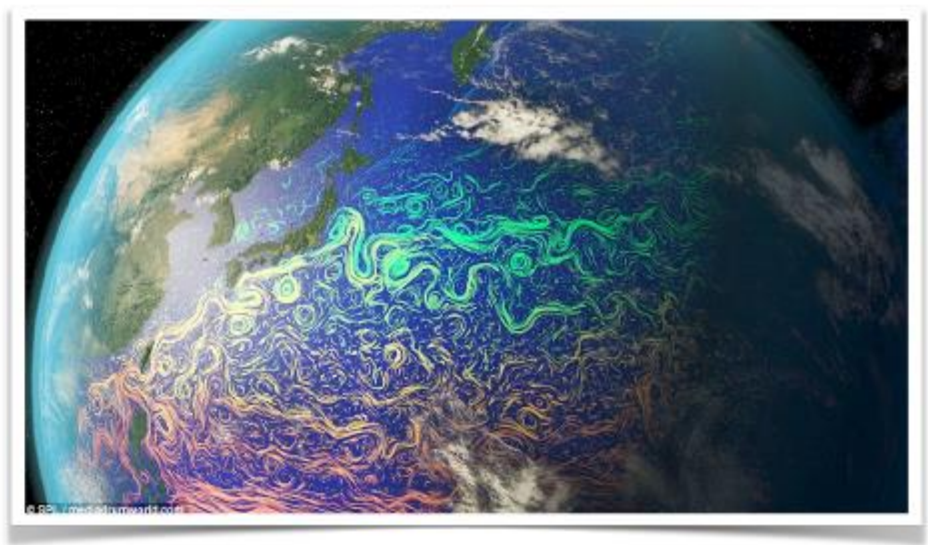
Flashback: Agents of Spatial Pattern

Considerations for marine systems

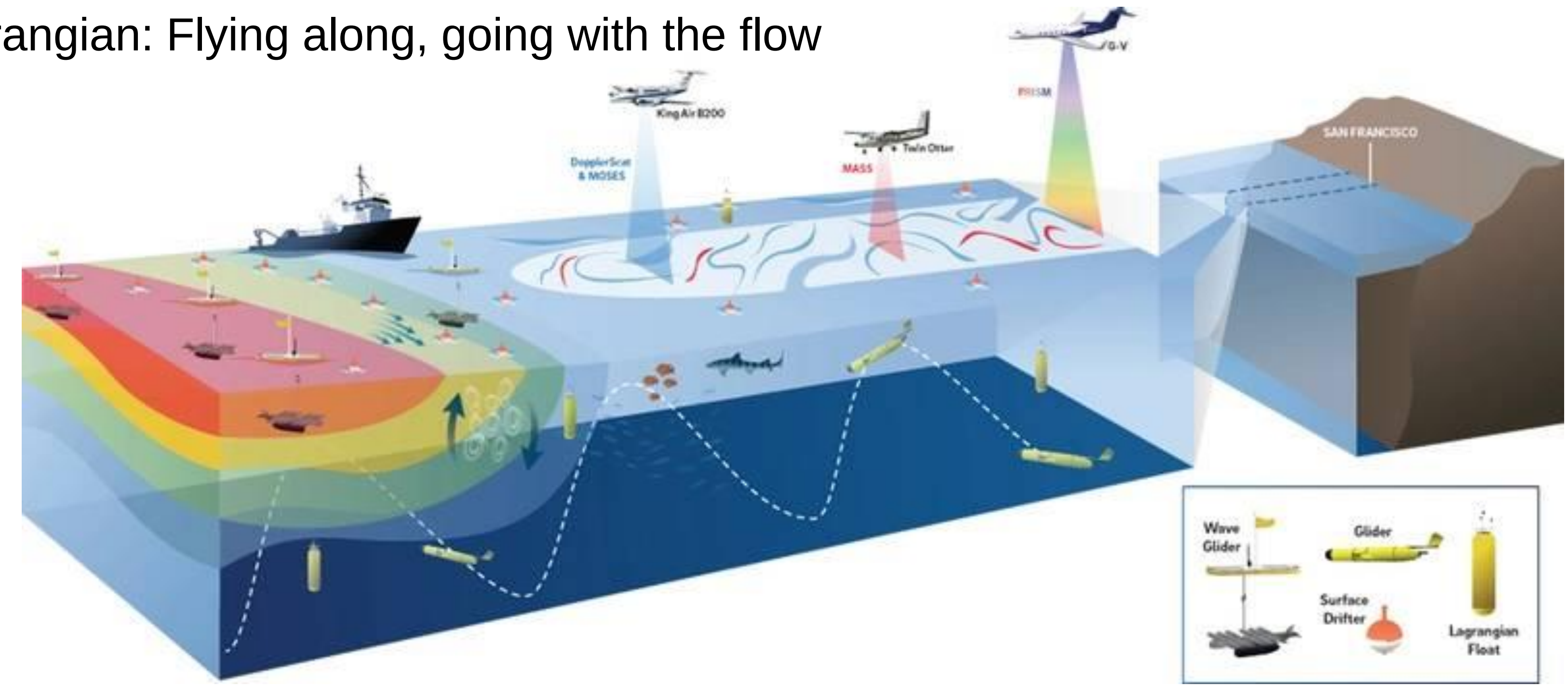
- Greater challenges than in terrestrial systems
- Temporal rates of change can be much more rapid (compare forest patch mosaics to eddies with patches of entrained phytoplankton)
- Importance of chemical seascapes and soundscapes that generate spatial and temporal patterns & are modified by human activities



Seascapes are…

1. Lagrangian, transient, dilute and patchy
2. Size-structured
3. Vertically heterogenous
4. Tractable with observing system capabilities
   1. Dynamic Ocean Management
   2. Offshore wind farm observatories

Lagrangian: Flying along, going with the flow



https://www.maritimemagazines.com/marine-technology/202202/s-mode-gathering-ocean-intel-from-above-on-and-under-the-waves/

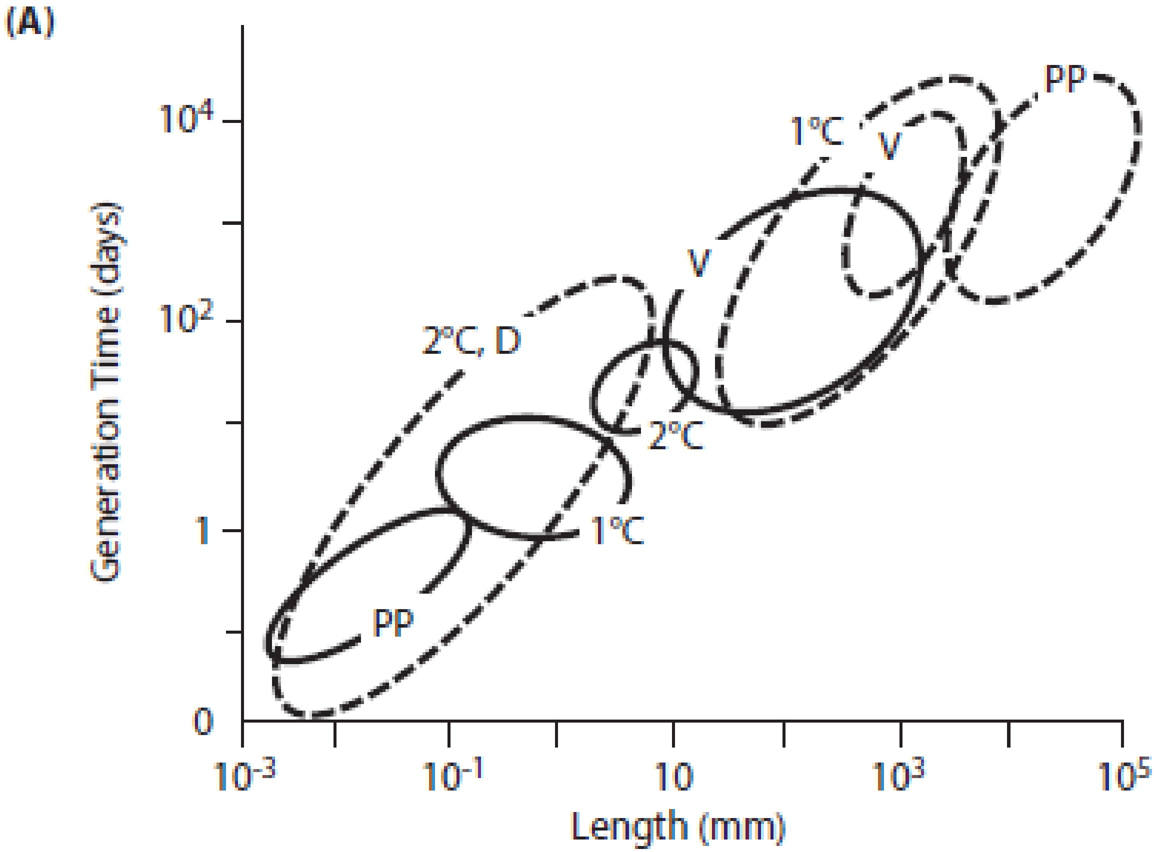
Dilute and Patchy:
How do aquatic food webs differ than terrestrial ones?

Table 1. Global comparison of marine and terrestrial food web attributes. Estimates are from Cohen (1994). Mean depth of life zone and related statistics are modified from Cohen's stipulated depth of 1.37 km.

Attribute	Marine	Terrestrial
Surface (% Earth)	71	29
Mean Depth of Life Zone (m)	500	50
Volume of Life Zone (10^8 km^3)	1.8	0.0075
Living Biomass (10^{15} g carbon)	2	560
Living Biomass Density (10^7 g carbon km^{-3})	1.1	7,500
Net Primary Production (10^{15} g yr^{-1})	20-44	48
Residence Time of Carbon in Biomass (yr)	0.08	11.2
Animal Biomass (% total)	10	0.01
Predator Animal Body Mass (g)	4700	140
Number of Trophic Links	High	Low

Secor. 2015. Migration Ecology of Marine Fishes. JHU Press.

Size structured - scale-free attribute
How do aquatic food webs differ than terrestrial ones?

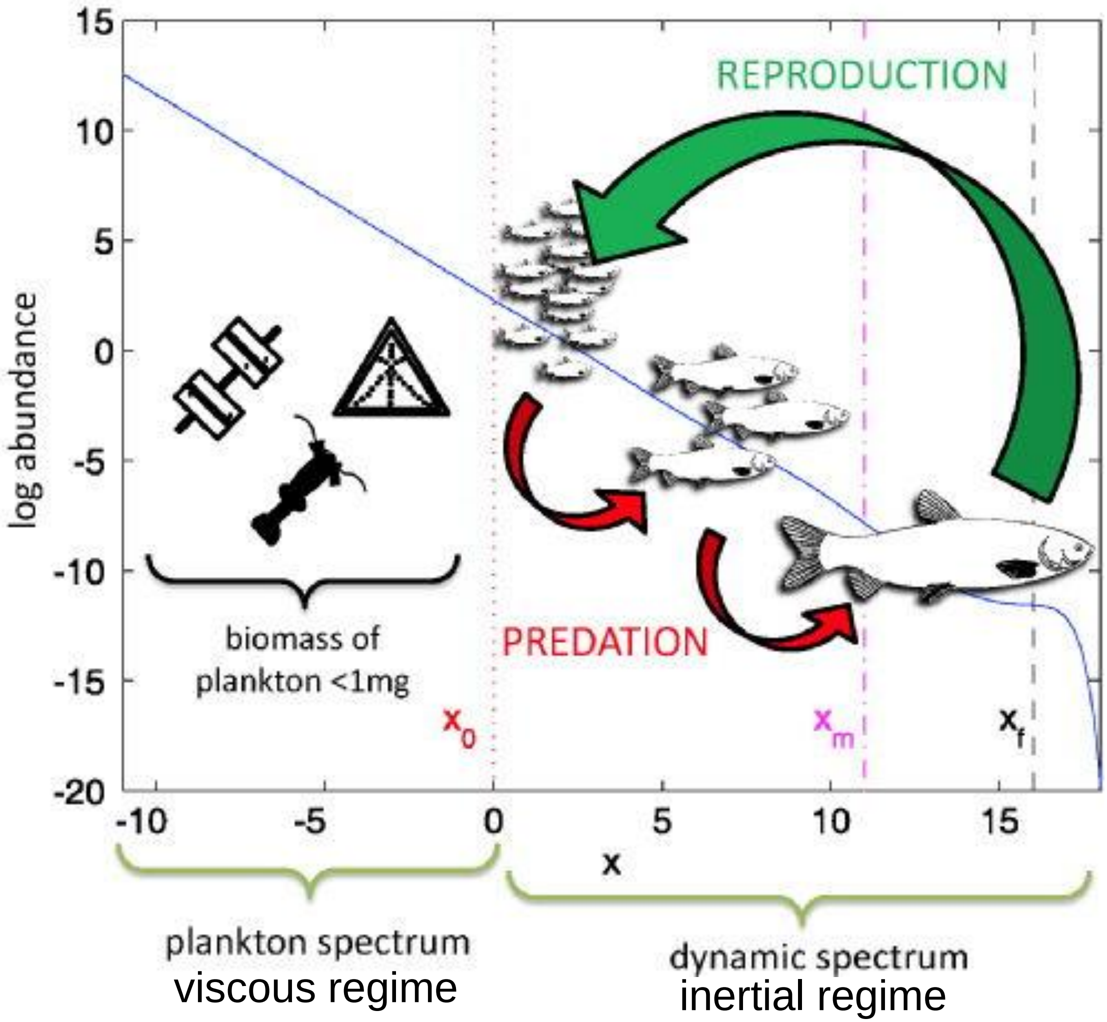


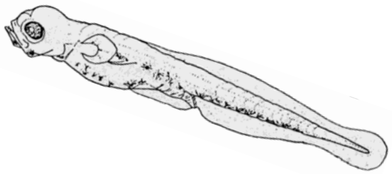
Secor. 2015. Migration Ecology of Marine Fishes. JHU Press.

