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Evaluation of Ecosystem Factors Influencing Blue Crab Populations

June 2019 Biannual Meeting
Sustainable Fisheries Goal Implementation Team
Horn Point Laboratory
June 26th, 2019

Miller, Liang, Wilberg, Nesslage

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Background and Motivation

- Blue crab are managed currently in a single species framework
  - Biomass reference point (depleted)
  - Exploitation reference point (overfishing)

  which are estimated using a peer-reviewed stock assessment model (Miller et al. 2011, updated MDNR 2019)
- Single species approach assumes blue crab abundance is regulated by internal dynamic process (recruitment, growth, natural mortality) and fisheries removals (commercial and recreational catch, by-catch)
- Fisheries management and the Chesapeake Bay Program are increasingly taking an ecosystem-based approach that recognizes external factors and explicitly recognizes trade-offs
- Can ecosystem-based approaches be adapted for management of blue crab in Chesapeake Bay?

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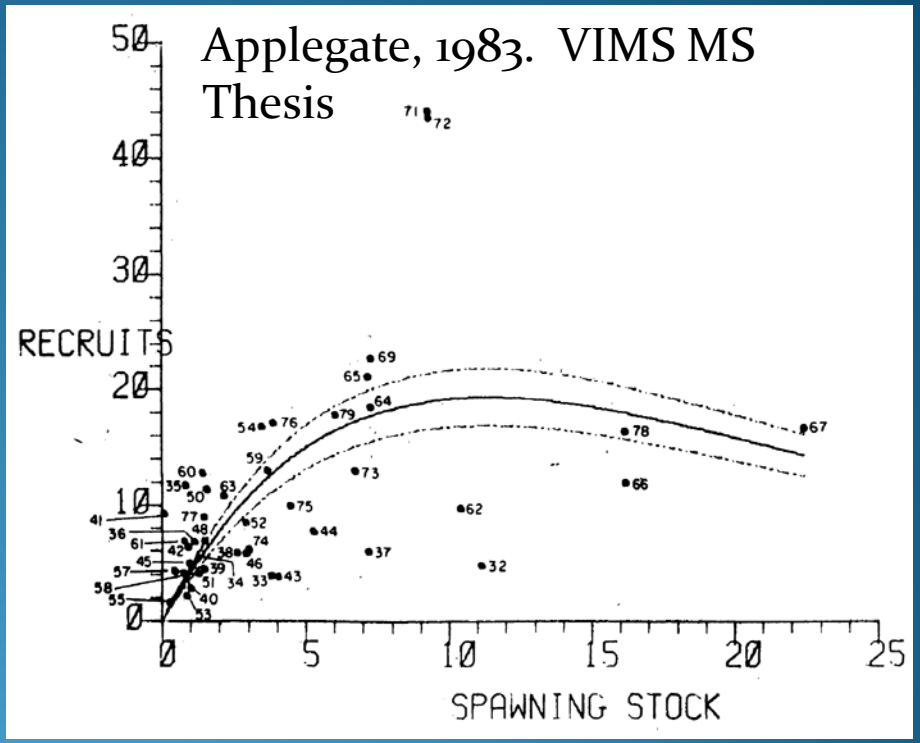
EBFM + Blue Crab

Incorporating external factors into single species models

Extensions of stock recruitment models to include environmental factors (e.g, Applegate, 1983, Tang et al. 1990, Lipcius & Van Engel 1990)



Determination of whether environmental effects improve recruitment models remains equivocal

