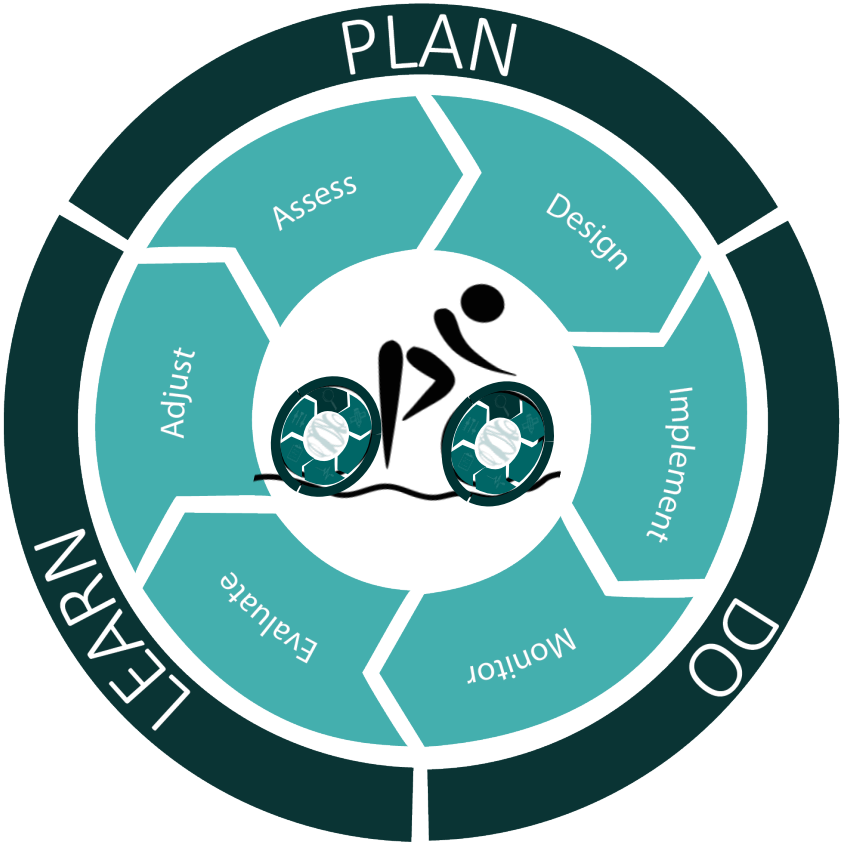
Enabling Adaptive Management in a Noisy and Complex World: *What Does It Take?*

Clint Alexander*, Marc Nelitz, David Marmorek, Carol Murray & Cedar Morton

Canadian Studies Program, UC Berkeley,
May 9, 2019

ESSA

Adaptive Management is….



a rigorous approach for designing and implementing management actions

to

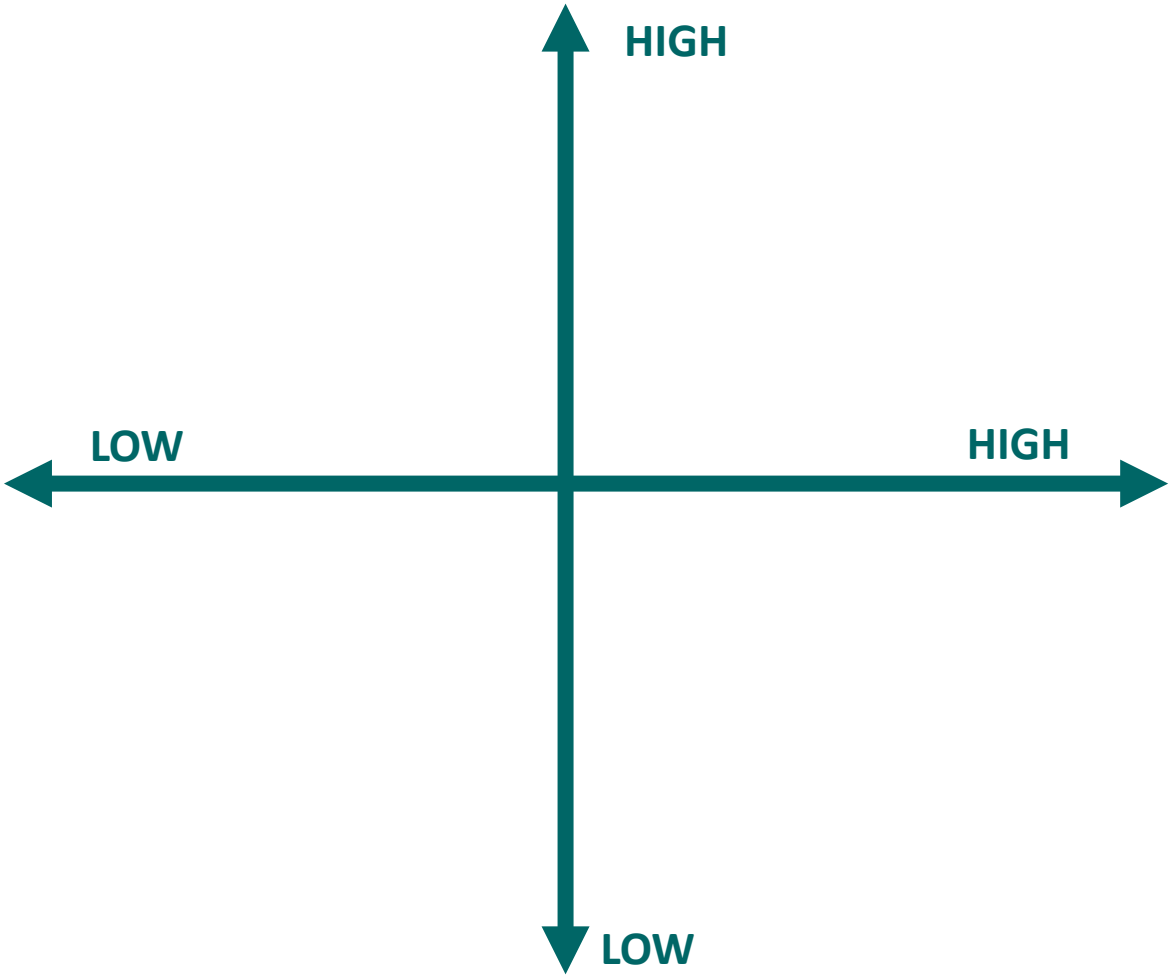
maximize learning about critical uncertainties that affect recurrent decisions

while simultaneously

striving to meet multiple management objectives.

Robust AM strives to balance learning and doing

DOING (Enabled by Institutional Factors)



LEARNING
(Enabled by
Technical Factors)

Adapted from Duitz and Galaz 2008

Robust AM strives to balance learning and doing

DOING (Enabled by Institutional Factors)

HIGH

LOW

HIGH

LEARNING
(Enabled by
Technical Factors)

"Autopilot"

LOW

Adapted from Duitz and Galaz 2008

Robust AM strives to balance learning and doing

DOING (Enabled by Institutional Factors)

HIGH

GAMBLING ON MY HUNCH

LOW

HIGH

LEARNING
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"Autopilot"

SCIENCE PROGRAM

LEARNING
(Enabled by Technical Factors)

LOW

Adapted from Duitz and Galaz 2008

Robust AM strives to balance learning and doing

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HIGH

GAMBLING ON MY HUNCH

ROBUST AM

LOW HIGH

LEARNING
(Enabled by Technical Factors)

"Autopilot"

SCIENCE PROGRAM

LOW

Adapted from Duitz and Galaz 2008

We've learned it takes...

Good governance to enable good science

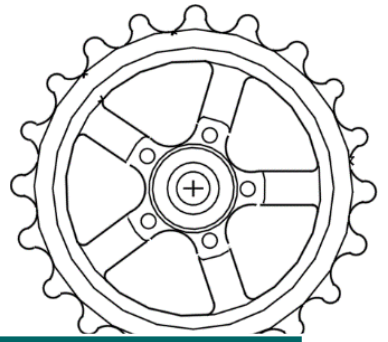
A common transboundary framework

Acceleration using real-time tools & "turn taking"

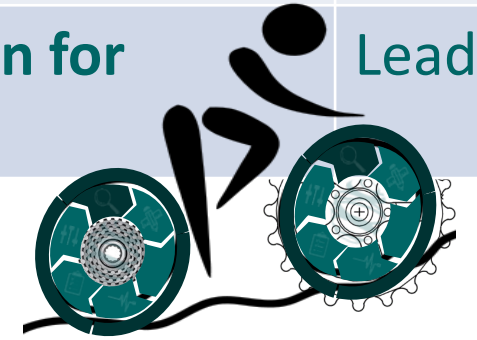
Integration of climate change adaptation

Key message 1: Focus first on institutional requirements; technical aspects will follow

Two wheels, multiple gears



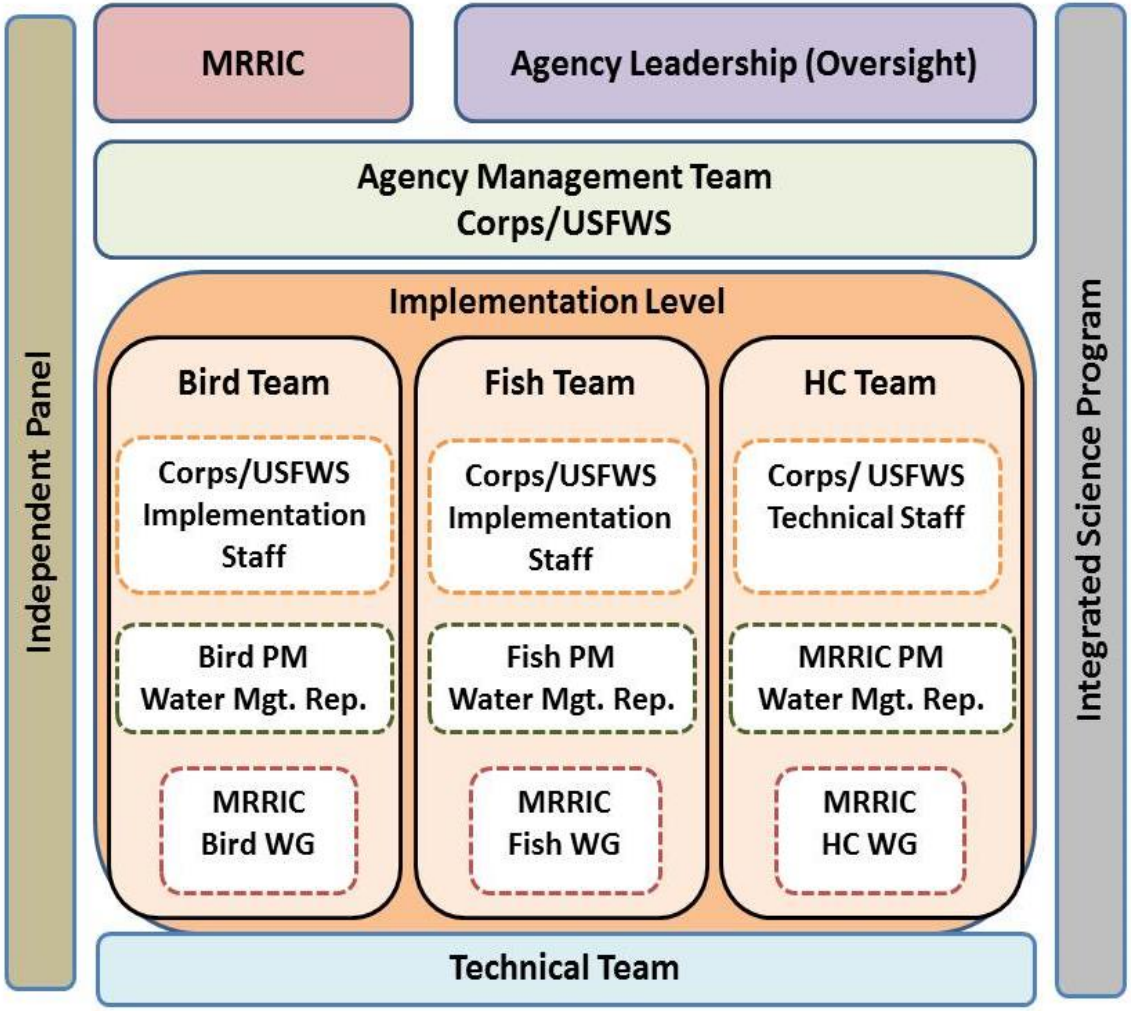
Technical Gears	Institutional Gears
Rigorous AM science	**Executive Direction / Authority**
• Thorough experimental design	**Strong Communication** within agencies & with stakeholders
• Strong contrasts, replication	**Effective Governance Arrangements**
• Targeted monitoring & rapid evaluation	Trust
Science boiled down for decision makers	Leadership



