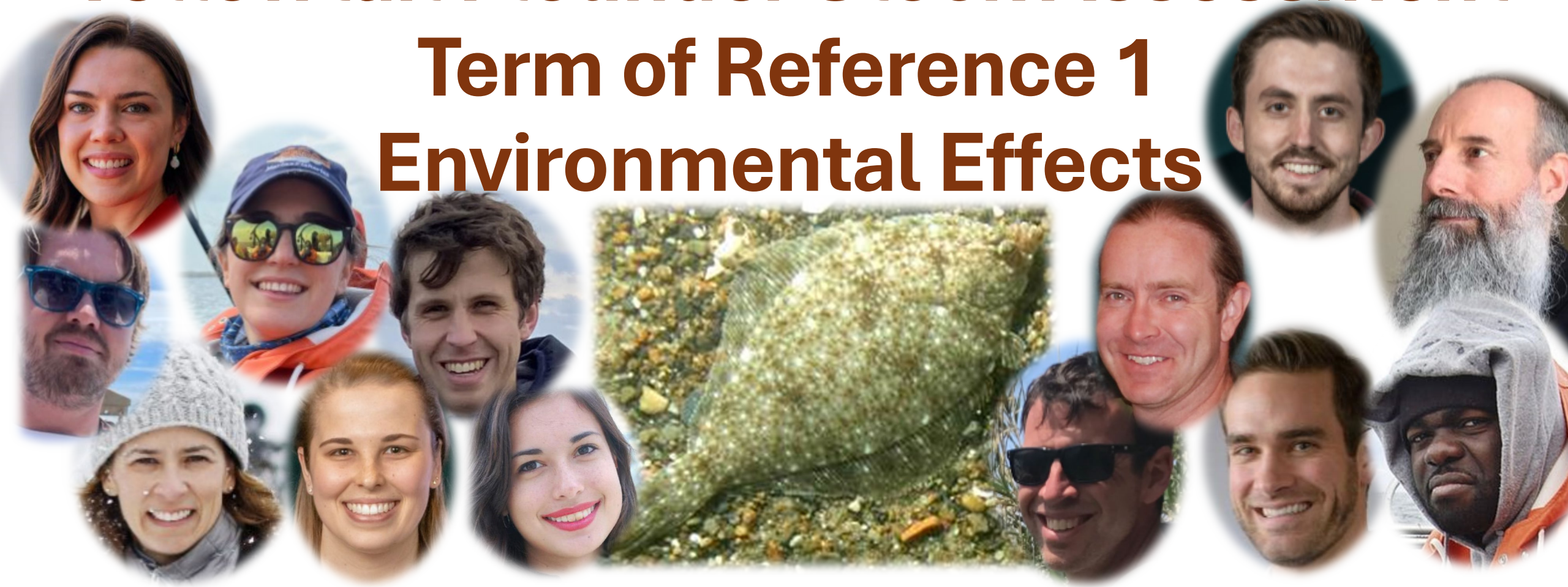
Yellowtail Flounder Stock Assessment
Term of Reference 1
Environmental Effects

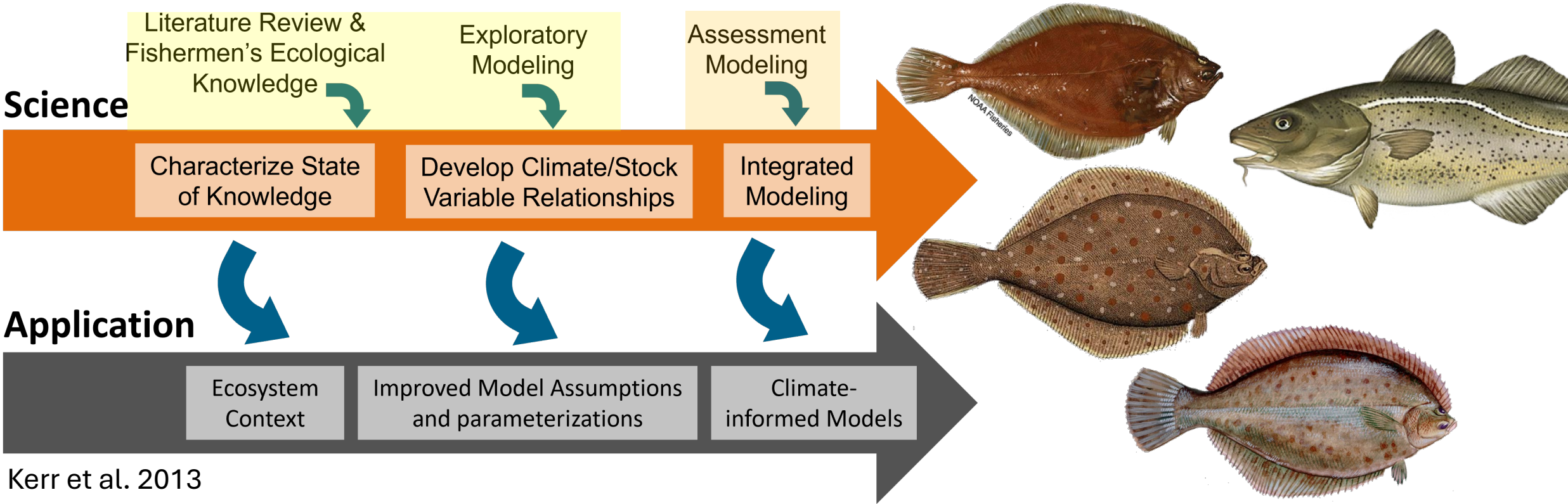


Steve Cadrin, **Jessie Kittel**, **Conor McManus**, Hubert duPontavice, Alex Hansell, Tara Dolan, Chris Legault, Chuck Adams, Lisa Kerr, Jamie Behan, Scott Large, Abby Tyrell, Larry Alade & Dave Richardson

Yellowtail Flounder Research Track Assessment Peer Review, November 18-22 2024

Term of Reference (ToR) #1

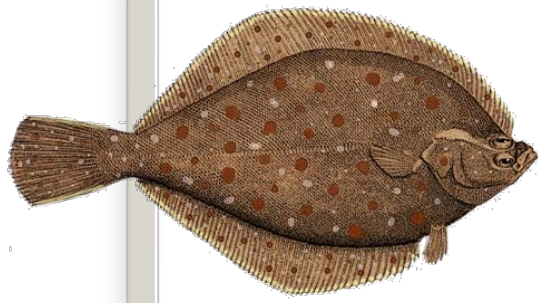
- Identify relevant ecosystem and climate influences on the stock.
- Characterize uncertainty in the relevant data and their link to stock dynamics.
- Consider findings in addressing other ToRs.
- Report how findings were considered under impacted ToRs…



Kerr et al. 2013

Yellowtail Flounder Environmental Effects

- Literature Review (Kittel et al. working paper)
- Stakeholder Perspectives (Working Group report)
- Data explorations (Kittel et al. working paper)
- Larval habitat (McManus & Richardson working paper)
- Recommendations (Working Group RTWG report)



