitment Biomass (1970-2015)



Greater Amberjack Recruitment Deviations

Calculated Recruitment Deviations (1970-2015)



Constrained Analysis Framework

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INDICATORS

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Effect ?

ONE WAY

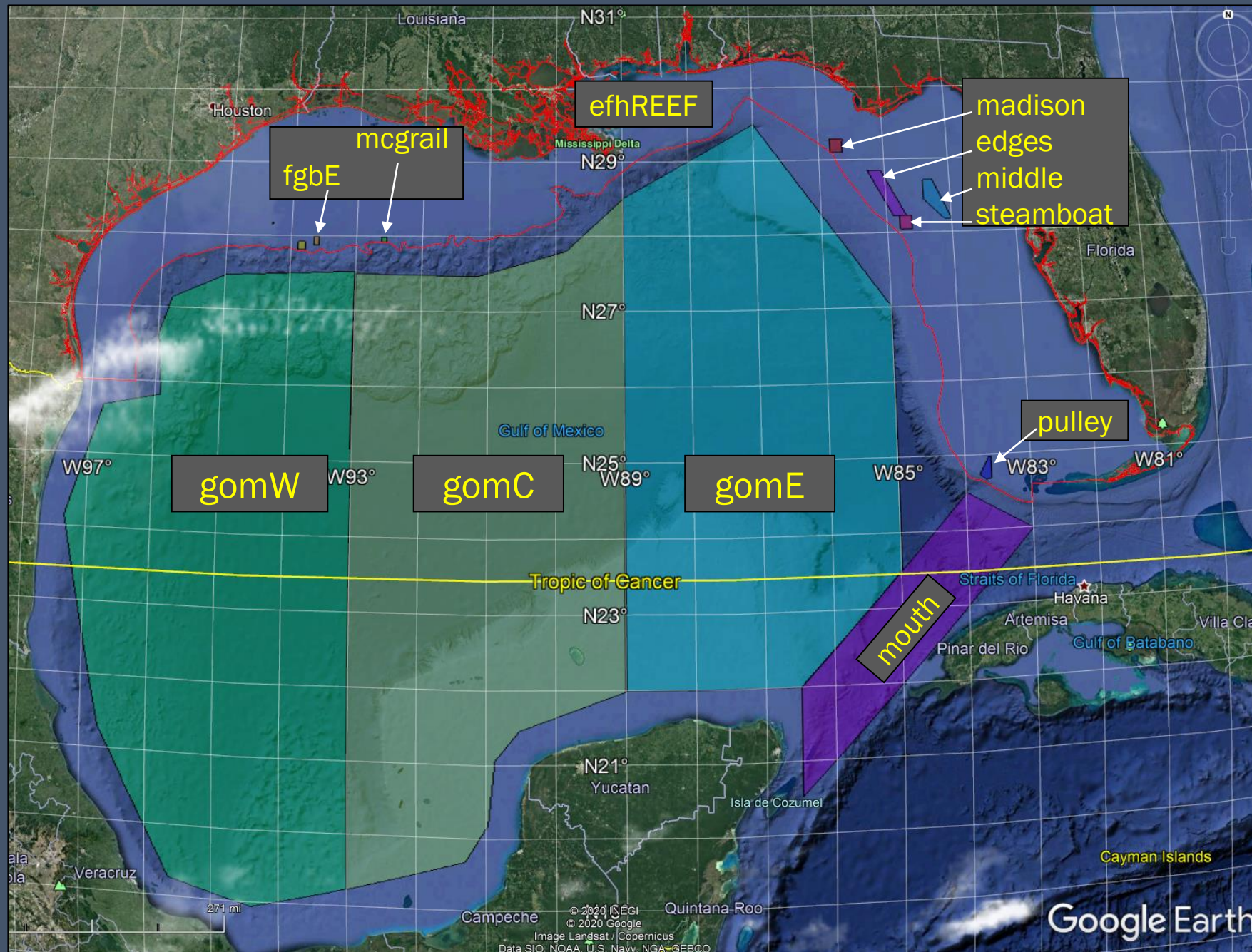
RESPONSE
INDICATOR

Y

Greater Amberjack
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Things we care about

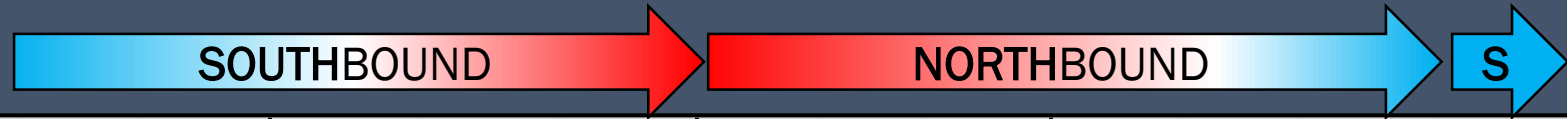


Sargassum Areal Coverage

Sampling the Gulf LME

- **Seven** Restricted Mgmt. Areas
- Reef-fish **EFH**
- **Five** Experimental Basin-scale Areas

Sargassum Models' Timing



			Spawn/Dispersal			Pelagic/Recruit						
Greater Amberjack Ontogenetic Stage	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Spawning			X	X	X	X						
Eggs			X	X	X	X						
Yolk-sack larvae				X	X	X	X					
Larvae (start feeding)				X	X	X	X					
Pelagic Juveniles (feeding pelagic)					X	X	X	X	X	X	X	X
Recruited stage (YOY > 150 days)								X	X	X	X	X
Peak-spawning-period spawned class												
Commercial Fishing Closed												
Recreational Fishing Closed												

- **Spawning/Larval Dispersal** period model: March → May
- **Pelagic Juvenile/Recruitment** period model: June → August

Ecological Models – *Sargassum* Time Series

***Sargassum* Areal Coverage Spawn/Dispersal Period (2000-2018)**

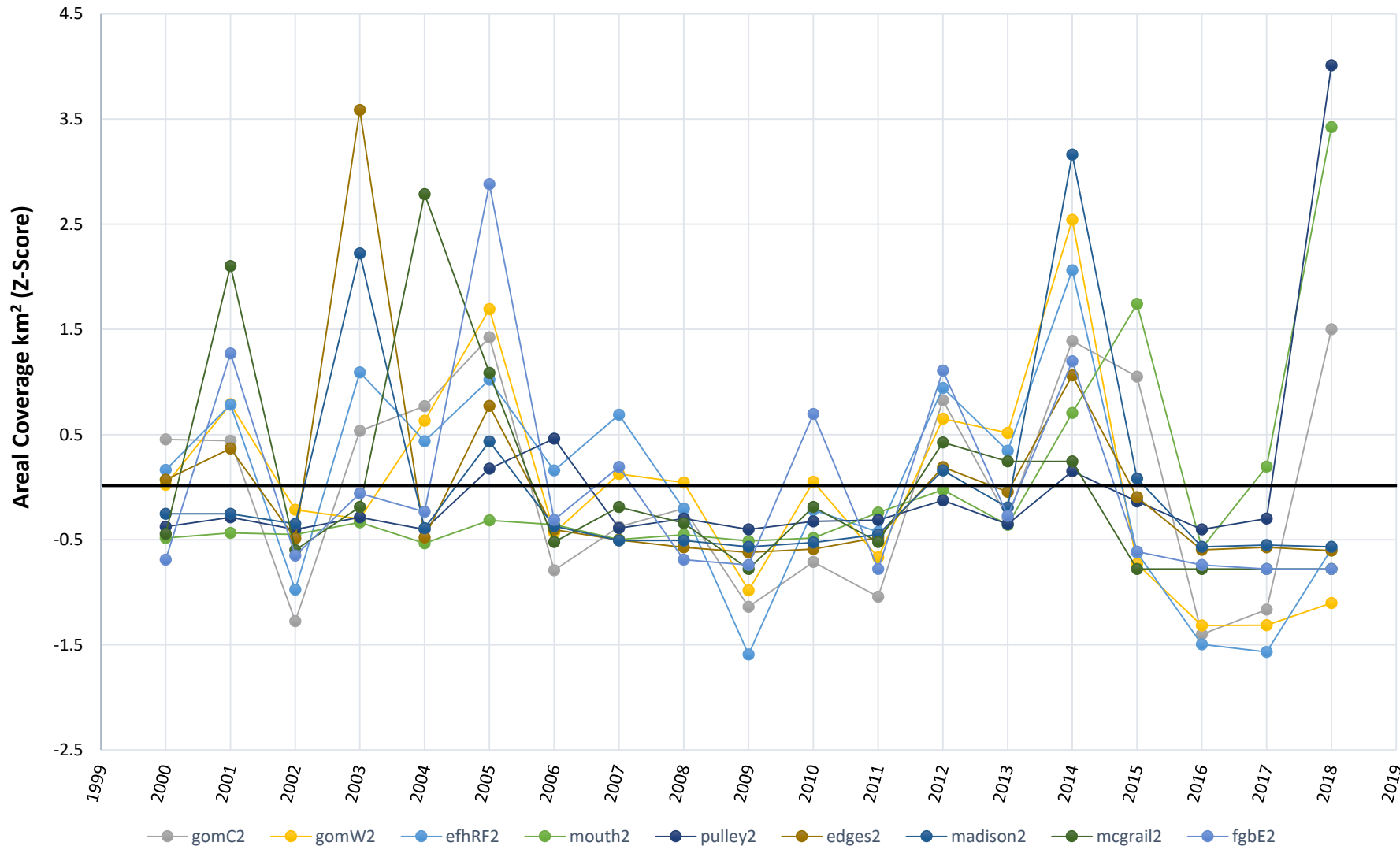


Spawning/Dispersal
Period Model

- **Six** Restricted Mgmt. Areas
- Reef-fish EFH
- **One** Experimental Basin-scale Areas

