Assessing Water Needs for the Sacramento-San Joaquin Delta

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Goals of Flow Estimates

- Examine Methods used that have provided insight into water needs
- Identify sustainable goals for ‘Future’ Delta
- Initiate systematic conversation on Delta flow

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Hydrologic and Ecosystem Links

- Flow Regime is a Major Determinant of Physical Habitat
- Species Life Histories Strategies Responded to Natural Flow Variations
- Habitat Connectivity is Essential to Many Species
- Invasive Species are Promoted by Flow Alterations

Bunn and Arthington 2002

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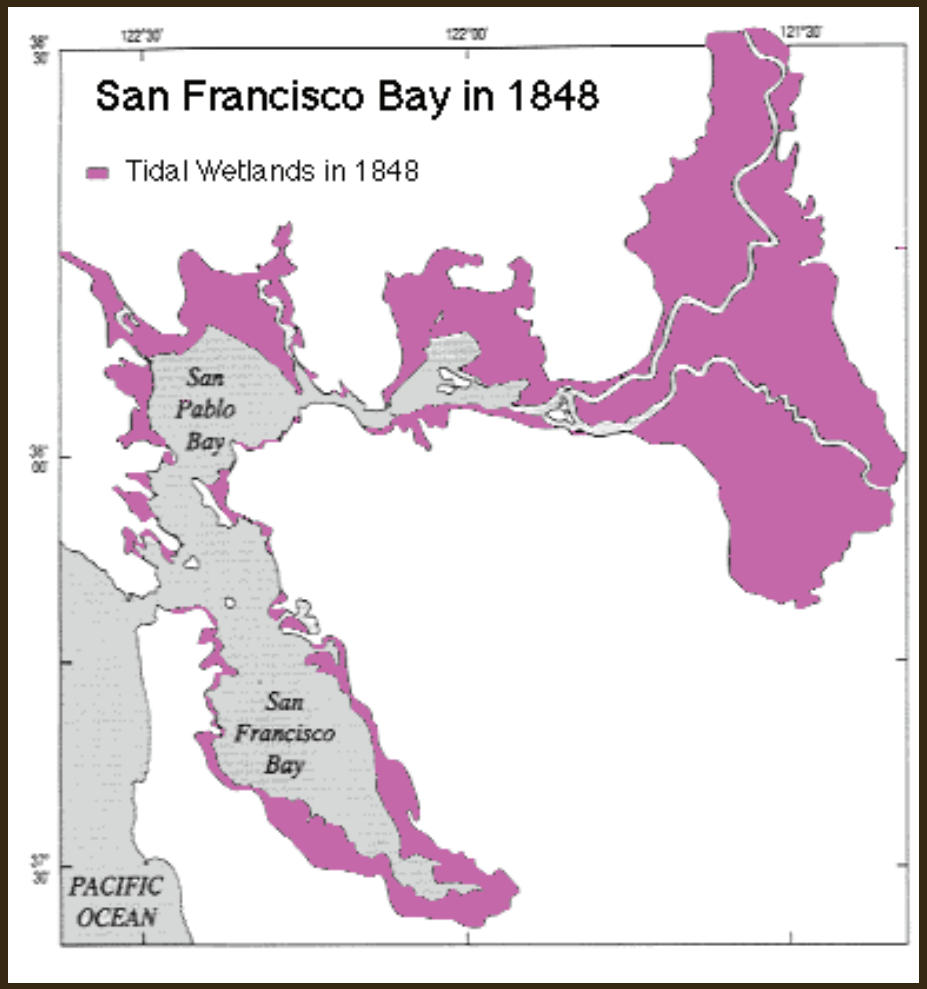
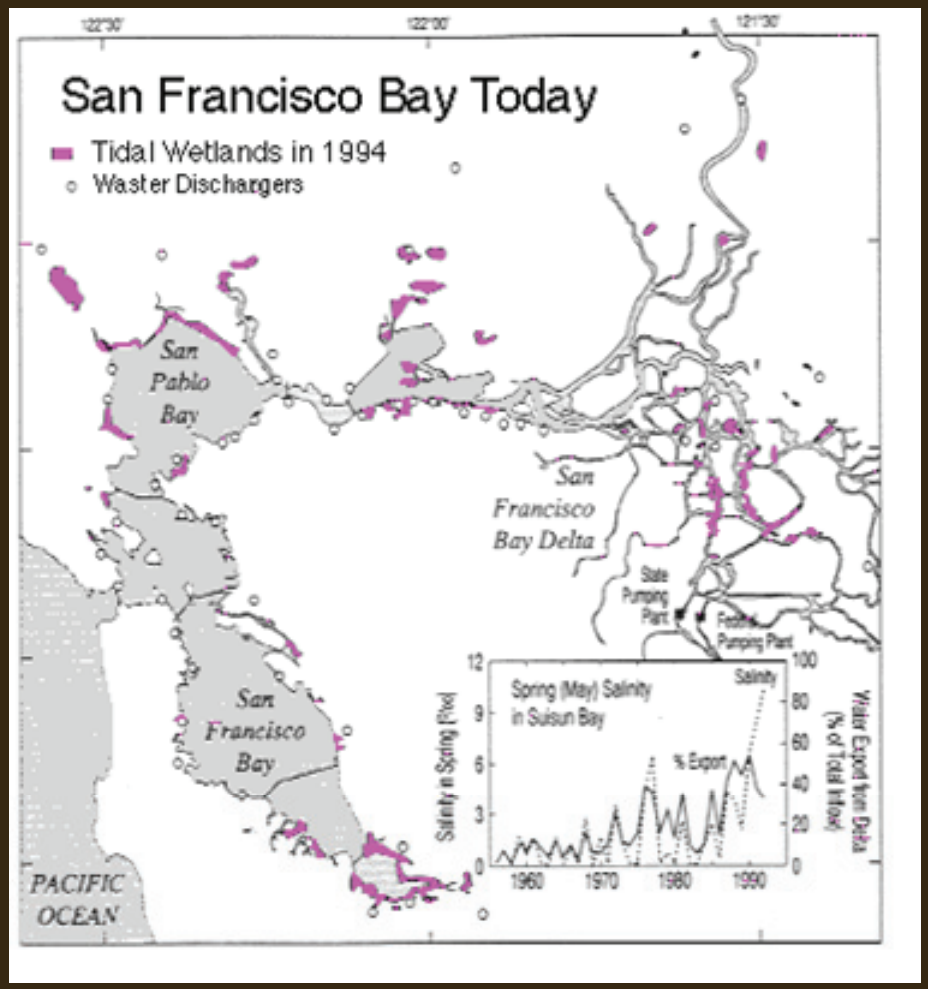
San Francisco Bay Estuary and Delta