No trade-offs considered

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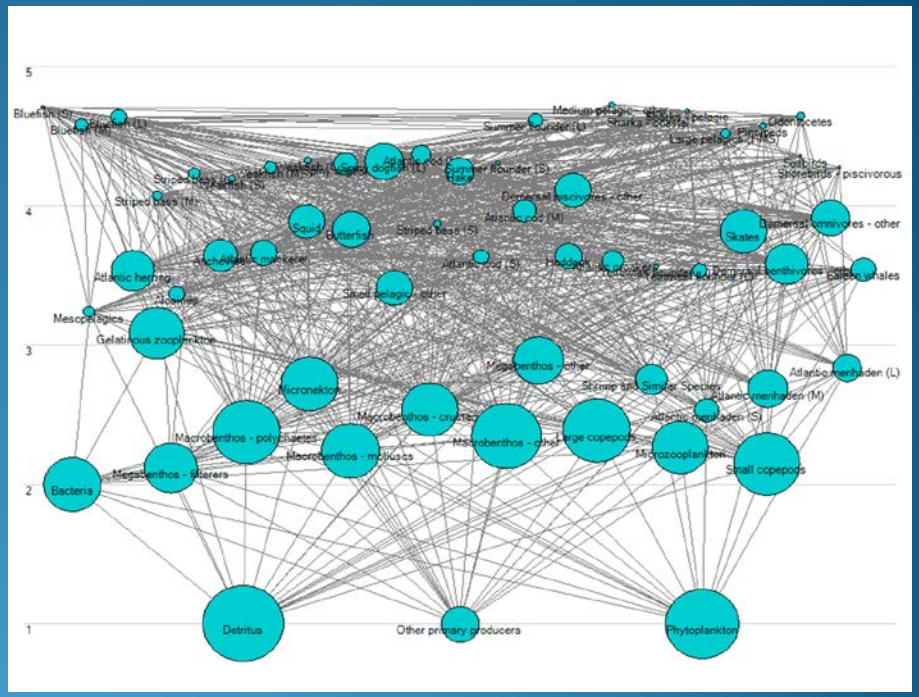
EBFM + Blue Crab

Incorporating external biological factors in an ecosystem model

Chesapeake Bay Ecopath with Ecosim Model – incorporating full food web, with limited environmental forcing (e.g., Ma et al. 2009, Buchheister et al. 2017)



Forecasts of response of blue crab to changes in the dynamics of predators or prey

Trade-offs considered explicitly

Environmental effects challenging

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EBFM + Blue Crab

Incorporating external factors into single species models	Incorporating external biological factors in an ecosystem model	Empirical Network Model
Extensions of stock recruitment models to include environmental factors (e.g, Applegate, 1983, Tang et al. 1990, Lipcius & Van Engel 1990)	Chesapeake Bay Ecopath with Ecosim Model – incorporating full food web, with limited environmental forcing (e.g., Ma et al. 2009, Buchheister et al. 2017)	Test hypotheses on the role of environmental **and** biological factors on the population abundance and resilience (e.g., Malick et al. 2015). Applied to blue crab – this project

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Approach

- Use expert judgement to establish a suite of "hypotheses" of how environmental and biological factors influence blue crab abundance and resilience
- Specify direct and indirect impact pathways
- Fit observed data on environmental factors and blue crab abundance using probabilistic network models.
- *Compare model fit statistics across alternative hypotheses to identify parsimonious models*

