Ecosystem Modeling for Fish and Shellfish: What to Expect?

Kenneth Rose
Department of Oceanography and Coastal Sciences
Louisiana State University

Ecosystem Modeling

- Fish and shellfish
- Responses to actions
- Higher level than individuals
- Recruitment, population, community, multi-species, food web

Expectations

- Temporal and spatial scales of the predictions
- How much of the biomass is accounted for
- Relative versus absolute predictions
- Appropriate level of confidence in predictions

Best Practices

Proposed Best Modeling Practices for Assessing the Effects of Ecosystem Restoration on Fish

Kenneth Rose, LSU
Shaye Sable, Dynamic Solutions
Donald DeAngelis, USGS
Simeon Yurek, Univ of Miami
Joel Trexler, Florida International UNiv
William Graf, Univ of South Carolina
Denise Reed, Water Institute of the Gulf

- Evolved from a report done for CPRA

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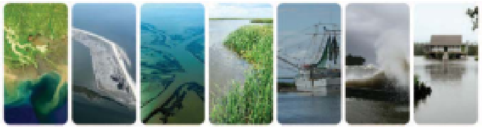
2017 Coastal Master Plan

Strategy for Selecting Fish Modeling Approaches



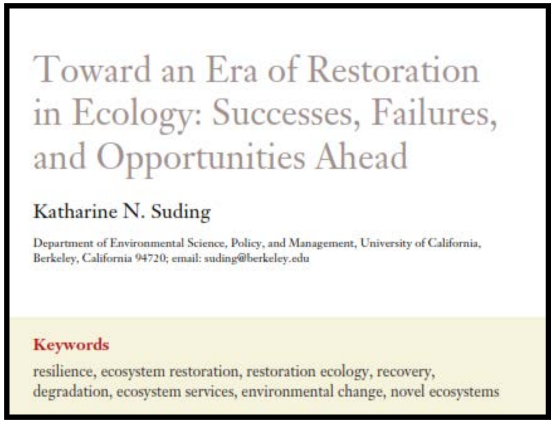
Report: Version I
Date: October 31, 2013
Prepared by: Kenneth A. Rose, Shaye Sable

Dynamic Solutions LLC

THE WATER INSTITUTE OF THE GULF

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

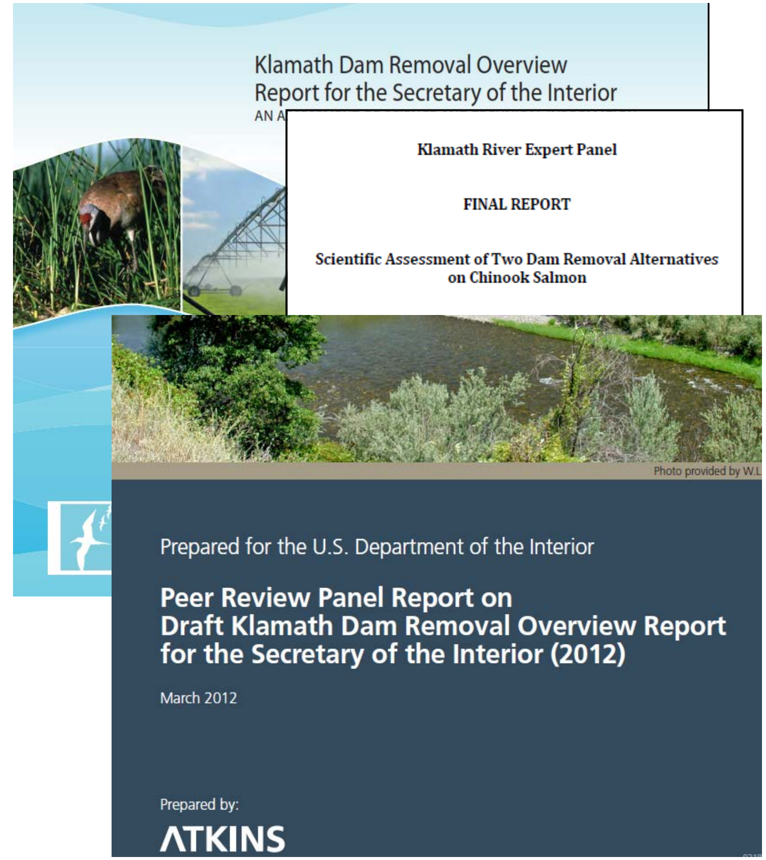
James M. Bullock[1], James Aronson[2,3], Adrian C. Newton[4], Richard F. Pywell[1] and Jose M. Rey-Benayas[5]