1848 before gold rush

1994 after development

http://sfbay.wr.usgs.gov/general _factsheets/change.html

Instream Flow Incremental Methodology (IFIM)

- Vilizzi 2004
- Tharme 2003
- Gore et al. 2001
- Vismara et al. 2001
- Elliott et al. 1999
- Jowett 1998
- Van Winkle et al. 1998
- Gore et al. 1998
- Leclerc et al. 1996
- Johnson et al. 1995
- Layzer and Madison 1995
- Gore et al. 1991

Based on mean or median Full Natural Runoff (FNR)

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Florida Flow Regulations

- Minimum is “the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area.”
- Originally set as a 10% impairment to the fresh water inflow
- Alafia River Estuary – studies set the limit at 19% of the low flow period – 2008
- A study on the Lower Hillsborough River doubled the previous minimum outflow to the estuary – 2006

Flannery *et al.* 2002, 2008
SWFWMD 2006

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Texas Flow Law Development

- In 1977 Texas law mandated "beneficial inflows" that are associated with "a salinity, nutrient, and sediment loading regime adequate to maintain an ecologically sound environment in the receiving bay and estuary system”
- Senate Bill 2 in 2001 - " establish … an instream flow data collection and evaluation program and … determine appropriate methodologies for determining flow conditions … necessary to support a sound ecological environment"

http://midgewater.twdb.state.tx.us/bays_estuaries/b_nEpage.html#methodology

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Texas Flow Guidelines

- sustains the full complement of native species in perpetuity;
- sustains key habitat features required by these species;
- retains key features of the natural flow regime required by these species to complete their life cycles; and
- sustains key ecosystem processes and services, such as elemental cycling and the productivity of important plant and animal populations.

TCEQ Report #SAC-2009-03

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Texas Flow Methods

- TXEMP – estuarine mathematical optimization programming model
  - quantitative inflow-salinity/inflow-abundance relationships
- TXBLEND – hydrodynamic and conservative transport model
  - Check on salinity output of the TXEMP empirical output

Longley, W.L., ed. 1994

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Texas Flow Methods Output

- **maxC** - flow of optimum abundance of species of interest
- **minQ** - minimum flow to obtain acceptable percentage of maxC
- **maxQ** - maximum flow to retain acceptable percent of maxC (20-90% of mean)
- **minQsal** - minimum flow based on desired salinity regime (~10-30% of mean)

Longley, W.L., ed. 1994

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New BBEST Rules

- Standard State Method
- Salinity Zone Approach
- Hydrology Based Approaches
  - hydrology-based environmental flow regime (HEFR)
- NWF Inflow Pattern Approach
  - primarily a natural flow approach
- Percent of Flow Approach
- TNC (IHA/EFC) Approach

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Texas Flow Methods Output

- Sabine Estuary
  - maxC – 9.6 maf
  - minQ – 7.1 maf
  - maxQ – 11.6 maf
- Trinity-San Jacinto Estuary
  - maxC – 5.22 maf
  - minQ – 4.16 maf
  - maxQ – not given

