Modeling: Diversion Effects on Fish and Best Practices

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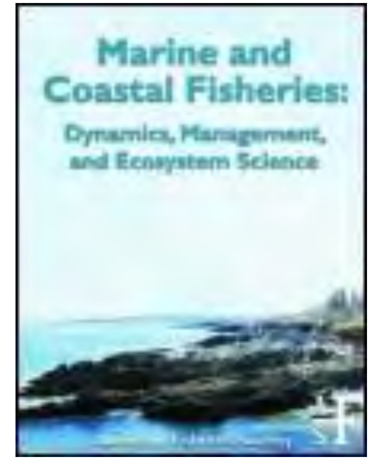
Introduction

- Two topics today:
  - Example of fish responses to diversions
  - Best practices for modeling fish responses to restoration

- Do not look for much connection

- Diversion example shows what is involved in predicting fish responses based on behavior

- Best practices is a recent paper (manuscript) to help ensure effective modeling



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ARTICLE

Simulating Fish Movement Responses to and Potential Salinity Stress from Large-Scale River Diversions

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Approach

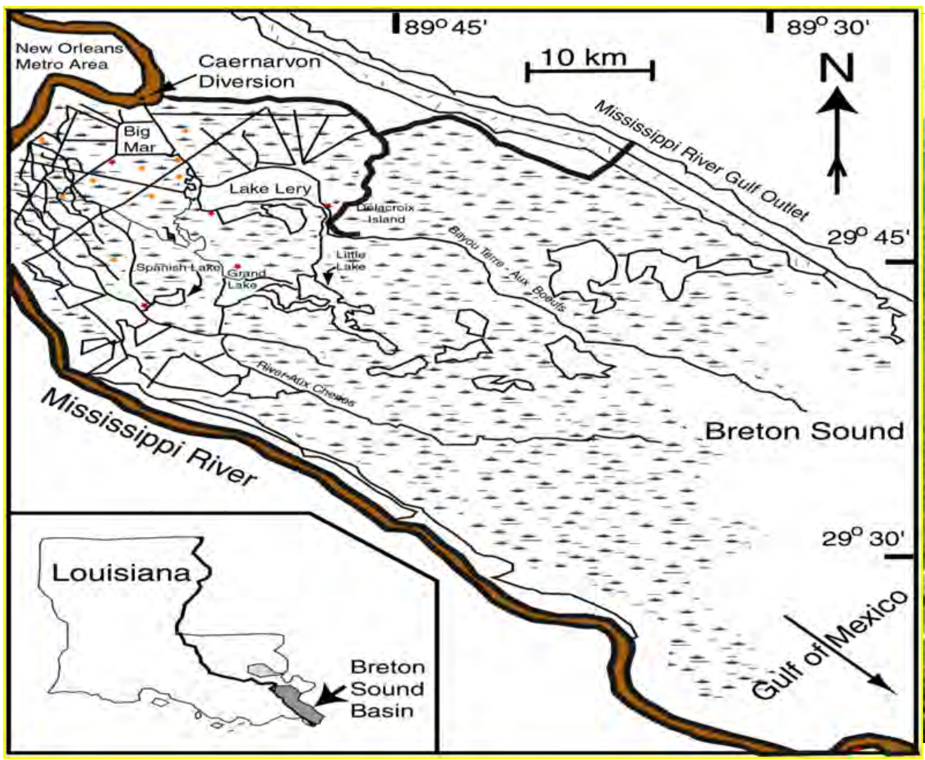
- Coupled models:
  - FVCOM hydrodynamics
  - Salinity module
  - Individual-based fish movement
- Challenges with spatial resolution and time stepping to ensure accurate and precise solutions

Why IBM for Fish

- Natural unit in nature
- Allows for local interactions and complex systems dynamics
- Complicated life histories
- Plasticity and size-based interactions
- Conceptually easier movement

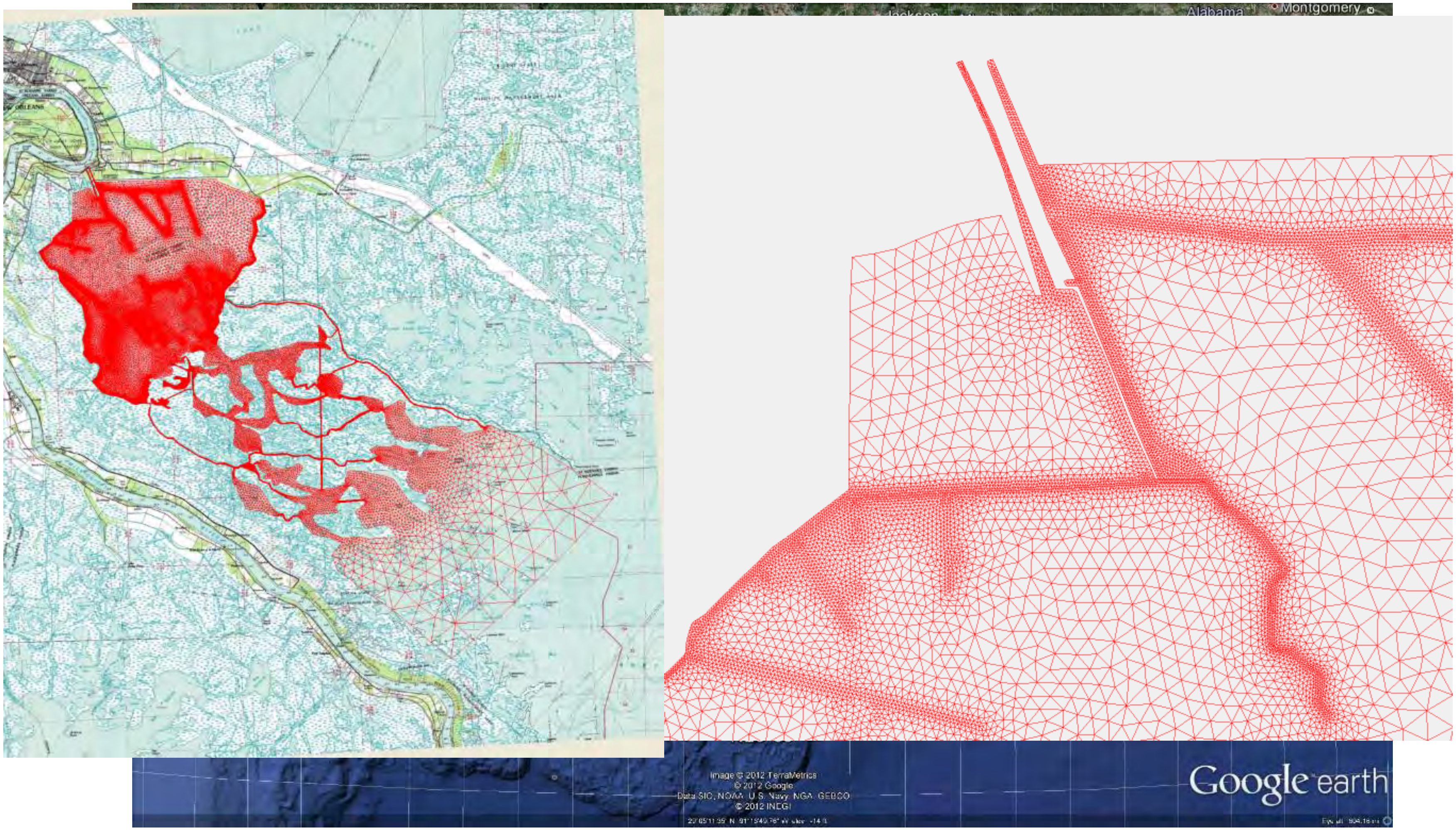
FVCOM Applications: Breton Sound Estuary