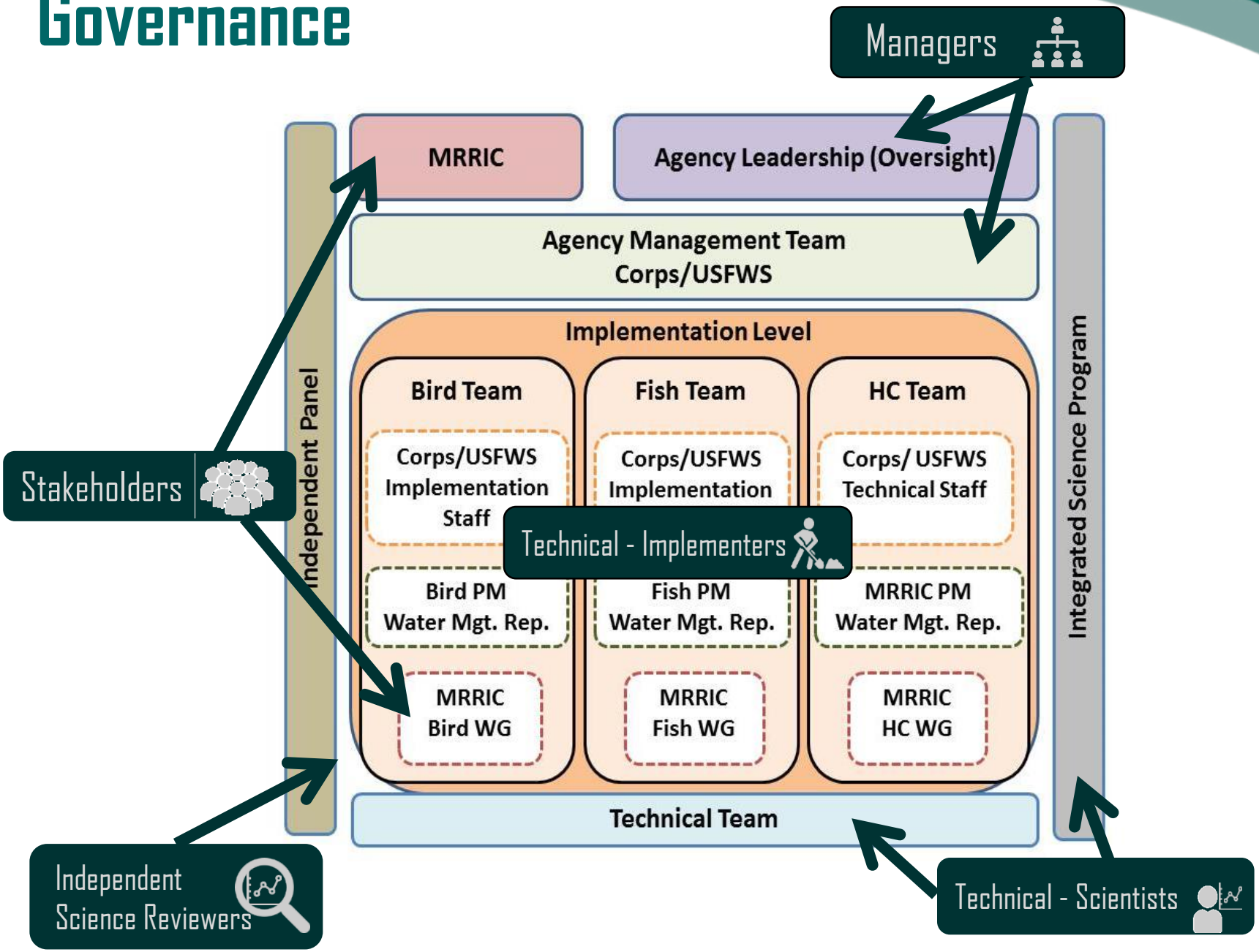
Missouri River: Many interests, many voices

- Navigation
- Irrigation
- Flood control
- Fish and wildlife
- Recreation
- Water quality
- Water supply
- Agriculture
- Conservation districts
- Waterway industries
- Major tributaries
- Thermal power
- Hydro power
- At large / other interests (cultural and historic preservation)
- Local government
- Environmental / conservation organizations

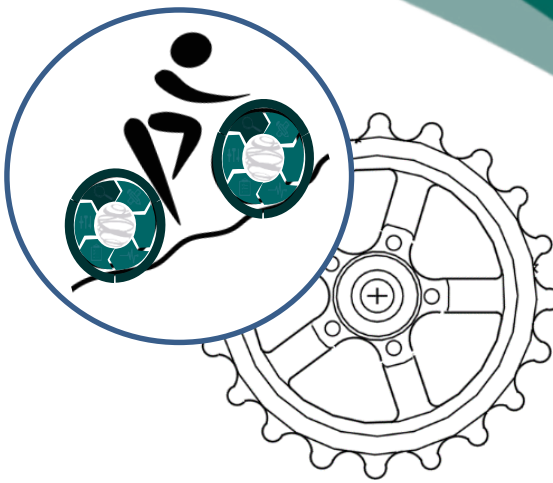
Governance


MRRIC
Agency Leadership (Oversight)
Agency Management Team
Corps/USFWS
Implementation Level
Bird Team
Corps/USFWS Implementation Staff
Bird PM Water Mgt. Rep.
MRRIC Bird WG
Fish Team
Corps/USFWS Implementation Staff
Fish PM Water Mgt. Rep.
MRRIC Fish WG
HC Team
Corps/ USFWS Technical Staff
MRRIC PM Water Mgt. Rep.
MRRIC HC WG
Technical Team
Independent Panel
Integrated Science Program

Governance


Managers
MRRIC
Agency Leadership (Oversight)
Agency Management Team
Corps/USFWS
Implementation Level
Bird Team
Fish Team
HC Team
Corps/USFWS Implementation Staff
Corps/USFWS Implementation
Corps/ USFWS Technical Staff
Technical - Implementers
Bird PM Water Mgt. Rep.
Fish PM Water Mgt. Rep.
MRRIC PM Water Mgt. Rep.
MRRIC Bird WG
MRRIC Fish WG
MRRIC HC WG
Technical Team
Independent Panel
Integrated Science Program
Stakeholders
Independent Science Reviewers
Technical - Scientists

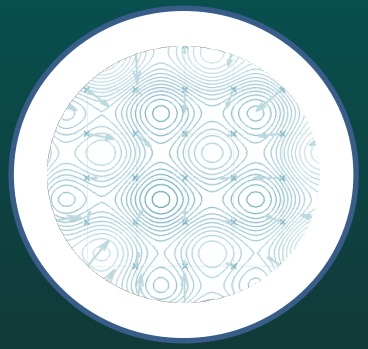
Key Contributions Enabling AM…



1. Robust governance *powers* technical underpinnings of AM
   - Technical gears don't turn efficiently (or at all) with ad hoc leadership structures
2. Clarity and separation of major roles with choreographed interactions enhances effectiveness

Key messages 2 & 3: Develop a common transboundary framework for describing problems

Then

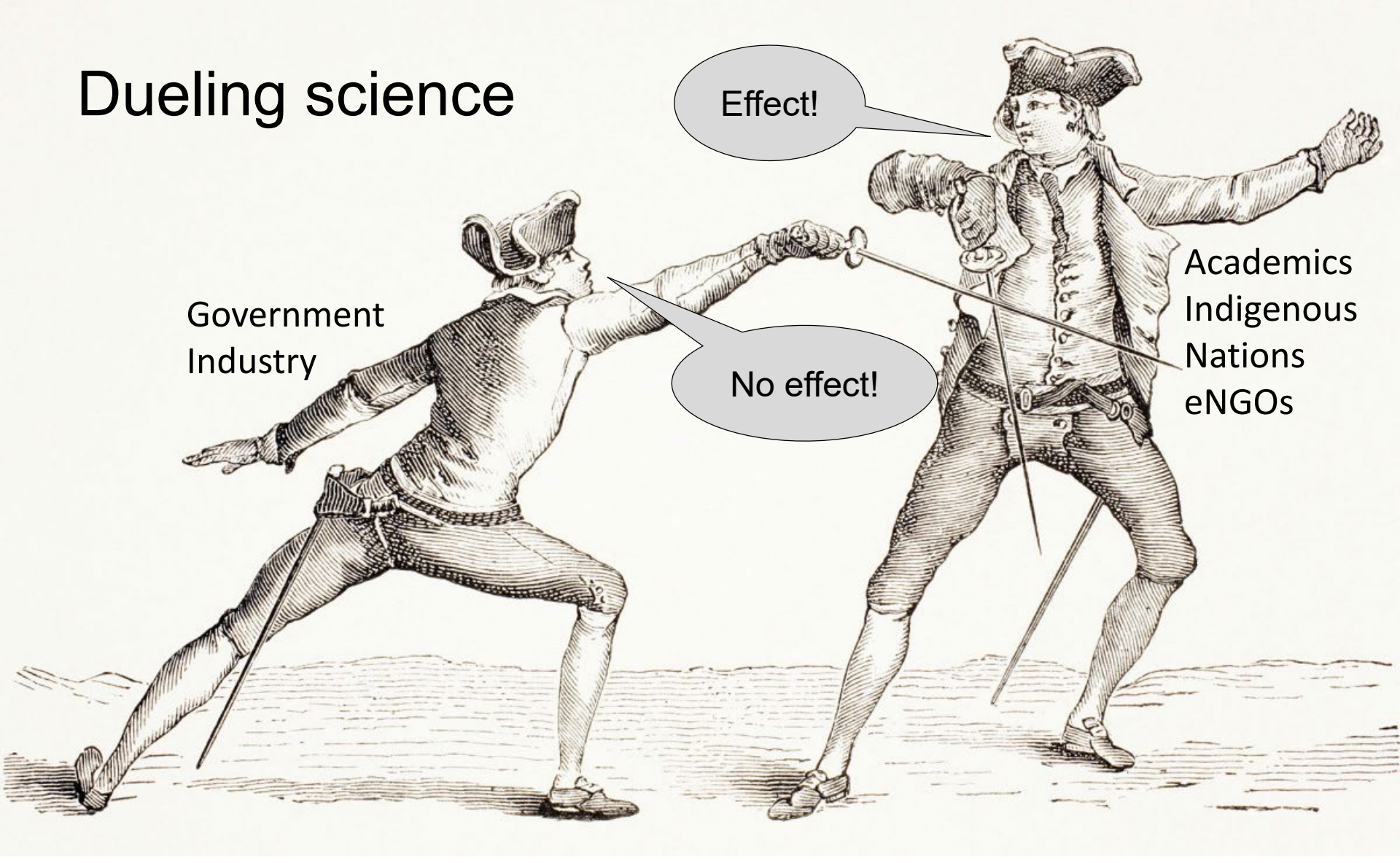


Accelerate balanced trade-off decisions using real-time tools and "turn-taking"

What Does a Common Transboundary AM Framework Look Like?