Kuhn, G.L. and G Chen 2005
Lee, W.D. *et al.* 2001

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Methods Considered

- Unimpaired Flows (1921-2003)
- Historical Flows when fish were ‘doing better’ (1949-1968)
- Historical Flows when fish were declining (1986-2005)
- Prescribed Flows based on recent research literature

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Unimpaired Flows (1921-2003)

- Not historic ‘natural’ flows into the Delta
  - Watershed receives more rain and less snow today and snow melt is earlier
  - Conveyances to the Delta no longer have floodplains to attenuate the flow peaks
  - Delta itself is channelized with little marsh or floodplains
  - Base-flow changes not considered

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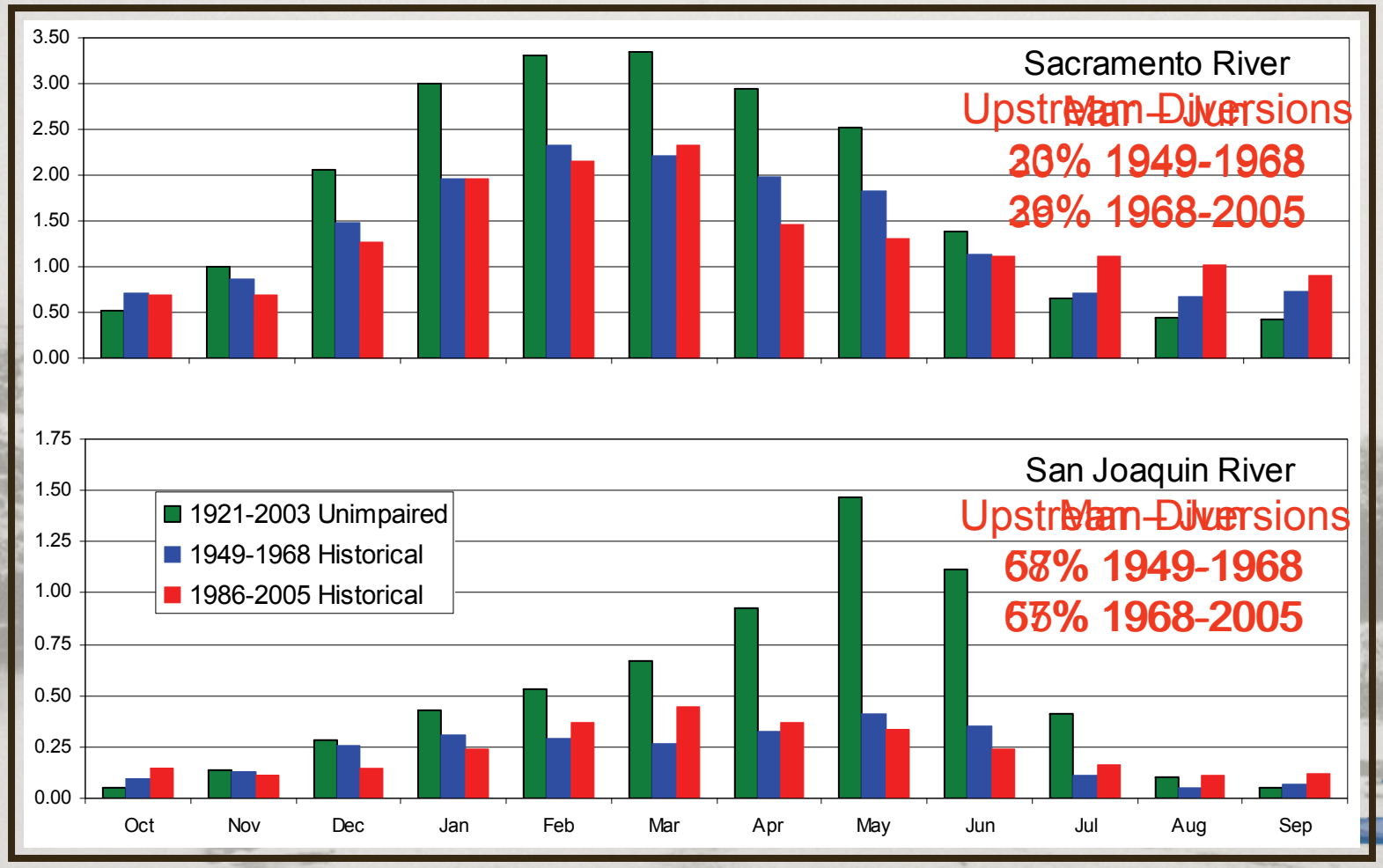
Major Inflows to Delta (maf/mo)

(mean annual flows)