- 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 Dam Removal Overview

Report for the Secretary of the Interior

Klamath River Expert Panel

FINAL REPORT

Scientific Assessment of Two Dam Removal Alternatives on Chinook Salmon

Photo provided by W.L

Prepared for the U.S. Department of the Interior

Peer Review Panel Report on Draft Klamath Dam Removal Overview Report for the Secretary of the Interior (2012)

March 2012

Prepared by:

ATKINS

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) 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) METROPOLITAN WATER DISTRICT v. UNITED STATES FISH AND WILDLIFE SERVICE, *et al.* (Case No. 1:09-cv-631) STEWART & JASPER ORCHARDS, *et al.* v. UNITED STATES FISH AND WILDLIFE SERVICE, *et al.* (Case No. 1:09-cv-892)	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 **REPLY DECLARATION OF DR. RICHARD B. DERISO IN SUPPORT OF MOTION FOR INTERIM RELIEF/PRELIMINARY INJUNCTION** Date: January 20, 2010 Time: 9:00 a.m. Ctrm: 3 Judge: Hon. Oliver W. Wanger

REPLY DECLARATION OF DR. RICHARD B. DERISO IN SUPPORT OF MOTION FOR INTERIM RELIEF/PRELIMINARY INJUNCTION
CASE NO.: 1:09-cv-00407 OWW GSA
sf-2786848

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

Environmental Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

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 21 (2006) 602–614
Environmental Modelling & Software
www.elsevier.com/locate/envsoft

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]

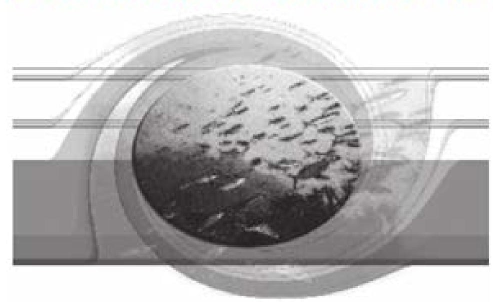
FAO TECHNICAL GUIDELINES FOR RESPONSIBLE FISHERIES

