

A Proposed Framework for Analyzing Water Quality and Habitat Effects on Aquatic Living Resources of Chesapeake Bay

Kenneth Rose

France-Merrick Professor in Sustainable Ecosystem Restoration
University of Maryland Center for Environmental Science
Horn Point Laboratory



University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE

Co-Authors

Kirk J. Havens

Virginia Institute of Marine Science,
Gloucester Point

Mark E Monaco

National Centers for Coastal Ocean
Science, NOAA

Jason Hubbard

West Virginia University
Morgantown

Eric Smith

Virginia Tech
Blacksburg

Tom Ihde

Morgan State University
St. Leonard

Jay Stauffer

Penn State University
University Park

CESR

- Achieving Water Quality Goals in the Chesapeake Bay: A **C**omprehensive **E**valuation of **S**ystem **R**esponse
- Independent report from STAC
- Three supporting documents

- Easton, Z., Stephenson, K., Benham, B., Böhlke, J. K., Brosch, C., Buda, A., Collick, A., Fowler, L., Gilinsky, E., Hershner, C., Miller, A., Noe, G., Palm-Forster, L., & Thompson, T. (2023). *Evaluation of watershed system response to nutrient and sediment policy and management.*
- Testa, J. M., Dennison, W. C., Ball, W. P., Boomer, K., Gibson, D. M., Linker, L., Runge, M. C., & Sanford, L. (2023). *Knowledge gaps, uncertainties, and opportunities regarding the response of the Chesapeake Bay estuary to proposed TMDLs.*
- Rose, K., Monaco, M. E., Ihde, T., Hubbart, J., Smith, E., Stauffer, J., & Havens, K. J. (2023). *Proposed framework for analyzing water quality and habitat effects on the living resources of Chesapeake Bay.*

Context

- Many reasons to relate water quality and habitat changes to living resources
 - Valued by stakeholders and society
 - Restoration is costly
 - Realistic and feasible targets and goals
 - Ecological and economic efficiency (“reckoning”)
 - Expectations
 - Adaptive management
 - Winner and losers

1 Introduction

2 Why now?

3 Management Questions that Could Be Answered

4 Existing Links Between WQ/Habitat & LR

4.1 Assessing Progress of Restoring LR of the CB

4.2 Example of Analyses for CB Living Resources

4.2.1 Habitat-based Assessment

4.2.2 Statistical Analysis of LR Monitoring Data

4.2.3 Living Resource Models

5 LR and Other Large-scale Restoration Efforts

6 Going Forward

7 Proposed Framework

- 7.1 Complex Life cycles and life history strategies
- 7.2 Variability, uncertainty, and stochasticity
- 7.3 Model complexity
- 7.4 Vital rates
- 7.5 Habitat suitability and capacity
- 7.6 Biological organization
- 7.7 Nonequilibrium theory and baseline
- 7.8 Multiple Influencing Factors
- 7.9 Tradeoffs (win-lose), Win-win, and Lose-lose
- 7.10 Power to detect responses
- 7.11 Explicit and implicit representations
- 7.12 Relative versus absolute predictions

8 Strategic determination of an analysis plan

8.1 Selecting species

8.2 Available Data

8.3 Response and explanatory variables

8.4 Biological, temporal, & spatial scales

8.5 Analytical approaches

8.6 Coordination and combining results

9 Final comments

10 Acknowledgements

11 References

Feasibility – Chesapeake Bay

- Historical focus on water quality
- Productivity and highly valued
- Information and data rich
- Many scientists = a lot of past and ongoing activities
- Done at other large-scale restoration efforts
- Q: How would we go about doing this (daunting) task?