- Hydrodynamics and salinity response to freshwater diversion
- Impact of pulsed re-introduction of Mississippi River freshwater on displacement and salinity stress of fish species

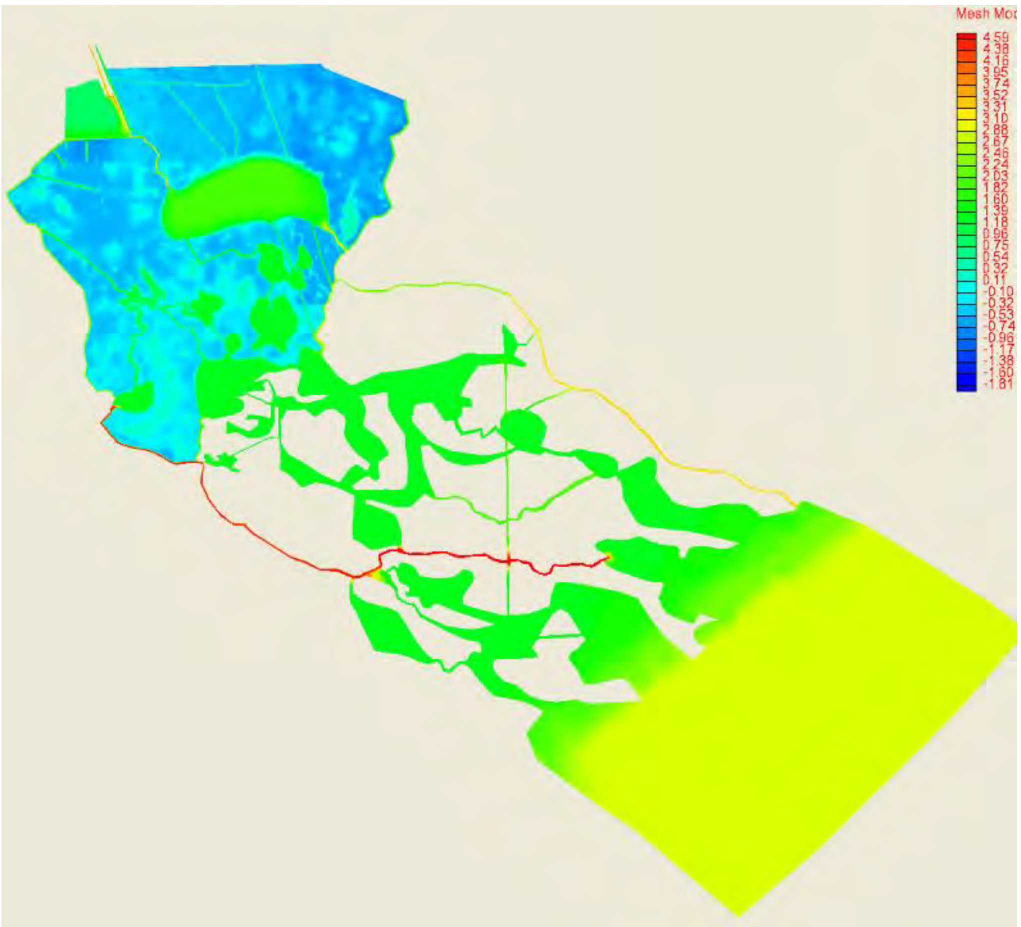


Huang et al., ECSS (2011)

FVCOM-Breton Sound



FVCOM - Bathymetry



Data Sources

LIDAR Digital Elevation Model: horizontal resolution 5 m X 5 m

Scanned Topographic Maps (from NOAA nautical charts)

Fish Movement

- Modified particle-tracking
- Velocities determined by behavior rather than water velocities
- Event-based algorithm
  - Game theoretic model
  - Anderson (2002); Watkins and me (2013)

Fish Movement

- Fish's environment is agents A_j (j = 1, 2, 3)
  - high salinity, low salinity, shallow water

- Fish encounters agents as it moves

$$e_j(t) = \begin{cases} 0, & \text{if event doesn't happen} \\ 1, & \text{if event does happen} \end{cases}$$

$$P_{j,k}(t) \;=\; m_k \cdot P_{j,k}(t - \Delta t) \;+ (1 - m_k) \cdot e_j(t)$$

- Two modes for each agent: Tactical (k=0) or Strategic (k=1)