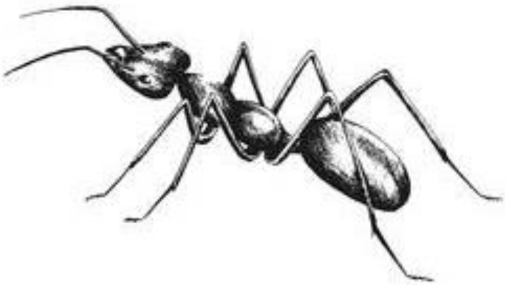
How do aquatic food webs differ than terrestrial ones?

Contrast a striped bass larva with an ant.

Teleost fish exhibit complex life cycles (life cycle omnivory)

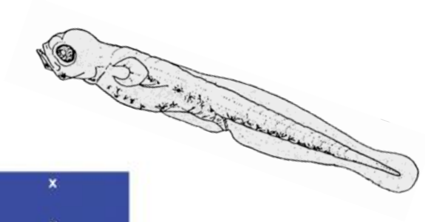


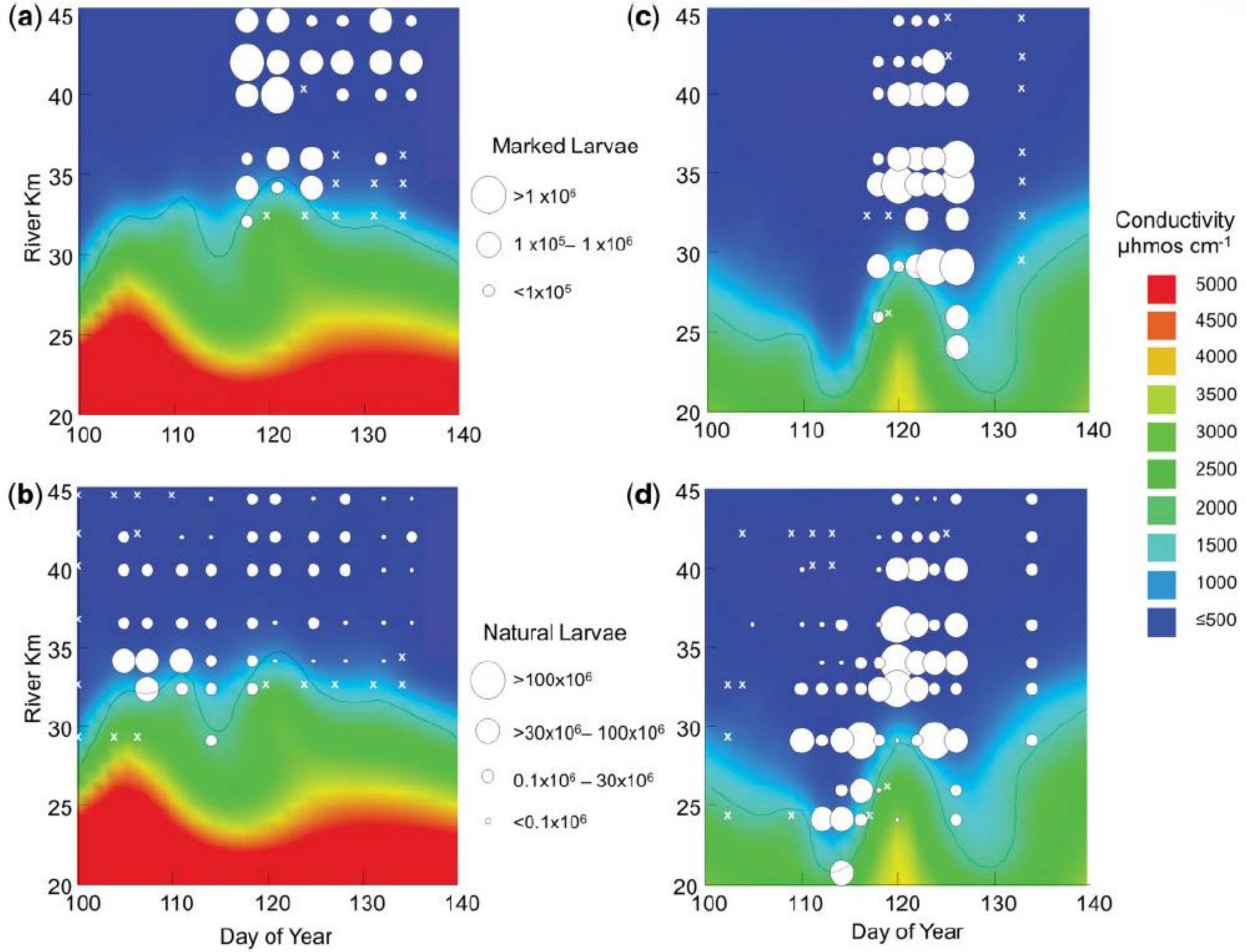




Patchiness - ecotones (frontal systems)

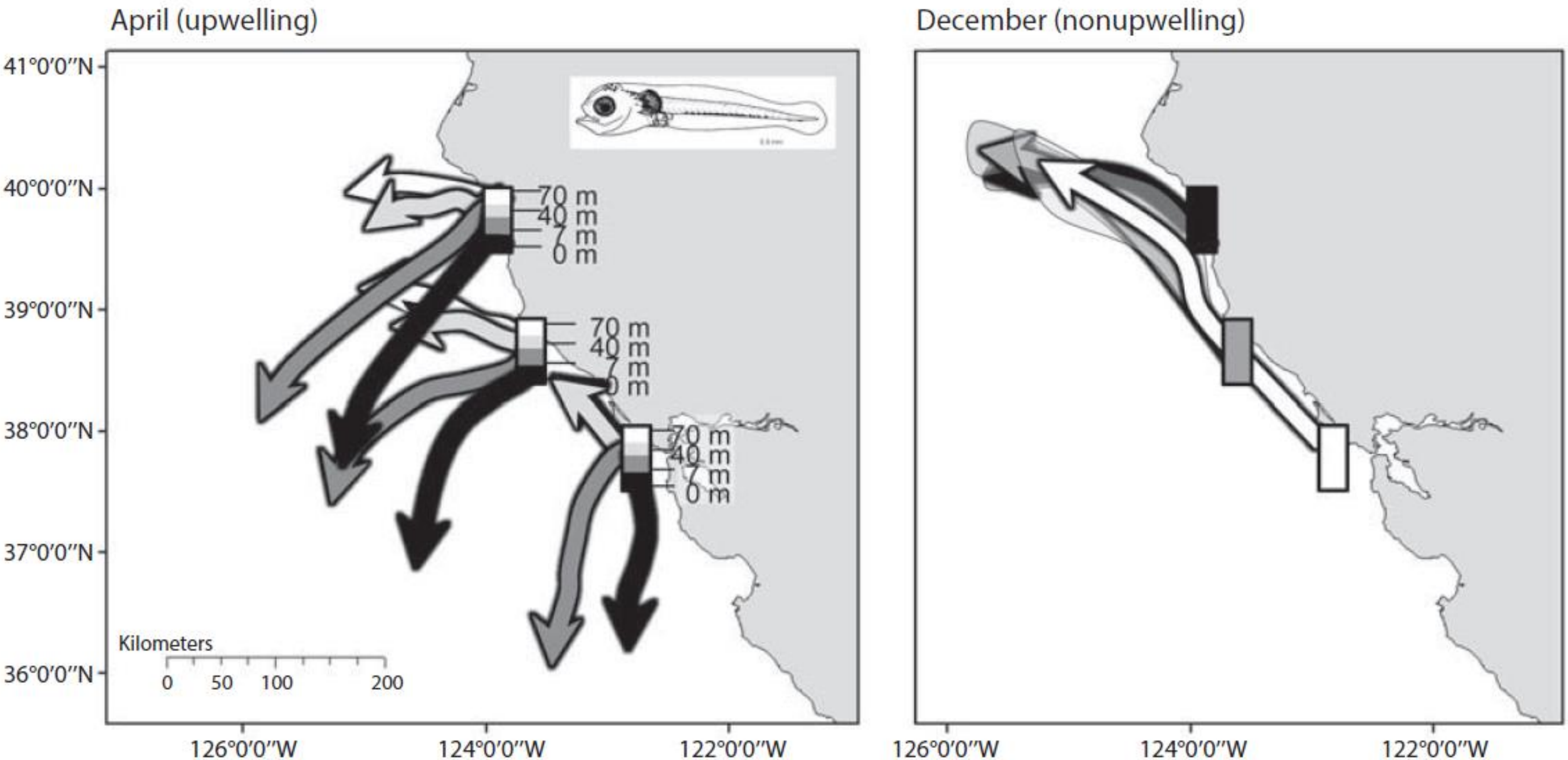
Striped bass - salinity



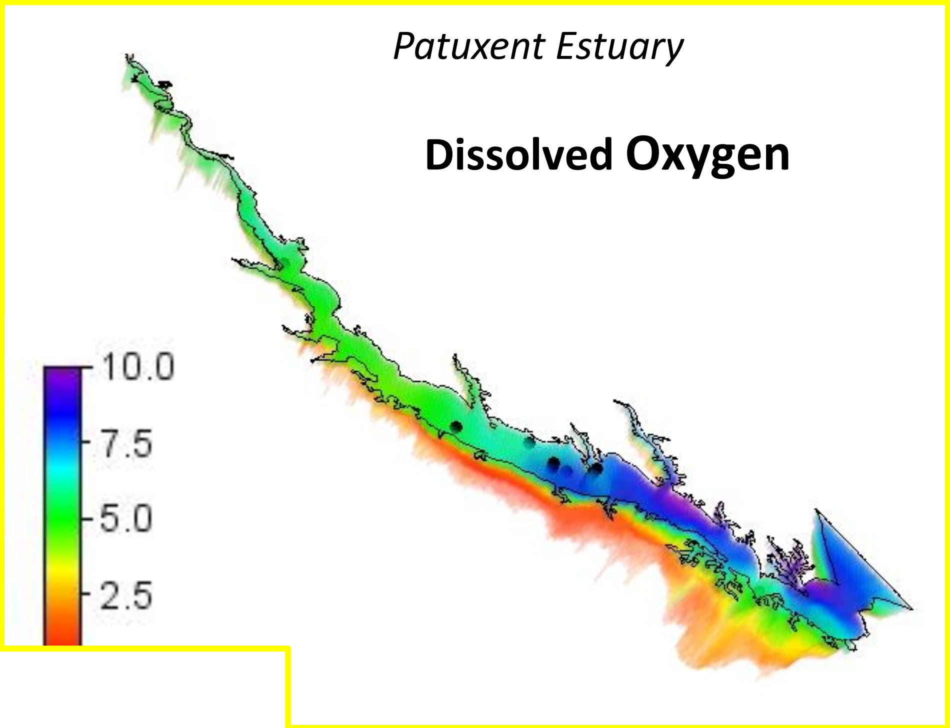


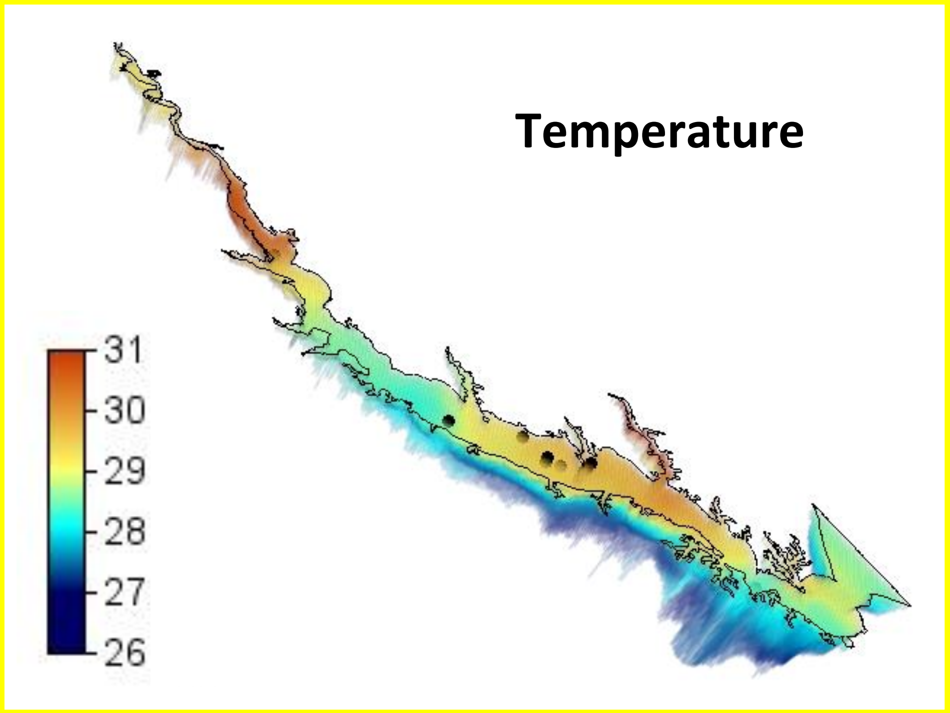
Secor, D.H., E.D. Houde, and L.L. Kellogg. 2017. Estuarine retention and production of striped bass larvae: a mark recapture experiment. ICES Journal of Marine Science 74:1735-1748.

