EFT
Ecological Flows Tool

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Multi-species Effects Analysis & Ecological Flow Criteria: Lessons from Application of the Ecological Flows Tool

Project leadership: **Ryan Luster**

Clint Alexander
Bay-Delta Science Conference
October 28 2014

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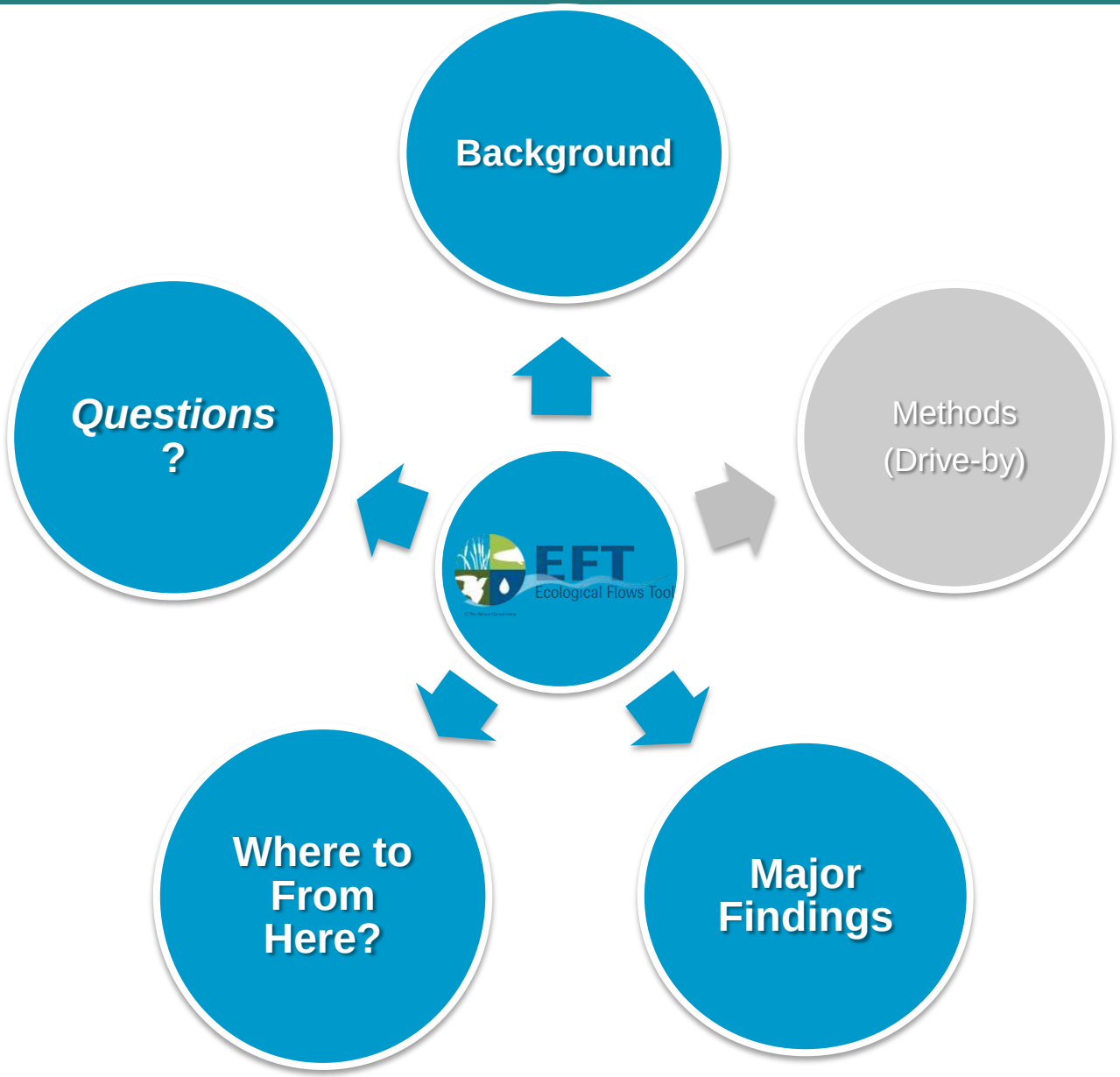
Outline


Background
Methods
(Drive-by)
Major
Findings
Where to
From
Here?
Questions
?
EFT
Ecological Flows Tool

“Ecological Flows Tool Final Report”

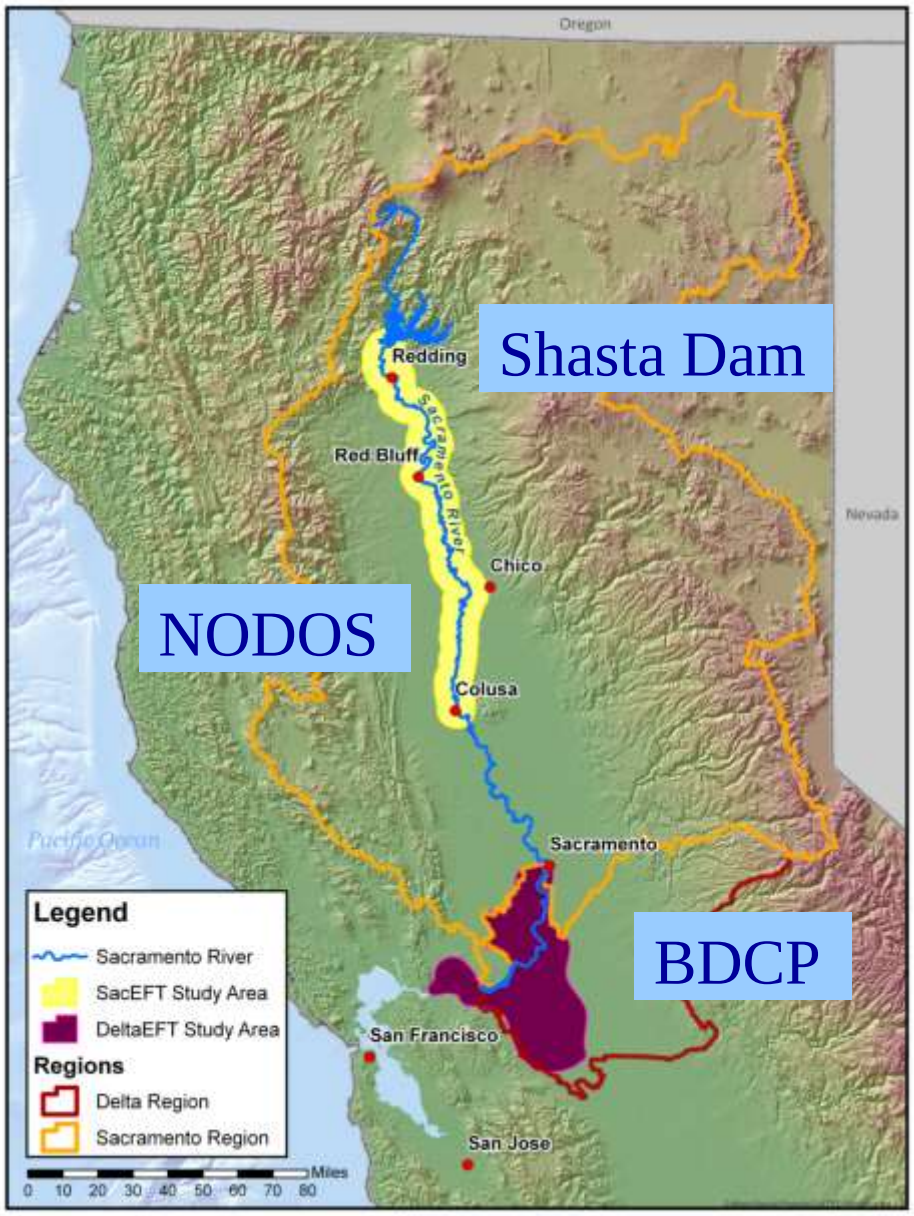
deltacouncil.ca.gov/sites/default/files/documents/files/EFT-Final-Report-2014-04-30.pdf

