Effects of Fall X2 on Delta Smelt

Current State of Knowledge

OC/ WEDNESDAY, JULY 4, 1990 A5

Second Front Page

Delta Smelt Threatens Water Supply

■ **Environment:** A state agency says the tiny fish is nearing extinction. Saving it might force a reduction in shipments to Southern California.

By RICHARD C. PADDOCK
TIMES STAFF WRITER

SACRAMENTO—In a serious challenge to California's vast water supply system, a small fish found only in the Sacramento-San Joaquin River Delta is nearing extinction and should be listed as a threatened species, the state Departments of Fish and Game has concluded.

question is how probable it is that they go extinct, and I don't think anybody knows."

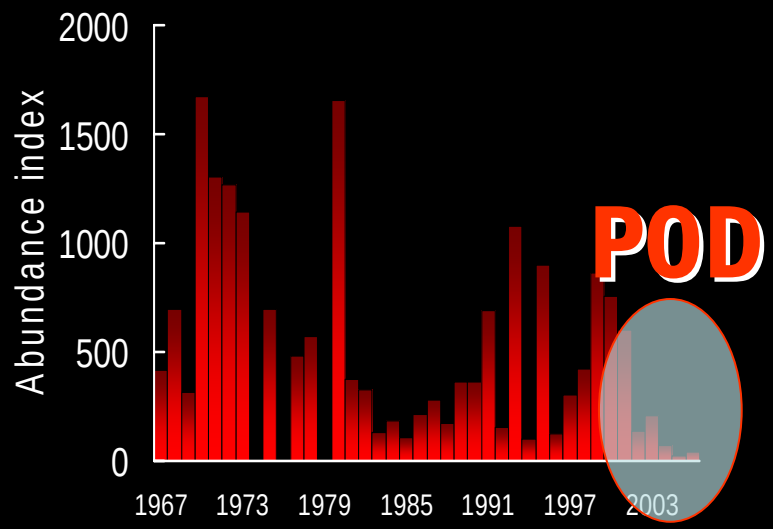
A declaration that the smelt is threatened could [illegible] cials to cut back [illegible] water pumped ou[illegible] residents and far[illegible] California.

"The only wa[illegible] some of their p[illegible] smelt] would be [illegible] duction in diver[illegible] thy Quinn, a dire[illegible] politan Water [illegible] would have a dev[illegible] us down here."

The sudden de[illegible] has revive[illegible] building a "pe[illegible] around the Delta [illegible] by voters in 19[illegible]

considering a petition filed by the American Fisheries Society requesting that the species be de-

report to the federal agency in January, 1989. The smelt, they noted, was once one of the most



NEWSFOCUS

Help

Delta Blues, California Style

The hub of California's freshwater system is plagued by crashing fisheries, high demand, invasive species, and pollution—and a major earthquake there could devastate the state's drinking water and agriculture

IRVIN, CALIFORNIA—In a makeshift laboratory that was once a refrigerated shipping container, Joan Lindberg, a research biologist at the University of California (UC), Davis, shines a small flashlight into a 2-meter-diameter water tank. Two-centimeter pencil-thin fish known as delta smelt dart away from the light. These small fish, native to the Sacramento–San Joaquin River Delta that flows just beyond these tanks, are bred and farmed out to fisheries biologists throughout the region who are racing to understand their life cycle, feeding habits, and vulnerabilities. It's a race that's now in full sprint, as the population of delta smelt in their native habitat is in free fall.

Historically, millions of the fish swam this delta, which sits just east of San Francisco Bay and is the largest estuary on the West Coast of the United States. But a survey of juvenile smelt conducted in June found only 37, down from 884 found a year earlier. More than 700 smelt were killed this spring by a series of massive pumps nearby that suck a river's worth of water out of the delta and send it south to Los Angeles and San Diego. But the water exports are only one of the smelts' problems, with pollution and invasive species also topping the list of concerns. Now, with the delta smelt teetering on the edge of extinction, Lindberg and her colleagues are looking into ramping up their fish-breeding efforts to try to prevent the fish from going extinct. "We're doing what we feel is prudent to save the wild fish," Lindberg says.

More than a kilometer up the road, a second set of massive pumps sucks out another river's worth of water and sends it primarily to farmers in California's Central Vall

Here, as techn[illegible] bucket water before intently for Today, no[illegible] of striped But one [illegible] was en[illegible] farmin[illegible] that b[illegible] fate [illegible] Jeff[illegible] US [illegible] fe[illegible] V[illegible]

442 27 JULY 2007 VOL 317 SCIENCE www.sciencemag.org

FEATURE: FISHERIES RESEARCH

The Collapse of Pelagic Fishes in the Upper San Francisco Estuary

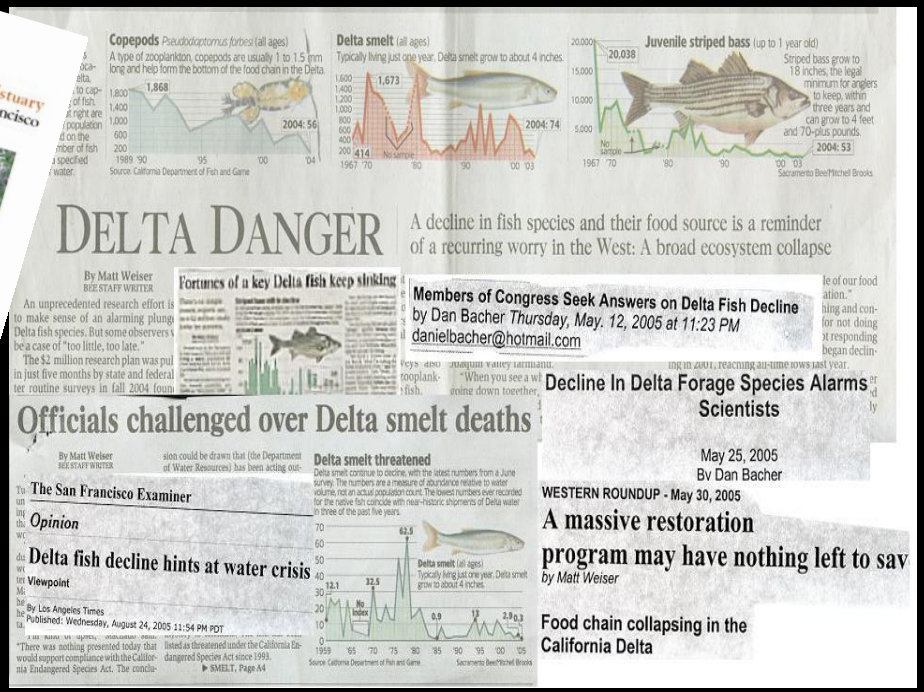
El Colapso de los Peces Pelágicos en La Cabecera Del Estuario San Francisco

Figure 1. The San Francisco estuary. The estuary includes the region from San Francisco Bay upstream to Sacramento and a location 58 km upstream of Stockton. The delta represents the portion of the estuary upstream of the confluence of the Sacramento and San Joaquin rivers.

Ted Sommer
Chuck Armor
Randall Baxter
Richard Breuer
Larry Brown
Mike Chotkowski
Steve Culberson
Fredrick Feyrer
Marty Gingras
Bruce Herbold
Wim Kimmerer
Anke Mueller-Solger
Matt Nobriga
Kelly Souza

Sommer is a senior environmental scientist at the California Department of Water Resources, Sacramento, and can be contacted at sommer@water.ca.gov. Armor is a regional manager, Baxter is a senior biologist, Gingras is a supervising biologist, and Souza is a senior environmental scientist with the California Department of Fish and Game, Stockton. Breuer is an environmental scientist at the California Department of Fish and Game, Stockton. Feyrer is an environmental scientist, and Mueller-Solger is a staff environmental scientist at the California Department of Water Resources, Sacramento. Brown is a research biologist at the U.S. Geological Survey, Sacramento, and Chotkowski is a fishery biologist at the U.S. Bureau of Reclamation, Sacramento. Culberson is a senior environmental scientist and biologist in an environmental consultant firm, Herbold is an environmental Program, Sacramento. Herbold is an environmental protection specialist at the U.S. Environmental Protection Agency, San Francisco, and Kimmerer is a research professor at San Francisco State University, Tiburon, California.

Fisheries • VOL 32 NO 6 • JUNE 2007 • www.fisheries.org



Copepods *Pseudodiaptomus forbesi* (all ages)
A type of zooplankton, copepods are usually 1 to 1.5 mm long and help form the bottom of the food chain in the Delta.
Source: California Department of Fish and Game

Delta smelt (all ages)
Typically living just one year, Delta smelt grow to about 4 inches.

Juvenile striped bass (up to 1 year old)
Striped bass grow to 18 inches, the legal minimum for anglers to keep, within three years and can grow to 4 feet and 70-plus pounds.
Sacramento Bee/Mitchell Brooks

DELTA DANGER

A decline in fish species and their food source is a reminder of a recurring worry in the West: A broad ecosystem collapse

By Matt Weiser
BEE STAFF WRITER

An unprecedented research effort is to make sense of an alarming plung Delta fish species. But some observers be a case of "too little, too late."

The $2 million research plan was pul in just five months by state and federal ter routine surveys in fall 2004 foun

Fortunes of a key Delta fish keep sinking

Members of Congress Seek Answers on Delta Fish Decline
by Dan Bacher *Thursday, May. 12, 2005 at 11:23 PM*
danielbacher@hotmail.com

Decline In Delta Forage Species Alarms Scientists

May 25, 2005
By Dan Bacher

WESTERN ROUNDUP - May 30, 2005

A massive restoration program may have nothing left to sav
by Matt Weiser

Food chain collapsing in the California Delta

Officials challenged over Delta smelt deaths

By Matt Weiser
BEE STAFF WRITER

sion could be drawn that (the Department of Water Resources) has been acting out-

Delta smelt threatened
Delta smelt continue to decline, with the latest numbers from a June survey. The numbers are a measure of abundance relative to water volume, not an actual population count. The lowest numbers ever recorded for the native fish coincide with near-historic shipments of Delta water in three of the past five years.
Source: California Department of Fish and Game
Sacramento Bee/Mitchell Brooks

The San Francisco Examiner

Opinion

Delta fish decline hints at water crisis

Viewpoint

By Los Angeles Times
Published: Wednesday, August 24, 2005 11:54 PM PDT

listed as threatened under the California Endangered Species Act since 1993.