Context

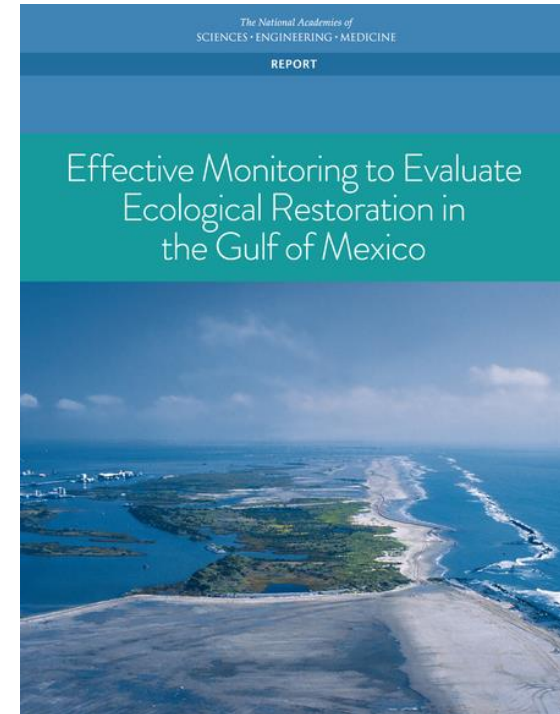
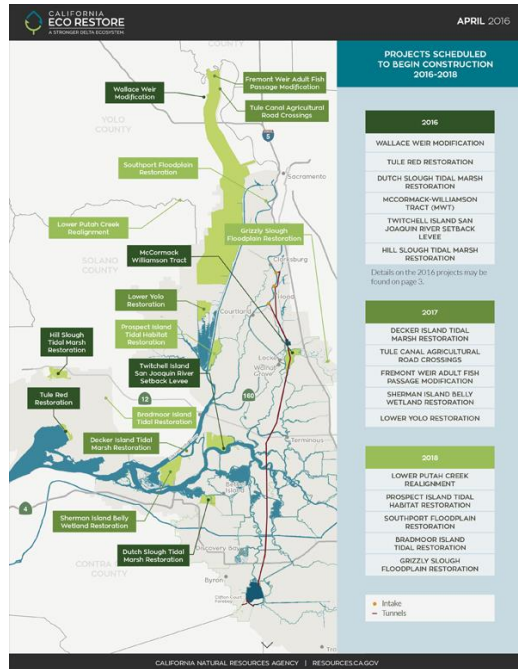
- TMDL
- 2025 assessment
- Not reaching some goals - why?
- Expectations

Historically

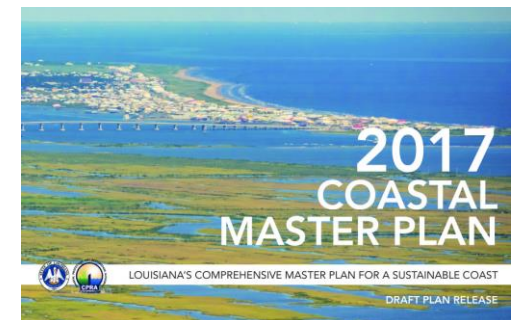
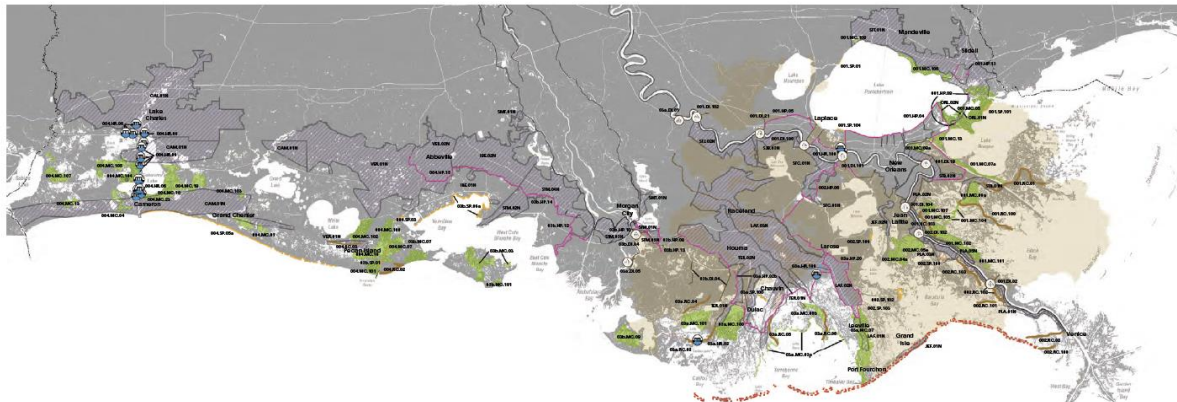
- Statuary lever is CWA
 - DO, nitrogen, chlorophyll
- Extensive analysis with lab data to derive WQS
 - Covered the entire Bay
- 2012 Agreement
 - Added many living resources goals
 - “in-situ” conditions

Chesapeake Bay is not alone!