http://essa.com/tools/ecological-flows-tool/

Why TNC developed EFT

1. Evaluate ecological trade-offs of water projects and their operations.
2. Develop a broader set of functional ecological flow guidelines.

Vision: ***one*** *integrated decision support platform for evaluating* ***multiple*** *species trade-offs*



Management actions evaluated

Reservoir Operations & Conveyance

- Sacramento River dam / diversion operations
- Delta conveyance & pumping operations
- Coordinated operational criteria (e.g., biological opinions, D-1641 variations)
- External climate forcing
- Alternative human population demands

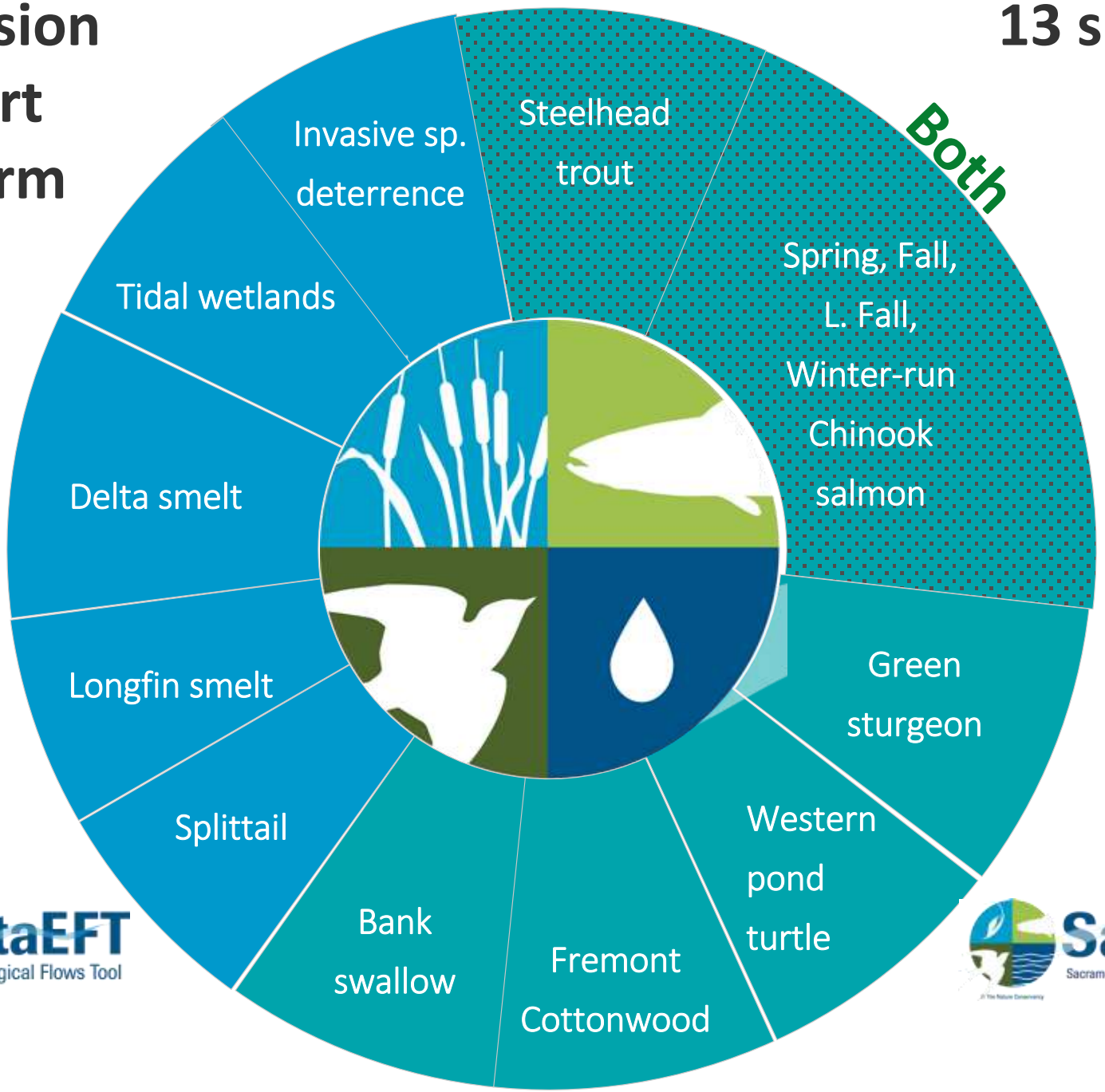
EFT
Ecological Flows Tool

Bank protection & gravel augmentation

- River meander , soil erosion
- Effects on bank swallow habitat suitability, large woody debris recruitment, flows
- TUGS model, effects on salmon spawning habitat suitability

