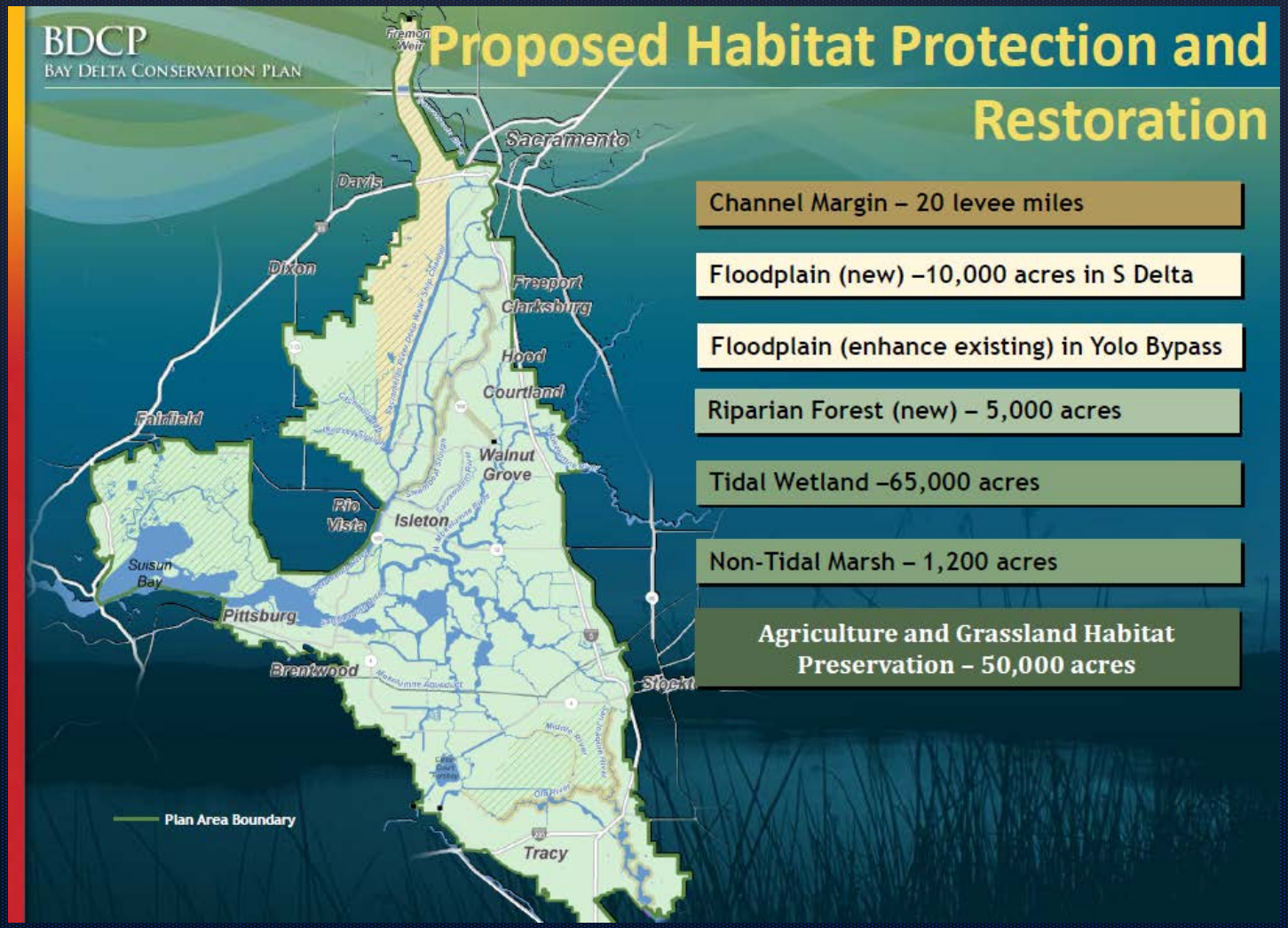
Implementing Large-Scale Tidal Marsh Restoration in a Stressed Ecosystem: How to Overcome the Challenges

