The Future of the Delta Ecosystem and its Fishes Appendix D

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November 12, 2008

BASIC FACTS ABOUT DELTA FISHES AND THEIR ECOSYSTEM

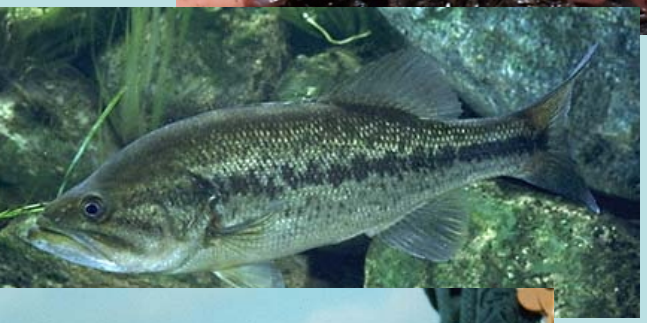
- Delta has a diverse fish fauna
- There will always be a Delta ecosystem
- The ESA gives Delta fish clout
- The Delta is poor habitat for key fish species
- The Delta cannot be maintained in its present configuration
- Major change is on its way

THE DELTA HAS A DIVERSE FISH FAUNA

26 common species

Fish fauna 50+ species, over 50% aliens

Fish fauna 50+ species, over 50% aliens



No matter what happens, the Delta will have lots of fish….

THERE WILL ALWAYS BE A DELTA ECOSYSTEM

Headlines, September 1, 2007

Federal judge's ruling will reduce water supply to save 3-inch-long smelt.

Order will slow delta's pumps

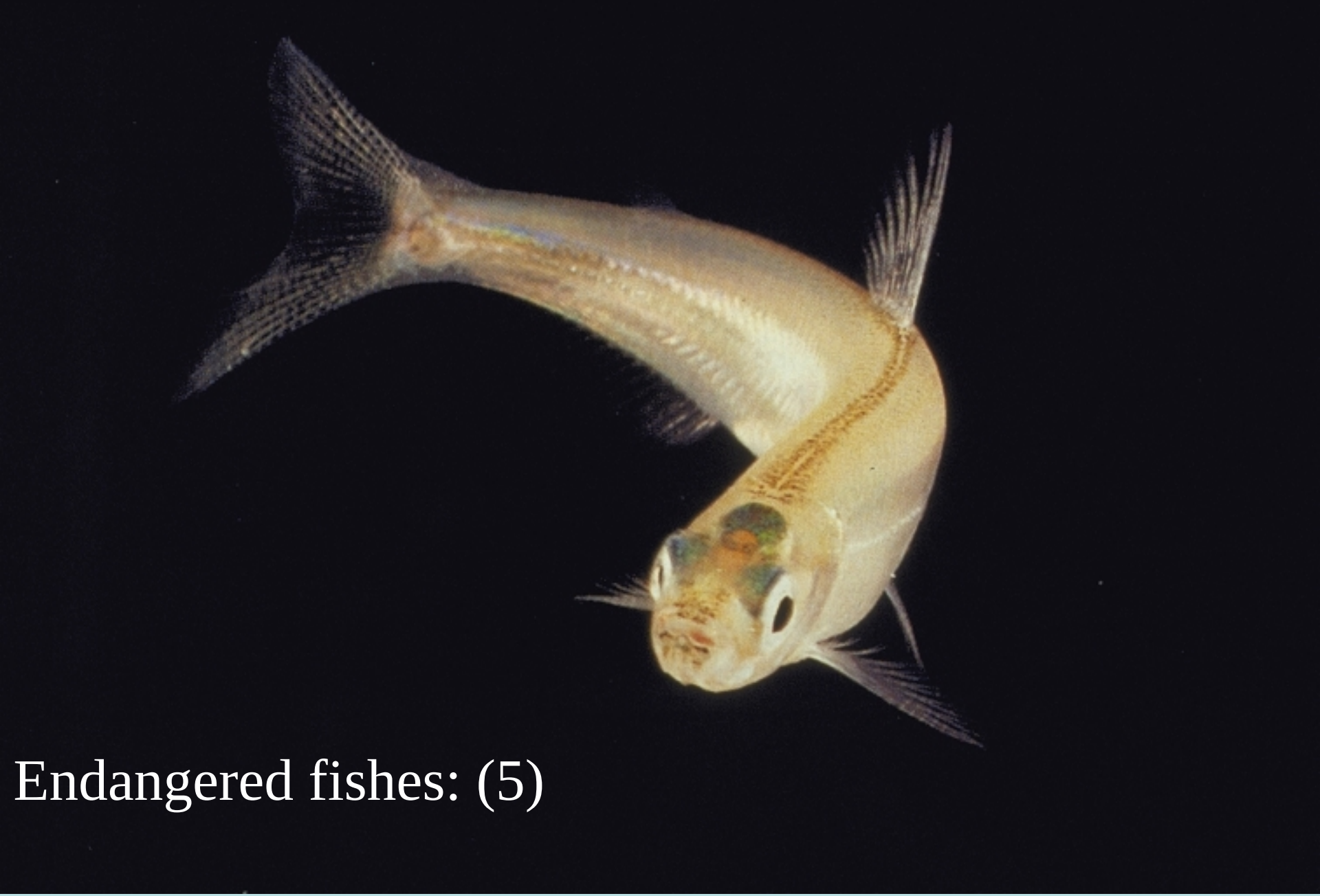
A judge's landmark ruling roils Delta waters

DELTA FISH HAVE CLOUT

Delta Smelt Ruling Cuts Water Deliveries to Humans

California Reeling From Delta Smelt Ruling

Ruling to protect delta smelt may force water rationing in Bay Area



Endangered fishes: (5)

ENDANGERED SPECIES

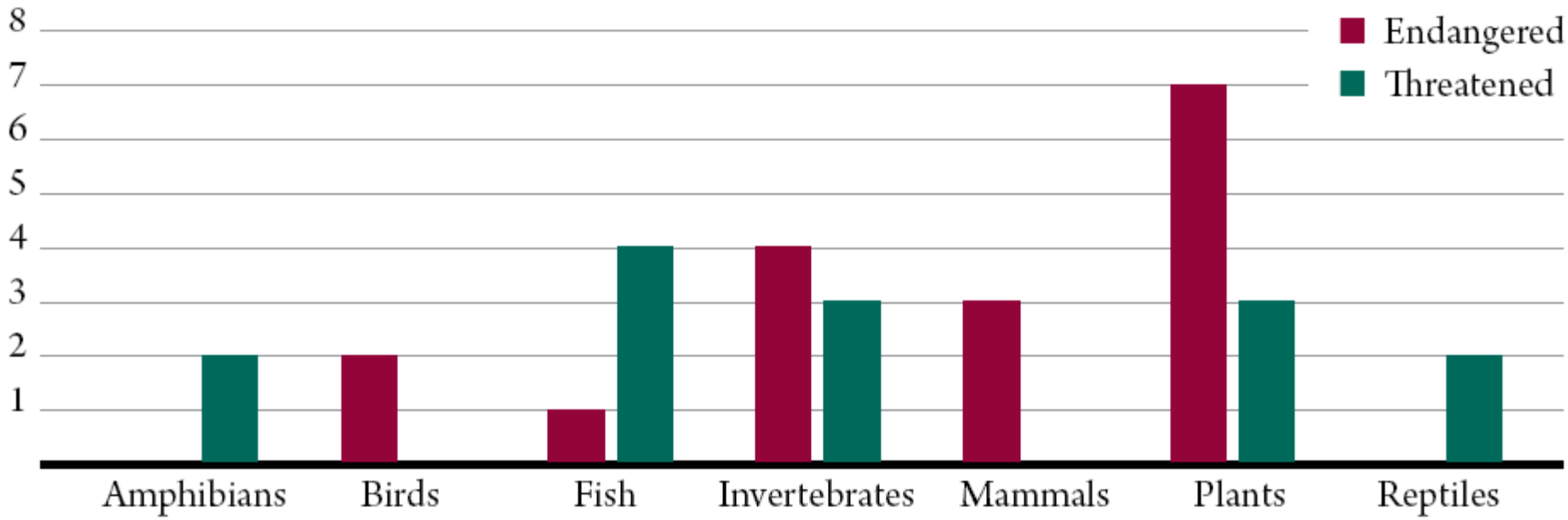
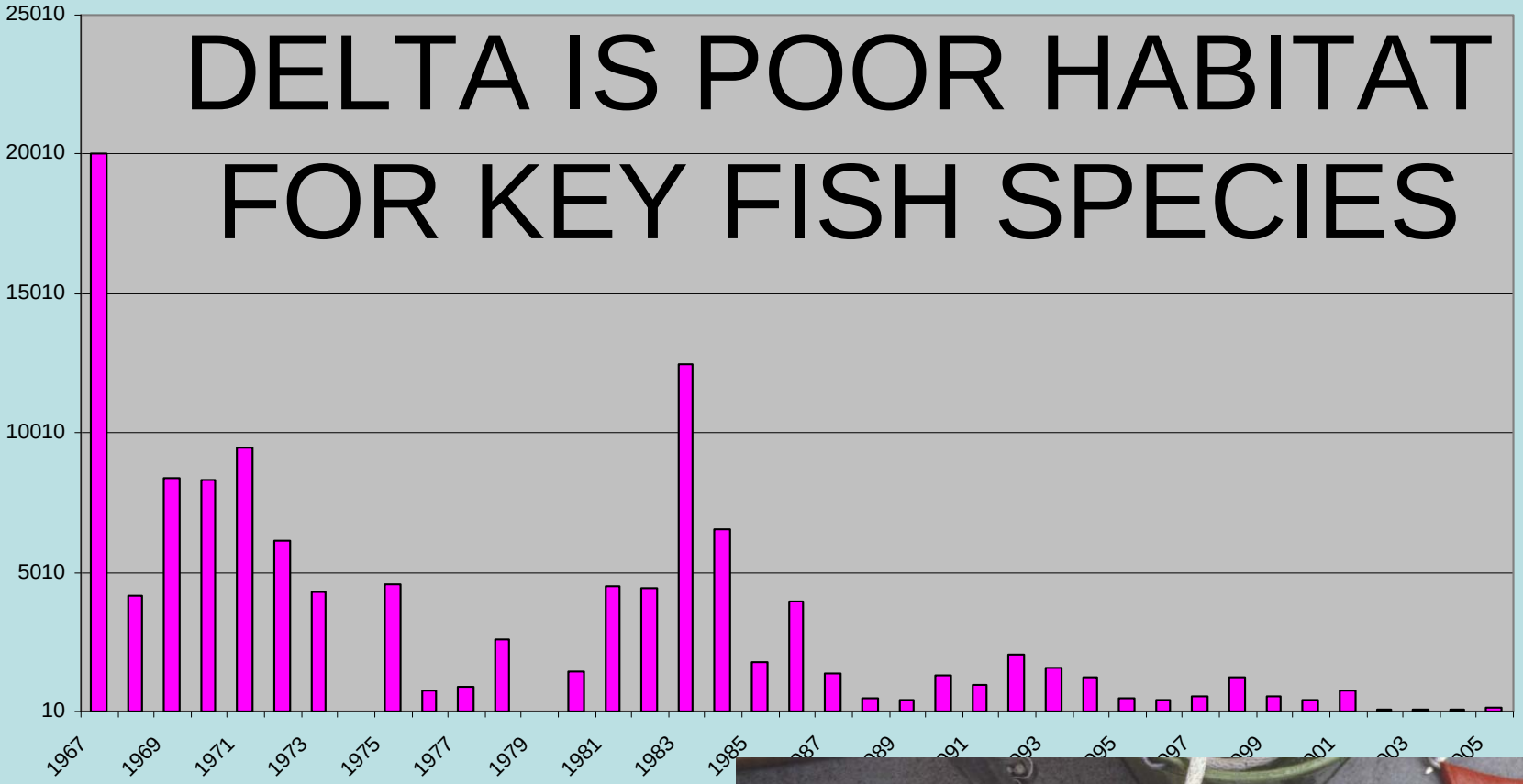


Figure 1.2. Numbers of species of different types of organisms in the Bay-Delta listed as threatened or endangered under state and federal law. (Source: Sacramento Fish and Wildlife Office: www.fws.gov/sacramento/es/spp_lists/regionActionPage.cfm)