Eckman (spiral) ecocline: seasonal transience in vertical shear



Secor. 2015. Migration Ecology of Marine Fishes. JHU Press.





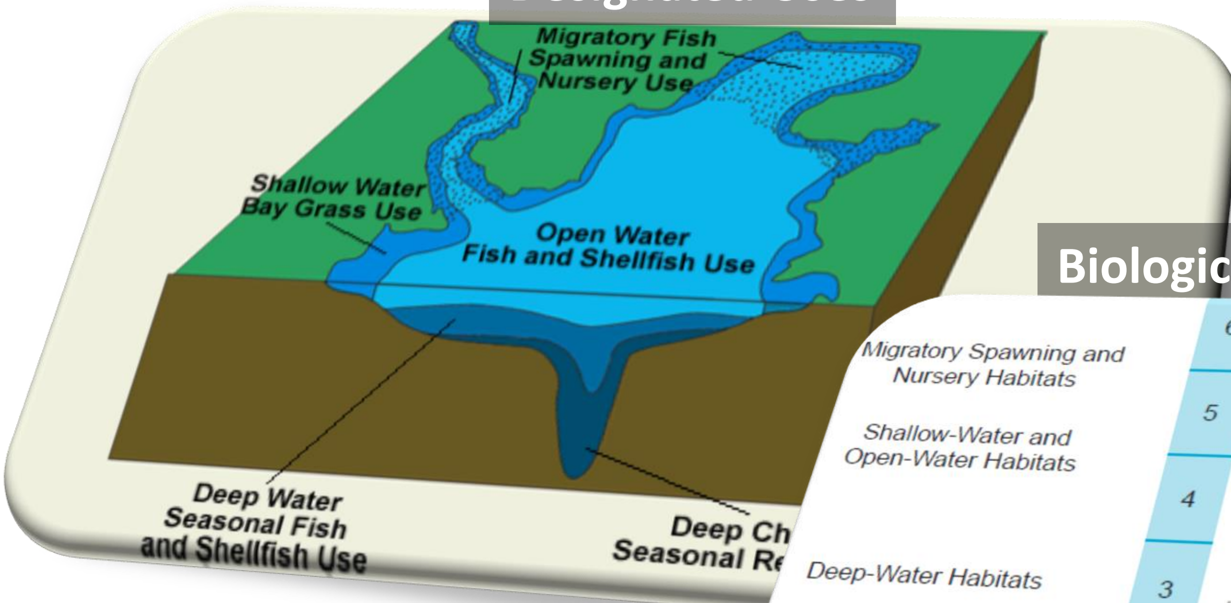
Vertical ecotone

Bottom hypoxia in Chesapeake

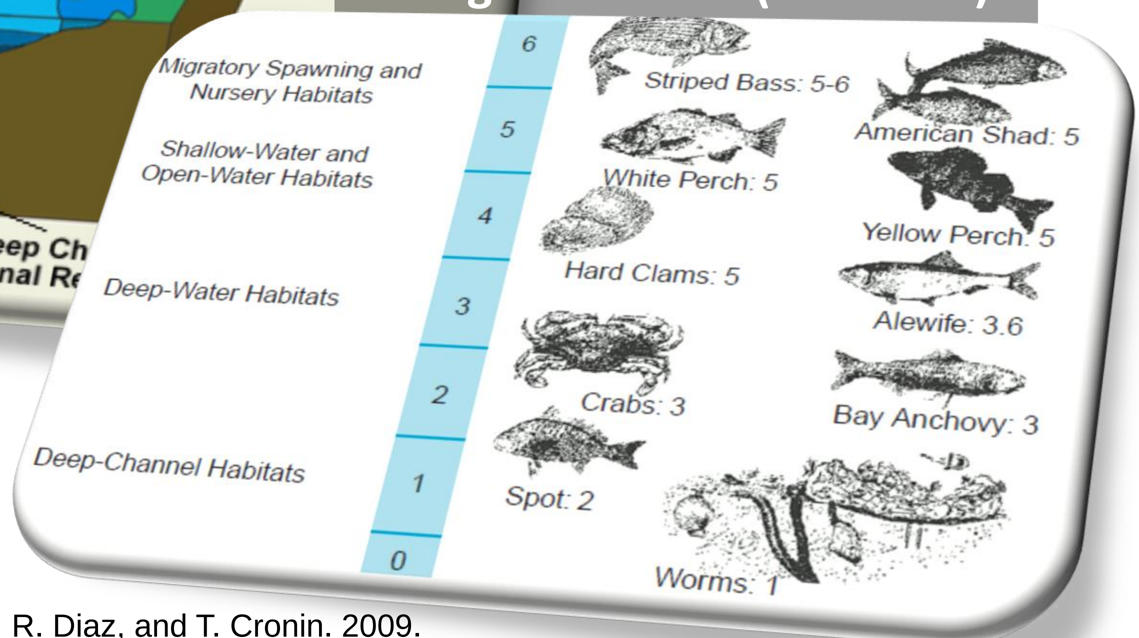
Kraus, R.T., D.H. Secor, and R.L. Wingate. 2015. Testing the thermal-niche oxygen-squeeze hypothesis for estuarine striped bass. Environmental Biology of Fishes 98: 2083-2092

Chesapeake seascapes managed on basis of vertical structure

Designated Uses

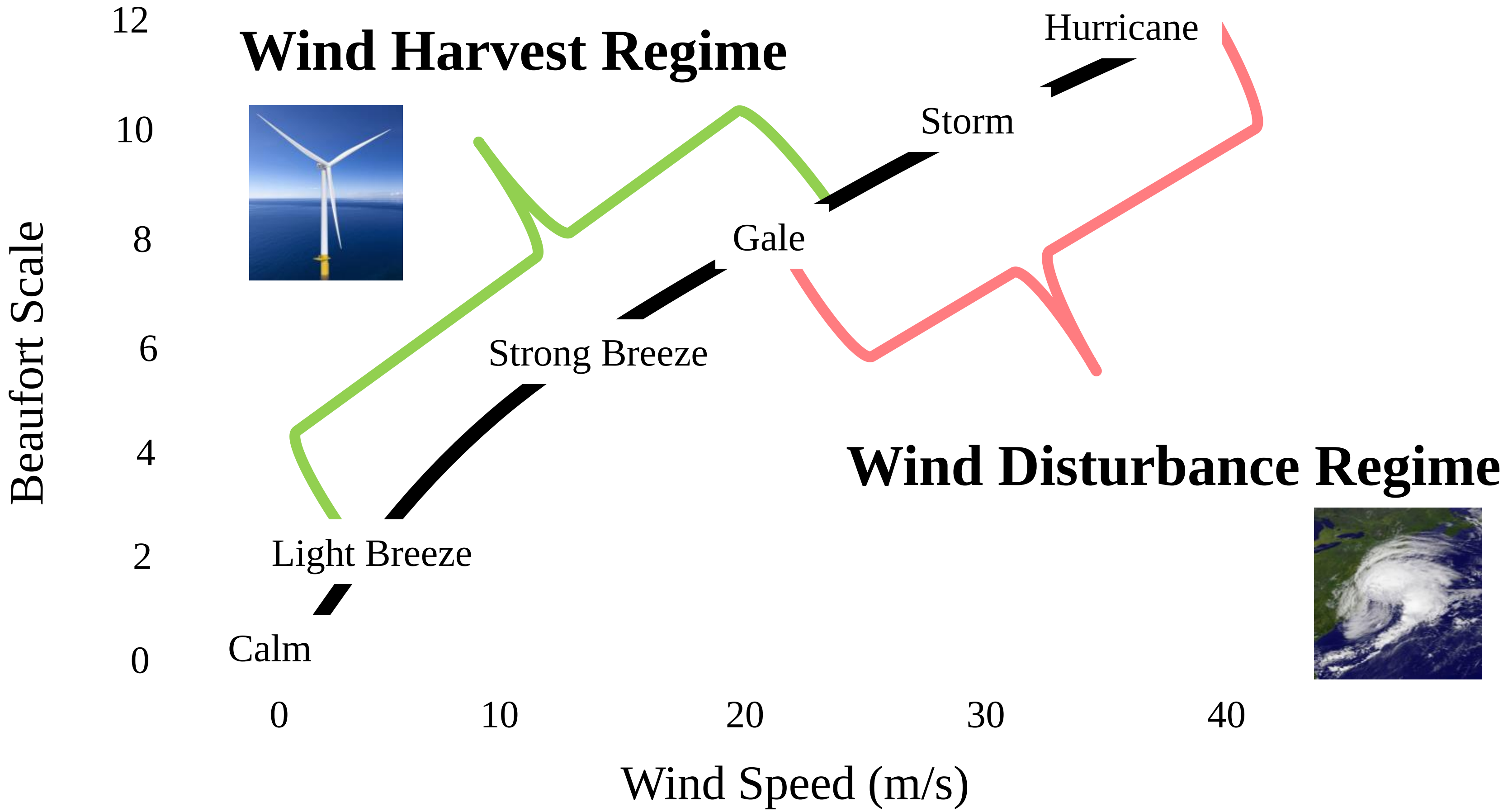


Biological Criteria (EPA 2003)

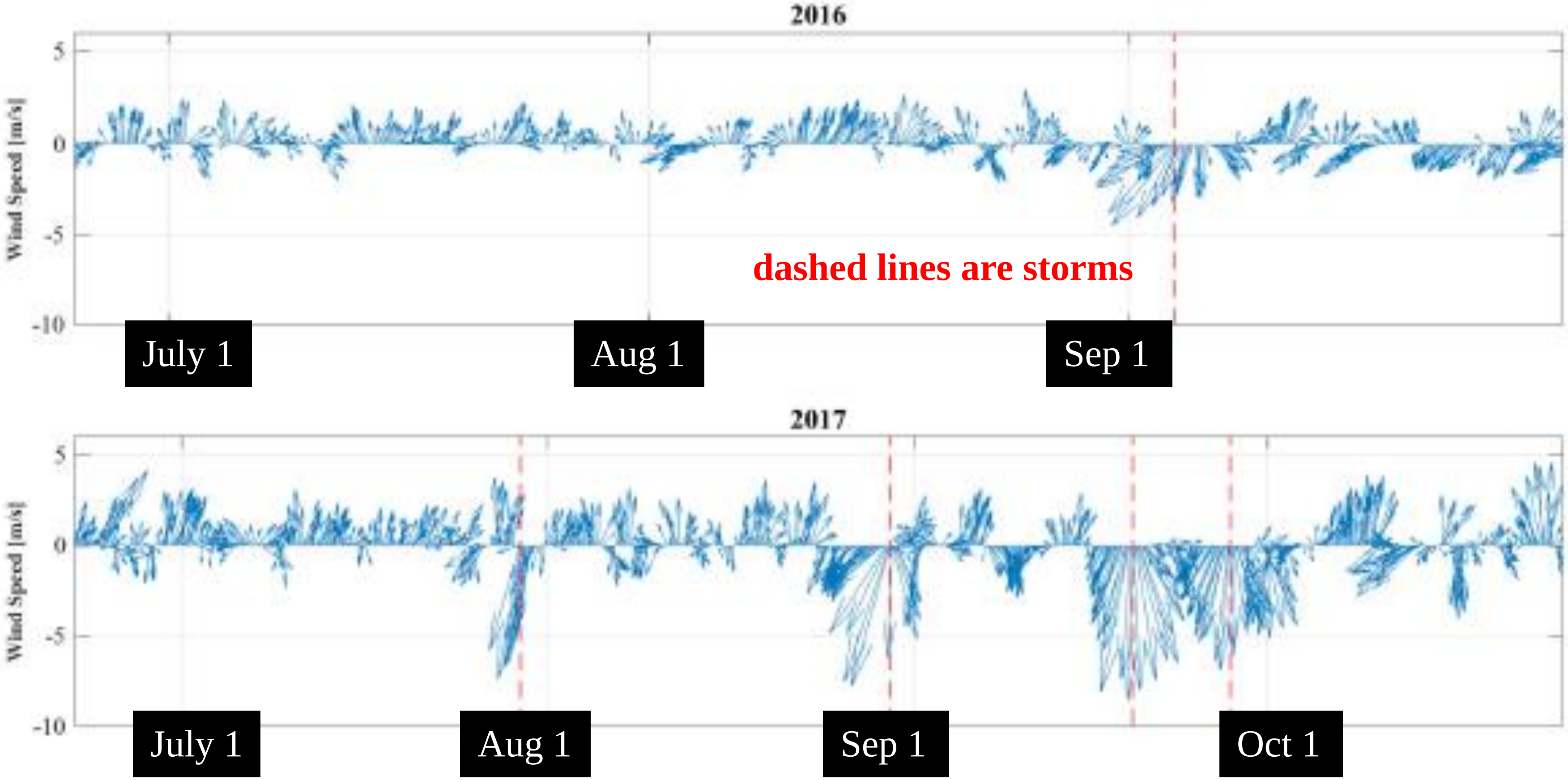


·Batiuk, R. D. Breitburg, G. Thursby, D. Secor, R. Diaz, and T. Cronin. 2009. Derivation of habitat-specific dissolved oxygen criteria for Chesapeake Bay and its tidal tributaries. J. Exp. Mar. Biol. Ecol. 381, Suppl. 1: 204-215.