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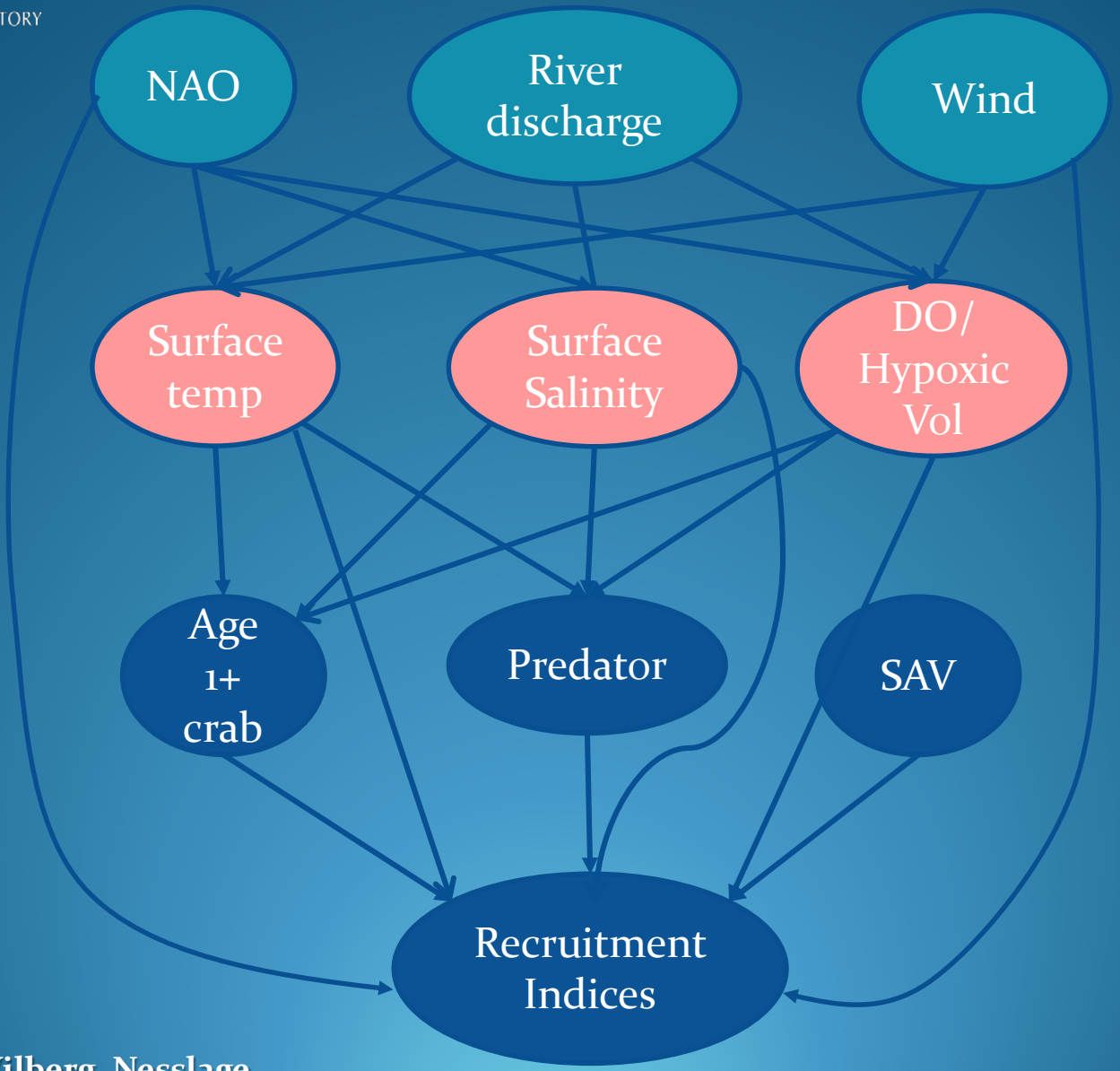
Example hypothesis of ecosystem impacts