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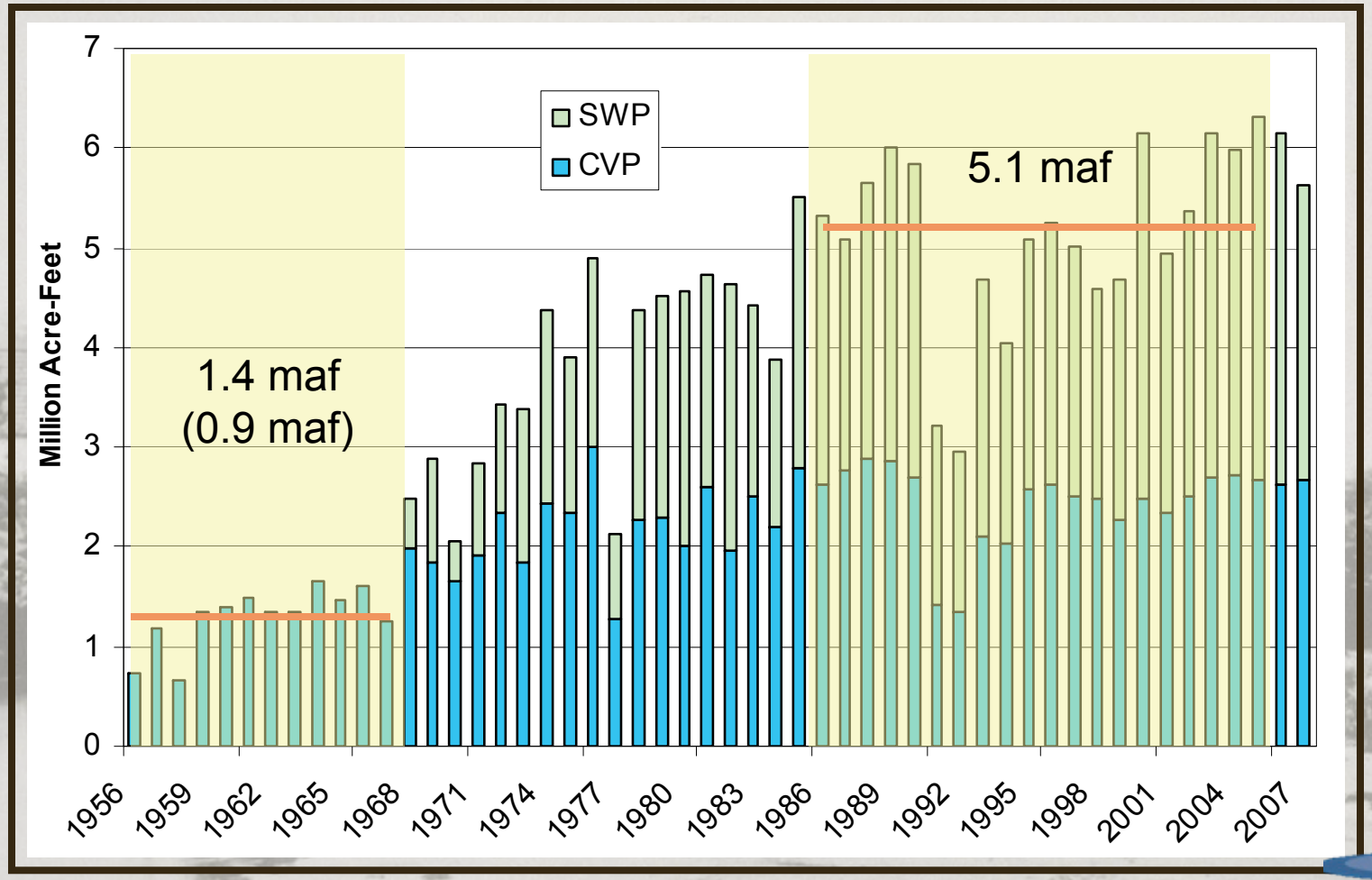
Exports from Delta (maf/yr)



