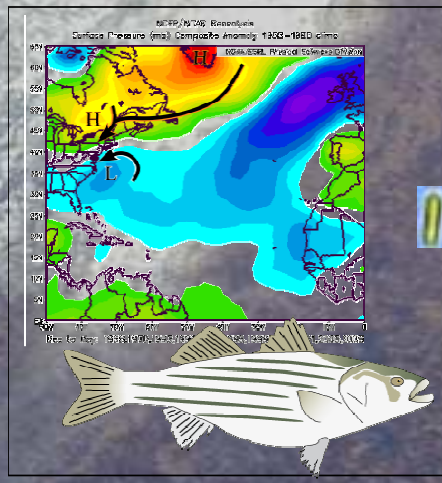
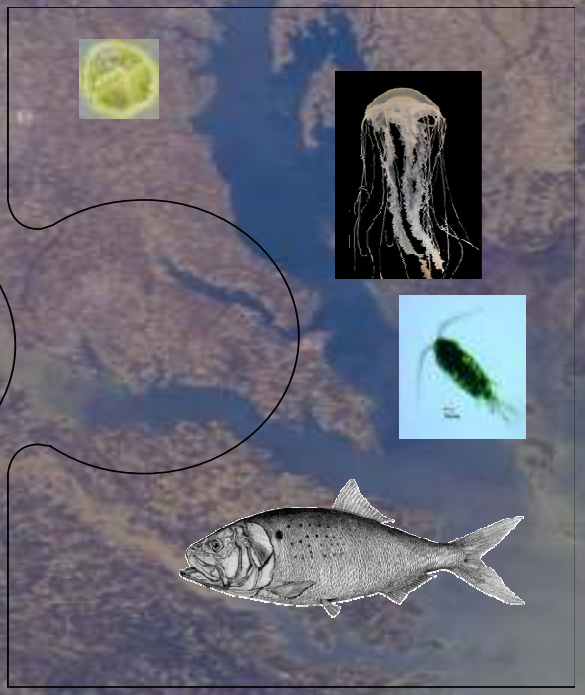
Decadal scale linkages between climate dynamics & fish production in Chesapeake Bay and beyond





Bob Wood

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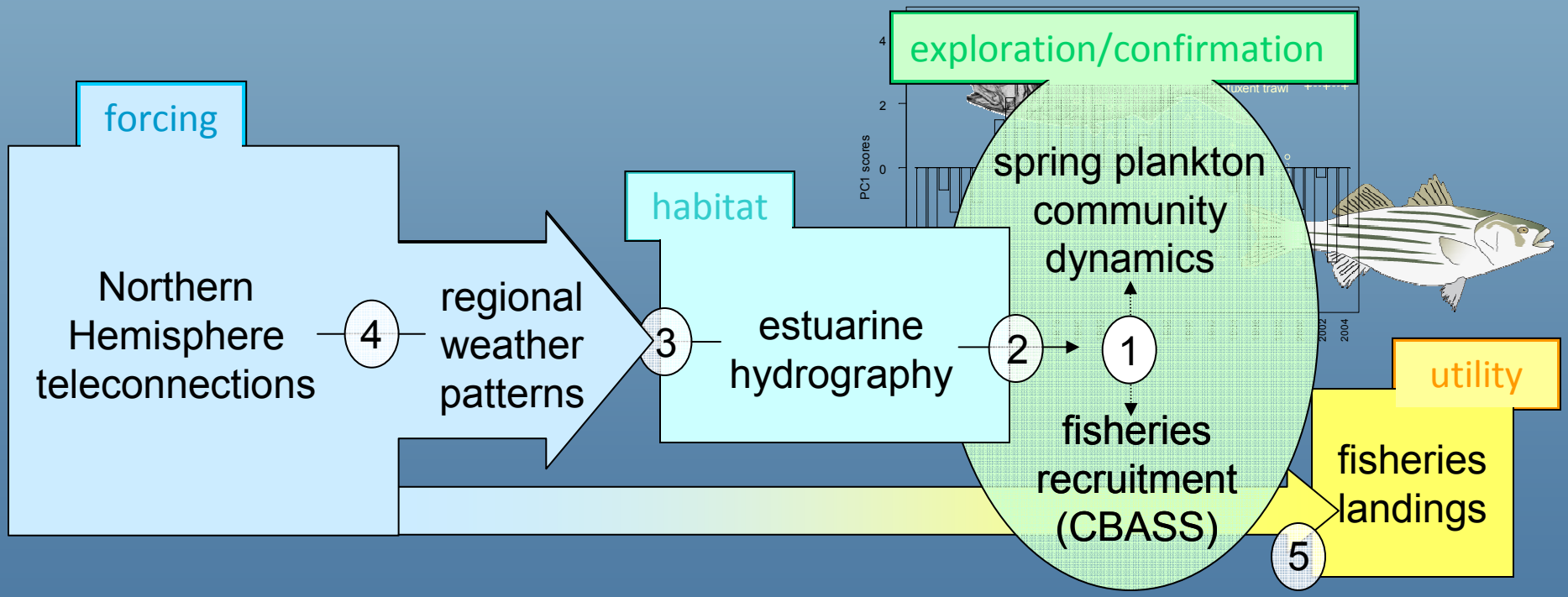
NOAA/NOS/NCCOS/Cooperative Oxford Lab

Co-authors: Jackie Johnson, Ed Martino, Xinsheng Zhang

Approach

Examining bio-physical linkages affecting fish production

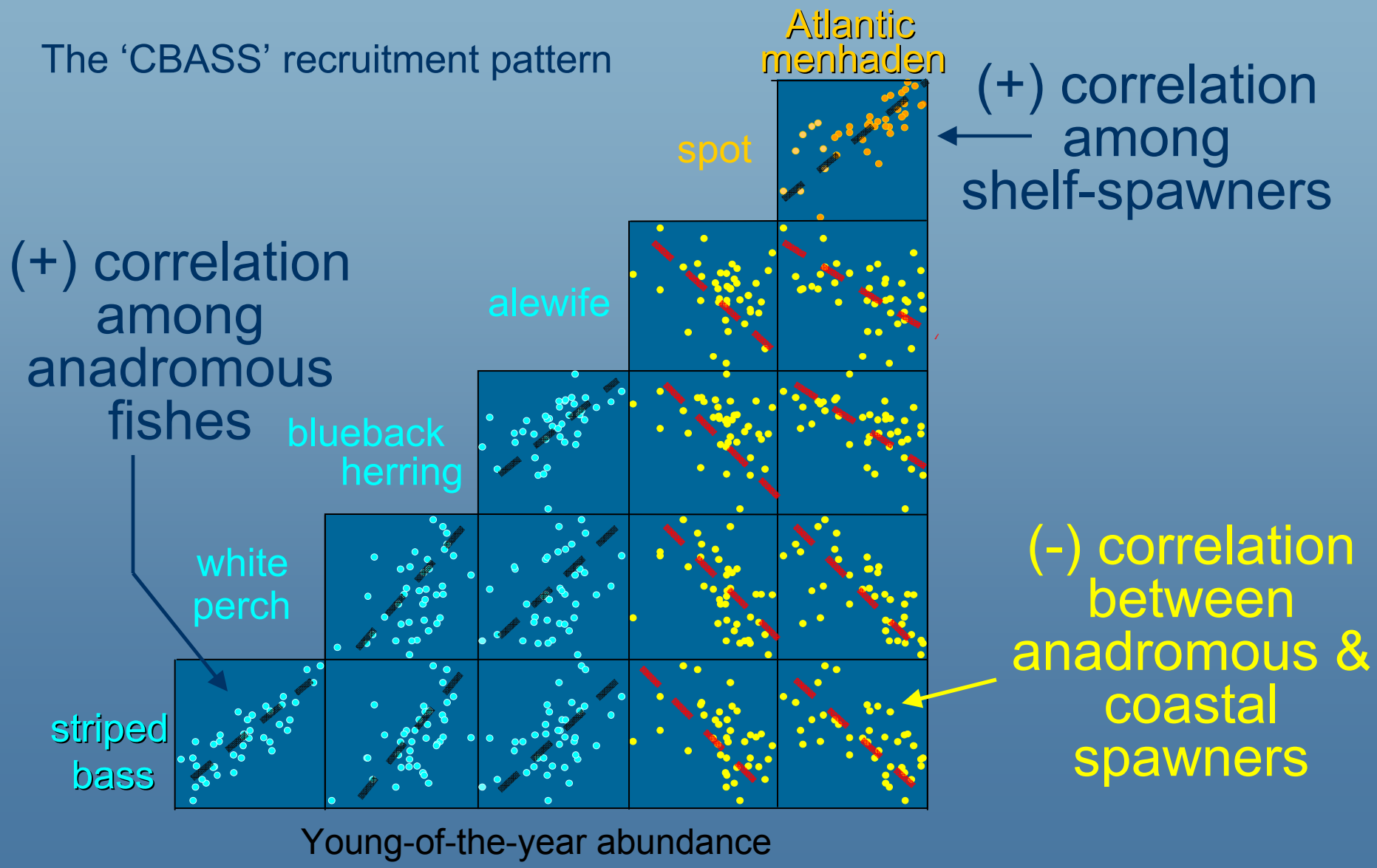
Working backwards…



Wood & Austin (2009)
CJFAS **66**/3

Fish production in Chesapeake Bay

young-of-the-year (YOY) recruitment scatter plots (1965-2004)