1 decision support platform

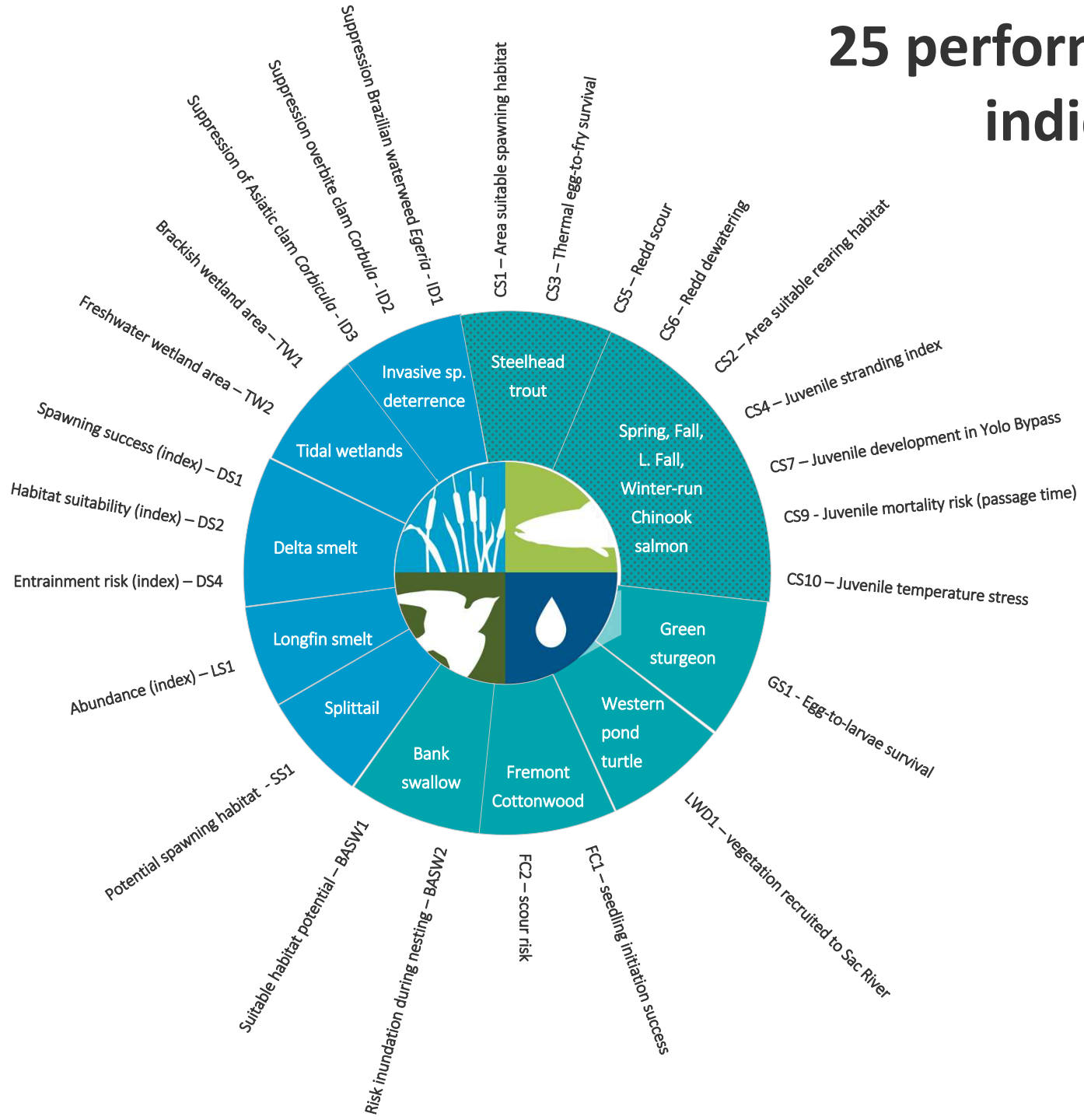
13 species



DeltaEFT
Delta Ecological Flows Tool

SacEFT
Sacramento River Ecological Flows Tool

25 performance indicators



Over 70 scientists

Core Team	SacEFT Workshop Participants		Delta EFT Workshop Participants & DeltaEFT Design contributors
Ryan Luster, TNC	Tricia Brachter, DFG	Peter Klimley, UC	Lori Chamurro, DFG
Mike Roberts, (formerly TNC)	Ron Schlorff, DFG	Eric Larsen, UC Davis	Dan Kratville, DFG
Greg Golet, TNC	Dave Zezulak DFG	Richard Corwin, USBR	Neil Clipperton, DFG
Maurice Hall, TNC	George Edwards, DFG	Ron Ganzfried, USBR	Tara Smith, DWR
Campbell Ingram, Delta Conservancy (formerly TNC)	Barry Garrison, DFG	John Hannon, USBR	Jim Long, DWR
Anthony Saracino, (formerly TNC)	Stacy Cepello, DWR	Buford Holt, USBR	Bill Harrell, DWR
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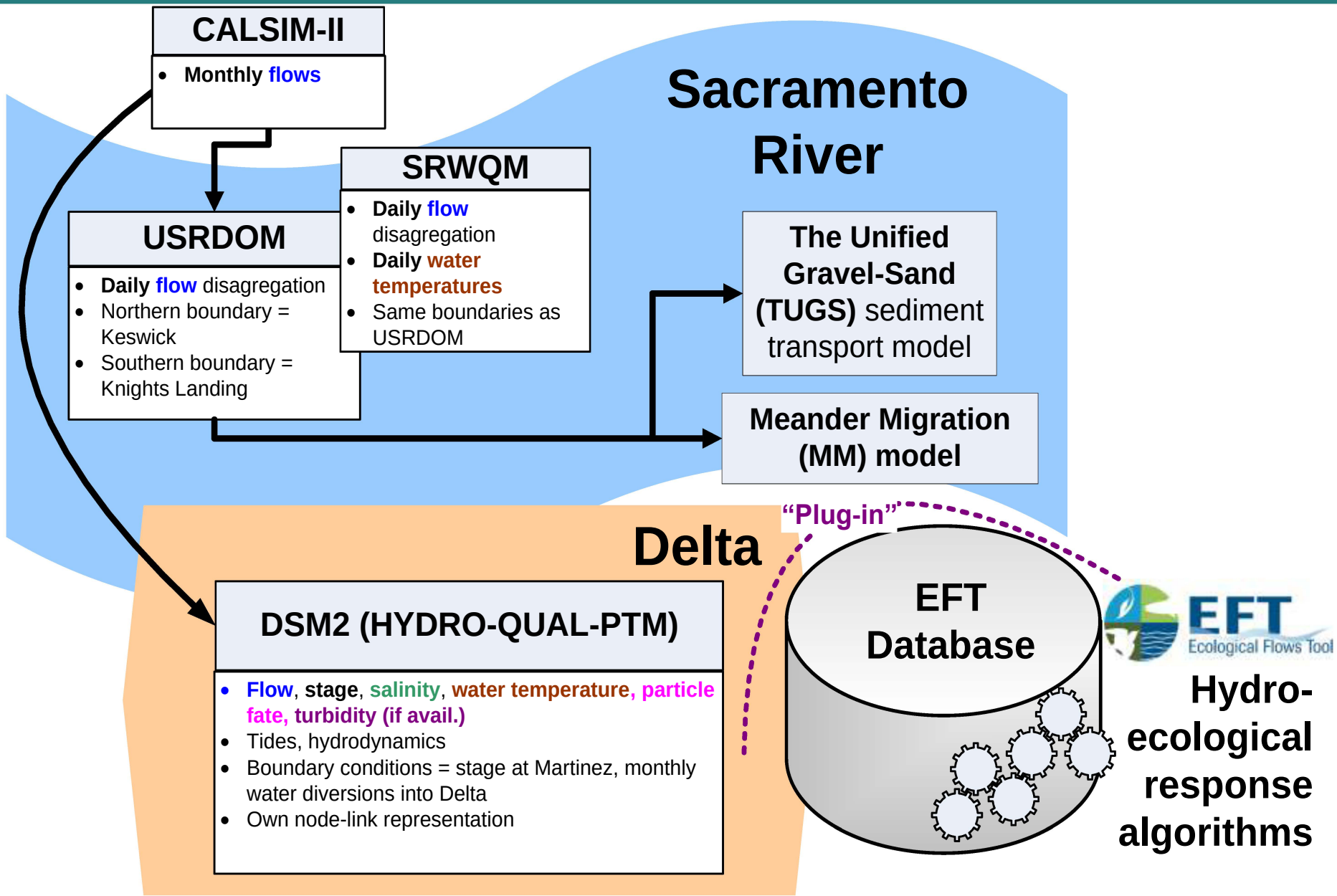
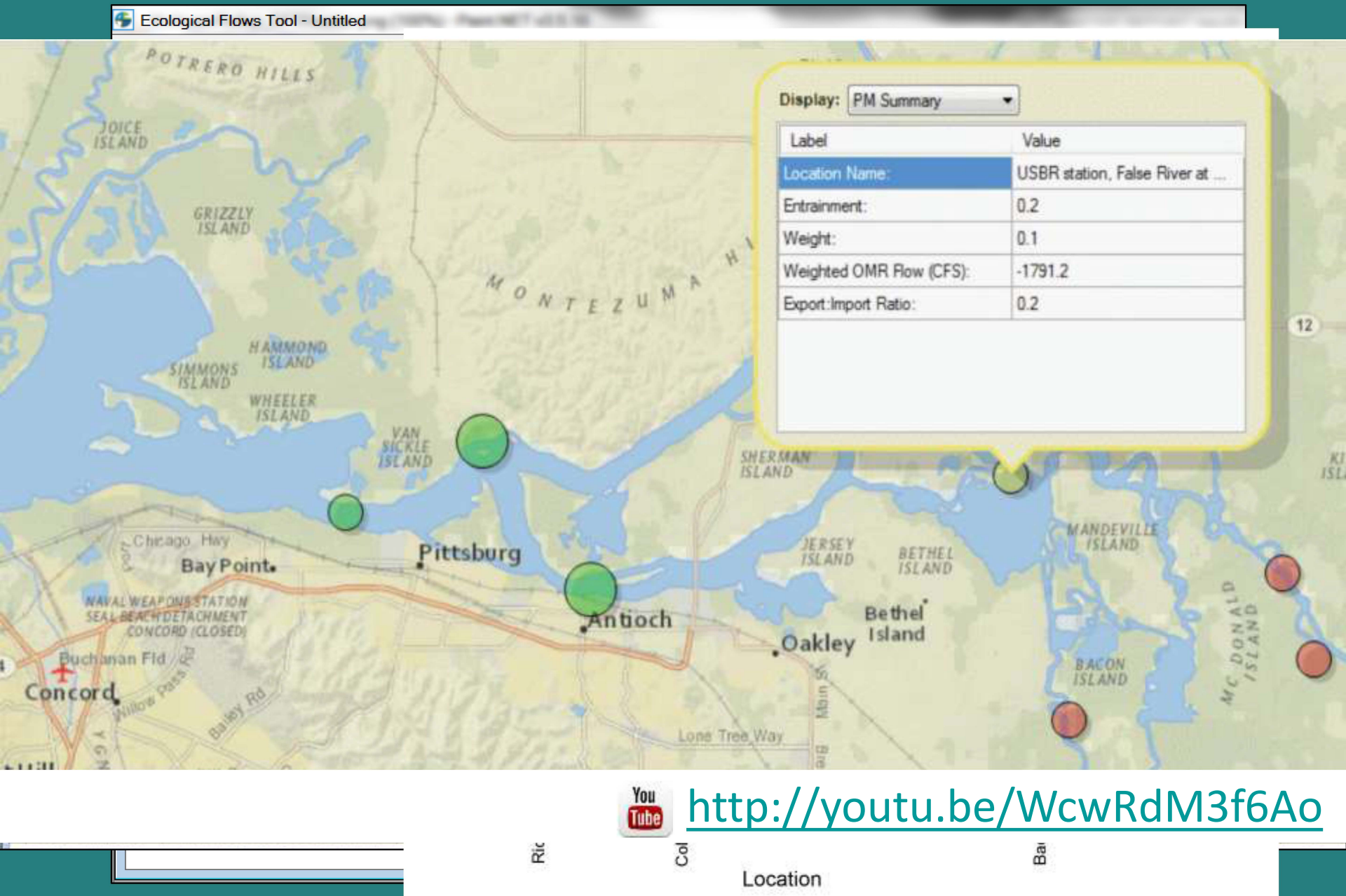