Ecological Models – *Sargassum* Time Series

***Sargassum* Areal Coverage Pelagic/Recruitment Period (2000-2018)**



Pelagic/Recruitment
Period Model

- **Five** Restricted Mgmt. Areas
- Reef-fish EFH
- **Two** Experimental Basin-scale Areas

Gulf LME Ecosystem Status Reports



NOAA Technical Memorandum NMFS-SEFSC-653

ECOSYSTEM STATUS REPORT FOR THE GULF OF MEXICO

Mandy Karnauskas, Michael J. Schirripa, Christopher R. Kelble, Geoffrey S. Cook
and J. Kevin Craig



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, Florida 33149

December 2013

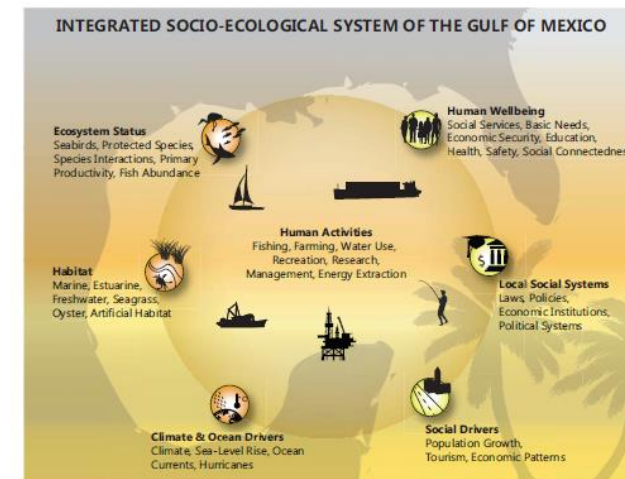
(2013)



NOAA Technical Memorandum NMFS-SEFSC-706

2017 ECOSYSTEM STATUS REPORT UPDATE FOR THE GULF OF MEXICO

Mandy Karnauskas, Christopher R. Kelble, Seann Regan, Charline Quenée, Rebecca Allee,
Michael Jepson, Amy Freitag, J. Kevin Craig, Cristina Carollo, Leticia Barbero, Neda
Trifonova, David Hanisko, and Glenn Zapfe



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, Florida 33149

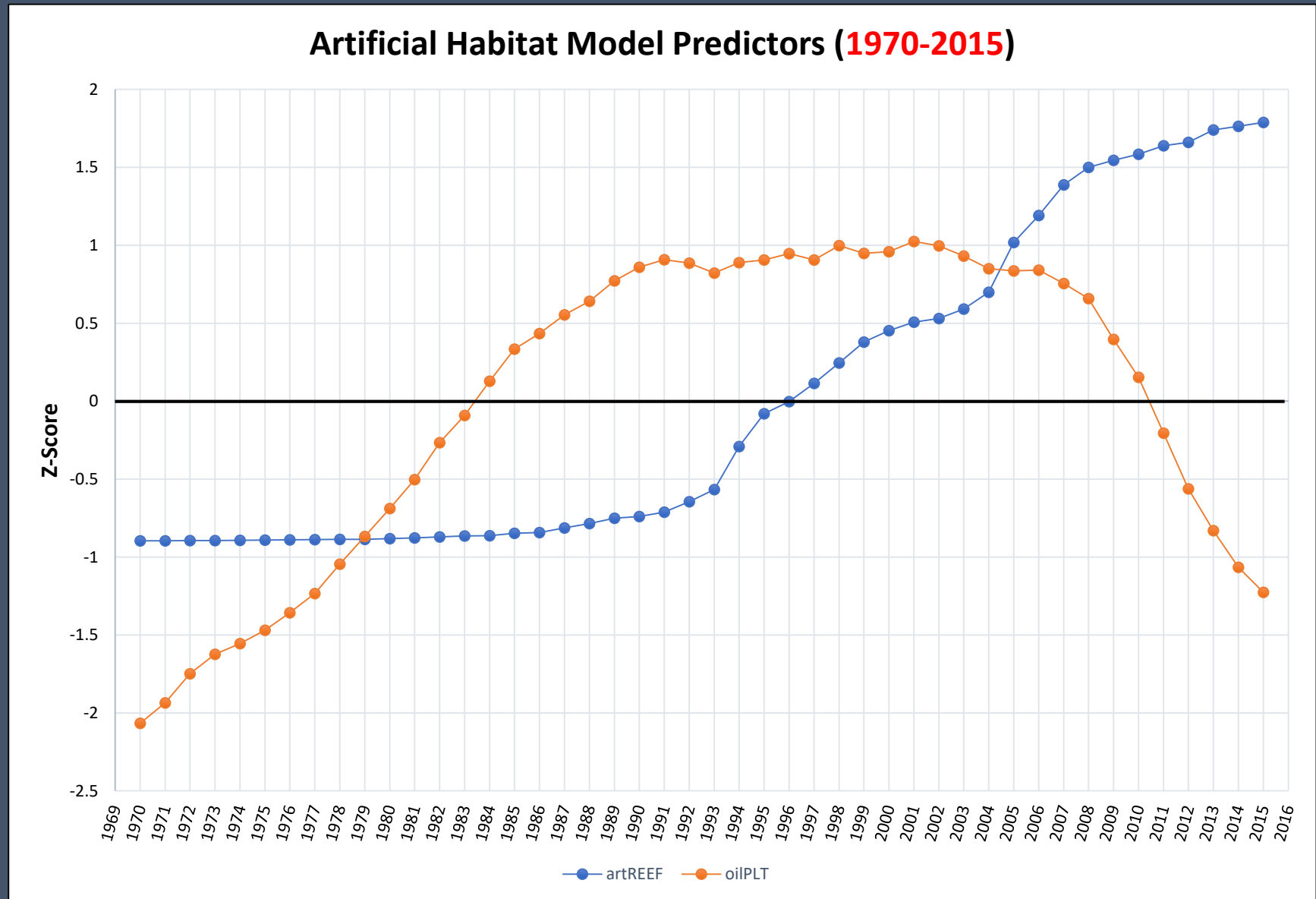
March 2017

(2017)