▶ SMELT, Page A4

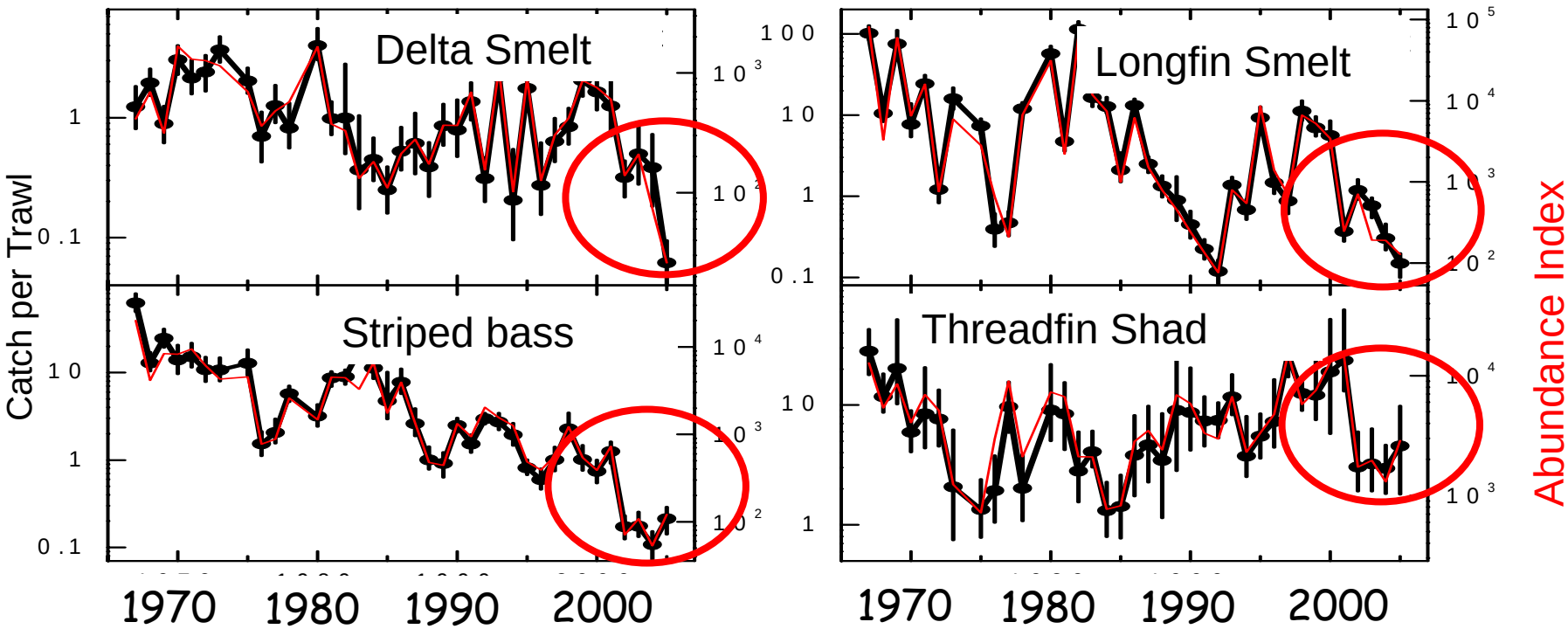
Delta smelt

Longfin smelt

Threadfin shad

Striped bass

The Pelagic Organism Decline (POD)



Source: Sommer et al. (2007)

POD Management Team

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Rich Breuer DWR
Larry Brown USGS
Mike Chotkowski BOR
Fred Feyrer BOR
Stephanie Fong SWRCB
Marty Gingras DFG
Pete Hrodey FWS
Bruce Herbold USEPA
Anke Mueller-Solger CALFED
Ted Sommer DWR
Kelly Souza DFG
Curtis Yip SWRCB

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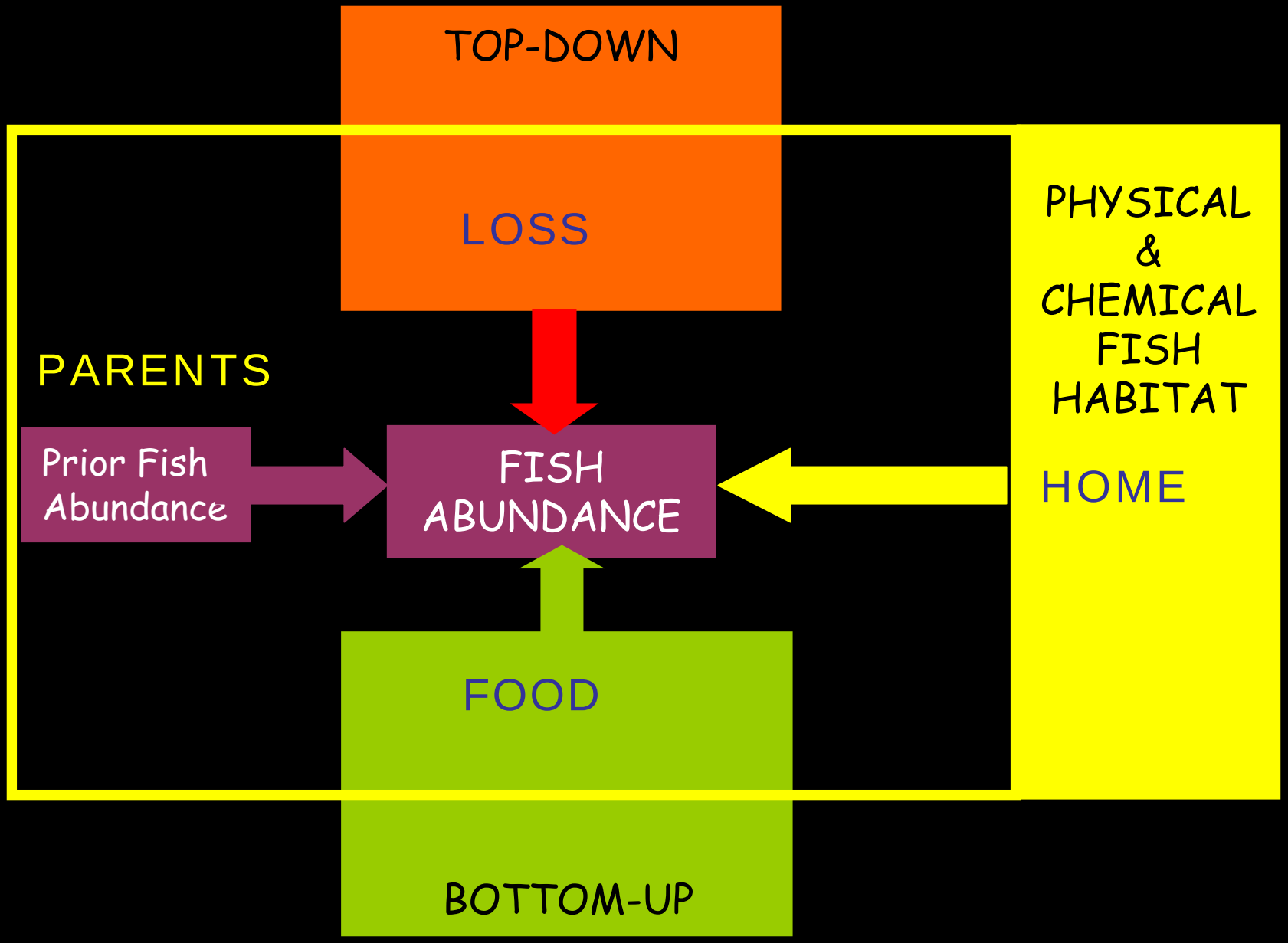
  - Randy Baxter, John Budrick, Kelly Souza, Steve Slater, Kathy Hieb, Marty Gingras
- Dept Water Resources
  - Ted Sommer, Bob Suits, Heather Peterson, Zoltan Matica, Peggy Lehman, Lenny Grimaldo, Mike Mierzwa, Jim Wilde, Karen Gehrts, Tanya Veldhuizen
- US Bureau of Reclamation
  - Mike Chotkowski, Lenny Grimaldo, Fred Feyrer
- US EPA
  - Bruce Herbold
- Consultants
  - BJ Miller, Bryan Manly
- US Fish and Wildlife Service
  - Gonzalo Castillo, Ken Newman, Scott Foote
- US Geological Survey
  - Joseph Simi, Cathy Ruhl, Pete Smith, Dave Schoellhamer
- UC Davis
  - Bill Bennett, Swee Teh, Inge Werner, David Ostrach, Frank Loge, Jim Hobbs
- SF State University
  - Wim Kimmerer, John Durand
- SF Estuary Institute
  - Daniel Oros, Geoff Siemering, Jennifer Hayworth


TOP-DOWN
LOSS
PARENTS
Prior Fish Abundance
FISH ABUNDANCE
PHYSICAL & CHEMICAL FISH HABITAT
HOME
FOOD
BOTTOM-UP

TOP-DOWN

POD Habitat Conditions and Trends Study Elements

1) Define suitable abiotic habitat.

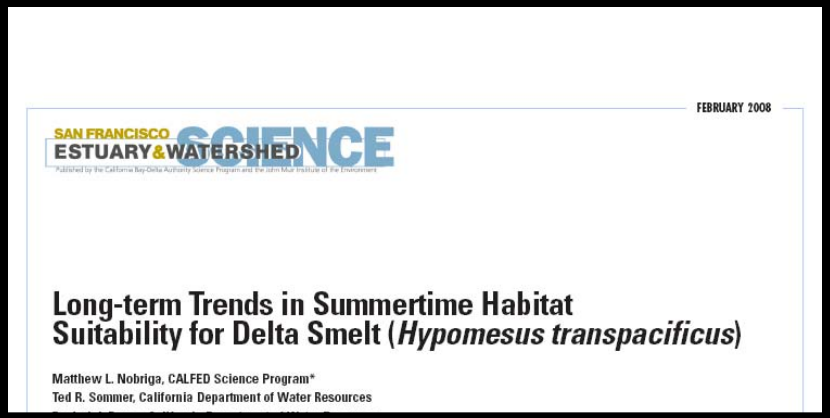
2) Examine temporal and spatial trends in habitat suitability.