Katy Bryan, ESSA	Sean Sou, DWR	Andrew Hamilton, USFWS	Chandra Chimalkuri, CH2M Hill
David Carr, ESSA	Howard Brown, NMFS	Derek Hilts, USFWS	Michael Tansey, USBR
	Steve Lindley, NMFS	Brenda Olson, USFWS	Allison Willy, USFWS
	Bruce Oppenheim, NMFS	Bill Poytress, USFWS	Jon Rosenfield , The Bay Institute
	Naseem Alston, NMFS	Joe Silveira, USFWS	Lisa Lucas, USGS
	Brian Ellrott, NMFS	Jim Smith, USFWS	Larry Brown, USGS
	Tag Engstrom, CSU Chico	Joseph Terry, USFWS	Brett Kawakami, CCWD
	Dave Germano, CSU	Bruce Bury, USGS	John DeGeorge, RMA
	Josh Israel, UC Davis	Larry Brown, USGS	Dave Harlow, SWS
	Steve Greco, UC Davis	John Bair, McBain and Trush	Dave Fullerton, MWD
	Joe Heubler, UC Davis	Brad Cavallo, Cramer Fish Sciences	Michael Williams, consultant
	Michael Singer, UCSB	Nadav Nur, PRBO	Matt Nobriga, USFWS
	Ken Kirby	Nat Seavy, PRBO	Frederick Feyrer, USBR
	Tom Smith, Ayres Associates	Chrissy Howell, PRBO	Wim Kimmerer, SFSU
	Dave Vogel	Joel Van Eenennaam, UC Davis	Ted Sommer, DWR