- Behavior selected every 9 sec with the highest utility

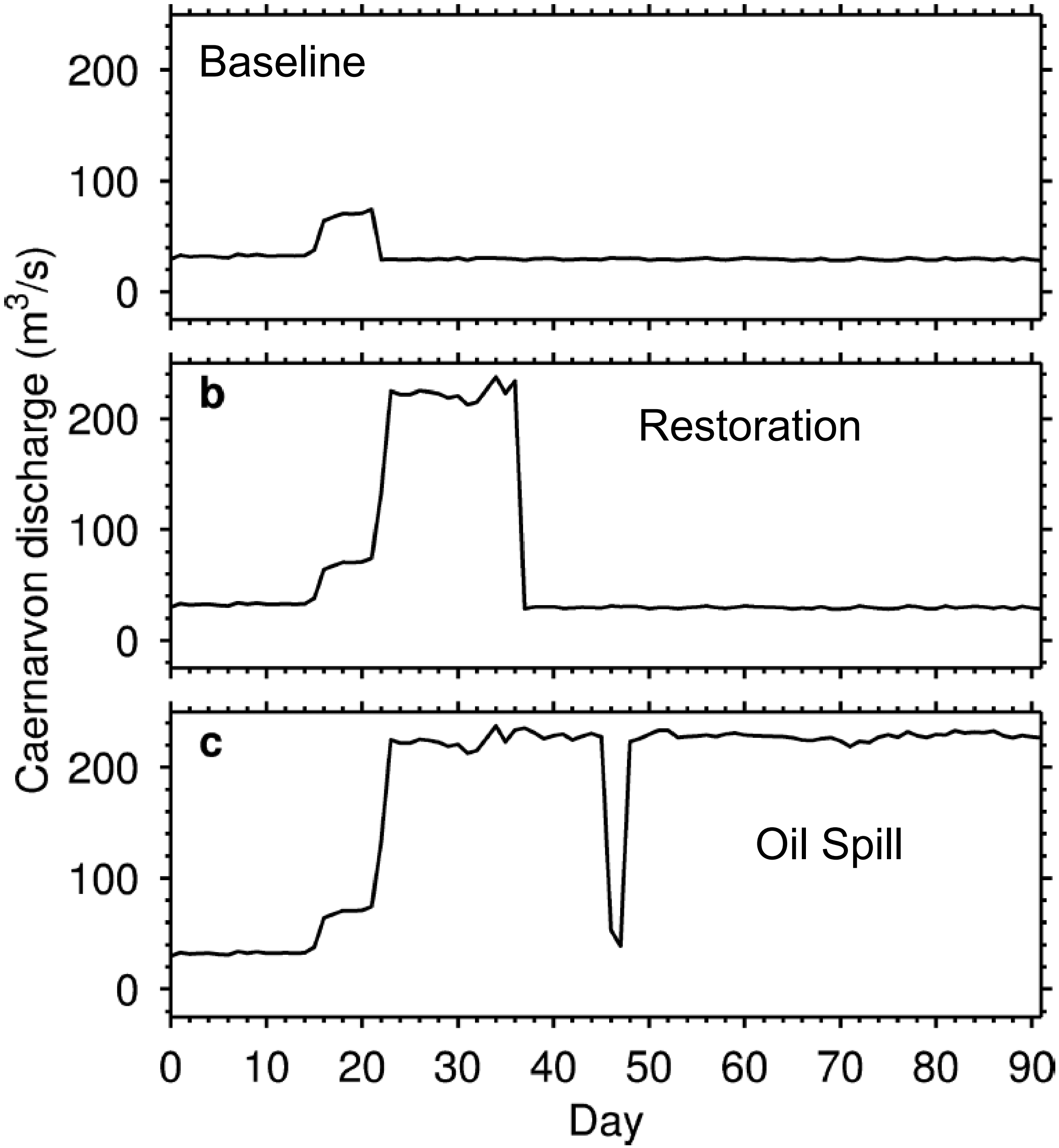
Behaviors

Movement parameter	High salinity		Low salinity		Shallow water		
	Strategic	Tactical	Strategic	Tactical	Strategic	Tactical	Default
θ^*	Previous	Toward	Previous	Toward	Previous	Toward	Velocity
θ_R	0.3π	0.3π	0.3π	0.3π	0.3π	0.3π	0.3π
V^*	1	2	1	2	0.8	2	Velocity
V_R	4	1	4	1	4	1	4

If all utilities below thresholds, then default:

random + transport

random only (alternative)



Baseline
b
Restoration
c
Oil Spill
Caernarvon discharge (m3/s)
Day
0
100
200
0
10
20
30
40
50
60
70
80
90

Simulations

- 91 days: April 1 to July 1, 2010
  - First 10 days were spin-up
  - Interpolated FVCOM every 9 seconds from 30 min output
- Fish:
  - 20 cm
  - Bay anchovy (corroboration, not shown)
  - Low-salinity (2 to 4)
  - Intermediate salinity (15 to 20)

Simulations

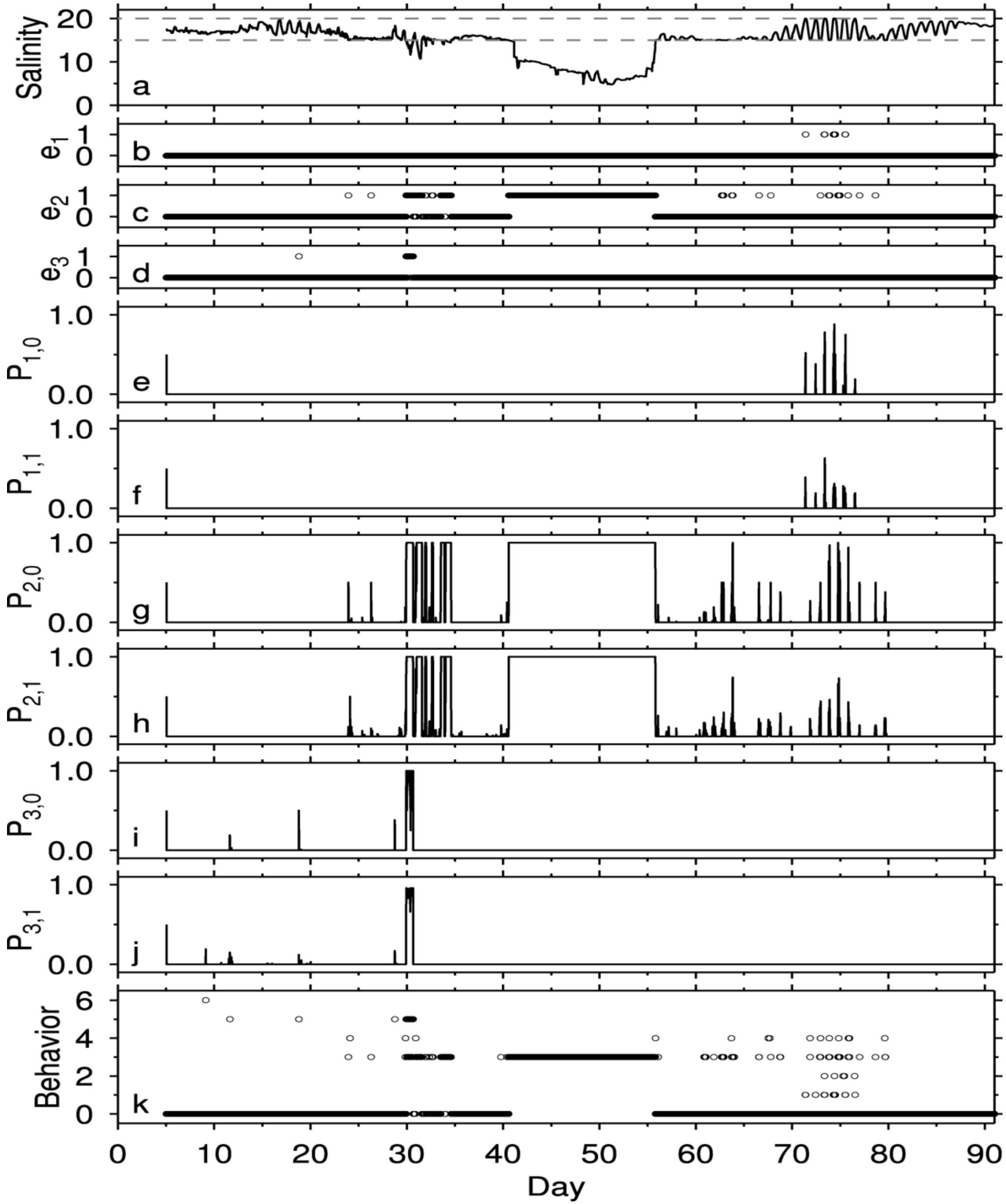
- Initial conditions
  - 450 individuals for low-salinity
  - 427 for bay anchovy and intermediate
  - Placed randomly within their salinity range
- Three diversion scenarios
- Sensitivity analysis (not shown)