Ecological Models – Ecosystem Status Report

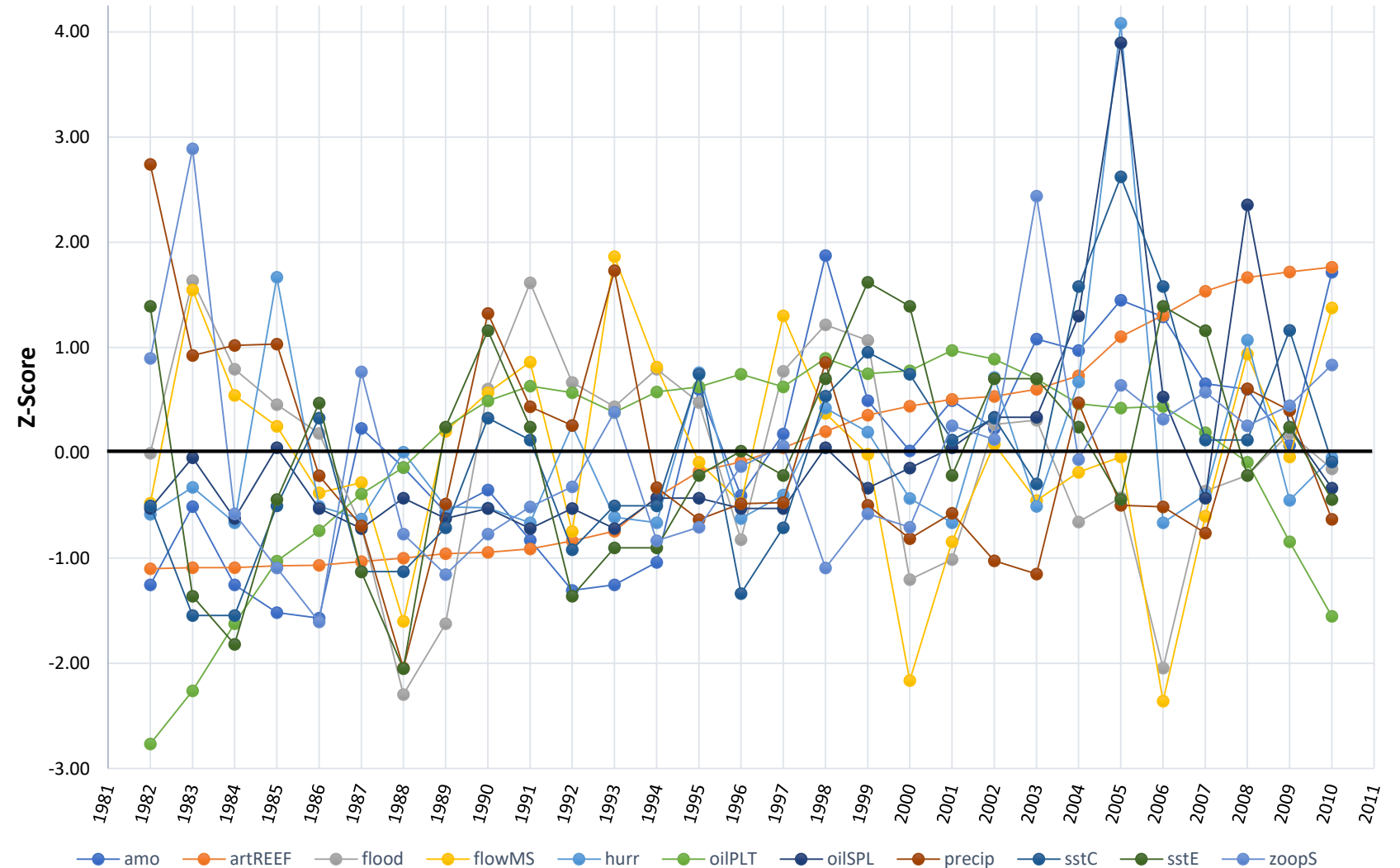
Artificial **Habitat** Model Predictors

- Oil platforms
- Non-oil industry artificial reefs



General Ecological Model Predictors

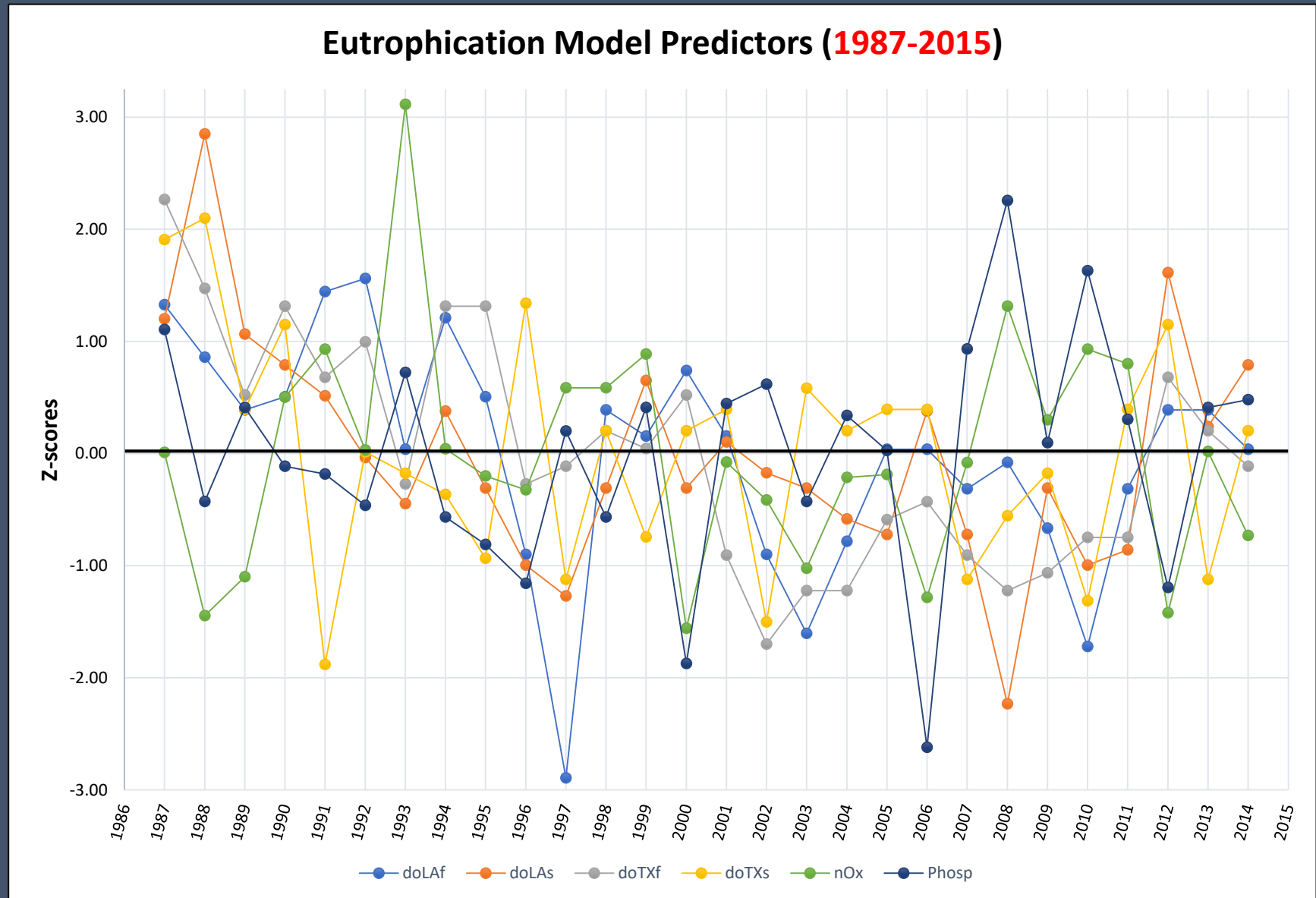
- ## Ecological Model Predictors (1982-2010)



Ecological Models – Ecosystem Status Report

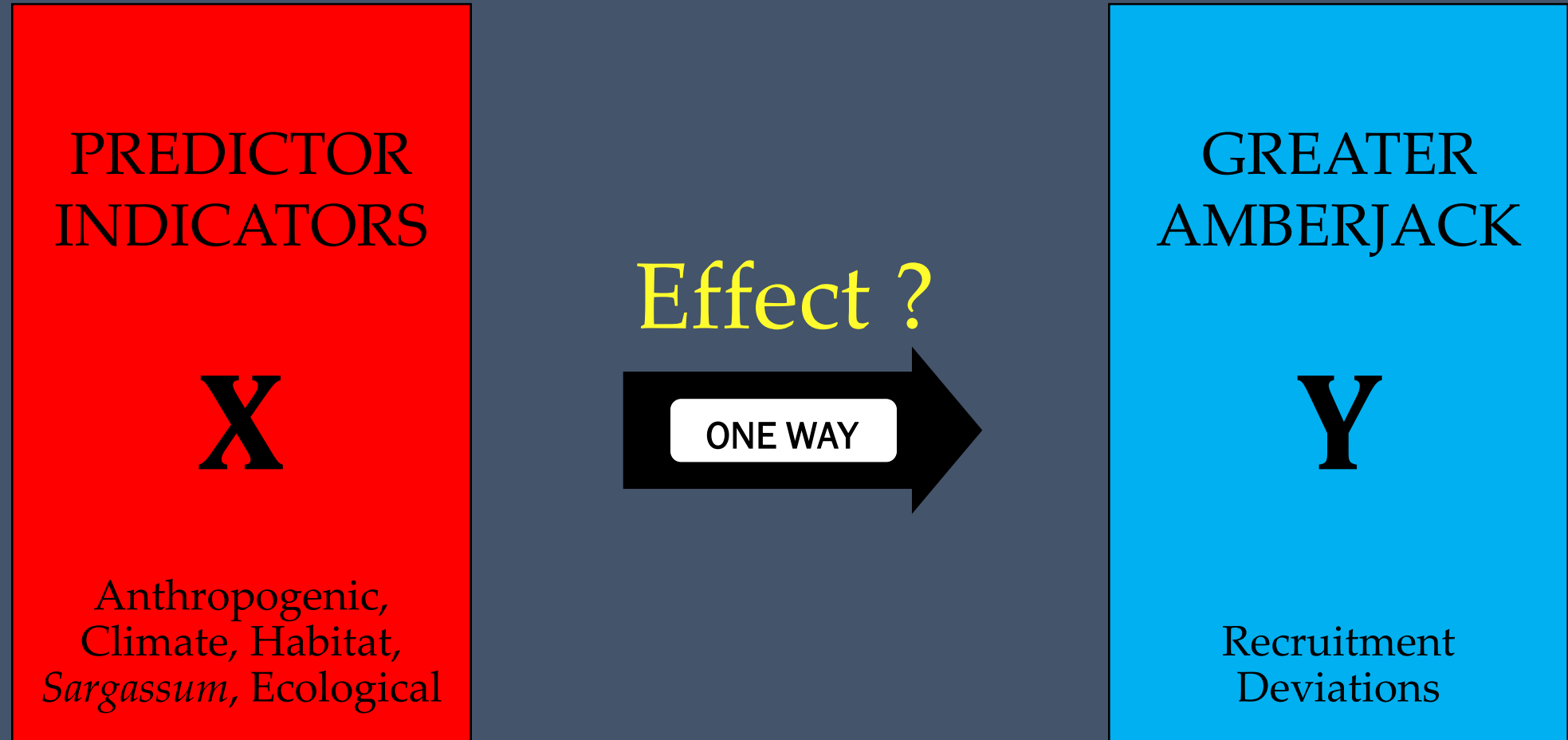
Eutrophication Model Predictors

- Dissolved Oxygen:
 - Spring/Fall
 - LA/TX
- MARB Influence:
 - Nitrogen Oxides
 - Total Phosphate