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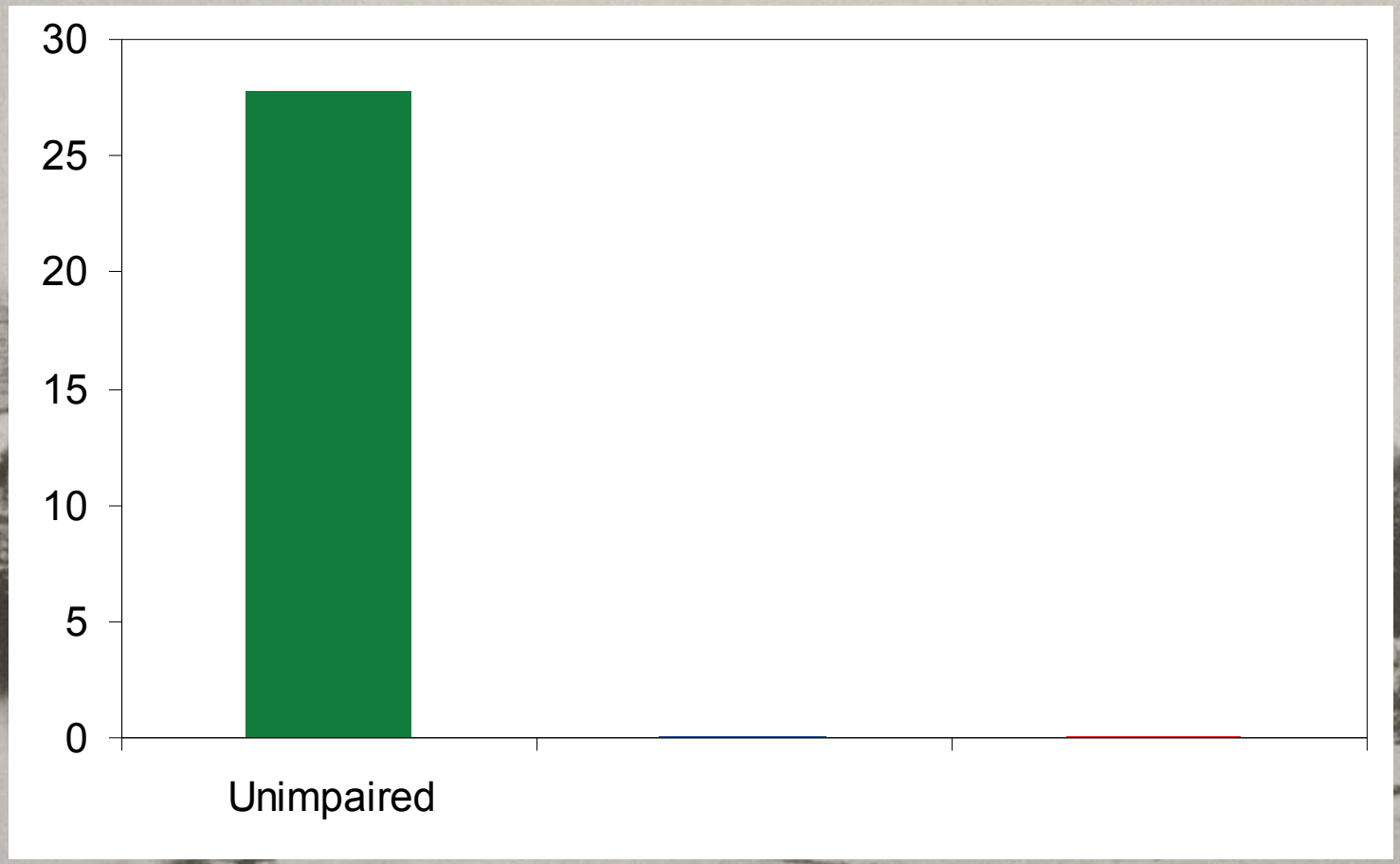
Total Delta Impairments (maf/yr)
(upstream and exports)



Prescribed Flow Method

Sacramento River & Yolo Bypass

Category	Item	Function	Flow (cfs)	Months Applied												Years of 10
				1	2	3	4	5	6	7	8	9	10	11	12	
1. Yolo Bypass	1a	juvenile salmon, adult splittail most years	2,500[a]		1	1	1									8
	1b	juvenile salmon, adult splittail pulses	4,000[b]			1	1									6
2. Sac River	2a	SR adult salmon	10,000	1	1	1	1	1	1				1	1	1	6
	2b	Juvenile salmon migration - SR	25,000			1	1	1	1							6
	2c	Adult sturgeon	70,000	1	1	1	1	1								1
	2d	Min flow past PC intake	10,000	1	1	1	1	1	1	1	1	1	1	1	1	10
		Safety Factor	20%													

[a,b] require flows at Freeport of approximately 39,000 and 42,000 cfs respectively

1a. & 1b. BDCP draft report 2008 , Moyle et al. 2004; Sommer et al. 2004; Harrell and Sommer 2003; Harrell et al. 2009

1c. BDCP draft report 2008

2a. & 2b. Newman and Rice 2002, Williams 2006; Harrell et al. 2009, USFWS Exhibit 31 1987, Kjelson and Brandes 1989

2c. Harrell and Sommer 2003

2d. Newman and Rice 2002

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Prescribed Flow Method

San Joaquin & Eastside Streams

Category	Item	Function		Flow (cfs)	Months Applied												Years of 10
					1	2	3	4	5	6	7	8	9	10	11	12	
3. SJ Valley	3a	SJR juvenile salmon	WET	20,000				1	1	1							2
			AN	15,000				1	1	0.5							4
			BN	10,000				1	1								6
			DRY	7,000				1	0.5								8
			CRIT	5,000				1									10
	3b	Stockton Ship Channel DO		2,000							1	1	1	1			10
	3c	SJR adult salmon		2,000	1	1	1	1	1	1	1	1	1	1	1	1	10
4. Eastside Streams	4a	Mokelumne River flows		1,500			1	1									8
	4b	Eastside Stream min flows		1,060	1	1	1	1	1	1	1	1	1	1	1	1	9
		Safety Factor		20%													