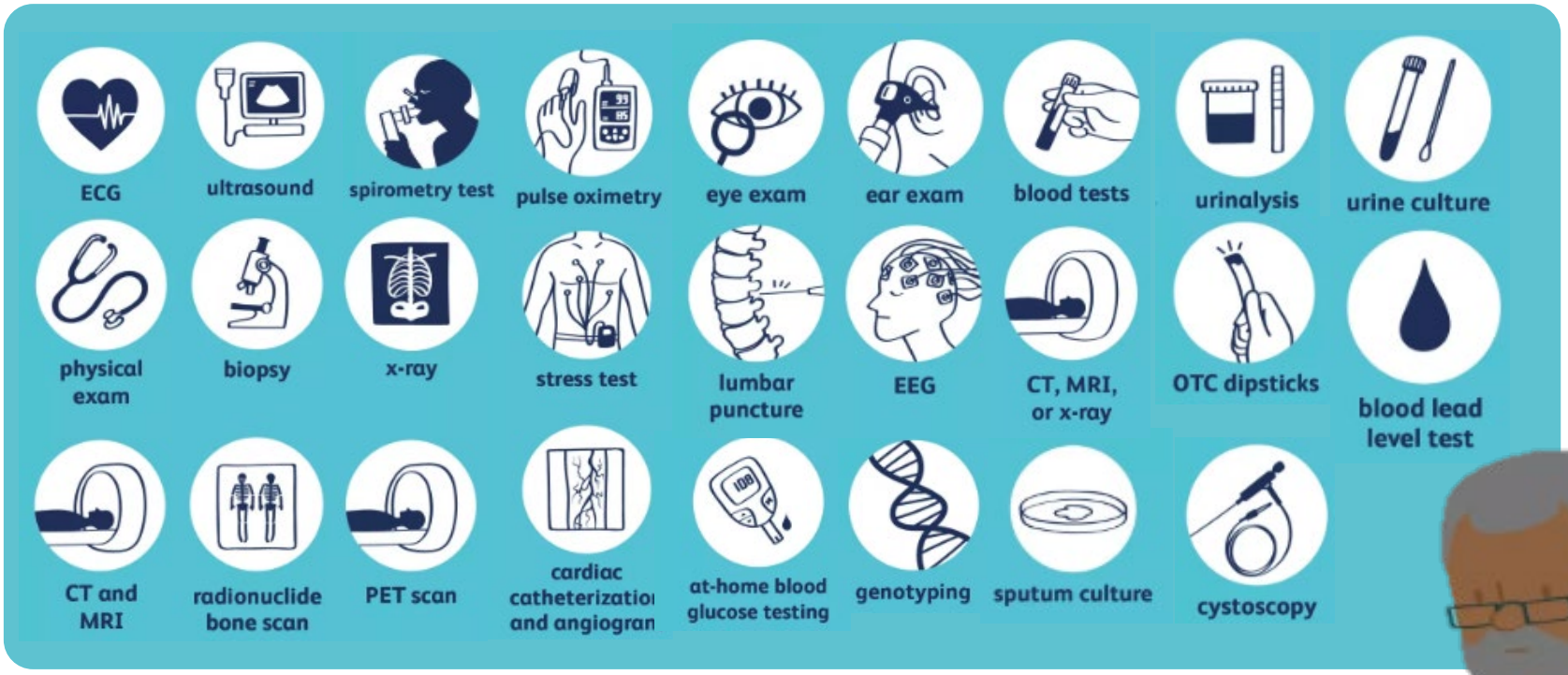
- **Common** input datasets and tools (powering indicator generation)
- **Collaborative** trade-off evaluation
- **Basin-wide** perspective, technical and institutional *flexibility*

Why? Important to AM because…



Common "Core" (Specific) Performance Measures

DIAGNOSTIC MEASURES →Candidate Performance Measures



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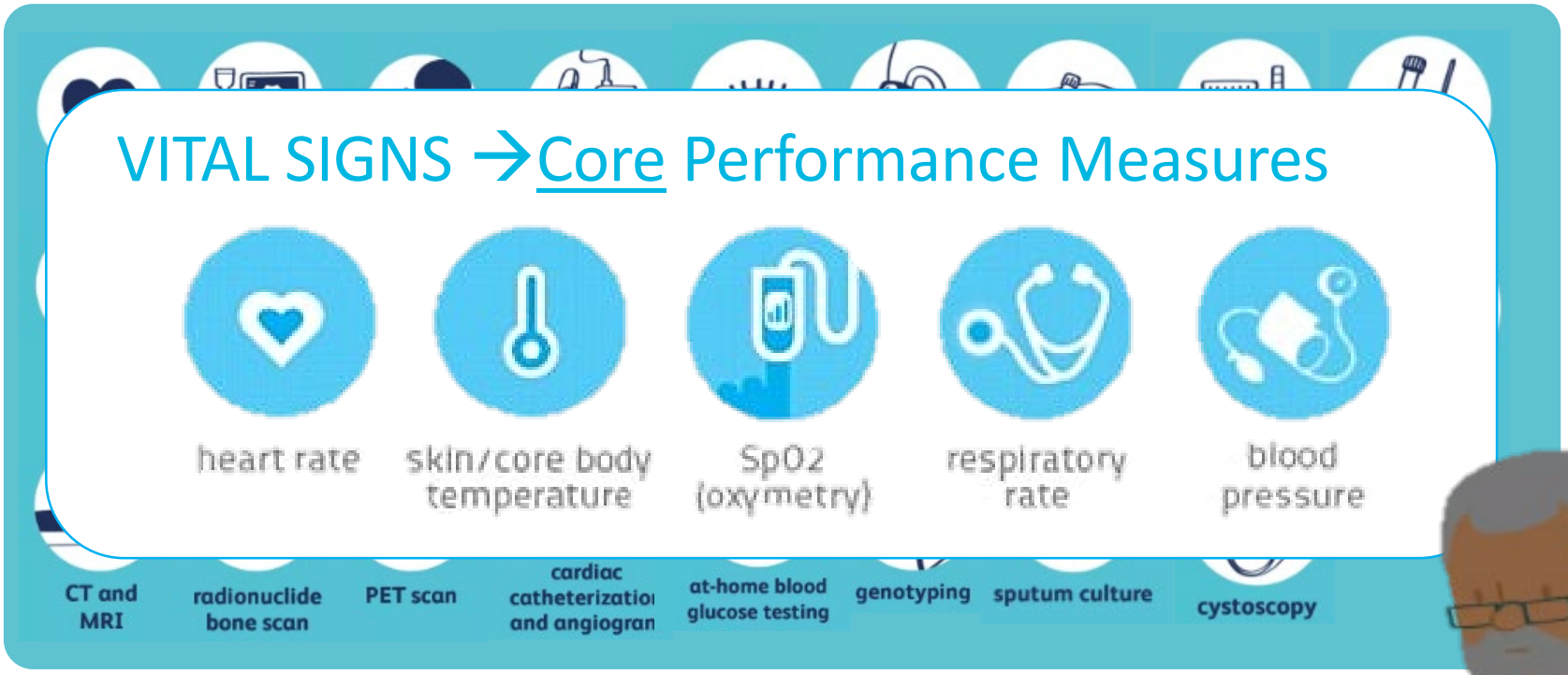
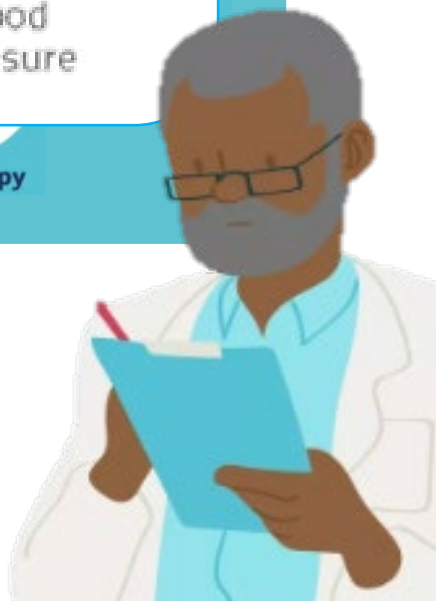
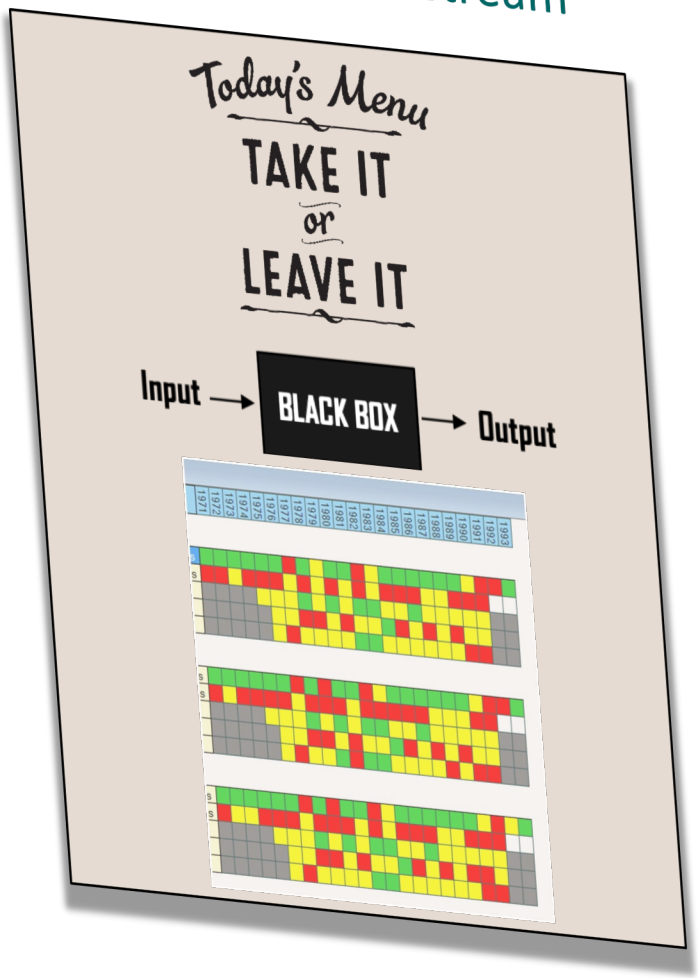