4

Suppl. 2 Add. 1

FISHERIES MANAGEMENT

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



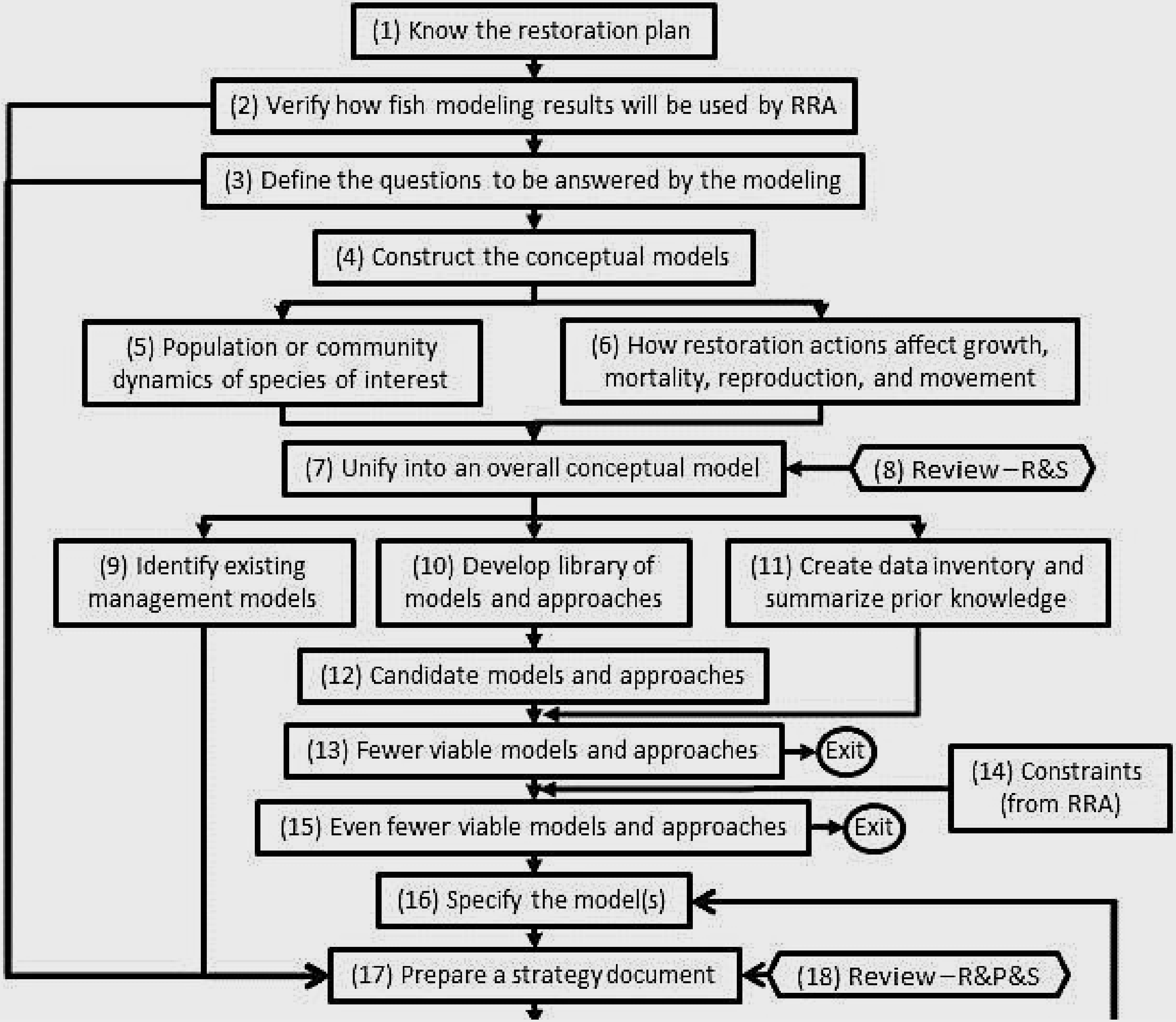
CHAPTER TWO

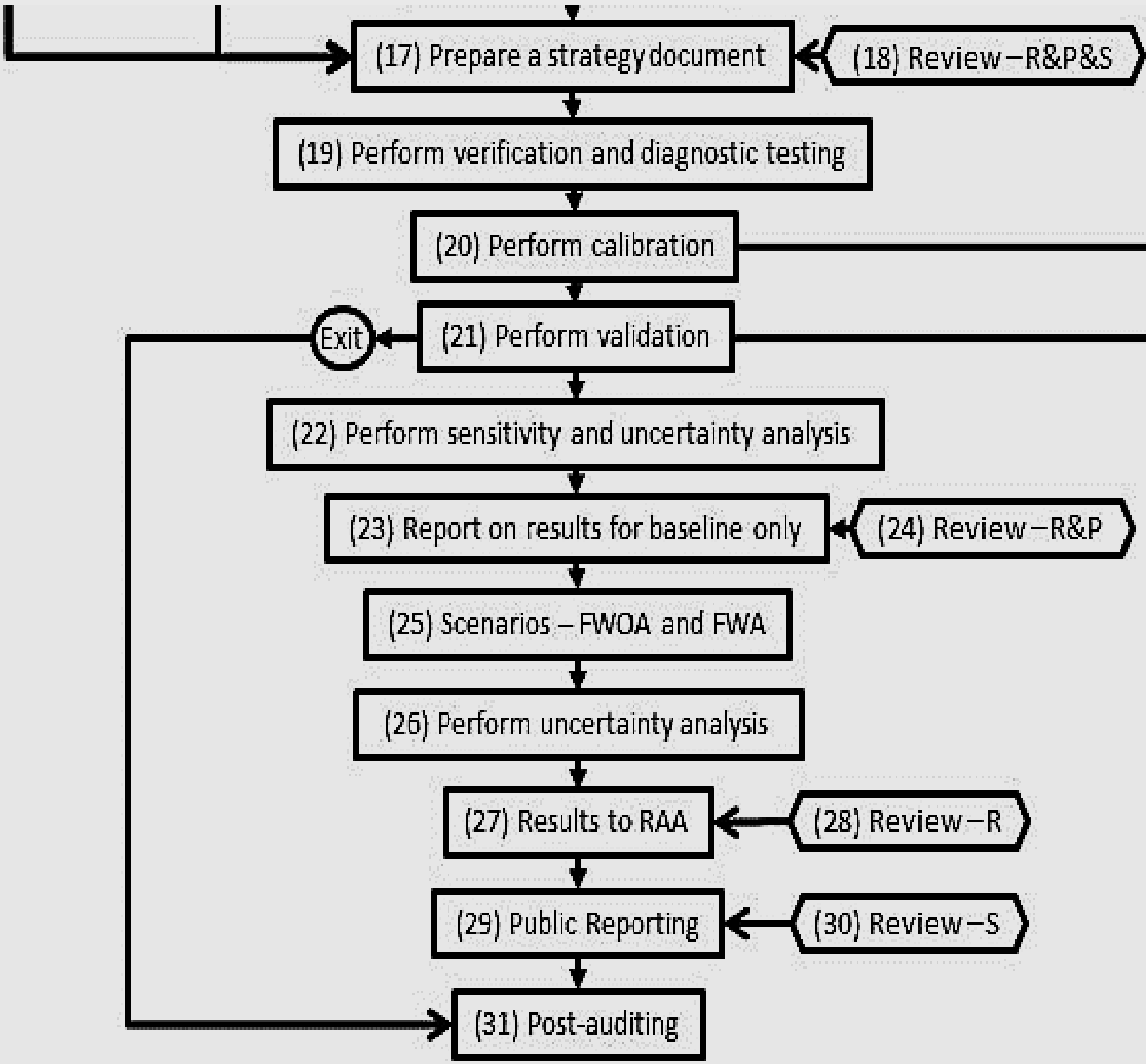
GOOD MODELLING PRACTICE

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]

Scheme for Fish and Restoration

- 31 steps
  - 5 of the steps (model selection) were actually done in the CPRA report
  - Dr. Cam Ainsworth will discuss 3 more of the steps
- 13 concepts
- Proposed best practices