Used for CCMP 2020



A \$50 BILLION INVESTMENT DESIGNED TO BUILD AND MAINTAIN LAND, REDUCE FLOOD RISK TO COMMUNITIES, AND PROVIDE HABITATS TO SUPPORT ECOSYSTEMS



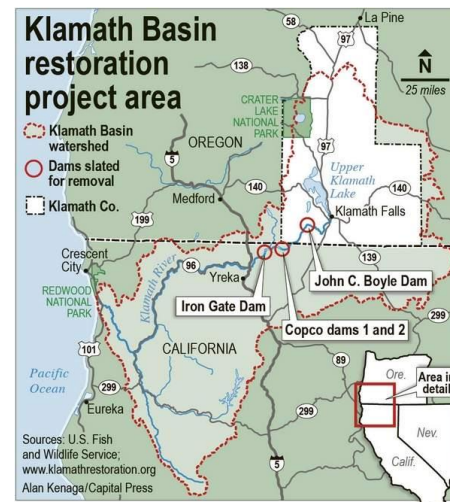
*Evaluation of the Predictive Ecological Model for the
Edwards Aquifer Habitat Conservation Plan:
An Interim Report as Part of Phase 2*

Committee to Review the Edwards Aquifer Habitat Conservation Plan

Water Science and Technology Board

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Question: Spending billions on restoration in the US and yet so many are unhappy



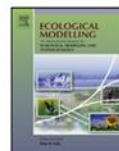


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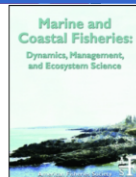


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Proposed best modeling practices for assessing the effects of ecosystem restoration on fish

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Marine and Coastal Fisheries

Dynamics, Management, and Ecosystem Science

ISSN: (Print) 1942-5120 (Online) Journal homepage: <http://www.tandfonline.com/loi/umcf20>

Recommendations on the Use of Ecosystem Modeling for Informing Ecosystem-Based Fisheries Management and Restoration Outcomes in the Gulf of Mexico

Arnaud Grüss, Kenneth A. Rose, James Simons, Cameron H. Ainsworth, Elizabeth A. Babcock, David D. Chagaris, Kim De Mutsert, John Froeschke, Peter Himchak, Isaac C. Kaplan, Halie O'Farrell & Manuel J. Zetina Rejon

D. Holzworthⁱ, J. Mysiak^k, J. Reichl^l, R. Seppelt^m, T. Wagenerⁿ, and P. Whitfield^oAvailable online at www.sciencedirect.com

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Water Plan

Selecting Fish Modeling Approaches



Report: Version I

Date: October 31, 2013

Prepared by: Kenneth A. Rose, Shaye Sable



Management Questions

- What is the expected (projected) response of living resources to water quality and habitat conditions in the Bay:
 - (a) without the TMDL and habitat targets
 - (b) present TMDL and habitat attainment continued
 - (c) under full TMDL and habitat goals

Management Questions

- Given the current state or condition, how can the analyses inform what types and magnitude of changes in water quality and habitat are needed to evoke an agreed-upon target set of the desired living resources' responses?
- What are the certainties and critical uncertainties of the analyses and how can they help guide future monitoring and modeling efforts?

Continued Status-Quo

- Provides much useful information on progress
- Focused on the first question
 - WQ
 - Habitat goals reached
 - Simple population status indicators
- Comprehensive approach - answer all questions
- Status-quo → moderate → major → comprehensive
 - More relevant questions and answers
 - Tradeoff is effort and uncertainties

Existing links WQ/Habitat to LR

- WQS
- Agreement indicators
- Report cards
- Others

Existing links WQ/Habitat to LR

- Seitz et al. 2009
 - Woodland et al. 2021
 - Adamack et al. 2017
 - Fulford et al. 2010
 - Ihde et al. 2016
-
- Monitoring data
 - WQ modeling system
 - Habitat → population → food web

Existing links WQ/Habitat to LR

- Many completed analyses
 - Excellent
 - Independent
- Species, methods, spatial/temporal coverage vary
- Addressed study-specific questions
 - Not “TMDL” and CBP habitat restoration

Different Situation to “WQ”

- Many critters move
- Affected by many factors in complex life cycles
- Responses are on longer time scales
- Challenging to isolate responses