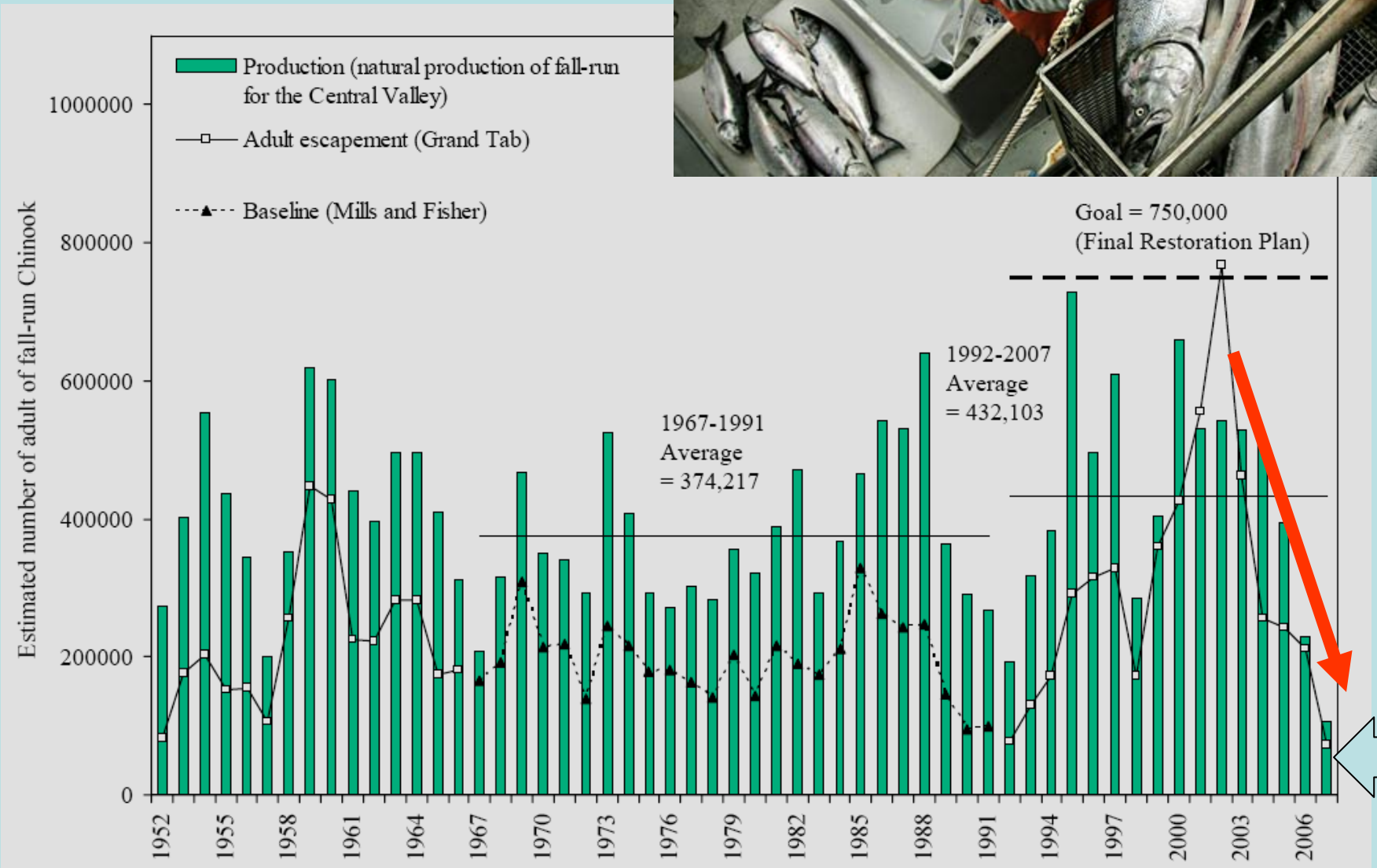
DELTA IS POOR HABITAT FOR KEY FISH SPECIES



POD

Striped bass
Delta smelt
Longfin smelt
Threadfin shad

Collapse of salmon fishery



THE DELTA CANNOT BE MAINTAINED IN ITS PRESENT CONFIGURATION (which is bad for fish)

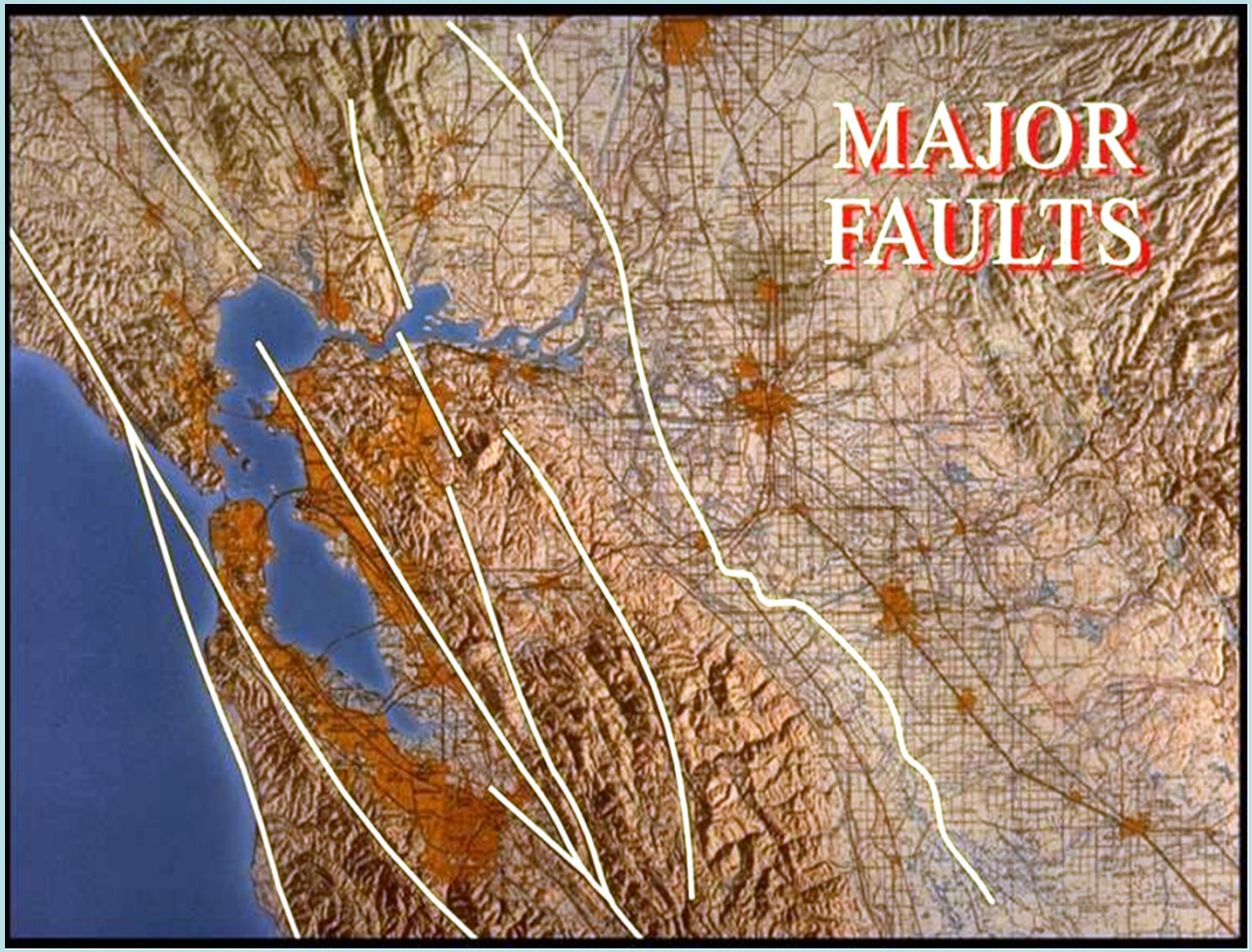
Major change is on its way

RECIEPE FOR MAJ0R HANGE (a.k.a. disaster)

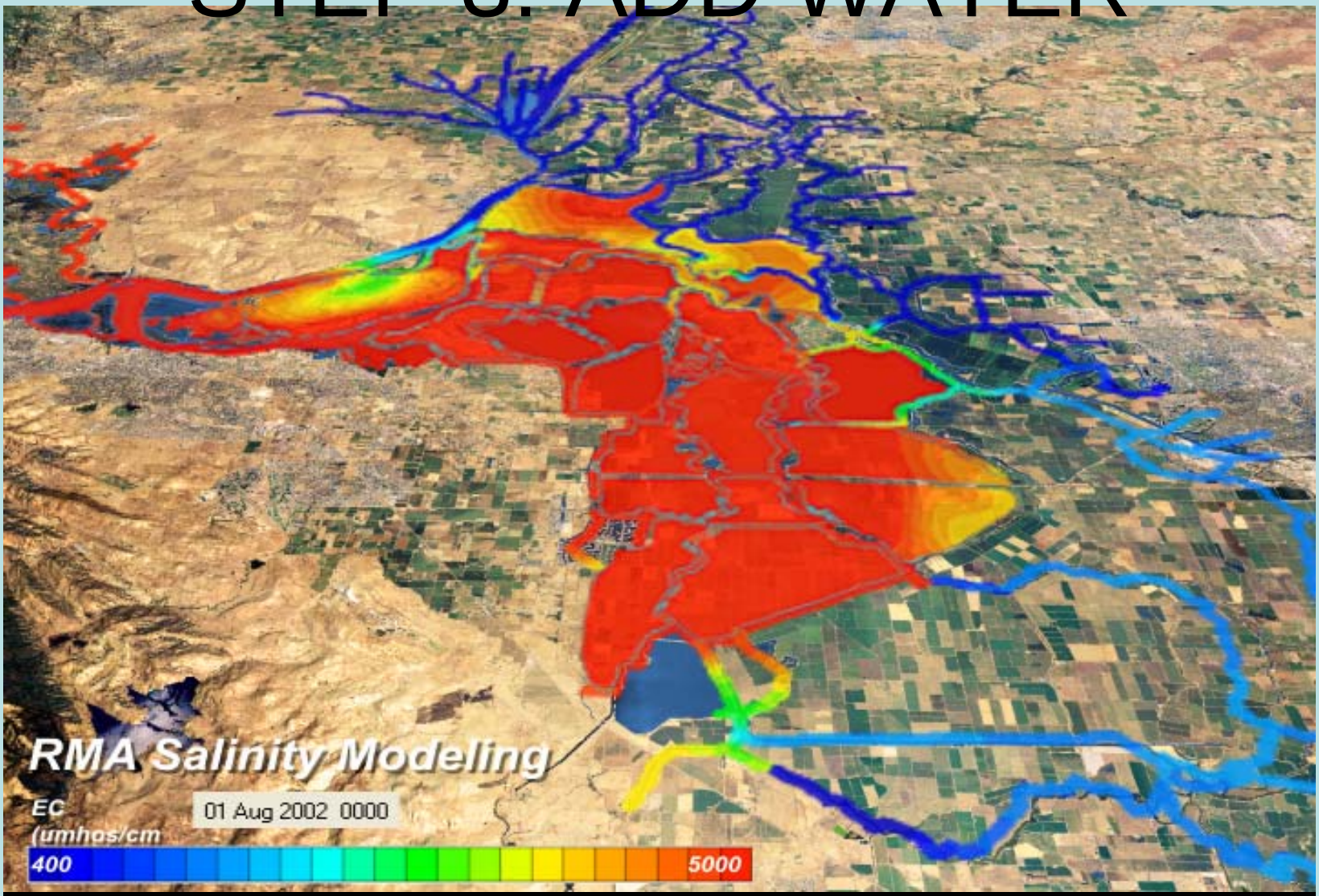
- **INGREDIENTS**
  - SUBSIDING LAND
  - RISING SEA LEVEL
  - MORE FREQUENT BIG FLOODS
  - WEAK LEVEES