Business as Usual "What if" Tooling

The "view" downstream



Scenario Generation

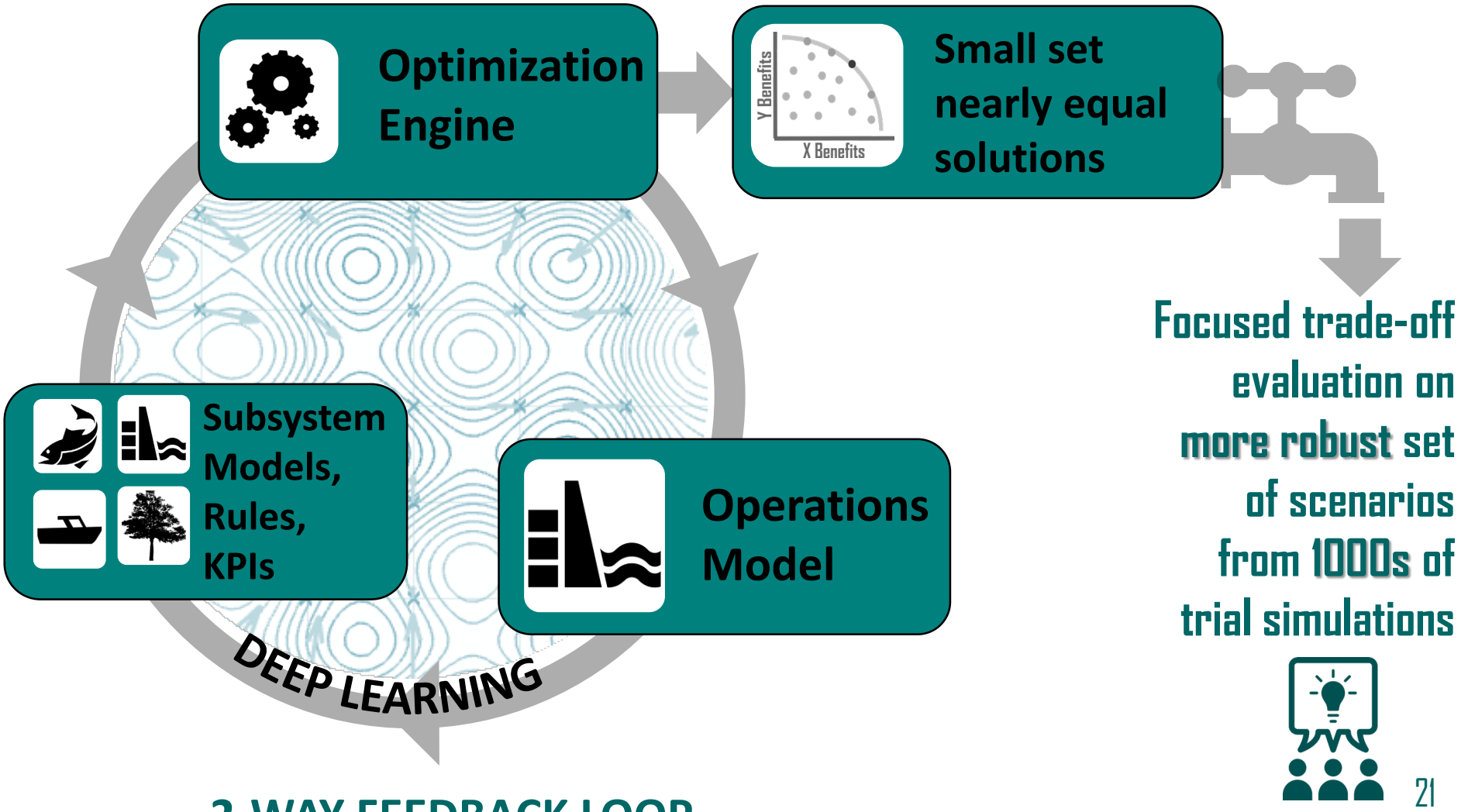
Operations Model

Multiple Subsystem Models/Rules, Performance Indicators

Multi-objective Tradeoff Summary

1-WAY SEQUENCE

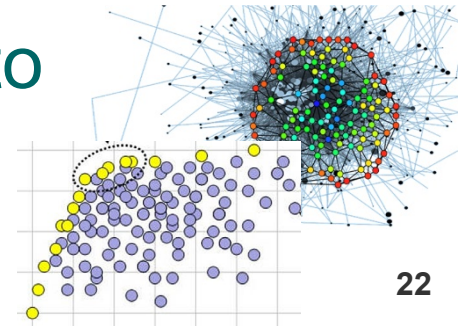
Coupled Modeling: Deep Learning Optimization/Feedback Loop



Key Contributions Enabling AM…

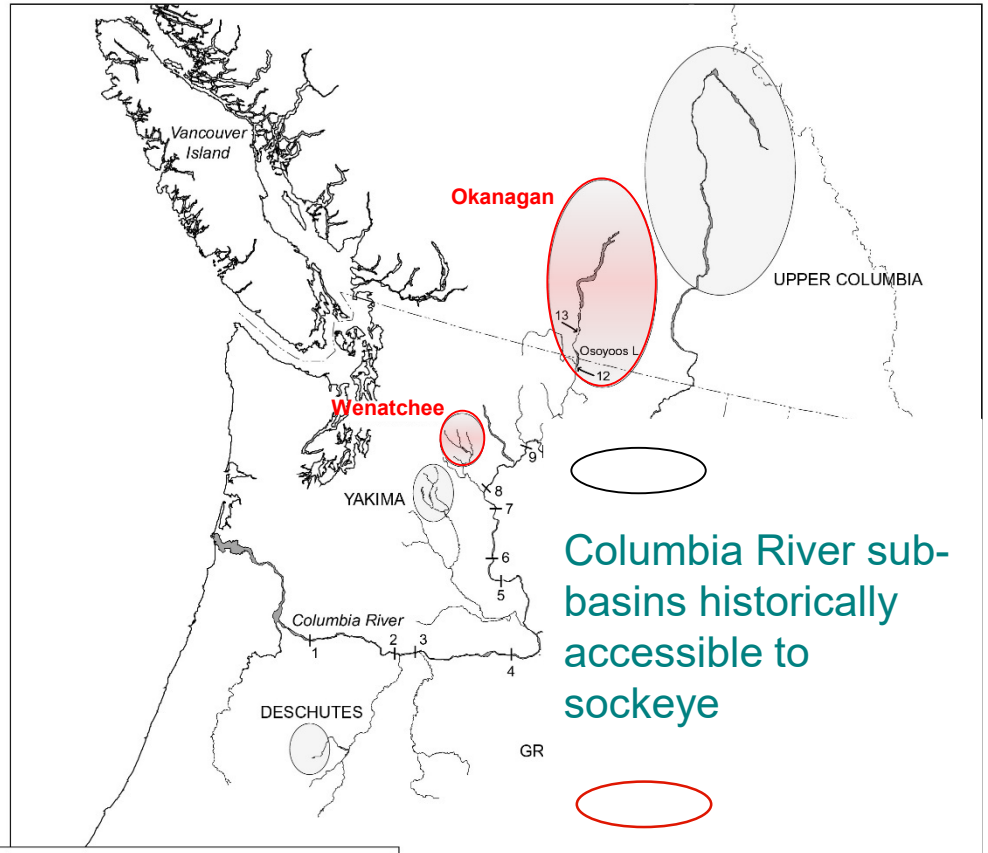
1. Clear **specific** core performance indicators
   - specific includes agreeing on performance that is “good enough” or “acceptable”
2. Common science foundation (models & tools) allows focus on hard trade-off decisions (values)

3. Can explore **<u>thousands</u>** of scenarios to find robust solutions



Success Story: Okanagan River Sockeye

- **Context:** Wells dam operators responsible to mitigate dam related fish losses (Douglas County Public Utility District)
- **Challenges:** Competing demands, changing climate, extreme events, Columbia River dam operations
- **AM:** Recover Okanagan sockeye by flow management, re-introduction to Skaha Lake