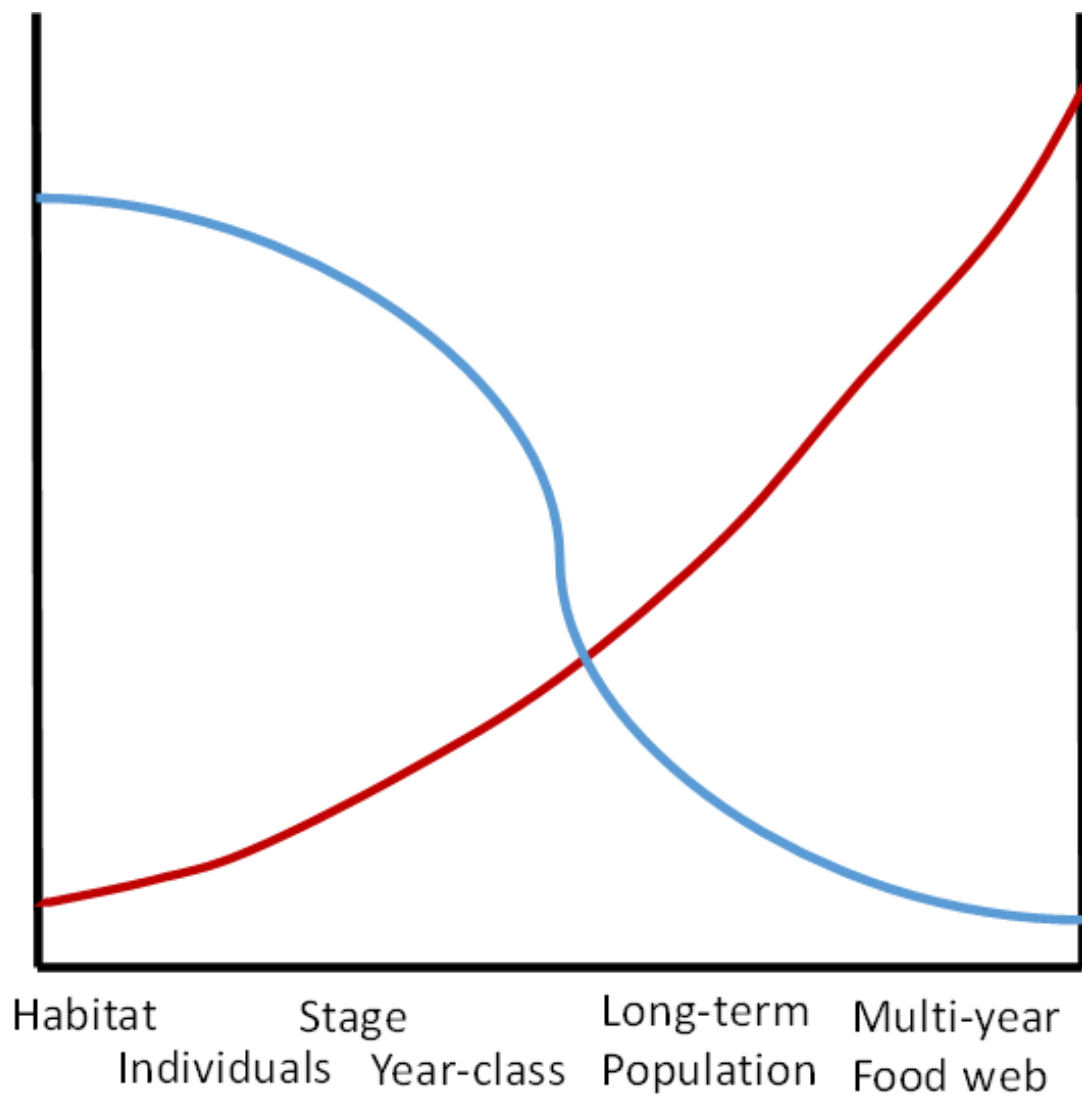
Going Forward

Foundational Concepts: Examples

- Variability, uncertainty, stochasticity
- Vital rates
 - Growth, mortality, reproduction
 - Movement
- Model complexity