3) Examine effects of habitat suitability on fish abundance.

PHYSICAL
&
CHEMICAL
FISH
HABITAT

HOME

BOTTOM-UP

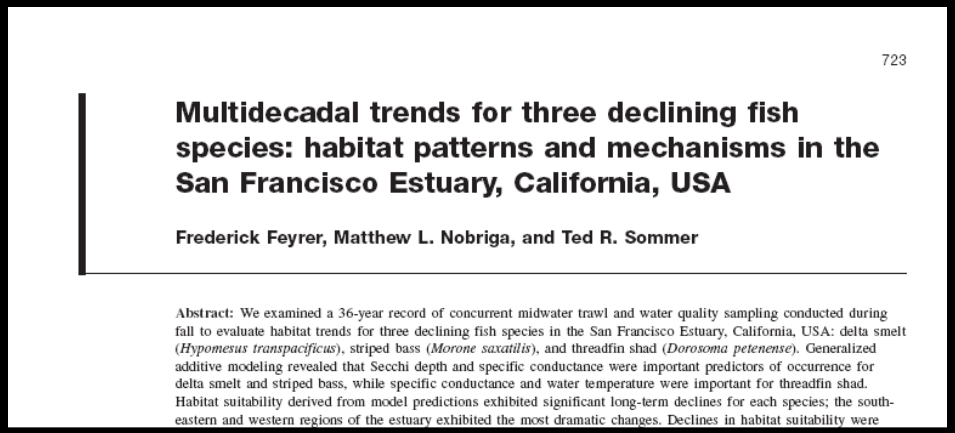


FEBRUARY 2008

SAN FRANCISCO ESTUARY & WATERSHED SCIENCE

Long-term Trends in Summertime Habitat Suitability for Delta Smelt (*Hypomesus transpacificus*)

Matthew L. Nobriga, CALFED Science Program*
Ted R. Sommer, California Department of Water Resources



Multidecadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA

Frederick Feyrer, Matthew L. Nobriga, and Ted R. Sommer

Abstract: We examined a 36-year record of concurrent midwater trawl and water quality sampling conducted during fall to evaluate habitat trends for three declining fish species in the San Francisco Estuary, California, USA: delta smelt (*Hypomesus transpacificus*), striped bass (*Morone saxatilis*), and threadfin shad (*Dorosoma petenense*). Generalized additive modeling revealed that Secchi depth and specific conductance were important predictors of occurrence for delta smelt and striped bass, while specific conductance and water temperature were important for threadfin shad. Habitat suitability derived from model predictions exhibited significant long-term declines for each species; the south-eastern and western regions of the estuary exhibited the most dramatic changes. Declines in habitat suitability were

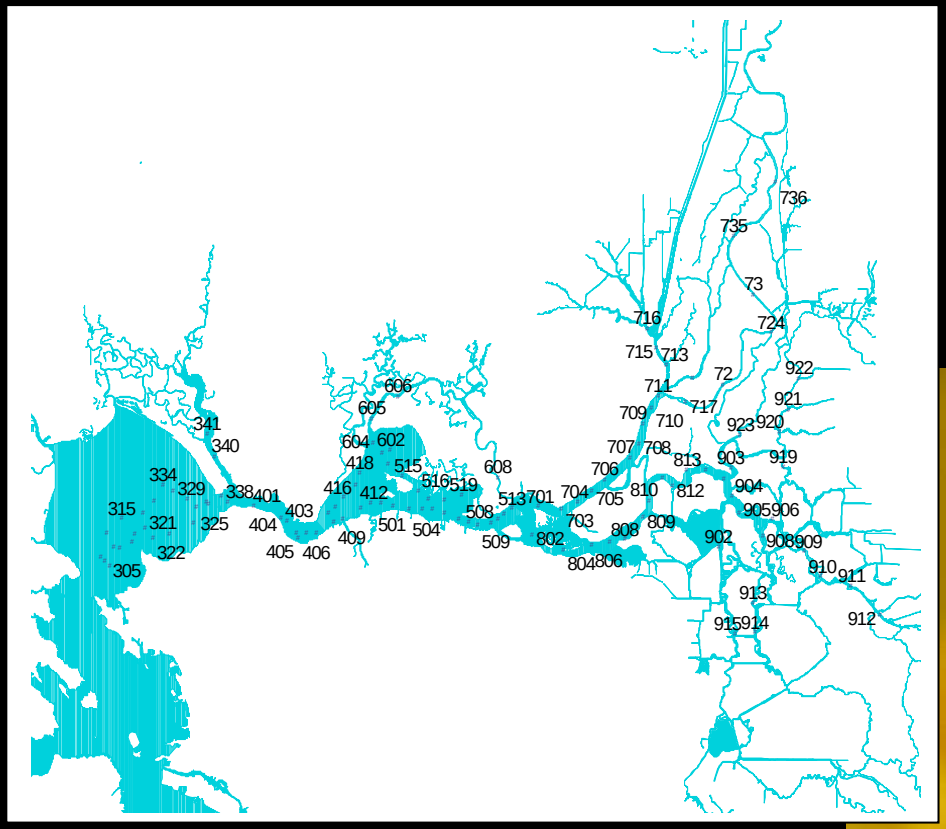
SUMMER ANALYSIS

1. Defined abiotic habitat.
2. Present habitat centered near the confluence.
3. Habitat related to abundance at regional scales.

FALL ANALYSIS

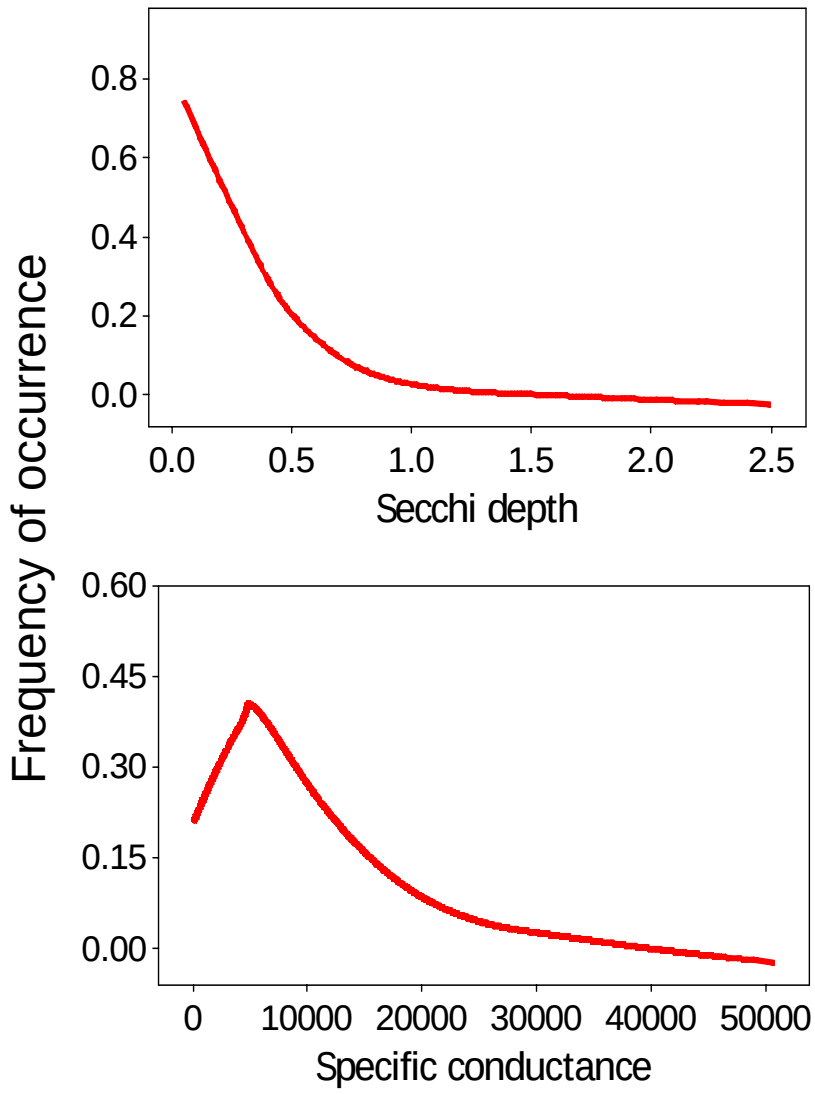
1. Defined abiotic habitat.
2. Present habitat centered near the confluence.
3. Apparent link between habitat and abundance.