Search Criteria Used

Assessment Year: 2024

Species Name: Yellowtail flounder

Stock Area: Yellowtail flounder

Review Type: Research Track

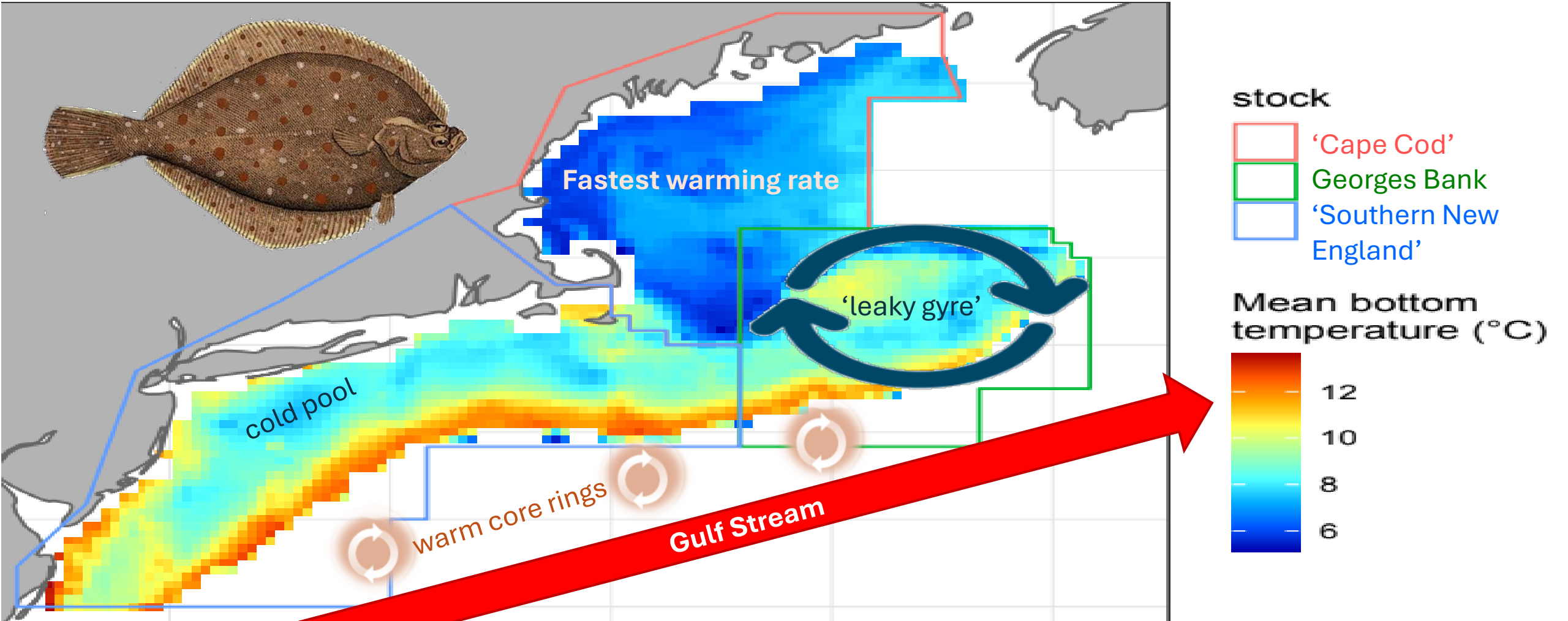
Information Type: Background

New Search

Information Type	File Name
Assessment Report	Yellowtail Flounder RT WG Report.pdf
Background	WP Cadrin LPUE.pdf
Background	WP Cadrin M approximations YTRTWG v7.pdf
Background	WP Cadrin Yellowtail Stock ID Summary.pdf
Background	WP Kittel et al Yellowtail Flounder Environmental Effects.pdf
Background	WP TOR1 McManus and Richardson Larval Habitat Suitability.pdf

Yellowtail Flounder Environmental Effects

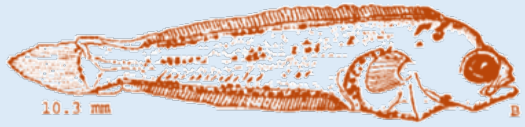
- Yellowtail was a primary target species in New England and is data-rich.
- Yellowtail stocks have different environments and responses to regional conditions.

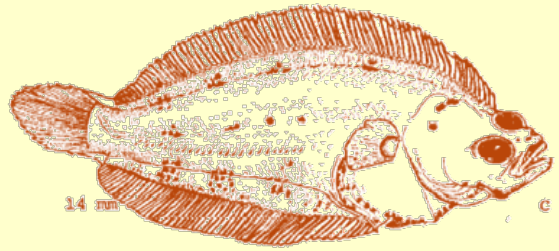


‘Yellowtail’ Lifecycle & Thermal Habitats

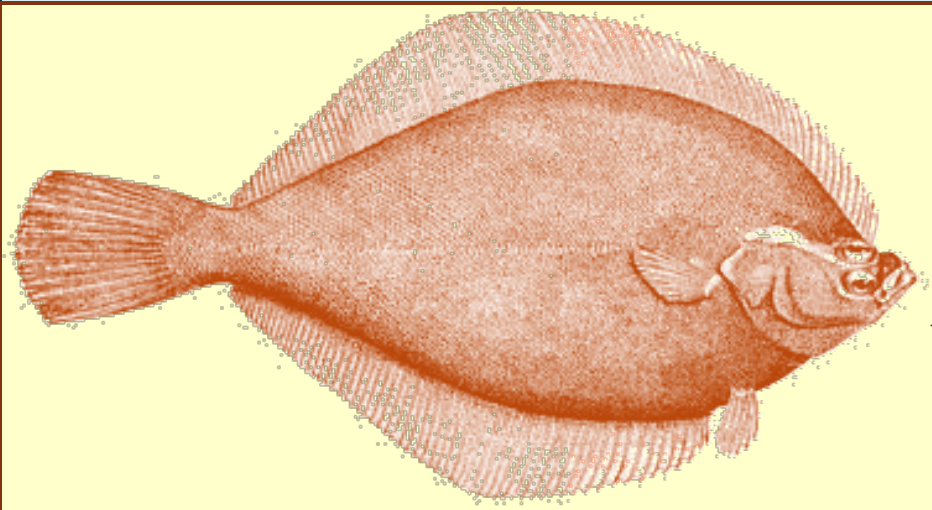
Buoyant, pelagic eggs, found in **2-15ºC**.

Eggs hatch ~5 days after fertilization at 10-11ºC (15 days at 4ºC).
Most larvae in **6-14ºC**





Most juveniles at **4-8ºC** in spring and **8-11ºC** in fall.

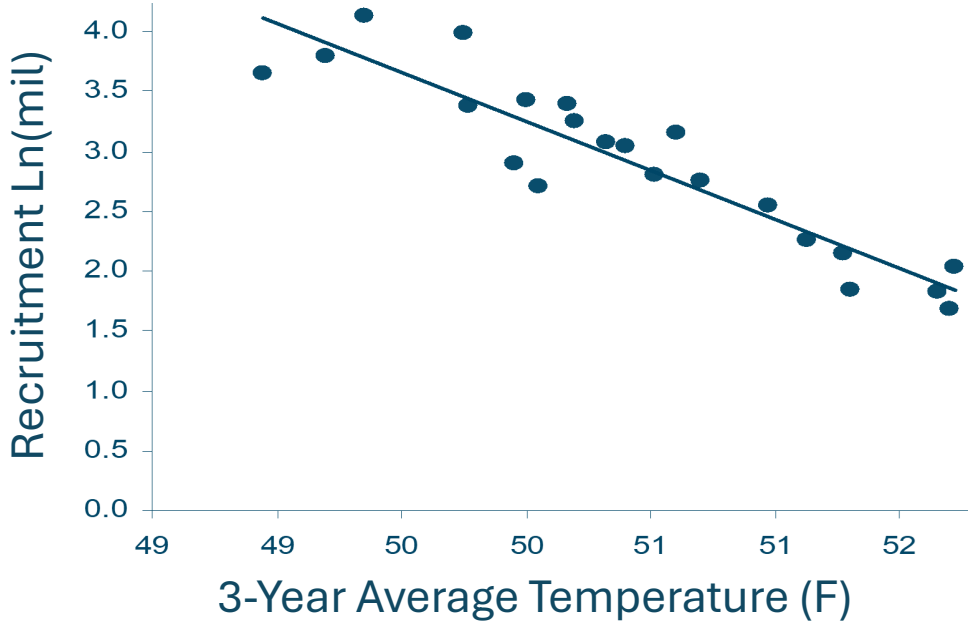


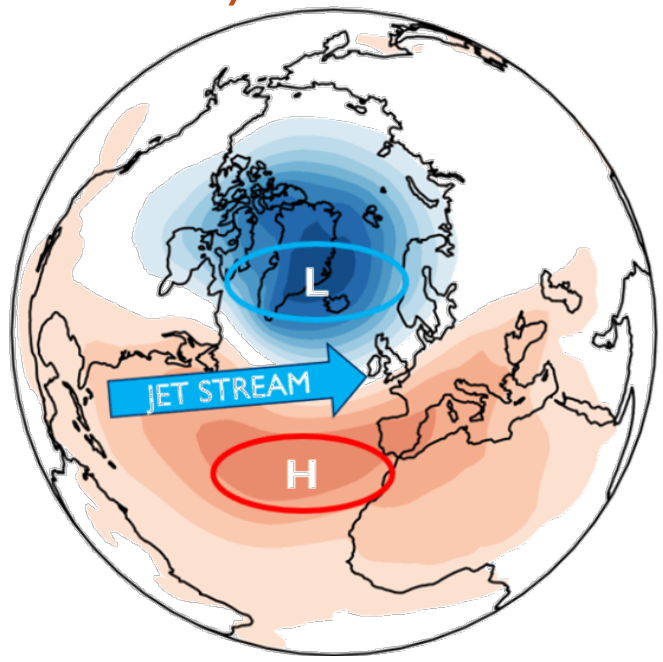
Median age at maturity for females is 1.6 years off southern New England, 1.8 years on Georges Bank, and 2.6 years off Cape Cod.
Adults found in **2-12ºC**.