Confidence

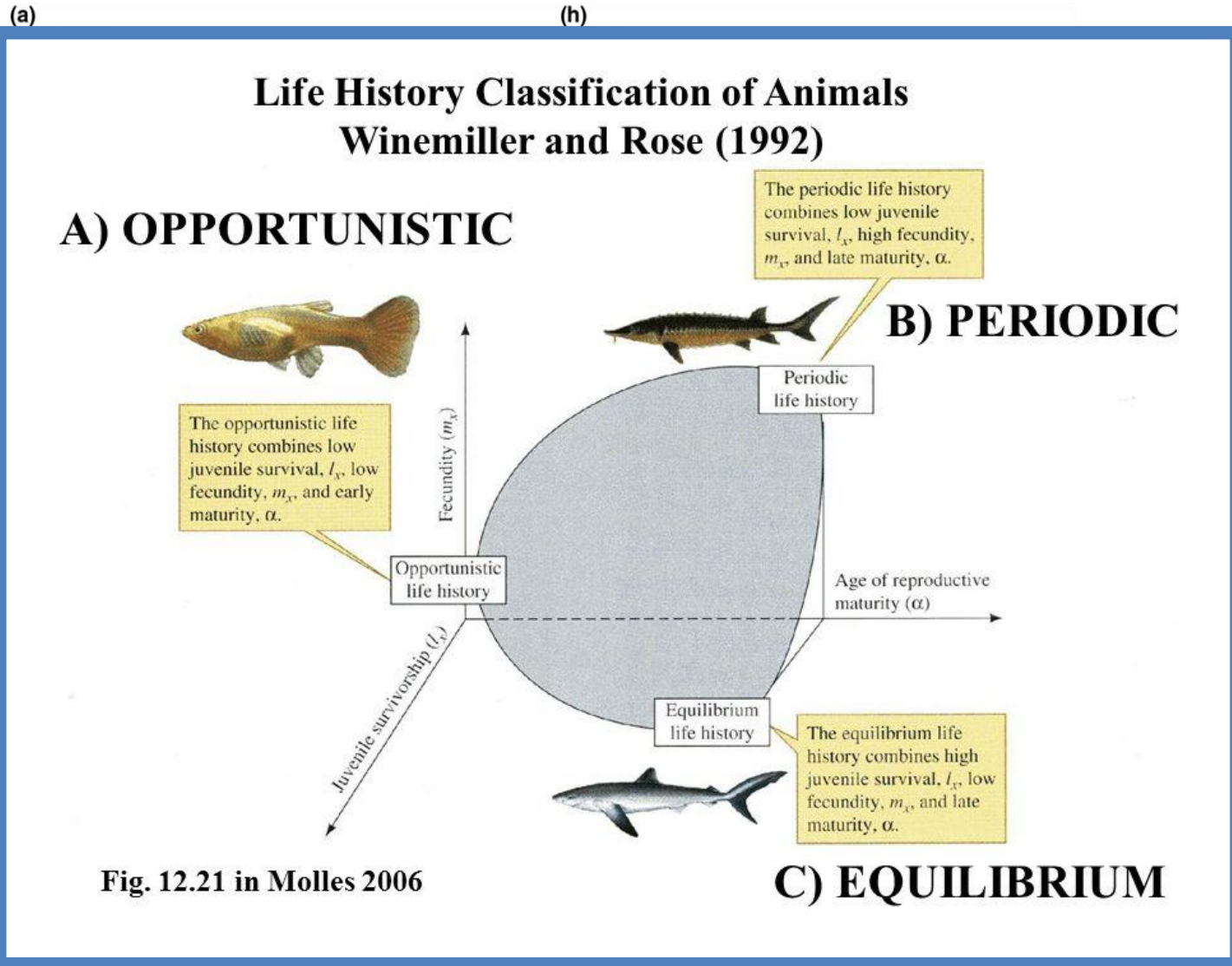
Relevance



Foundational Concepts: Examples

- Habitat suitability and capacity
 - What is habitat?
 - How does it relate to abundance?
- Biological organization
 - Life stages (recruitment)
 - Population
 - Multi-species and Food web
- Complex life cycles and strategies