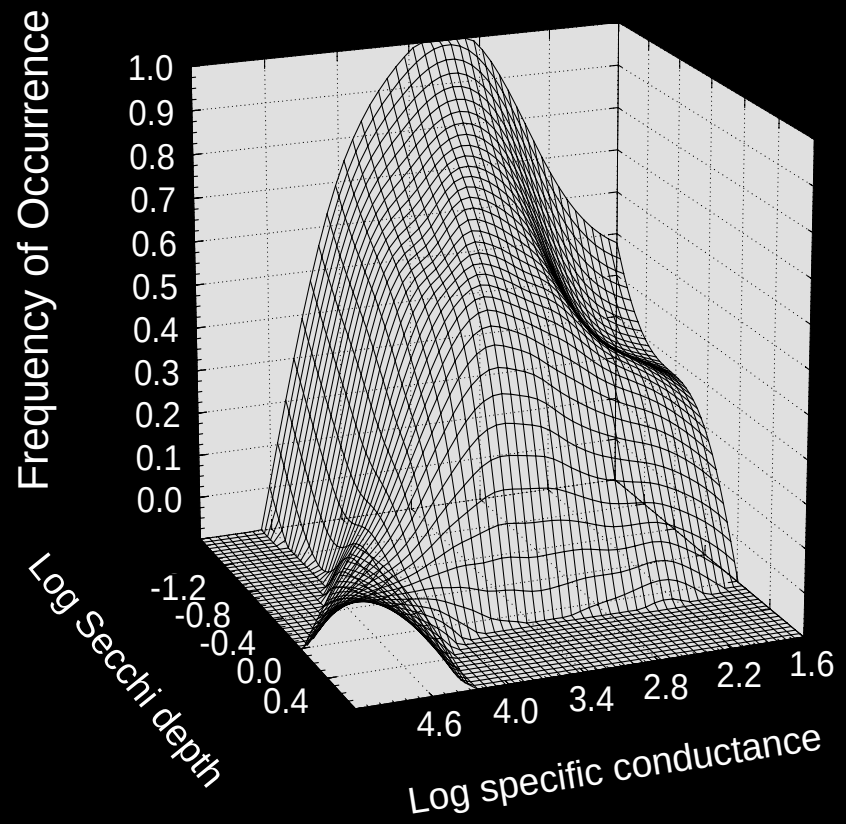
Fall Midwater Trawl Survey

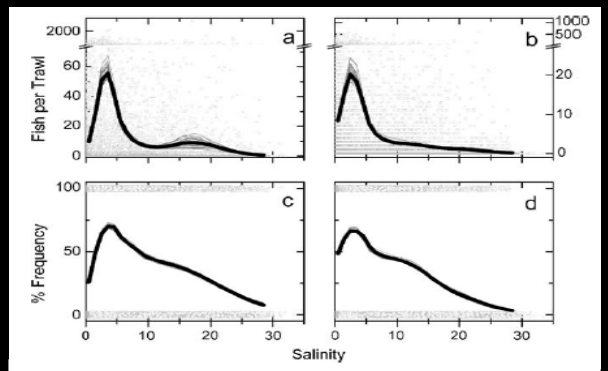


1967 – present
100+ stations sampled 4x, September-December
water temperature, specific conductance, Secchi depth

$$\pi_{y,m,s} \sim (temp, Secchi, cond)$$

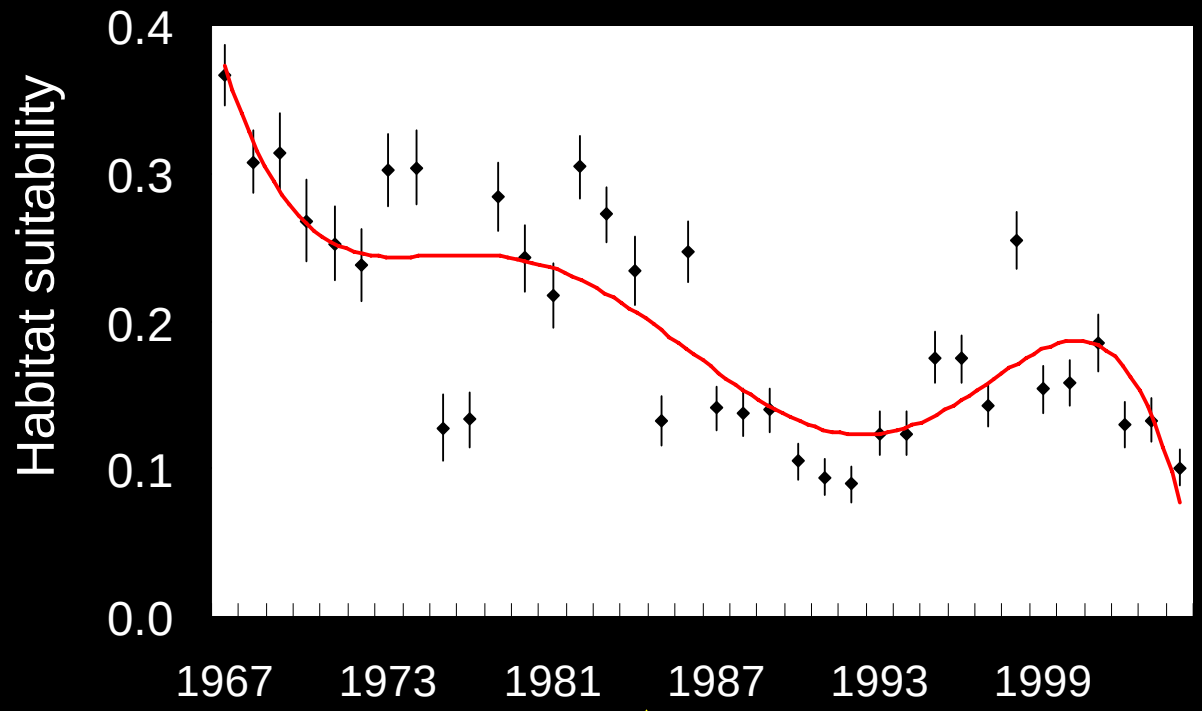


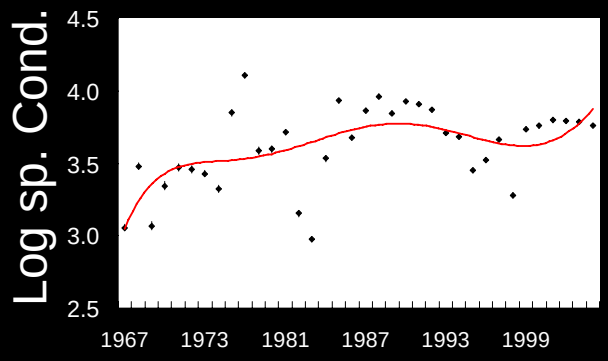




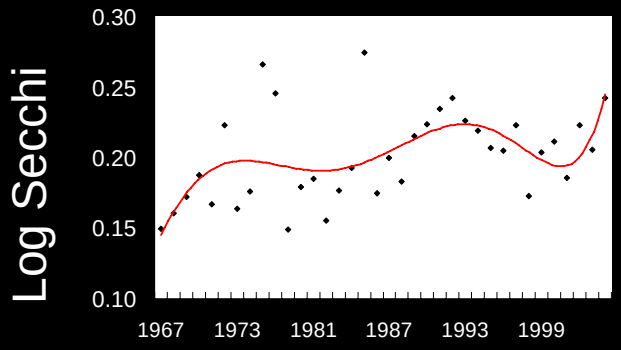
Kimmerer et al. 2009

Long-Term Decline in Habitat Suitability

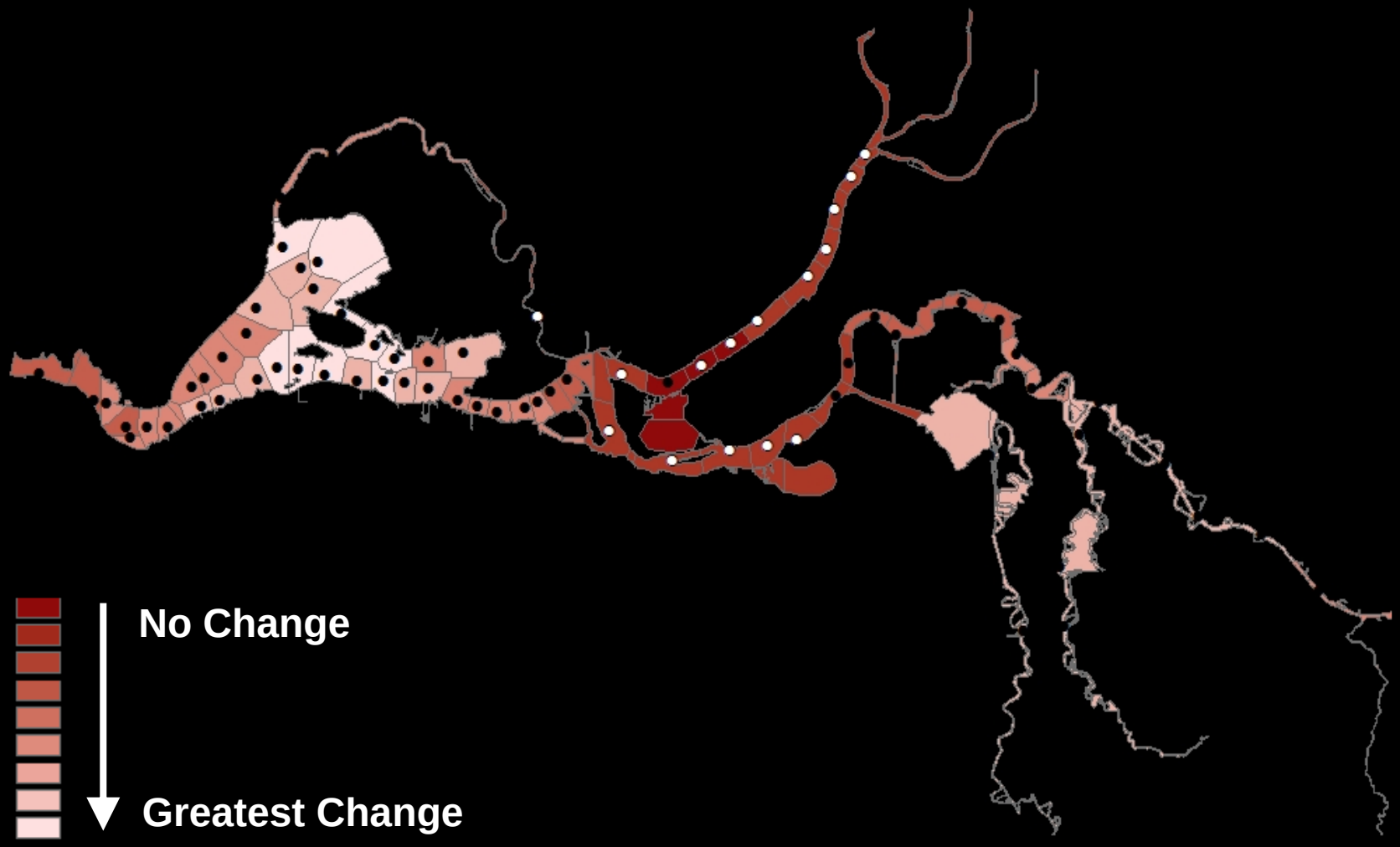




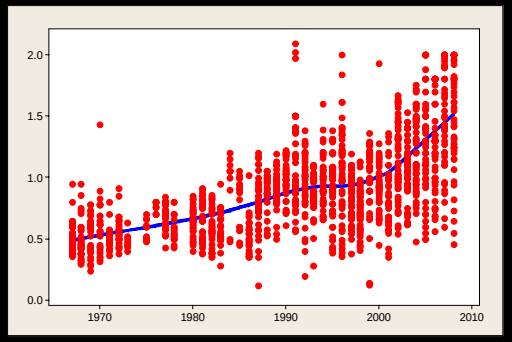
Long-term increase in salinity and transparency