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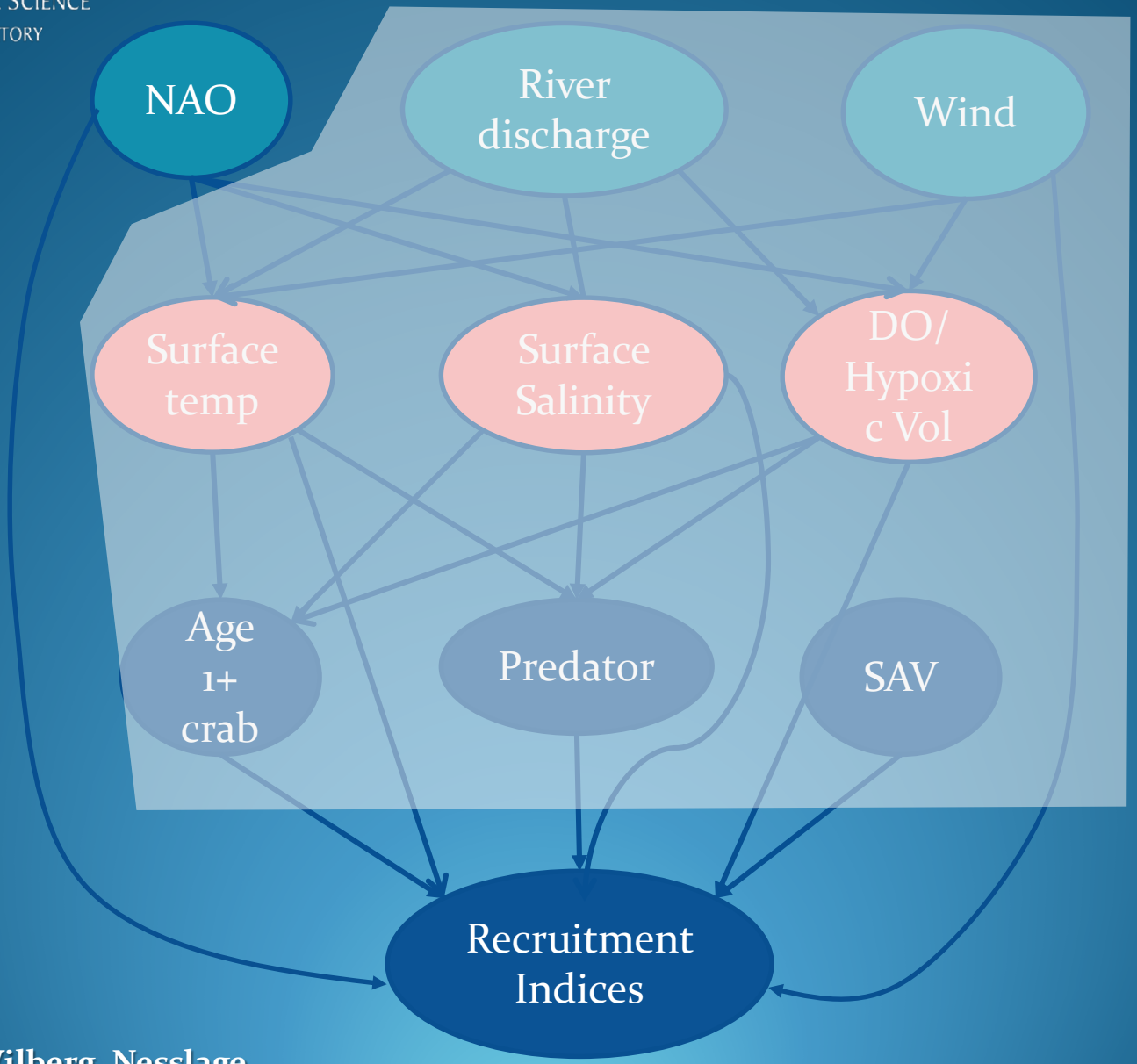
Example hypothesis of ecosystem impacts