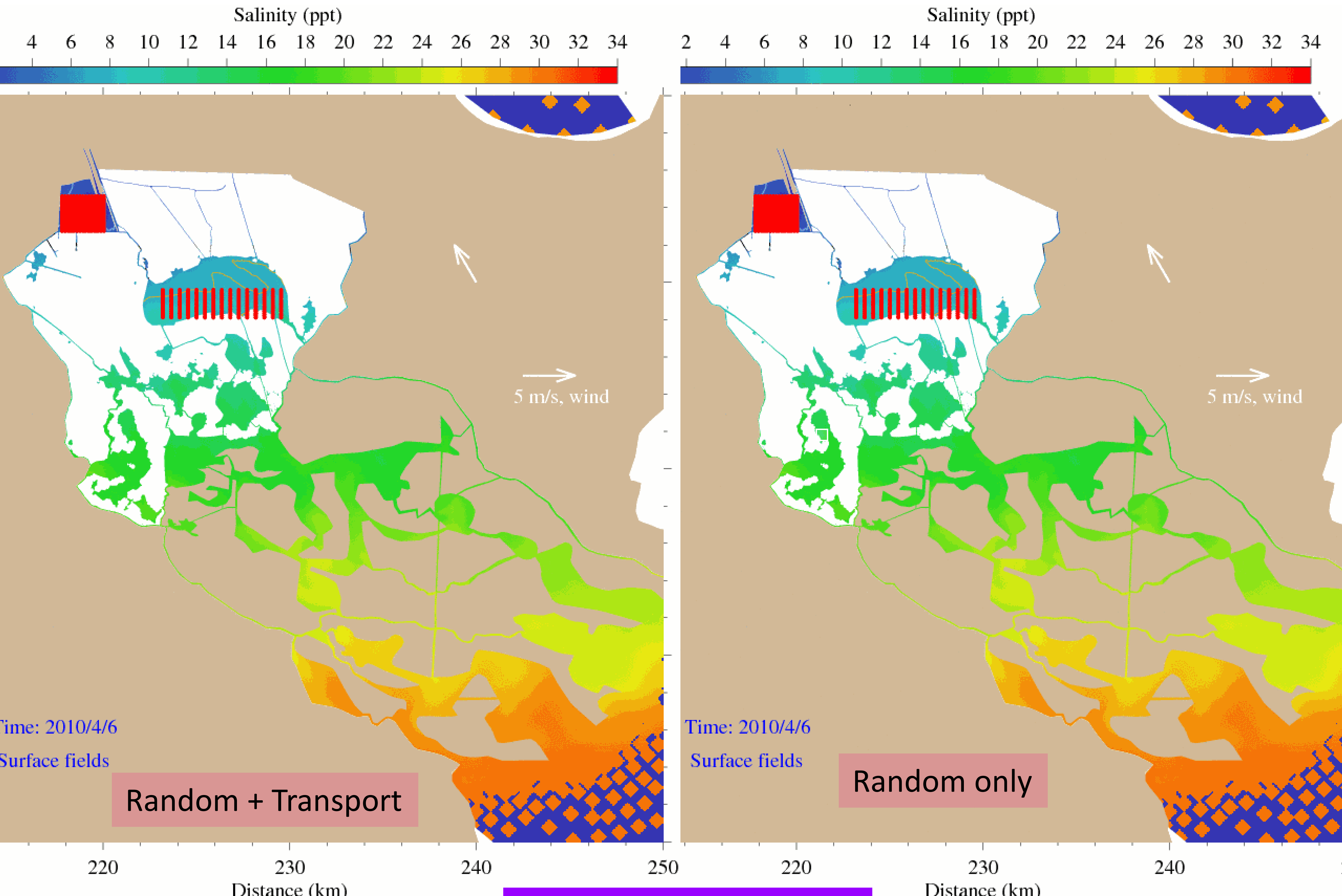
Simulation Outputs

- Behavior of an individual over time
- Percentiles over individuals each 30 min
  - Salinity
  - Distance from the diversion

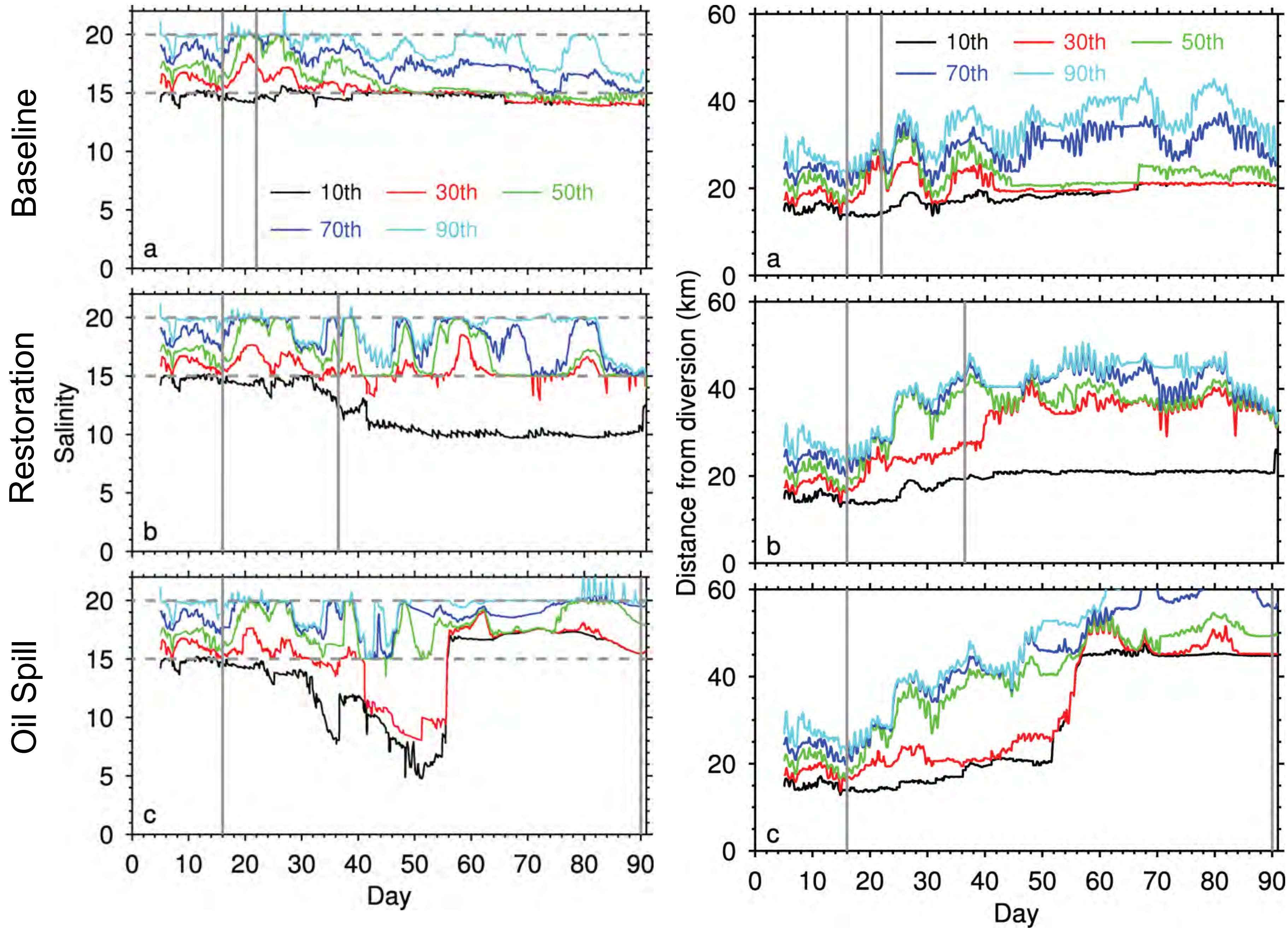
Intermediate salinity fish
Oil Spill diversion