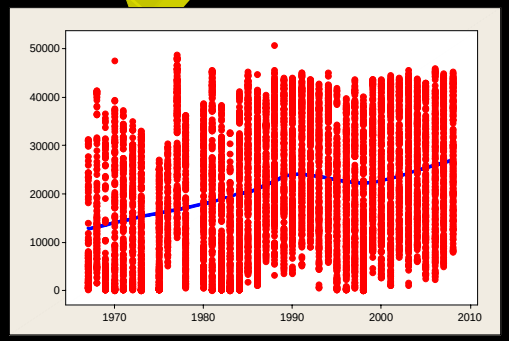
Spatio-Temporal Patterns



Spatio-Temporal Patterns

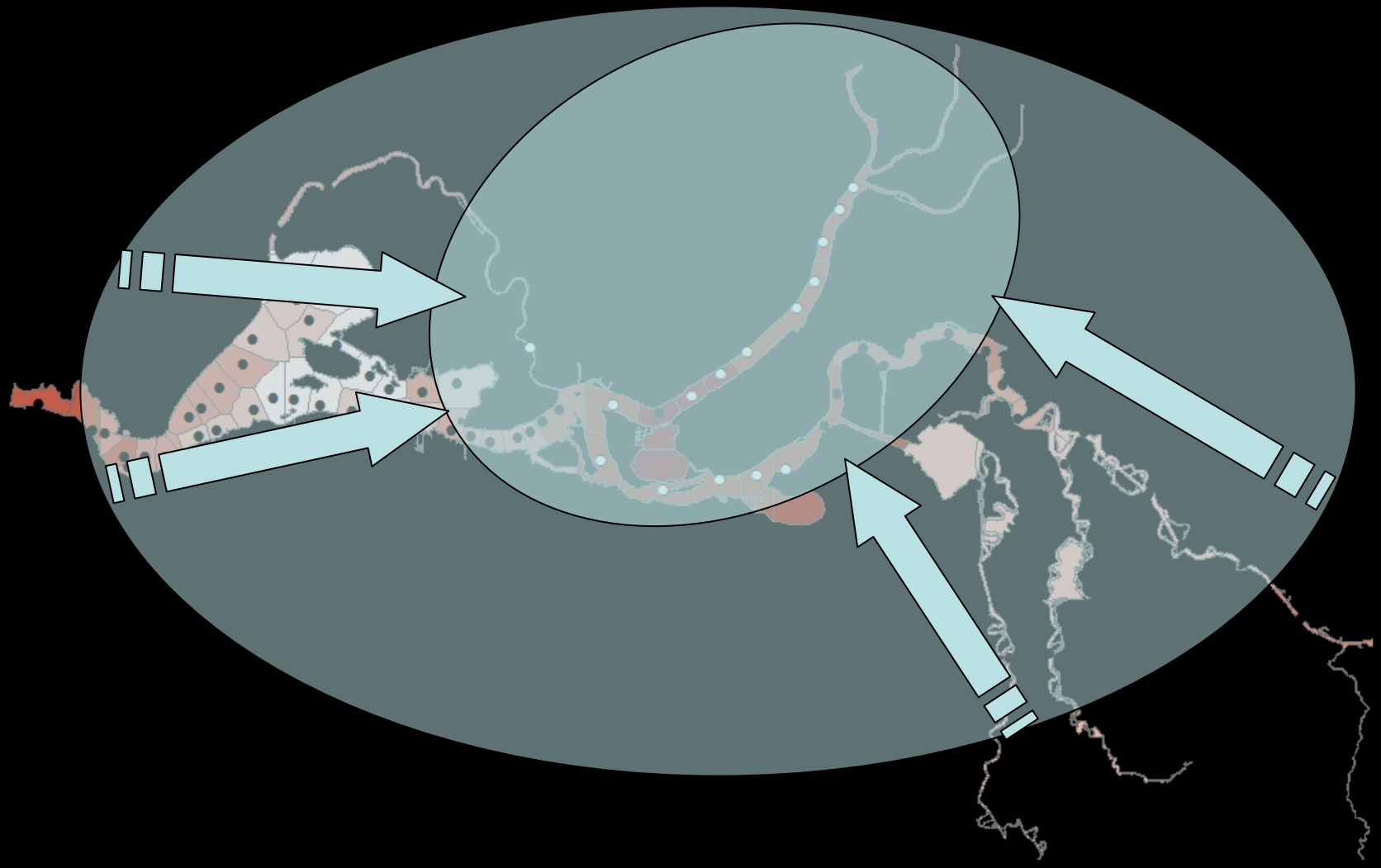


Increasingly clear

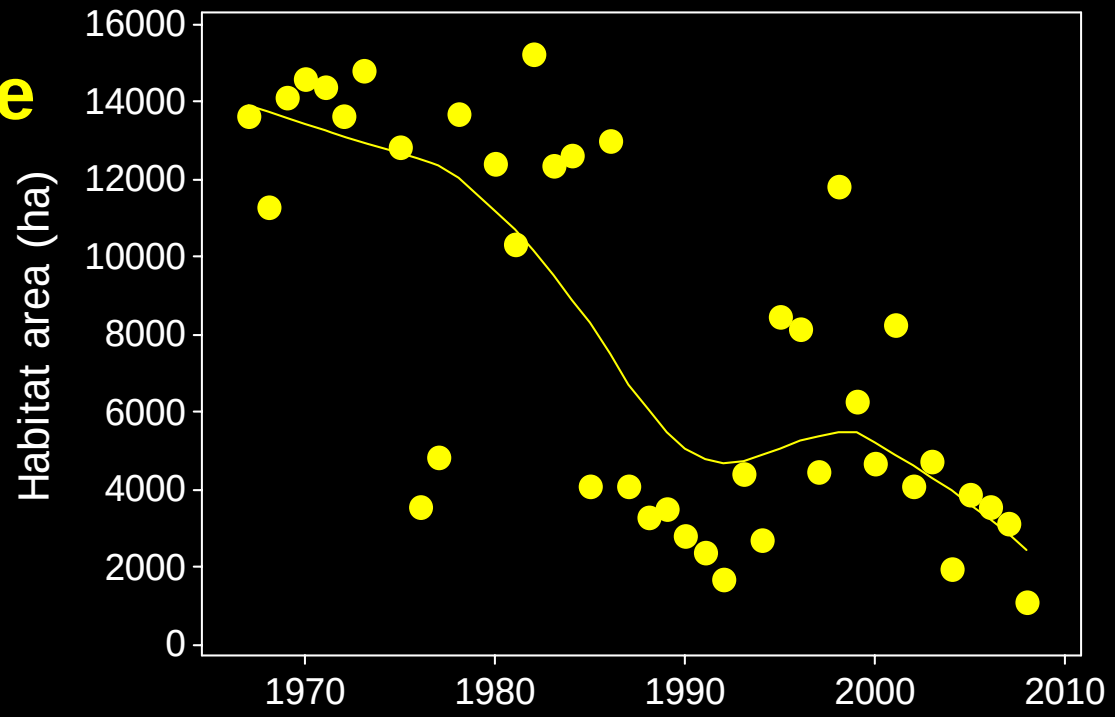


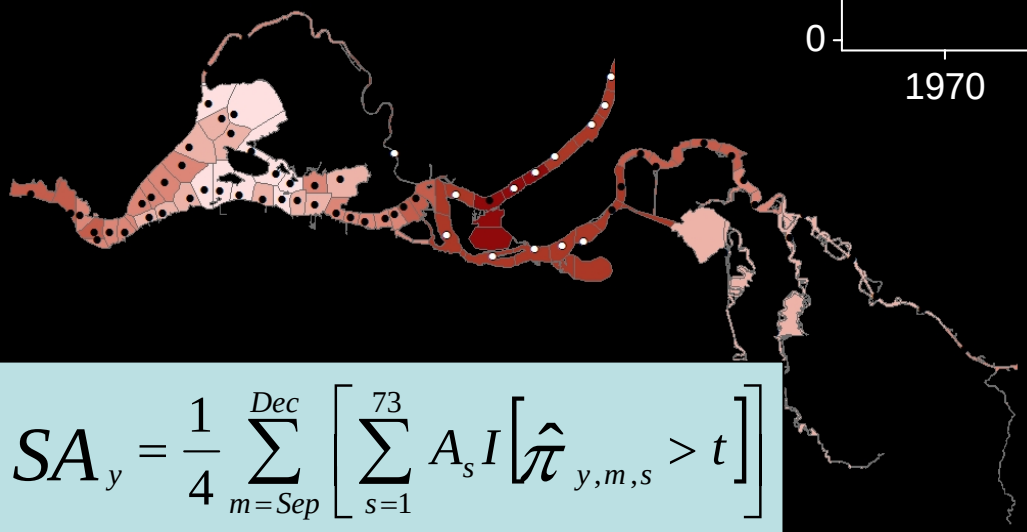
Increasingly salty

Constriction of Habitat Space



Long-term decrease surface area of suitable abiotic habitat

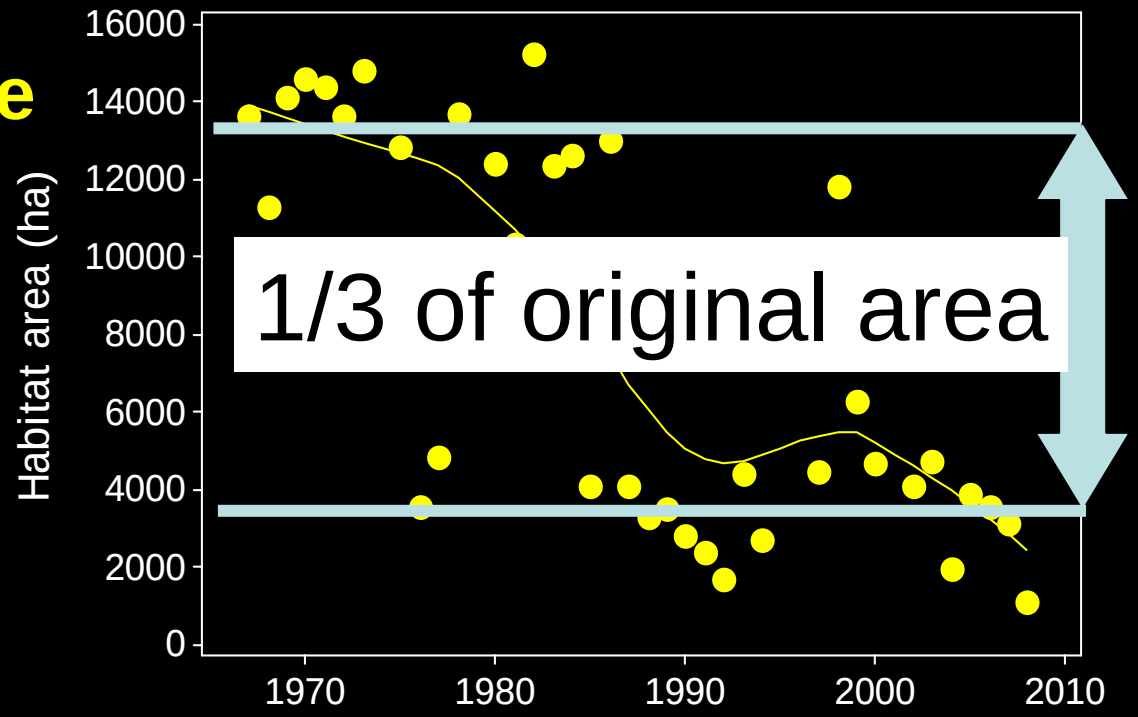


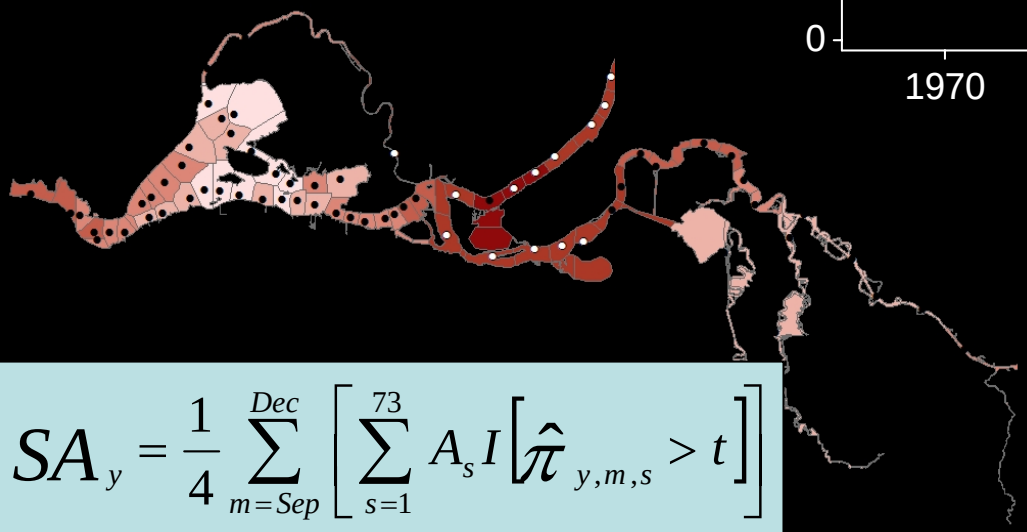