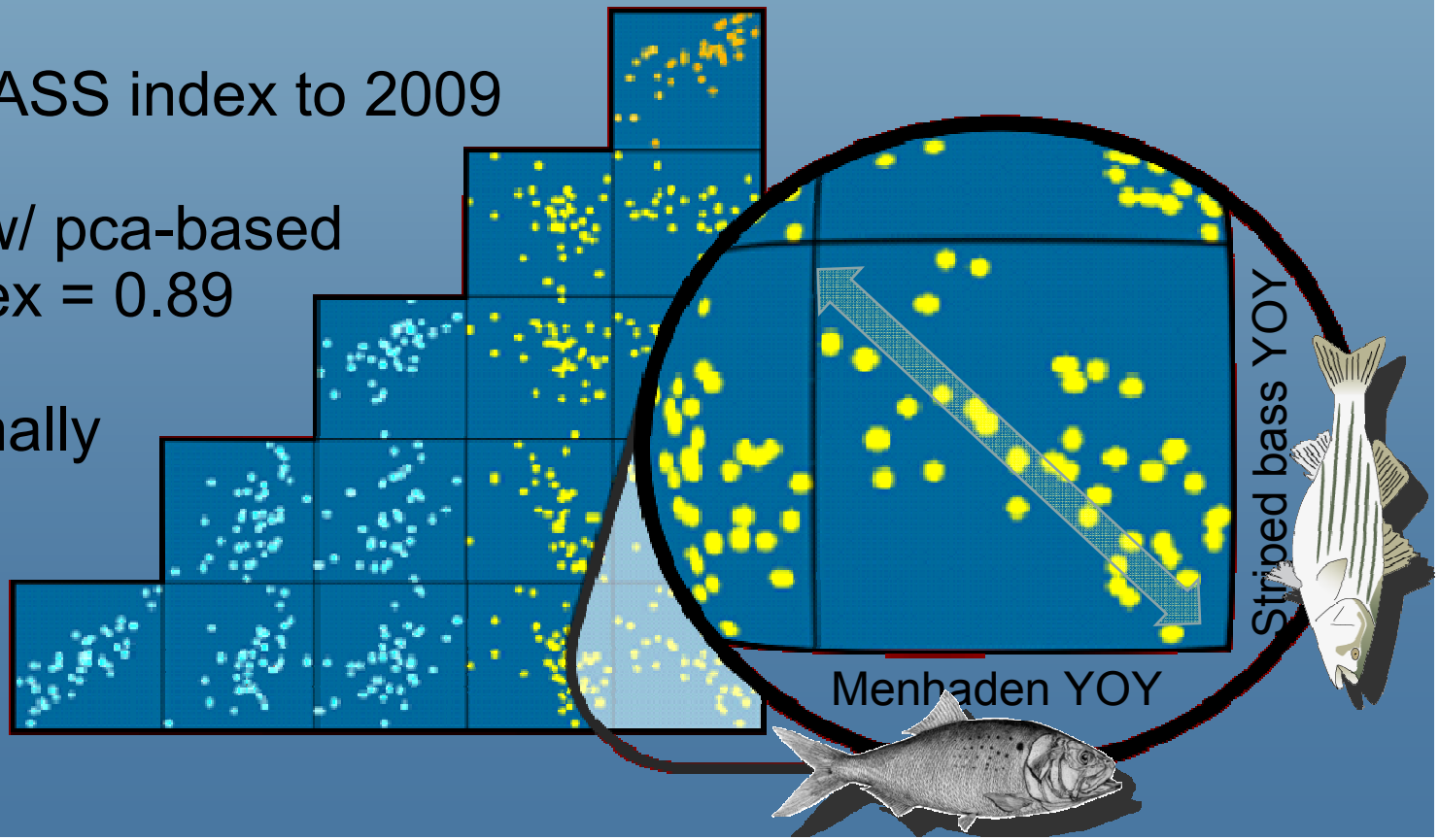


A simpler CBASS index

the CBASS ratio-based-index ($CBASS_{rbi}$)

$$CBASS_{rbi} = \text{Log}_{10} \text{ (menhaden JAI / striped bass JAI)}$$

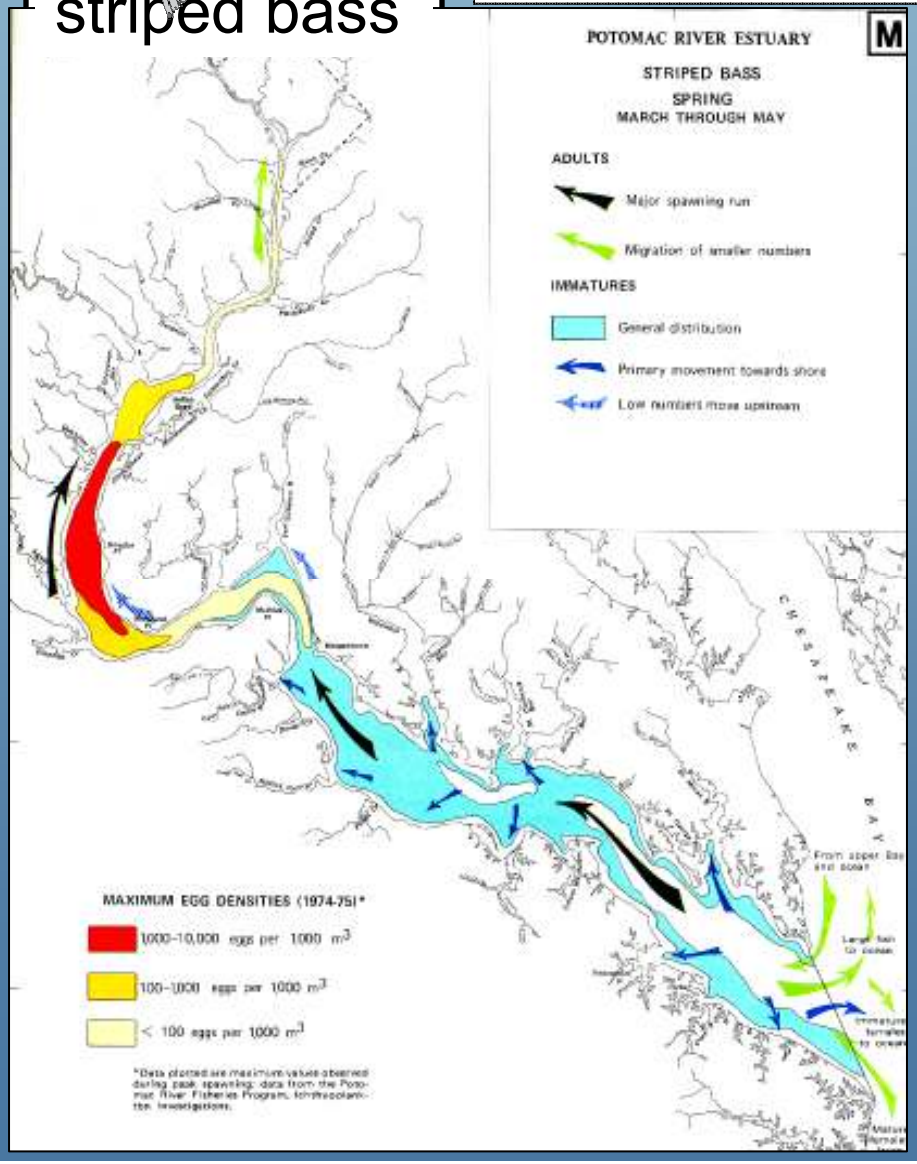
- Juvenile abundance indices (JAI) publicly available:
  www.dnr.state.md.us/fisheries/juvindex/index.html
- extends CBASS index to 2009
- correlation w/ pca-based CBASS index = 0.89
- ratio is normally distributed



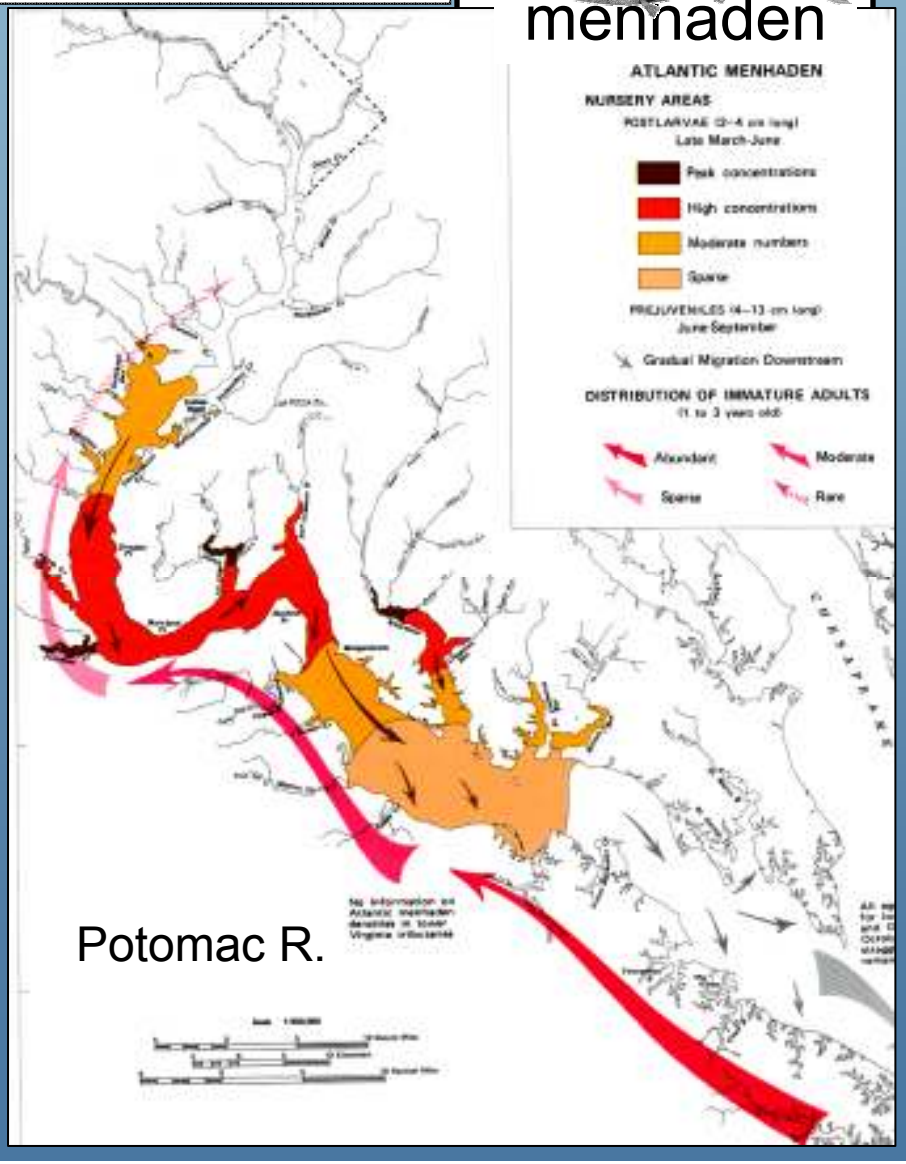
Anticipated joint CBASS research projects (OMTZ)

Common nursery areas

striped bass

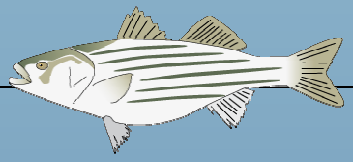


menhaden



Potomac R.

And different life history strategies



Spawning	Estuarine fresh-saltwater boundary late April	Peak Mid-Atlantic coastal spawning Dec-Feb
Estuarine nursery area	Retention within oligohaline-mesohaline transition zone (OMTZ)	Up-estuary migration to OMTZ Feb-June (late-postlarvae to early juveniles)
First feeding YOY prey (Mar-Jun)	Oligohaline, winter-spring zooplankton species (May-Jun)	First-feeding larvae: zooplankton YOY to juveniles: phytoplankton

Is the Bay's plankton community responsive to the same signal?