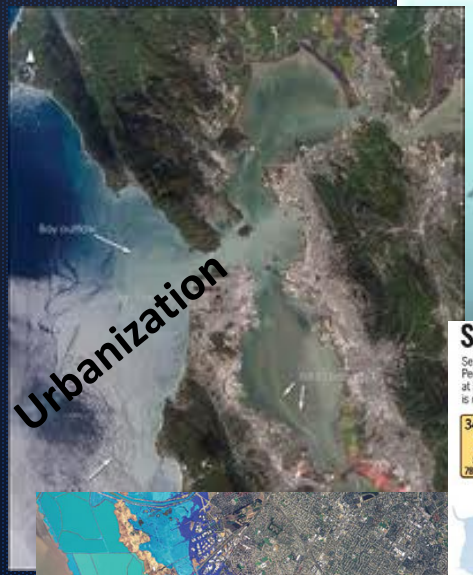
Lenny Grimaldo, Ph.D.
ICF International

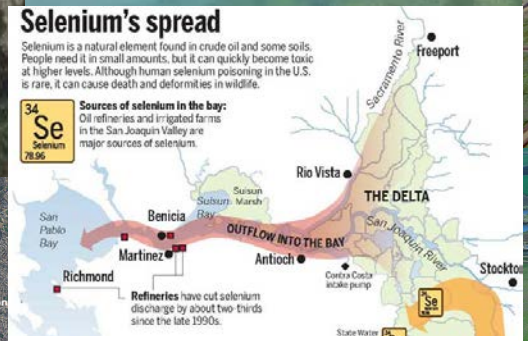
Delta Science Council
Independent Science Board Meeting
December 11th, 2014

Large-scale restoration on the horizon

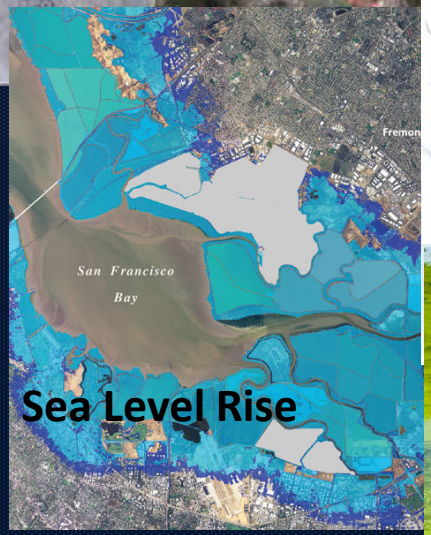


Major Challenges





Contaminants



Focus For Today—Fish and their habitats

1. How should tidal marsh restoration be designed to benefit habitats and functions for native fish?

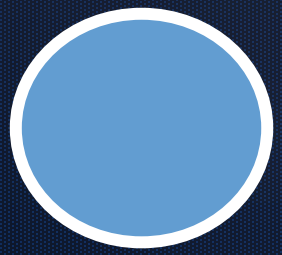
2. Where should restoration be focused and prioritized to benefit native fish and their habitats?

Overarching take home messages:

- *Manage to your certainty*
- *Improved knowledge of ecosystem functions and wiser management decisions can be acquired through actions not prescribed through a rigid adaptive management framework*