Seascapes forced by wind regimes



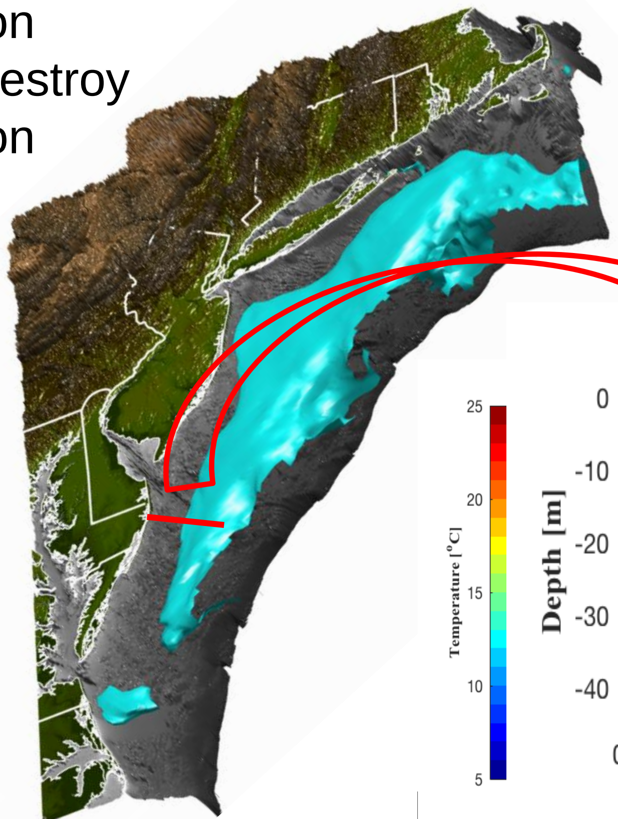
- US NW Atlantic wind velocity regime: low in summer; high in fall
- Climate change will impact seasonal distribution of wind velocities
- Increased hurricane amplitude and frequency is predicted



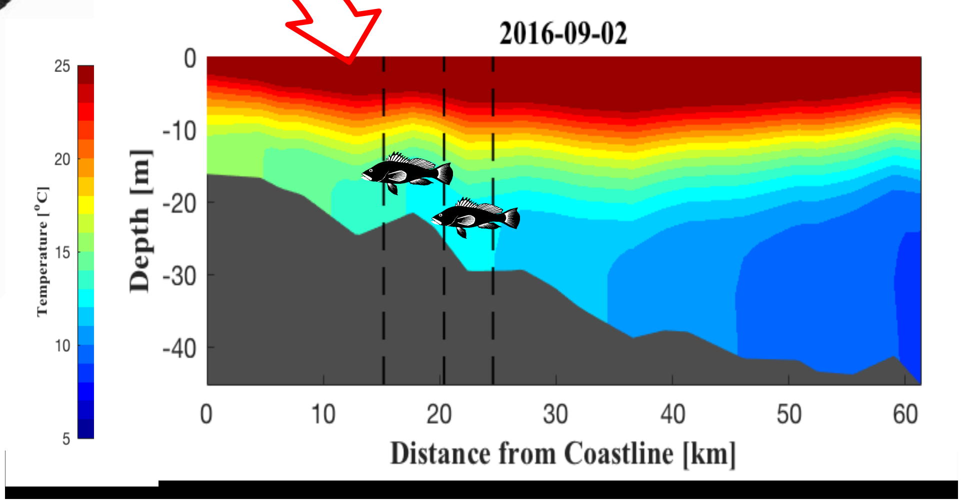
Mid-Atlantic Bight (MAB)
Cold Pool: May-Sept

- Spring warming “traps” winter water
- Quiescent summer period intensifies stratification
- Summer storms disturb the stratification
- Fall storm(s) destroy the stratification

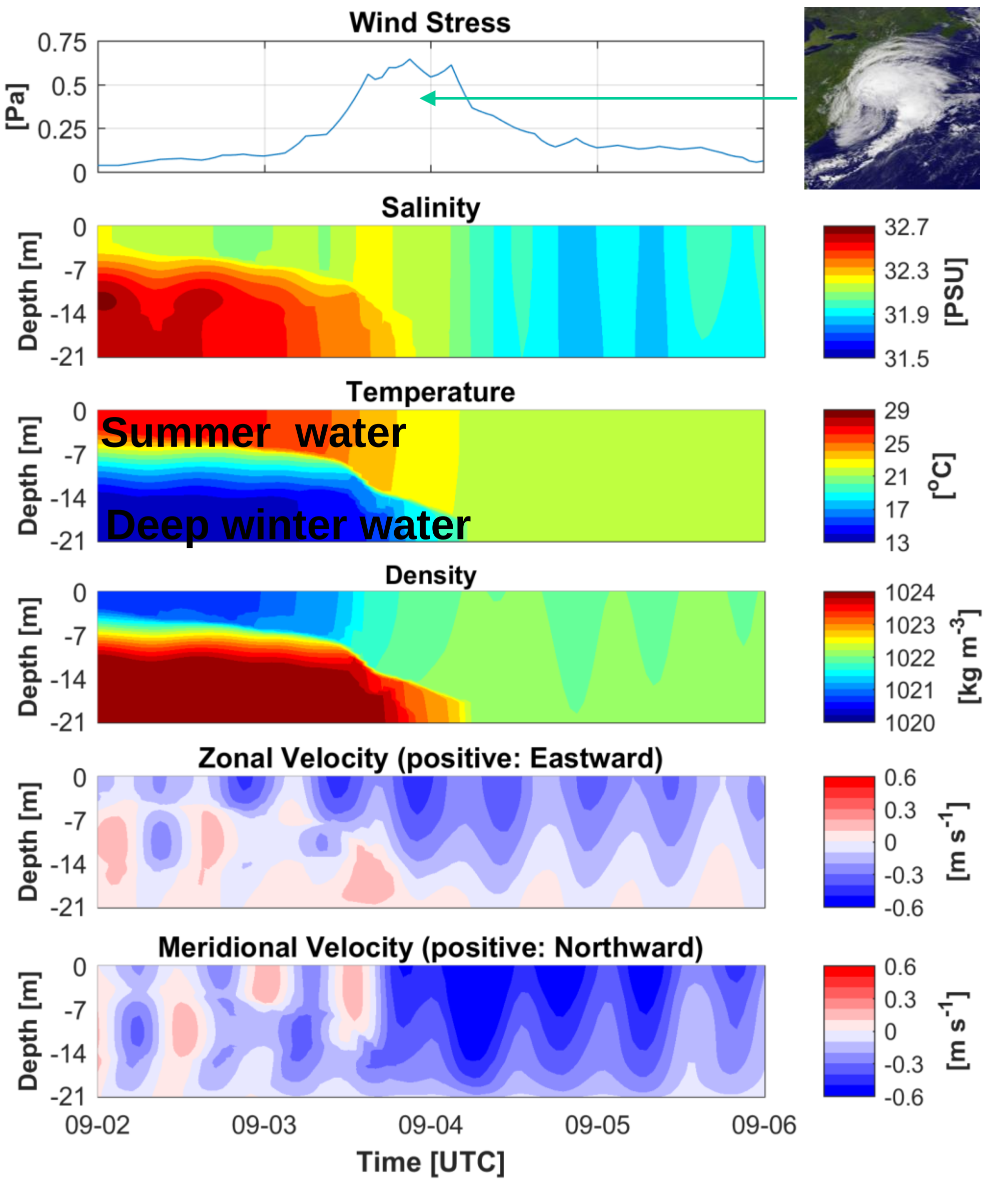
Most productive black sea bass habitats in MAB occur within the bottom “cold pool”