3a. CDFG 2005, USFWS Exhibit 31 1987, Newman and Rice 2002, Williams 2006

3b. Lehman et al. 2004, Jassby and Van Nieuwenhuyse 2005, USFWS Exhibit 31 1987, Newman and Rice 2002, Williams 2006

3c. USFWS Exhibit 31 1987, Newman and Rice 2002, Williams 2006

4a. Henson et al. 2007

4b. Moyle et al. 2007

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Prescribed Flow Method

Net Delta Outflows

Category	Item	Function	Flow (cfs)	Months Applied												Years of 10
				1	2	3	4	5	6	7	8	9	10	11	12	
5. Net Delta Outflows	5a	Delta smelt flows	48,000			1	1	1								5
	5b	Egeria suppression by reducing outflows	8,000							1	1					3
	5c	Overbite clam suppression by increasing flows	120,000		1	1	1									3
Other	6a	Suisun Marsh Flows														
	6b	Close or Limit exports														
		Safety Factor	20%													

5a. Bennett 2005, Hobbs et al. 2005

5b. Hauenstein and Ramirez 1986

5c. Thompson 2005, Moyle personal comm.

6a. Bennett personal comm.

6b. Your favorite federal judge

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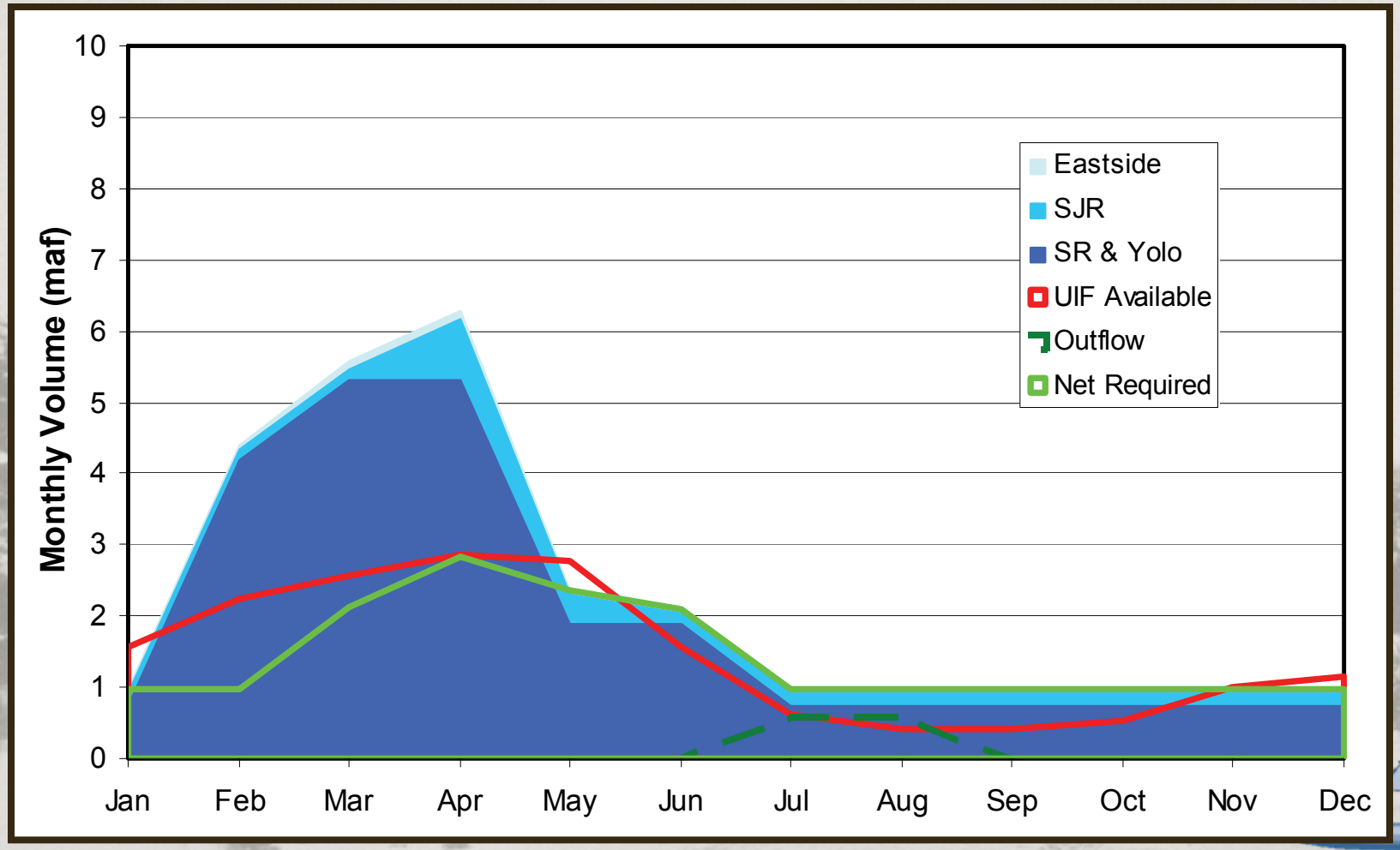
30 Percentile Flows