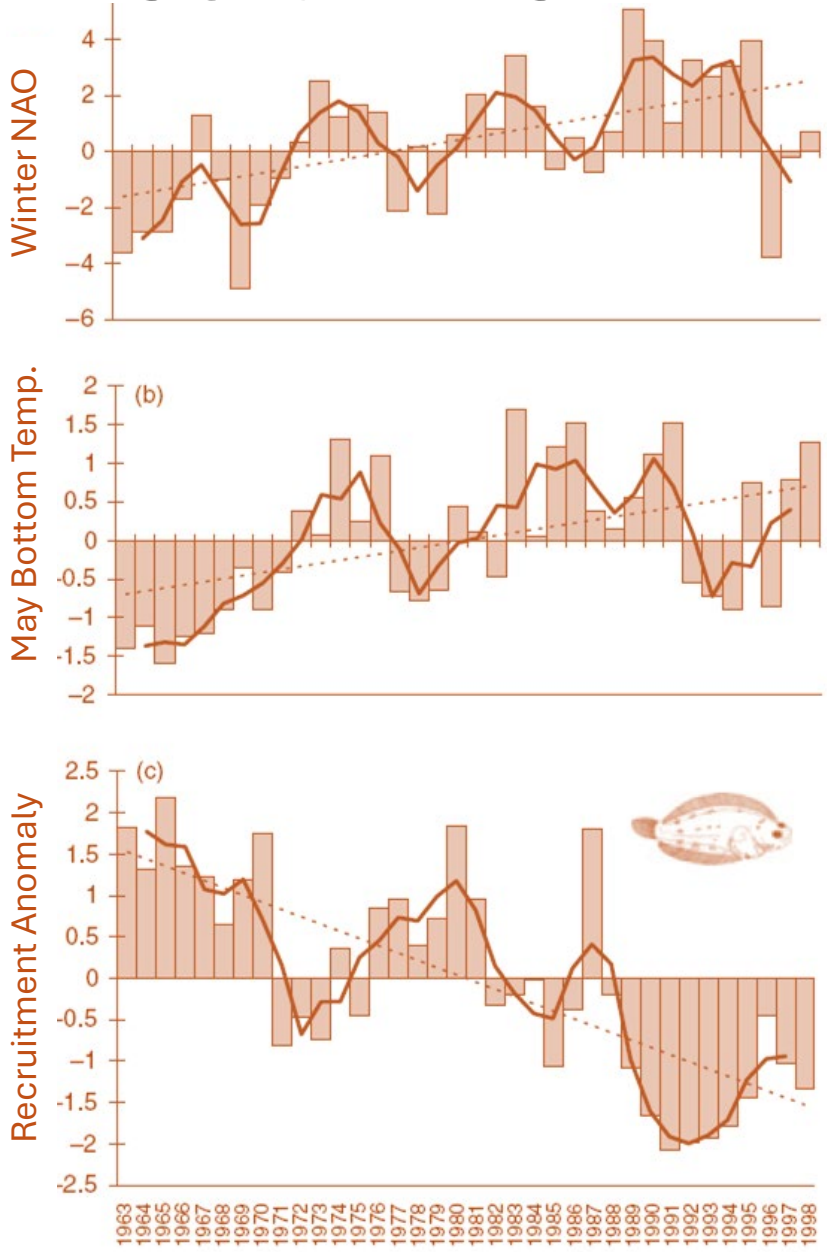
Johnson et al. (1999) Yellowtail Flounder Life History & Habitat…

Environmental Relationships with Recruitment

- Annual recruitment (1944-1965) of southern New England yellowtail was negatively correlated with atmospheric temperature (Sissenwine 1974).
- Later recruitment (1963-1998) was negatively correlated with winter atmospheric temperature, bottom temperature, and the North Atlantic Oscillation (NAO; Sullivan et al. 2005).