Direct impacts



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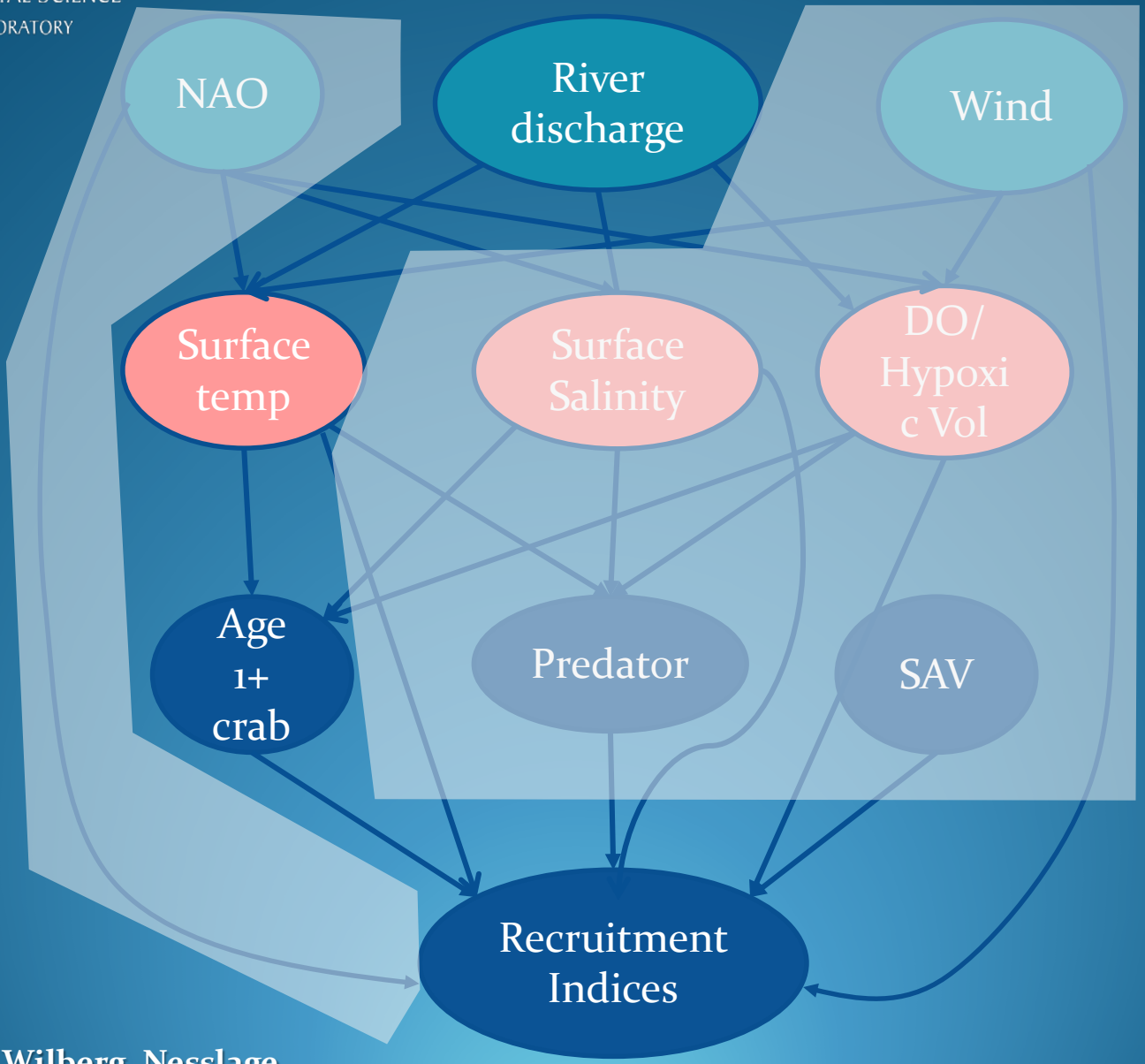
Example hypothesis of ecosystem impacts