$$SA_y = \frac{1}{4} \sum_{m=Sep}^{Dec} \left[\sum_{s=1}^{73} A_s I\left[\hat{\pi}_{y,m,s} > t\right] \right]$$

New unpublished work

Long-term decrease surface area of suitable abiotic habitat





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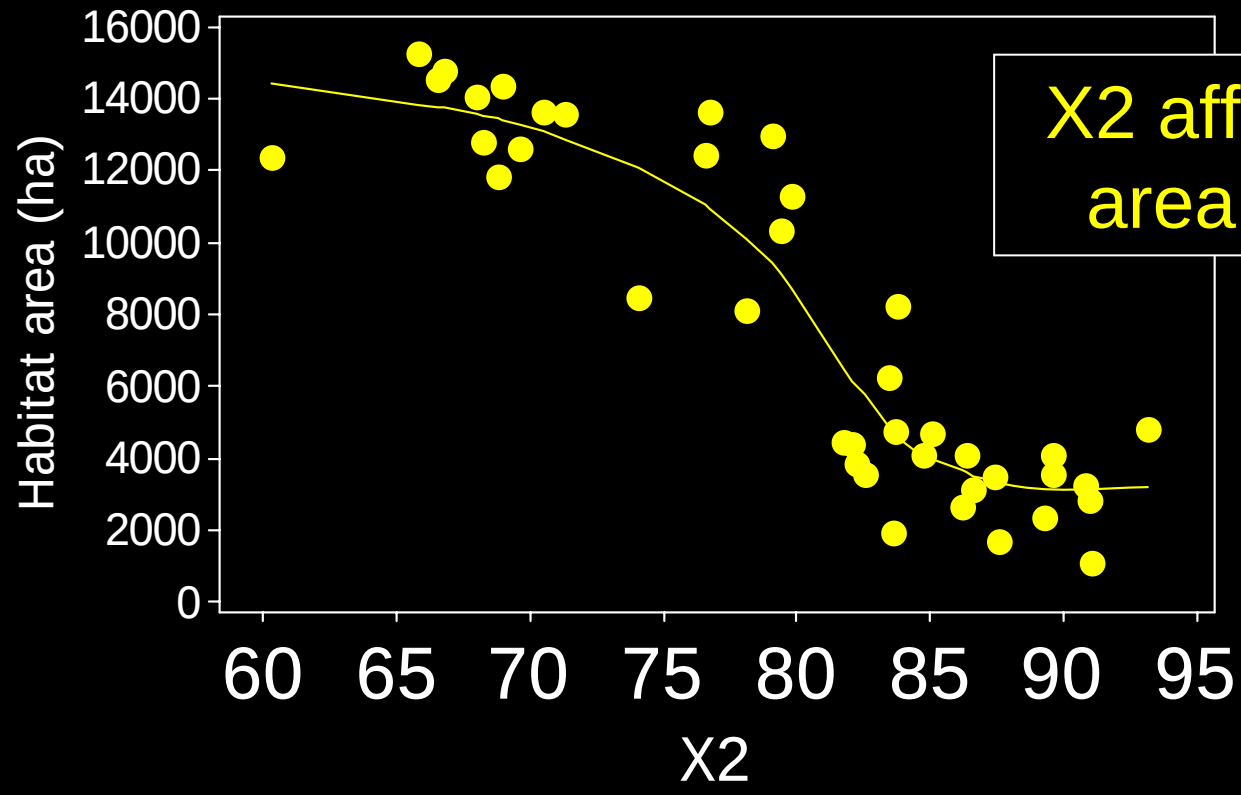
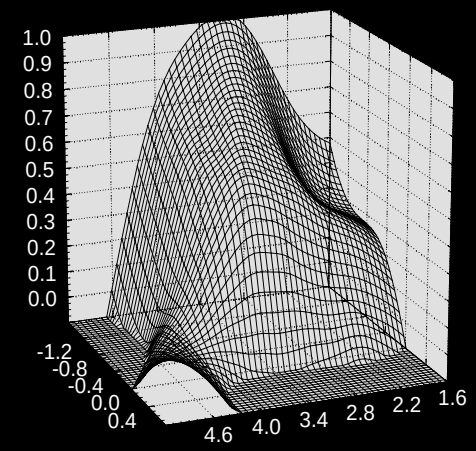
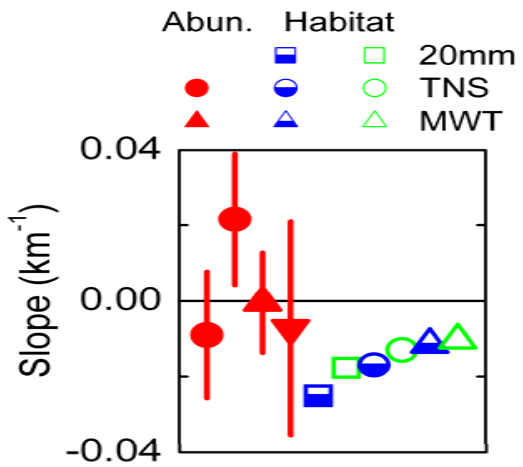
New unpublished work