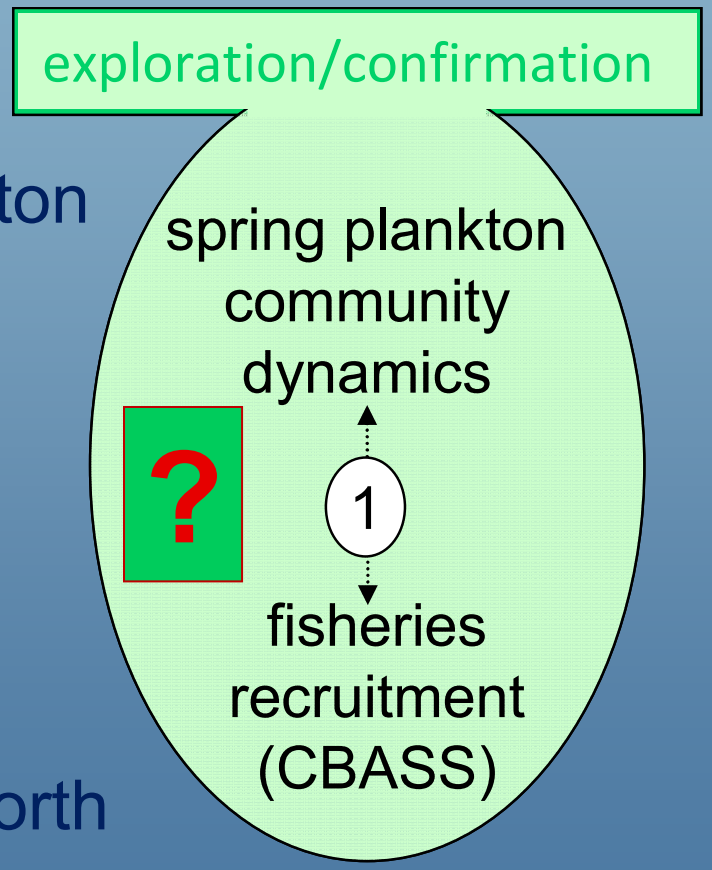
PCA used to isolate strongest spring plankton dynamics

Chesapeake Bay Program's plankton survey (1985-2001):

Northern Bay stations only

1.longest fish recruitment survey monitors only MD waters

2.collection differences between north & south Bay inhibit comparability

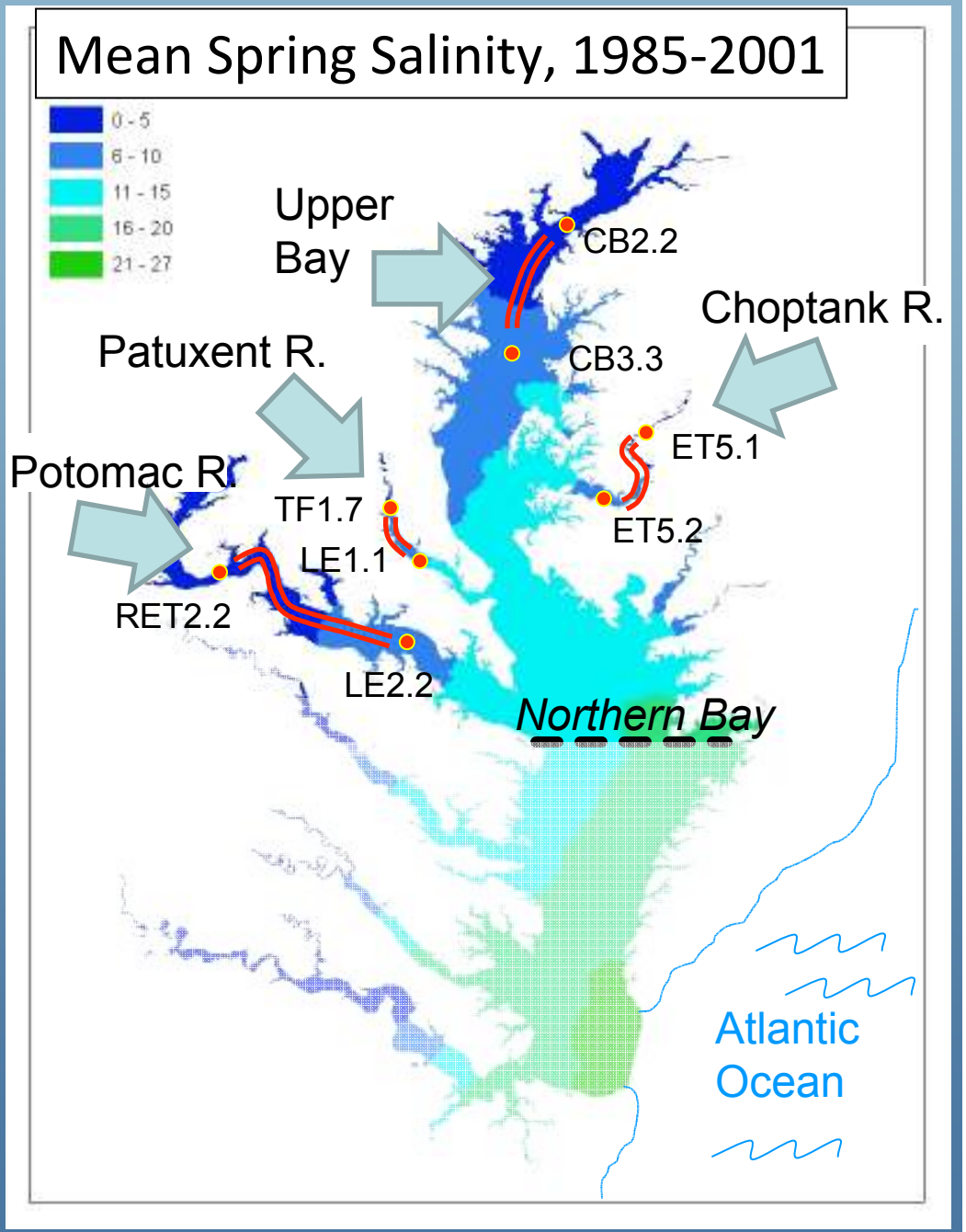


Plankton data
(for PCA)

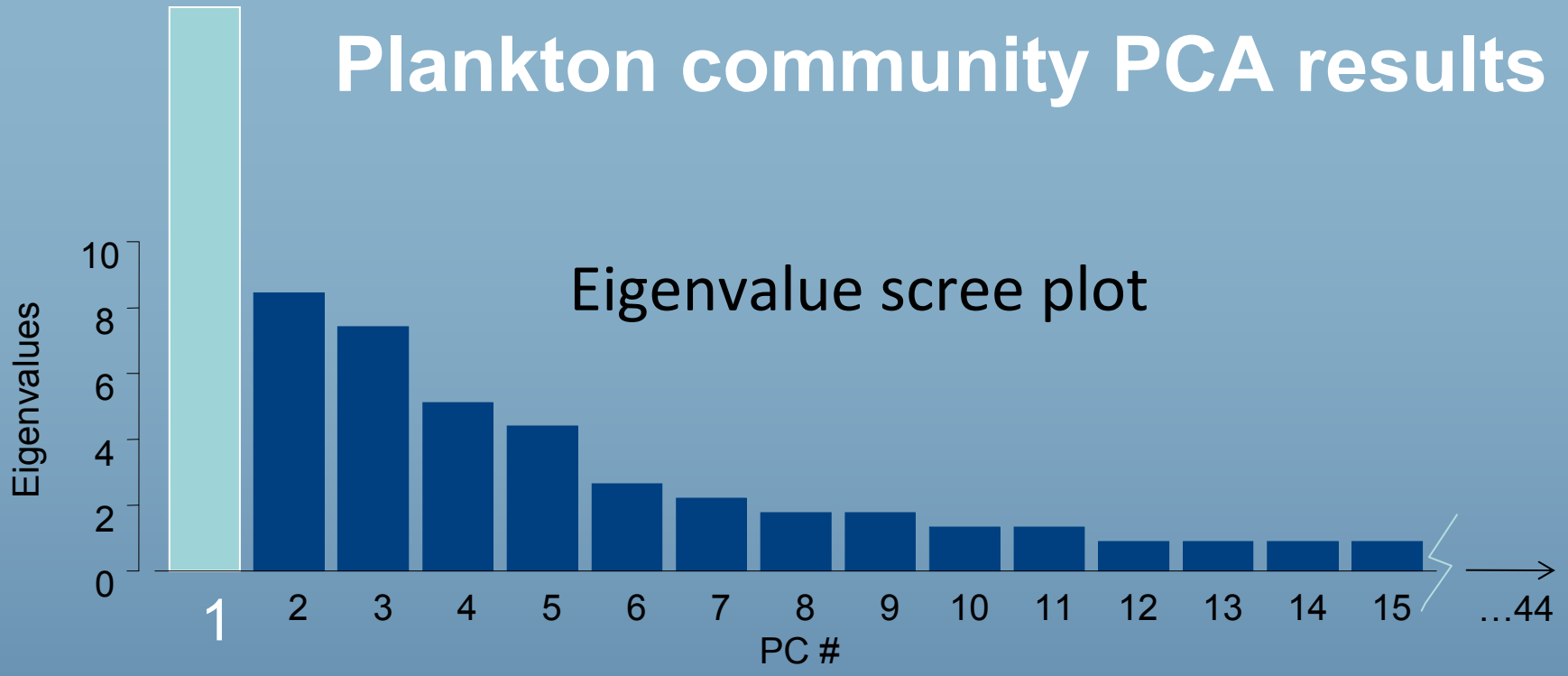
Mean monthly plankton counts:
March-June

aggregated across the northern Bay's oligohaline-mesohaline transition zones (OMTZ)

Note: OMTZ spans the nursery grounds for striped bass & menhaden YOY



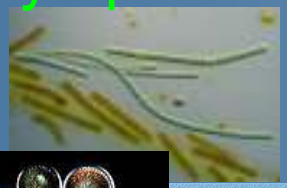
Plankton community PCA results



Plankton PC #	Eigenvalue	Plankton data set's proportion of variance	Cumulative variance %	Correlation with $CBASS_{rbi}$
1	14.5	0.26	26%	**0.88** *p<0.0001
2	8.01	0.14	40%	0.34
3	6.9	0.12	52%	0.07
4	5.2	0.09	61%	0.19
5	4.7	0.08	69%	0.04

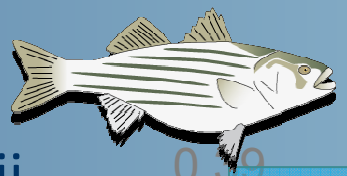
PC1-species correlations

phytoplankton



zooplankton

Taxa	March	April	May	June
Chlorophytes	0.67	0.60	0.12	0.26
Cryptophytes	0.47	0.71	0.84	0.50
Cyanophytes				0.25
Diatoms	0.79	0.51	0.09	-0.28
Dinoflagellates	-0.23	0.32	0.65	-0.37
Acartia sp.	0.36	0.57	-0.67	-0.50
Cladocera		-0.42	-0.53	-0.60
Copepod nauplii	0.39	-0.13	-0.56	-0.73
Cyclopoida	-0.25	-0.70	-0.65	-0.69
Eurytemora	-0.07	-0.57	-0.68	-0.78
Harpacticoida	-0.5	-0.58	-0.54	-0.40
Ctenophora	□	□	□	-0.26