(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

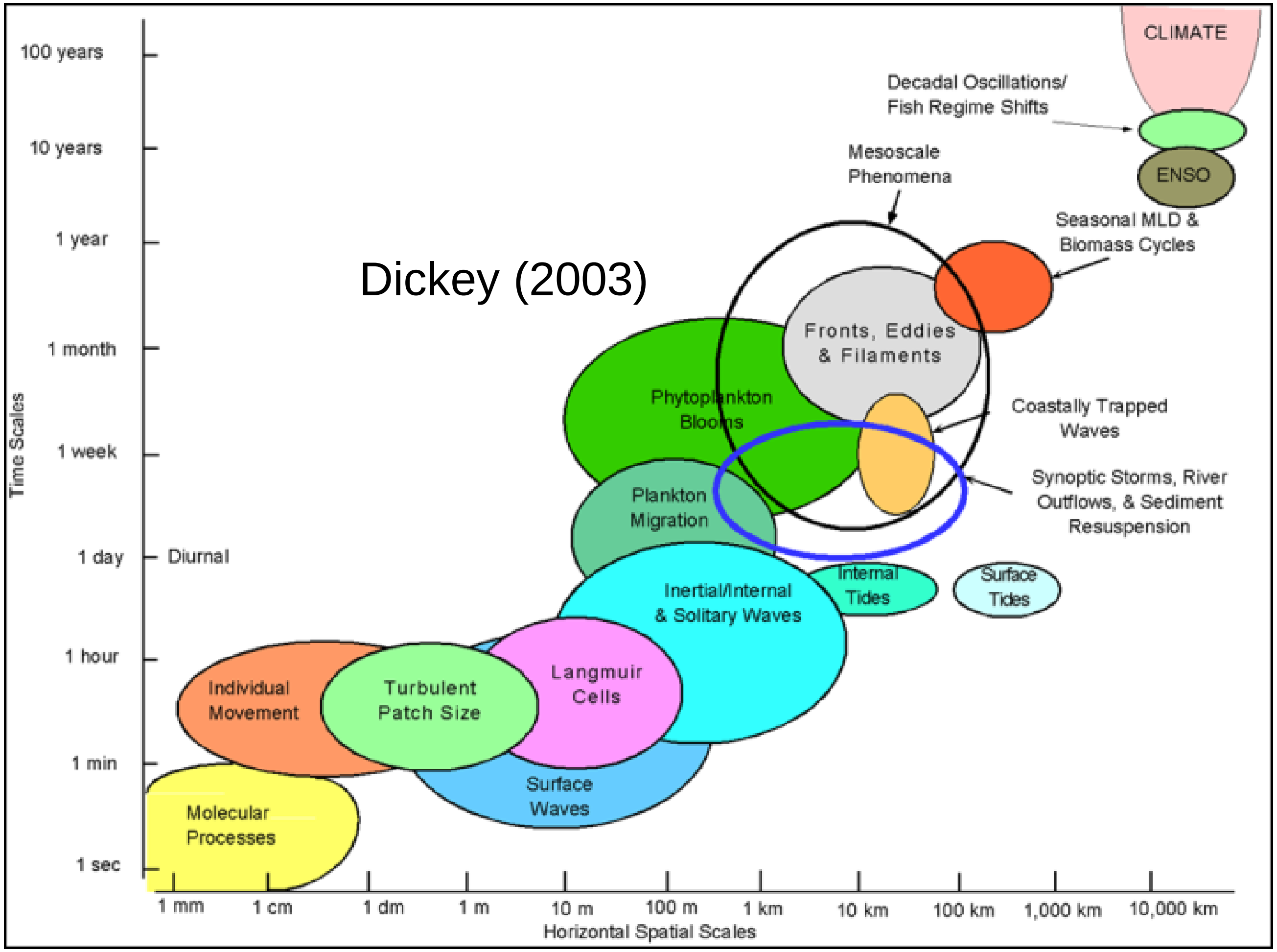

(17) Prepare a strategy document
(18) Review – R&P&S
(19) Perform verification and diagnostic testing
(20) Perform calibration
(21) Perform validation
Exit
(22) Perform sensitivity and uncertainty analysis
(23) Report on results for baseline only
(24) Review – R&P
(25) Scenarios – FWOA and FWA
(26) Perform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

13 Concepts

1. Life cycles and strategies
2. Variability, uncertainty, stochasticity
3. Generality-precision-realism
4. Nonequilibrium theory
5. Scaling
6. Explicit versus implicit representations
7. Population definition
8. Density-dependence
9. Verification, calibration, validation
10. Sensitivity and uncertainty analysis
11. Multiple models
12. Food web dynamics
13. Hidden assumptions