Indirect impacts



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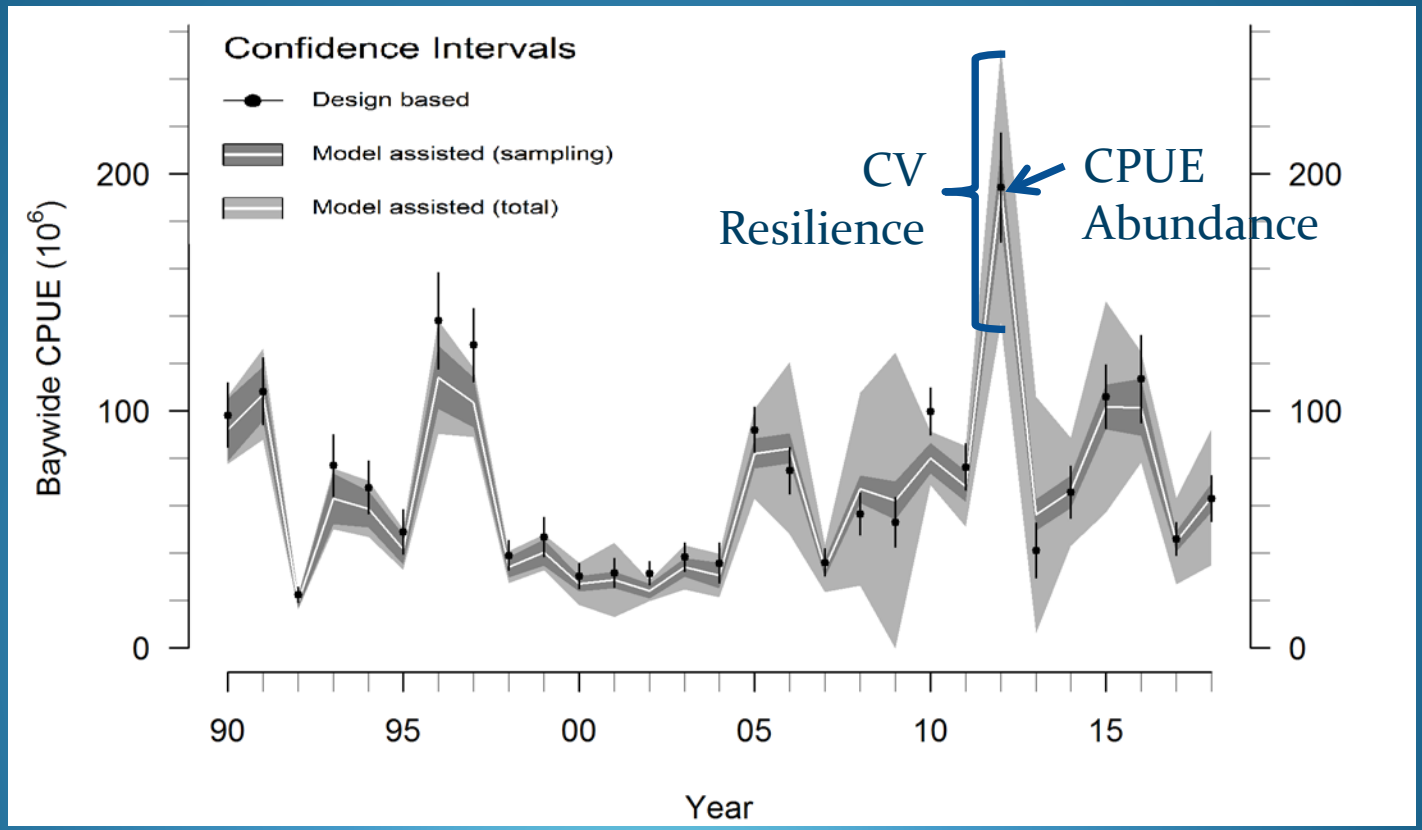
Recruitment Indices

Age-0
CPUE or CV



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Climatic factors

NAO

River discharge

Wind

- North Atlantic Oscillation (NCEP/NOAA)
  - Twelve monthly mean
- River Discharge (Conowingo USGS)
  - Twelve monthly mean
- Wind Forcing (NCDC/NOAA)
  - Fall average NW speed & days with gust

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Water Quality factors

Surface temp

Surface Salinity

DO/ Hyoxic Vol

- Surface Temperature and Salinity (Datahub)
  - Summer average Baywide
  - Fall average Lower Bay
- Hypoxic Volume (Datahub)
  - Summer Baywide
  - Vol3DInterp

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Biological factors

Age 1+ crab

Predator

SAV

- Blue Crab (WDS)
- SAV (Aerial Survey, VIMS)
- Predator (MRIP)
  - Striped bass (Adult VA+MD)

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Model development and testing

- Developed hypotheses for ecosystem impacts on both blue abundance and resilience (variance)
- Examined climatic, water quality and biological factors at a range of appropriate temporal lags
- We examined graphs with 391 links modeling 783 different hypotheses of ecosystem impacts on blue crab abundance and resilience
- Model fits converged to graphs with ~ 190 links.
- Fit diagrams show all factors considered in model fit, with only significant connections shown by lines