STEP 1: MIX

STEP 2: SHAKE WELL

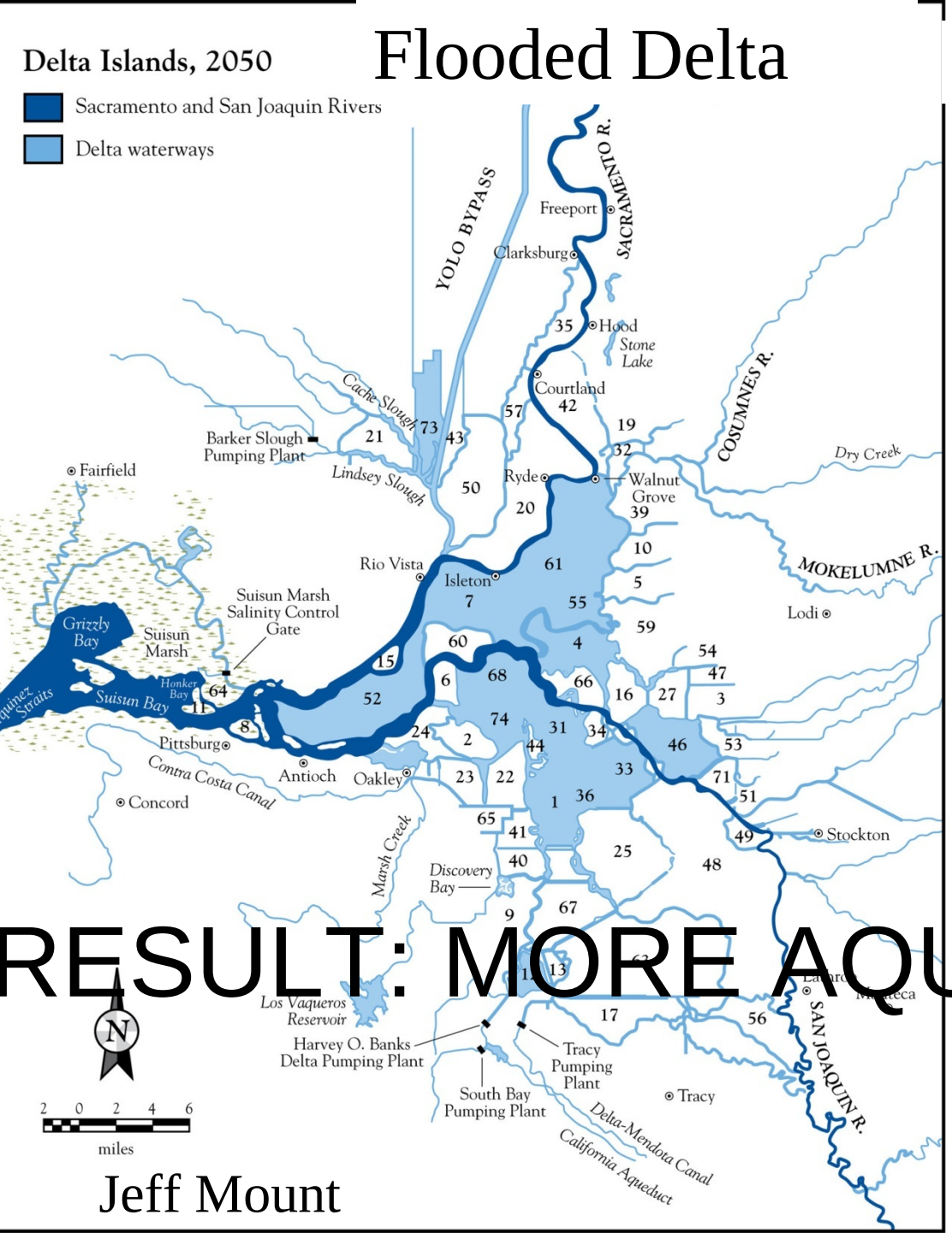


STEP 3: ADD WATER

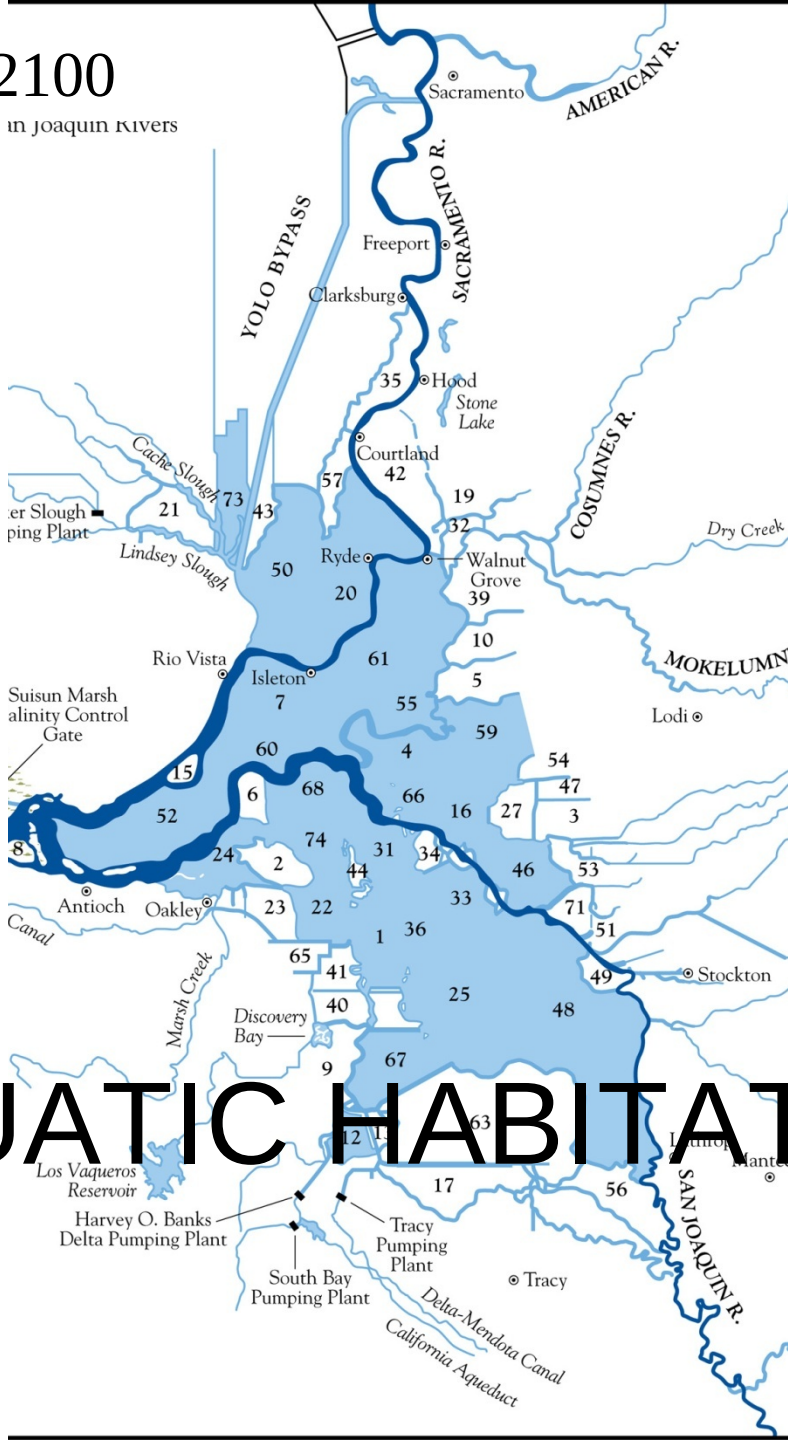


30 days:

Flooded Delta

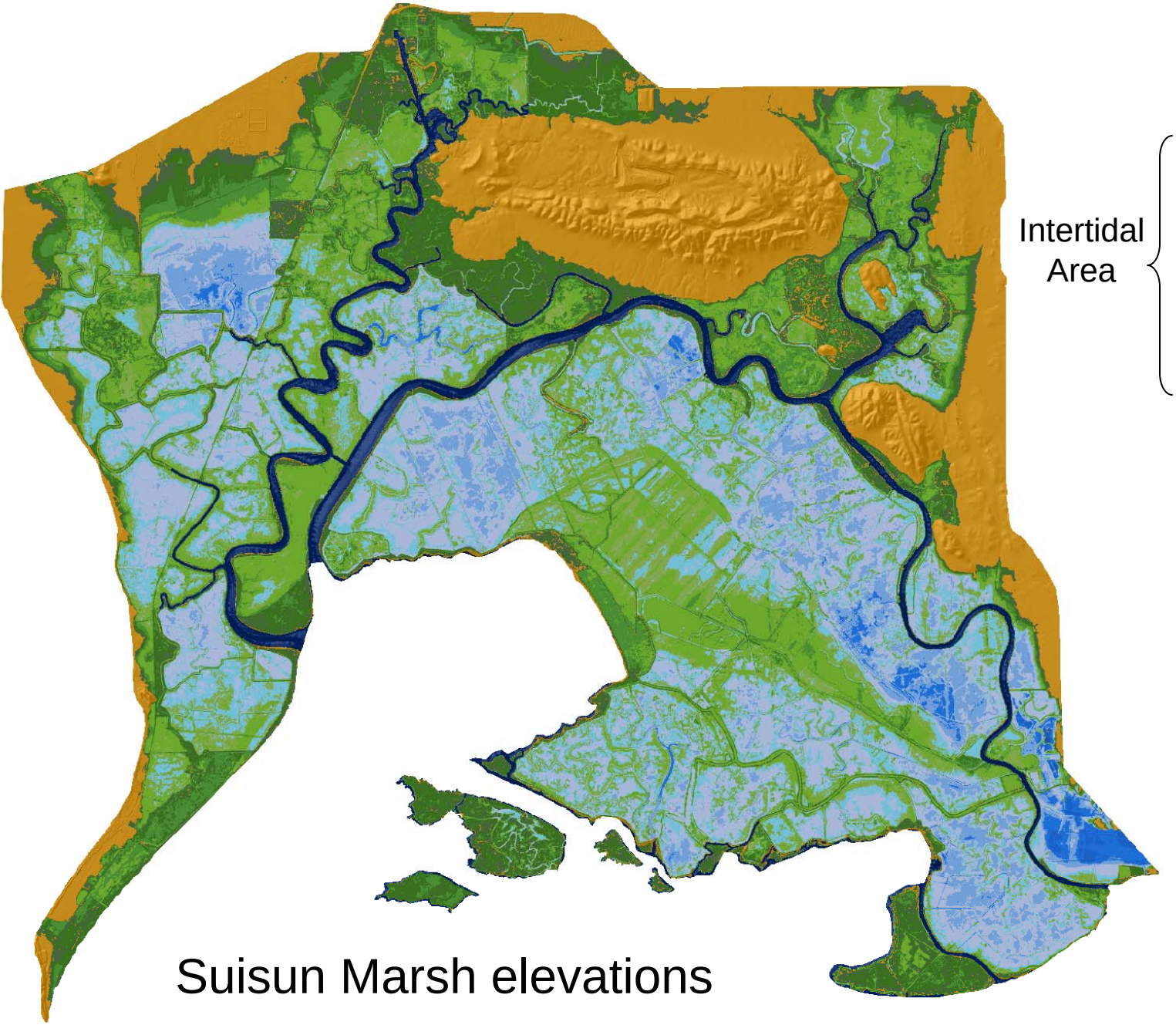


2100



RESULT: MORE AQUATIC HABITAT

Jeff Mount



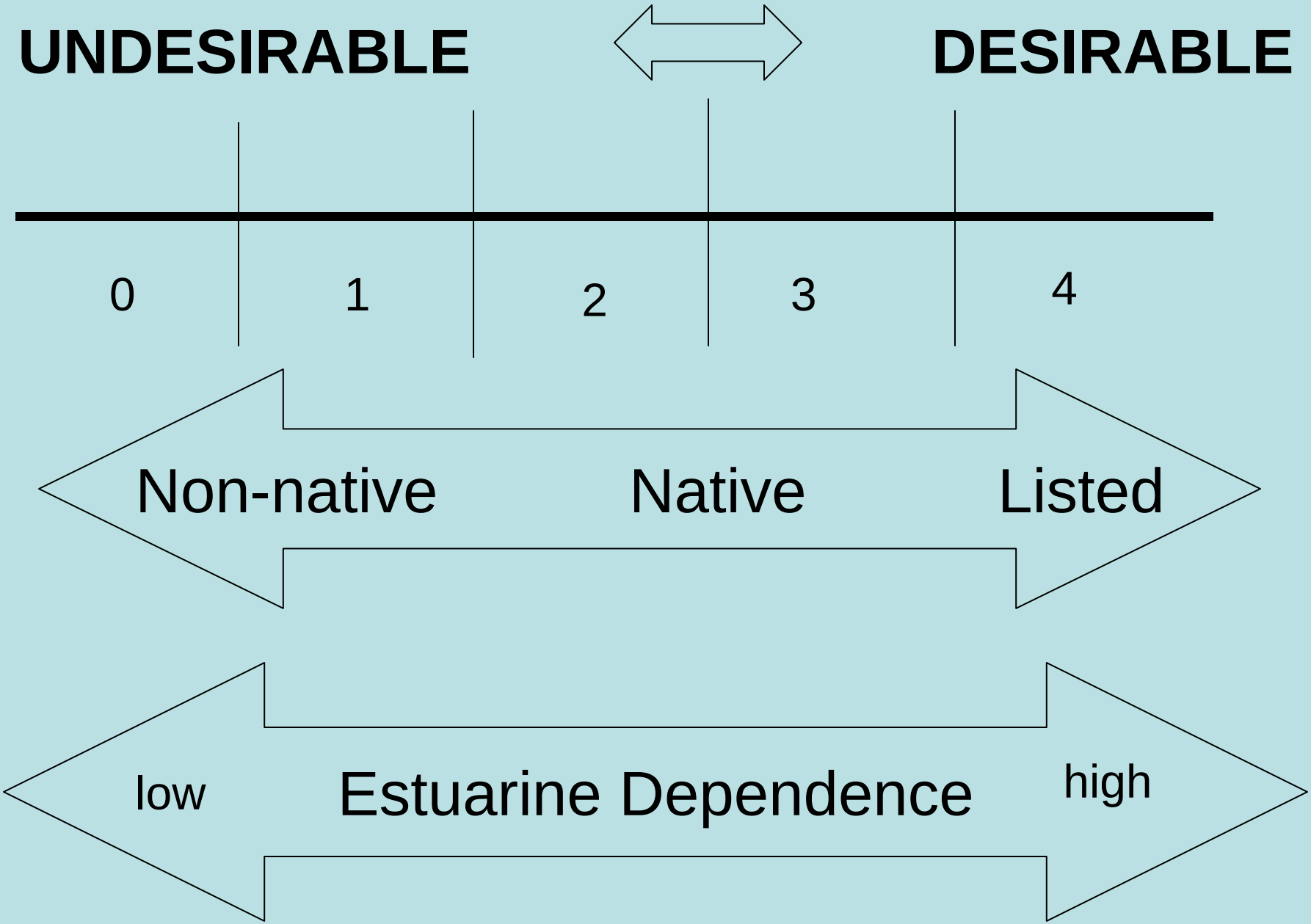
Suisun Marsh elevations

Basic questions
Appendix D

- What species are most desirable?
  - What species do we manage for?
- How are the fishes affected by ecosystem change?
- How will water export alternatives affect the fishes?
- What actions will improve the Delta for desirable fishes?