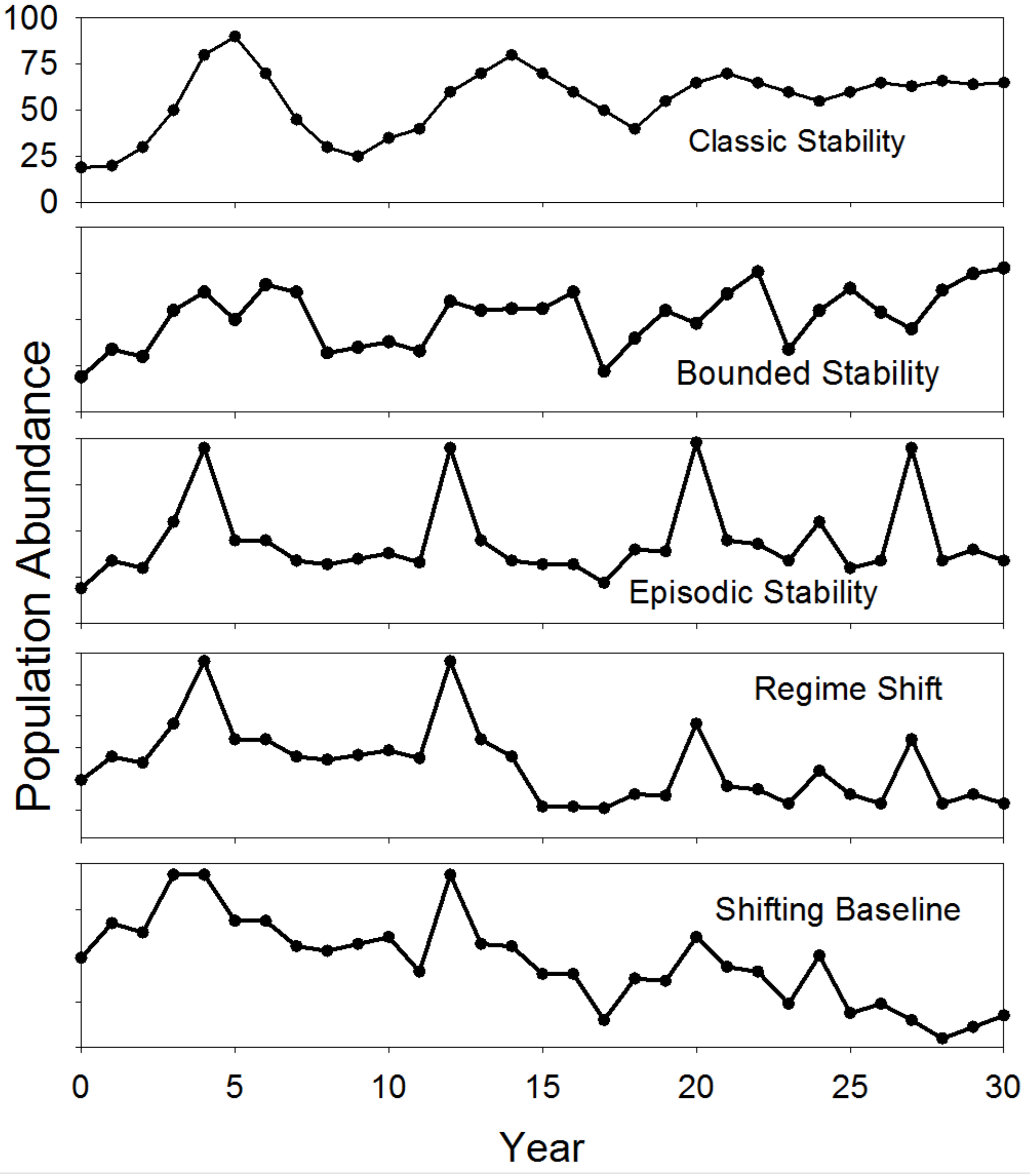
13 Concepts

- Example: Scaling



13 Concepts

- Example: Nonequilibrium Theory, Stability, and Recruitment



Our Strategy

- Combine steps with concepts

- Illustrate key steps and concepts:
  - Everglades
    - Steps 2, 3, 11, 15, and aspects of 17, 19, & 22

  - Colorado River (Glen Canyon Dam)
    - Steps 4 and 11

  - Planning for the Louisiana 2017 Master Plan
    - Step 3 (Define questions)
    - Steps 10-15 (Model selection incl Data inventory)

Categorization Scheme

Biological		Spatial	Temporal	Reproduction
Currency	Organization			
State variable	Single-species	Point	Seasonal	Forced recruitment
Age-structured	Multispecies	Spatially-explicit	One year	Full life cycle
Stage-structured	Community		Multiple years	
Individual-based	Foodweb Ecosystem			

Step 10 - Library

Table 5. Example listing of the initial models considered for the Louisiana Master plan.
Six are shown from a total of more than 30.
Sources: [a]Whipple et al. (2000); [b]West et al. (2013); [c]de Mutsert et al. (2012); [d]Bartell et al. (2010); [e]Roth et al. (2008); [f]Ault et al. (1999).