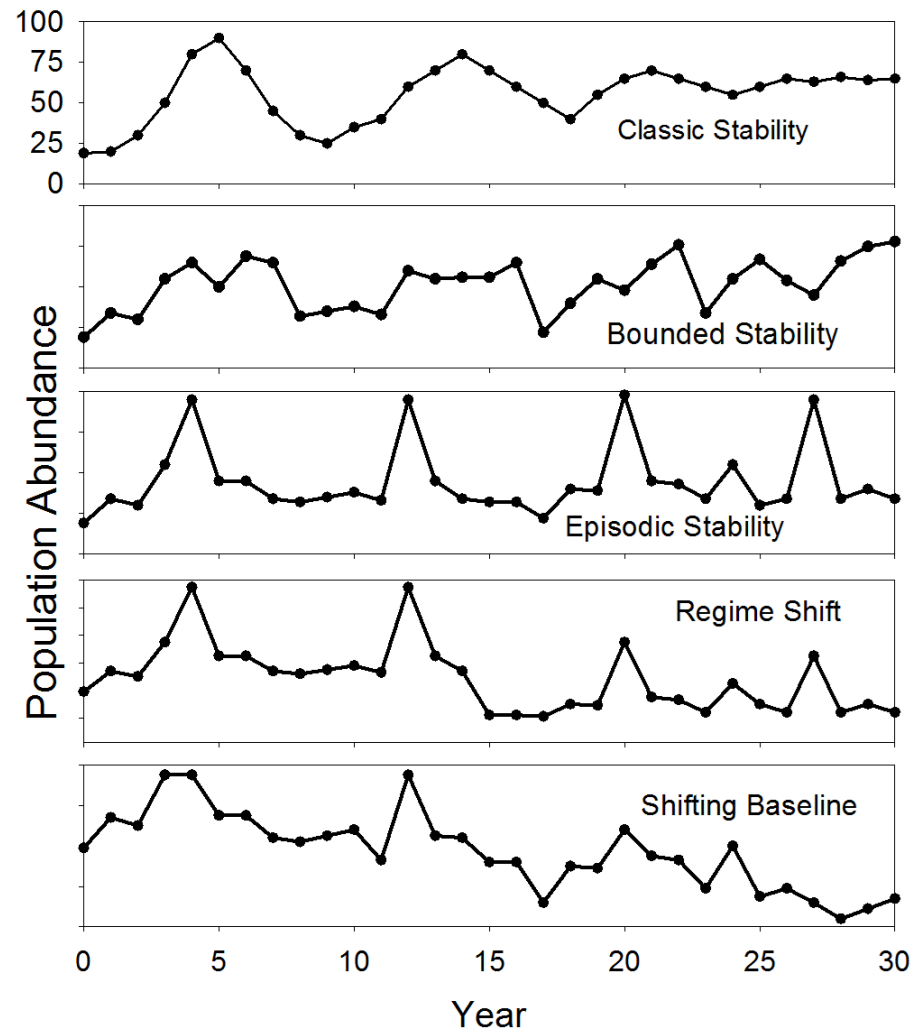
Foundational Concepts – Life Cycles



Foundational Concepts: Examples

- Multiple Stressors and Influencing Factors
 - Ocean conditions
 - Fisheries management
 - Climate change
- Tradeoffs
 - Win-lose
 - Win-win
 - Lose-lose
- Nonequilibrium theory and baseline

Foundational Concepts – Nonequilibrium Theory

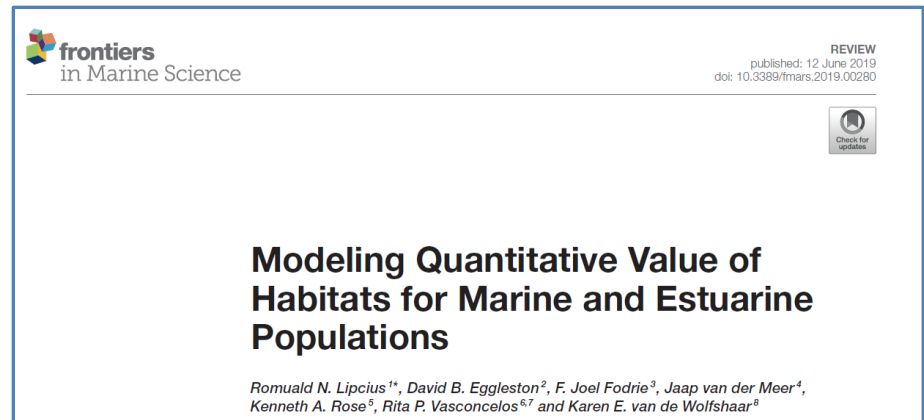


Foundational Concepts: Examples

- Power – ability to truly distinguish differences
- Relative versus absolute predictions
- Explicit and implicit representations

Foundational Concepts –Explicit vs Implicit Representations

- Turbidity not in model but can assess its effects
- Formulations
 - Implied in the model so can still answer questions
 - Bridge calculations
- Do not believe labels
- Aside: Define habitat



Lessons Learned

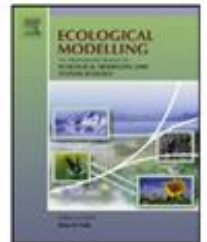
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Proposed best modeling practices for assessing the effects of ecosystem restoration on fish