Temporal Detrending via Asymmetric Eigenvector Mapping (AEM)

Constrained Analysis Framework



Hypothesized to affect
things we care about

Things we care about

Constrained Analysis Framework

PREDICTOR
INDICATORS

X

Anthropogenic,
Climate, Habitat,
Sargassum, Ecological

TIME

GREATER
AMBERJACK

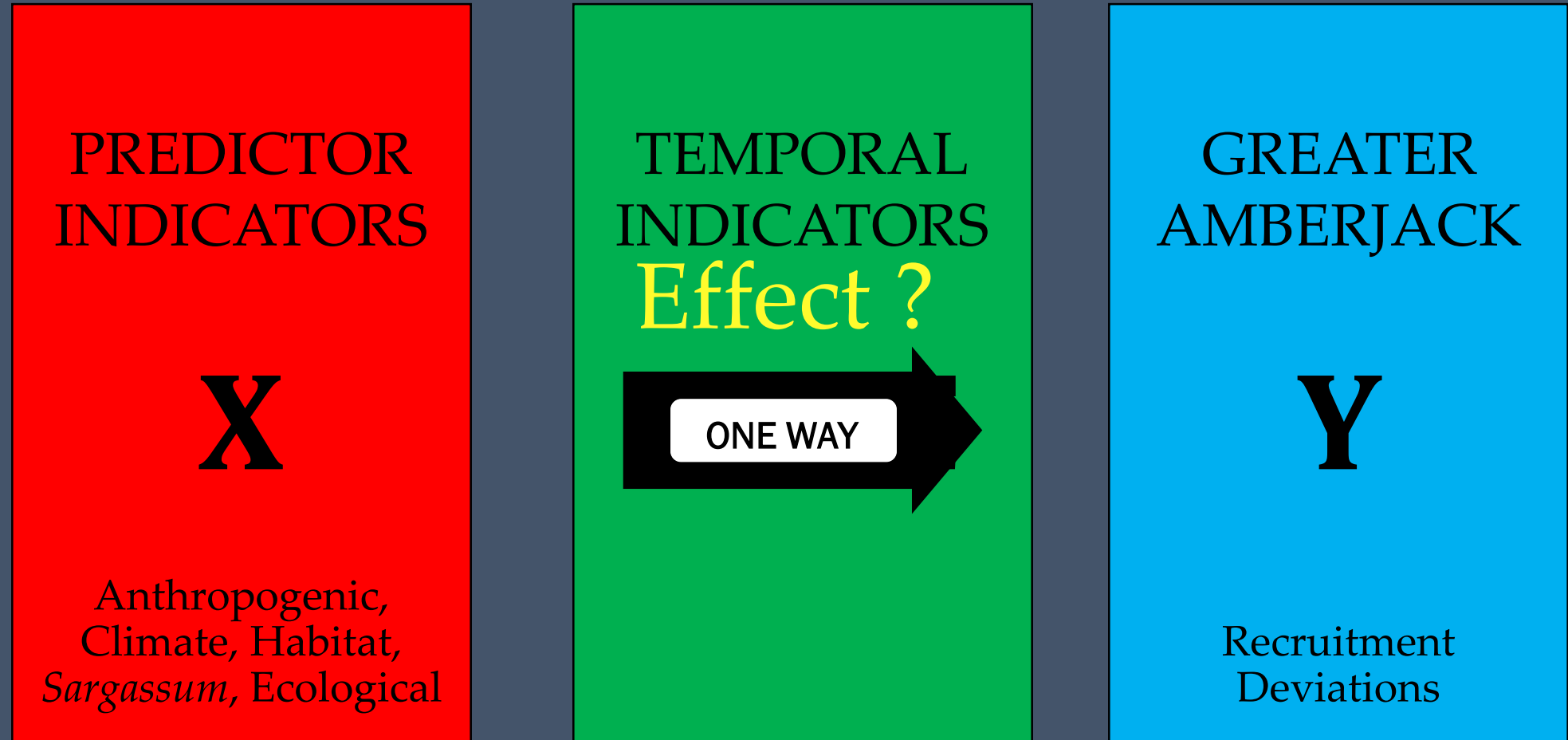
Y

Recruitment
Deviations

Hypothesized to affect
things we care about

Things we care about

Constrained Analysis Framework



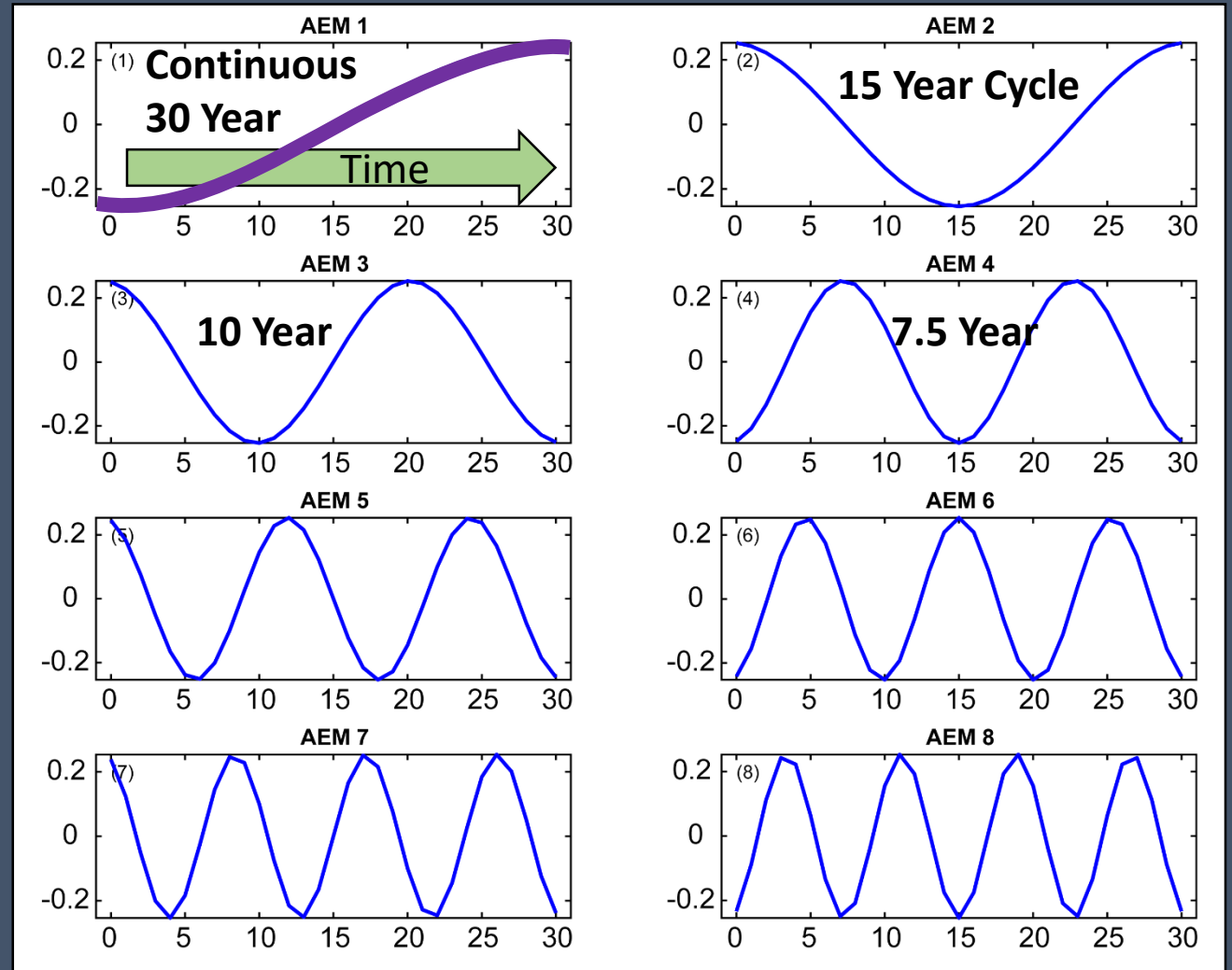
Hypothesized to affect
things we care about

Things we care about

Modeling Time with AEMs

TEMPORAL
INDICATORS

AEMs



Temporal structure
in sampling universe

Constrained Analysis Framework

TEMPORAL
INDICATORS

AEMs

Effect ?