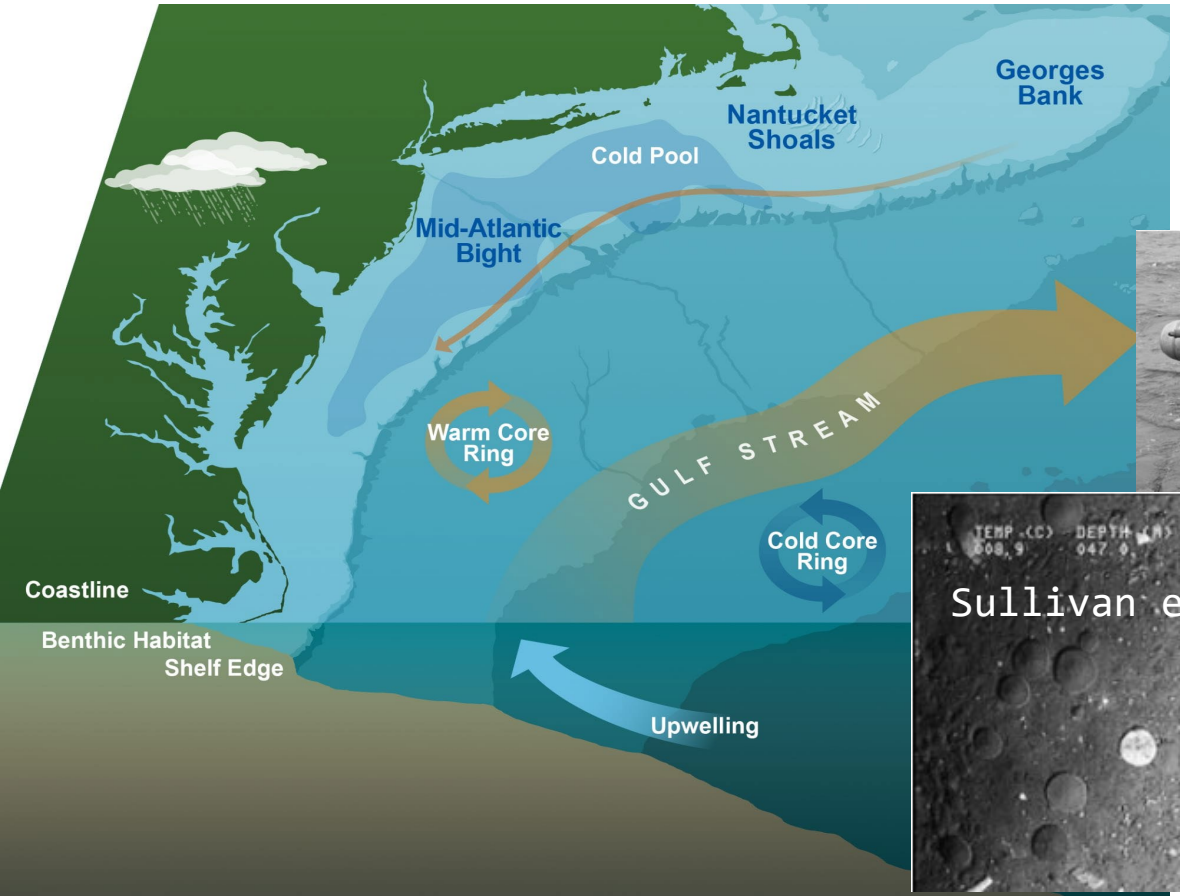


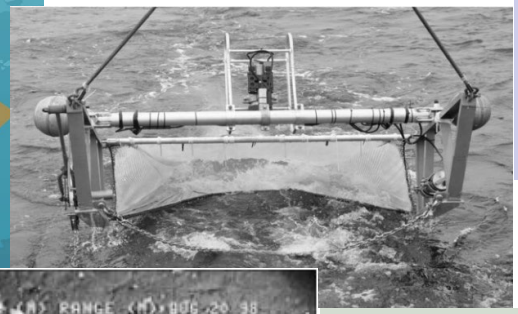


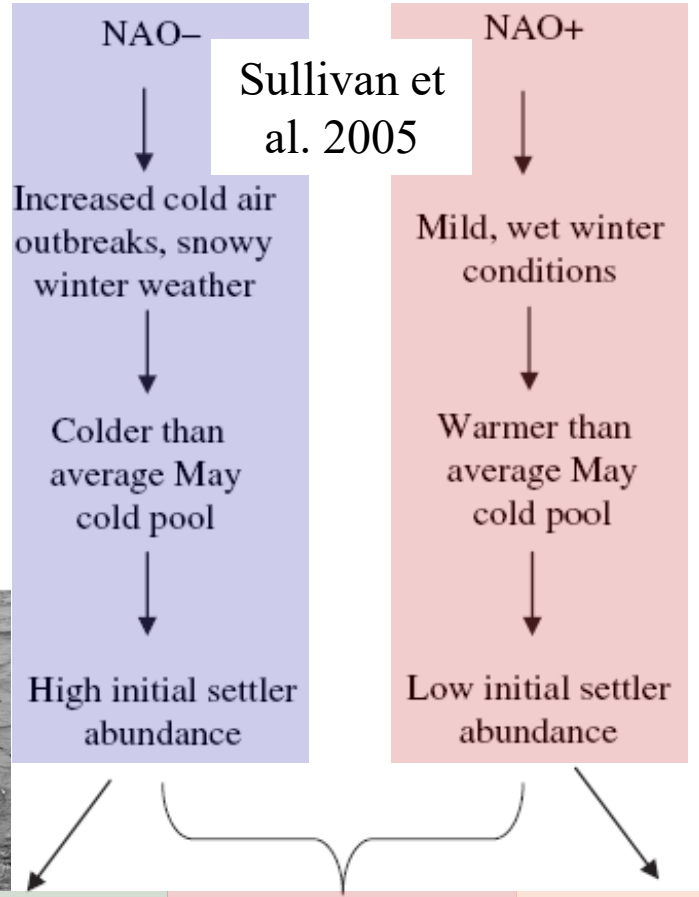


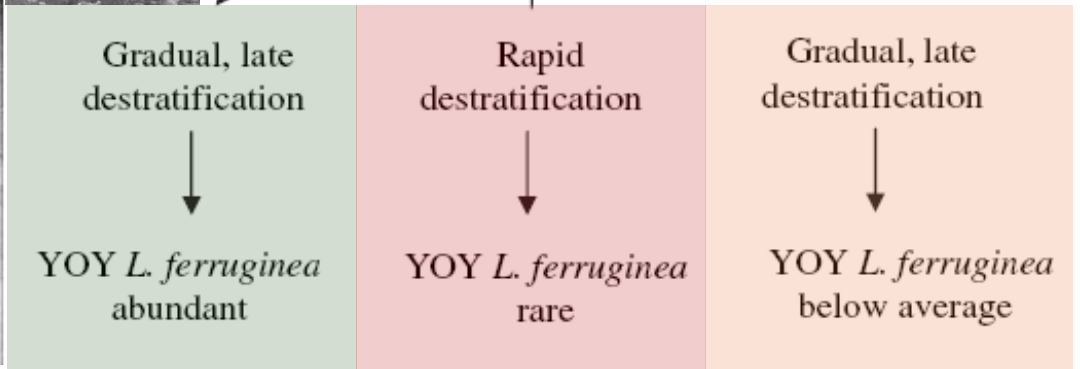
Environmental Mechanisms of Recruitment

- Southern New England recruitment success results from a complex interaction between
  - large-scale phenomena (NAO) and
  - more local features (Mid-Atlantic Bight cold pool).