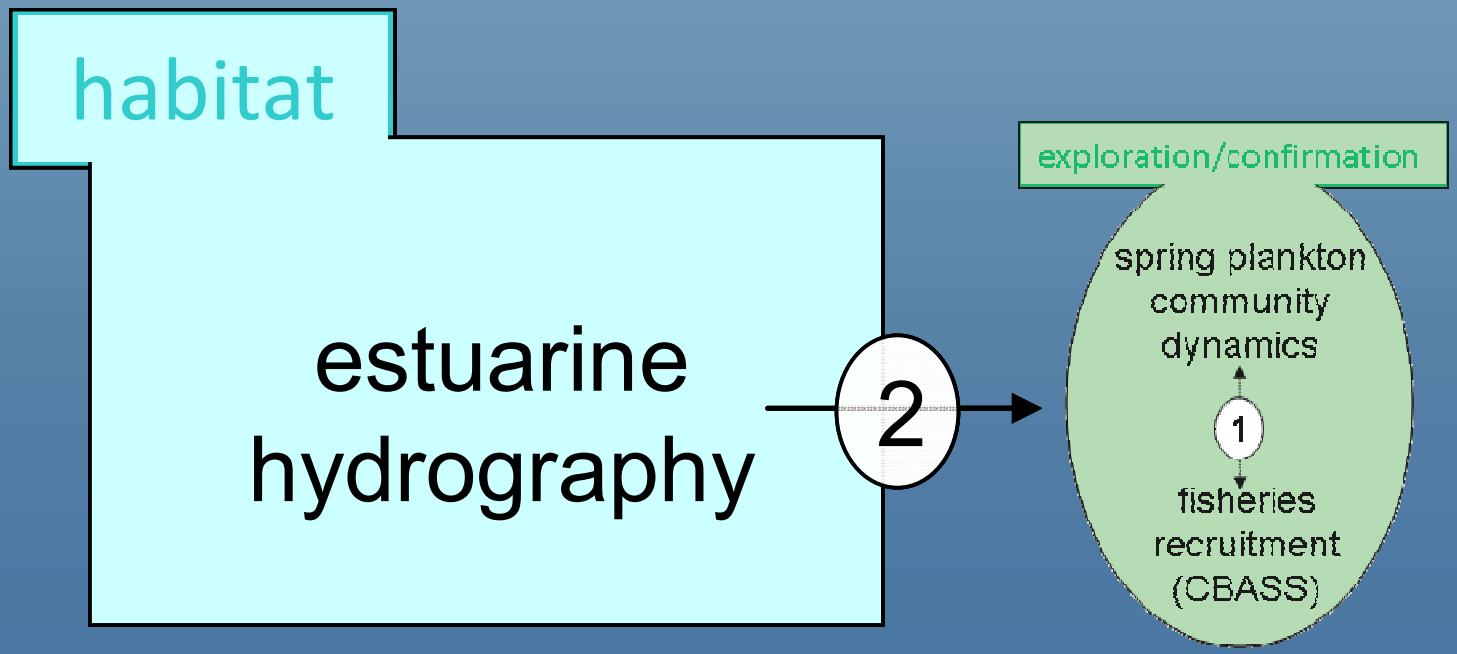


spawning

Habitat

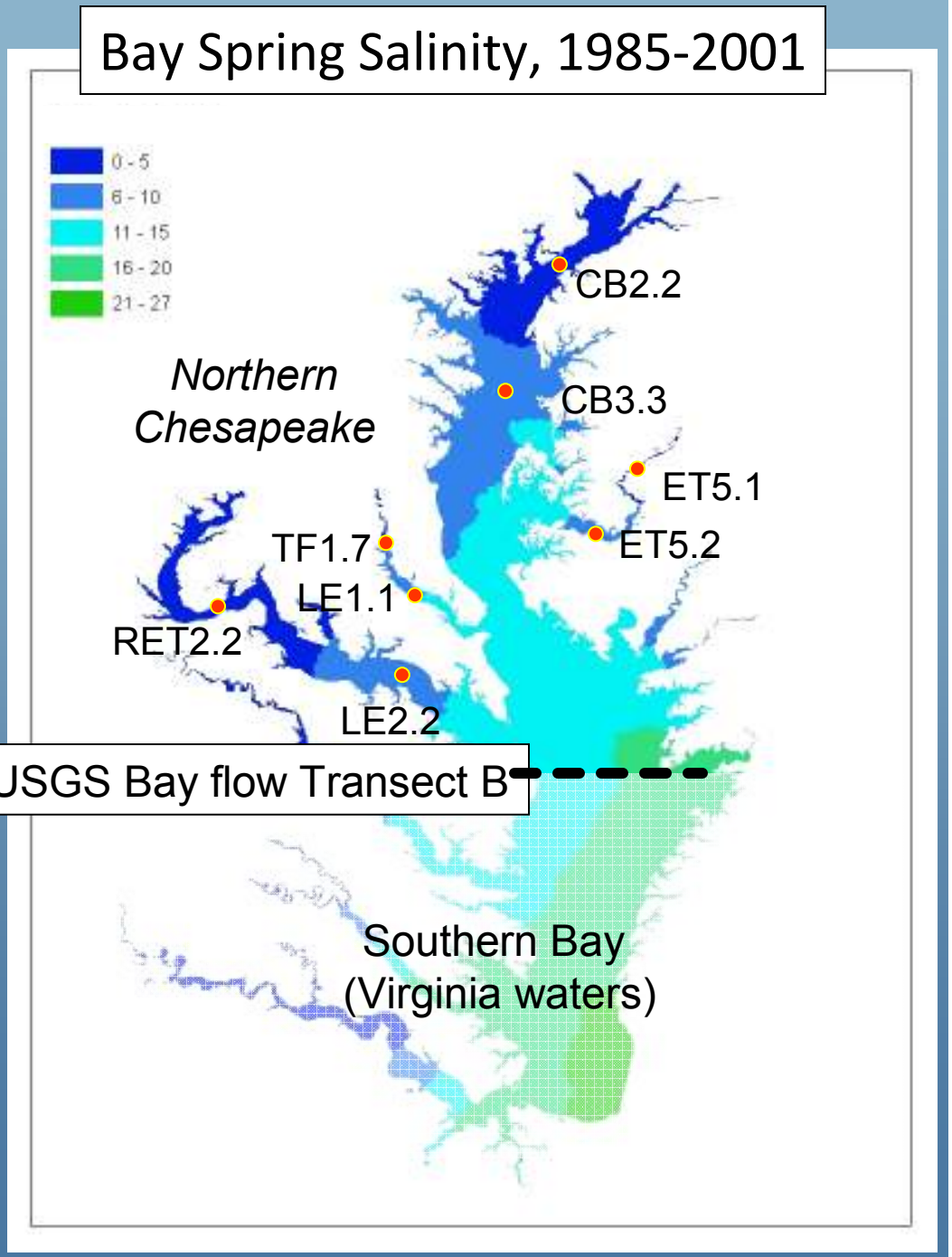
Investigate:

Habitat-hydrographical variability as a likely force behind the coupled CBASS-plankton dynamics



Hydrographical data

- Temporal resolution: monthly March-June
- Spatial resolution: Mean conditions aggregated across all stations bounding the oligohaline-mesohaline transition zone (aka – the OMTZ)

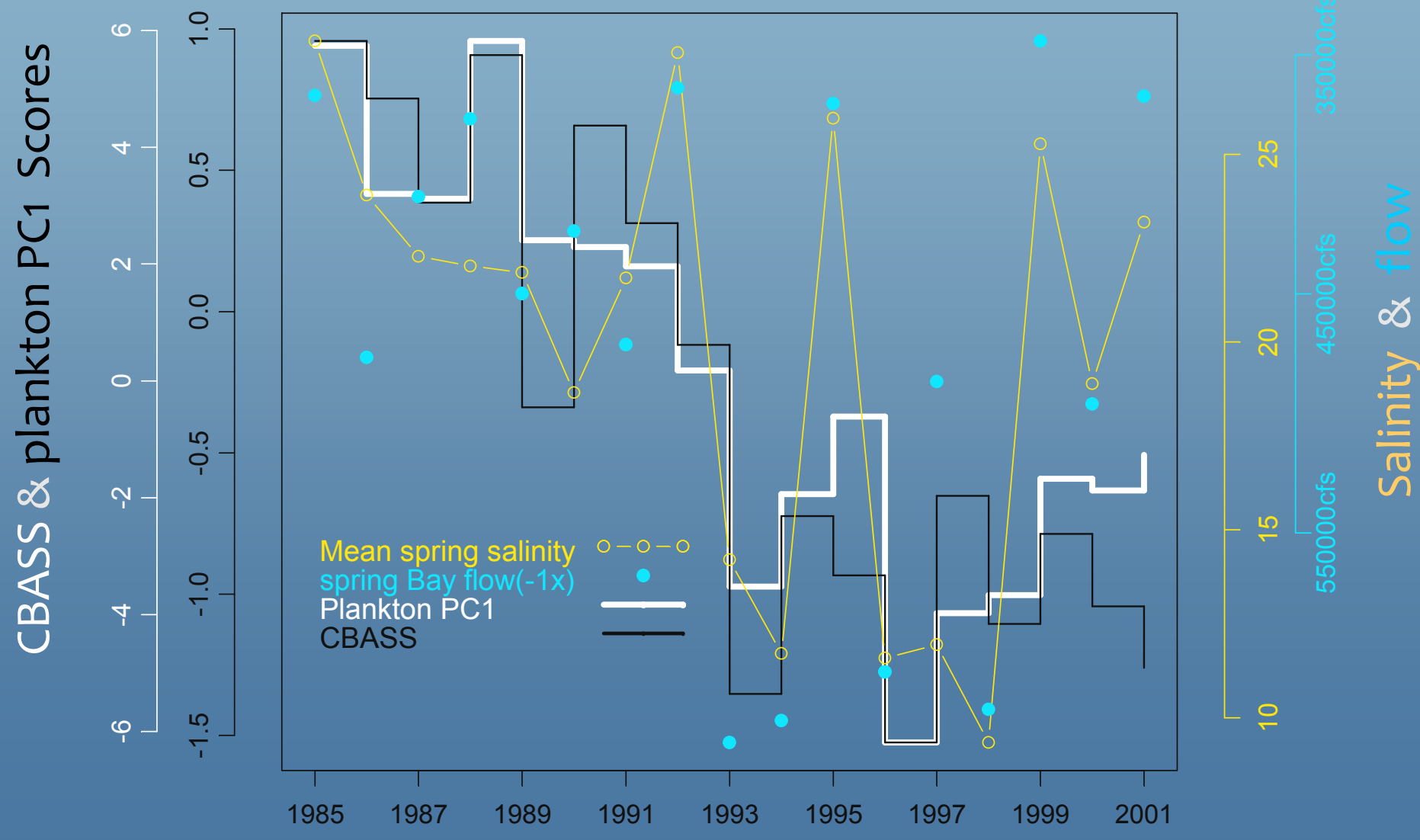


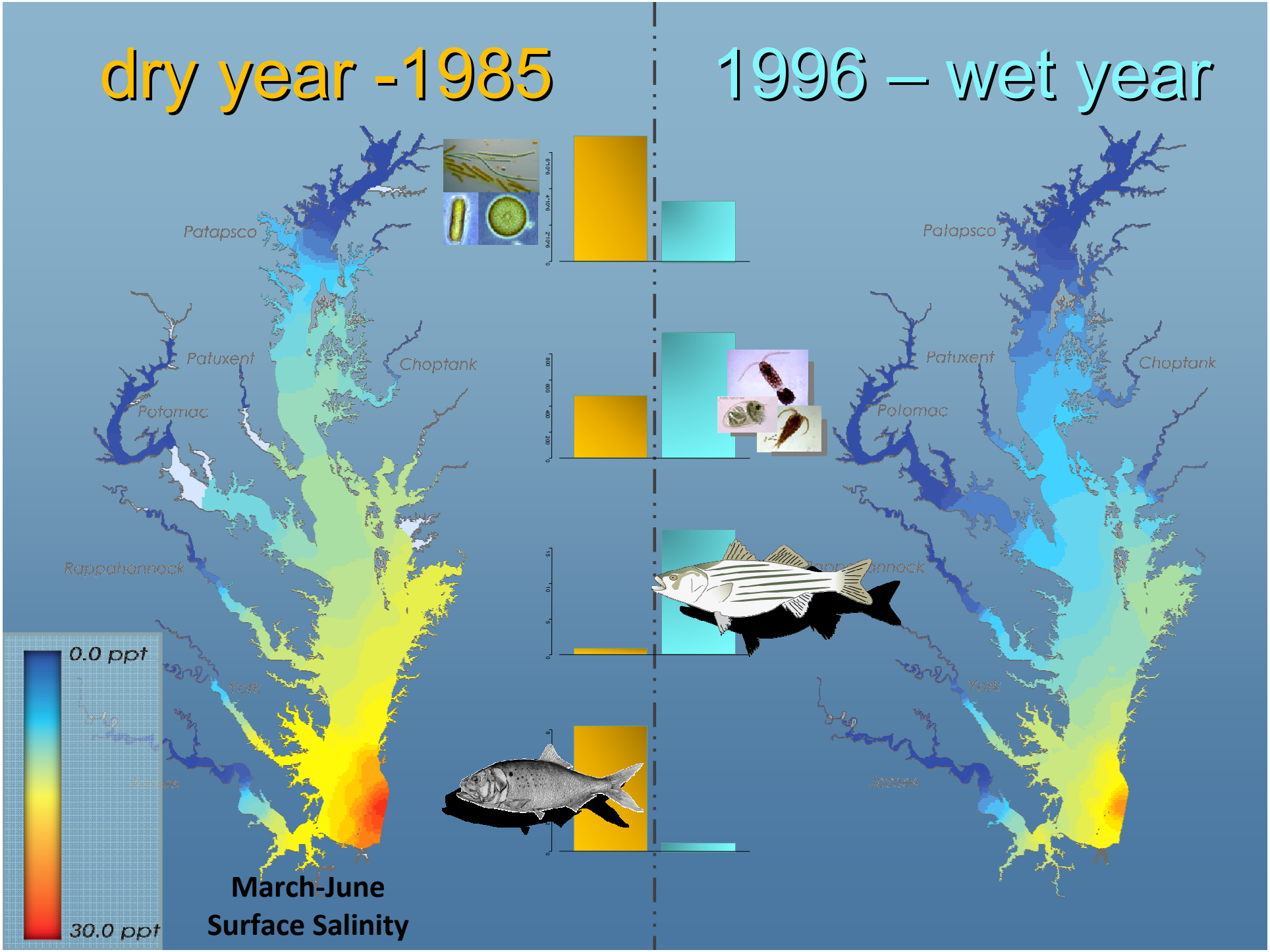
Correlation:
Spring hydrography & plankton PC1 scores