Coupled modeling



Multiple outputs



http://youtu.be/WcwRdM3f6Ao

BDCP Effects Analysis Findings

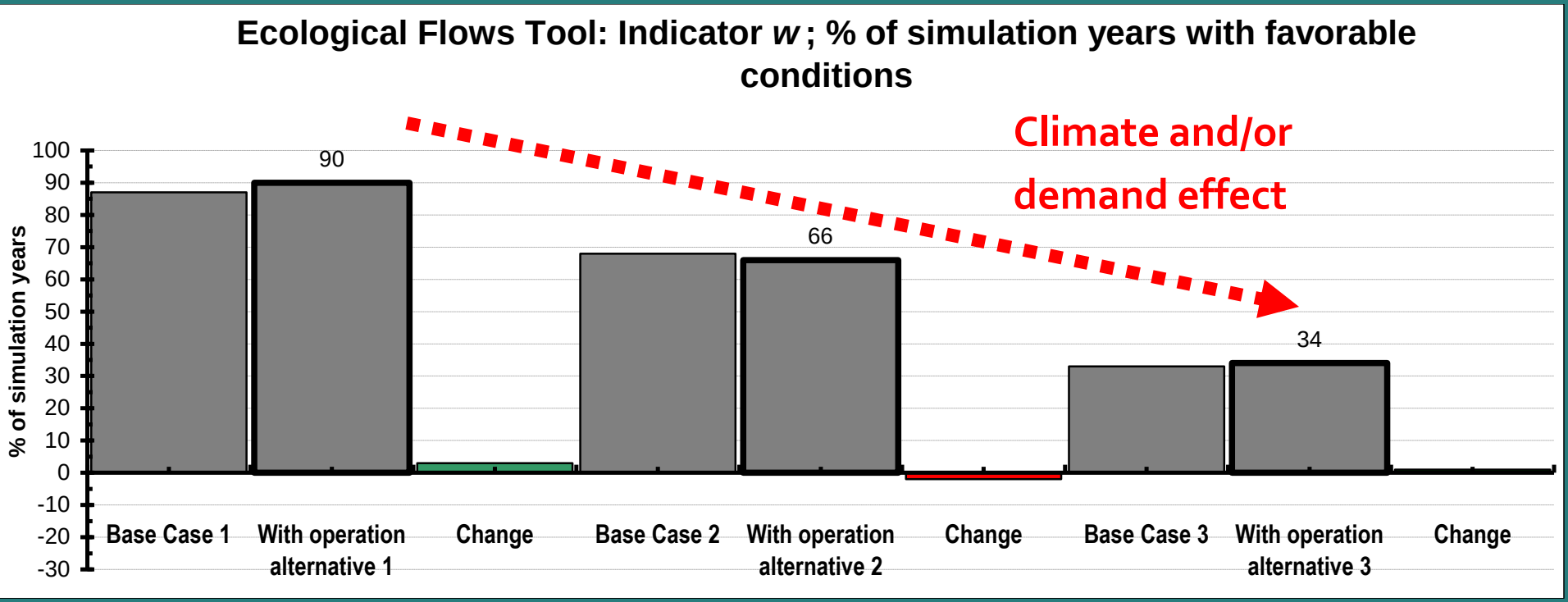
… "A world of winners & losers"

Table 3.36: Overall summary of "winners and losers" for the selected BDCP alternatives.

			Sacramento River species	San Joaquin-Delta species		
Focal species	***All Alternatives***	**ESO-ELT (237)**	**LOS-ELT (238)**	**HOS-ELT (242)**	**Primary benefit / [Challenge]**	**Caveats**
Fall Chinook	↑				**CS1**	
Late Fall Chinook	↑	*<benefit from ELT baseline conditions, not the alternatives>*			**CS2, CS7** [CS10]	Delta thermal stress (CS10)
Spring Chinook		↓	↑	↓	**CS1, CS6, CS2**	
Winter Chinook	No clear discriminatory results/preferences amongst alternatives (though *some* evidence conditions better under HOS)					Delta thermal stress (CS10)
Steelhead	No clear discriminatory results/preferences amongst alternatives					Delta thermal stress (CS10)
Bank Swallows	No clear discriminatory results/preferences amongst alternatives					
Green sturgeon	↓				[GS1]	
Fremont cottonwood	No clear discriminatory results/preferences amongst alternatives					
Large woody debris	No clear discriminatory results/preferences amongst alternatives					
Splittail	↑				Fremont weir notch included in all project alternatives	
Delta Smelt			↓		[DS2]	
Longfin Smelt				↑	**LS1**	
Invasive Deterrence	↓				[ID2]	
Tidal Wetlands	↓				We do not consider physical habitat restoration effects in this EFT analysis (did not have post restoration DEM)	

Climate change dwarfs effects of operational alternatives

- **Deteriorating baseline comparisons mask "what matters" ecologically**



Current **ELT** **LLT**

BDCP effects analysis findings

Major finding No.4:

- **Reservoir operation criteria cemented in BDCP effects modeling are highly constrained, limiting ability of BDCP to fully explore & realize opportunities.**