0 = default
1 = tactical high salinity
2 = strategic high salinity
3 = tactical low salinity
4 = strategic low salinity
5 = tactical shallow depth
6 = strategic shallow depth.





Restoration pulse



Baseline
Restoration
Oil Spill
Salinity
Distance from diversion (km)
Day
10th
30th
50th
70th
90th
a
b
c

Best Practices

Proposed Best Modeling Practices for Assessing the Effects on Fish of Ecosystem Restoration and other Futures Scenarios

K.A. Rose, S. Sable, S. Yurek, D. L. DeAngelis,
J. C. Trexler, W. Graf, D. Reed

- Evolved from a report done for CPRA

Why?

- Large-scale restoration
  - Increasing
  - Expensive
  - Controversial
  - Necessary

Toward an Era of Restoration in Ecology: Successes, Failures, and Opportunities Ahead

Katharine N. Suding

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Keywords

resilience, ecosystem restoration, restoration ecology, recovery, degradation, ecosystem services, environmental change, novel ecosystems

Review

Restoration of ecosystem services and biodiversity: conflicts and opportunities

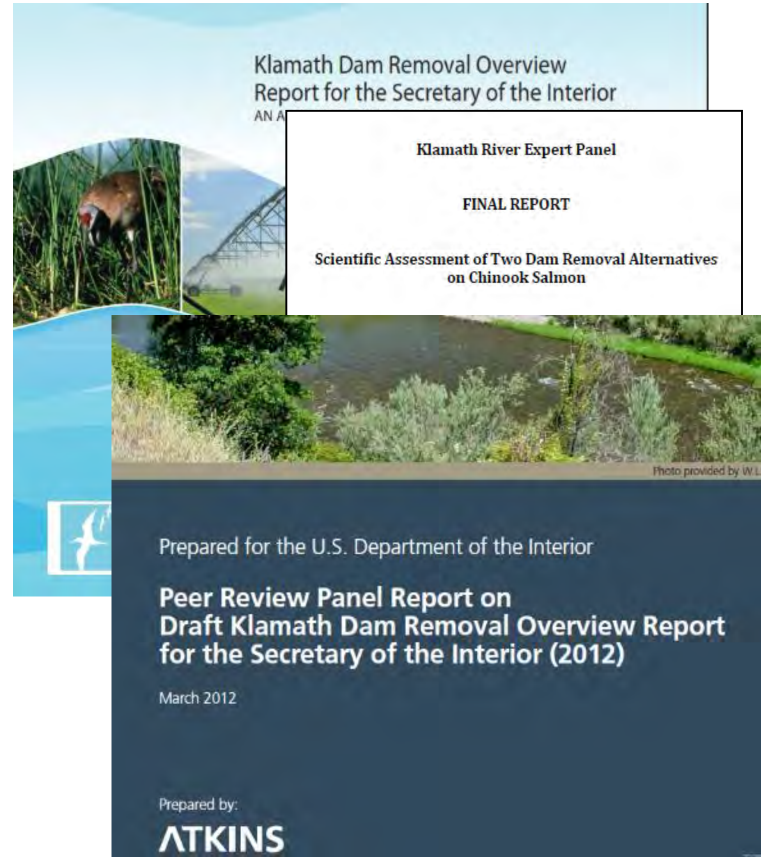
James M. Bullock[1], James Aronson[2,3], Adrian C. Newton[4], Richard F. Pywell[1] and Jose M. Rey-Benayas[5]

- Often, gravitates to fish and models

Todd Trumbull / The Chronicle

Klamath controversy continues

An agreement to remove four dams has been reached, but barriers remain



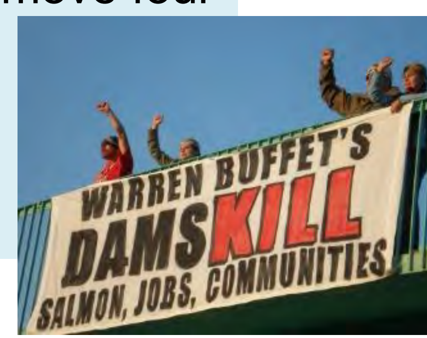
Klamath Propaganda: Who do you believe?

Independent Peer Review Says Klamath Dam Removal Science "Sound" and "Reliable"

Klamath River: A Big Dam Controversy Finally Resolved

Whistleblower is taking his case to the public

Paul Houser, the Bureau of Reclamation's former scientific integrity adviser, says he was fired for voicing concerns that the decision to remove four Klamath River dams is being based on politics and money not science. He spoke at a Tea Party meeting Sunday in Klamath Falls.