Environmental variable	Plankton PC1	$CBASS_{rbi}$
water temp. March	0.16	-0.04
water temp. April	0.20	-0.02
water temp. May	-0.21	-0.36
water temp. June	0.32	0.09
salinity March	0.51*	0.21
salinity April	0.76**	0.51*
salinity May	0.81**	0.68**
salinity June	0.61**	0.41
Salinity March-June	**0.76****	**0.51***

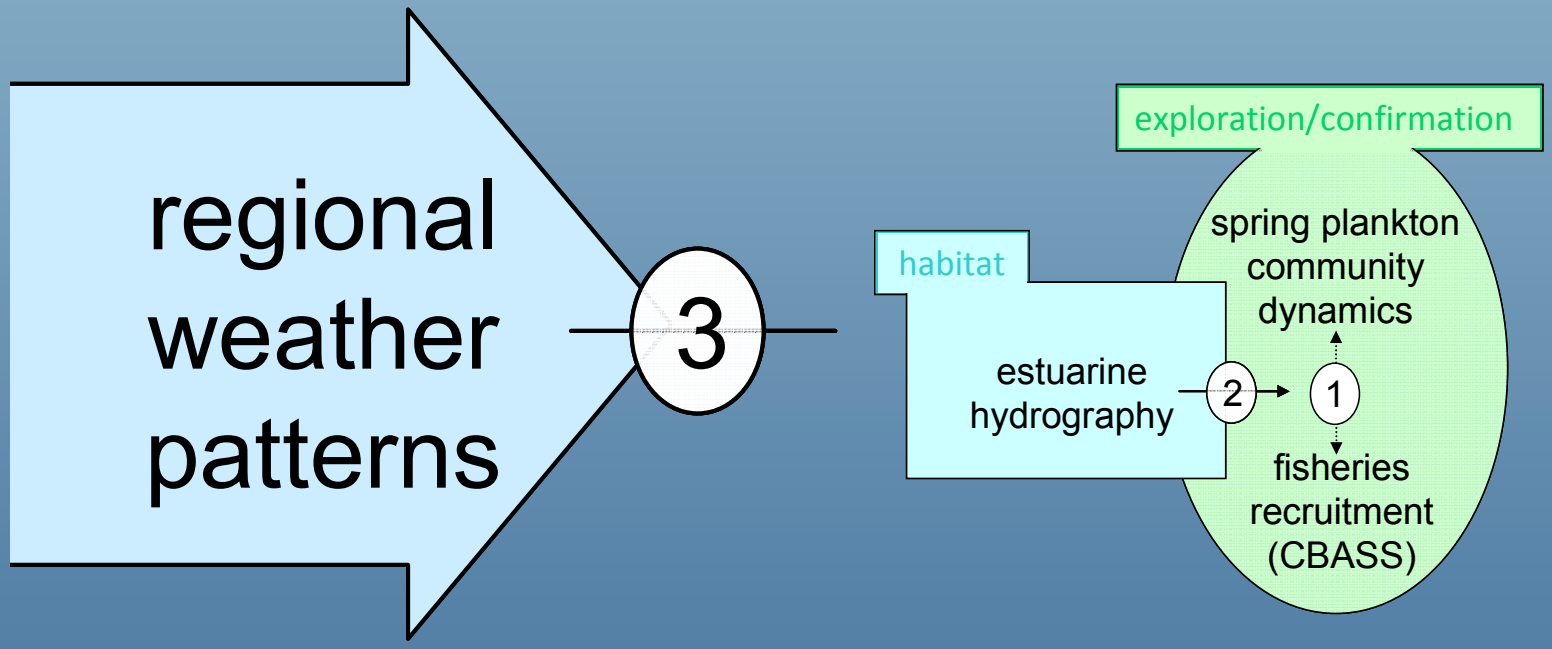
*p<0.05 **p<0.01

Correspondence among hydrographic conditions, $CBASS_{rbi}$, & plankton PC1

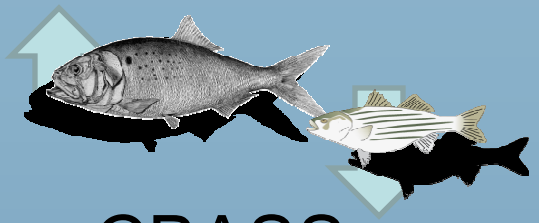



dry year -1985
1996 – wet year
Patapsco
Patuxent
Choptank
Potomac
Rappahannock
York
James
0.0 ppt
30.0 ppt
March-June
Surface Salinity

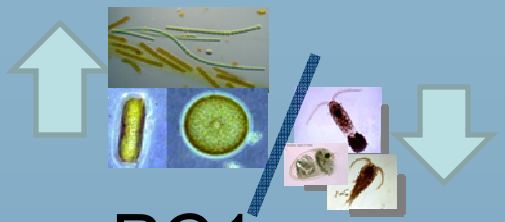
Climate Forcing



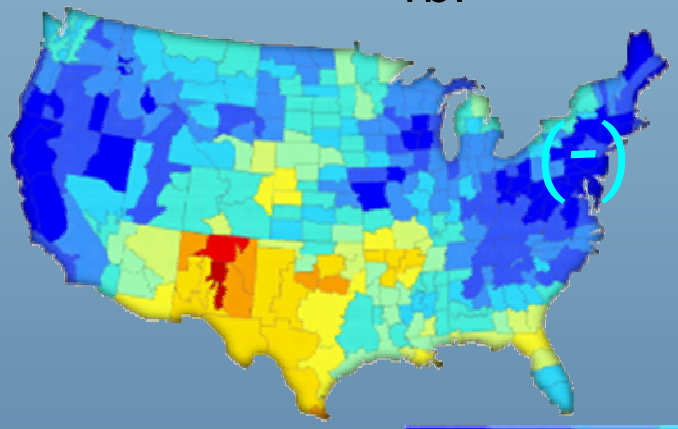
US climate division weather correlations with…



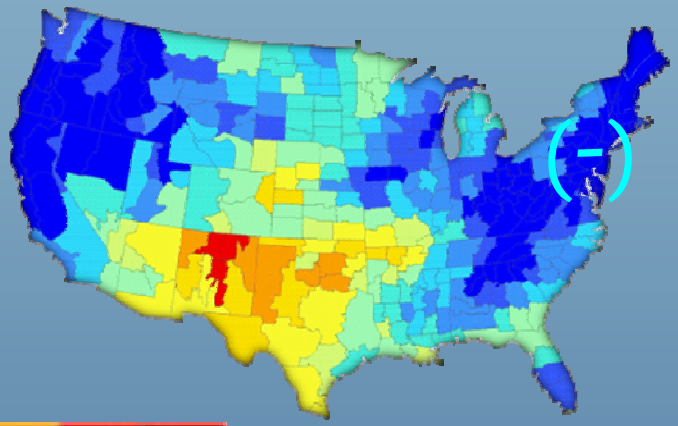
$CBASS_{rbi}$



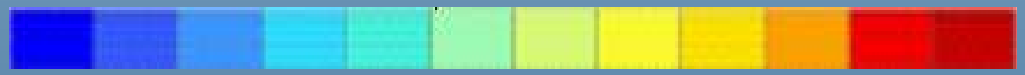
Plankton PC1 scores

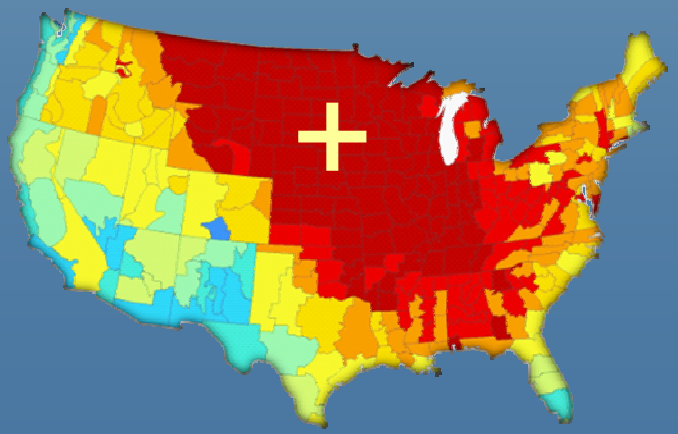


Winter-Spring precipitation (Dec-Jun)

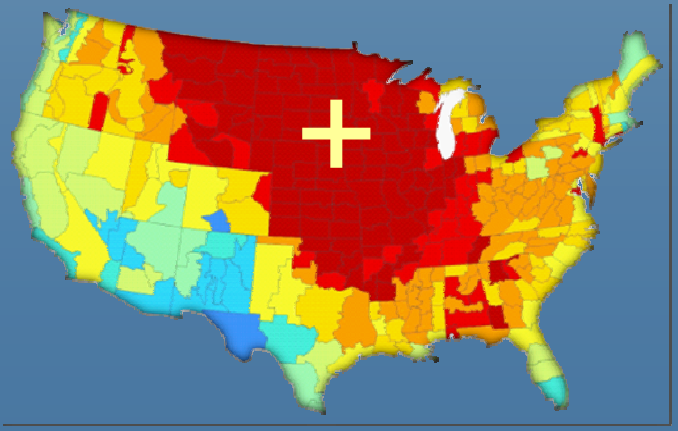


r value





Spring temperature (March-May)



Spring sea level pressure anomalies during very strong fish production years (1st quartile)