Manage to your certainty

Ecosystem services and functions

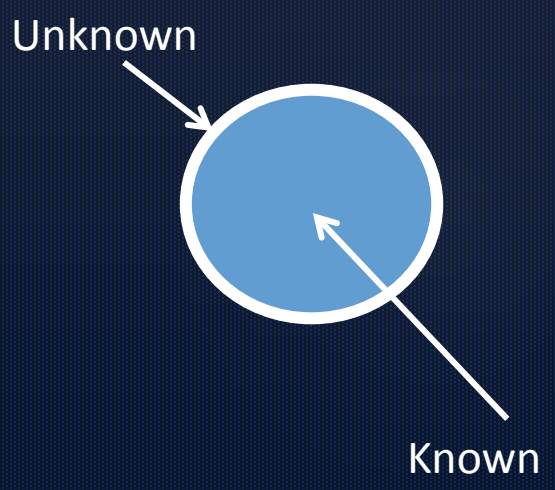


Initial state of knowledge

Modified from Peter Goodwin, Delta Science Program Lead Scientist

Manage to your certainty

Ecosystem services and functions



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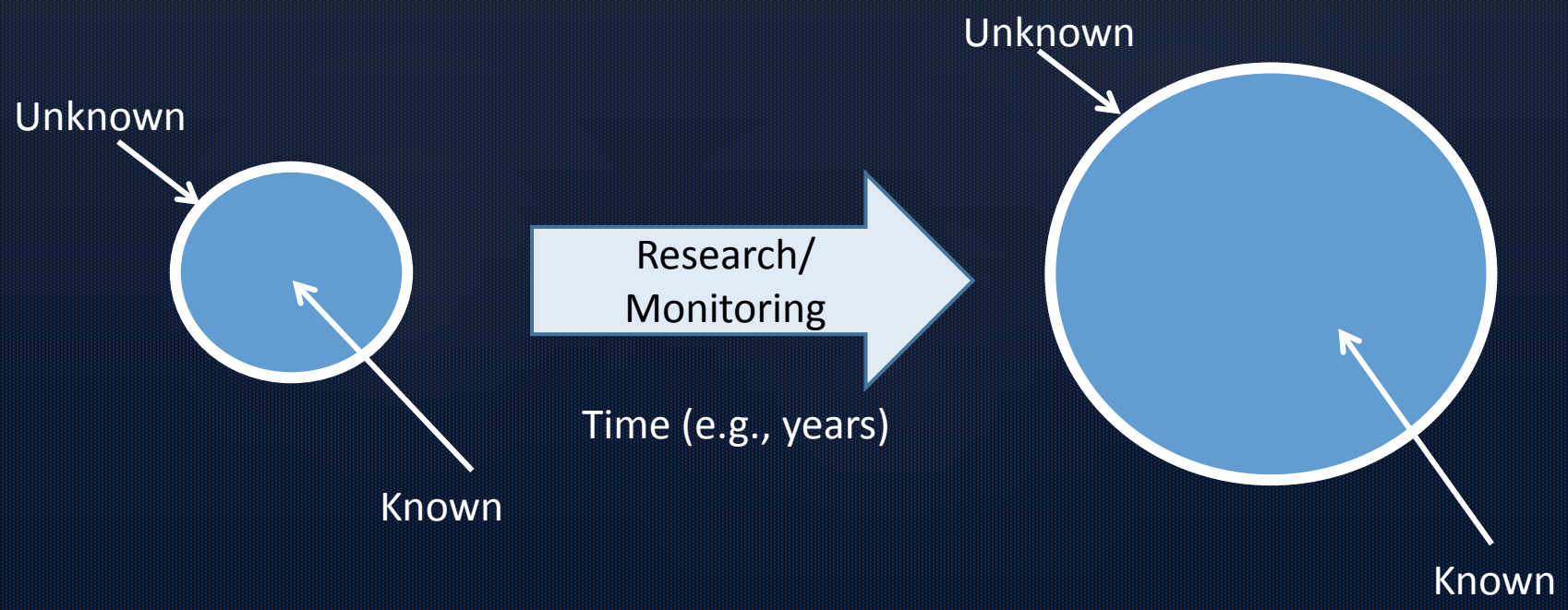
Take home message: *Manage to your certainty*