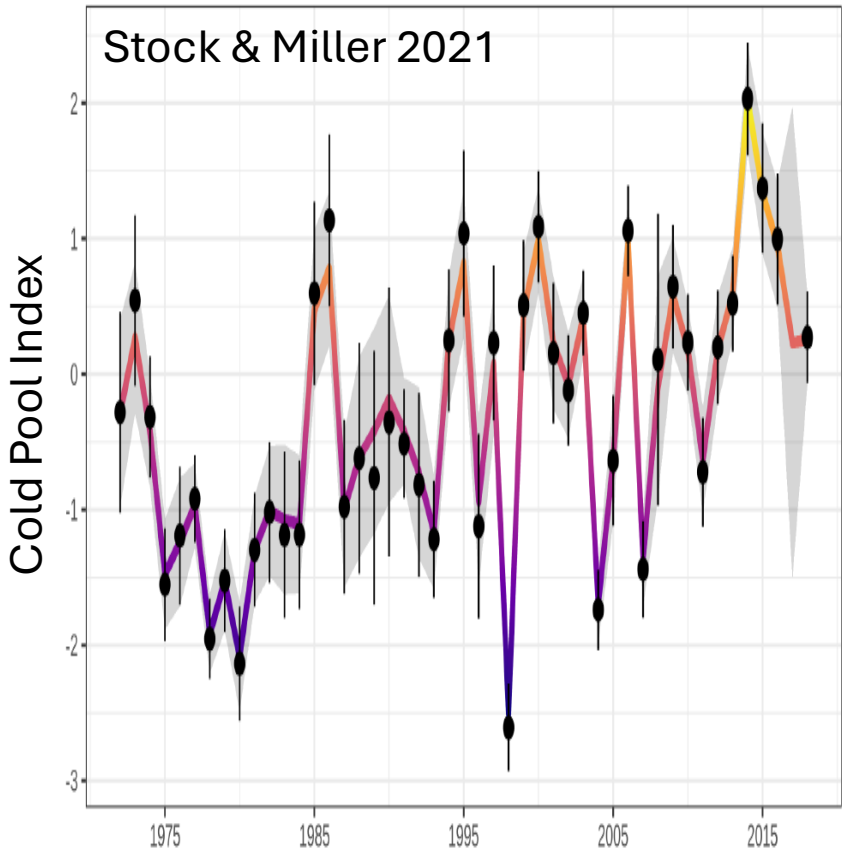


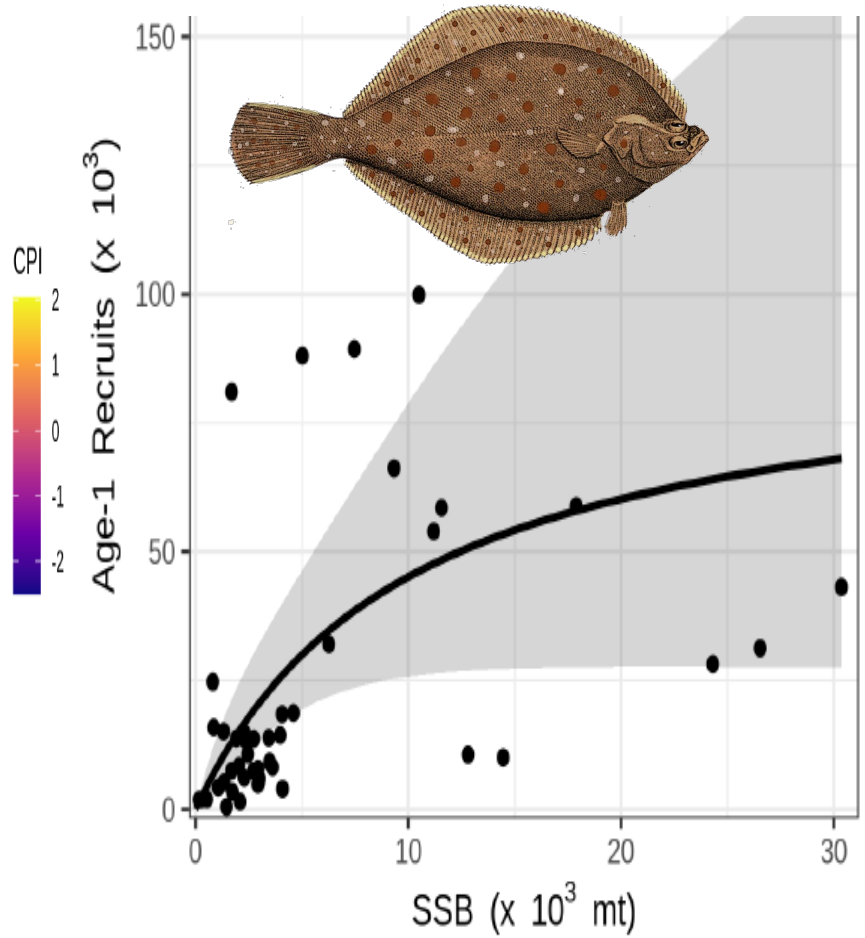


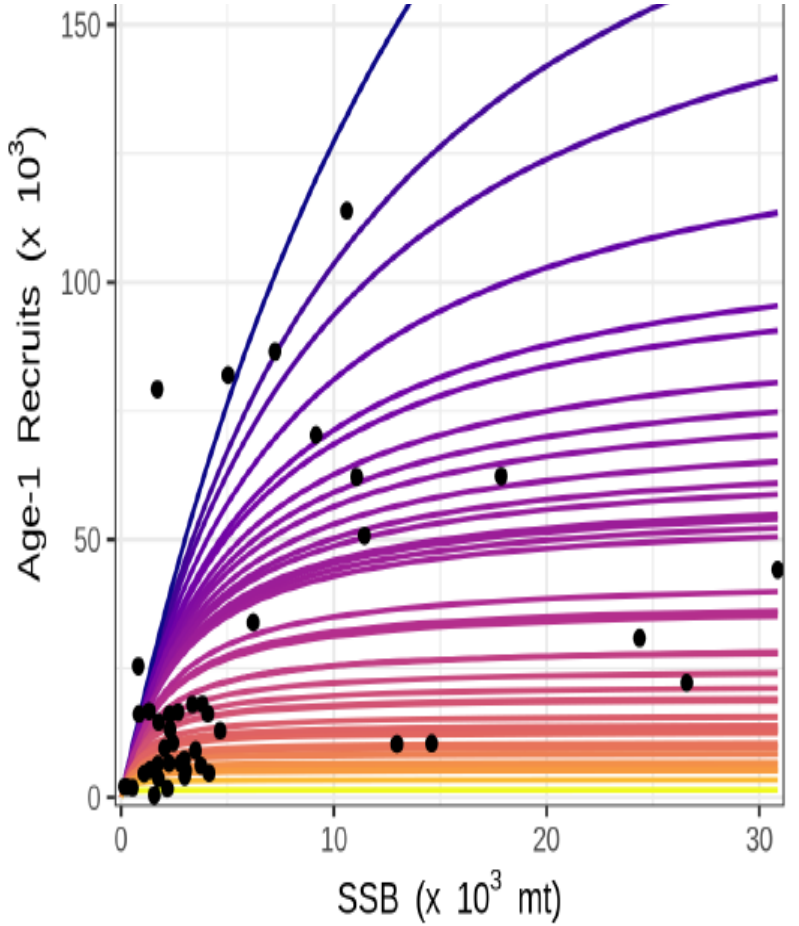


Environmental Covariates of Recruitment

- Exploratory assessments of ‘southern New England yellowtail’ included cold pool indices (Miller et al. 2016, Stock & Miller 2021, du Pontavice et al. 2022) or Gulf Stream Index (Xu et al. 2018) as covariates of recruitment deviations

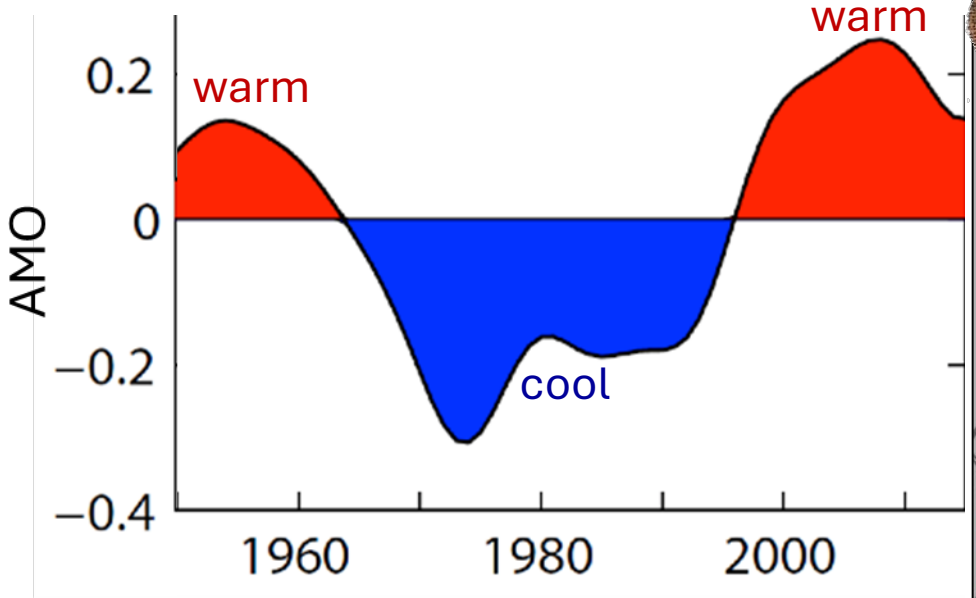


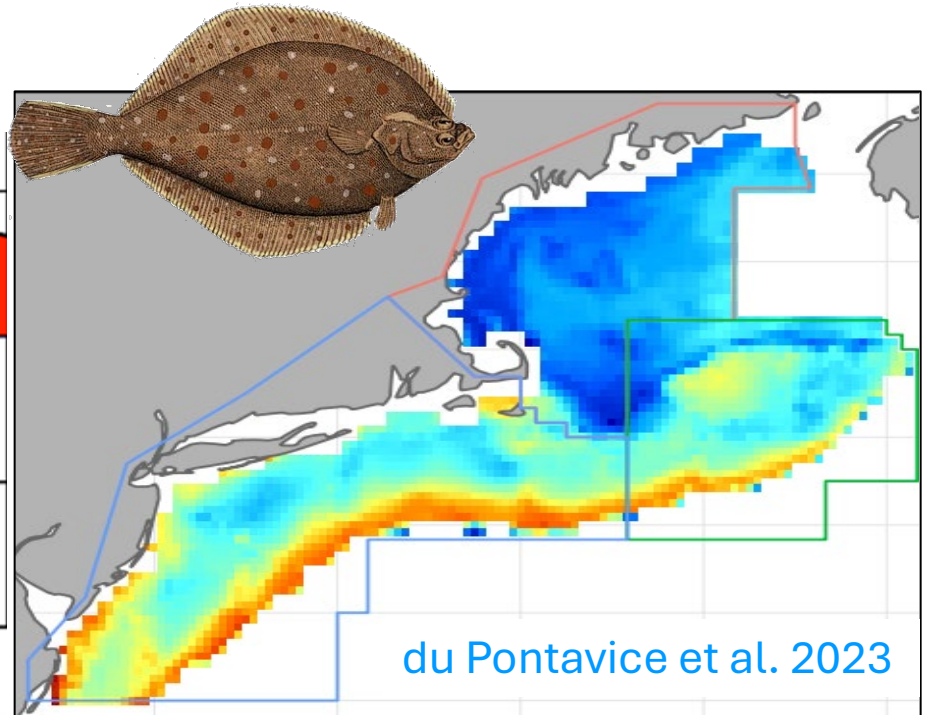


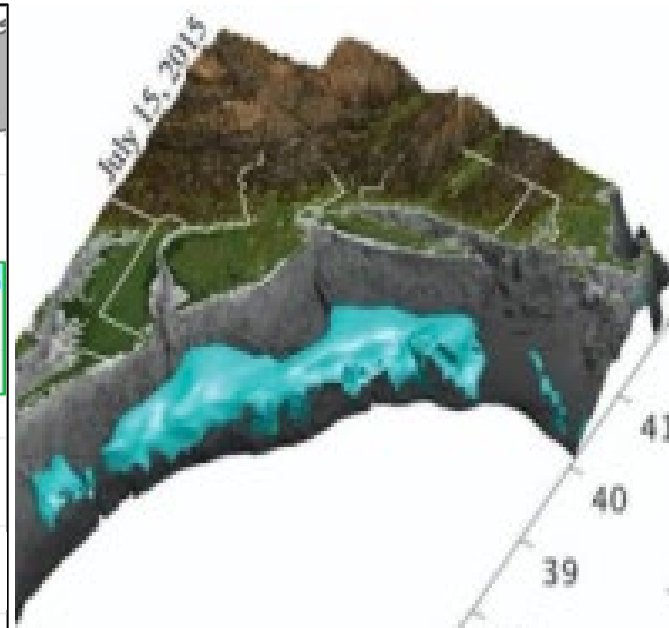


Literature Review Summary

- Yellowtail flounder are vulnerable to climate change, affecting their distribution, recruitment, and potentially other components of production such as natural mortality and growth.
- The environmental covariates with the most support for further exploration include the Atlantic Multidecadal Oscillation (AMO), North Atlantic Oscillation, bottom temperature, Gulf Stream Index, and the Cold Pool Indices.