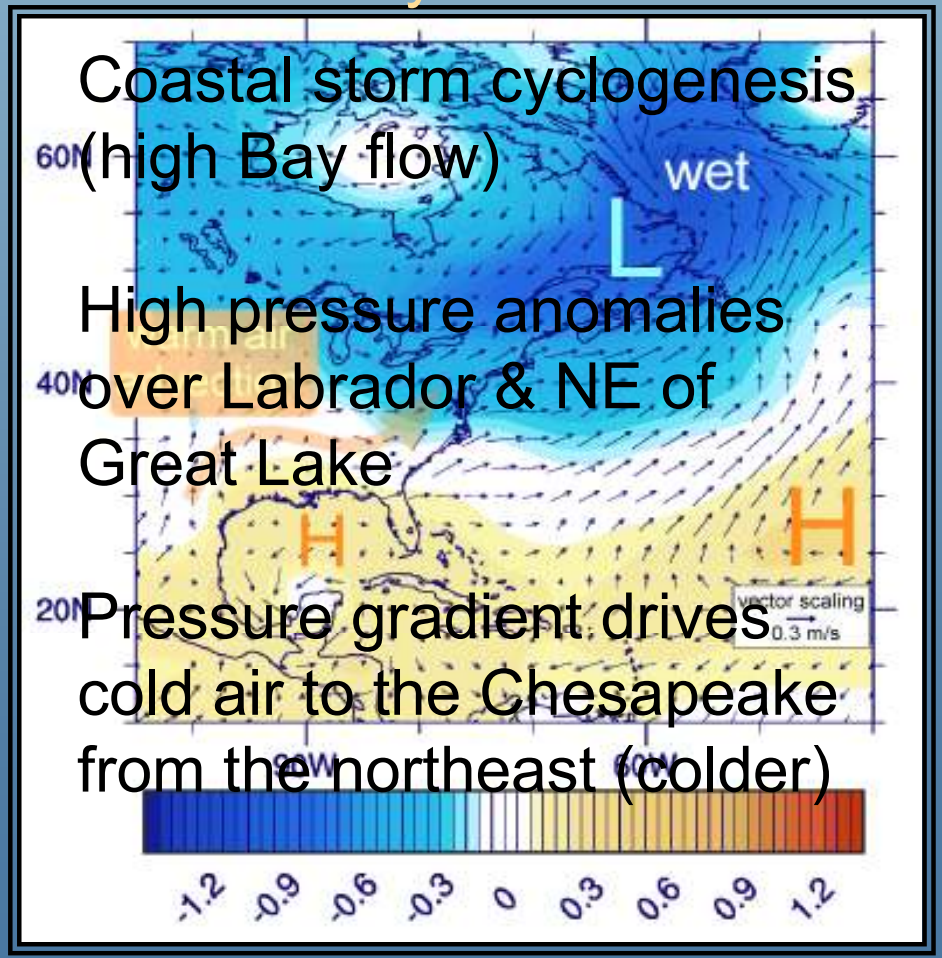
Atlantic menhaden

dry & warm

Coastal storm cyclogenesis (high Bay flow)

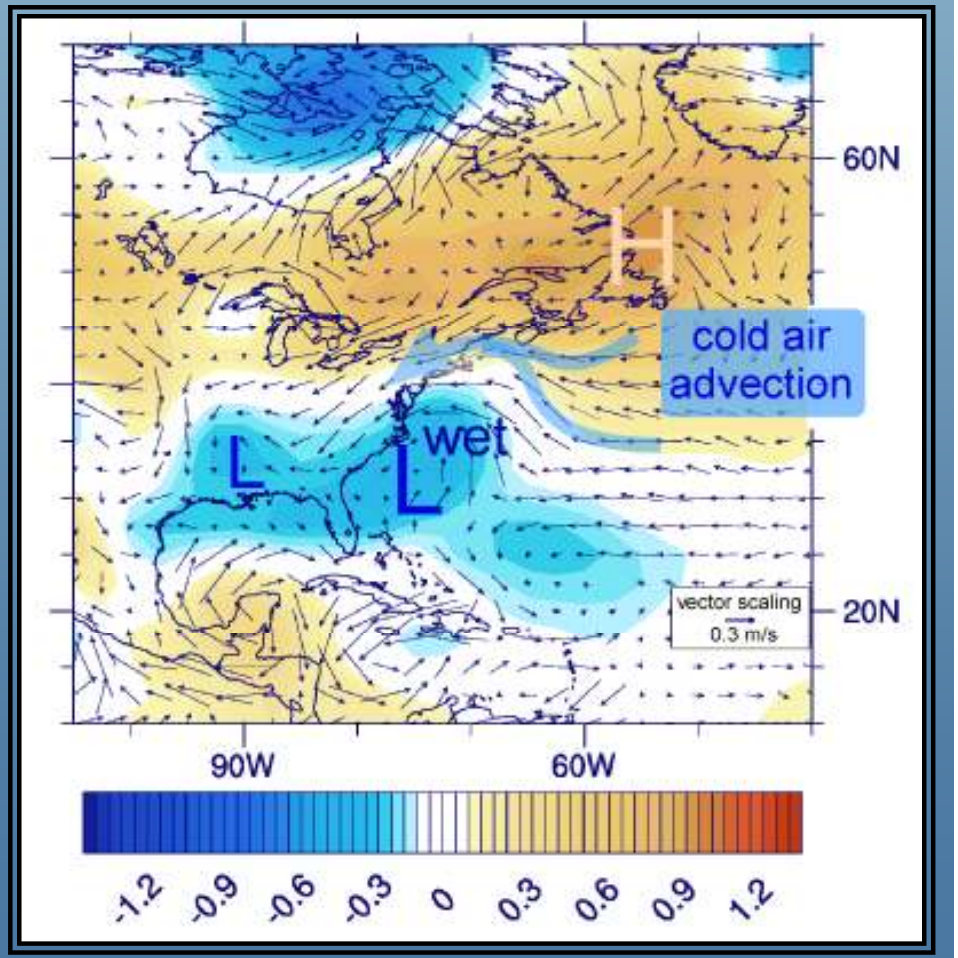
High pressure anomalies over Labrador & NE of Great Lake

Pressure gradient drives cold air to the Chesapeake from the northeast (colder)

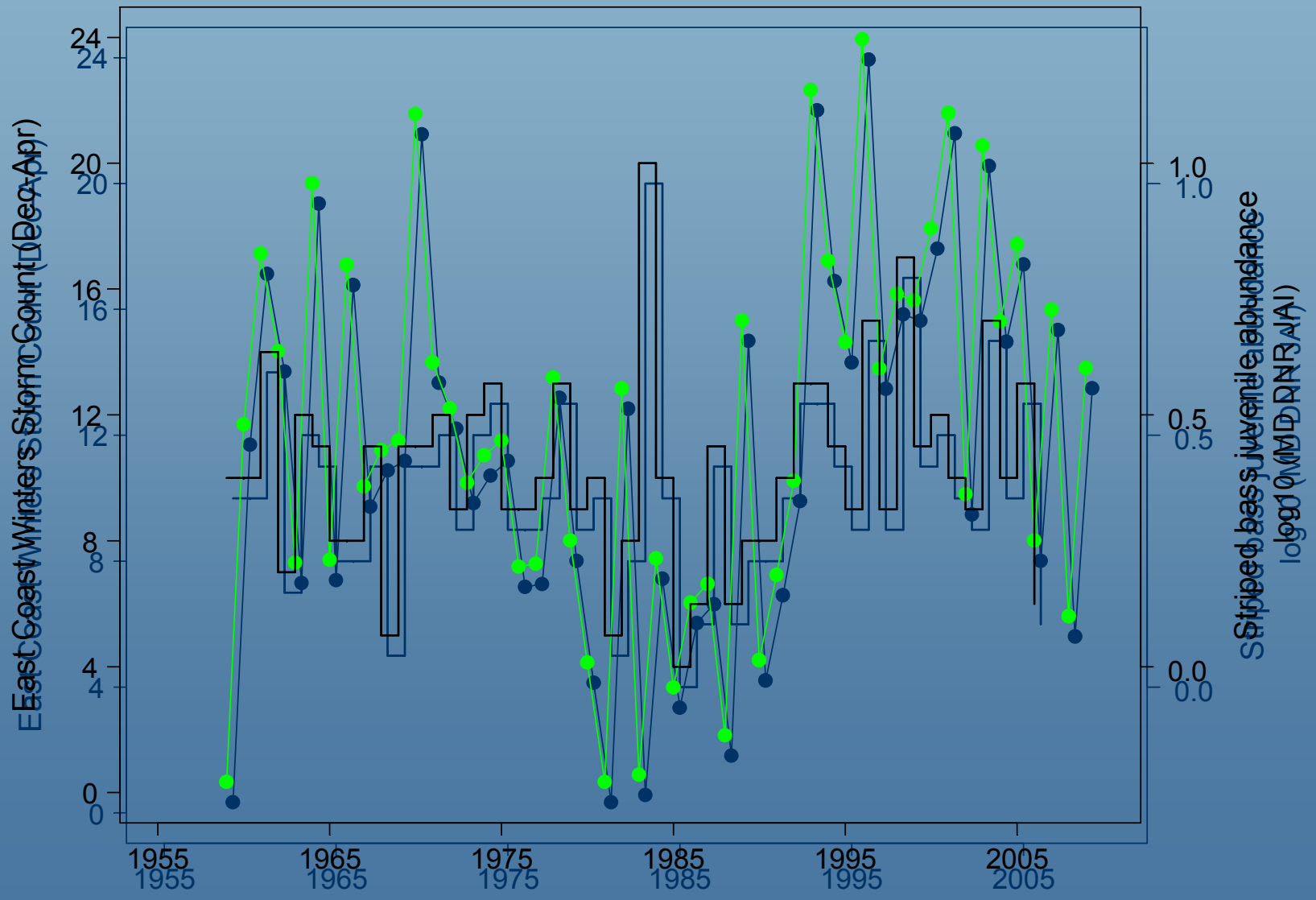


striped bass

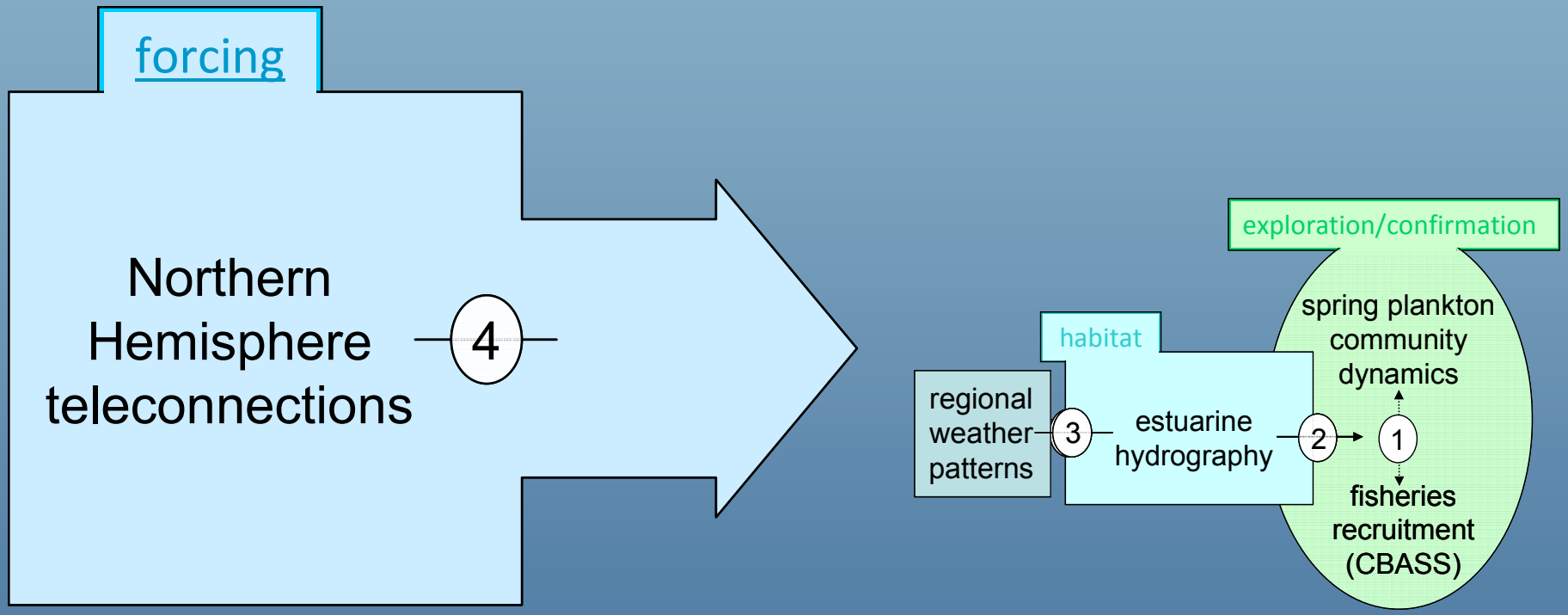
wet & cool



Correlation between East Coast Winter Storms (Nor'easters) & the striped bass JAI (MD DNR)