What species are most desirable?

- T & E species
- Native (endemic)
- Support fisheries
- Estuarine dependent


UNDESIRABLE
DESIRABLE
0
1
2
3
4
Non-native
Native
Listed
low
Estuarine Dependence
high

UNDESIRABLE ⟷ **DESIRABLE**

0	1	2	3	4

Largemouth bass
Carp
Wakasagi
Inland silverside
Bluegill
Threadfin shad

Delta smelt
Longfin smelt
Gr sturgeon
Steelhead
Spr chinook
W chinook

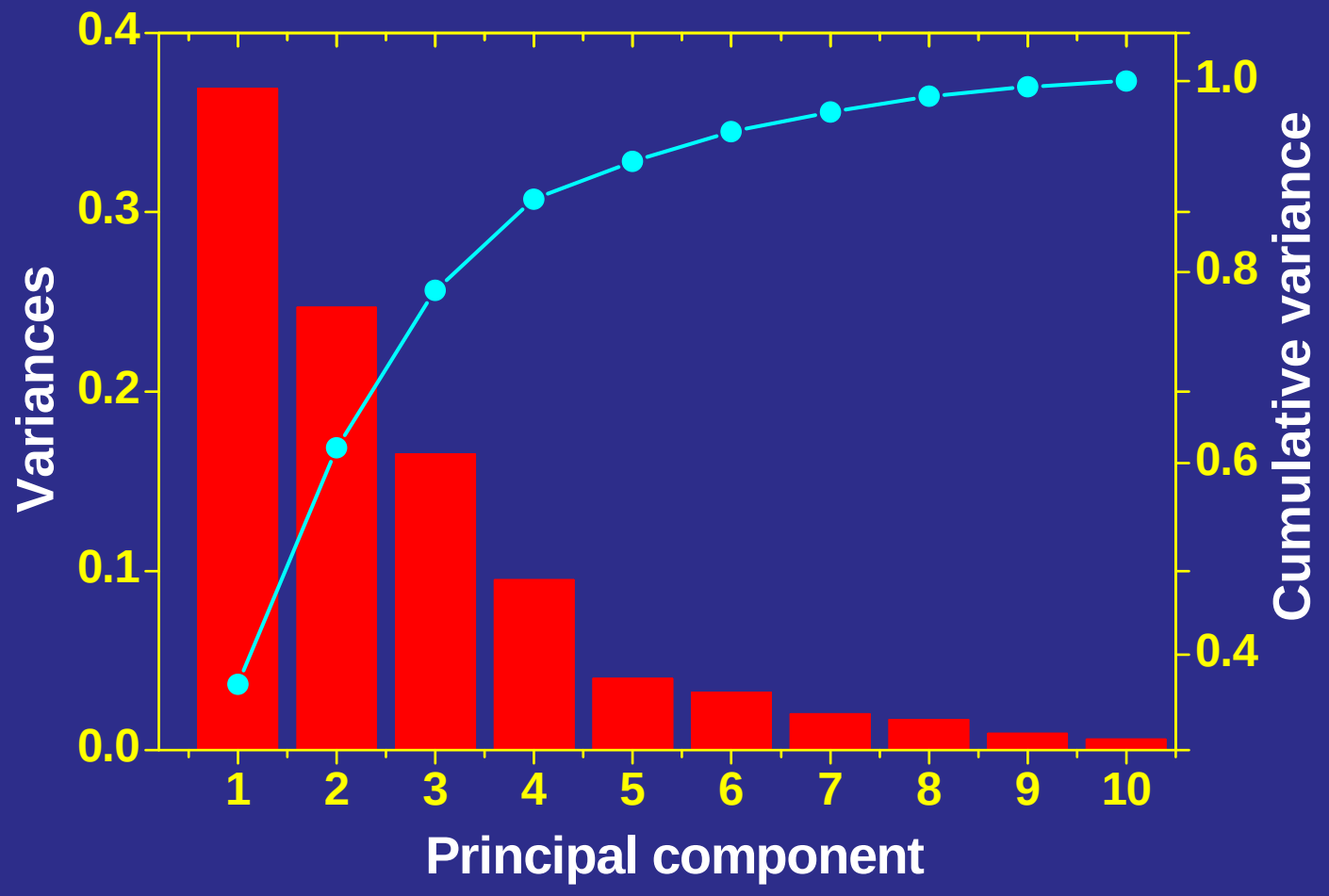
Do Delta fishes fall into ecological clusters?

Bill Bennett will have answers!

Component Loadings

Life History Metric	PC 1	PC 2	PC 3
Spawn frequency	0.12290	-0.20717	0.04870
Life Span	-0.46604	-0.38186	-0.16339
Size at Maturity	-0.48997	0.04263	-0.25761
Fecundity	-0.30002	-0.01987	0.17554
Anadromous	-0.26211	0.52748	-0.15117
Generation time	-0.46539	-0.20798	-0.18254
Parental care	0.35633	-0.07910	-0.56904
Temperature	0.04276	-0.38309	0.27890
Salinity	-0.02242	0.51485	-0.18810
Habitat	0.15177	-0.26359	-0.61694

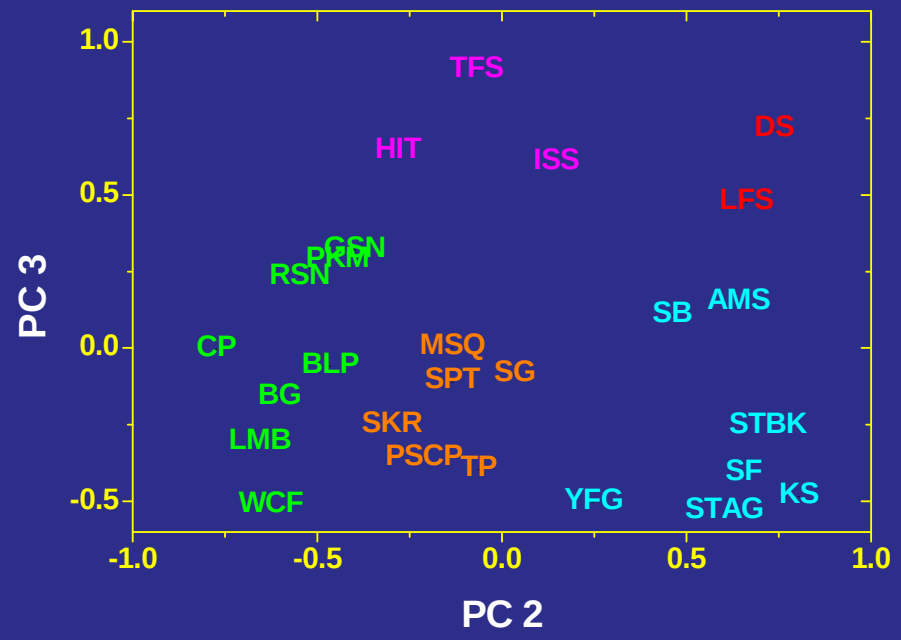
Scree Plot


0.4
0.3
0.2
0.1
0.0
Variances
1.0
0.8
0.6
0.4
Cumulative variance
1
2
3
4
5
6
7
8
9
10
Principal component

Fish Species Assemblages In the Delta

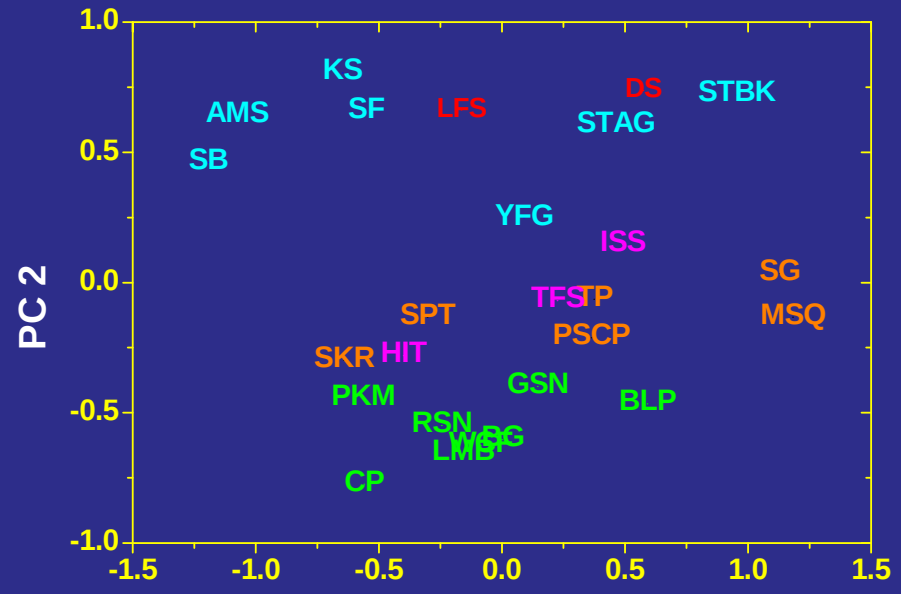
Open-water
Lower salinity
Broadcast spawn
Smaller size

Aquatic vegetation
Freshwater
Nest builders
Larger size



Anadramous
Salty, Cool,
Open water
Short life span
& generations
Single spawn

Resident
Warm , Freshwater,
Aquatic vegetation
Longer life
& generations
Multiple spawns



Longer life & enerations
Larger size, fecundity

PC 1

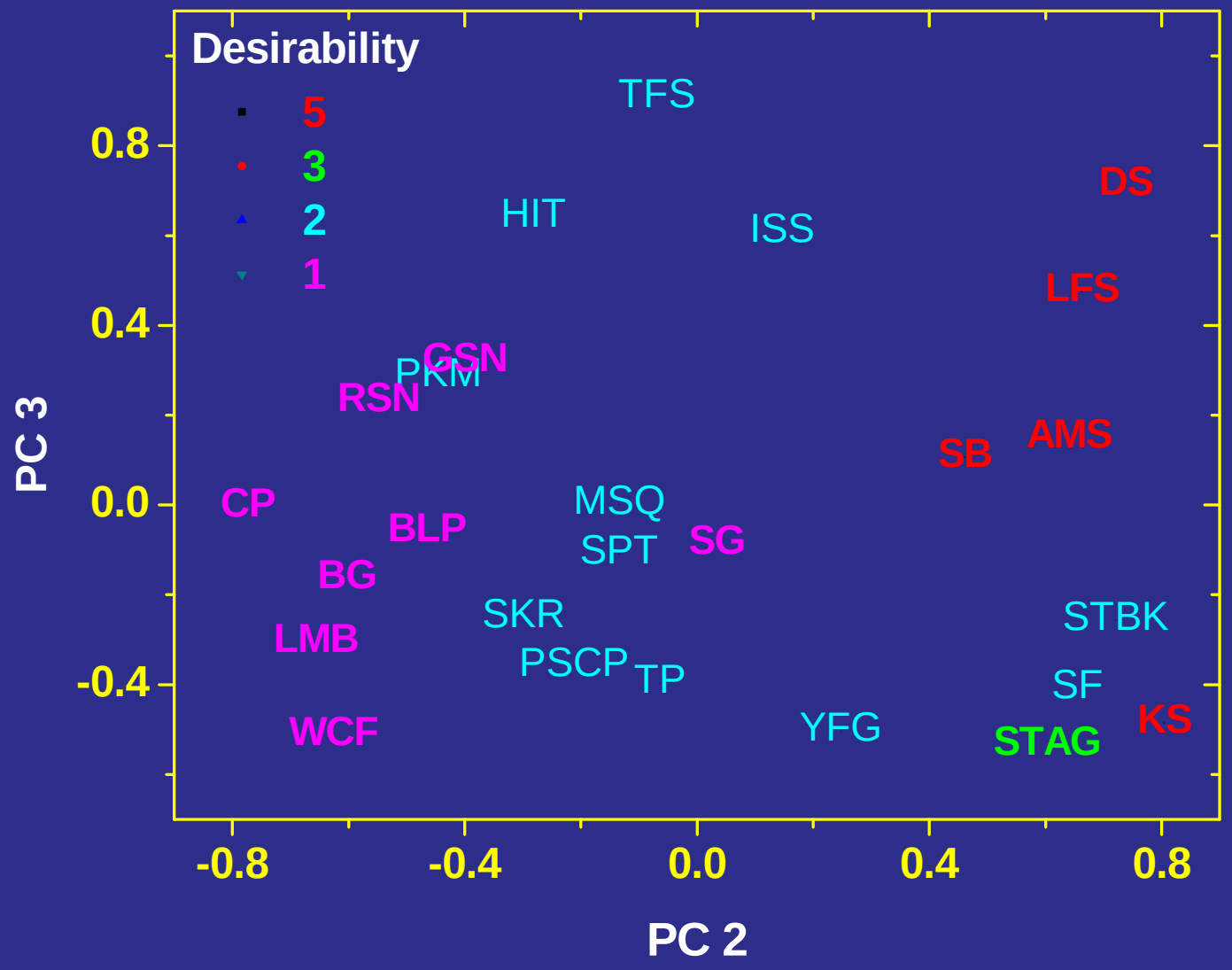
Short life & generations
Small size, fecundity