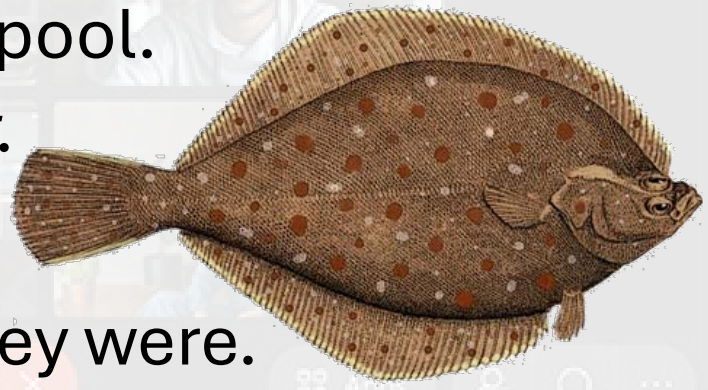






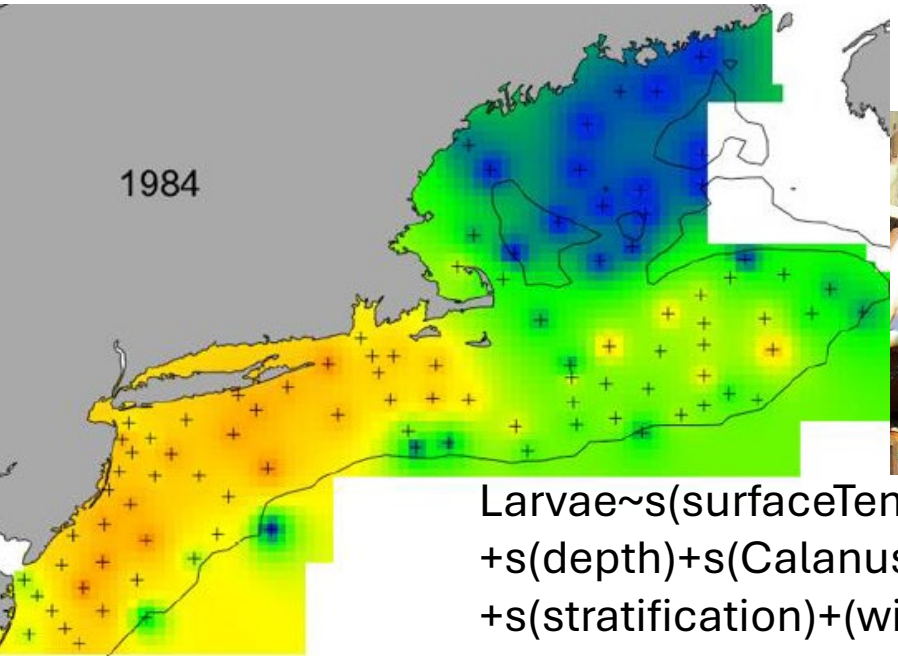
Stakeholder Engagement Meeting (Tara's notes)

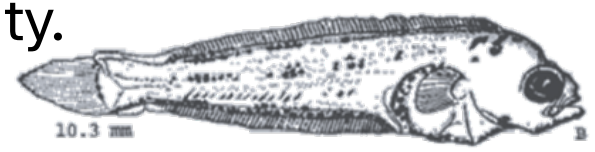
- Distribution
  - Yellowtail flounder may be shifting deeper throughout their range.
  - Many flatfishes are now occupying deeper habitats.
- Abundance
  - Scallopers and bycatch surveys aren't catching many yellowtail on Georges Bank, but they can still be found in the Cape Cod area.
  - The Gulf of Maine has warmed, but fishermen haven't observed a decrease in recruitment.
  - Yellowtail are affected by the Mid Atlantic Bight cold pool.
  - *There hasn't much of a market for yellowtail flounder.*
- Growth
  - Georges Bank yellowtail flounder are smaller than they were.

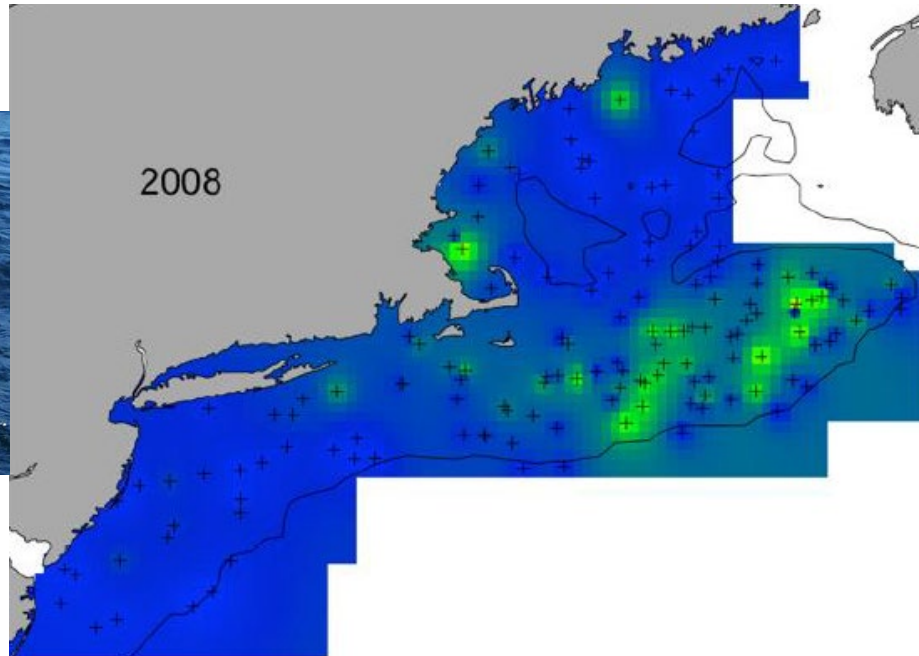


Yellowtail Flounder Larval Habitat Suitability

- Habitat suitability was estimated to determine how environmental variables correspond to larval presence or density.
  - Several variables corresponded to larval abundance (sea temperature 5-15ºC, copepod abundance, North Atlantic Oscillation).
  - Habitat suitability indices increased in the 1970s-1980s and declined in the 2000s.
  - Larval indices for the 'Southern New England' were significantly, but weakly, correlated with the stock's habitat suitability.