ONE WAY

GREATER
AMBERJACK

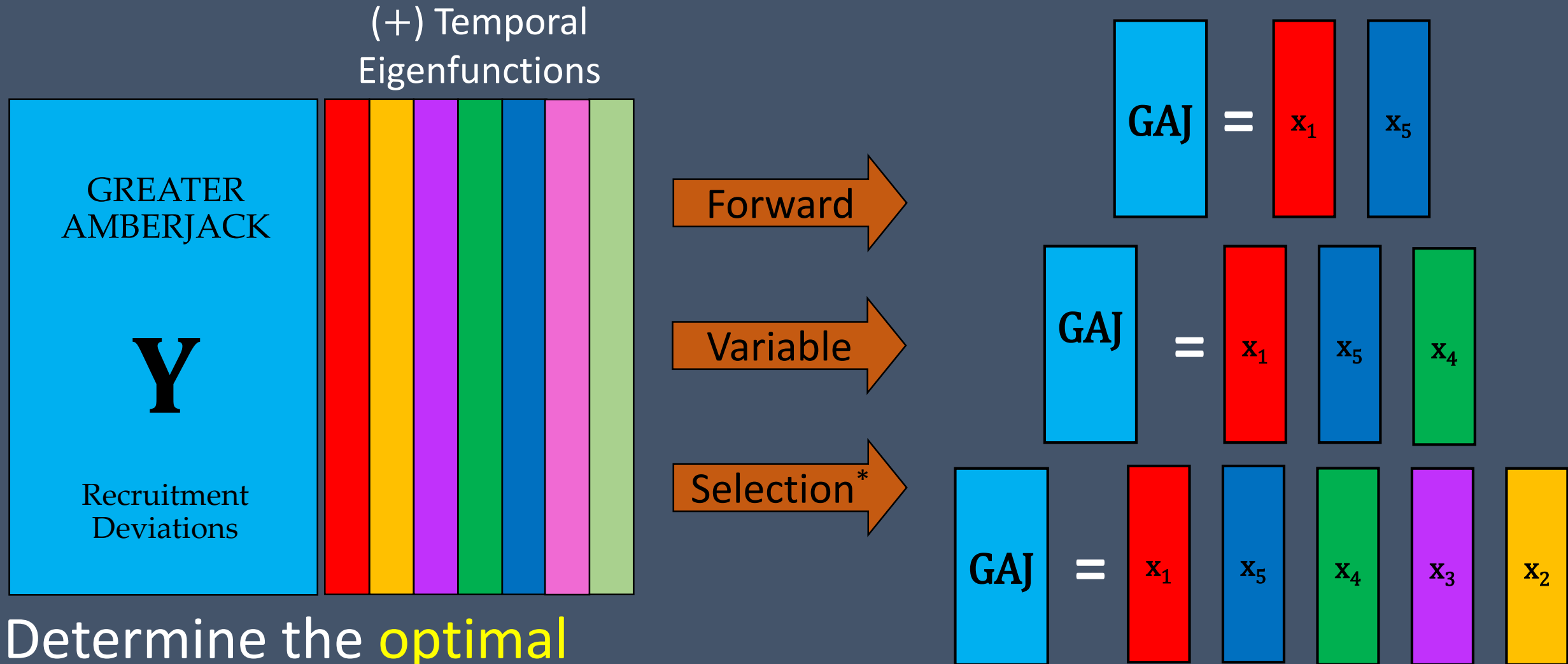
Y

Recruitment
Deviations

Temporal structure
in sampling universe

Things we care about

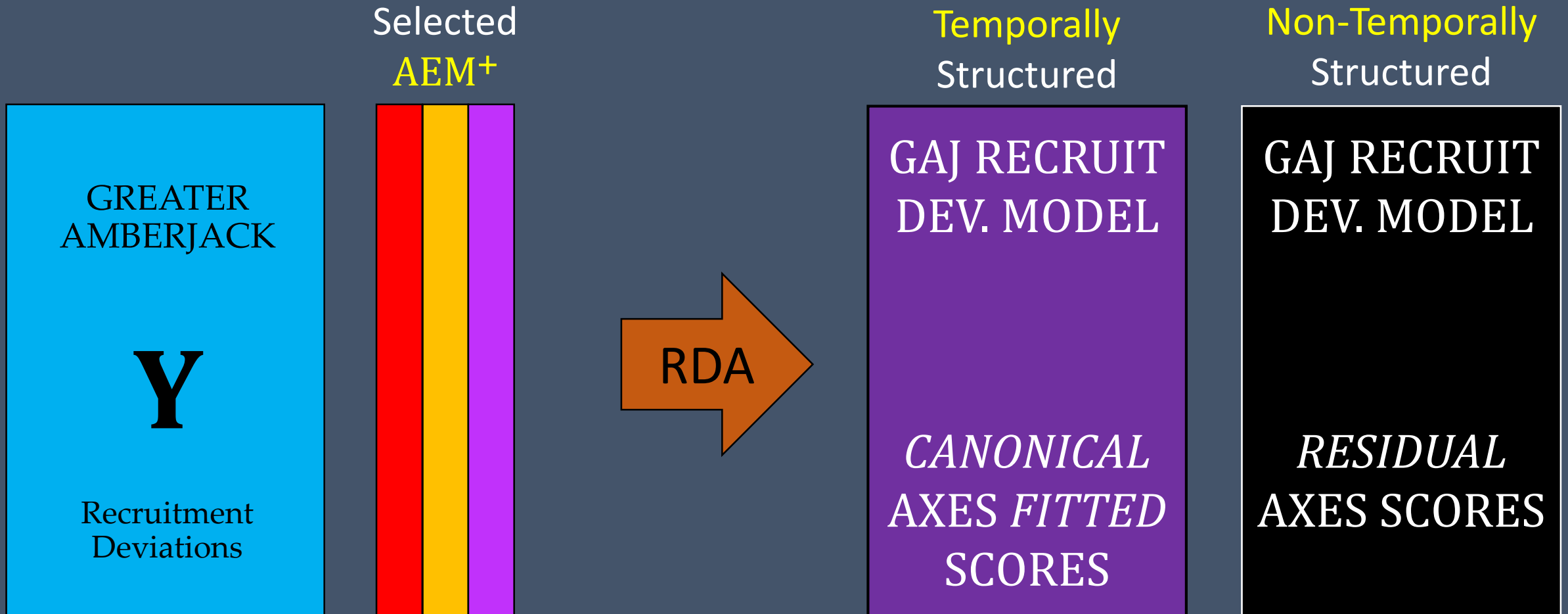
AEM⁺ Optimal Model Selection



Determine the **optimal**
AEM⁺ model for GAJ

*Using the method of Blanchet, Legendre, and Borcard (2008)

AEM⁺ Constrained Analysis



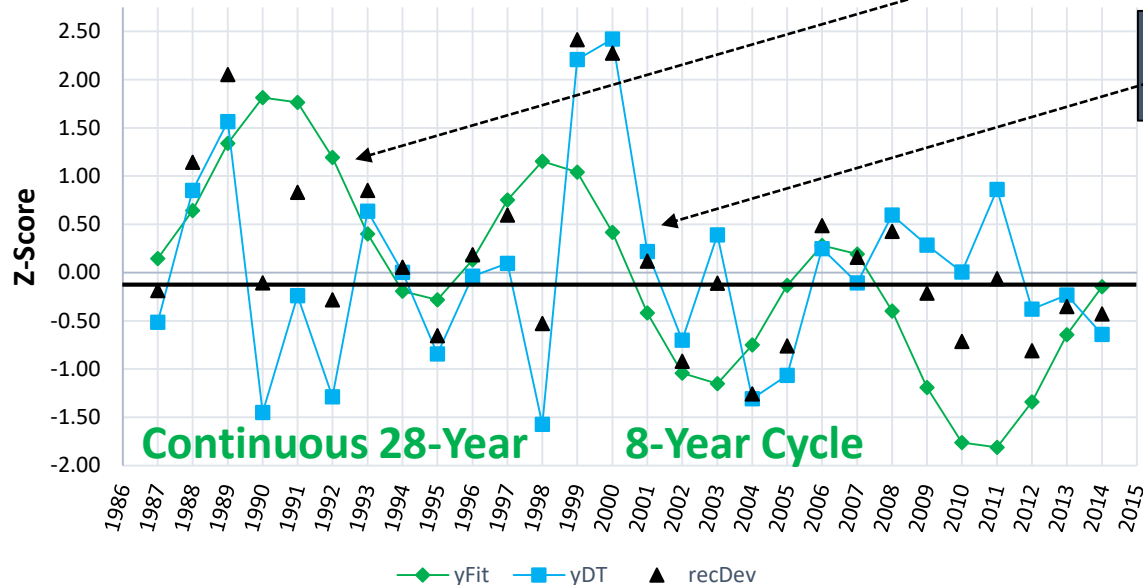
Create the final temporal model for GAJ using selected AEM⁺