Ecosystem services and functions



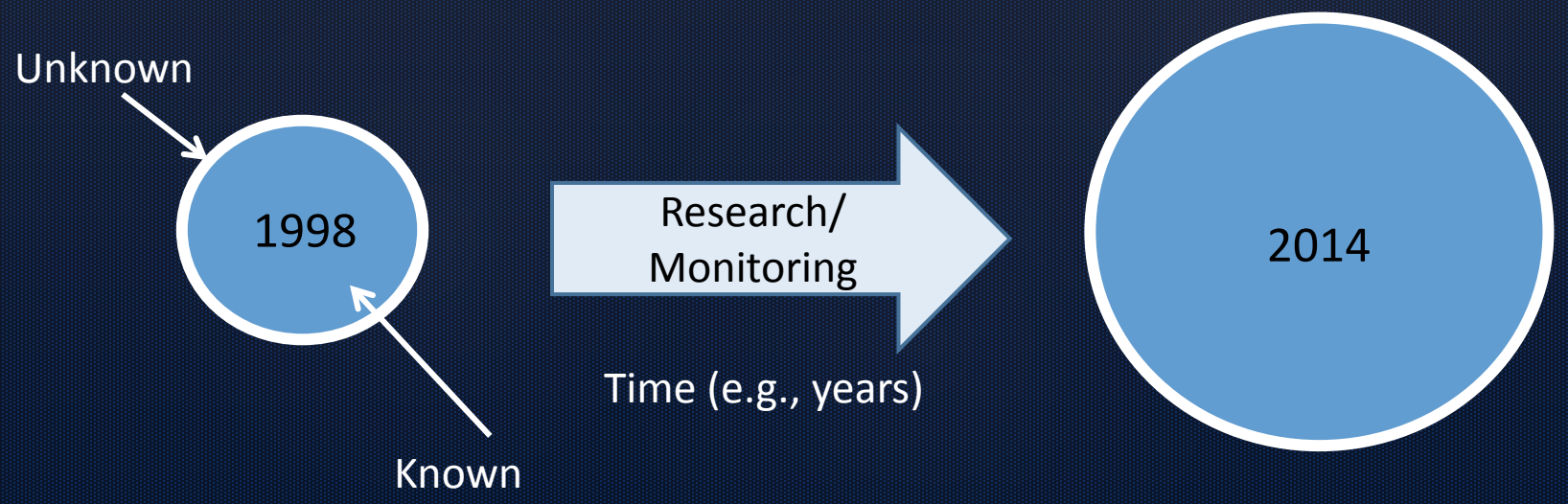
Initial state of knowledge

Future knowledge

Modified from Peter Goodwin, Delta Science Program Lead Scientist

Take home message: *Manage to your certainty*

Ecosystem services and functions



Initial state of knowledge

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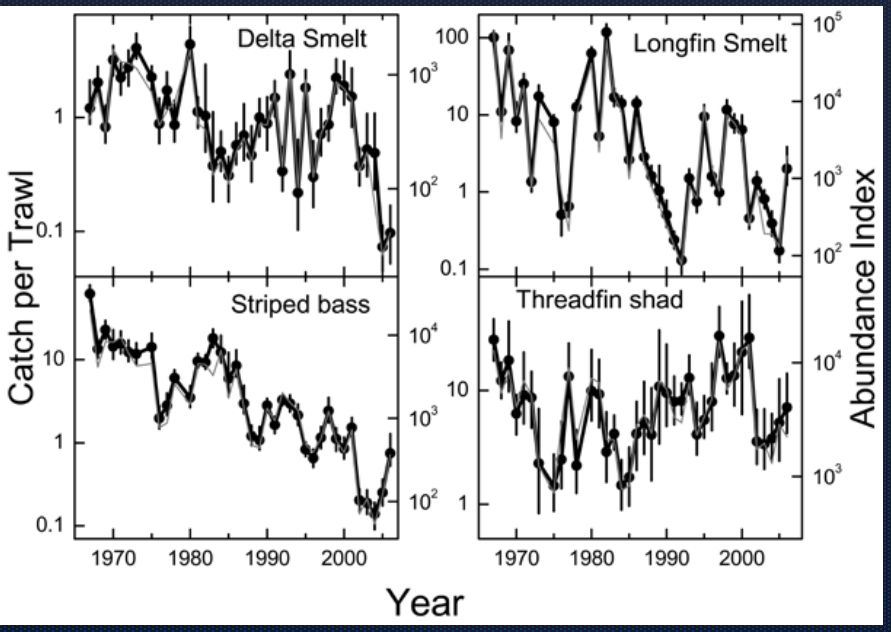
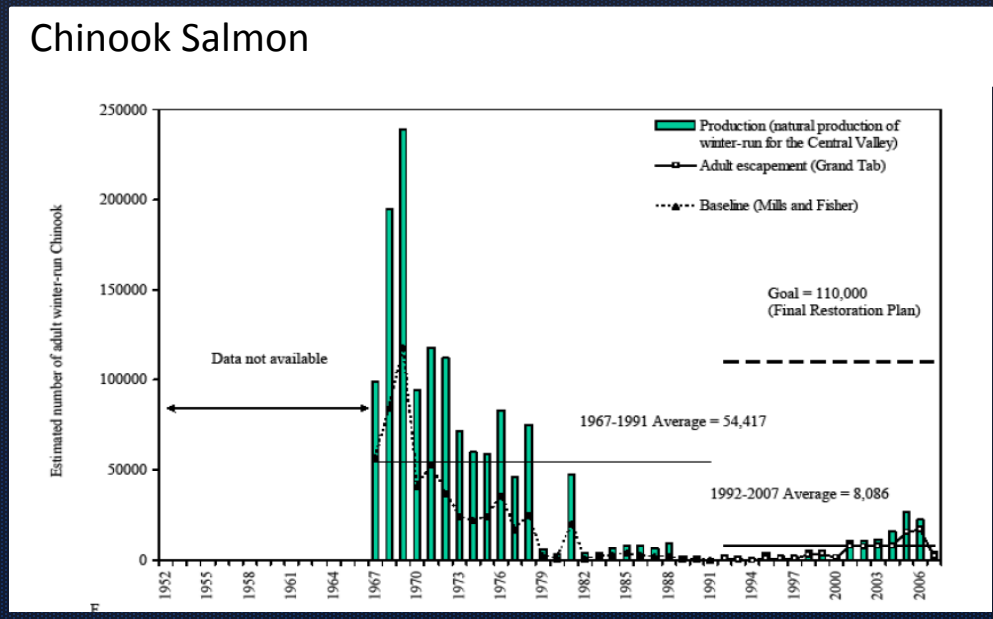
Major Declines in Native Fish Populations