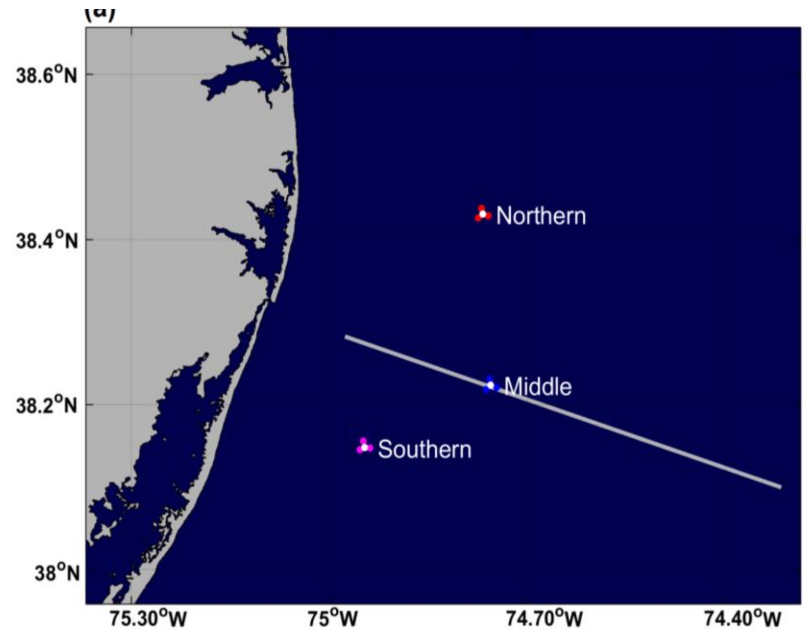
MARACOOS
H. Roarty, J. Keroot



Hurricane Hermine

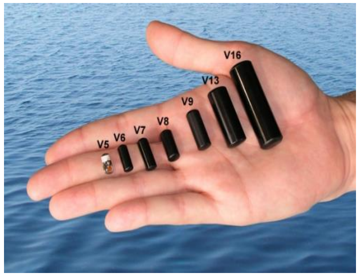


Middle Reference Site



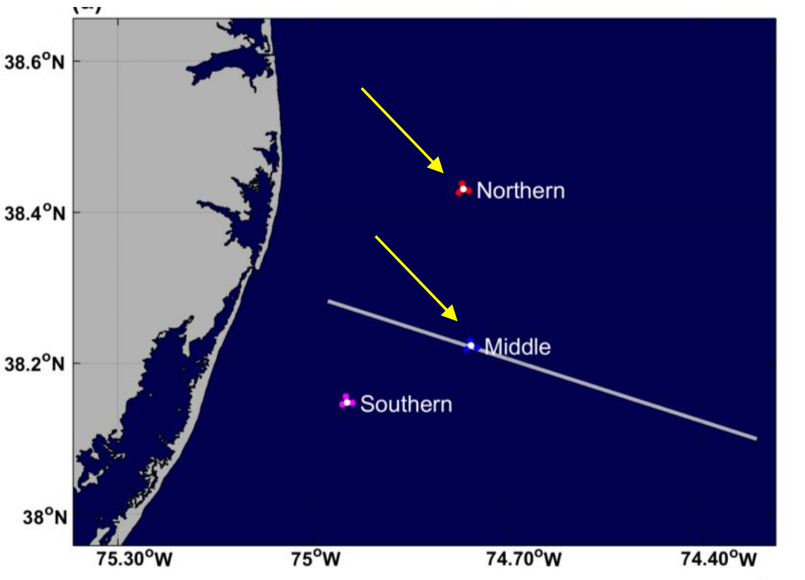
FV-COM Output

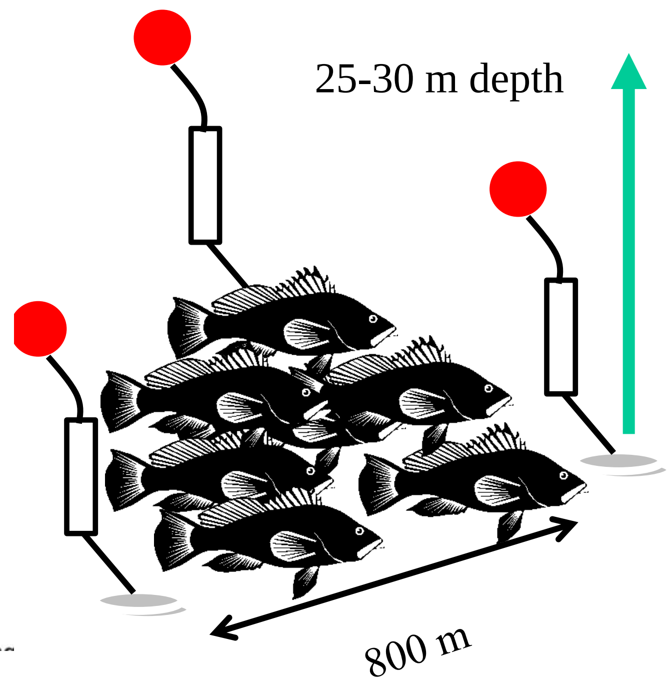
Study design

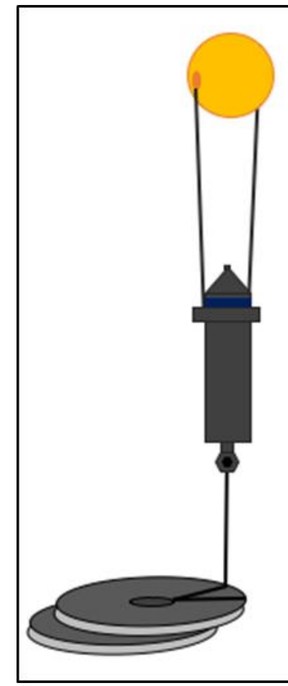


<u>Telemetry Study</u>

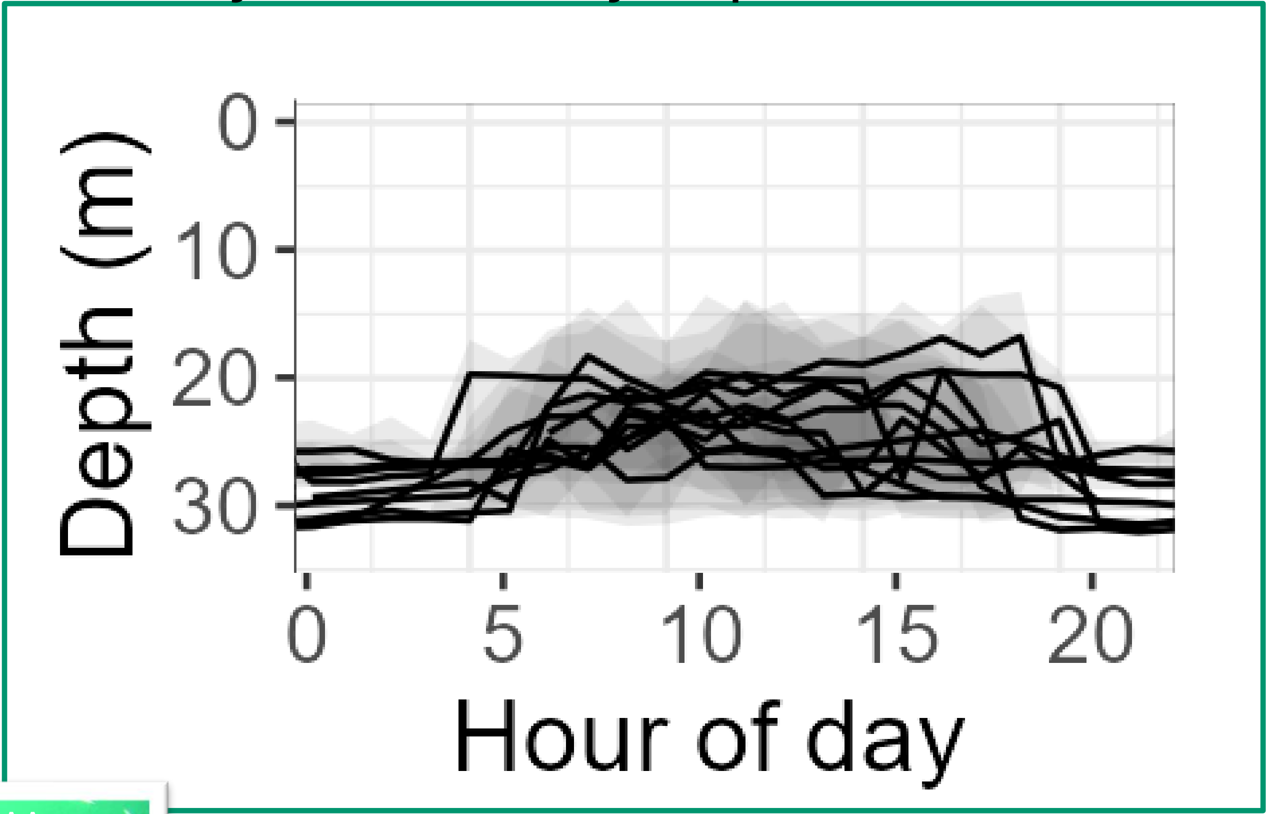
- Undersized fish implanted across two sites with pressure sensing tags
- Acoustic release VEMCO receivers at 800 m distances 0°, 120°, 240° N from release site

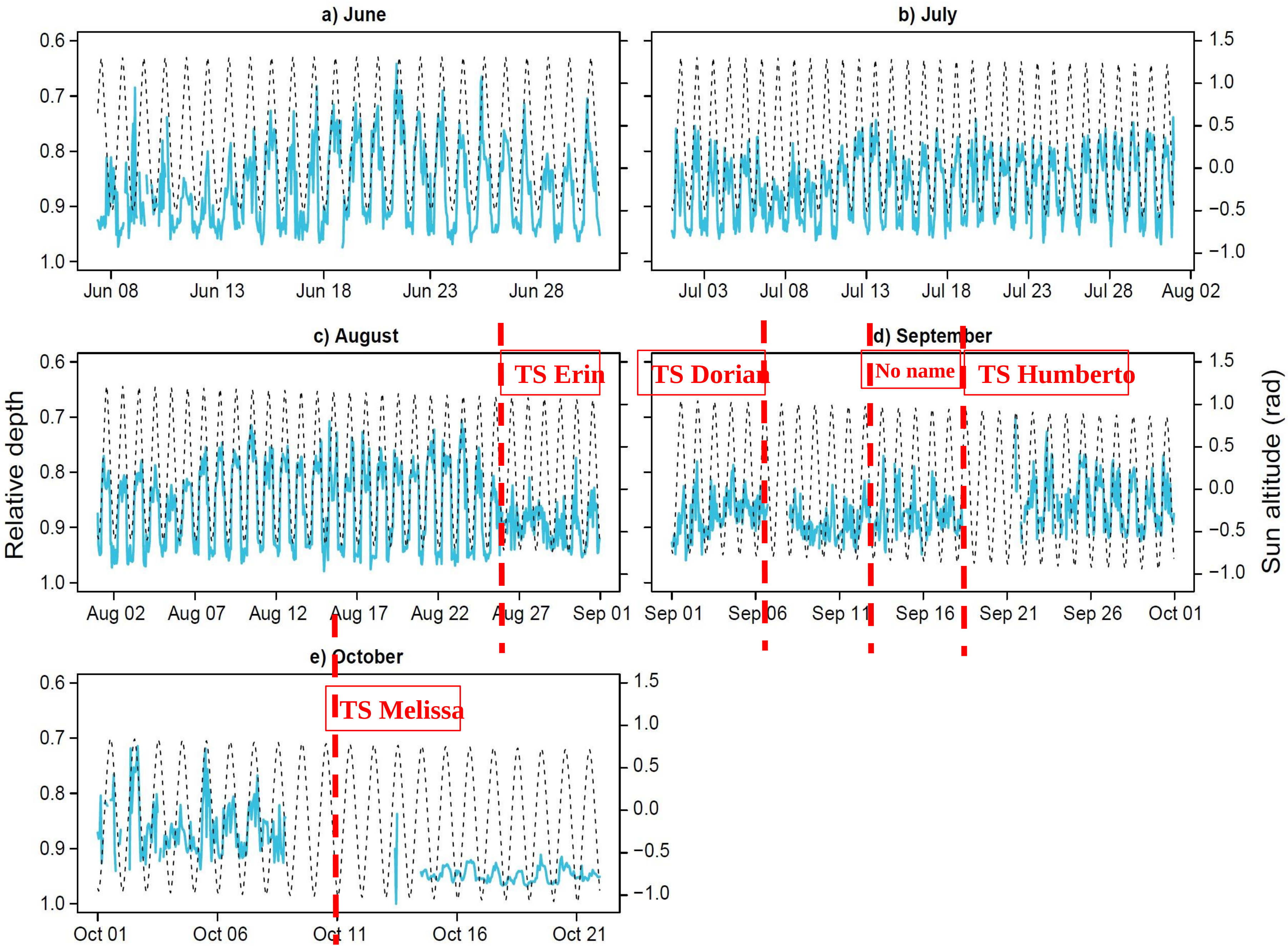




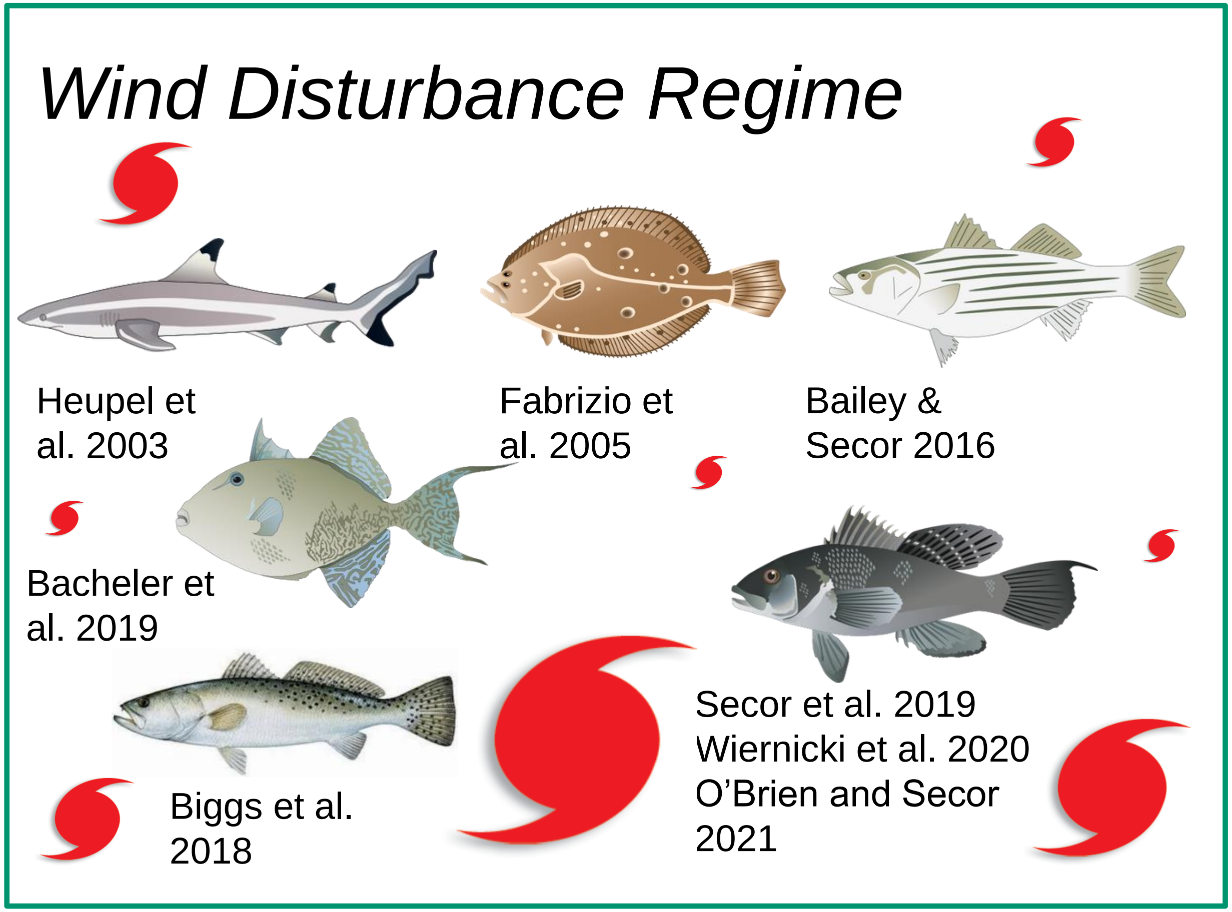


Mid-July week: hourly depths, 8 individuals





a) June
b) July
c) August
d) September
e) October
Relative depth
Sun altitude (rad)
TS Erin
TS Dorian
No name
TS Humberto
TS Melissa
0.6
0.7
0.8
0.9
1.0
1.5
1.0
0.5
0.0
−0.5
−1.0
Jun 08
Jun 13
Jun 18
Jun 23
Jun 28
Jul 03
Jul 08
Jul 13
Jul 18
Jul 23
Jul 28
Aug 02
Aug 07
Aug 12
Aug 17
Aug 22
Aug 27
Sep 01
Sep 06
Sep 11
Sep 16
Sep 21
Sep 26
Oct 01
Oct 06
Oct 11
Oct 16
Oct 21



Black sea bass

- In MAB storms regularly impact black sea bass habitat through recurring and permanent destratification (destruction of the cold pool)
- Incomplete evacuations
- Depressed vertical movement behaviors
- Telemetry can assay fish behaviors during, and in the wake of storms (with caveats)

Secor, D.H., F. Zhang, M. O'Brien, and M. Li. 2019. Ocean destratification and fish evacuation caused by a Mid-Atlantic Tropical Storm. ICES Journal of Marine Science 76:573-584.

Wiernicki, C. M.O. Brien, F. Zhang, V. Lyubchich, M. Li and D. Secor. 2020. The recurring role of storm disturbance on black sea bass (*Centropristis striata*) movement behaviors in the Mid-Atlantic Bight. Plos One 15(12):e0239919.