Temporal Detrending Results

Model	Period	n	Λ_i (Period 1)	Λ_i (Period 2)	F	R^2	R^2_{adj}	p -value
Habitat	1970-2015	46	Λ_2 (23 years)	-	10.5	0.1922	0.1738	0.0029
Ecological	1982-2010	29	Λ_5 (11 years)	-	7.0	0.2067	0.1773	0.0141
Eutrophication	1987-2014	28	Λ_1 (28 years)	Λ_7 (8 years)	4.9	0.2794	0.2218	0.0169
<i>Sargassum</i>	2000-2015	16	Λ_4 (8 years)	-	7.9	0.3621	0.3165	0.0071

Temporal Detrending Results

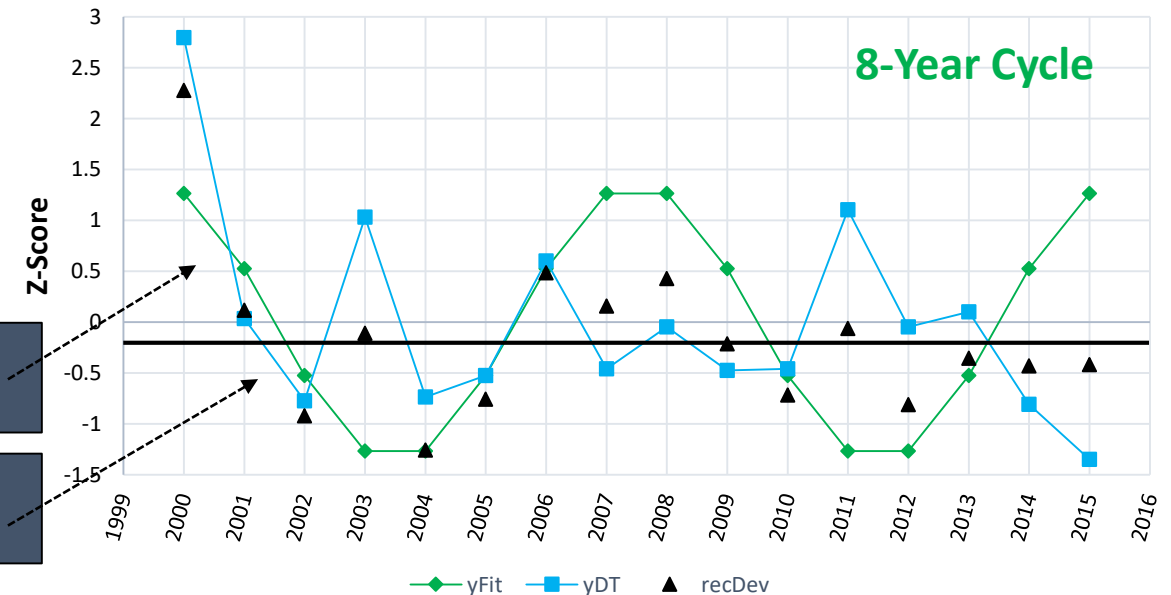
Modeled and Detrended GAJ Recruitment Deviations (Eutrophication Model 1987-2014)



~22% of GAJ recruit deviations expl. by AEMs

~78% of GAJ recruit unexplained by AEMs

Modeled and Detrended GAJ Recruitment Deviations (Sargassum Model 2000-2015)

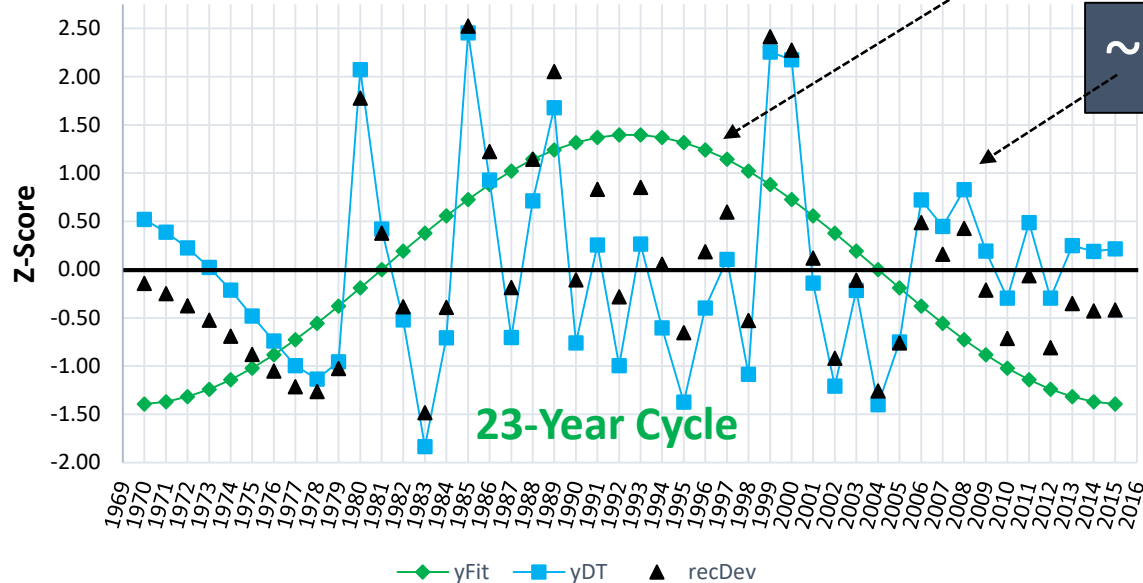


~32% of GAJ rec. dev. explained

~68% of GAJ rec. dev. unexplained

Temporal Detrending Results

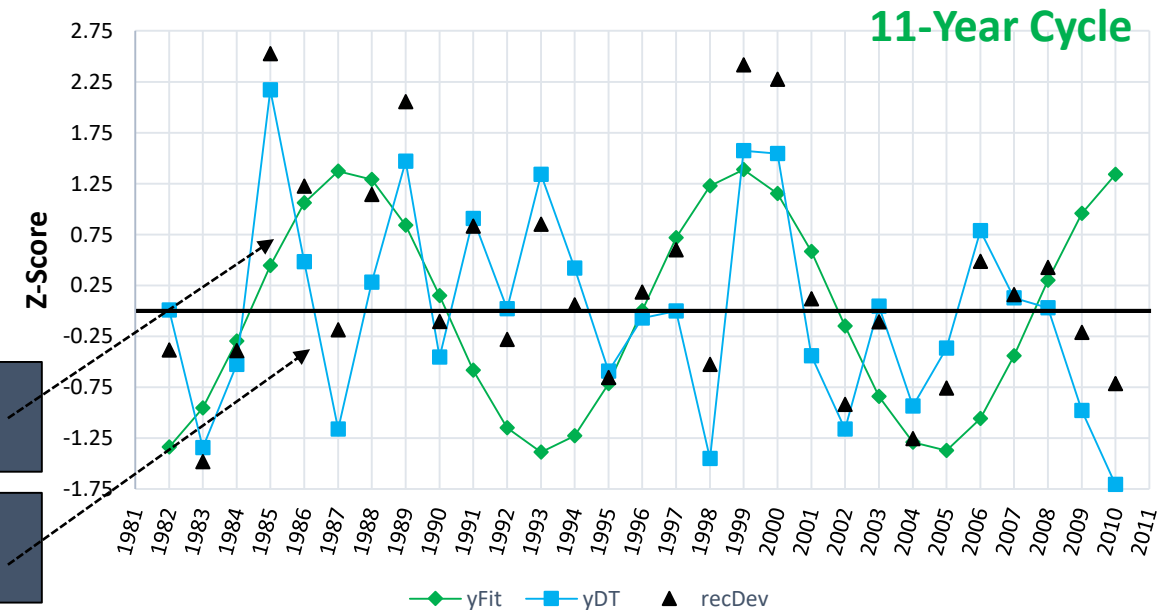
Modeled and Detrended GAJ Recruitment Deviations (Habitat Model 1970-2015)



~17% of GAJ recruit deviations **expl.** by AEMs

~83% of GAJ recruit unexplained by AEMs

Modeled and Detrended GAJ Recruitment Deviations (Ecological Model 1982-2010)



~18% of GAJ rec. dev. **explained**

~82% of GAJ rec. dev. unexplained

AEM Constrained Analysis #2 (continued...)