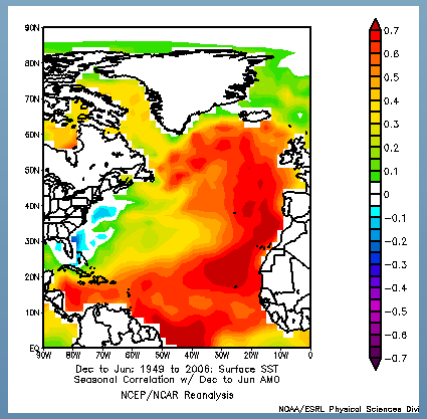


Role of teleconnections?



Teleconnections that affect the mid-Atlantic US: correlations with fish & plankton dynamics

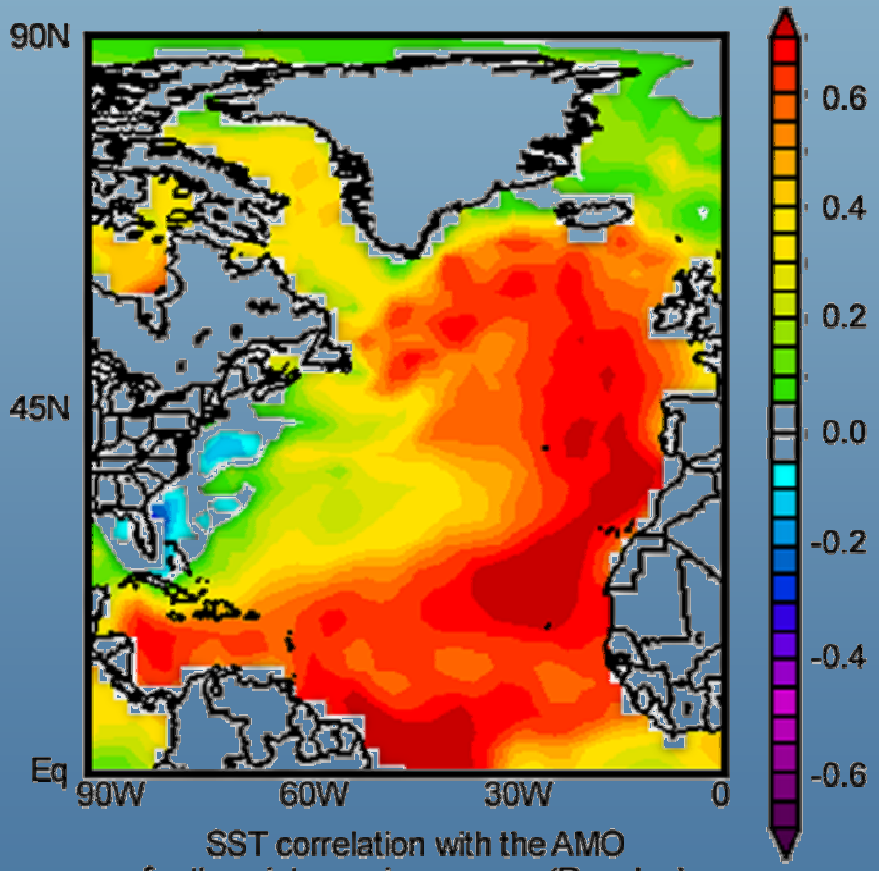
telecon'xn indices	CBASS ratio r = …	Plankton PC1 r = …
AMO | Dec-Jun	***-0.51	*0.44
AMO | Mar-Jun	**-0.43	0.36
NAO | Dec-Jun	0.03	-0.24
NAO | Mar-Jun	0.00	-0.28
PDO | Dec-Jun	0.07	-0.08
PDO | Mar-Jun	0.04	0.21
SOI | Dec-Jun	0.03	-0.06
SOI | Mar-Jun	0.07	-0.15
PNA | Dec-Jun	-0.03	0.17
PNA | Mar-Jun	-0.07	0.17



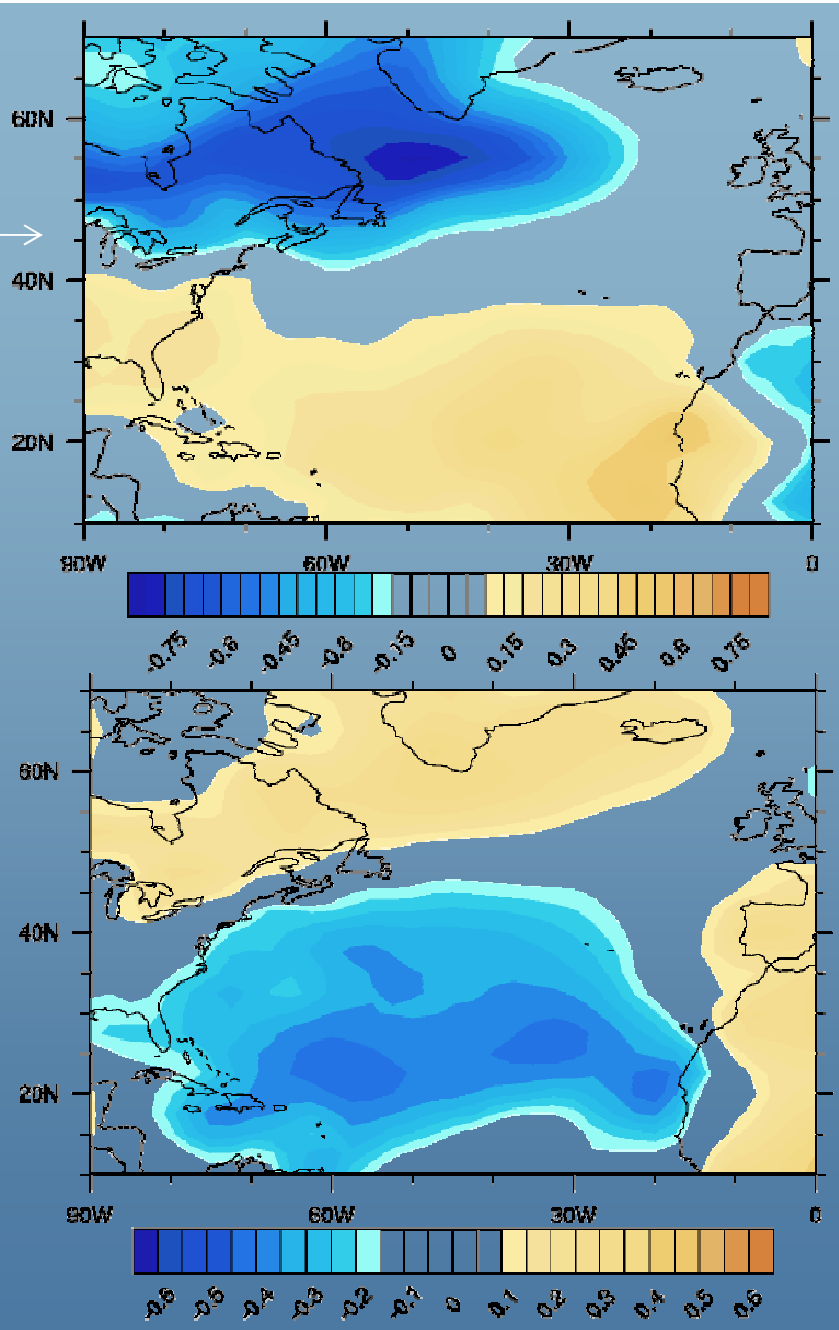
p-value key: ***0.001 ; **0.005; *0.1;