Pilot test: integrating EFT with systems operations models

CALSIM suite → EFT Ecological Flows Tool

Incorporating EFT derived ecological flow criteria to CALSIM

CALSIM suite ⇄ EFT Ecological Flows Tool

Initial Pilot Results

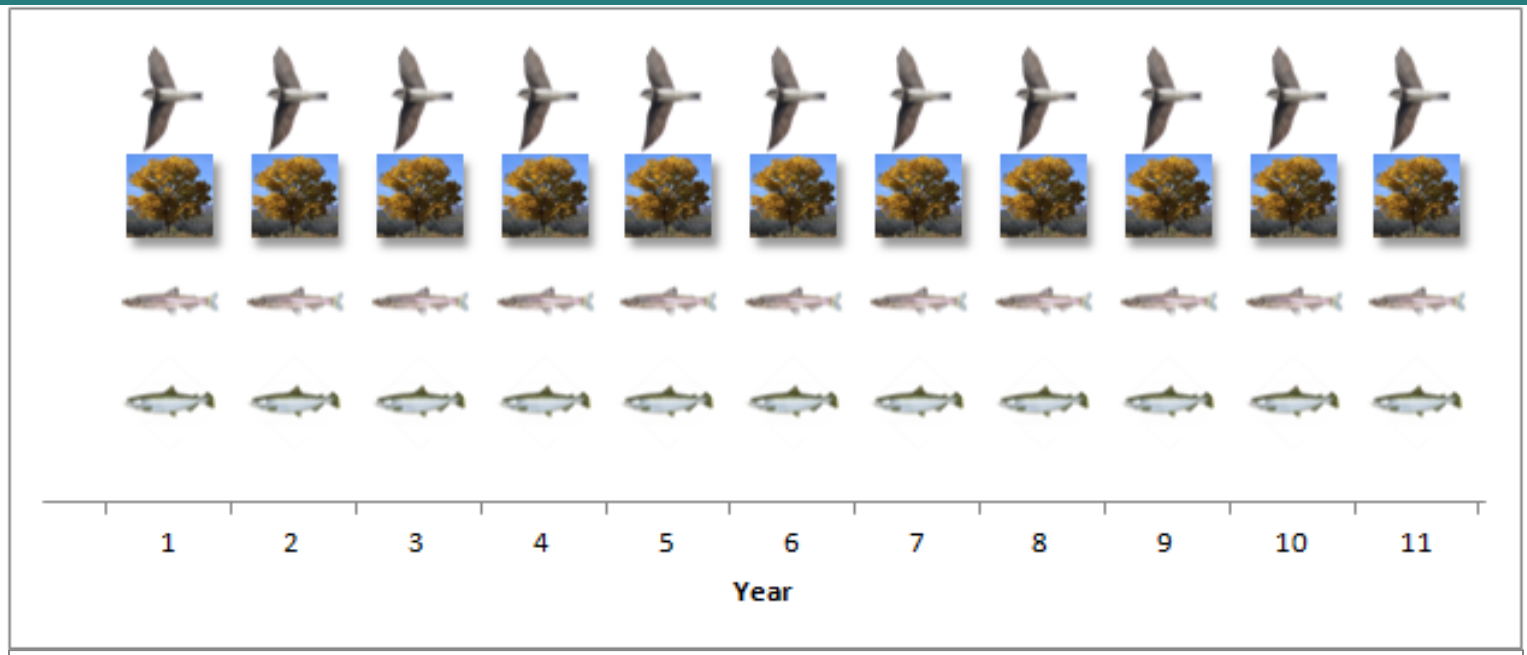
Fall Chinook	Spawning WUA (CS1)	-14
	Thermal egg mortality (CS3)	4
	Redd Dewatering (CS6)	-1
	Redd Scour (CS5)	0
	Juvenile Stranding (CS4)	0
	Rearing WUA (CS2)	-5
Late Fall Chinook	Spawning WUA (CS1)	-2
	Thermal egg mortality (CS3)	0
	Redd Dewatering (CS6)	1
	Redd Scour (CS5)	0
	Juvenile Stranding (CS4)	0
	Rearing WUA (CS2)	3
Spring Chinook	Spawning WUA (CS1)	-15
	Thermal egg mortality (CS3)	11
	Redd Dewatering (CS6)	36
	Redd Scour (CS5)	2
	Juvenile Stranding (CS4)	5
	Rearing WUA (CS2)	-12
Winter Chinook	Spawning WUA (CS1)	35
	Thermal egg mortality (CS3)	2
	Redd Dewatering (CS6)	21
	Redd Scour (CS5)	0
	Juvenile Stranding (CS4)	34
	Rearing WUA (CS2)	-10
Steelhead	Spawning WUA (CS1)	-1
	Thermal egg mortality (CS3)	0
	Redd Dewatering (CS6)	-2
	Redd Scour (CS5)	3
	Juvenile Stranding (CS4)	2
	Rearing WUA (CS2)	-13

- Jagger's Law*: inverse correlations exist

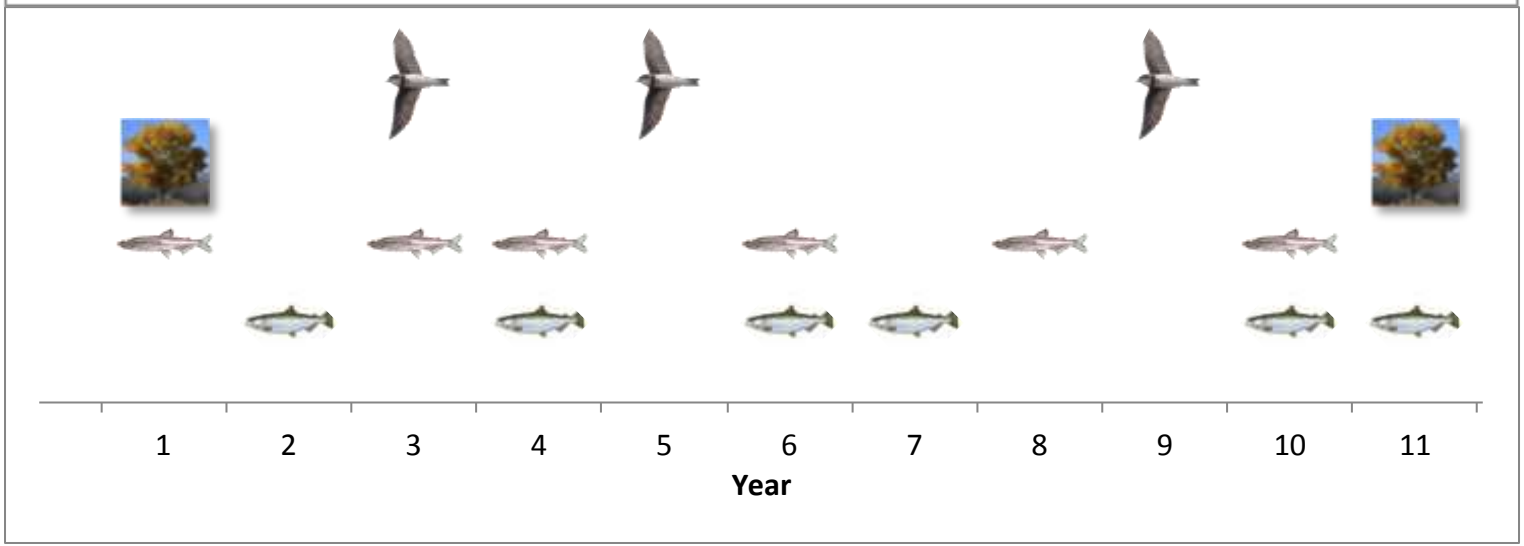
**** You can't always get what you want***