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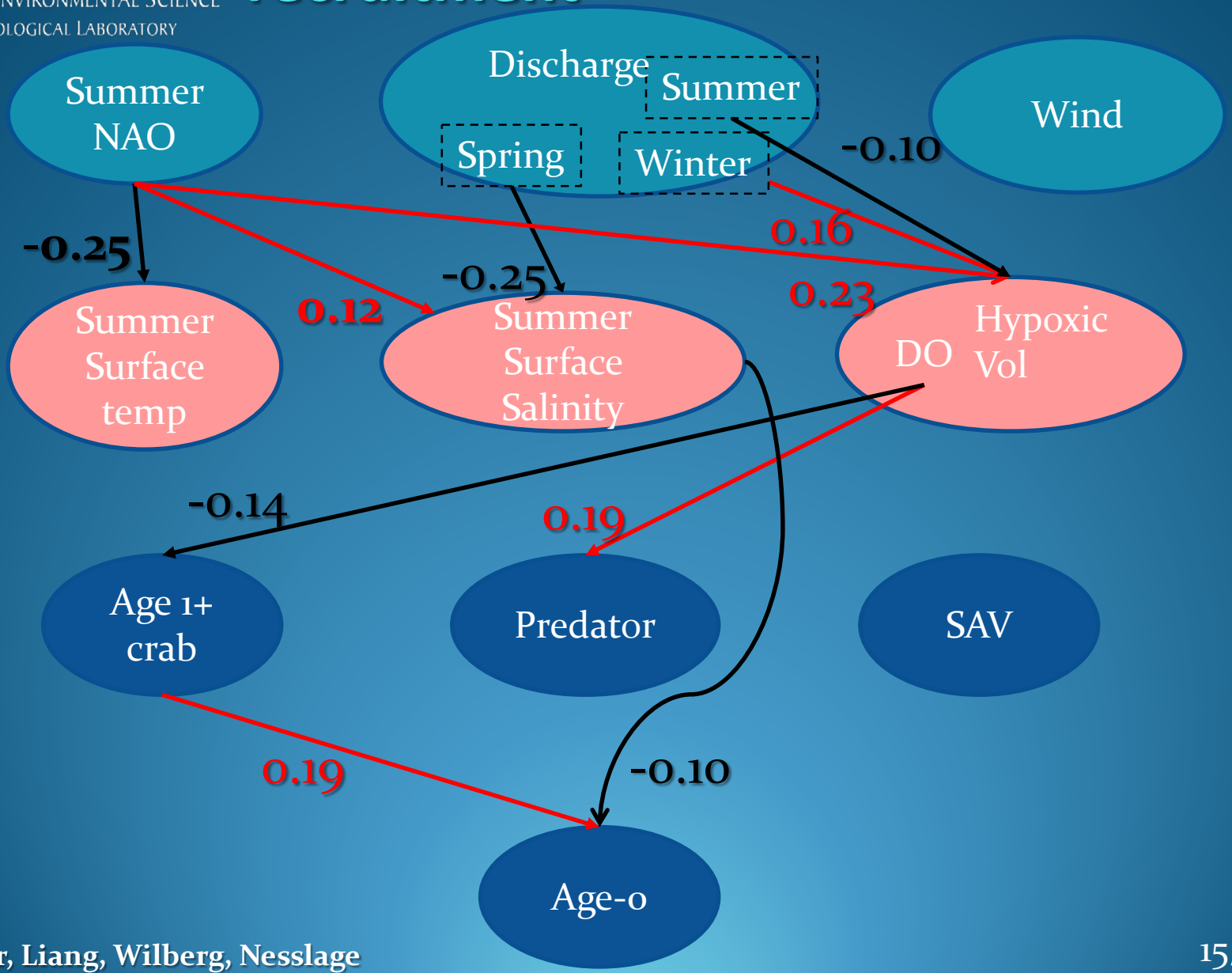
Ecosystem impacts on blue crab recruitment