Case 1:09-cv-00407-OWW-DLB Document 508 Filed 01/26/2010 Page 1 of 17

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UNITED STATES DISTRICT COURT

EASTERN DISTRICT OF CALIFORNIA

THE DELTA SMELT CASES, SAN LUIS & DELTA-MENDOTA WATER AUTHORITY, *et al.* v. SALAZAR, *et al.* (Case No. 1:09-cv-407)	1:09-cv-407 OWW GSA 1:09-cv-422 OWW GSA 1:09-cv-631 OWW GSA 1:09-cv-892 OWW GSA PARTIALLY CONSOLIDATED WITH: 1:09-cv-480 OWW GSA
STATE WATER CONTRACTORS v. SALAZAR, *et al.* (Case No. 1:09-cv-422)	
COALITION FOR A SUSTAINABLE DELTA, *et al.* v. UNITED STATES FISH AND WILDLIFE SERVICE, *et al.* (Case No. 1:09-cv-480)	**REPLY DECLARATION OF DR. RICHARD B. DERISO IN SUPPORT OF MOTION FOR INTERIM RELIEF/PRELIMINARY INJUNCTION**
METROPOLITAN WATER DISTRICT v. UNITED STATES FISH AND WILDLIFE SERVICE, *et al.* (Case No. 1:09-cv-631)	Date: January 20, 2010 Time: 9:00 a.m. Ctrm: 3 Judge: Hon. Oliver W. Wanger
STEWART & JASPER ORCHARDS, *et al.* v. UNITED STATES FISH AND WILDLIFE SERVICE, *et al.* (Case No. 1:09-cv-892)	

PPIC PUBLIC POLICY INSTITUTE OF CALIFORNIA

Costs of Ecosystem Management Actions for the Sacramento–San Joaquin Delta

April 2013

Josué Medellín-Azuara, John Durand, William Fleenor, Ellen Hanak, Jay Lund, Peter Moyle, and Caitrin Phillips

Supported with funding from the S. D. Bechtel, Jr. Foundation

SCIENCE REVIEW OF TESTIMONY IN THE DELTA SMELT CASES

Summary Report

ATKINS

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December 2011

Environmental Economics, Volume 3, Issue 1, 2012

Andrew Schmitz (USA), P. Lynn Kennedy (USA), Julie Hill-Gabriel (USA)

Restoring the Florida Everglades through a sugar lanc benefits, costs, and legal challenges

Congressional Research Service
Informing the legislative debate since 1914

The Great Lakes Restoration Initiative: Background and Issues

Pervaze A. Sheikh
Specialist in Natural Resources Policy

September 30, 2013

Schemes

- Many have been suggested
- FAO, ACOE, papers
- We focus on fish and restoration
  - Steps
  - Concepts
  - Case studies

ERDC/EL TR-12-18

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Environmental Benefits Analysis Program

Ecological Modeling Guide for Ecosystem Restoration and Management

Todd M. Swannack, J. Craig Fischenich, and David J. Tazik

August 2012

Approved for public release; distribution is unlimited.

Available online at www.sciencedirect.com

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Environmental Modelling & Software

Position Paper[1]

Ten iterative steps in development and evaluation of environmental models

A.J. Jakeman [a,b,*], R.A. Letcher [a,c], J.P. Norton [a,c]