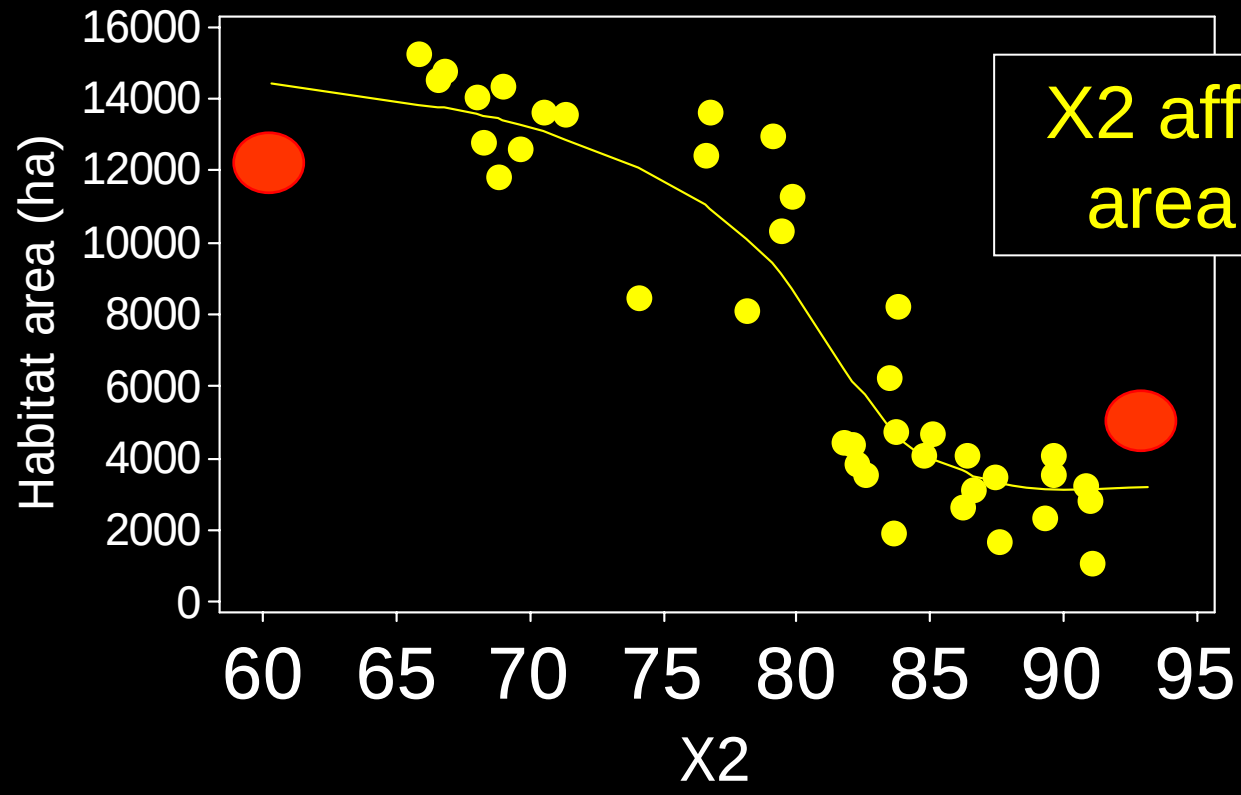
X2 affects habitat area during fall



X2 affects habitat volume all year downstream of the Delta



Kimmerer et al. 2009



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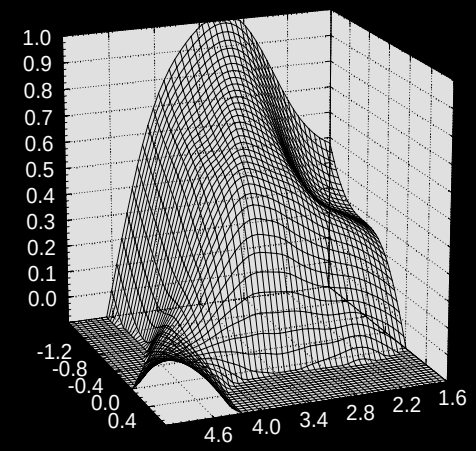

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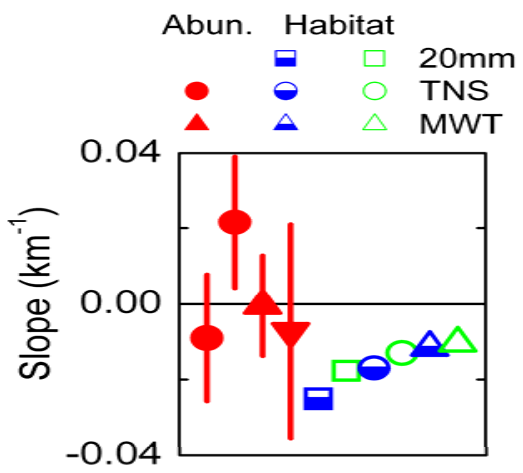
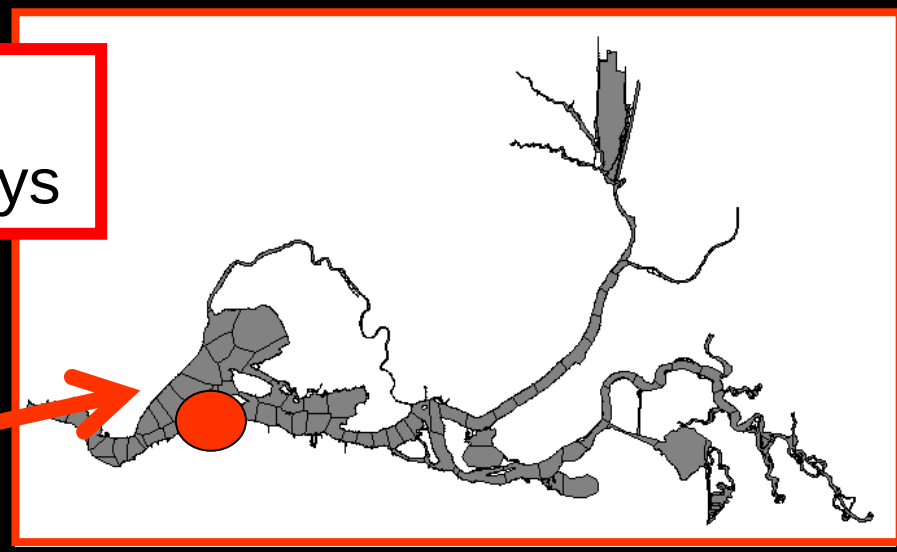
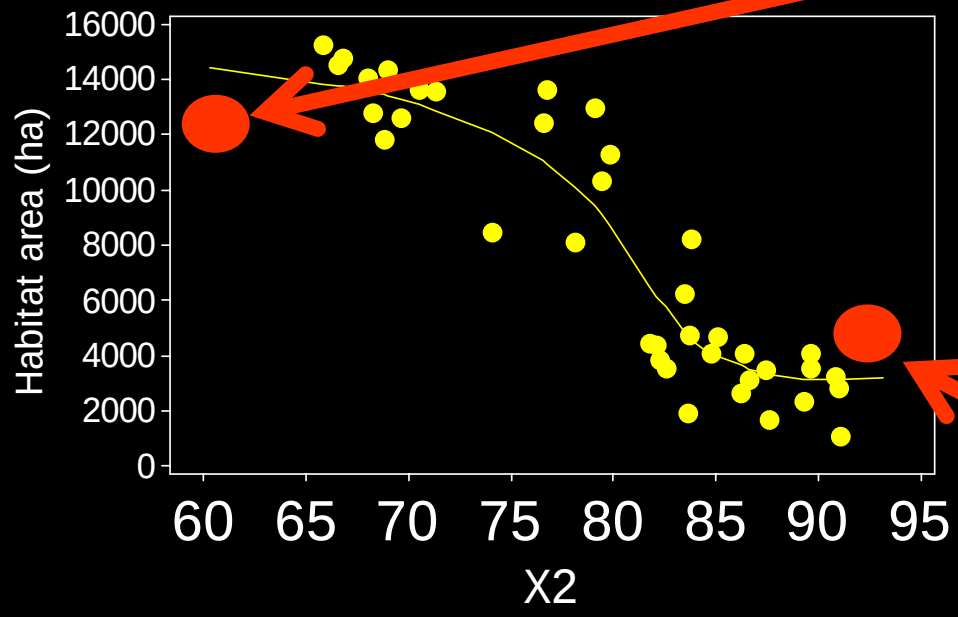
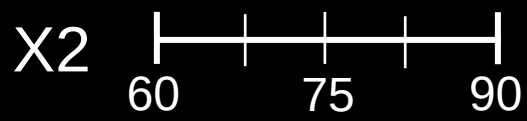


Kimmerer et al. 2009

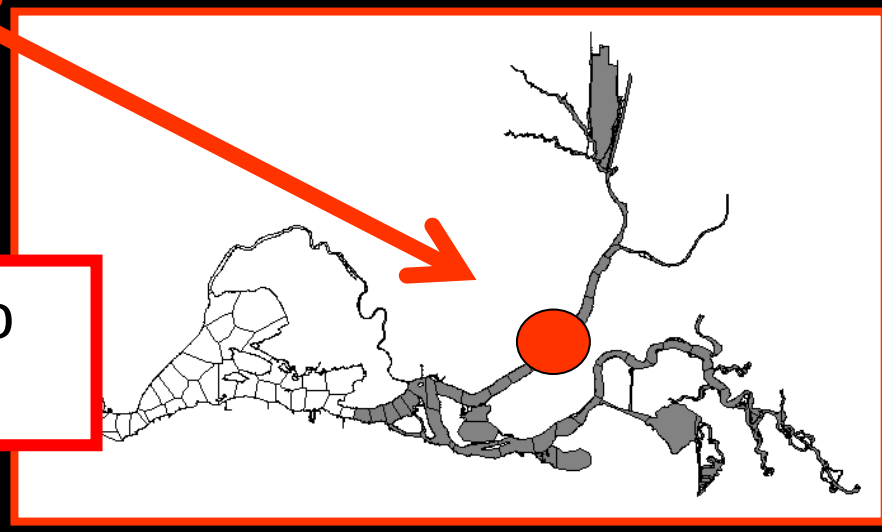
Low X2 ***expands*** habitat into broad shallow downstream bays