Sommer et al. 2007

Chinook Salmon



NMFS 2008

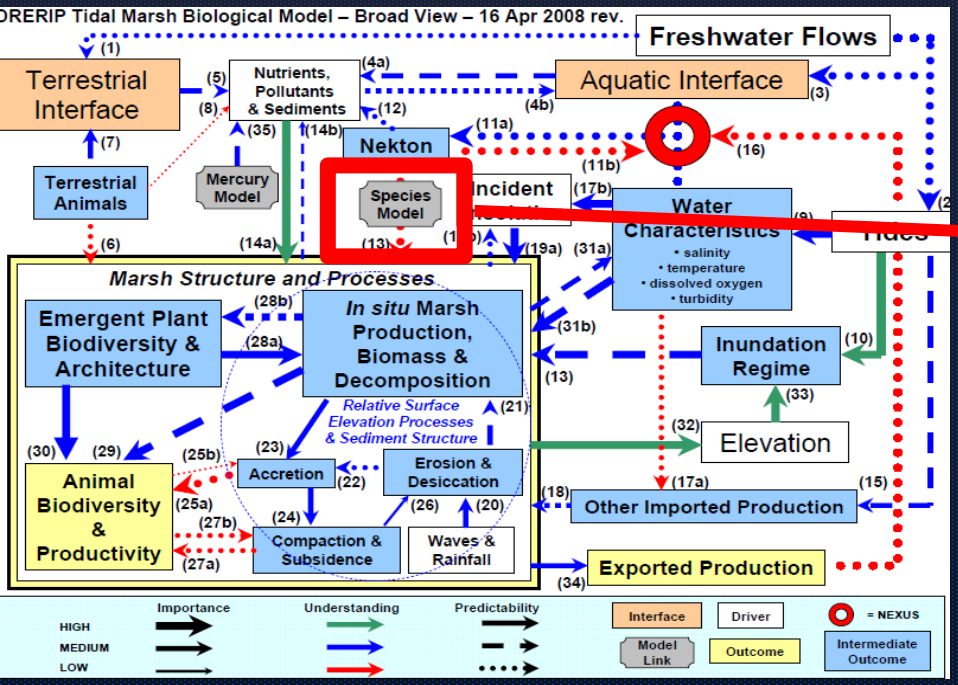
Delta smelt

Chinook salmon

Can tidal marsh restoration reverse the trends?