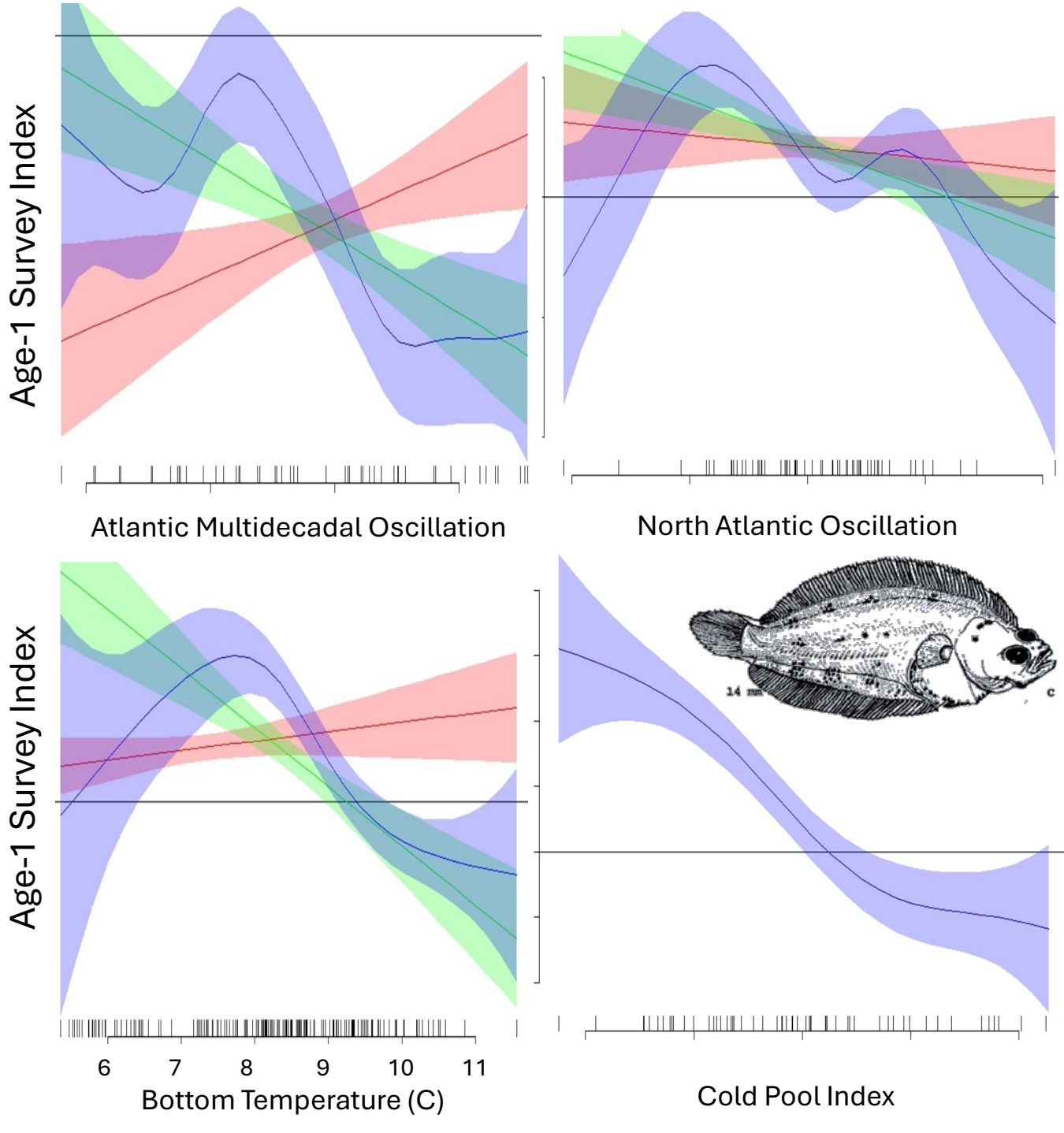




Larvae~s(surfaceTemperature)+s(surfaceSalinity)
+s(depth)+s(Calanus finmarchicus)+s(smallCopepods)
+s(stratification)+(winterNAO)+stock

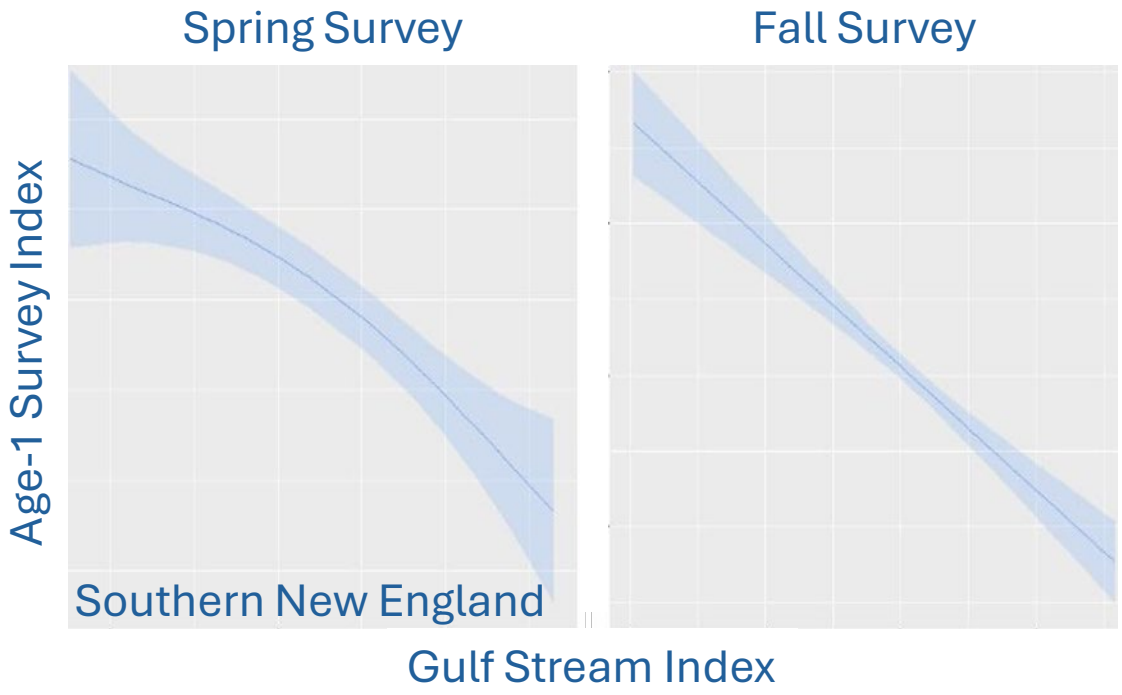
Data Explorations

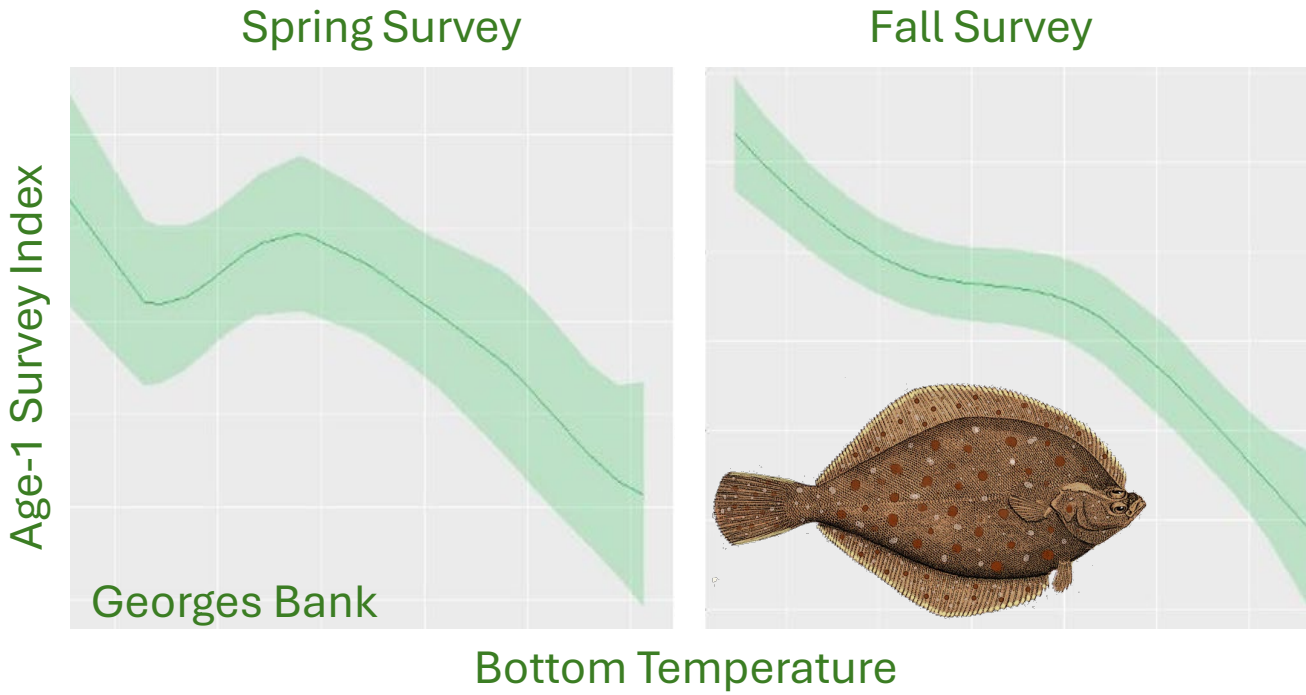
- Environmental effects varied among stocks:
  - ‘Southern New England’ recruitment indices were correlated to the Gulf Stream Index (-) and the Cold Pool Index (-).
  - Georges Bank recruitment indices were correlated with bottom temperature (-), and the Atlantic Multidecadal Oscillation (AMO, -).
  - ‘Cape Cod’ recruitment indices were correlated with bottom temperature (+) and AMO (+).
  - Growth was most related to bottom temperature (+/- spring, + fall) and Gulf Stream Index (+/- spring, + fall), strongest on Georges Bank and ‘southern New England’.