Model	Location	Habitat	Currency	Biological Organization	Spatial	Temporal	Reproduction
Lotka-Volterra[a]	None	Not specific	State variable	Multispecies	Point	Multiple years	Implicitly represented
	Reason Eliminated: Model is highly aggregated and does not allow for sufficient realism nor the representation of the many effects to hydrology and water quality.						
Striped mullet stock assessment[b]	Louisiana	Coastwide	Age-structured	Single species	Point	Multiple years	Full life cycle
	Reason Eliminated: A statistical catch-at-age model does not permit easy simulation of the effects on hydrology and water quality.						
EwE[c]	Breton Sound, Louisiana	Estuary	Age-structured for some; State variable for others	Ecosystem	Point	Multiple years	Forced recruitment
	Reason Eliminated: EwE was not eliminated and was used to illustrate an approach; Gulf of Mexico and Louisiana versions exist.						
CASM[d]	Pontchartrain Basin, Louisiana	Estuary	State variables	Ecosystem	Point	1989-2007	Forced recruitment
	Reason Eliminated: CASM was not eliminated and was used to illustrate an approach; Louisiana versions exist.						
Shrimp IBM[e]	Louisiana and Texas marshes	Vegetation and open water	Individual juvenile brown shrimp	Single species	Spatially explicit	One year	
	Reason Eliminated: Not eliminated and used to illustrate an approach. However, the fine spatial resolution (meters) limits the geographic scale of model predictions.						
Spatial dynamic multistock production model[f]	Biscayne Bay, Florida	Coral, seagrass, hard and soft bottom	Age-structured	Multispecies	Spatially explicit	One year	Full life cycle
	Reason Eliminated: Not eliminated and used to illustrate an approach.						

Step 15 – Recommended Approaches

Table 6. A subset of the features from the full list for three of nine modeling approaches identified as being candidate approaches for the 2017 Master Plan. The subset of features illustrate the types of information found in the full version of the Table used for model selection.

Features	Ecopath with Ecosim (EwE)	CASM	Spatial Dynamic Multi-Stock Production Model
Examples	Breton Sound (BS): deMutsert et al. (2012) West Florida Shelf (WFS): Chagaris (2013)	Barataria Basin (BB): Dynamic Solutions (2013) Mississippi River Gulf Outlet (MRGO): Bartell et al. (2010)	Biscayne Bay : Ault et al. (1999)
Number of modeled species or groups	BS: 39 groups including phytoplankton, zooplankton, SAV, benthos WFS: 60 groups including multiple plankton groups, seabirds, sharks	BB: 30 groups including phytoplankton, zooplankton, periphyton, zoobenthos MRGO: 35 groups including phytoplankton, periphyton, zooplankton, zoobenthos, several aquatic vegetation groups	Two-species predator-prey model
Environmental inputs to existing models	BS: Monthly and annual salinity WFS: Mississippi River nitrogen loads	Daily surface light, water temperature, nutrients, depth, velocity, suspended sediments, Particulate organic carbon, salinity	Coral reef, seagrass, hard bottom, bare bottom habitats, salinity, temperature, velocity
Calibration and parameter Uncertainty	ECORANGER used to mass balance Ecopath model based on uncertainty, also to fit Ecosim to annual time series of abundance and catch data	Fitted to monthly biomass data for systematic calibration and parameter sensitivity using parameter estimation software called PEST (Dynamic Solutions, 2012)	Predicted growth of seatrout calibrated with sizes at age; seasonal abundance and densities of pink shrimp by habitat type validated with field data
Model transparency and ease of use	Free online software with a user interface makes it easy to use but difficult to customize the code; source code is now available but public version of source code continues to be developed	Input files and code customized for each project and source code must be obtained from model developer	Input files and code was customized for the project and source code must be obtained from the model developer

Final

- Repeat 2012 HSI analysis
- Improve HSI
- CASM (or TroSIM) and/or EwE
  - Cautions, e.g., movement
  - Suggestions
- Spatially-explicit IBM
  - Focus is movement

Concluding Remarks

- Best practices scheme offers a systematic way to evaluate a modeling effort
  - Steps were done
  - Results of the steps

- Good modelers do most of these but often they do not document them in this format

Acknowledgements

This paper evolved from a variety of workshops involving some of the authors on how to use ecological and fish models, a report for the California Delta Science Program on how to develop and implement salmon life cycle models (with James Anderson, Michelle McClure, and Greg Ruggerone), and a report prepared by KAR and SS to the Louisiana's Coastal Protection and Restoration Authority on how to select fish models for evaluating restoration plans. KAR and SS want to thank CPRA and The Water Institute of the Gulf for their funding support to write this paper.

Contributions: KAR and SS developed the overall scheme; DLD, SY, and JCT provided the Everglades example; WG provided the Colorado River example; DJR worked with KAR and SS on the Coastal Louisiana example; all authors contributed to the final document.