The linkage between the AMO & CBASS

SLP correlation w/CBASS



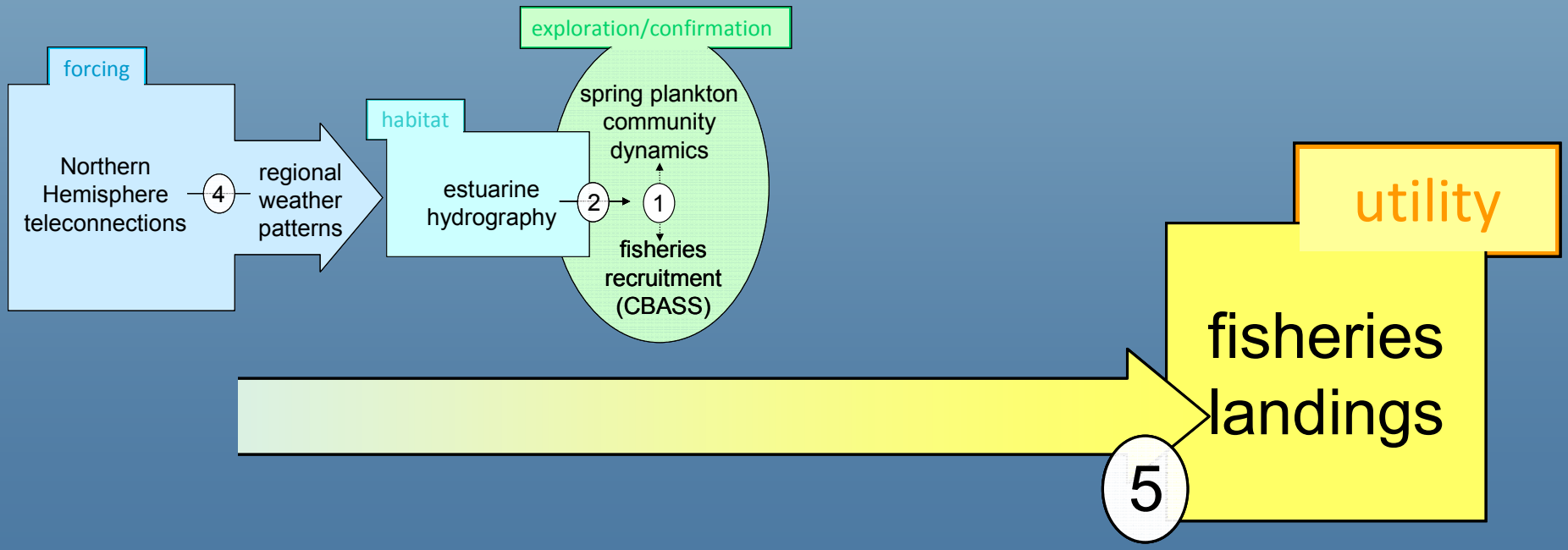
SST-AMO correlation



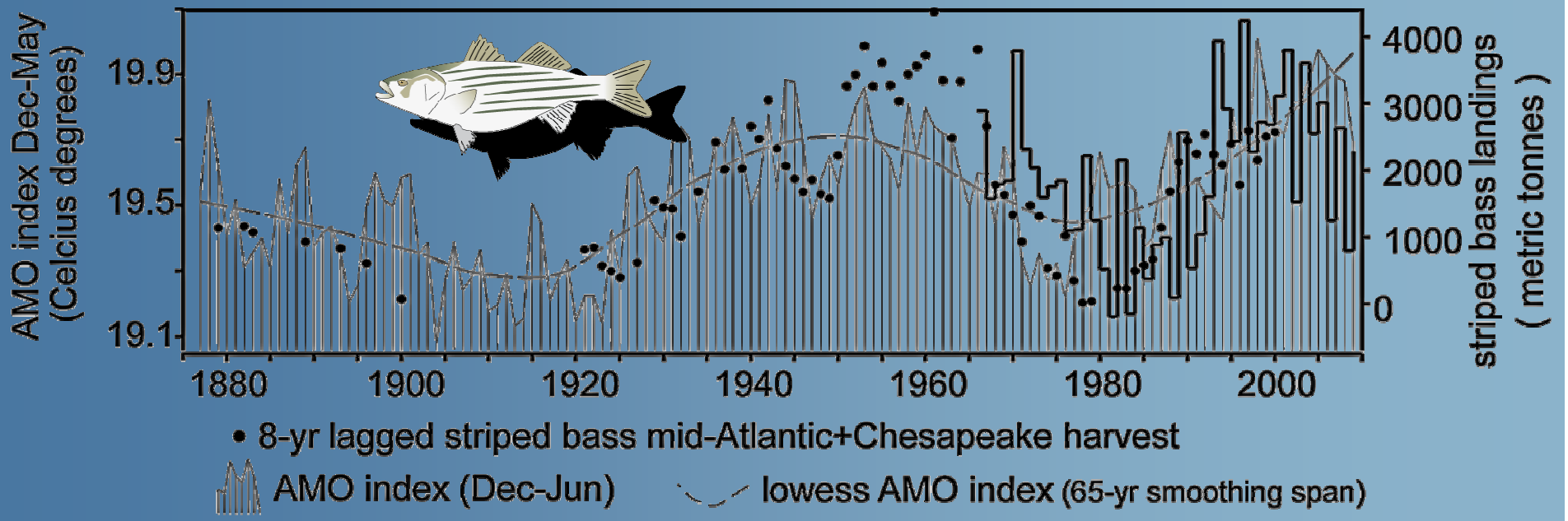
SLP-AMO correlation

Management utility

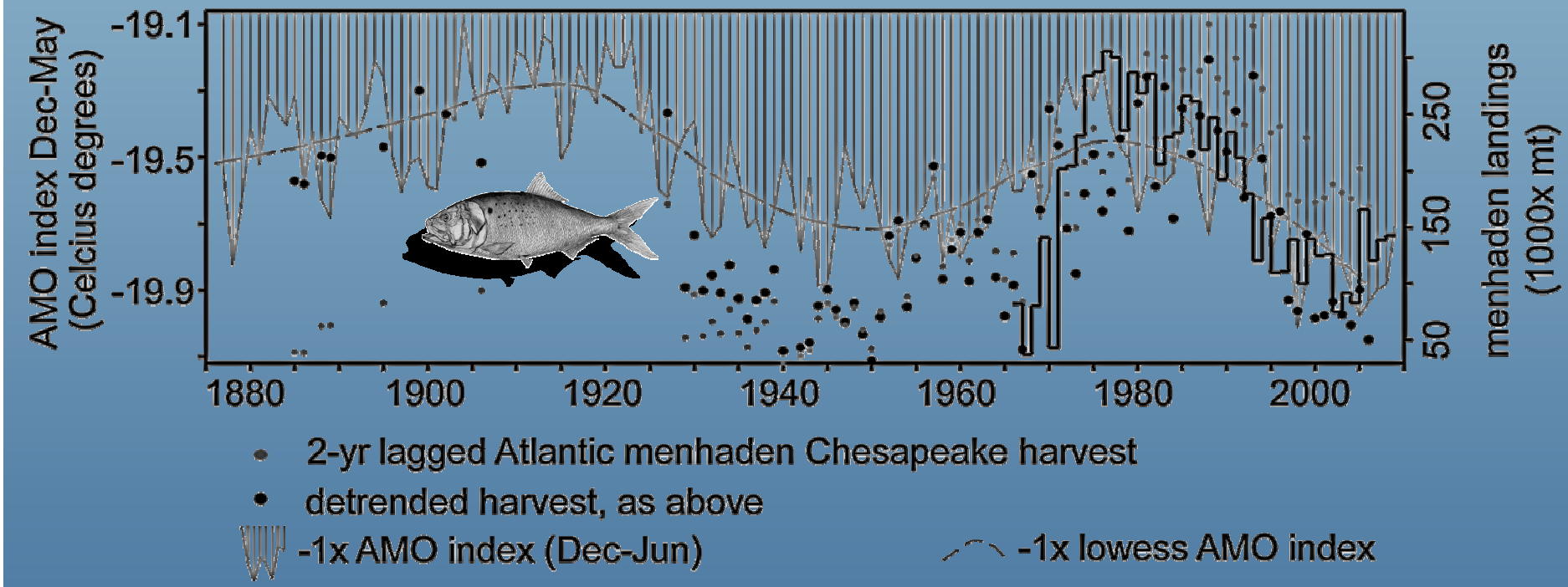
does this mean anything for fishery landings?



Striped bass landings and the AMO



Atlantic menhaden landings & the AMO



“take-homes”

The Chesapeake ecosystem is highly responsive to climate variability, especially with respect to the winter-spring transition

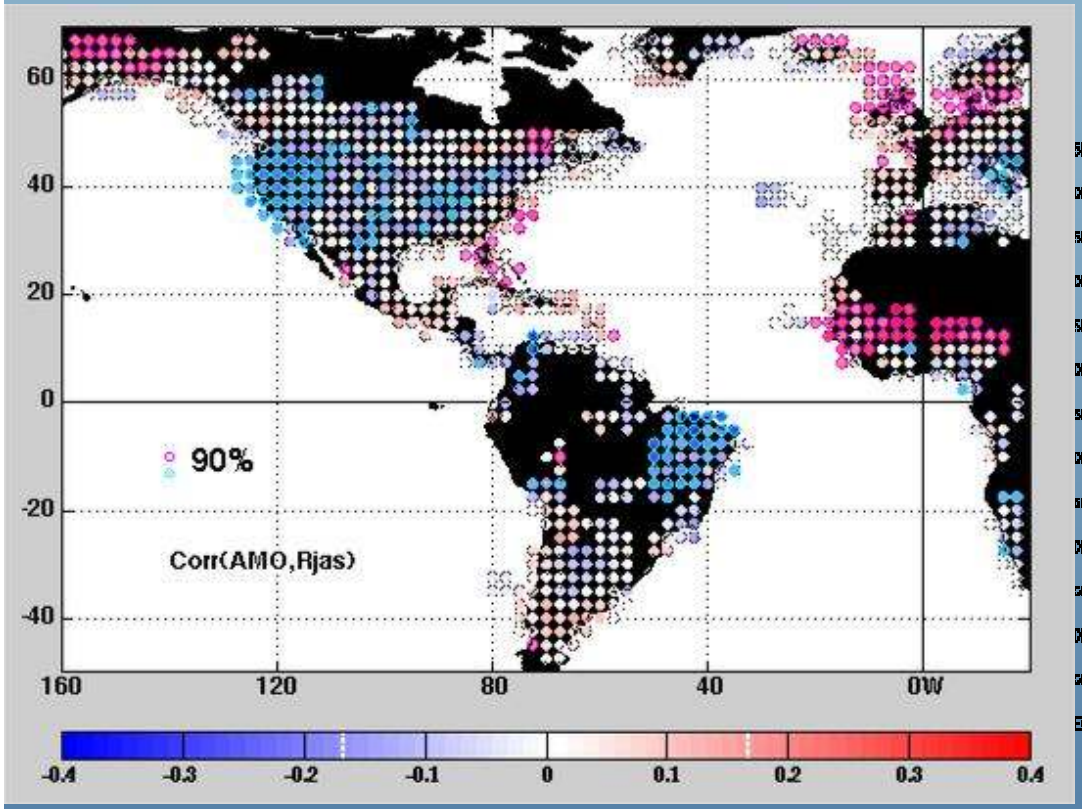
The Chesapeake appears to have been responding strongly to the AMO for over a century

These fluctuations seem to be driving production & commercial landings within and beyond the Chesapeake for economically and ecologically valuable fishes

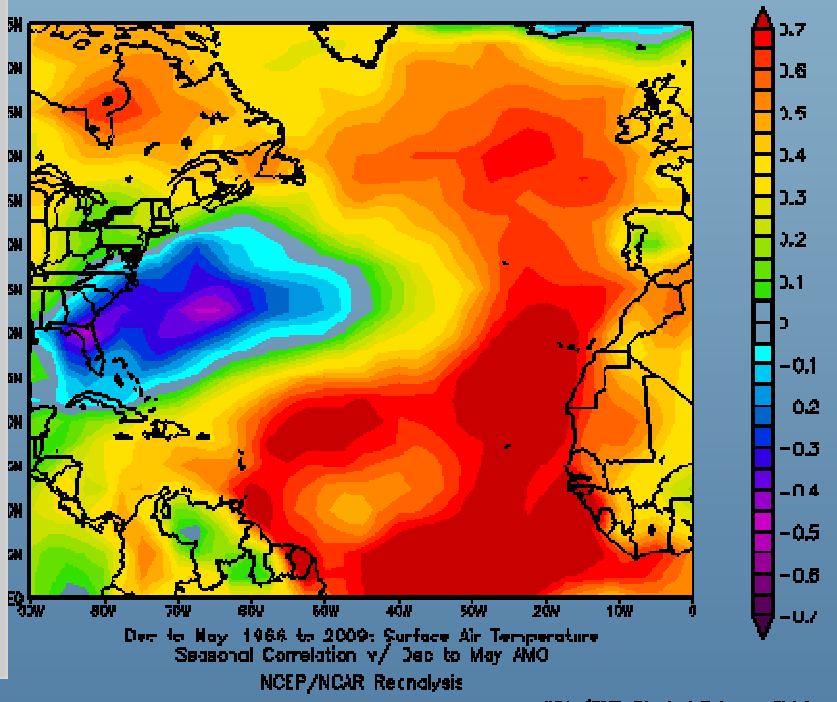
The stable nature of the AMO’s ~65-year periodicity may help prevent collapses by allowing managers to anticipate persistent recruitment declines

The Atlantic Multidecadal Oscillation

AMO correlation maps …



Surface air temperature



http://www.aoml.noaa.gov/phod/faq_fig1.php
(Enfiield et al., 2001)

+AMO = wet/cool = -CBASS

-AMO = dry/warm = +CBASS