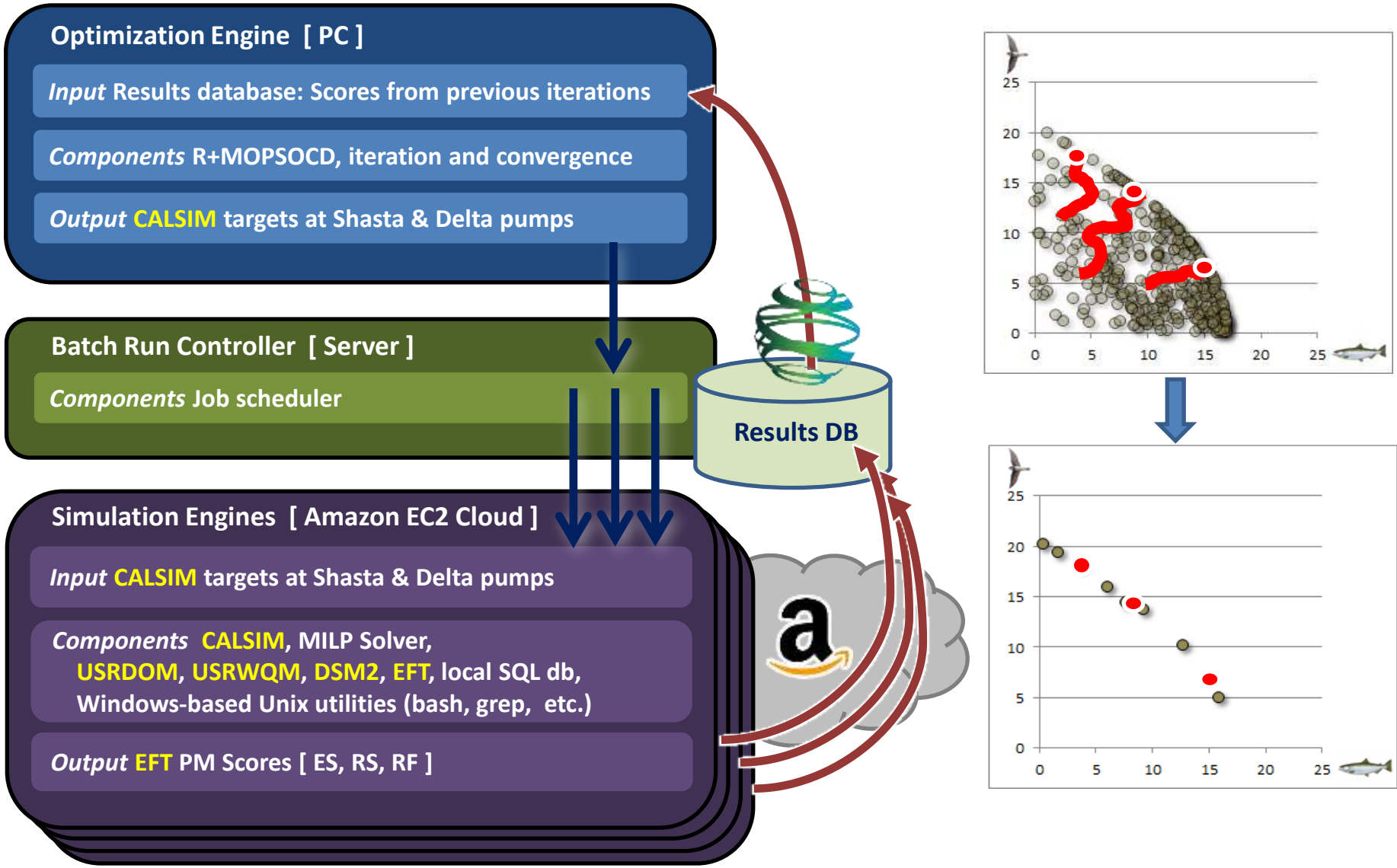
A New Paradigm:
Flexible ecosystem priorities

Existing



New Paradigm




Optimization Engine [PC]
Input Results database: Scores from previous iterations
Components R+MOPSOCD, iteration and convergence
Output CALSIM targets at Shasta & Delta pumps
Batch Run Controller [Server]
Components Job scheduler
Results DB
Simulation Engines [Amazon EC2 Cloud]
Input CALSIM targets at Shasta & Delta pumps
Components CALSIM, MILP Solver,
USRDOM, USRWQM, DSM2, EFT, local SQL db,
Windows-based Unix utilities (bash, grep, etc.)
Output EFT PM Scores [ES, RS, RF]
0
5
10
15
20
25

Where to from Here?

A new paradigm: **flexible** ecosystem priorities

- **Multiple, equally acceptable solutions exist**
- **Smart, state-dependent priorities**
- **Build multi-objective, state-dependent optimization engine**

Sustained refinement & application of EFT

- **EFT one element of community modeling hub**
- "Gathering place" for generally accepted functional relationships / algorithms
- Every CALSIM run should be coupled with an EFT run

Design **adaptive management** experiments, **real-time** decision support tools

- Disproportionate amount of effort devoted to water planning models in California

Information

EFT software & Final Report:

essa.com/tools/ecological-flows-tool/

eft-userguide.essa.com/

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RESERVES

(e.g., to support Q&A)

Recent EFT applications

North-of-the-Delta Offstream Storage Investigation

- SacEFT
- 5 alternatives including reference case

BDCP

- SacEFT & DeltaEFT
- 8 alternatives including reference case and future climate change variants
- Full analysis

Pilot investigation – Incorporating EFT Derived Ecological Flow Criteria to CALSIM

- Rule-sets converted to WRESL
- Winter-run chinook and Delta smelt

History

2004-2007

- TNC pilot studies riparian vegetation Sacramento River
- **Flows Study**

2008

- Finished Flows Study
- **Delivered SacEFT v.1**

2009

- **DeltaEFT design workshop**
- <California Bond Freeze>

2010

- **SacEFT v.2**
- Completed DeltaEFT design guidelines
- **SacEFT v.2 applied to BDCP**
- Data access negotiations for DeltaEFT (protracted)

History (cont'd)

2011

- SacEFT CWEMF presentation
- **SacEFT v.2 applied to NODOS EIS/R**
- DeltaEFT development