GAJ
MODEL

Fitted
Axes

Temporally Structured
Biological Response

Temporally Structured
Ecological Forcing Models
(*Temporal Autocorrelation*)

PREDICTOR
MODELS

X

Climate, Habitat,
Sargassum,
Ecological

Stepwise Variable Selection with
Akaike's Information Criterion (AIC)

$$AIC = n * \log_e \left(\frac{SS_{residuals}}{n} \right) + 2K$$

GAJ
MODEL

Residual
Axes

Non-Temporally Structured
Biological Response

Non-Temporally Structured
Ecological Forcing Models

Model Selection Results

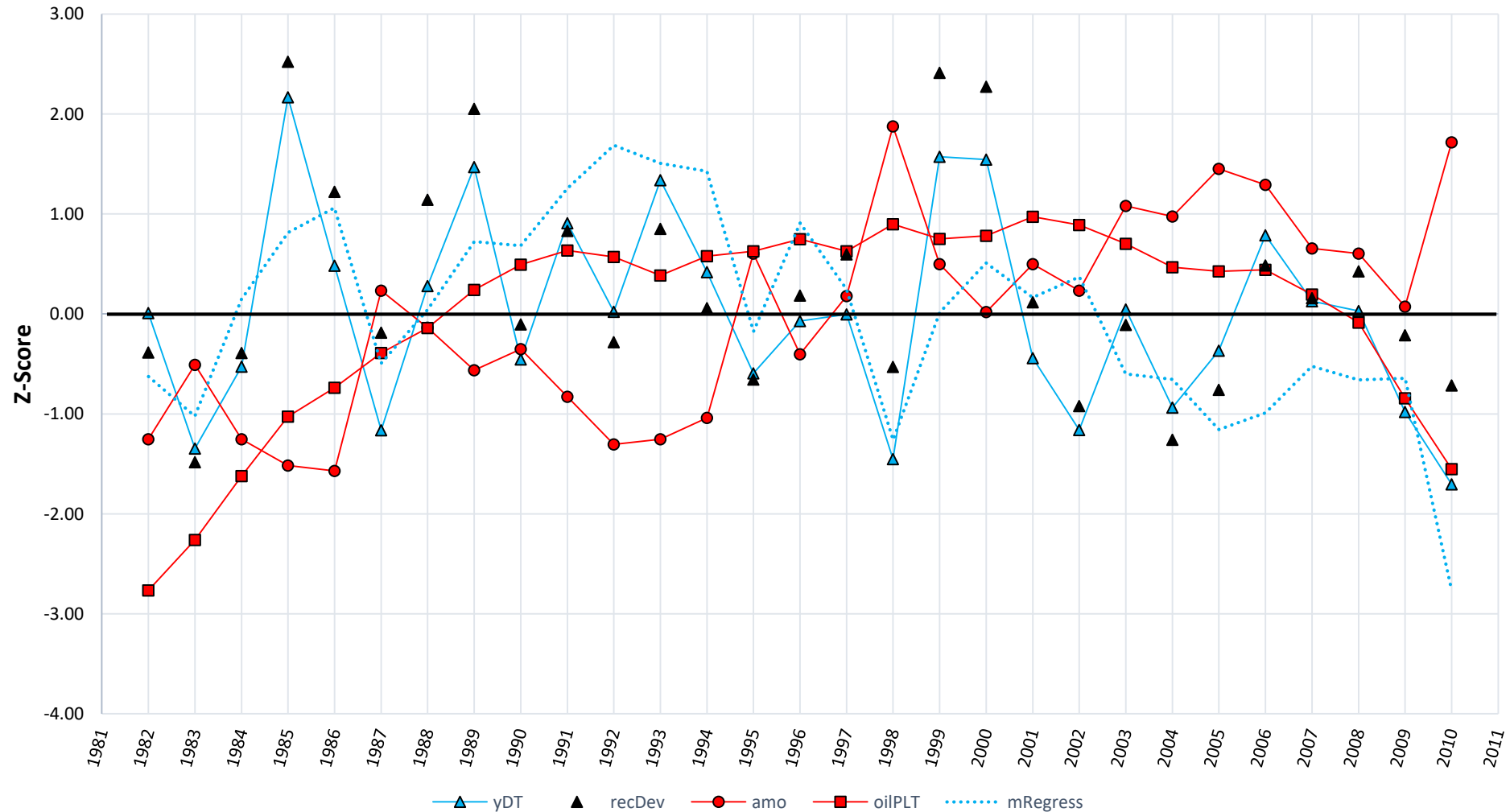
Model	Fit R^2_{adj} (Dtrnd.)	Period	Selected Predictors		F		R^2_{adj}		p -Value	
			Fit	Dtrnd.	Fit	Dtrnd.	Fit	Dtrnd.	Fit	Dtrnd.
Habitat	0.1738 (0.8262)	1970-2015	'oilPLT' + 'artReef'		239.12	-	0.9137	-	0.0001	-
Ecological	0.1773 (0.8227)	1982-2010	'precip'	'amo' + 'oilPLT'	3.94	6.75	0.0949	0.2910	0.0586	0.0050
Eutrophication	0.2218 (0.7782)	1987-2014	'doTXf'		9.69	-	0.2434	-	0.0045	-
Sargassum #1	0.3165 (0.6835)	2000-2015	'middle1'		5.15	-	0.2167	-	0.0378	-
Sargassum #2	0.3165 (0.6835)	2000-2015	'mouth2'		-	2.57	-	0.0949	-	0.0884

Model	Proportion of Total	Modeled Prop.	Total % Modeled
Habitat	0.1738	0.9137	16%
Ecological*	0.8227	0.291	24%
Eutrophication	0.2218	0.2434	5%
Sargassum #1	0.3165	0.2167	7%

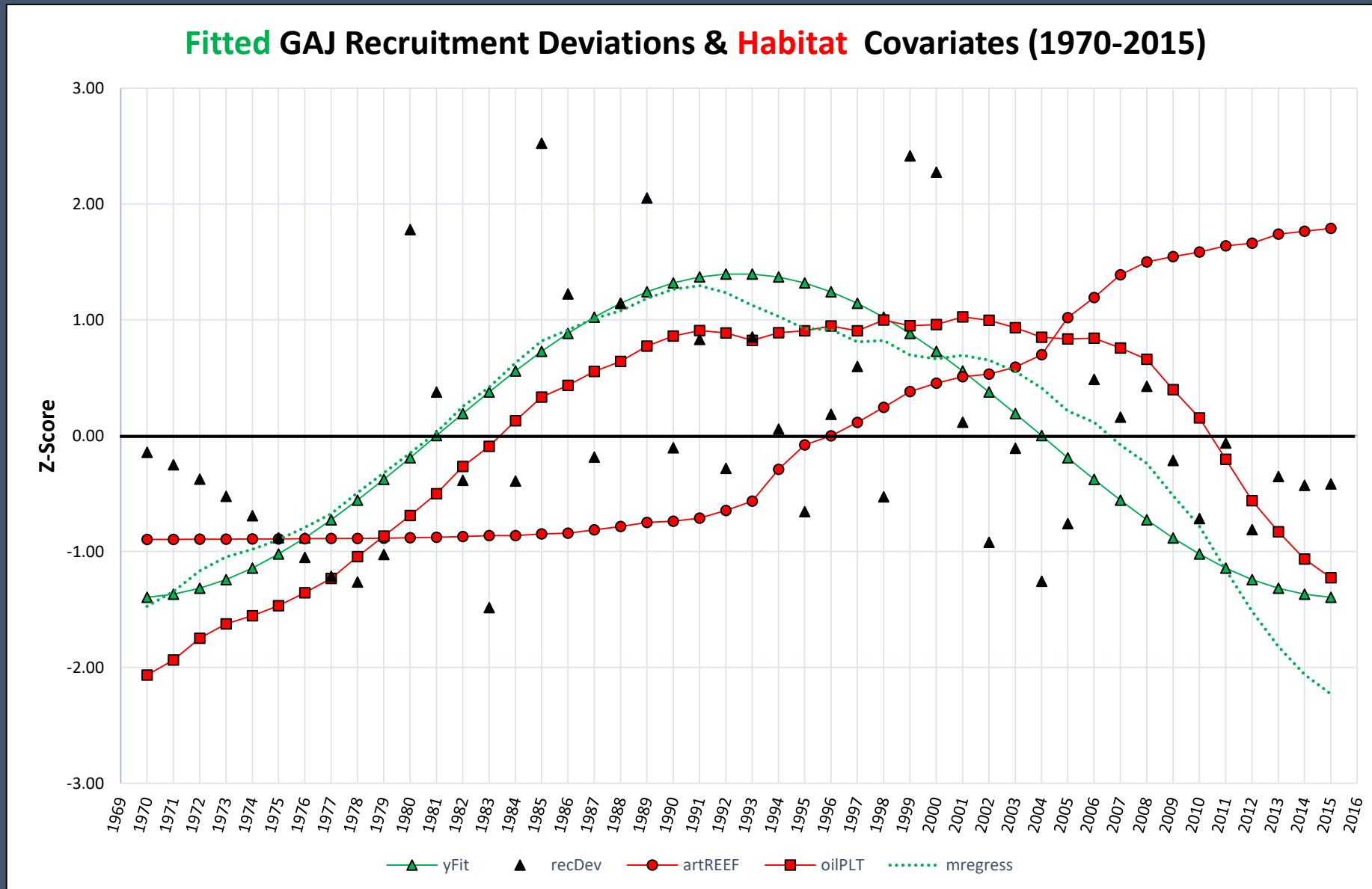
NO AEM CONSTRAINTS

Leading Ecological Indicators

Detrended GAJ Recruitment Deviations & **Ecological** Covariates
(1982-2010)