ToR1 Recommendations for Assessment Models

- The Yellowtail Flounder Research Track Working Group decided to
  - apply time-varying size at age from annual samples or multi-annual samples, and
  - explore environmental covariates to recruitment deviations
    - ‘Southern New England’ recruitment informed by Gulf Stream Index or Cold Pool Index
    - Georges Bank recruitment informed by bottom temperature or Atlantic Multidecadal Oscillation,
    - ‘Cape Cod’ recruitment informed by bottom temperature.





Supplemental Information

- Kittle et al. WP Table 2. Environmental relationships with recruitment
  - Probability (• not significant, consistency)
  - CPI Cold Pool Index (temperature in area)
    - PI persistence index (seasonal stabilization)
    - EI extent index (area)
  - NAO North Atlantic Oscillation
  - AMO Atlantic Multidecadal Oscillation
  - GSI Gulf Stream Index
  - BT bottom temperature
  - %DE deviance explained (>40%)
    - * highest deviance explained for each index
  - 6 or 12 month lagged indices

Stock	Survey	Env Var	Each index-all stocks	All indices-each stock	Each index-each stock	Each index-each stock DE (%)	6 or 12
SNEMA	Fall	CPI	NA	.	<2e-16	44.9	
		PI	NA	.	1.27E-06	32.8	
		EI	NA	0.01088	2.66E-06	31.9	
		NAO 6	.	.	.	.	
		AMO 6	4.11E-07	.	5.90E-05	33.9	
		GSI 6	< 2e-16	.	< 2e-16	54	N
		BT 6	< 2e-16	.	< 2e-16	47.7	N
		NAO 12	6.87E-05	.	0.0108	18.2	
		AMO 12	9.36E-07	.	8.73E-05	28.5	
		GSI 12	< 2e-16	0.00485	< 2e-16	61.7	Y
		BT 12	< 2e-16	0.05177	< 2e-16	47.3	Y
	Spring	CPI	NA	.	< 2e-16	53.8	
		PI	NA	.	1.36E-06	27.8	
		EI	NA	.	< 2e-16	31	
		NAO 6	2.74E-05	.	0.000159	29.3	
		AMO 6	2.58E-05	0.0811	0.000949	31.5	Y
		GSI 6	5.11E-07	.	2.47E-05	27.8	
		BT 6	6.95E-07	.	8.36E-06	50.5	
		NAO 12	0.00358	.	0.00776	15.9	
		AMO 12	0.000102	0.0265	0.00137	28.1	N
		GSI 12	8.33E-07	.	1.75E-05	27.4	
		BT 12	4.02E-07	.	9.57E-06	41	
CCGOM	Fall	NAO 6	.	.	.	.	
		AMO 6	.	.	.	.	
		GSI 6	.	.	0.0886	9.22	
		BT 6	.	.	.	.	
		NAO 12	.	.	.	.	
		AMO 12	.	.	.	.	
		GSI 12	0.0757	.	0.0583	9.15	
		BT 12	.	.	.	.	
	Spring	NAO 6	.	.	0.0893	5.96	
		AMO 6	0.017744	0.01455	0.00941	13.7	N
		GSI 6	.	.	.	13.4	
		BT 6	0.0772	.	0.00227	50.2	?
		NAO 12	.	.	0.0015	53.1	
		AMO 12	0.014884	0.03135	0.0074	15.5	Y
		GSI 12	.	.	.	18.6	
		BT 12	0.02702	0.00692	0.00194	49.1	?
GB	Fall	NAO 6	.	.	.	.	
		AMO 6	0.00809	0.0192	0.0137	7.31	
		GSI 6	6.14E-06	.	5.63E-05	23.9	
		BT 6	6.28E-07	0.00841	4.28E-05	19.9	N
		NAO 12	0.001	.	0.0014	12	
		AMO 12	0.0875	0.02078	.	.	
		GSI 12	1.24E-06	.	2.28E-05	25.3	
		BT 12	< 2e-16	0.00043	< 2e-16	41.7	Y
	Spring	NAO 6	.	.	.	.	
		AMO 6	0.000139	.	0.000368	23.1	
		GSI 6	0.00209	.	0.00321	24.3	
		BT 6	2.71E-05	0.0452	0.000265	24	Y
		NAO 12	.	.	.	.	
		AMO 12	0.000201	.	0.000466	24.7	
		GSI 12	0.00838	.	0.0139	16.6	
		BT 12	0.00035	0.0602	0.00252	19.5	N

Supplemental Information

- Kittle et al. WP Table 3. Environmental relationships with weight at age
  - AMO Atlantic Multidecadal Oscillation
  - GSI Gulf Stream Index
  - BT bottom temperature
  - CPI Cold Pool Index (temperature in area)
  - PI persistence index (seasonal stabilization)
  - EI extent index (area)
  - 6-12 month lagged indices
  - P-value significance (• not significant, consistent)
  - %DE deviance explained (>40%)
  - * highest deviance explained for each index

			Each index-all stocks		Each index-each stock		
Survey	Env Var	Stock	p-value	%DE	p-value	%DE	
Fall	AMO 6	CCGOM	.		0.0113	10.2	
	AMO 12	SNEMA	.		0.0717	19.5	*
		CCGOM	.		0.00329	14.1	
	GSI 6	SNEMA	0.0679	5.49	0.00452	19.8	
		CCGOM			0.00105	25	
		GB	0.0223		0.000174	28.8	*
	GSI 12	SNEMA	0.0503	6.34	0.00197	25.7	
		CCGOM	.		0.000245	23.3	
		GB	0.0126		4.49E-05	36.5	*
	BT 6	SNEMA	< 2e-16	78.8	0.000109	23.6	
		CCGOM	< 2e-16		0.000552	19.6	
		GB	7.32E-05		9.37E-05	33	*
	BT 12	SNEMA	< 2e-16	77.7	0.000561	24.8	
		CCGOM	< 2e-16		0.000469	20.2	
		GB	2.39E-06		2.34E-06	42	*
	CPI	SNEMA	NA		0.000249	34	
	PI	SNEMA	NA		0.000426	18.8	
	EI	SNEMA	NA		0.000478	30.5	
Spring	NAO 6	SNEMA	0.05977	25.9	0.0139	15.1	
		CCGOM	0.07286		.	4.96	
		GB	0.00765		0.0203	30.6	*
	NAO 12	SNEMA	.		0.0205	12.8	
	AMO 6	SNEMA	.		0.0672	25.6	
	AMO 12	SNEMA	.		0.132	26.6	
	GSI 6	SNEMA	0.02735	39.3	0.0135	15.5	
		CCGOM	0.00336		0.00562	46.7	
		GB	0.00102		0.00206	51.7	*
	GSI 12	SNEMA	0.0659	22.5	0.0475	10.3	
		CCGOM	0.0238		0.0533	22.4	
		GB	0.0111		0.0161	32.1	*
	BT 6	SNEMA	0.011846	42.5	0.000229	30.5	
		CCGOM	4.82E-07		0.0426	25.3	
		GB	0.000899		0.00926	32.9	*
	BT 12	SNEMA	.	39	0.00293	20.7	
		CCGOM	3.48E-07		0.0221	27.8	
		GB	0.000114		0.00538	30.8	*
	CPI	SNEMA	NA		0.00747	17.5	
	PI	SNEMA	NA		0.0202	13.5	
	EI	SNEMA	NA		0.0194	13.9	