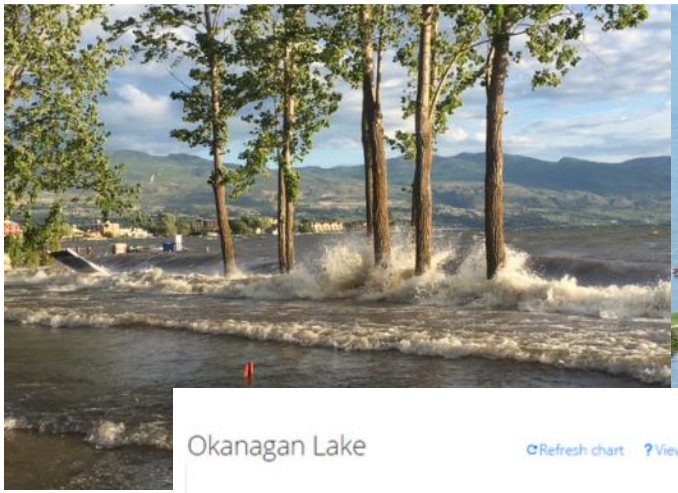


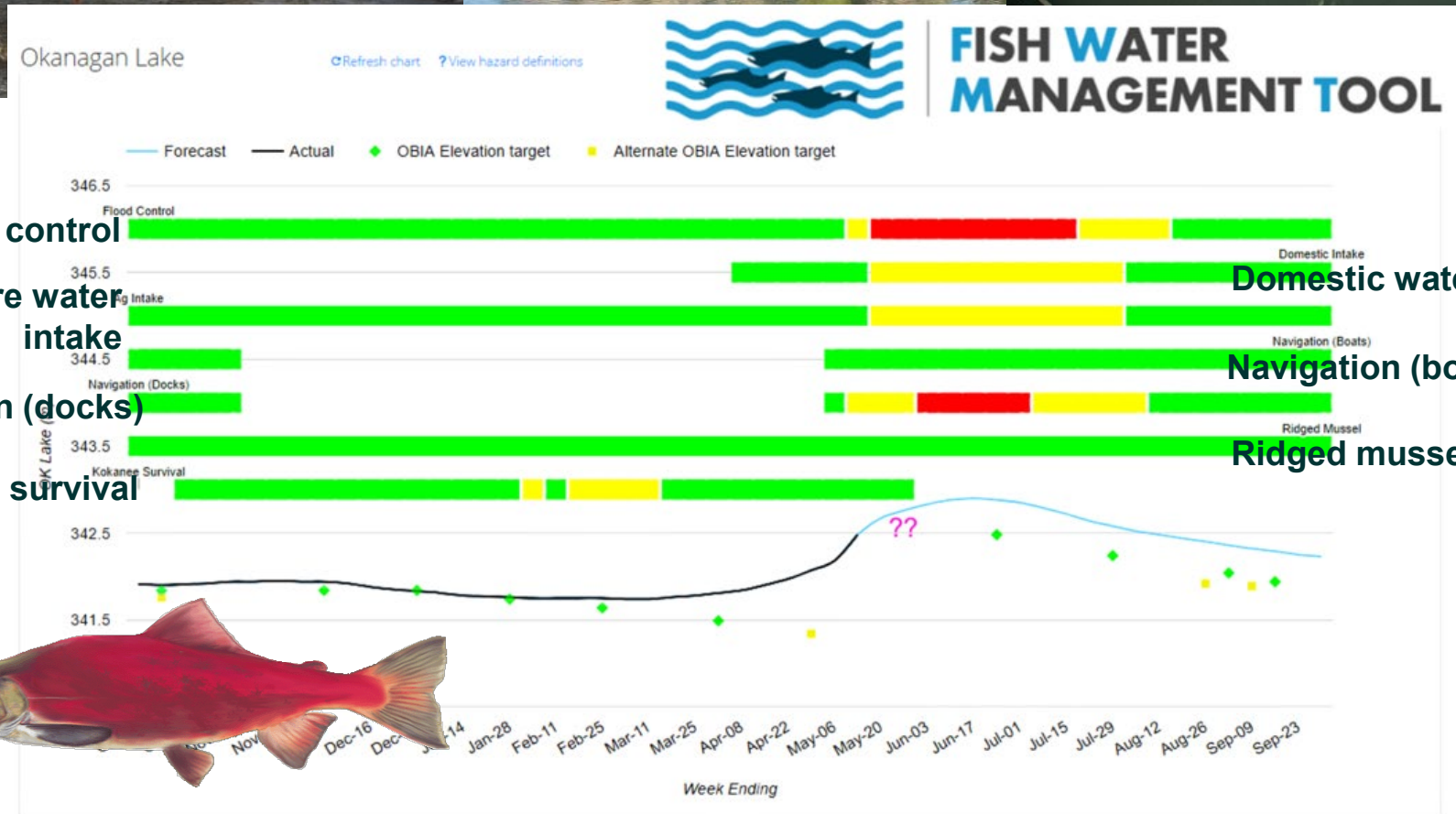
COLUMBIA RIVER DAM SITES

1	Bonneville	7	Rock Island
2	The Dalles	8	Rocky Reach
3	John Day	9	Wells
4	McNary	10	Chief Joseph
5	Priest Rapids	11	Grand Coulee
6	Wanapum	12	Zosel
		13	McIntyre

Success Story: Okanagan River Sockeye

Coupled Subsystem Models & Real-Time Decision Making





Flood control

Agriculture water intake

Navigation (docks)

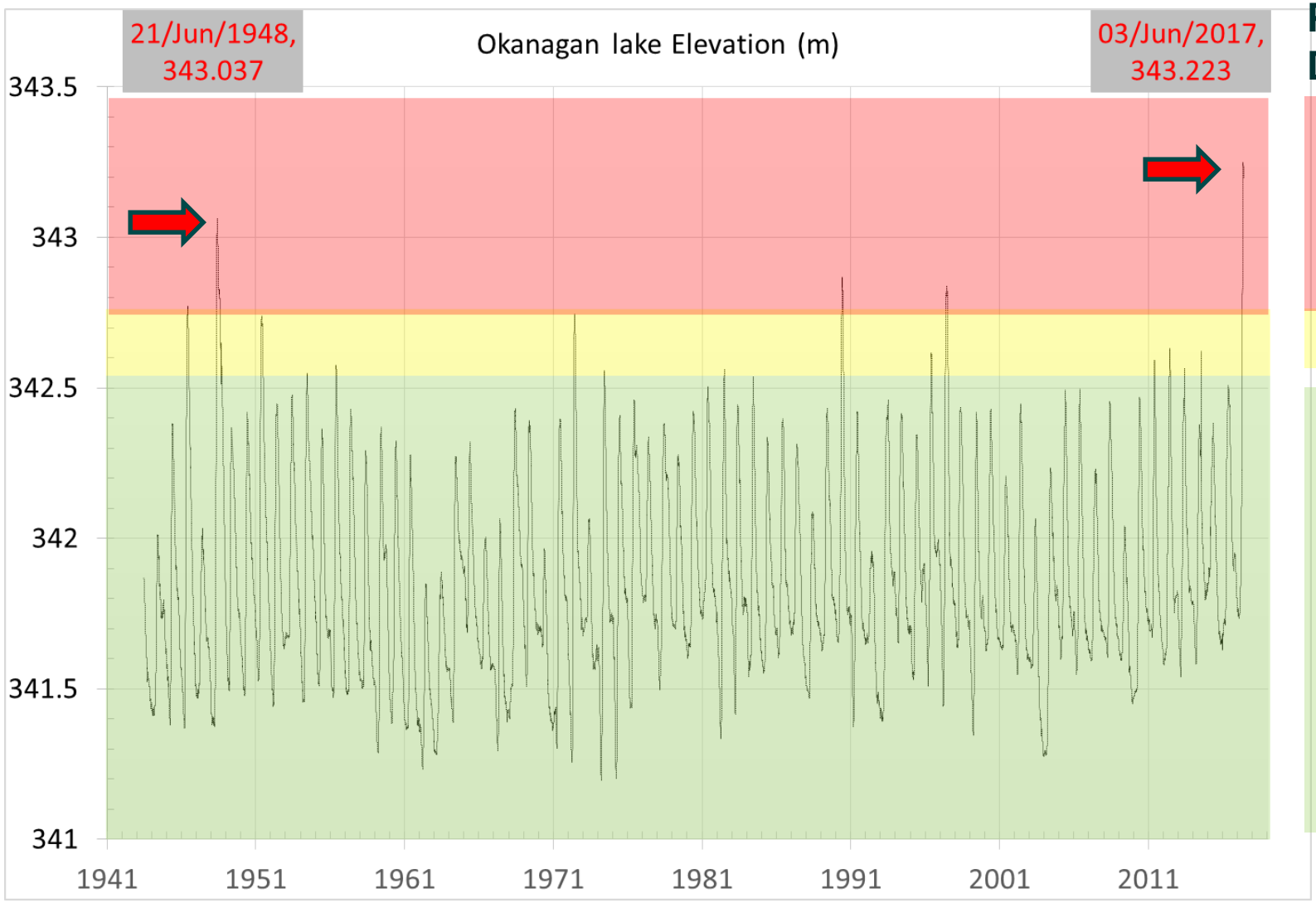
Kokanee survival

Domestic water intake

Navigation (boats)

Ridged mussel

Need Earlier Warnings of Extreme Events



Estimated Property Damage

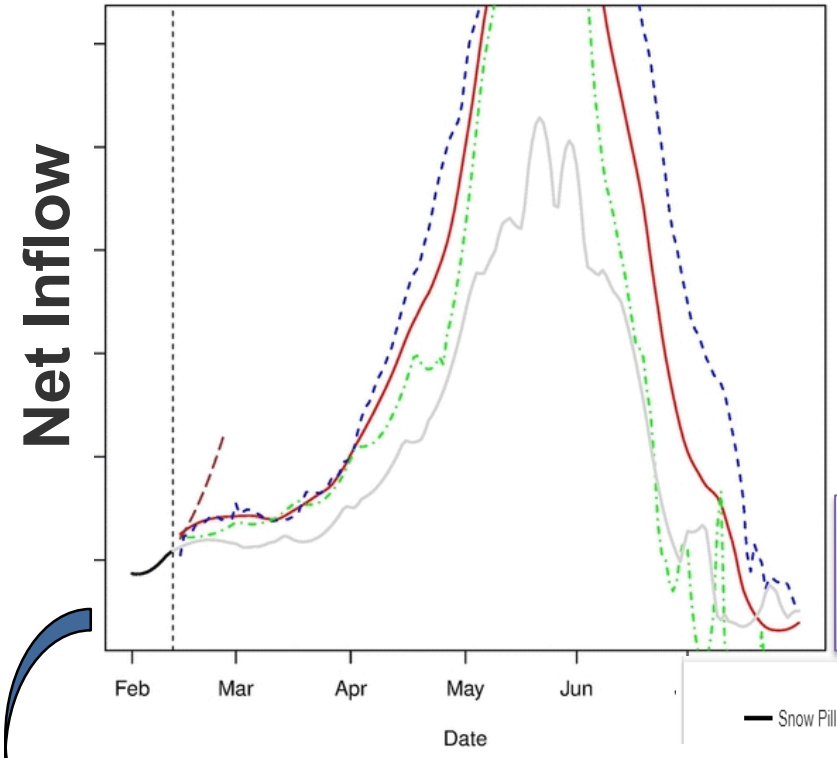
> $20M

$1.5-20M

<< $.5M

FISH WATER MANAGEMENT TOOL

Real-time predictions & anomaly detection



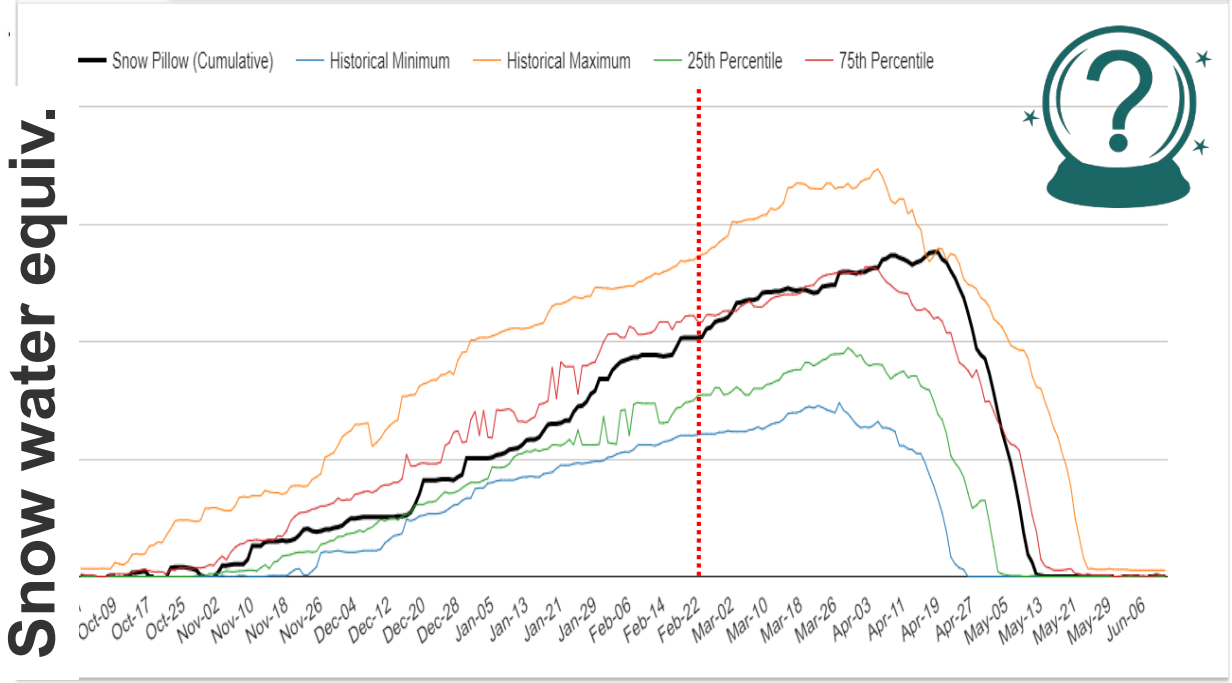
The snow pillow data for Mission Creek is currently above the 91st percentile which is rare for the week of Feb 26. Our analysis shows this may lead to a very wet year.