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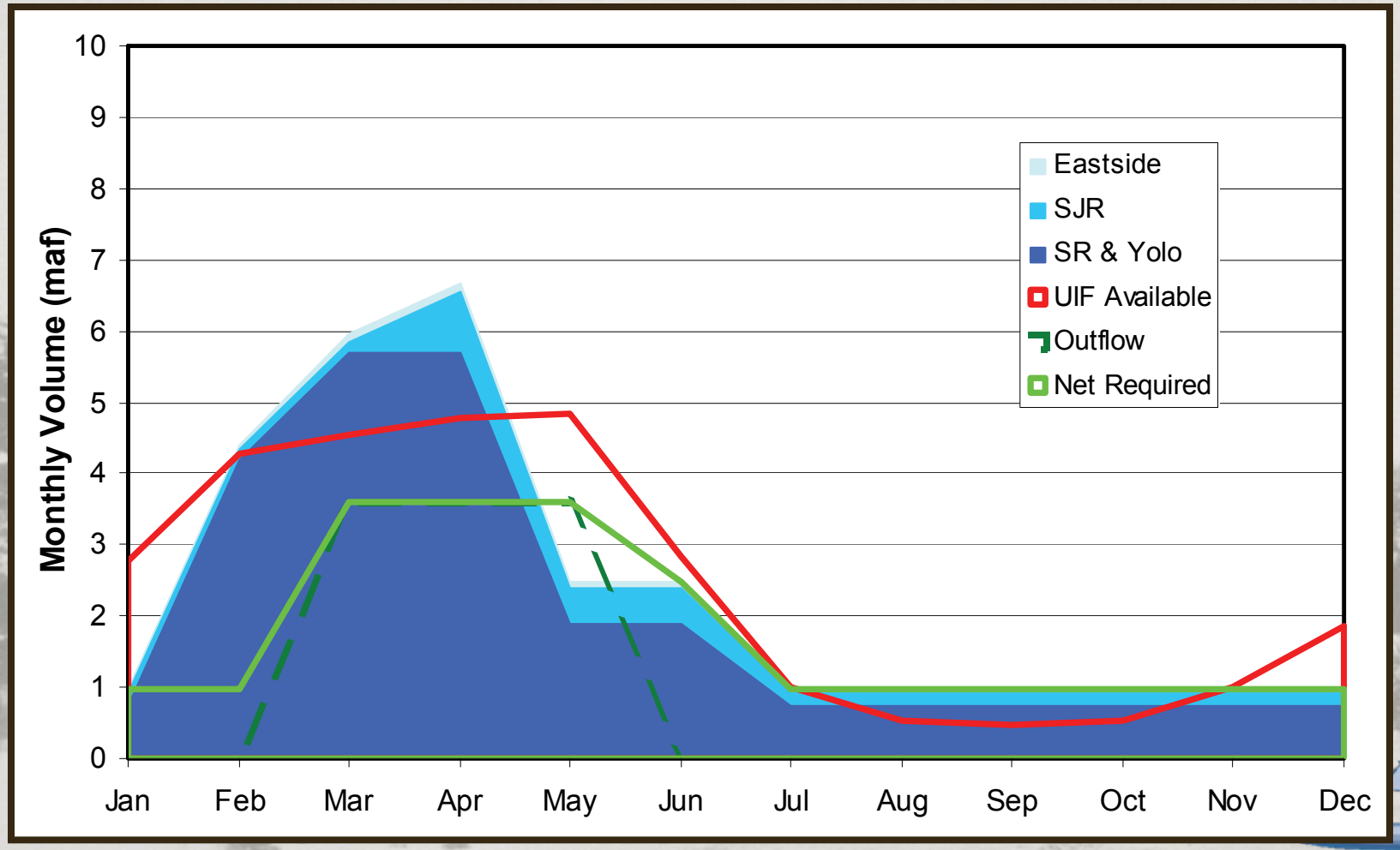
60 Percentile Flows