Fish Groups

Are there management clusters?
PCA analysis

- **Native smelt**
  - Delta and longfin smelt
- **Planktivorous fishes**
  - Mostly undesirable
- **Anadromous fishes**
  - Salmon, striped bass, Amer. shad
- **Slough resident fishes**
  - Mostly undesirable non-natives
- **Benthic fishes**
  - Mixed native and non-native

Species Clusters versus Desirability



REGIME SHIFT IN THE DELTA ~ TRAIN WRECK

CONCEPTS TO APPLICATION

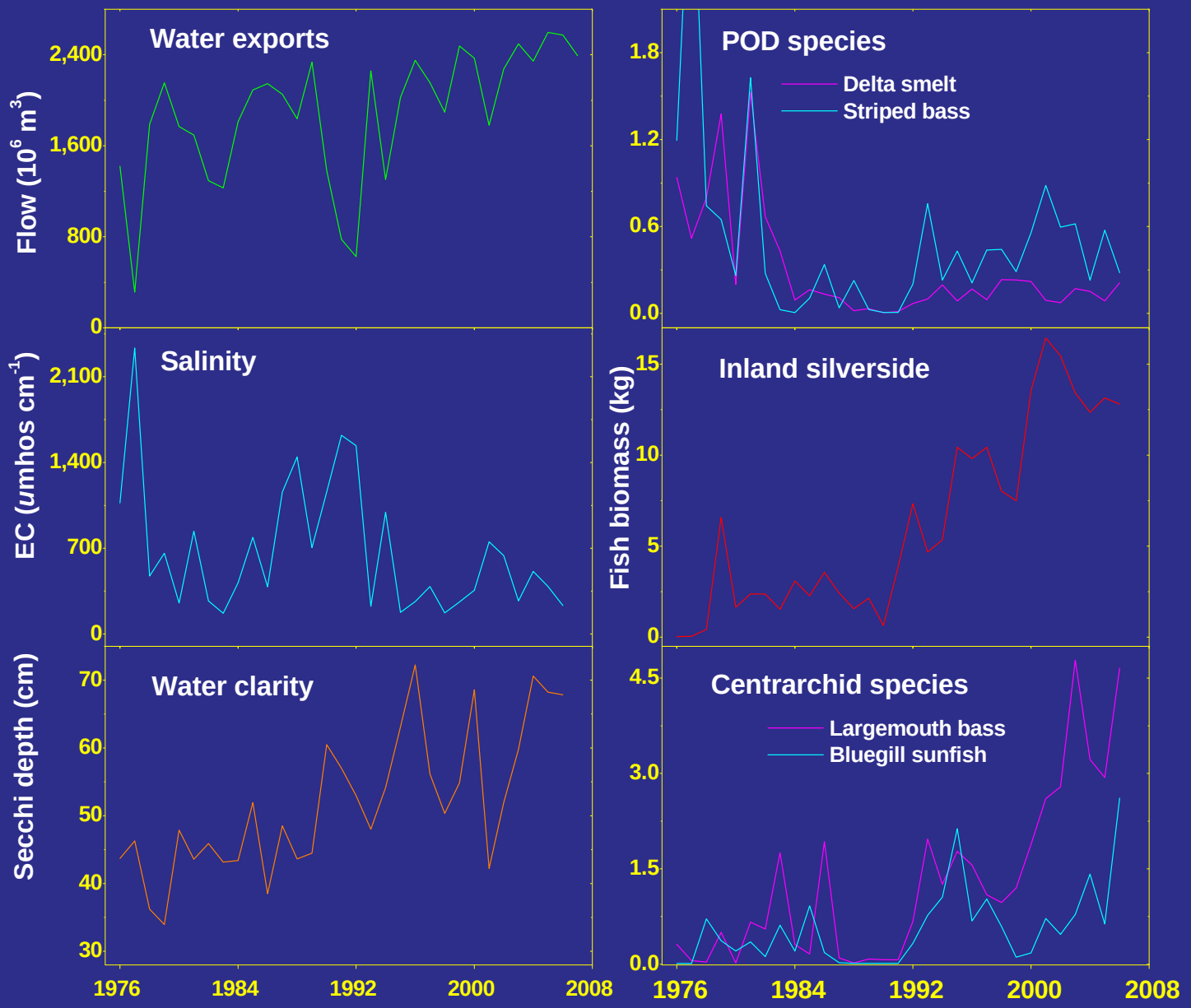
Dynamic Systems Behavior

- **REGIME SHIFT** ~ Interplay of External slow & Internal fast processes

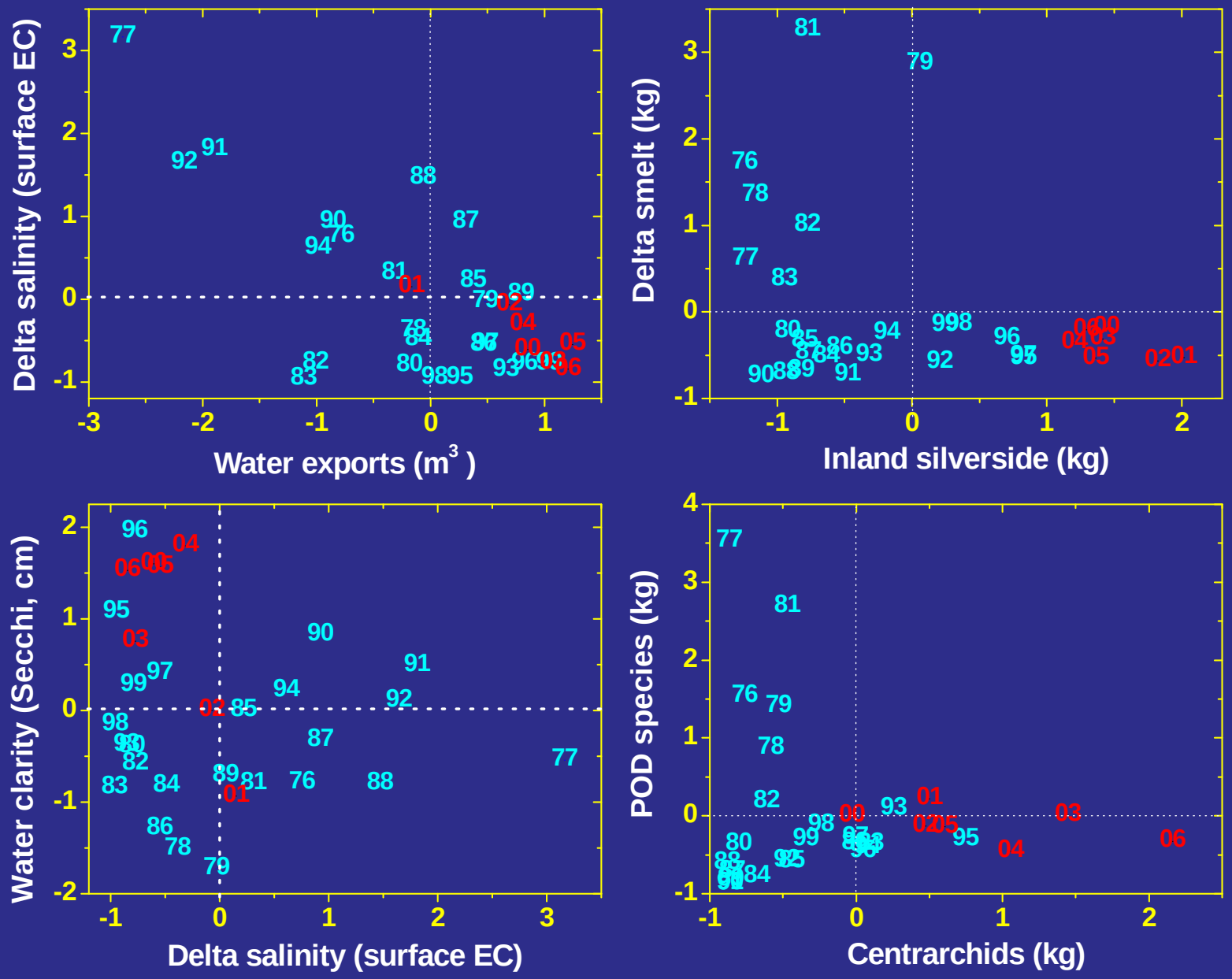
- **RESILIENCE** ~ Capacity of system to absorb disturbance and reorganize to retain original properties

- **HYSTERESIS** ~ Ability to reverse regime shift Is typically much more difficult

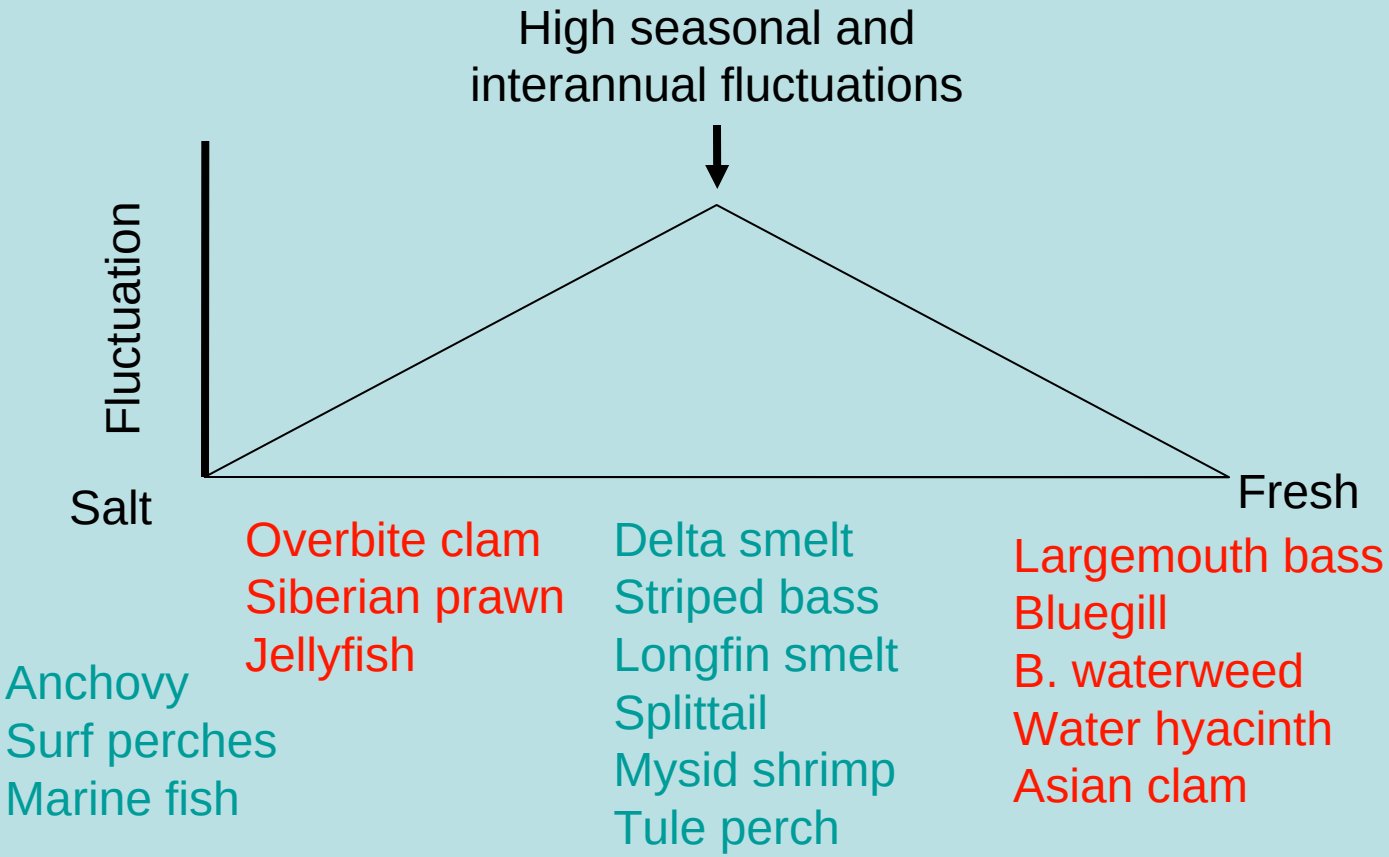
Summer Trends in Key Ecosystem Components



Ecosystem Regime Shift in the Delta ?