Overall Prediction

Prediction from RFC

Prediction from Historical

Prediction from Current



Key Contributions Enabling AM…

4. **Coupled**, *real-time* models accelerate shared understanding
   - Less information lost than if relying on paper ‘master manuals’
   - Operators and planners brought *together*
5. Automated forecasts & early warnings allow for more proactive adjustments

MARCH 2018

SAN FRANCISCO ESTUARY & WATERSHED SCIENCE

Sponsored by the Delta Science Program and the UC Davis John Muir Institute of the Environment

RESEARCH

Improving Multi-Objective Ecological Flow Management with Flexible Priorities and Turn-Taking: A Case Study from the Sacramento River and Sacramento–San Joaquin Delta

Clint A. D. Alexander*,[1], Frank Poulsen[1], Donald C. E. Robinson[1], Brian O. Ma[1], and Ryan A. Luster[2]

Volume 16, Issue 1 | Article 2

https://doi.org/10.15447/sfews.2018v16iss1art1

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Vancouver, BC Canada V6H 3H4

2 Water Science Program
The Nature Conservancy of California
Chico, CA 95928 USA

with the Ecological Flows Tool (EFT): a multi-species decision support framework to evaluate how specific components of the flow regime promote and balance favorable habitat conditions for 15 representative and 31 indicators within the SRD. Applying ach incorporates the existing ntation of socio-economic water a, priorities, and constraints—and ase patterns each water year shifting set of EFT indicators. pting to optimize conditions for dicators every year, TTO creates

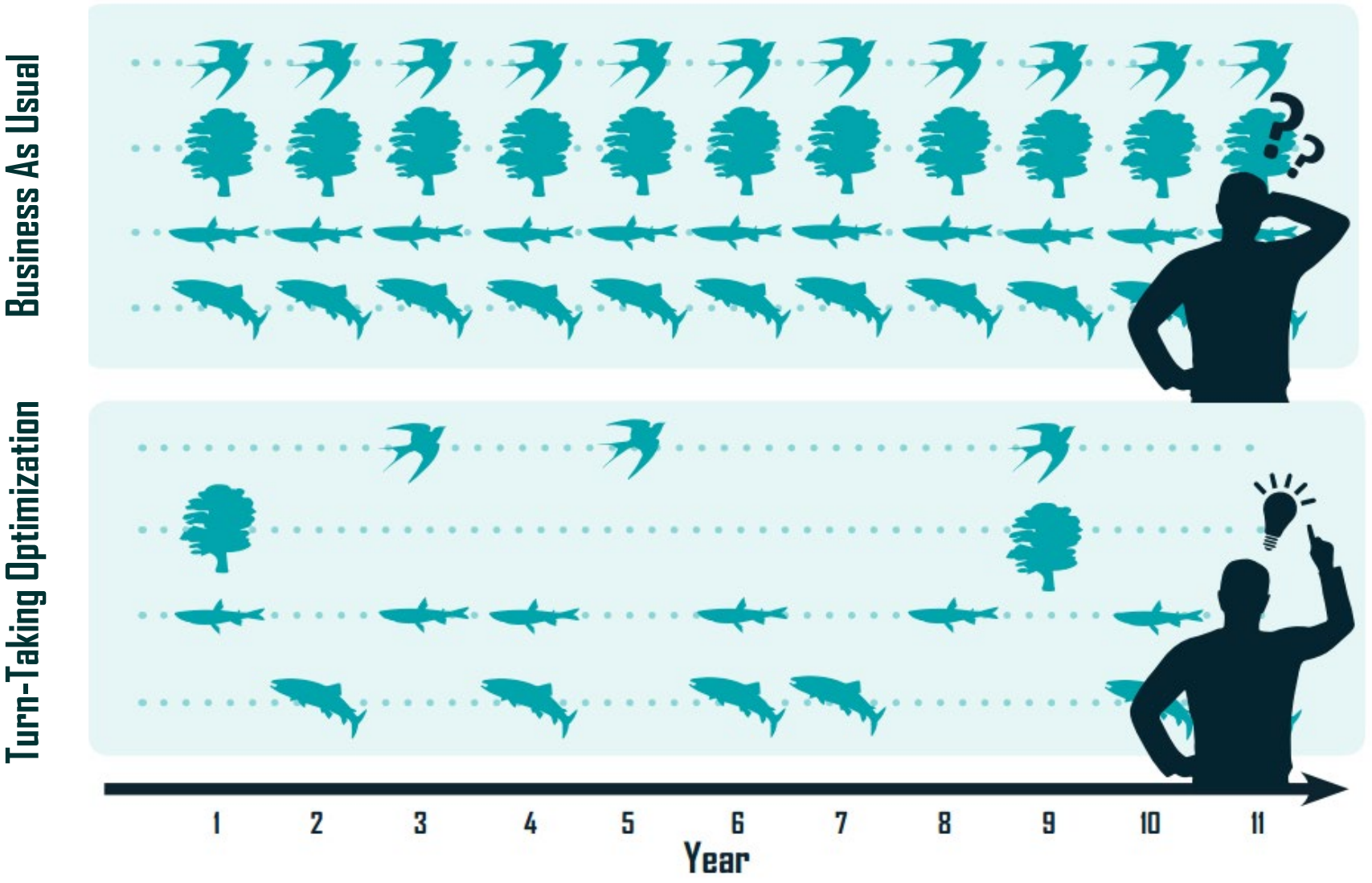
Jagger's Law

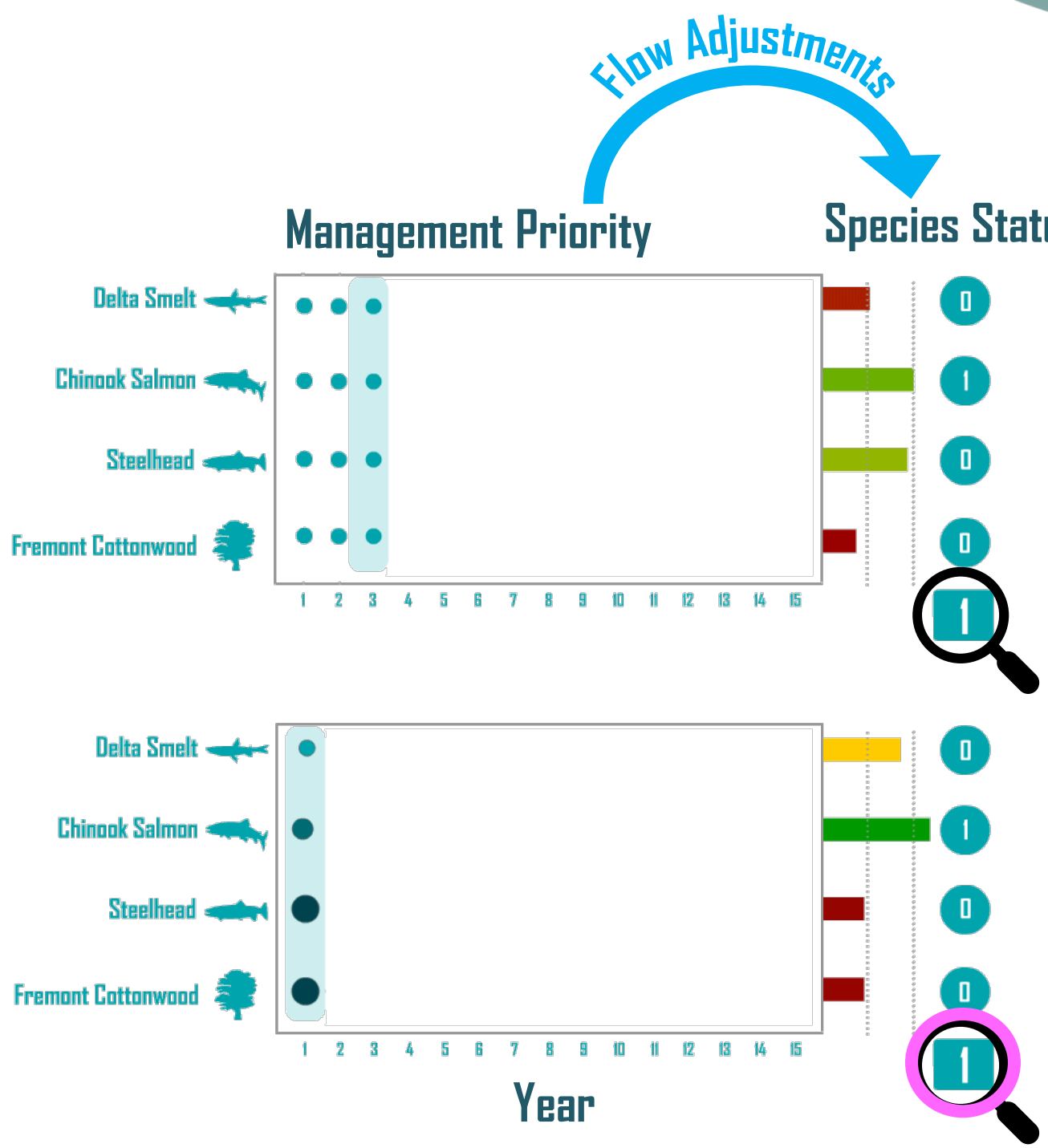
You can't always get what you want
But if you try sometimes, well you just might find
You get what you need

—Jagger and Richards, 1969

Jagger MP, Richards K. 1969. You can't always get what you want. Let it Bleed, Decca Records, Side 2, Band 4, LP.

What Does Turn-Taking Look Like?