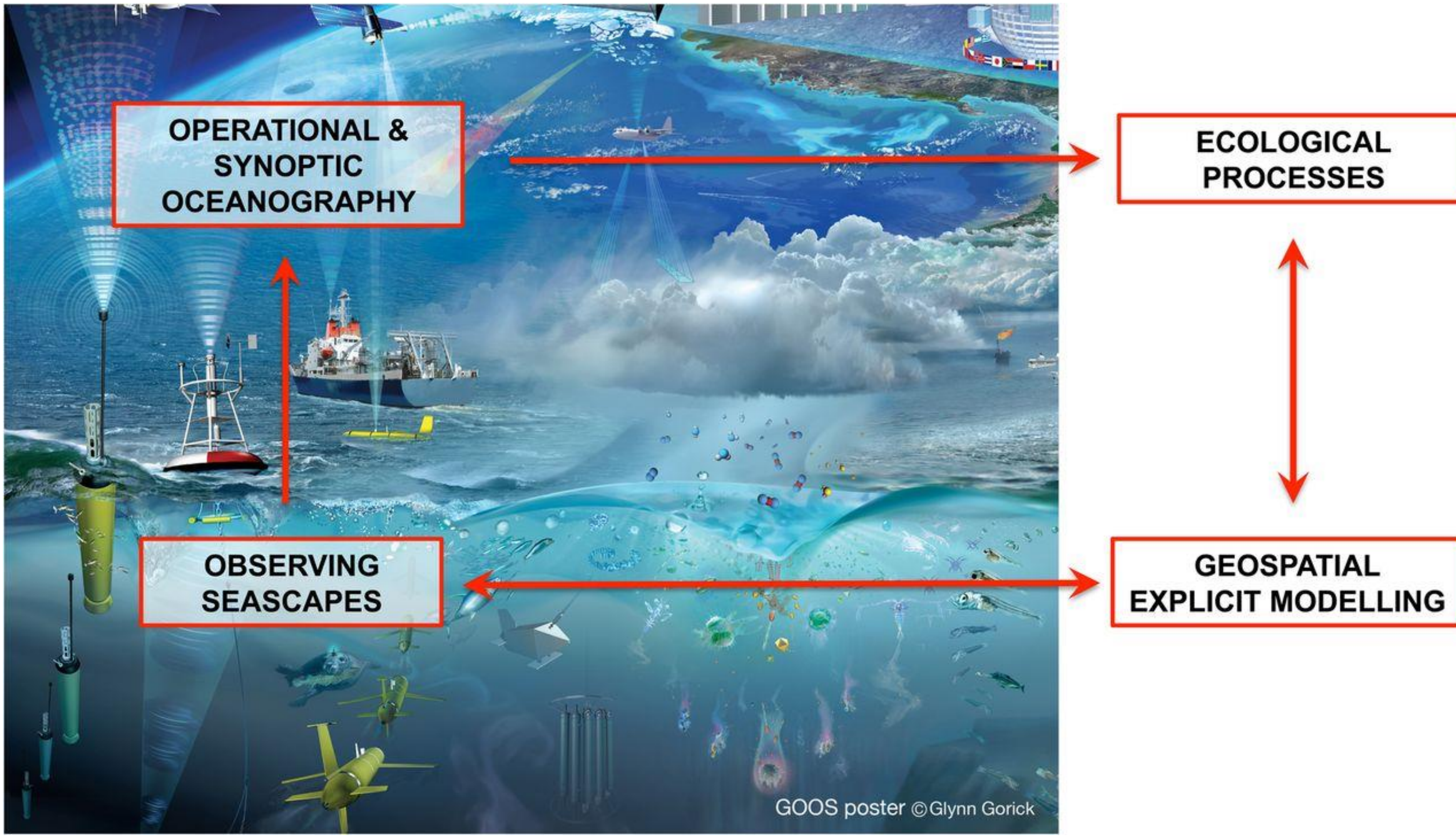
O'Brien, M.H.P. and D.H. Secor. 2021. Influence of thermal stratification and storms on acoustic telemetry detection efficiency: a year-long test in the US Southern Mid-Atlantic Bight. Animal Biotelemetry

Seascapes are…

1. Lagrangian, transient, dilute and patchy
2. Size-structured
3. Vertically heterogenous
4. **Tractable with observing system capabilities**
   1. **Dynamic Ocean Management**
   2. **Offshore wind farm observatories**

Seascape ecology entails a recursive approach, where observed oceanographic variables are made operational (accessible) and synoptic through wide bandwidth telecommunication.

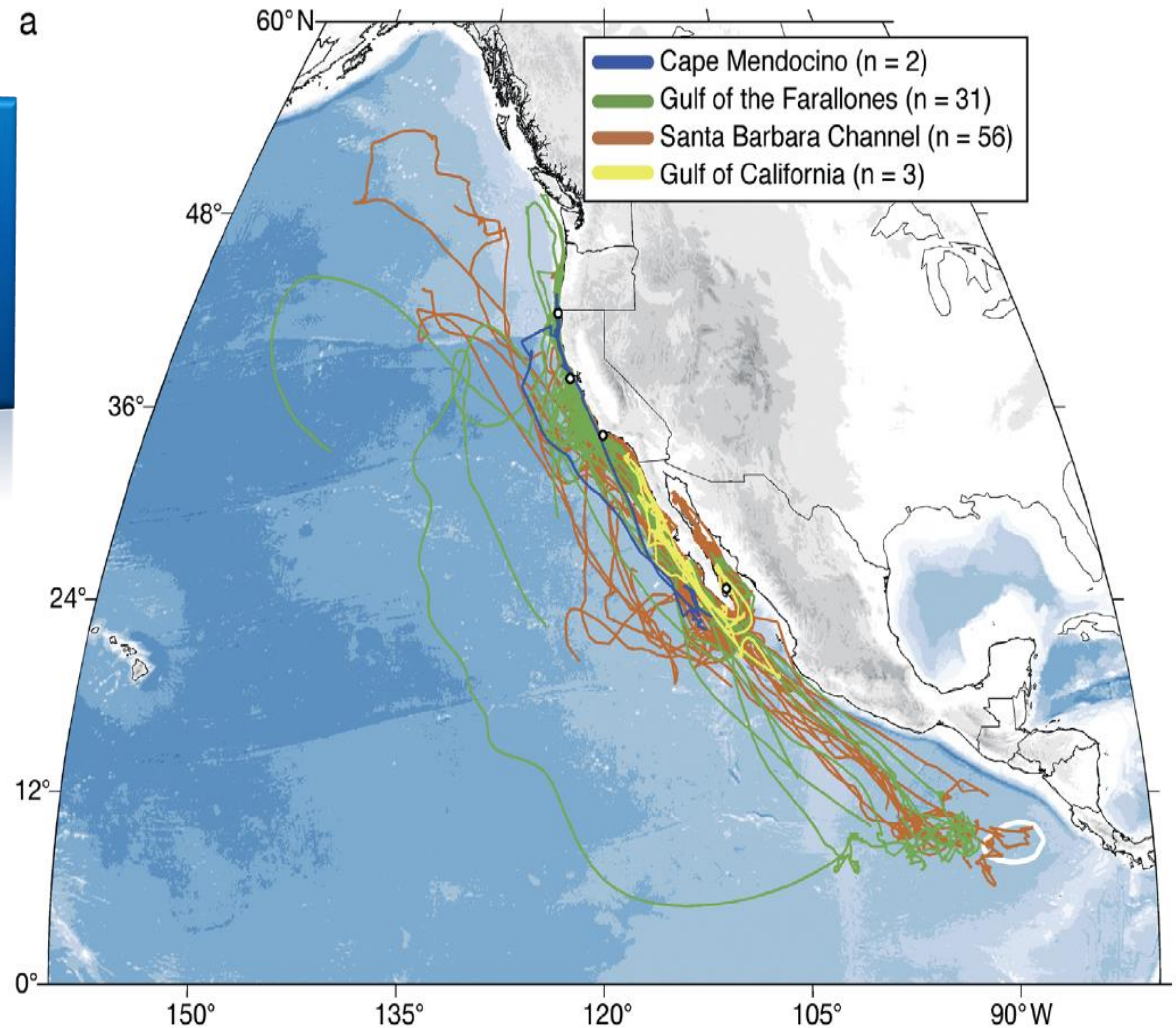
Knowledge of ecological and oceanographic processes is incorporated into spatially explicit models that permit predictions of the dynamic distributions of marine populations and related ecosystem properties.



Manuel Hidalgo, D. Secor and H. Browman 2016. Observing and managing seascapes: linking synoptic oceanography, ecological processes, and geospatial modeling **ICES J. Mar. Sci. 2016;icesjms.fsw079**

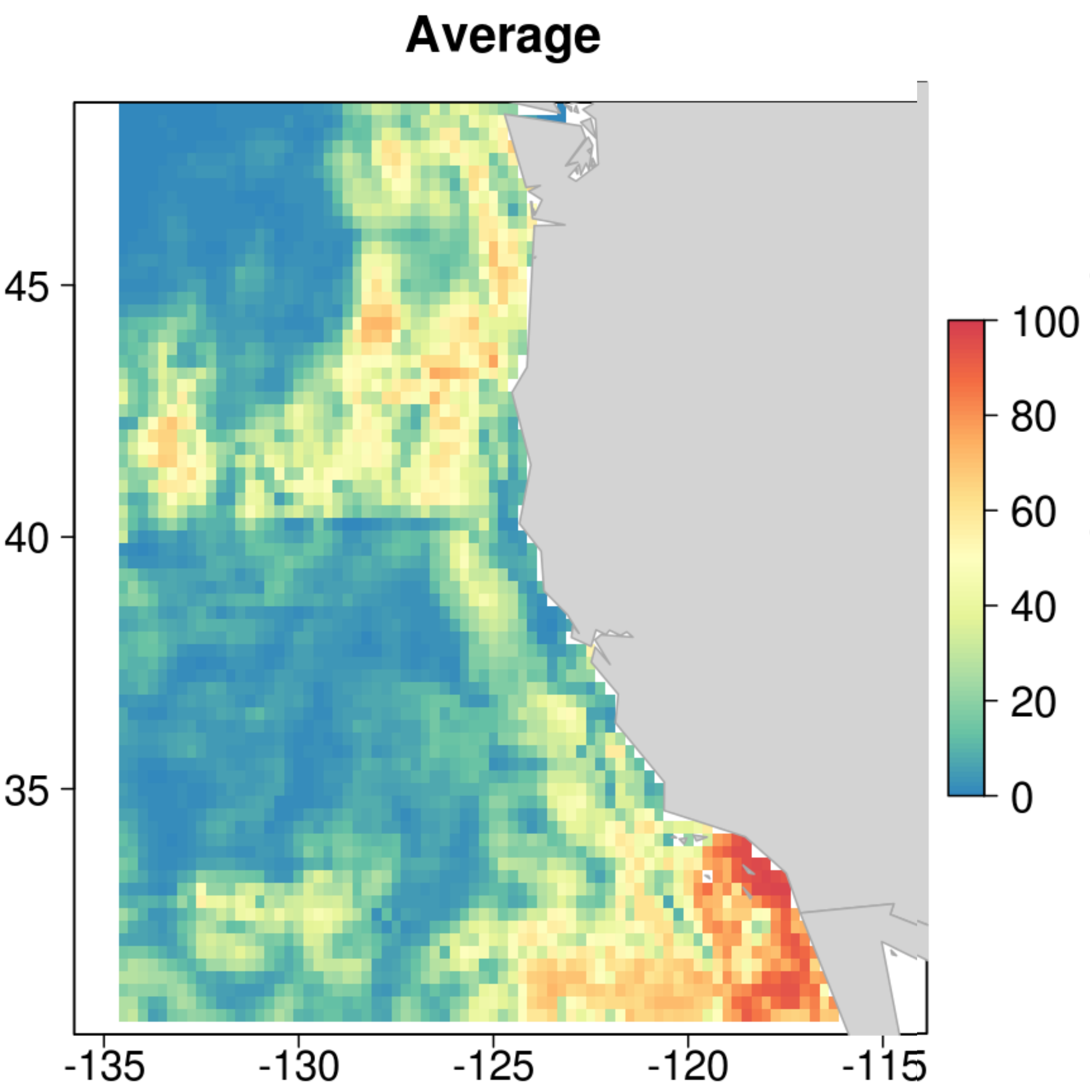
Movement Ecology: Reduce, reconstitute, predict

http://www.westcoast.fisheries.noaa.gov/whalewatch/



Bailey, H., et al. 2009. Endangered Species Research 10:93-

Likelihood of Occurrence



Dynamic Marine Management

Telemetry (state-space movement model)

↓

Observed Ocean Variables

↓

Species Distribution Model

↓

Operational synoptic oceanography
(ocean observing x telecommunications)