How are the fishes affected by ecosystem change?



Conceptual model of desirable and undesirable species in relation to the estuarine salinity gradient and habitat fluctuations

Effects of Delta & Suisun flooding

- Much uncertainty
  - Water quality, productivity, alien species
- More brackish water habitat
- More open water habitat
- More habitat diversity
- More fish
  - More desirable fish?

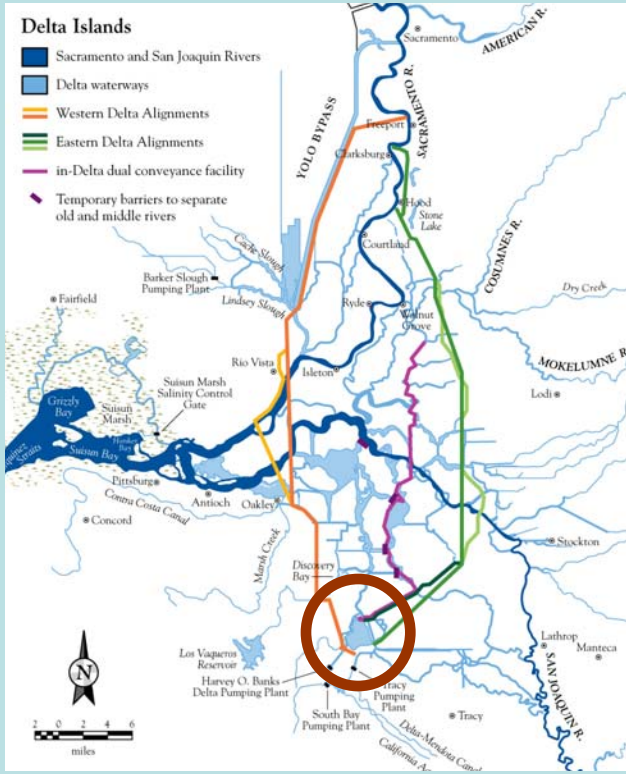
How will water export alternatives affect the fishes?

“Co-Equal” Goals
ecosystem and reliable water supply

- Delta ecosystem
  - Delta Vision: “sustainable environment”
  - Our report: viability of native fish populations
- Water supply
  - Delta Vision: “reliable water supply”
  - Our report: statewide economic costs

4 Basic Water Export Strategies

- Through the Delta: current strategy
- Peripheral Canal: around the Delta
- Dual Conveyance: both through and around the Delta
- No Exports:use other water sources and use less



IEP-EET workshop February 2008

- Survey of experts on Delta
- 39 respondents
- Rated effects of 7 water management factors on 4 species
- Rated viability of 4 options on 4 species
- Appendix E
- Used to support decision making analysis (Appendix J).

Effects of 7 water management factors on 4 species

- EET Most harmful factors:

- Pumping in south Delta,
- Reduced Delta inflows from Sacramento River.

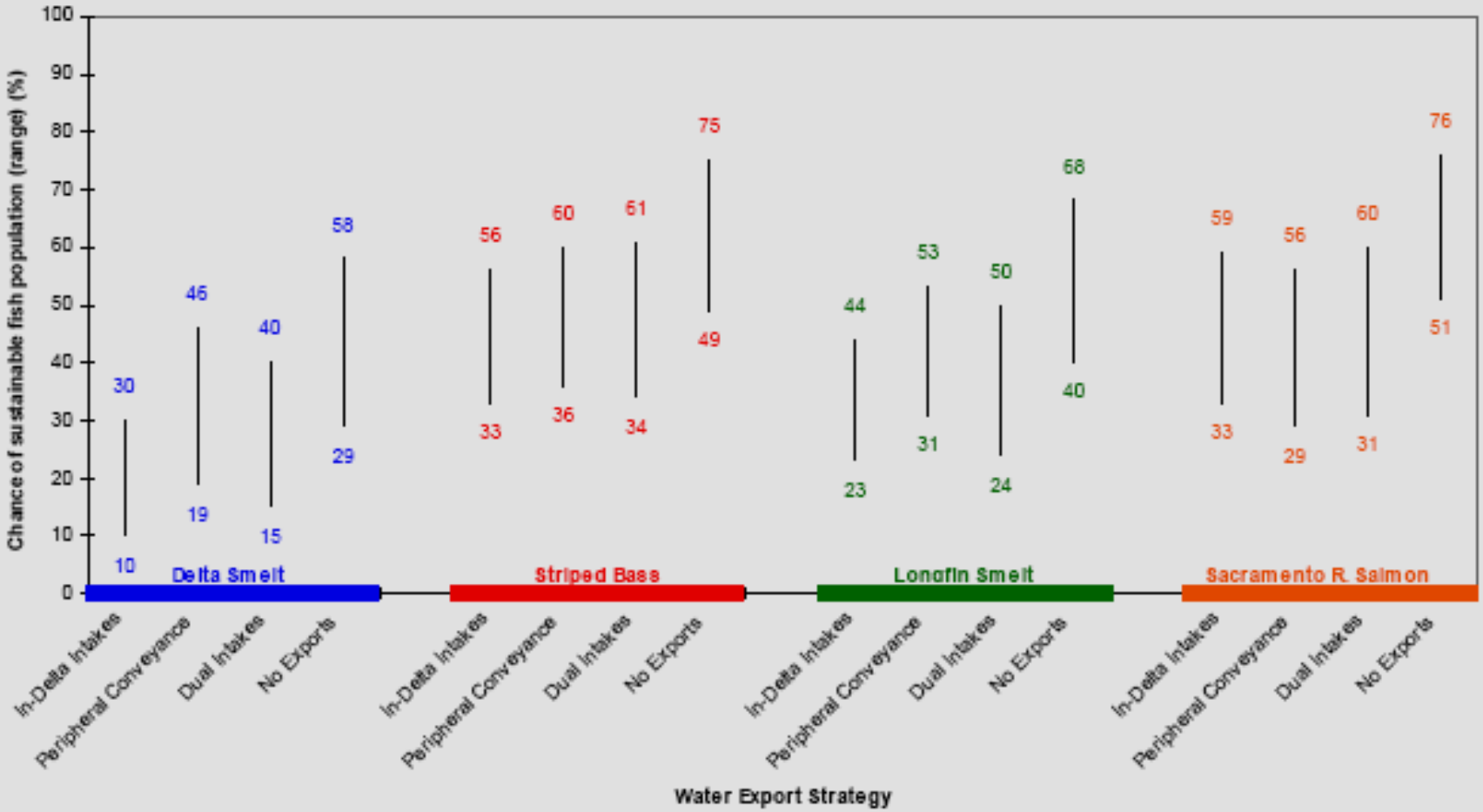
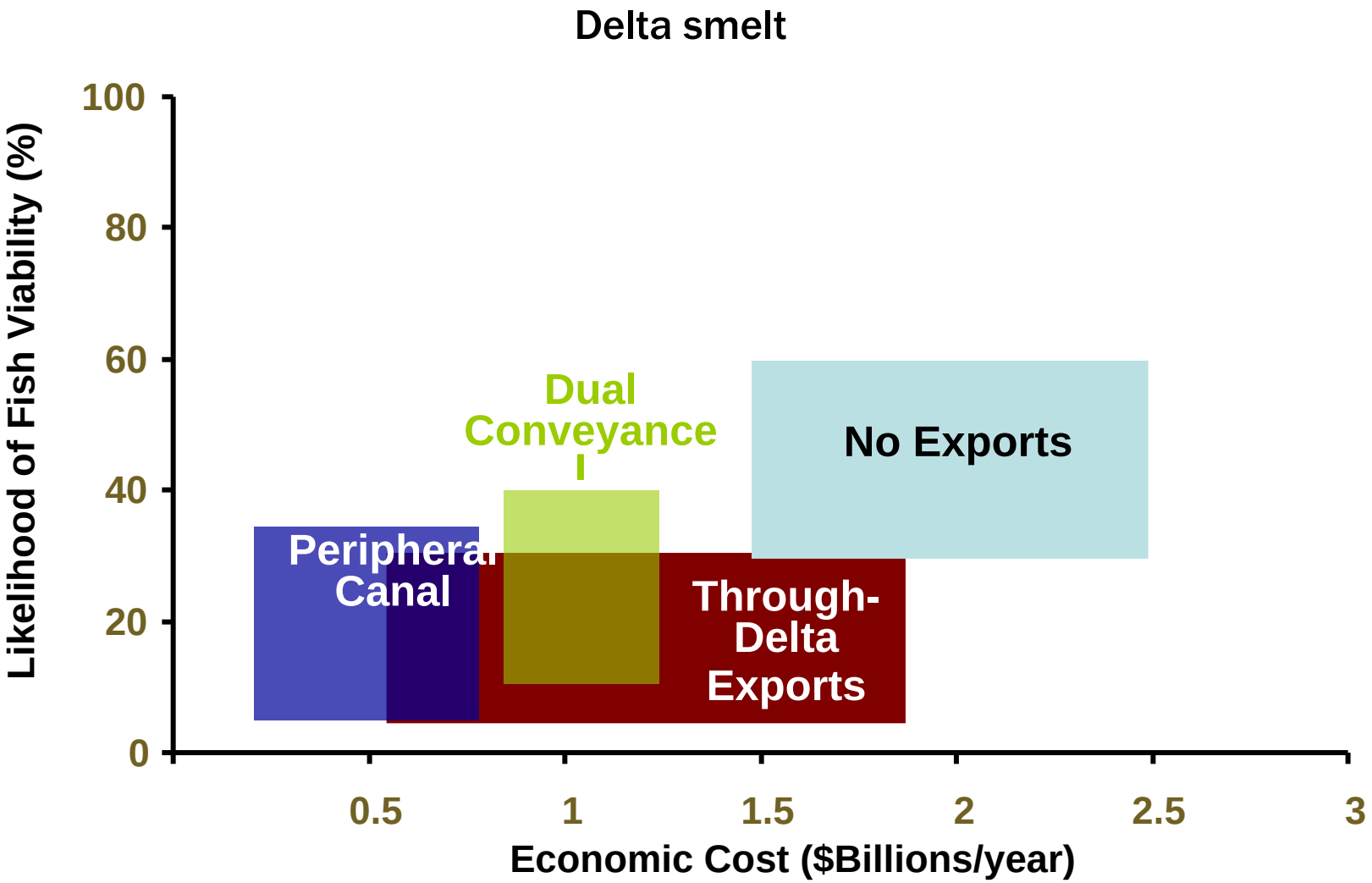


Figure E.1a. Probability of Viable Fish Populations under Different Export Management Alternatives, Current Conditions

Notes: Low and high end of range correspond to sample means for "all things done wrong" and "all things done right," respectively.

Decision Analysis Appendix J (Jay Lund)



UNDESIRABLE FISHES **DESIRABLE**

0 1 2 3 4

All things being equal

PC

BAU Dual Facility No Exports

What actions will improve the Delta for desirable fishes?