Business as Usual

Turn Taking Optimization

Key Contributions Enabling AM…

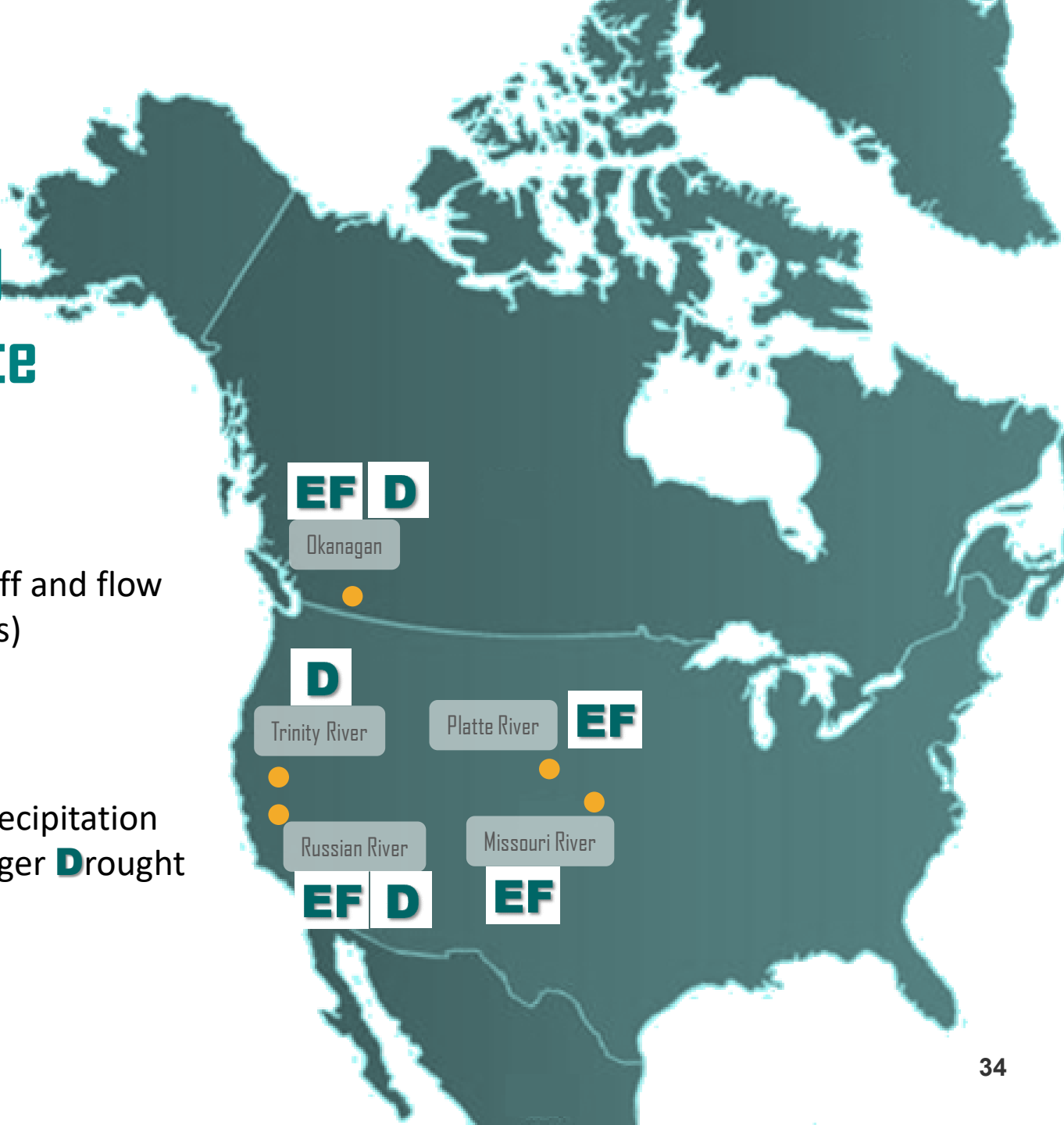
6. Turn-taking expands solution space when confronted with **multitude** of objectives
   - Don't have to pick "winners and losers"
   - Responsive to natural (climate) conditions
   - Ready-made for operational (not just planning) context

Key message 4: Blend principles / practices of adaptive management (AM) and climate change adaptation (CCA)

Recent river basin AM projects facing extreme climate events

Extreme runoff and flow events (**F**loods)

Decreasing precipitation leading to longer **D**rought



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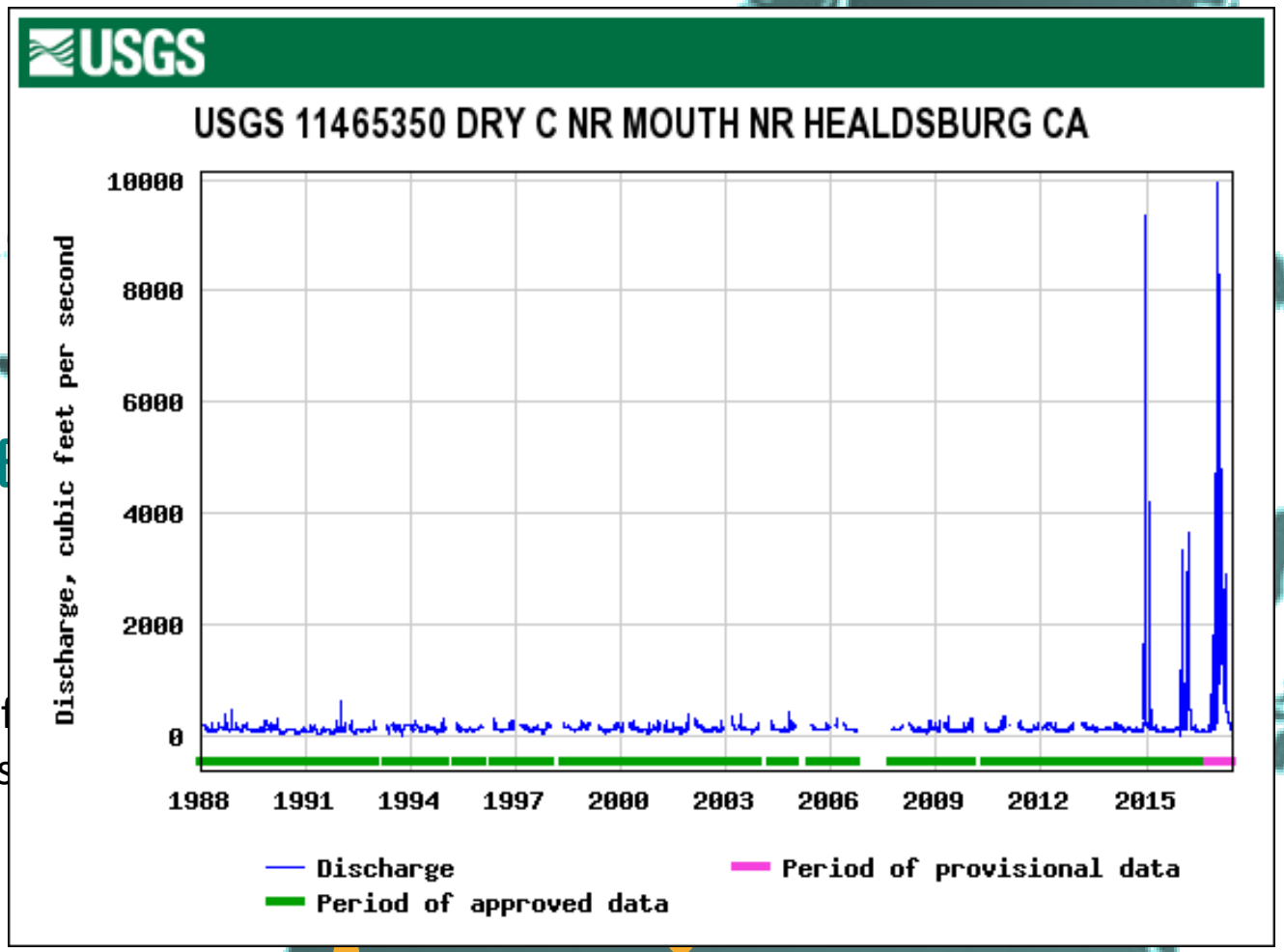

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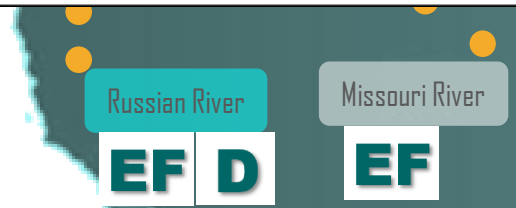

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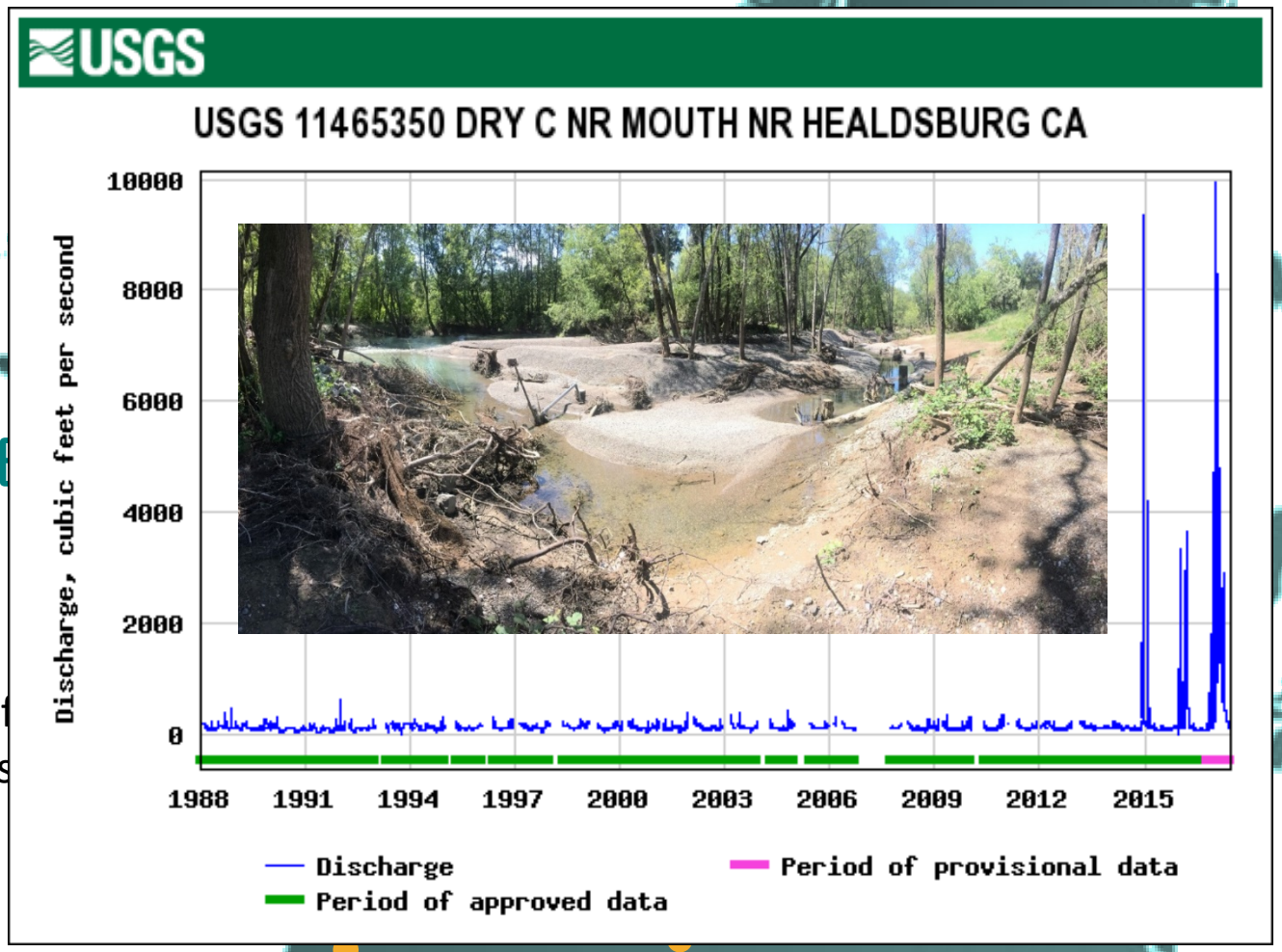