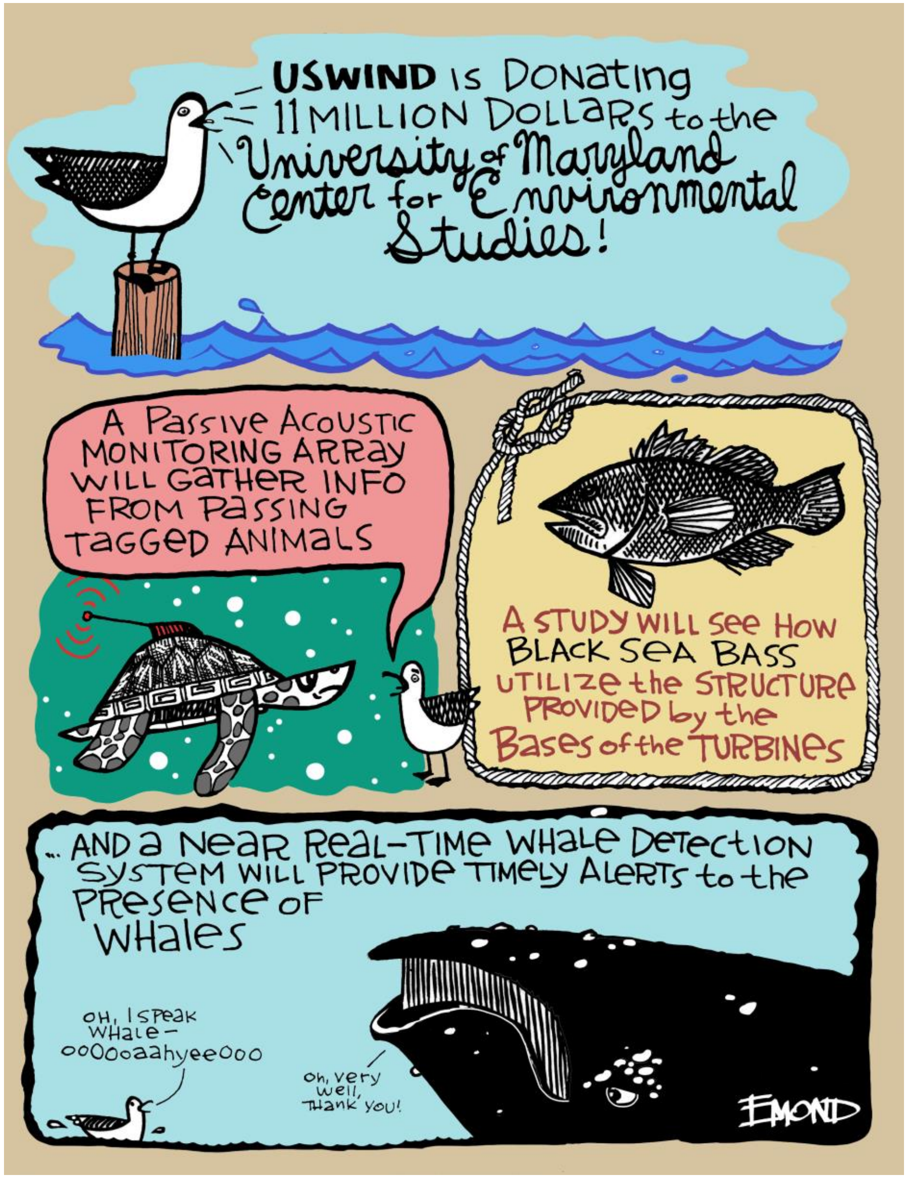
↓

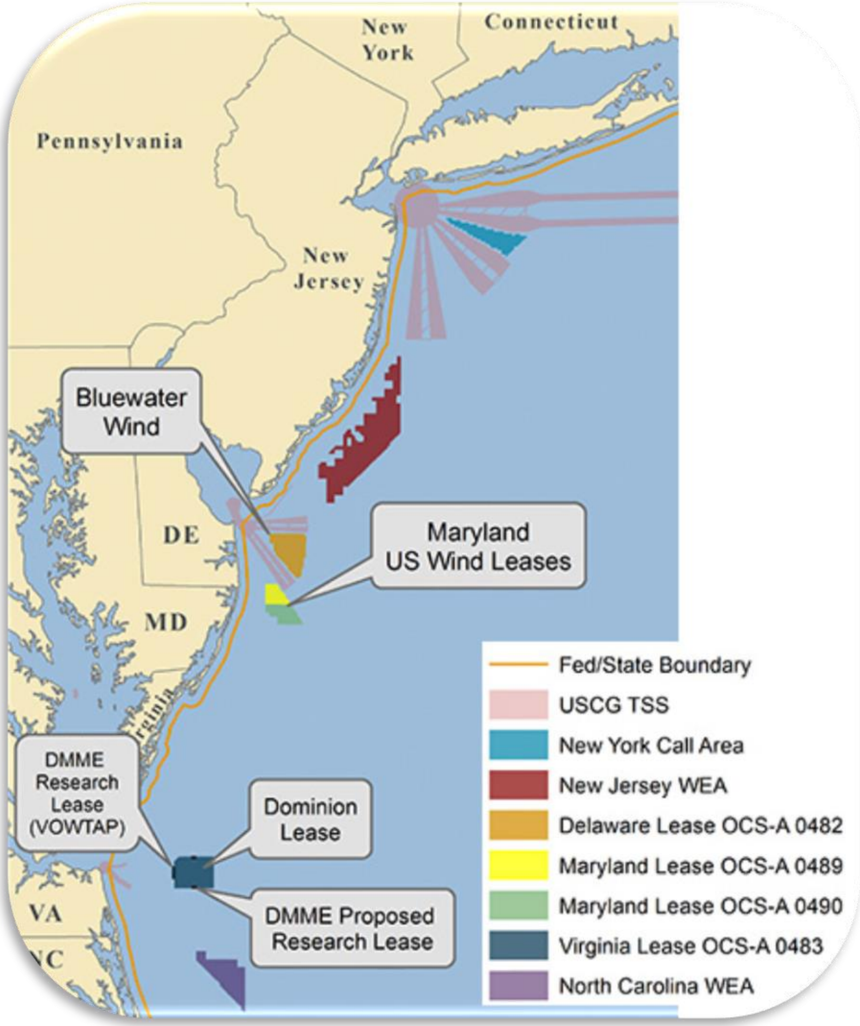
Near real-time collision risk maps

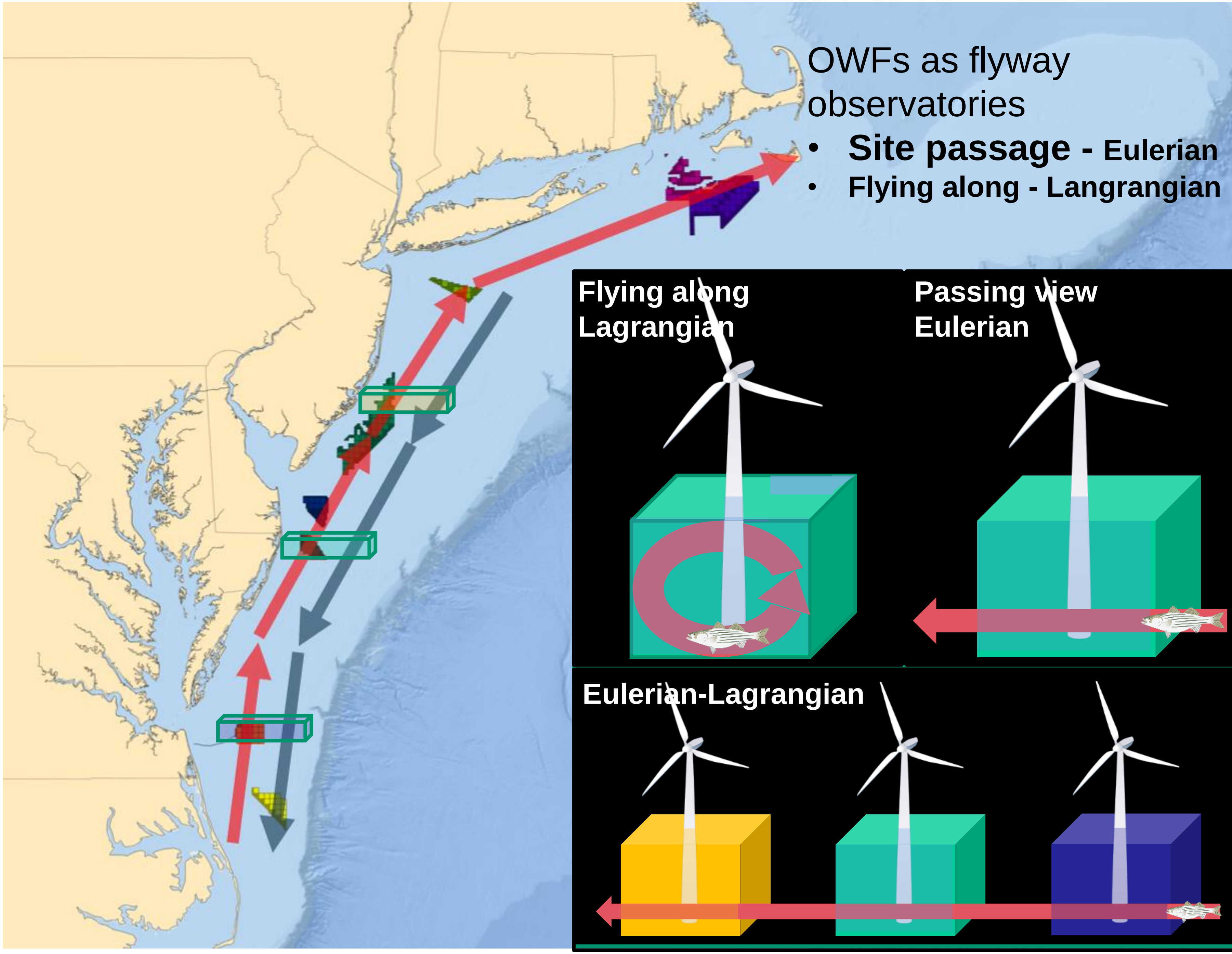
Bailey, H., et al. 2009. Endangered Species Research 10:93-106.