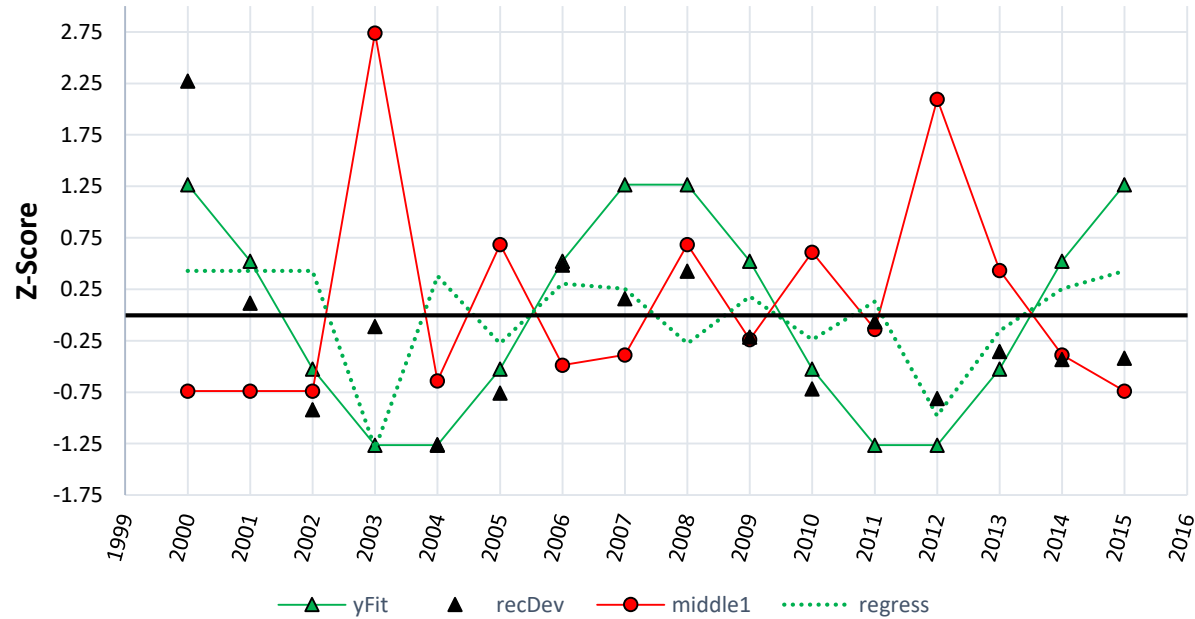


Leading Habitat Indicators

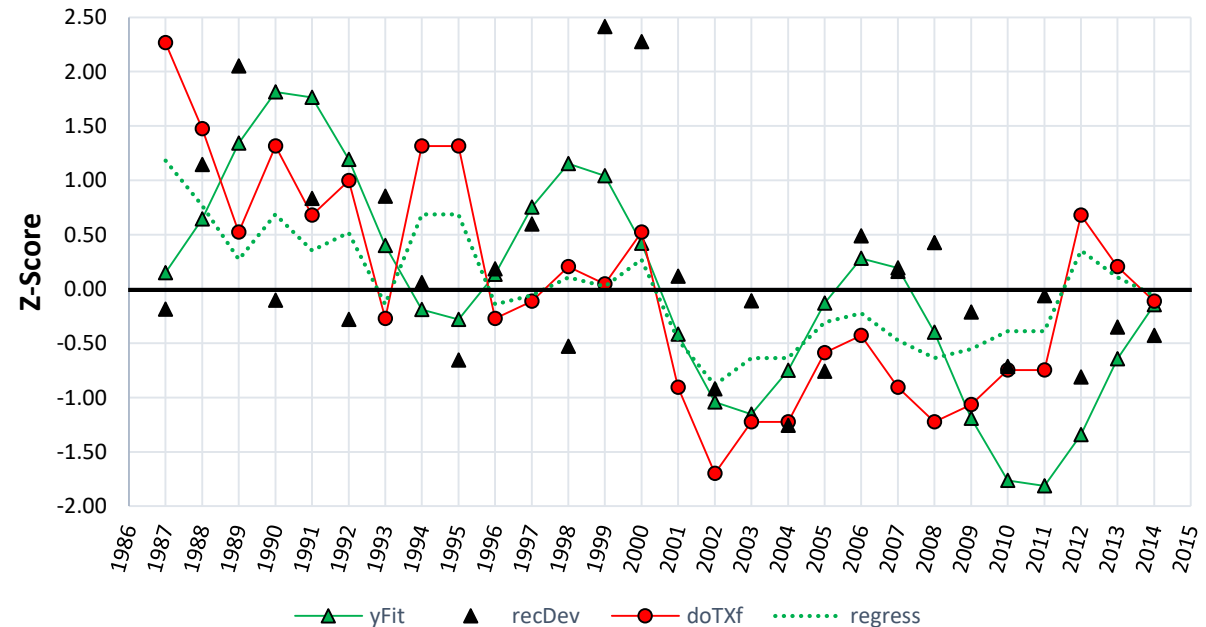


Leading Sargassum & Eutrophication Indicators

Fitted GAJ Recruitment Deviations & *Sargassum* Covariate (2000-2015)



Fitted GAJ Recruitment Deviations & Eutrophication Covariate (1987-2014)



Putting it All Together

Summary – Ecological & Habitat Models

- **Ecological Model (24%)** captured the most unexplained variability in Greater Amberjack recruit deviations
 - Model *not temporally autocorrelated* (i.e., detrended)
 - AMO inversely related: $\uparrow \text{AMO} = \downarrow \text{GAJ dev.}$
 - Oil Platforms positive: $\uparrow \text{oilPLT} = \uparrow \text{GAJ dev.}$
- **Habitat Model (16%)** captured the 2nd most variability in Greater Amberjack recruit deviations
 - *Temporally autocorrelated* (23-yr Cycle)
 - Art. Reefs inversely related: $\uparrow \text{artREEF} = \downarrow \text{GAJ dev.}$
 - Oil Platforms positive: $\uparrow \text{oilPLT} = \uparrow \text{GAJ dev.}$

Summary – *Sargassum* & Eutrophication Models

- *Sargassum* Model (7%)

- Temporally autocorrelated (8-yr Cycle)
- Middle Grounds inversely related: $\uparrow \text{middle} = \downarrow \text{GAJ dev.}$

- Eutrophication Model (5%)

- Temporally autocorrelated (28-yr Cycle & 8-yr Cycle)
- Texas Fall DO positively related: $\uparrow \text{DOtxFall} = \uparrow \text{GAJ dev.}$

Leading Indicators – Climate + Habitat

Model	Proportion of Total	Modeled Prop.	Total % Modeled
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1982-2010

11-year AEM cycle (18% GAJ Devs.)

AMO & Oil Plats. (24% GAJ Devs.)

+

Total GAJ Recruitment Devs. 42%

- Explained the most GAJ new recruit variability out of all models
- Potential to reduce over/under-estimating new recruits
- AMO a complex signal with many teleconnections in Gulf LME
- Oil Platforms is ambiguous from spatial perspectives
- Artificial structure is important
 - *Which type(s)*
 - *Why?*

Leading Indicators – *Sargassum* + Dissolved O₂

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Sargassum #1	0.3165	0.2167	7%

- Explained the least variability out of all models
- Florida Middle Grounds an important area?
- DO offshore Texas in Fall?
- Larval Habitat and Water Quality are important
 - *Why?*
 - *How?*

Temporal Autocorrelation Considerations

Model	Period	n	Λ_i (Period 1)	Λ_i (Period 2)	F	R^2	R^2_{adj}	p -value
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- Between **17-32%** of all GAJ recruitment deviation explained by synthetic **autocorrelation** structures (AEMs)
- Between 8 and 11-year “**decadal**” signal apparent in 60% models
- Approximately 25-year “**multi-decadal**” signal in 40% of models
 - *Unaccounted for temporal processes?*
 - *Mechanistic bias in assessment model?*

Final Recommendations

- Informing Interim Assessments/Updates:
 - Readily accessible data needed for interim activities
 - Limited capacity to immediately improve upon SS3 models
- Model Reconnaissance and Updating:
 - Scale matters
 - Temporal and spatial mismatches apparent in public data
 - Consistent updating of leading indicators required
 - Constant reassessment needed to avoid chaotic regime changes

Final Recommendations

- Immediate/Near-term Incorporation to Formal Assessment:
 - All models identified new covariates of interest
 - Spatial & Temporal variability across LME
 - Water quality effects lab-testable to refine mathematical models
 - Sargassum and other Habitat considerations require focused field work:
 - Type preferences (e.g., art. vs nat. structure, algal mats vs windrows)
 - Utilization: Age structures and life stages
 - Disentangling AMO and Gulf-wide teleconnections
 - Simulation studies and management strategy evaluations

fin.

Thank You!