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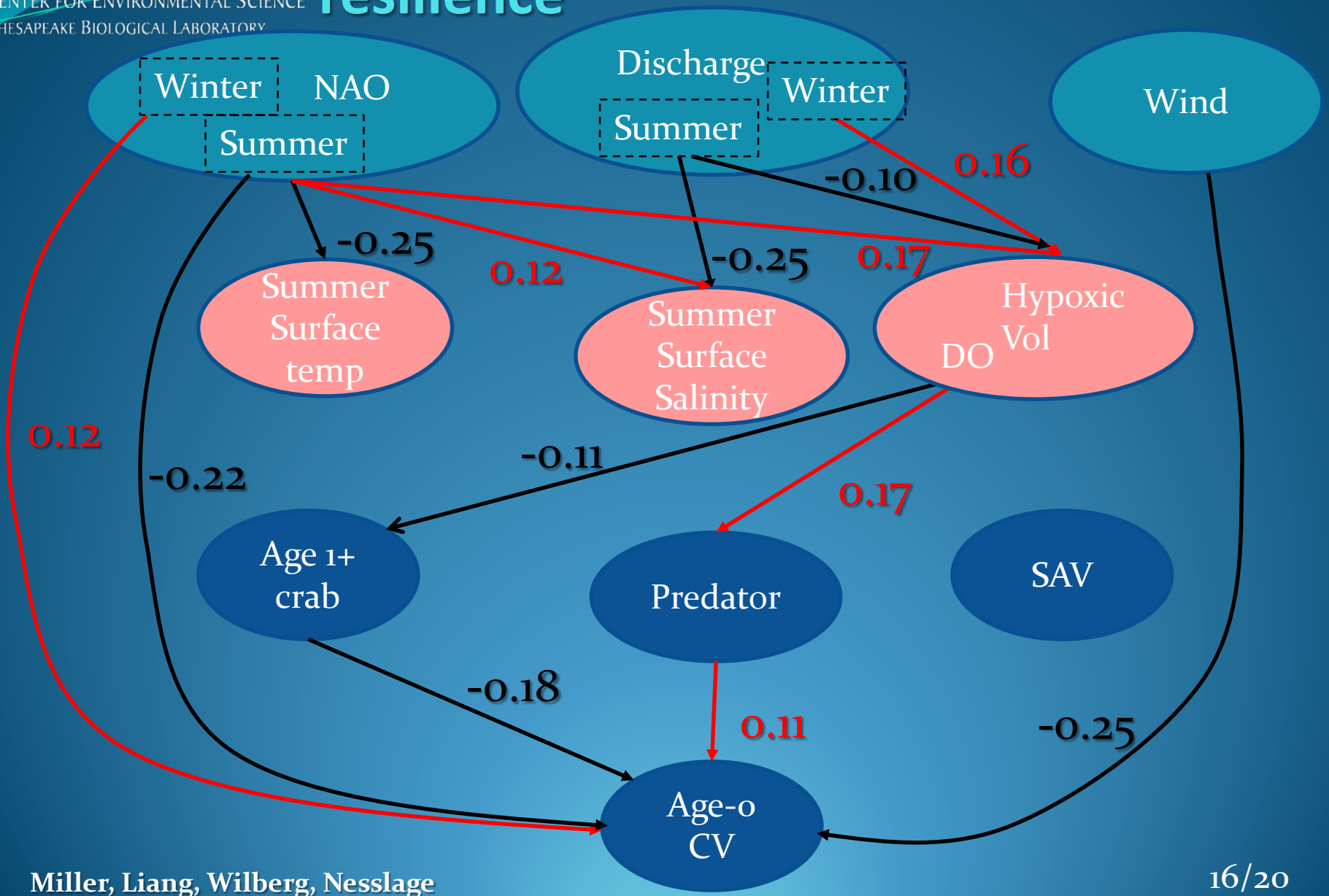
Ecosystem impacts on blue crab resilience



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Conclusions

- Blue crab spawning stock size was always a significant factor in final models
  - Although effects are not strong, sustaining blue crab spawning stocks should remain a central objective of blue crab management
- Both direct and indirect effects were present in our ecosystem network models
- Ecosystem effects were generally weaker than direct effects of blue crab dynamics
- Climatic, water quality and biological factors were found to influence the level and variability of blue crab recruitment
  - Importance of considering ecosystem context of blue crab management
  - Time lags were an important component of final models, but were not consistent across all ecosystem factors

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Conclusions

- Large scale climatic patterns influence both the level and variation in blue crab recruitment
  - Phases of climate indicators worthy of considering in understanding stock performance
  - Not under direct CBP regulation
- Water quality patterns– particularly dissolved oxygen- effects both the level and variation in blue crab recruitment
  - Water quality conditions are currently used in explaining stock performance (e.g., incidences of cold winters)
  - Influence of water quality parameters – particularly DO – requires more work to understand mechanisms
  - Influenced by CBP regulation
- Biological patterns (predation) has stronger impacts on the resilience of recruitment than on the overall level

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Next steps

- Using foodweb models to generate hypotheses for ecological impacts that can be tested by empirical network models (not just blue crab)
- Development of Github R codes for general usage

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Acknowledgements

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