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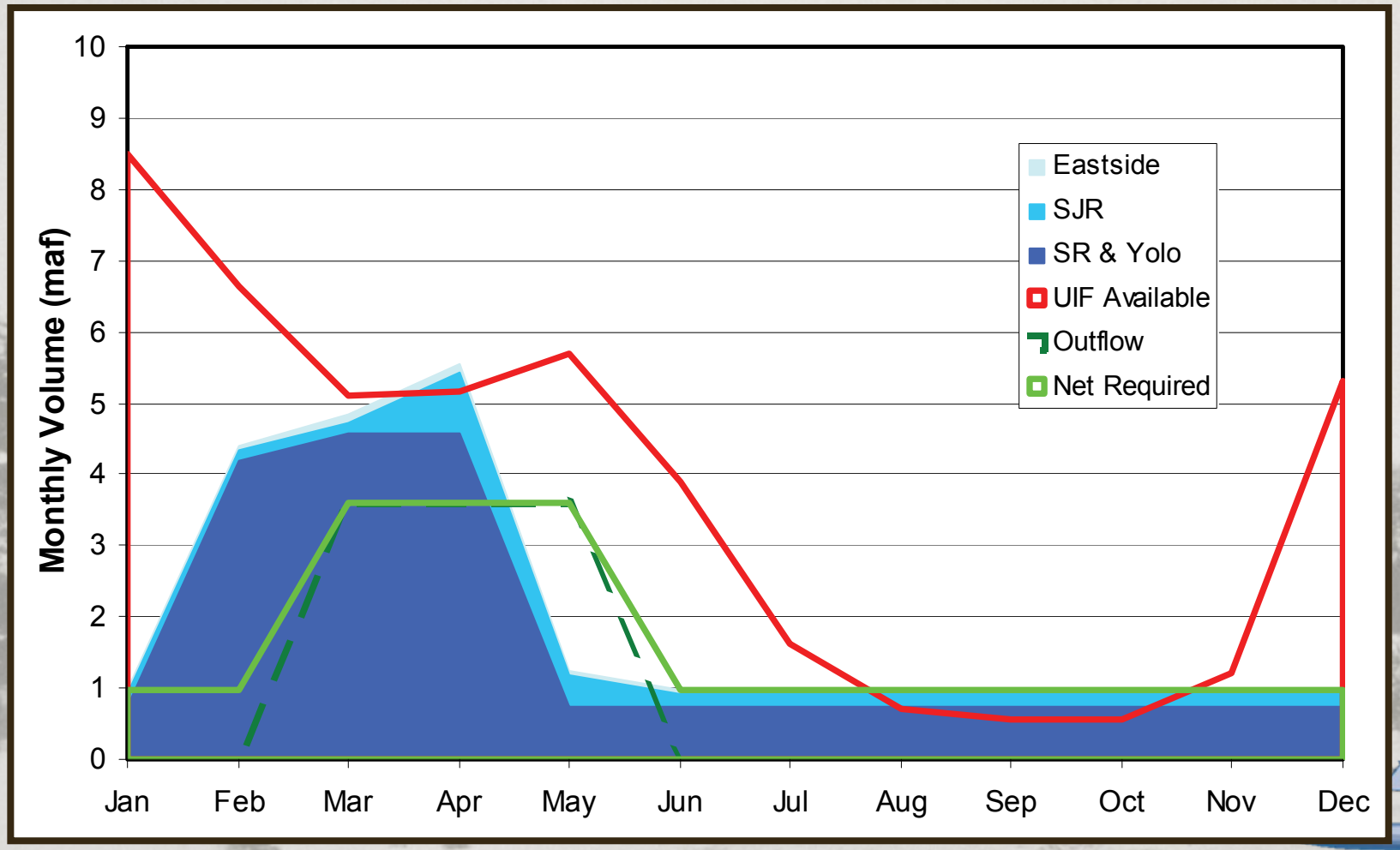
90 Percentile Flows



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Tiburon Report

Dr. Luna Leopold, 1987

… the amount of water diverted has continued to increase with time despite the data on biologic populations and salinity that have given ample warnings that even the present amount of diversion is impacting the ecosystem.

20 years after 1987 exports have increased 30+% over previous 20 years

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Questions?

Where do we go from here?

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Method Comparison

Flow	Average Historical Annual Flows (maf/yr)		Unimpaired (maf/yr)
	1949-1968 (Low, **Ave,** High)	**1986-2005**	**1921-2003**
Sacramento River (including YBP)	10.9, **19.1**, 35.5	7.6, **18.8**, 38.7	5.6, **21.6**, 48.4
San Joaquin River	0.4, **2.7**, 7.1	0.7, **2.8**, 8.5	1.1, **6.2**, 19.0
Eastside Streams	0.1, **1.4**, 3.5	0.1, **0.9**, 2.6	0.2, **1.6**, 5.5
Delta outflows	9.6, **21.3**, 42.8	3.9, **16.6**, 43.6	5.6, **28.2**, 71.9