FAO TECHNICAL GUIDELINES FOR RESPONSIBLE FISHERIES

4

Suppl. 2

FISHERIES MANAGEMENT

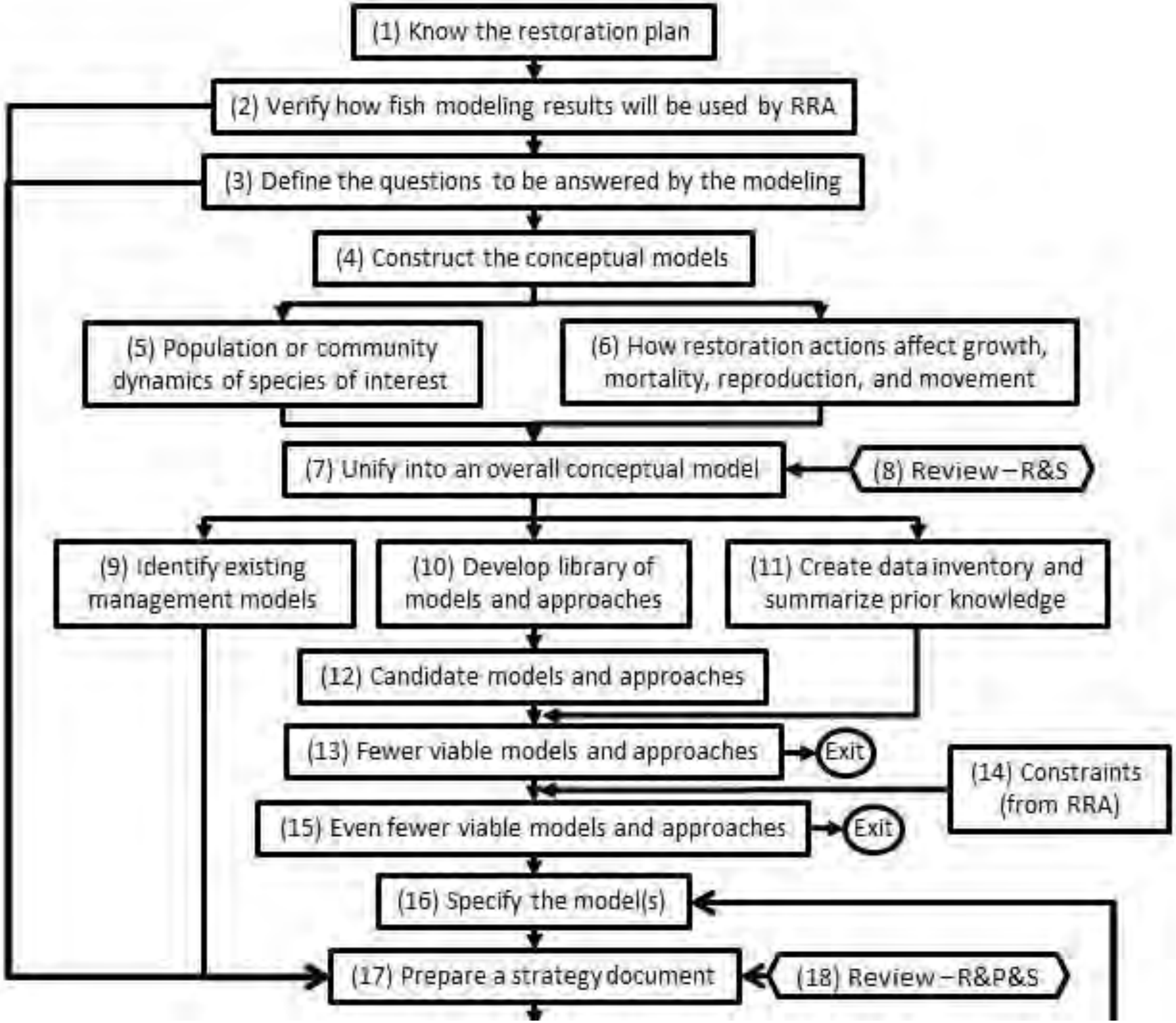
2. The ecosystem approach to fisheries

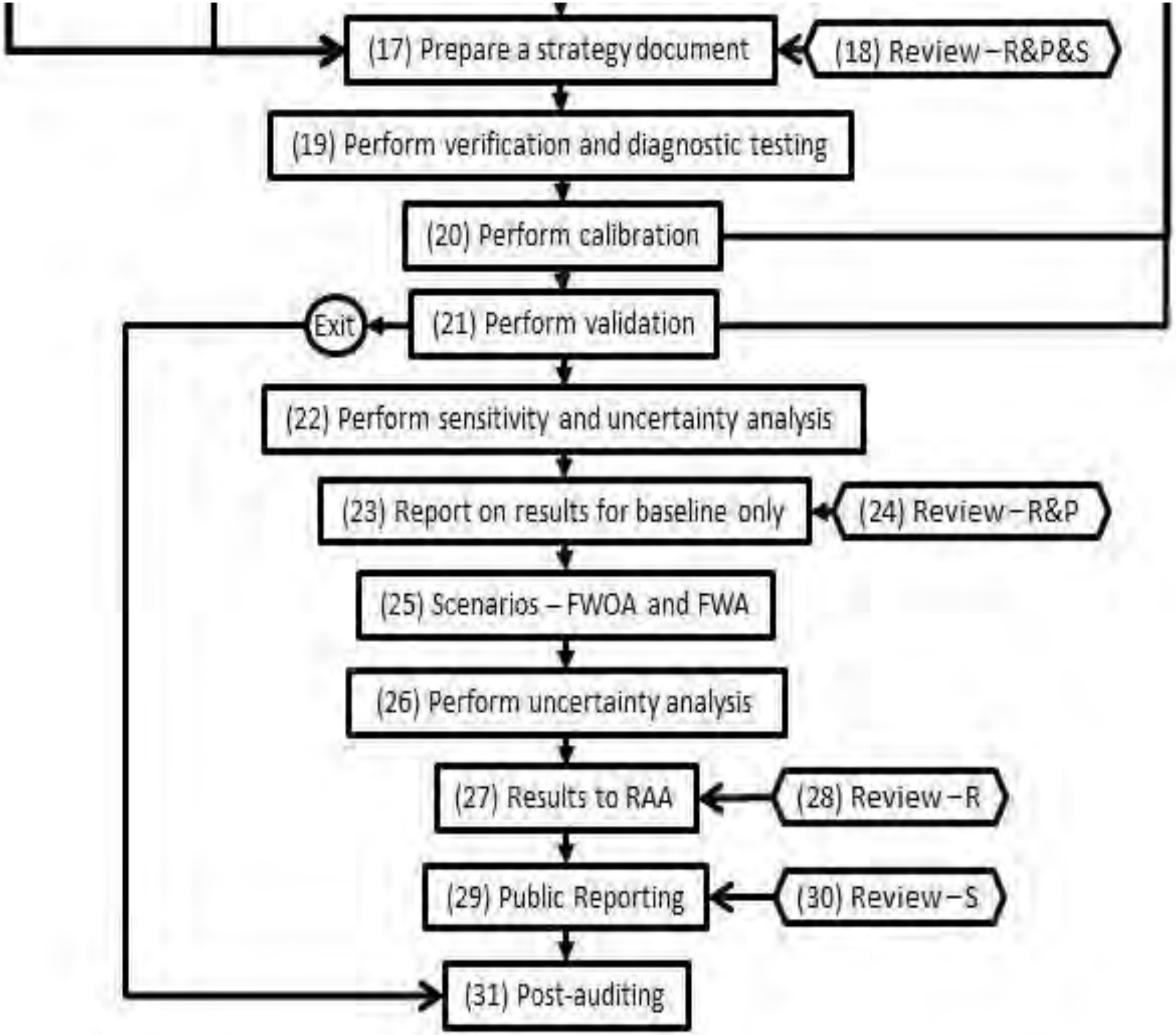
2.1 Best practices in ecosystem modelling for informing an ecosystem approach to fisheries

CHAPTER TWO

Good Modelling Practice

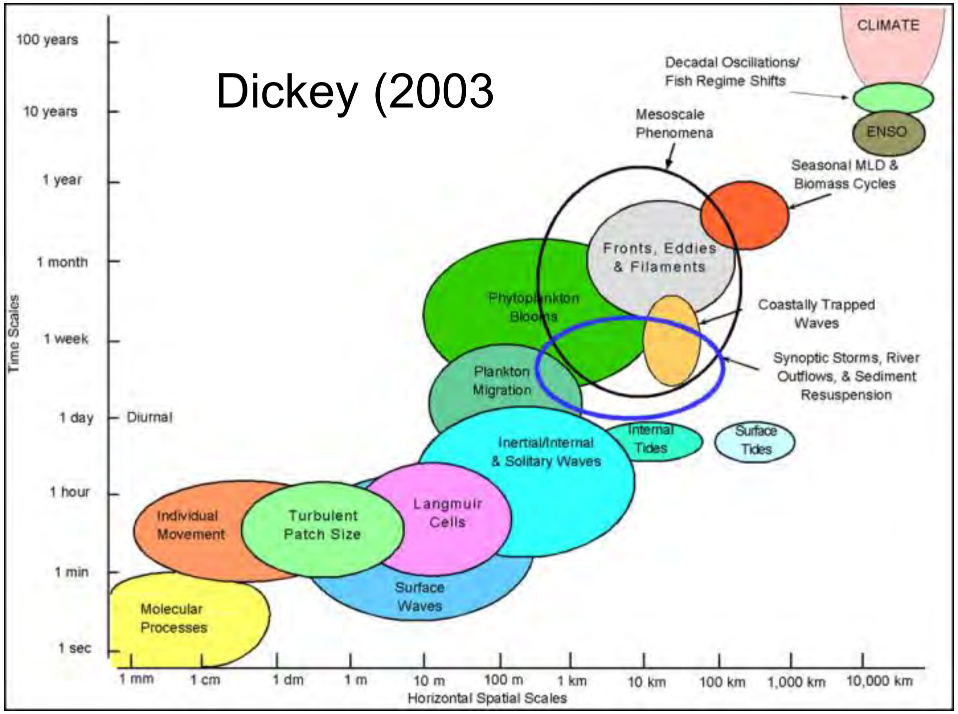
N. Crout [a], T. Kokkonen [b], A.J. Jakeman [c], J.P. Norton [d], L.T.H. Newham [c], R. Anderson [e], H. Assaf [f], B.F.W. Croke [g], N. Gaber [h], J. Gibbons [i], D. Holzworth [j], J. Mysiak [k], J. Reichl [l], R. Seppelt [m], T. Wagener [n], *and* P. Whitfield [o]


(1) Know the restoration plan
(2) Verify how fish modeling results will be used by RRA
(3) Define the questions to be answered by the modeling
(4) Construct the conceptual models
(5) Population or community dynamics of species of interest
(6) How restoration actions affect growth, mortality, reproduction, and movement
(7) Unify into an overall conceptual model
(8) Review – R&S
(9) Identify existing management models
(10) Develop library of models and approaches
(11) Create data inventory and summarize prior knowledge
(12) Candidate models and approaches
(13) Fewer viable models and approaches
Exit
(14) Constraints (from RRA)
(15) Even fewer viable models and approaches
Exit
(16) Specify the model(s)
(17) Prepare a strategy document
(18) Review – R&P&S