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Framework

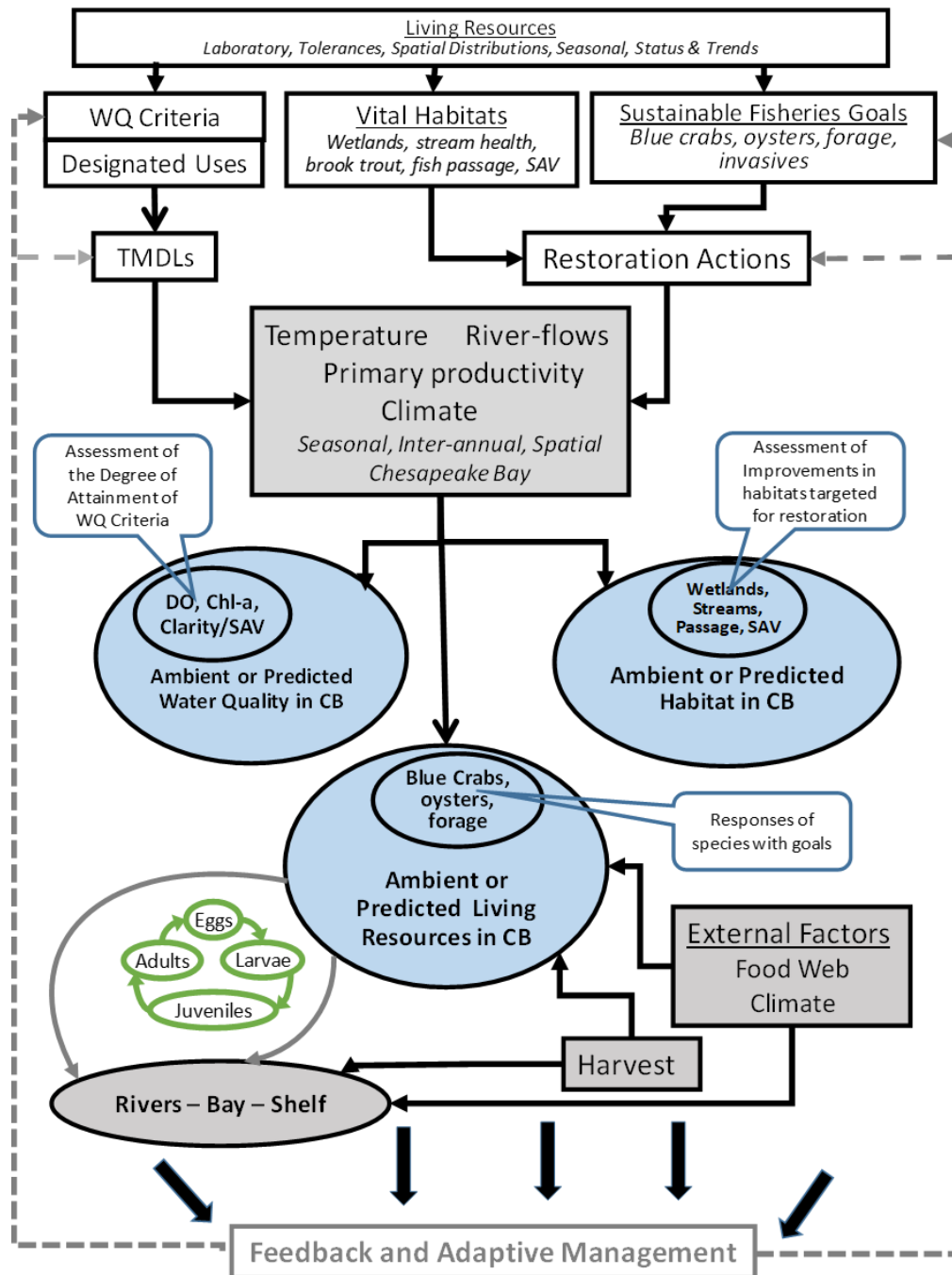
- Uses the results of the watershed and estuary
 - Types, timing, locations, magnitude
 - WQ and habitat
- Describes how to translate these changes into responses of living resources
 - Habitat suitability
 - Recruitment, population
 - Stages in subregions
 - Food web

Framework

- Clearly show the linkages
 - Long-lived, complex life cycles
 - Affected by other factors than TMDL
- Realistic expectations
- Interpretative guide
 - Generally
 - Case-by-case basis
- Someone could actually implement the framework
 - Step-wise

Living Resources: Framework

1. Selecting species
2. Available data
3. Response and explanatory variables
4. Biological, temporal, and spatial scales
5. Analytical approaches
6. Coordination and combining results