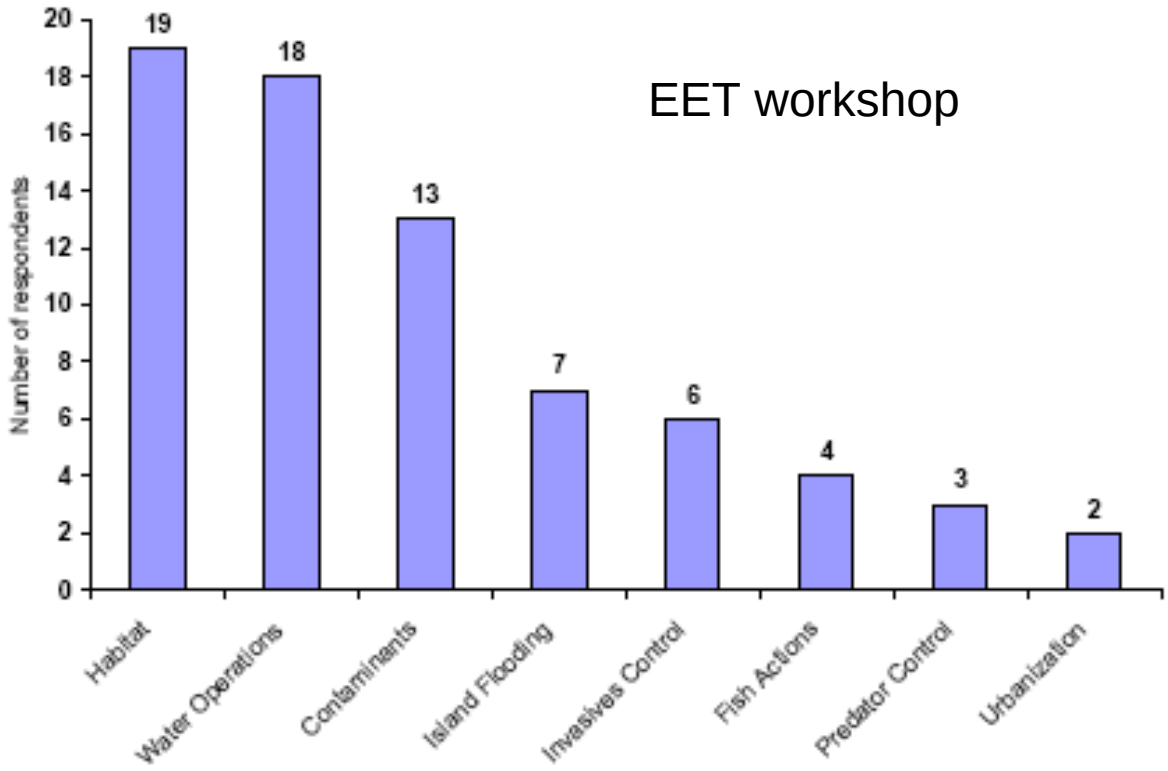


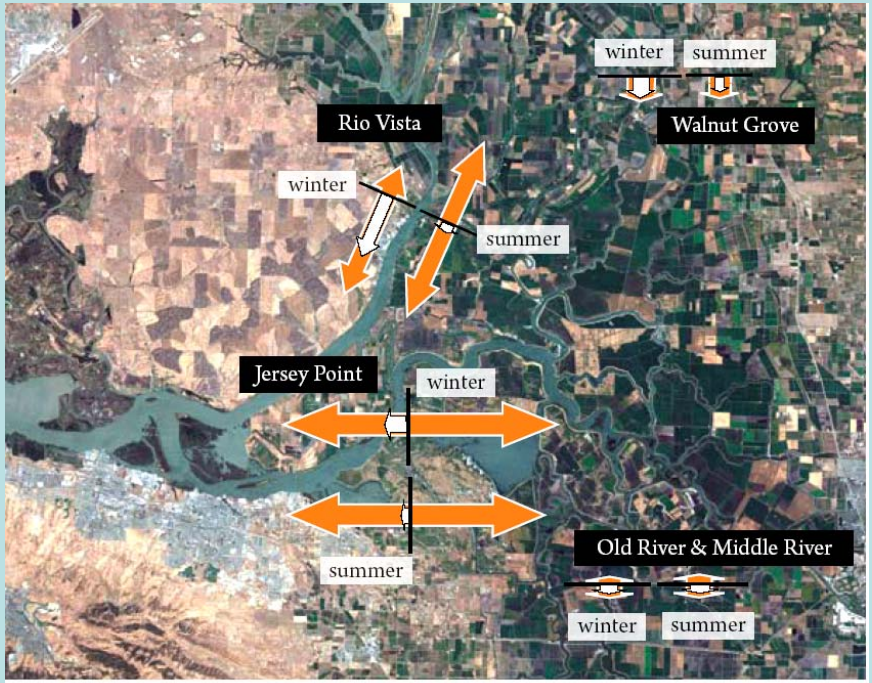
Figure E.2. Ecosystem Investments to Improve Fish Populations

What actions will improve the Delta for desirable fishes?

- Create natural flow regime
- Reduce alien species
- Reduce toxicants
- Improve San Joaquin River WQ
- Reduce entrainment
- Create tidal habitats
- Increase floodplains
- Manipulate islands
- Anticipate climate change

Create Natural Flow Regime

- Mimic but not duplicate historic flow regime, including tidal cycles
- Net downstream flows
- High annual variation
- High interannual variation
  - Variable salinity
- Favor desirable species



Reduce alien species

- Prevention
- Reduction
  - Change environment
  - Experimental control

STOP THIS TREND!

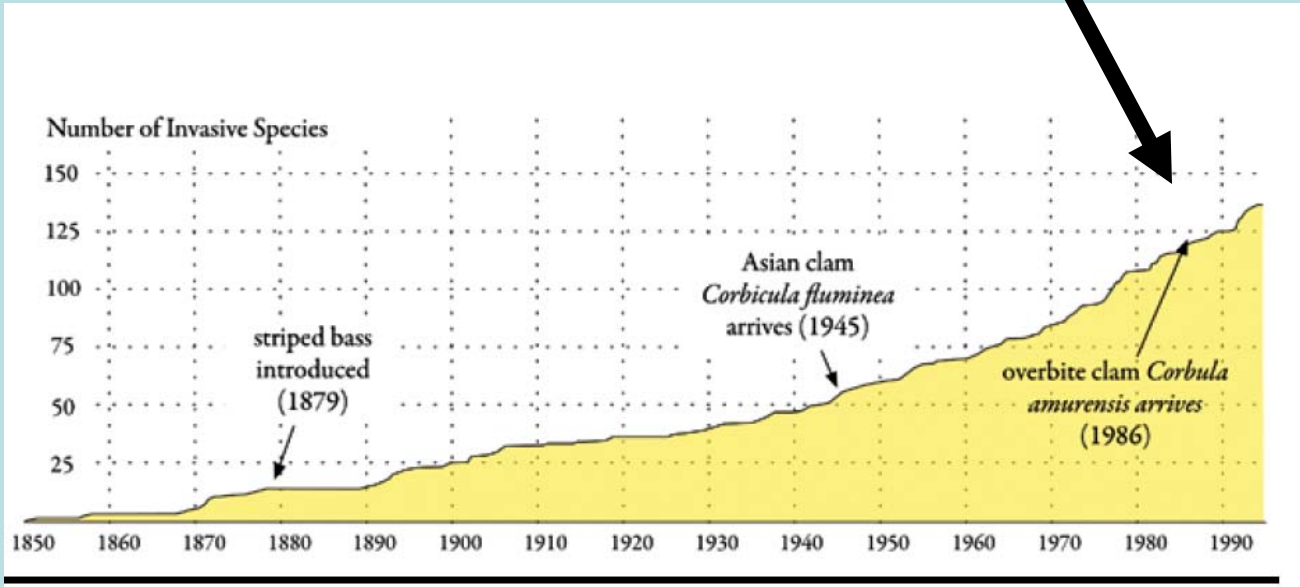


Figure I.1. The estimated number of invasive species in the San Francisco Estuary from 1850 to 1995. (Source: Adapted from Cohen and Carlton 1998)

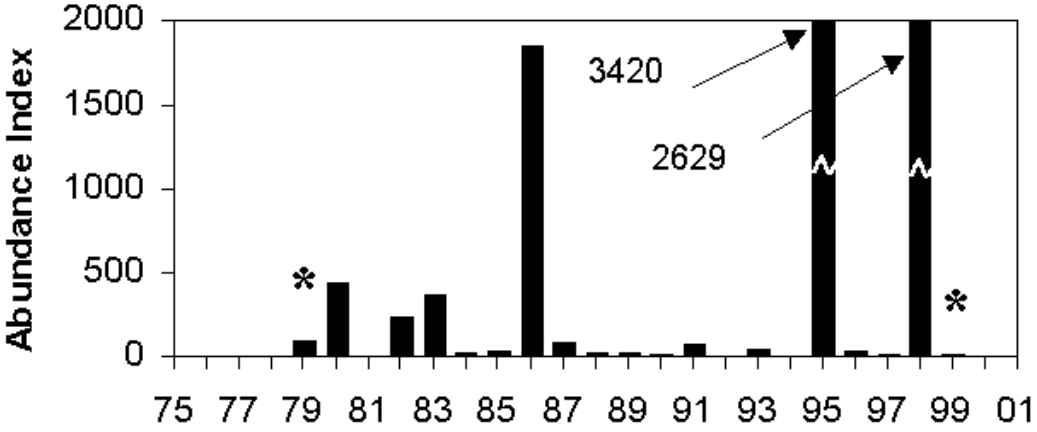
EXPERIMENTAL DREDGING FOR OVERBITE CLAM?