2012

- **Completed DeltaEFT v.1**
- EFT users guide (Reader software)
- DeltaEFT applied to BDCP
- DeltaEFT presentations to SWRCB

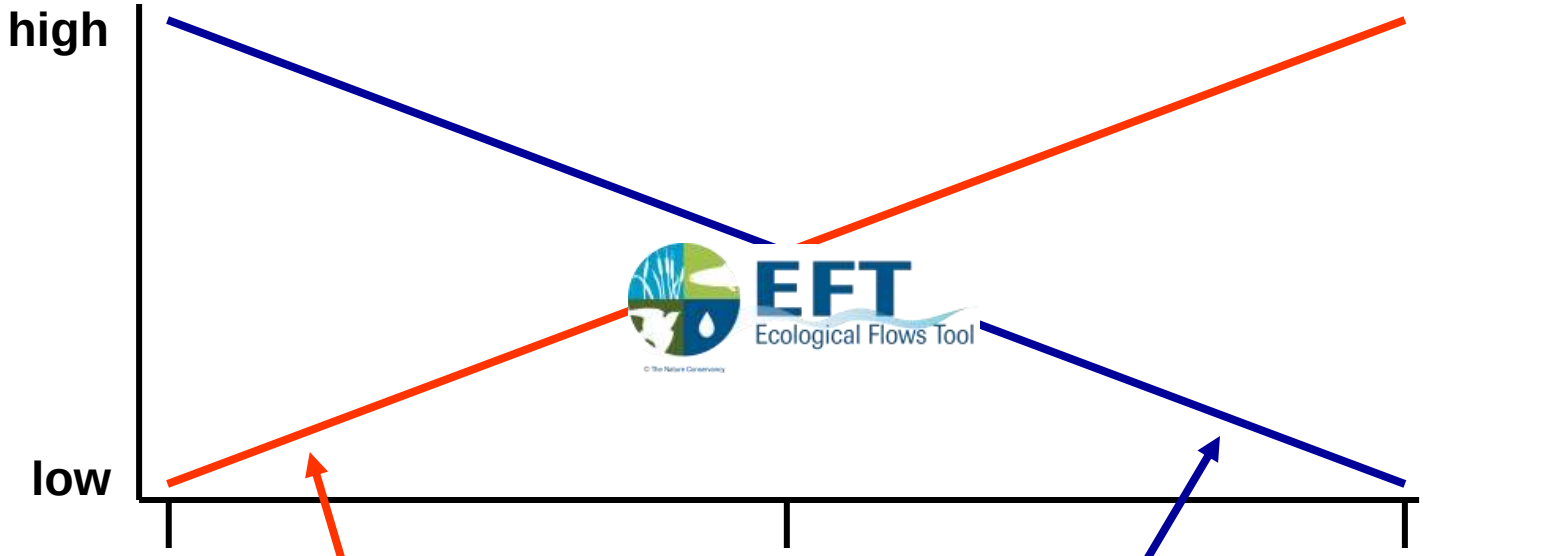
2013

- **Full BDCP effects analysis modelling**
- **Testing alternative EFT flow requirements** (CALSIM)

2014

- **Completed EFT Final Report**

Sufficient detail …



Things that increase w complexity

- spatial / temporal resolution
- acceptability to disciplinary specialist
- perceived "realism" of process representation
- cost
- tuning & equifinality

Things that decrease w complexity

- ability to understand model behaviour
- ease of application (data, cost)
- ease of interdisciplinary linkage
- community of users (shrinks)

EFT relative suitability (RS) thresholds

Table 2.10: Summary of the default relative suitability (RS) thresholds and associated reference time periods used to rate EFT indicators as favorable, fair, or poor. Refer to Appendix G for additional details. Dates for some major infrastructure works are also indicated. [δ]

Indicator Name	Good [δ]		Threshold Setting Method			
			A	D	T	Years for D,T
Sacramento River Ecoregion						
Shasta Dam: construction began 1937, complete 1945 Keswick Dam: construction began 1941, complete 1950						
FC1 Cottonwood initiation		↑			✓	1943 – 2004 (H); n = 62
FC2 Cottonwood scour risk	↓		✓			–
BASW1 Bank swallow habitat potential		↑			✓	1940 – 1994 (H); n=55
BASW2 Bank swallow inundation risk	↓		✓			–
LWD1 Large woody debris recruitment		↑			✓	1940 – 1994 (H); n=55
GS1 Green sturgeon egg-to-larvae survival		↑	✓			–
CS1 Salmonid spawning habitat		↑		✓		1939 – 2002 (H); n=64
CS3 Salmonid egg-to-fry survival		↑	✓			–
CS5 Salmonid redd scour	↓		✓			–
CS6 Salmonid redd dewatering	↓			✓		1971 – 2002 (H); n=32
CS2 Salmonid rearing habitat		↑			✓	1939 – 2002 (H); n=64
CS4 Salmonid juvenile stranding	↓				✓	1971 – 2002 (H); n=32
Delta Ecoregion						
Banks pumping plant: complete 1963 Tracy pumping plant: construction began 1963, complete 1967						
CS7 Salmonid juvenile development in Yolo		↑		✓		2002 – 2007 (H); 1976 – 1991 (S); n=22
CS9 Salmonid juvenile mortality risk	↓			✓		2002 – 2007 (H); 1976 – 1991 (S); n=22
CS10 Salmonid juvenile temperature preference	↓			✓		2002 – 2007 (H); 1976 – 1991 (S); n=22
DS1 Delta smelt spawning success		↑			✓	2002 – 2010 (H); n=9
DS2 Delta smelt habitat suitability		↑	✓			–
DS4 Delta smelt entrainment risk	↓				✓	1989 – 2000 (H); 1975 – 1991 (S); n=29
LS1 Longfin smelt abundance		↑			✓	2002 – 2008 (H); 1975 – 1991 (S); n=24
SS1 Splittail spawning habitat		↑			✓	1989 – 2010 (H); n=22
TW1 Brackish tidal wetland		↑			✓	2002 – 2006 (H); 1975 – 1991 (S); n=22
TW2 Freshwater tidal wetland		↑			✓	1997 – 2010 (H); 1975 – 1991 (S); n=31
ID1 Egeria suppression		↑	✓			–
ID2 Corbula suppression		↑	✓			–
ID3 Corbicula suppression		↑	✓			–

[δ] *Key to Good:* ↑ = More of the indicator is better; ↓ = Less of the indicator is better. *Key to Threshold Setting Method:* A = Absolute; D = Discontinuity; T = Tercile. *Key to Years:* H = Historical observations; S = Simulated/proxy data intended to portray a typical condition.