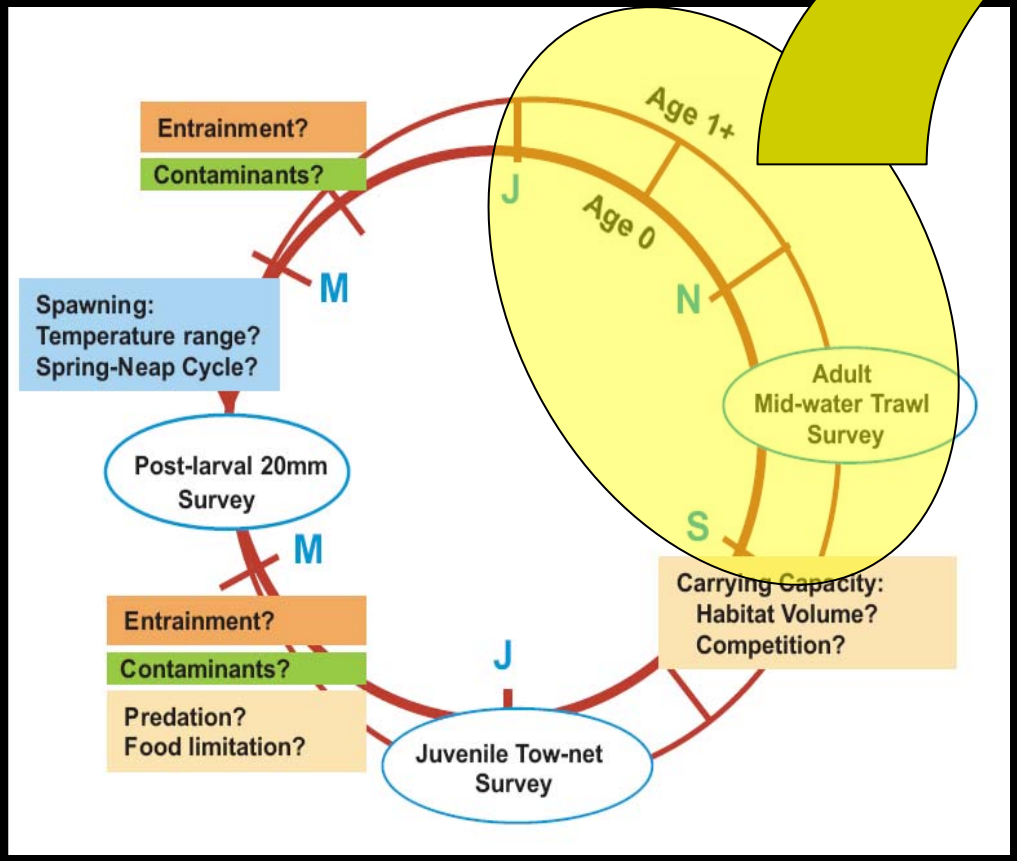




High X2 ***restricts*** habitat to narrow upstream channels



Conceptual model of delta smelt life cycle

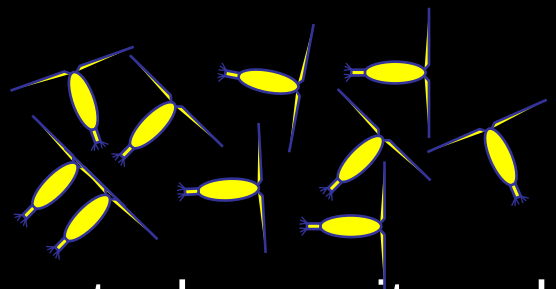


Bennett WA (2005) Critical assessment of the delta smelt population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science.

Importance of Fall

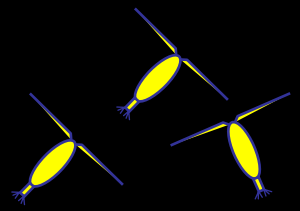
- ¼ of delta smelt life span
- Juveniles mature into adults
- Estuarine dependency
- Setting up for spawning migration

Apparent link to abundance



Pre-*Corbula* (~more food)

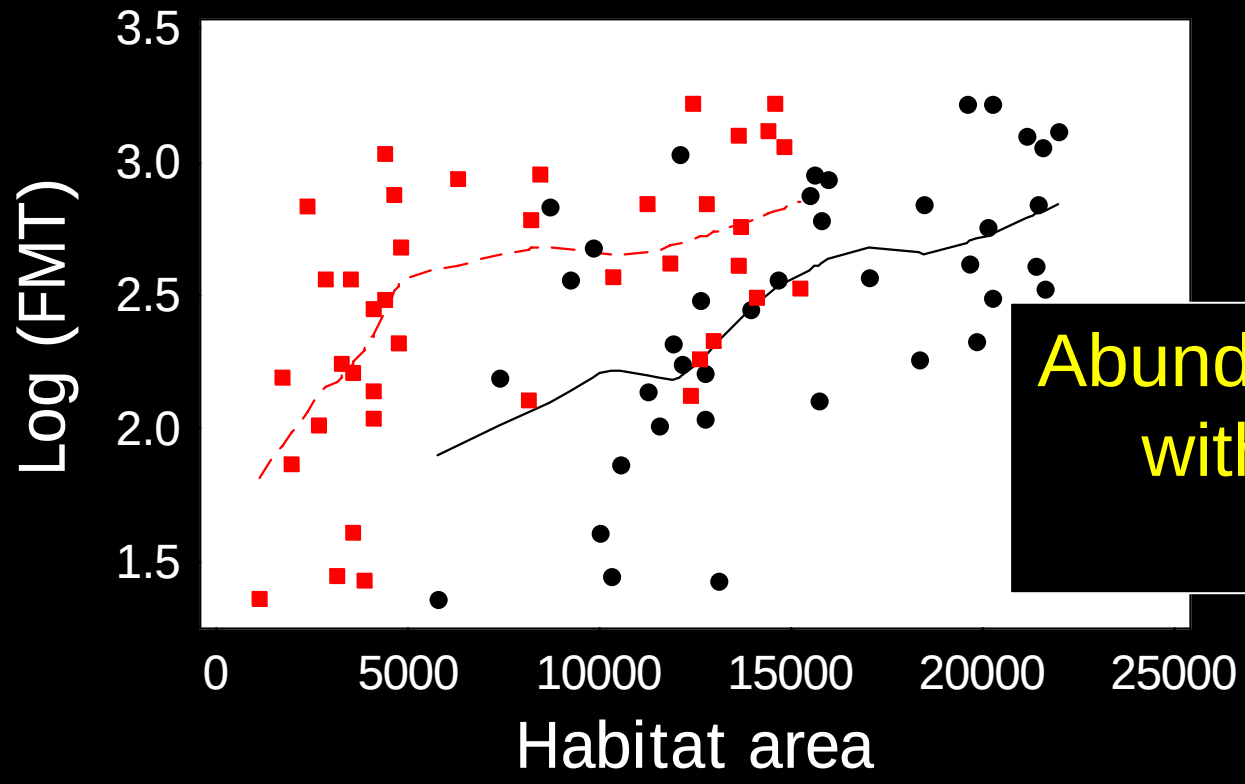
Habitat variables no effect on stock-recruit model



Post-*Corbula* (~less food)

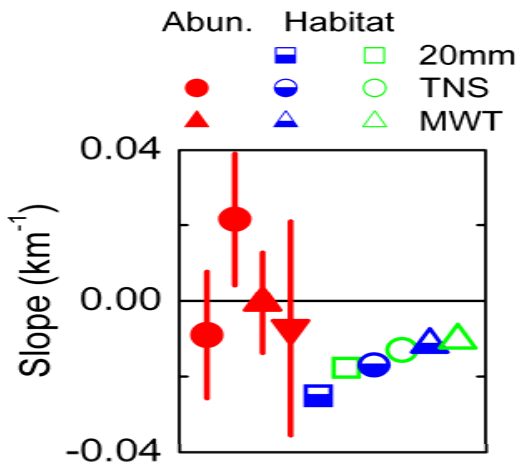
Habitat variables improved stock-recruit model

Model	P-Value	R2	AIC
Stock	0.005	39.5	96
Stock + Secchi	0.018	41.6	97
Stock + EC	0.001	59.6	90
Global	0.0004	59.6	93



Abundance associated with habitat area during fall

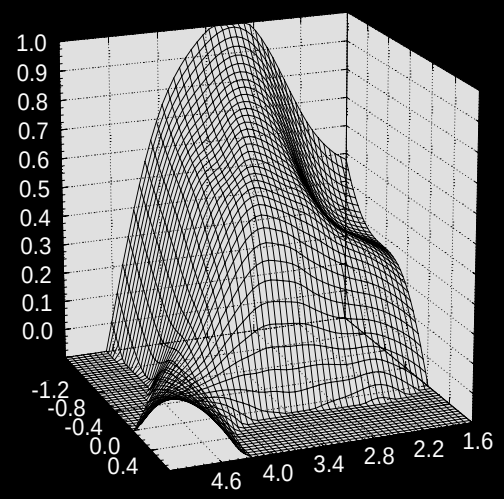
Spring habitat volume not associated with summer or fall abundance



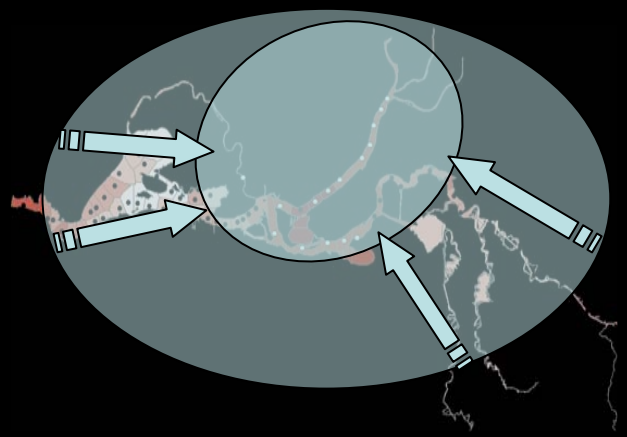
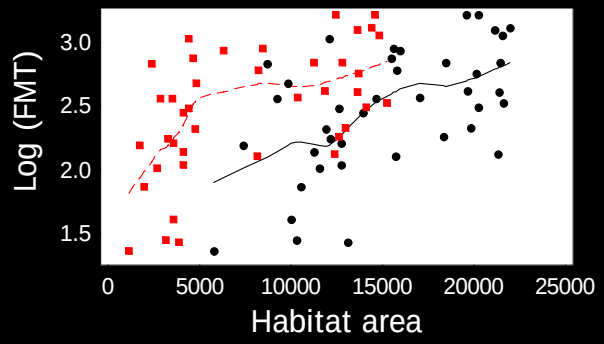
Kimmerer et al. 2009

Conclusions

1. *Abiotic habitat*
   ƒ(salinity,Secchi)



2. *Long-term decrease*
   in habitat area.



3. *Mechanistic links to*
   abundance?