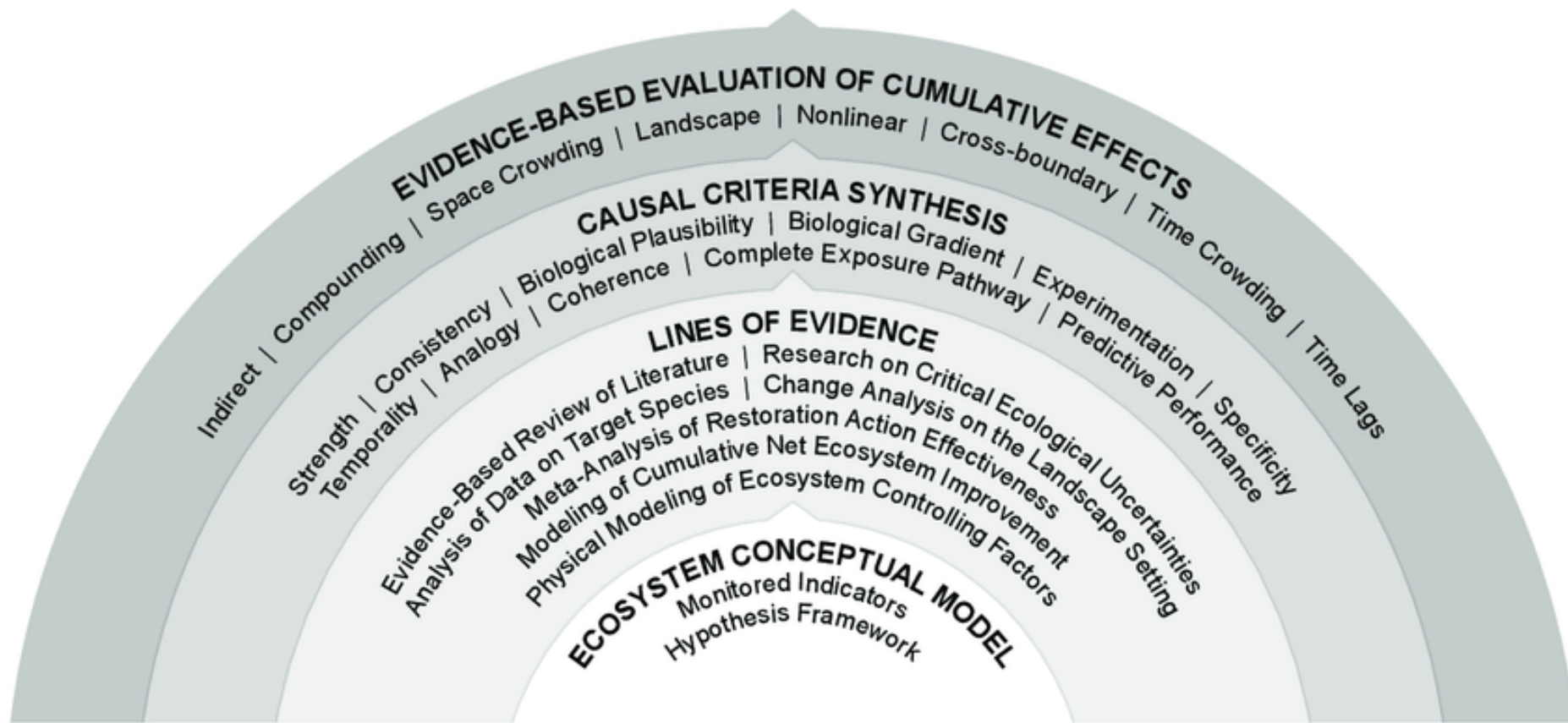


Figure 11. Example of a formal process for integrating and synthesizing information analysis results to assess the responses of the ecosystem to restoration. (from Diefenderfer et al. 2016).

Final Comments

- We know the question(s)
- Incentive (demand?) and ingredients are available
 - “most studied estuary in the world”
 - Other restoration programs are assessing LR response
- Leverage existing analyses; identify new analyses
- Follow the framework, we can add analyses
 - “meta-methods”
 - “meta-results”

Final Comments

- Living Resource Modeling & Assessment WG
- Assessment of LR responses and likely responses
 - “expectations”
- Use it to “optimize” WQ and habitat efforts
 - “inverse problem”
- Start with feasibility using low hanging fruit
 - “test the waters”