Wind Harvest Regime

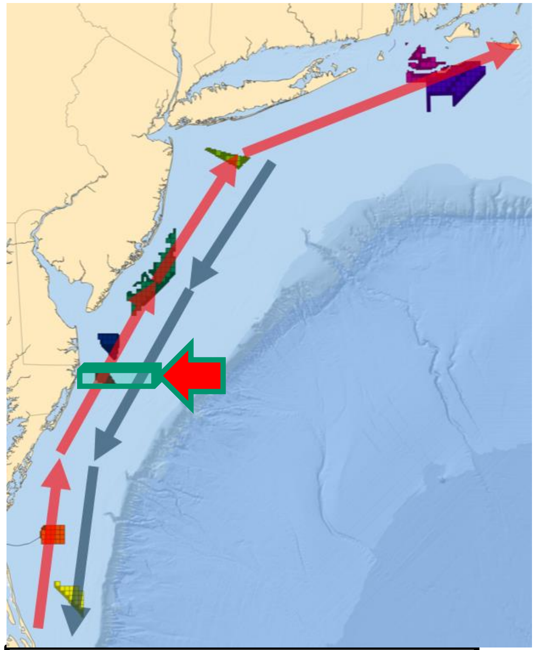
UMCES TAILWINDS Project

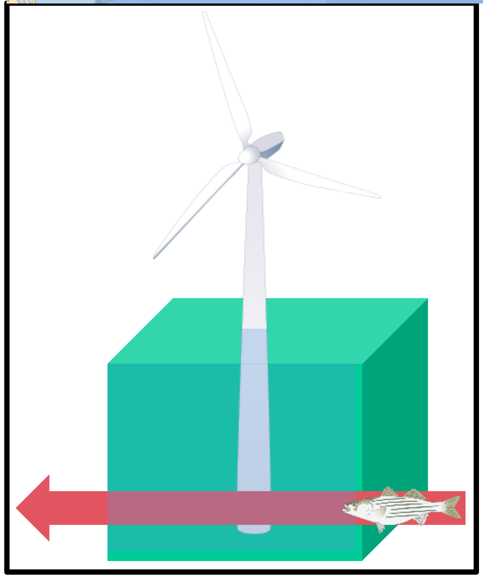


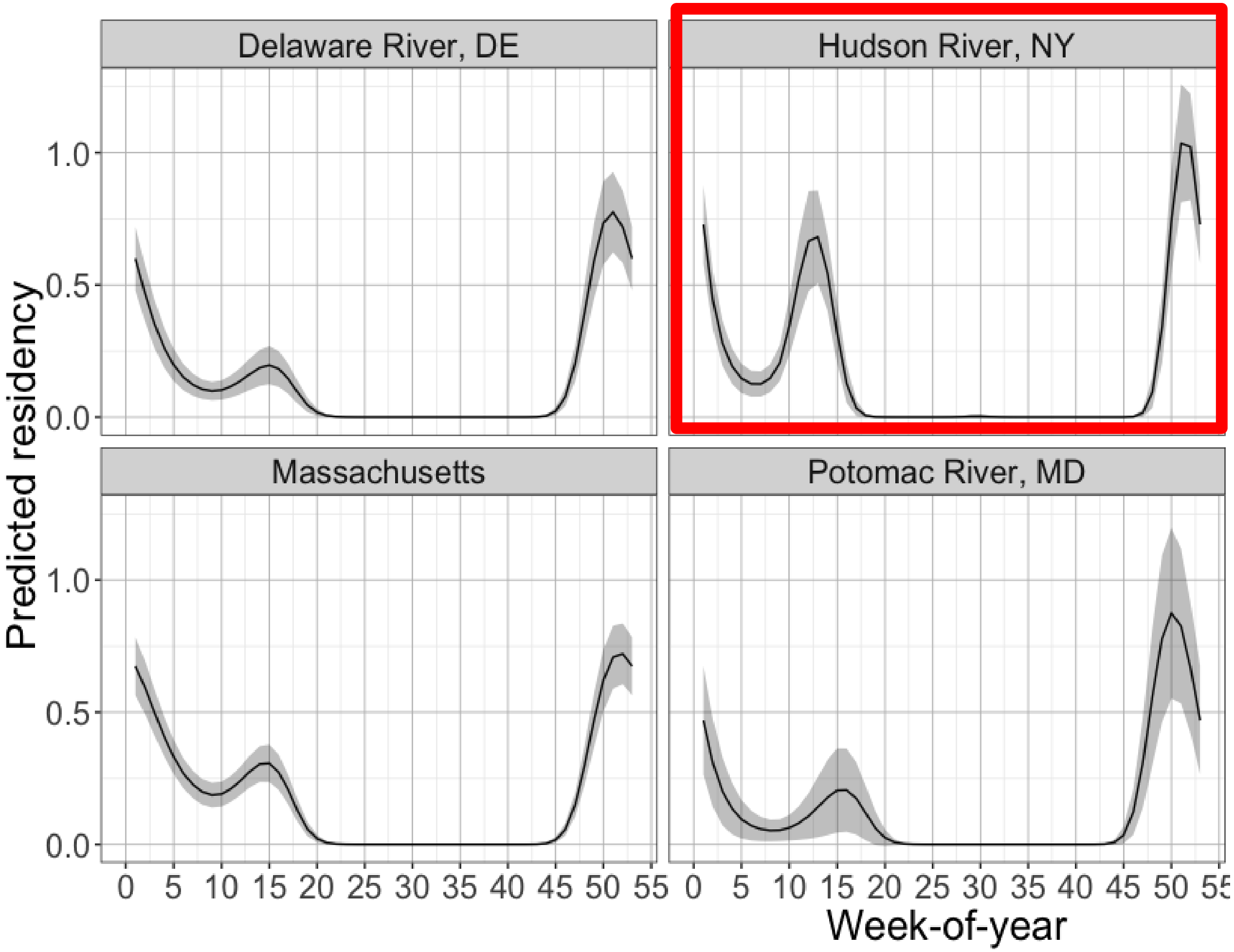



OWFs as flyway observatories
• Site passage - Eulerian
• Flying along - Langrangian
Flying along Lagrangian
Passing view Eulerian
Eulerian-Lagrangian

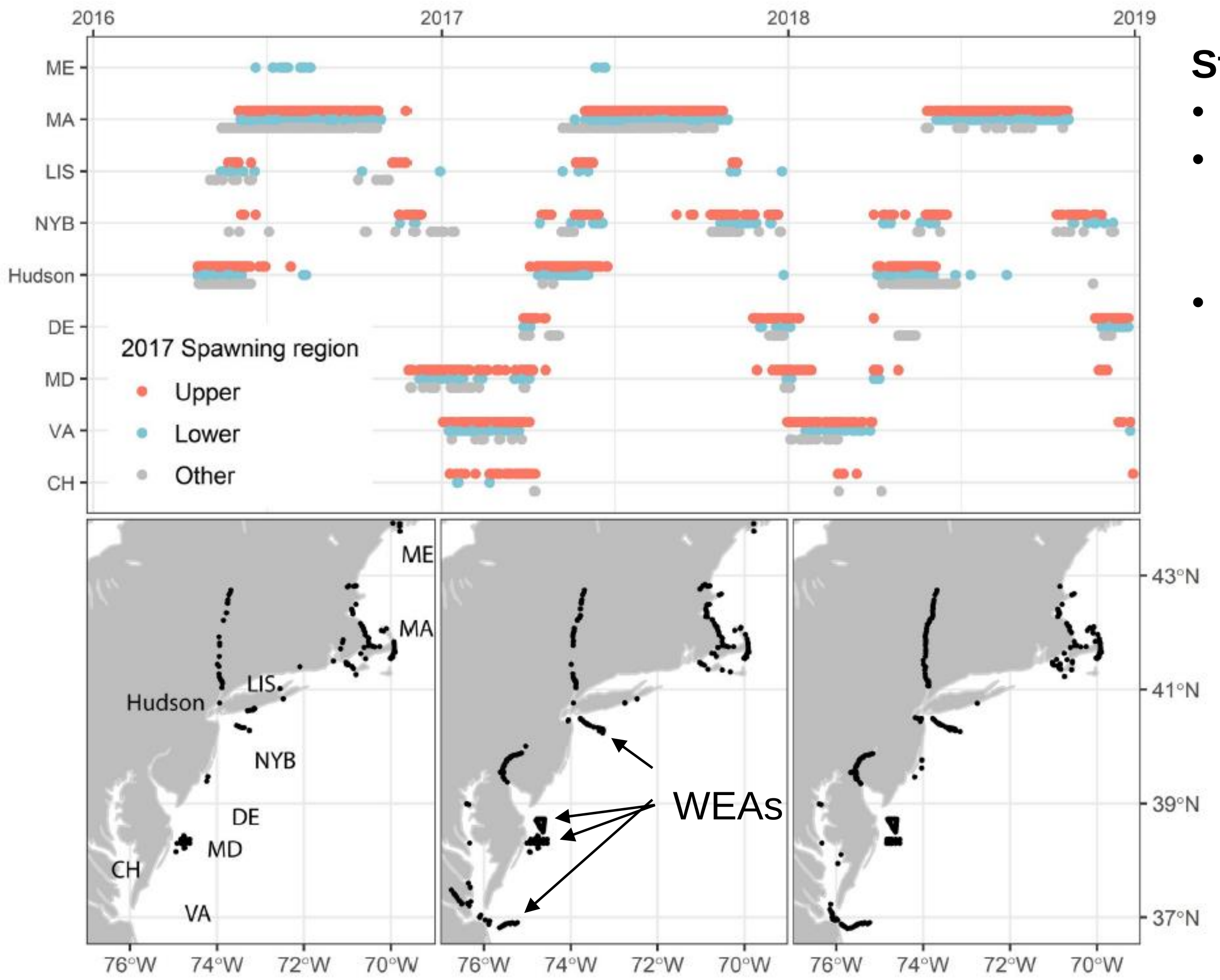
Fall-Spring Migrations - Passing through (Eulerian). Flux of different striped bass populations







Movement and Habitat Selection by Migratory Fishes within the Maryland Wind Energy Area and Adjacent Reference Sites.
https://espis.boem.gov/final%20reports/BOEM_2020-030.pdf



Striped Bass Flyway

- Hudson River striped bass
- Receiver arrayed across latitudes: coming attractions for OWFs
- Flyway information on.
  - Migrations: spawning, spring, and fall
  - Destinations: summer feeding and overwintering habitats

Secor, et al. 2021. Plos One 15(11):e0242797

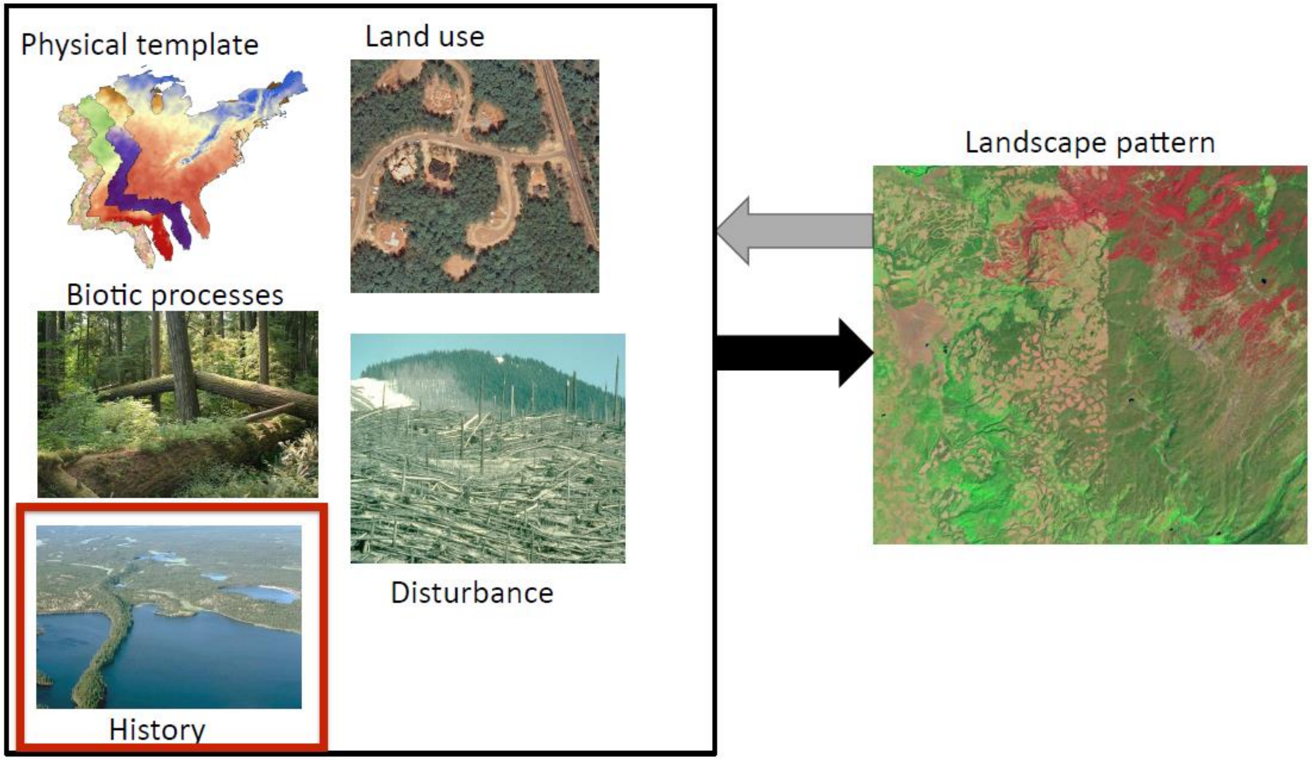
Key Challenge: How does one model species distributions on the basis of Lagrangian data? (Animals and encountered environments simultaneously changing in time).

Point Counterpoint: Landscape v. Seascape

Four primary drivers

1. **Abiotic conditions**: Climate, topography, landform, soils, flow, depth/light, salinity, temperature, nutrients, turbidity
2. **Biotic processes**: species interactions, demographics including dispersal
3. **Disturbance** and succession
4. **Land use and history**

Landscape Ecology: Emergent patterns from underlying ecological processes



Take home points: agents of spatial ecology (terrestrial)

1. Physical template (abiotic environment) is the arena in which biotic processes and disturbance regimes interact.
2. Landform (terrain) modifies climate to produce microclimate variations
3. Historical continencies and legacies are critical to understanding current landscape patterns
4. Spatial hierarchy allows tractable analysis of spatial ecology: local, landscape, regional, and global scales.

Take home points: agents of spatial ecology (marine/aquatic)

1. Physical ~~template~~ transience (abiotic environment) is the arena in which biotic processes and disturbance regimes interact.
2. ~~Landform (terrain)~~ Wind and ocean current regimes modify climate to produce mesoscale ~~microclimate~~ variations
3. Historical contingencies and legacies are less critical to understanding current patterns
4. Spatial ~~hierarchy allows tractable~~ analysis is confounded by transience and vertical heterogeneity at local, ~~landscape~~ seascape, regional, and global scales.
5. Distribution of biota is dilute, size-structured and characterized by high patchiness.

Point Counterpoint

Contribution to the Themed Section: '*Seascape Ecology*'

Food for Thought

Seascapes are not landscapes: an analysis performed using Bernhard Riemann's rules

John Pilling Manderson*

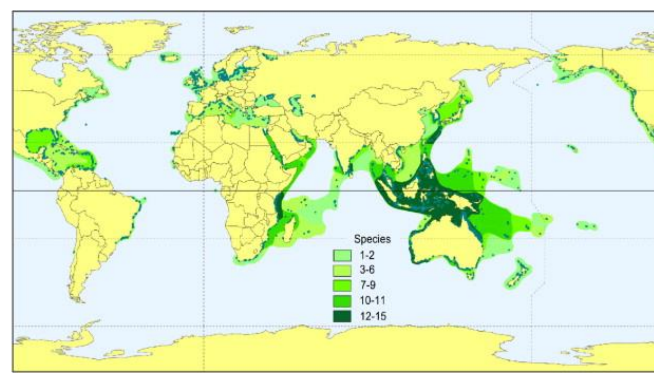
Comment

Seascapes are landscapes after all; Comment on Manderson (2016): Seascapes are not landscapes: an analysis performed using Bernhard Riemann's rules. ICES Journal of Marine Science, 73:1831–1838

Susan S. Bell[1,*] and Bradley T. Furman[2]

Reply

Response to Bell and Furman (2017): Seascapes are landscapes after all; Comment on Manderson (2016): Seascapes are not landscapes: an analysis performed using Bernhard Riemann's rules: ICES Journal of Marine Science, 73:1831–1838



Discussion Questions

The point-counterpoint on the overlap between landscape and seascape ecology seems to center on dimension and scale. Describe how types of dimension and types of scale define key points of difference between Manderson's and Bell and Furmans' views.

Would subdividing seascape ecology into "demersal (seabed) seascape ecology" and "pelagic seascape ecology" resolve issues raised in the point-counterpoint?

Landscape ecology emphasizes emergent properties and synthesis. Would the bioenergetics (cellular) approach adopted by Manderson to define seascapes offer improved perspectives in landscape ecology?

Are applications in movement ecology similar between landscapes and seascapes?