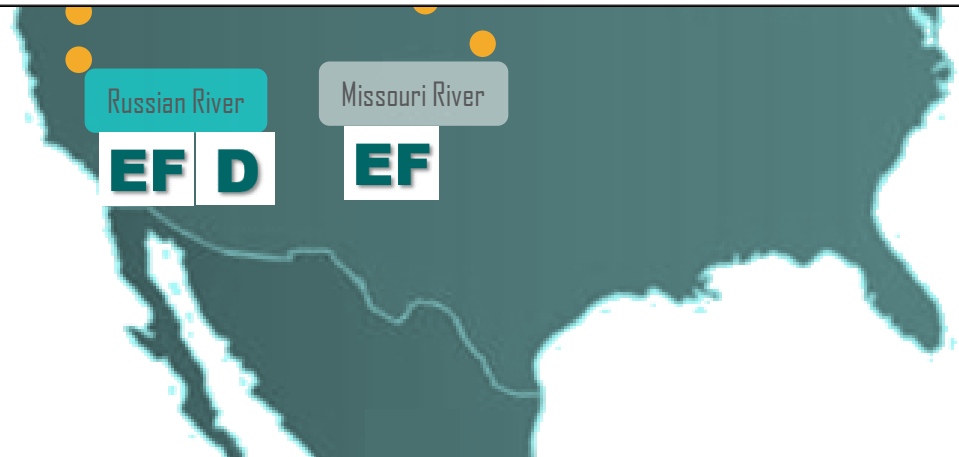

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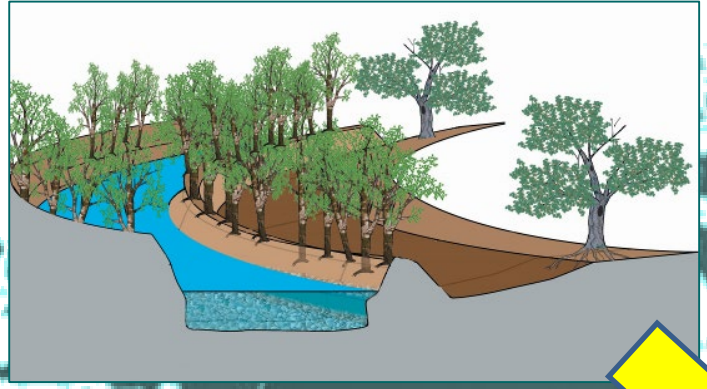

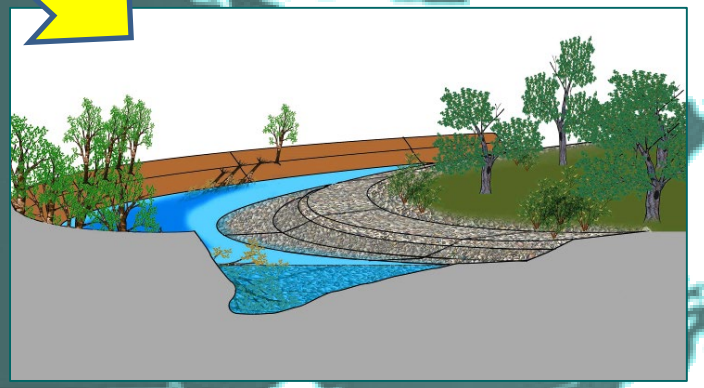

Extreme runoff and flow events (**F**loods)

Decreasing precipitation leading to longer **D**rought

EF **D**
Okanagan

D
Trinity River

Platte River **EF**

Russian River
EF **D**

Missouri River
EF

Recent river

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Recent river basin AM projects facing extreme climate events

Extreme runoff and flow events (**F**loods)

Decreasing precipitation leading to longer **D**rought

EF **D** Okanagan

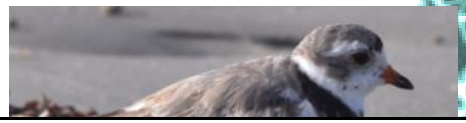
D Trinity River

Platte River **EF**

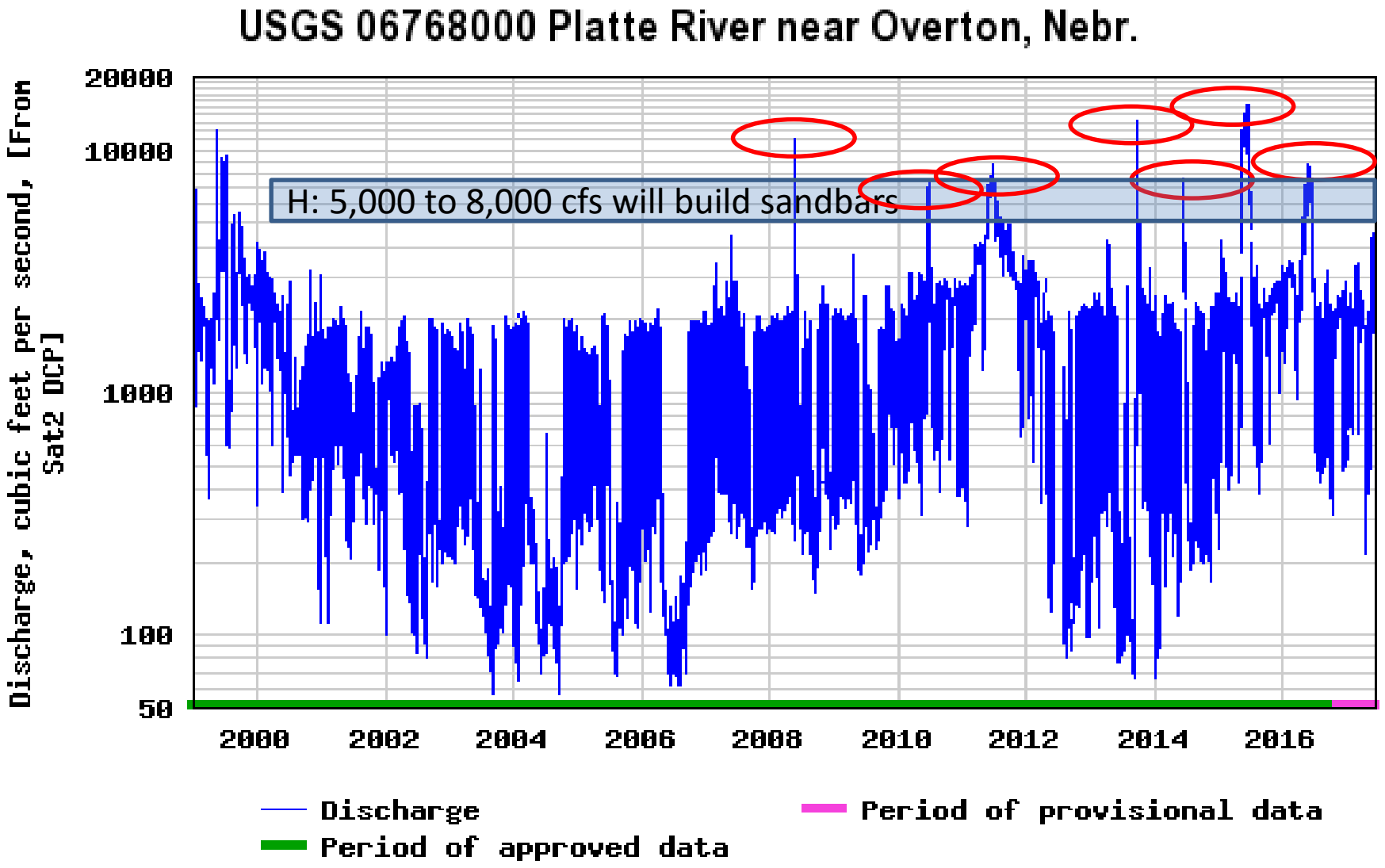
Russian River **EF** **D**

Missouri River **EF**

Recent river



USGS



Climate change adaptation strategies can benefit AM projects

1. Use variability in flow to test flow-habitat hypotheses
2. Develop real-time systems for anomaly detection and flood forecasting from weather
3. Leverage storage (dams, groundwater, wetlands, ponds) to reduce impacts of drought
4. Rethink and re-design habitat restoration for greater resilience during droughts and floods
5. Implement actions to reduce water demand
6. Revise basin-wide water management strategies to meet species' needs and accommodate increased variability in flows

Climate change adaptation strategies can benefit AM projects

1. Use
2. Dev
   for
3. Lev
   red
4. Ret
   dur
5. Imp
6. Rev
   spe

In Review, American Water Resource Association

Adaptive Management and Climate Change Adaptation: Two Mutually Beneficial Areas of Practice

David Marmorek, Marc Nelitz, Jimena Eyzaguirre, Carol Murray and Clint Alexander

ESSA Technologies Ltd. (Marmorek, Nelitz, Murray, Alexander), Vancouver, British Columbia, CAN; and ESSA Technologies Ltd. (Eyzaguirre), Ottawa, Ontario, CAN (Correspondence to: Marmorek: dmarmorek@essa.com)

Research Impact Statement: Adaptive Management (a rigorous approach to learning while doing) and Climate Change Adaptation (a way to reduce risks from climate change) are mutually beneficial and supportive fields of practice.

Abstract: Adaptive management (AM) is a rigorous approach to implementing, monitoring and evaluating actions, so as to learn and adjust those actions. Existing AM projects are at risk from climate change, and current AM guidance does not provide adequate methods to deal with this risk. Climate change adaptation (CCA) is an approach to plan and implement actions to reduce

nce

ows

In Summary!

Front ‘governance’ gears first rear ‘technical’ gears will follow

Establish common transboundary framework & tools

Accelerate using real-time tools & “turn taking”

Integrate climate change adaptation

Thank you!

https://essa.com/approach/

http://essa.com/services/adaptive-management/

Marmorek, D.R., M. Nelitz, J. Eyzaguirre, C. Murray and C. Alexander. [in review]. Adaptive Management and Climate Change Adaptation: Two Mutually Beneficial Areas of Practice. For submission to J.A.W.R.A.

Kim D. Hyatt, Clint A. D. Alexander & Margot M. Stockwell. 2015. A decision support system for improving "fish friendly" flow compliance in the regulated Okanagan Lake and River System of British Columbia, Canadian Water Resources Journal, 40:1, 87-110, DOI: 10.1080/07011784.2014.985510.

Alexander, C.A., Poulsen, F., Robinson, D.C., Ma, B.O. and Luster, R.A., 2018. Improving Multi-Objective Ecological Flow Management with Flexible Priorities and Turn-Taking: A Case Study from the Sacramento River and Sacramento–San Joaquin Delta. San Francisco Estuary and Watershed Science, 16(1).

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