Reduce toxicants

- Agriculture
- Sewage
- Urban storm drains
- Legacy metals

Improve San Joaquin River Water Quality

YOY splittail captured at SWP facility



REDUCE ENTRAINMENT

Create tidal habitats: Cache Slough region

Suisun Marsh

“conversion”, freshwater to brackish tidal

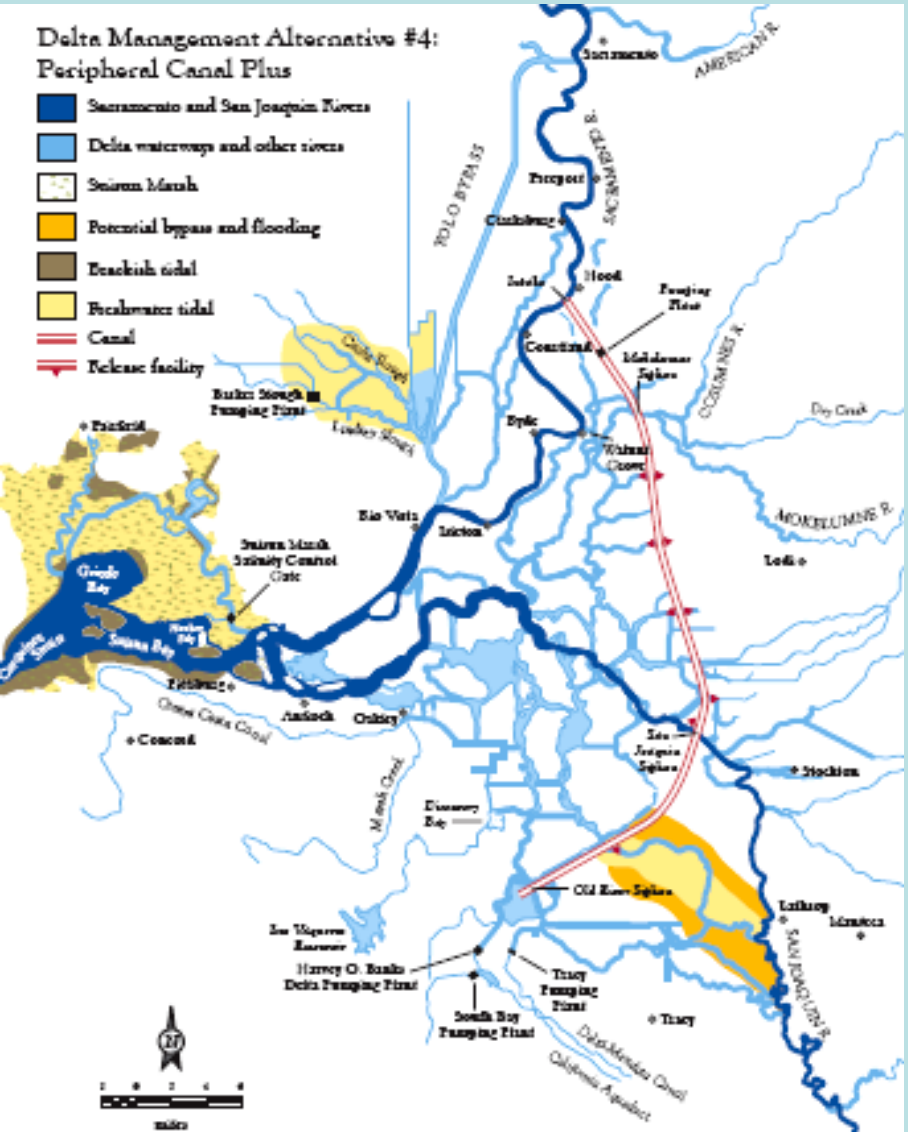
Increase flood plains

Credit: Dave Feliz

YOLO BYPASS

Manipulate islands

ALL ALTERNATIVES MUST INCLUDE RESTORATION ACTIONS



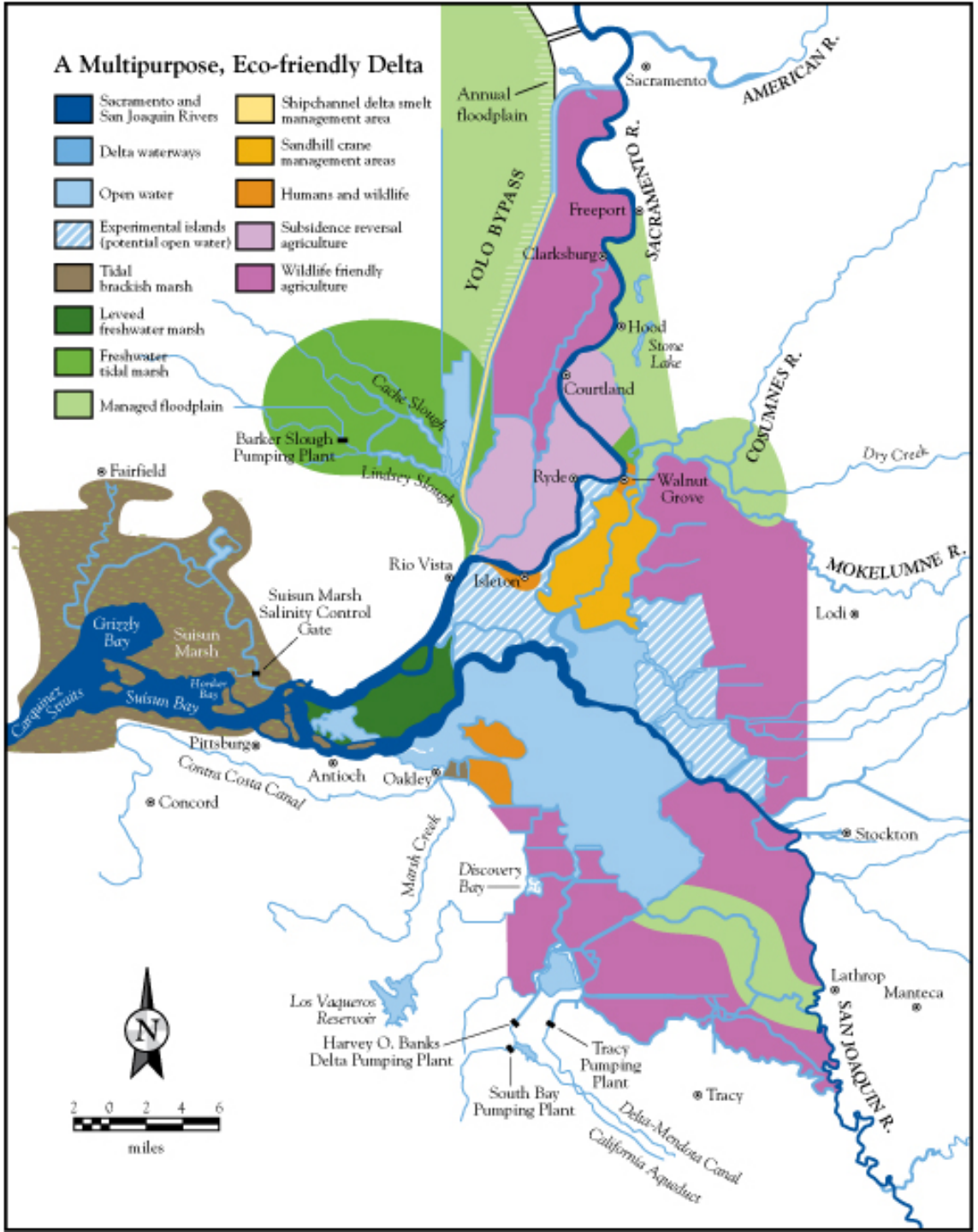
- restore desirable fish
- increase water supply reliability
- high costs

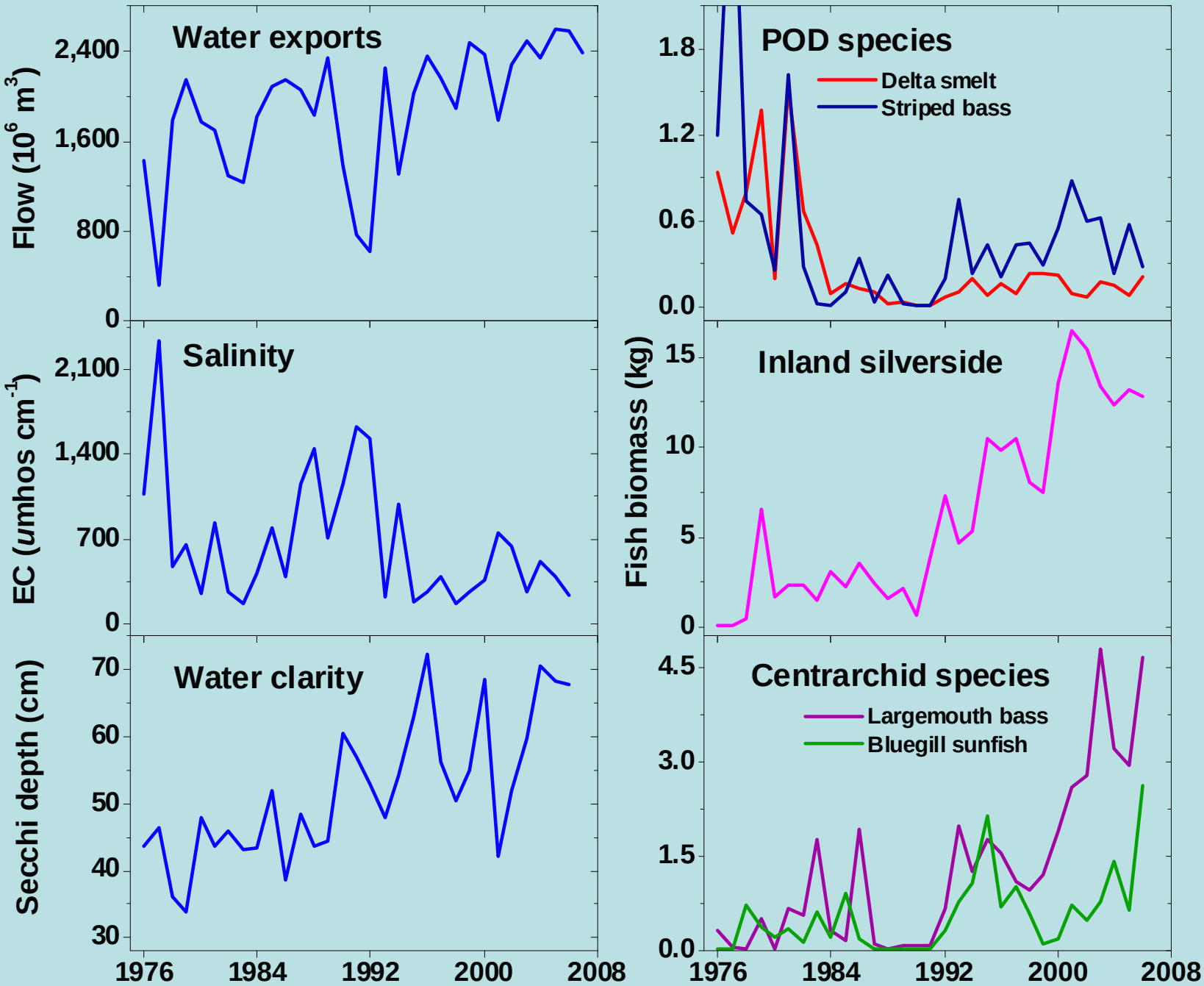
If the ‘good’ fish could choose…

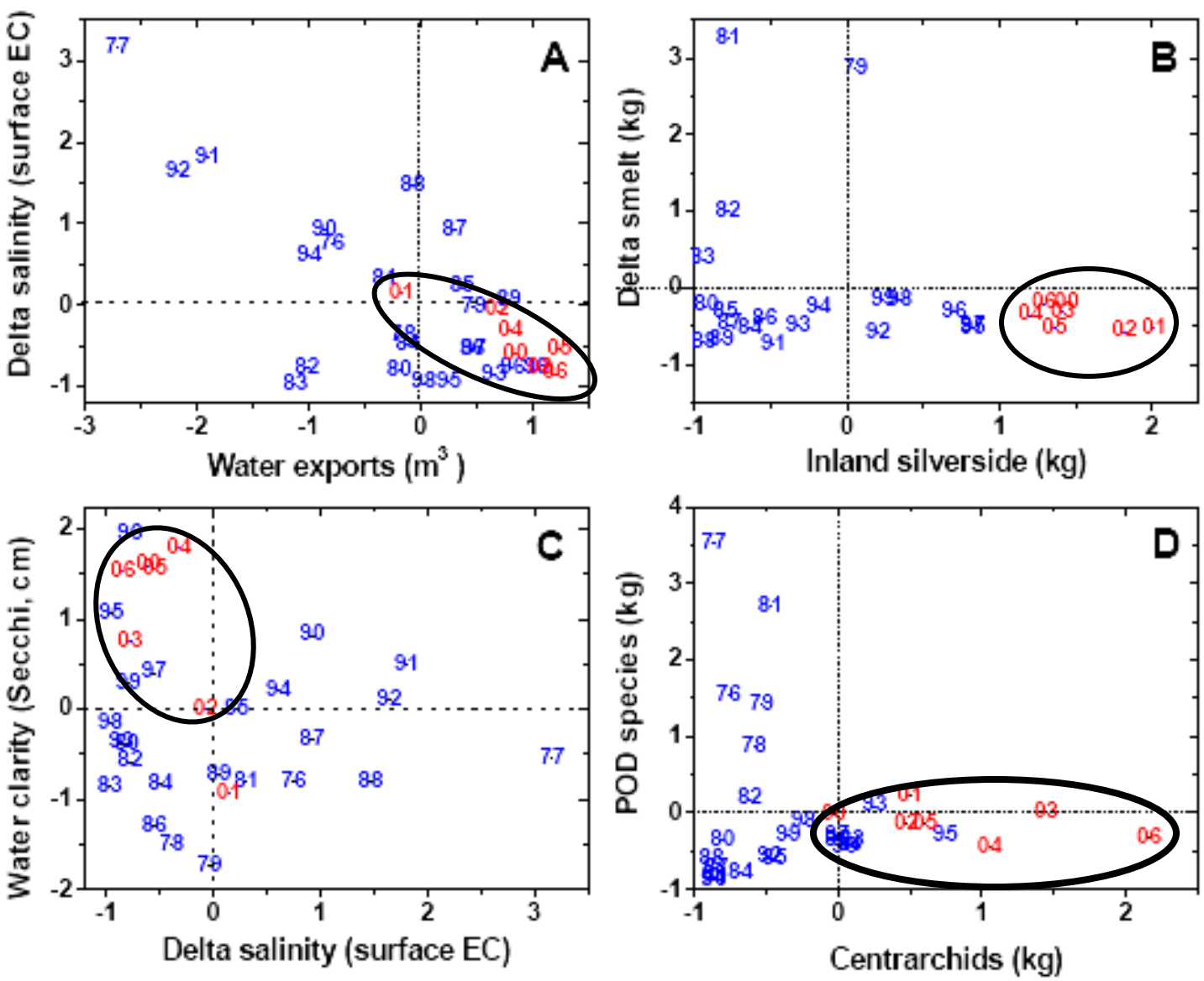
1. Present Delta
2. Open water Delta
   abandoned
3. Partially flooded Delta
4. Heterogeneous Delta

WORST

BEST


A Multipurpose, Eco-friendly Delta
Sacramento and San Joaquin Rivers
Delta waterways
Open water
Experimental islands (potential open water)
Tidal brackish marsh
Leveed freshwater marsh
Freshwater tidal marsh
Managed floodplain
Shipchannel delta smelt management area
Sandhill crane management areas
Humans and wildlife
Subsidence reversal agriculture
Wildlife friendly agriculture
Annual floodplain
Sacramento
AMERICAN R.
YOLO BYPASS
SACRAMENTO R.
Freeport
Clarksburg
Hood
Stone Lake
Courtland
COSUMNES R.
Cache Slough
Barker Slough Pumping Plant
Lindsey Slough
Dry Creek
Ryde
Walnut Grove
Fairfield
Rio Vista
Isleton
MOKELUMNE R.
Lodi
Suisun Marsh Salinity Control Gate
Grizzly Bay
Suisun Marsh
Honker Bay
Suisun Bay
Carquinez Straits
Pittsburg
Antioch
Oakley
Contra Costa Canal
Concord
Stockton
Marsh Creek
Discovery Bay
Lathrop
Manteca
Los Vaqueros Reservoir
Harvey O. Banks Delta Pumping Plant
Tracy Pumping Plant
South Bay Pumping Plant
Tracy
Delta-Mendota Canal
California Aqueduct
SAN JOAQUIN R.
N
2 0 2 4 6
miles


Water exports
Flow (10^6 m^3)
2,400
1,600
800
0
POD species
Delta smelt
Striped bass
1.8
1.2
0.6
0.0
Salinity
EC (umhos cm^{-1})
2,100
1,400
700
0
Inland silverside
Fish biomass (kg)
15
10
5
0
Water clarity
Secchi depth (cm)
70
60
50
40
30
Centrarchid species
Largemouth bass
Bluegill sunfish
4.5
3.0
1.5
0.0
1976
1984
1992
2000
2008



RED = 2000-2006

Figure D.4 Phase-space plots of physical variables and fish species or assemblages in the Delta, 1976 - 2006

Fish Groups

Are there management clusters?
PCA analysis

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  - Delta and longfin smelt
- **Planktivorous fishes**
  - Mostly undesirable
- **Anadromous fishes**
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