(17) Prepare a strategy document
(18) Review – R&P&S
(19) Perform verification and diagnostic testing
(20) Perform calibration
Exit
(21) Perform validation
(22) Perform sensitivity and uncertainty analysis
(23) Report on results for baseline only
(24) Review – R&P
(25) Scenarios – FWOA and FWA
(26) Perform uncertainty analysis
(27) Results to RAA
(28) Review – R
(29) Public Reporting
(30) Review – S
(31) Post-auditing

13 Concepts

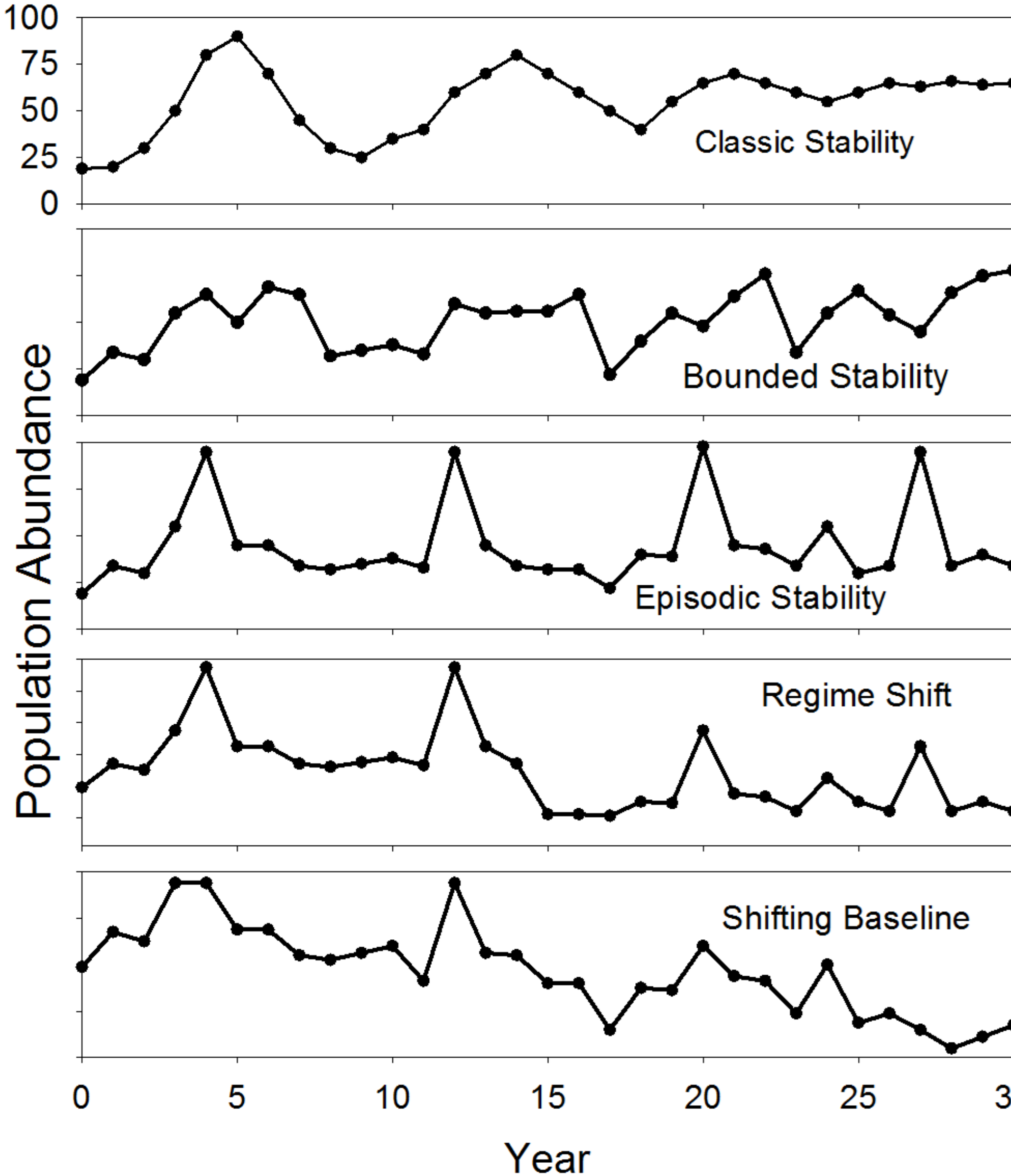
- Life cycles and strategies
  - Complex cycle
  - Rate of progressing through cycle
  - Context
- Variability, uncertainty, and stochasticity
  - Model not nature
  - Reducible or not
  - Data are not truth
- Generality-precision-realism
  - Levin is still relevant
  - Cannot have it all
- Scaling



Dickey (2003

13 Concepts

- Nonequilibrium Theory, Stability, and Recruitment



13 Concepts

- Explicit versus Implicit Representations
  - Dial labels confused with their needs and desires
  - Equations and code
- Population definition
  - Often assume closed
- Density-dependence
  - Required for long-term
  - Difficult to quantify
- Verification, Calibration, and Validation
  - Verification is often ignored
  - Calibration and validation viewed relative to predictions that will be used
- Sensitivity and uncertainty analysis
  - Over-sold

13 Concepts

- Multiple models strategy
  - Dueling, coupled, ensemble
  - Ill-defined independence, actually about 1.2 models
- Food web dynamics
  - Not ignore but implicit
  - Needed, at minimum, for context and reminders
- Hidden Assumptions and Domain of Applicability
  - Example is foraging arena theory in ECOSIM
  - Functions rarely cover the range being evaluated under restoration

Our Strategy

- Combine steps with concepts

- Illustrate key steps and concepts:
  - Everglades
  - Colorado River (Glen Canyon Dam)
  - Planning for the Louisiana 2017 Master Plan

Concluding Remarks

- Showed how we are starting to model fish behavioral movement
- Increasingly important to assessment
- Diversions: Minimize the short-term fish impacts while maximizing the long-term restoration results
  - "reduction-displacement-enhancement" (Cafey and Schexnayder 2002)
- Avoided conclusions as this talk focused on methods
- Challenge
  - "If fish were dumber or people were smarter"
  - "Can the people and data keep up with the computers?"

Concluding Remarks

- Best practices for modeling fish responses to restoration
- Center of controversy
- Collective wisdom
  - Really “pretty good”

Acknowledgements

Diversion effects

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Best Practices

Funded by CPRA of Louisiana under Cooperative Endeavor Agreement 2503-12-58 with The Water Institute of the Gulf