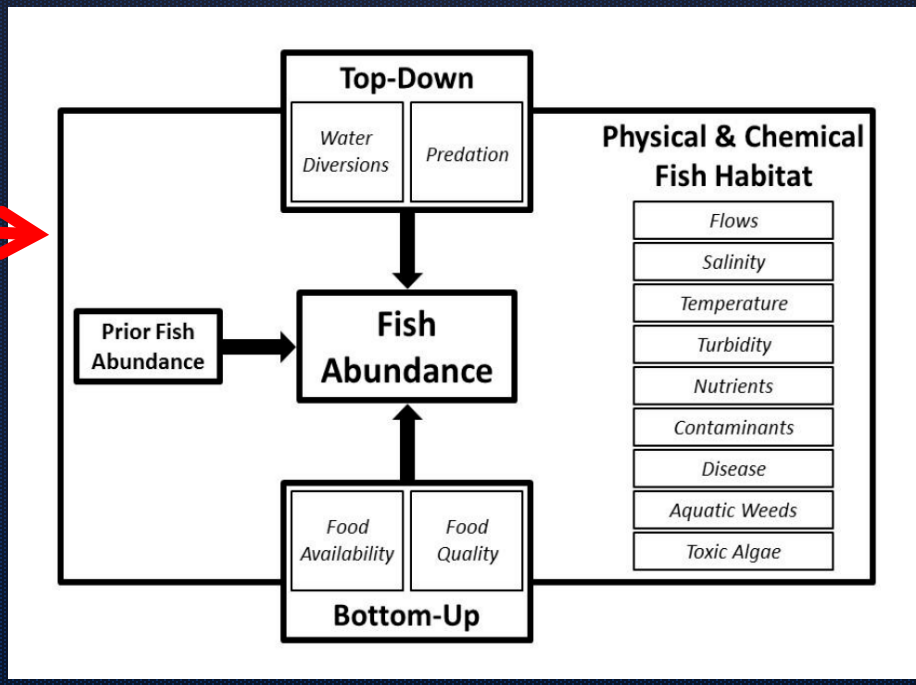
It will be very difficult to detect a signal of tidal marsh benefits to key species at the population level

Tidal marsh landscape conceptual model



Kneib et al. 2008

Species conceptual model



Sommer et al. 2007

…and yes, there will be uncertainty….but focus on what you know!

How should tidal marsh restoration be designed to benefit habitats and functions for native fish?

Early Conceptual Model of Tidal Marsh Restoration Benefits for the Upper San Francisco Estuary

CALFED Bay-Delta Environmental Restoration Program. 2000

Southeast and Pacific Northwest Restoration Paradigms Shaped the Early Thinking

Build it and they will come

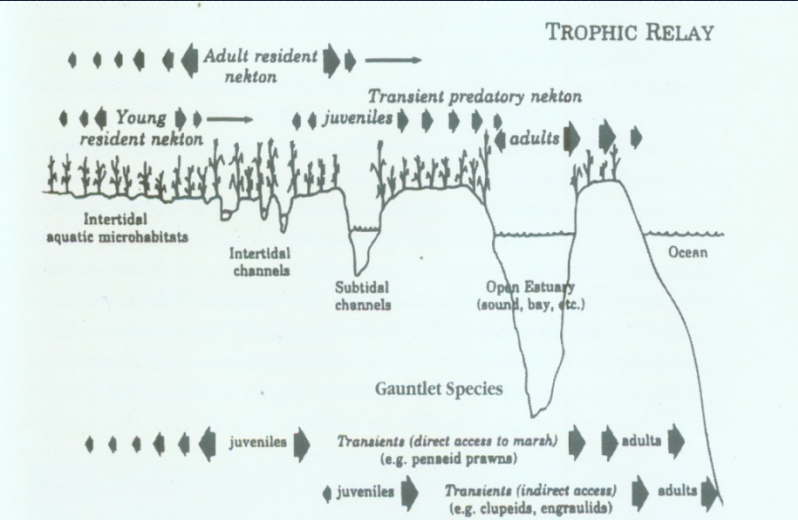


FIGURE 16-2 Trophic relay of intertidal marsh production involving different life stages of resident and transient nekton across habitat landscapes (from Kneib 1997, used with permission); gauntlet species are nekton, particularly forage fishes, whose juveniles encounter a gauntlet of predators during their large-scale migrations from the spawning ground to the estuary and back.

Kneib 1997

Our canvas is a little different….

~ 90% marshes have been diked drained in SF Estuary

Most invaded estuary in the world
~ 30 common introduced fish species in the Delta

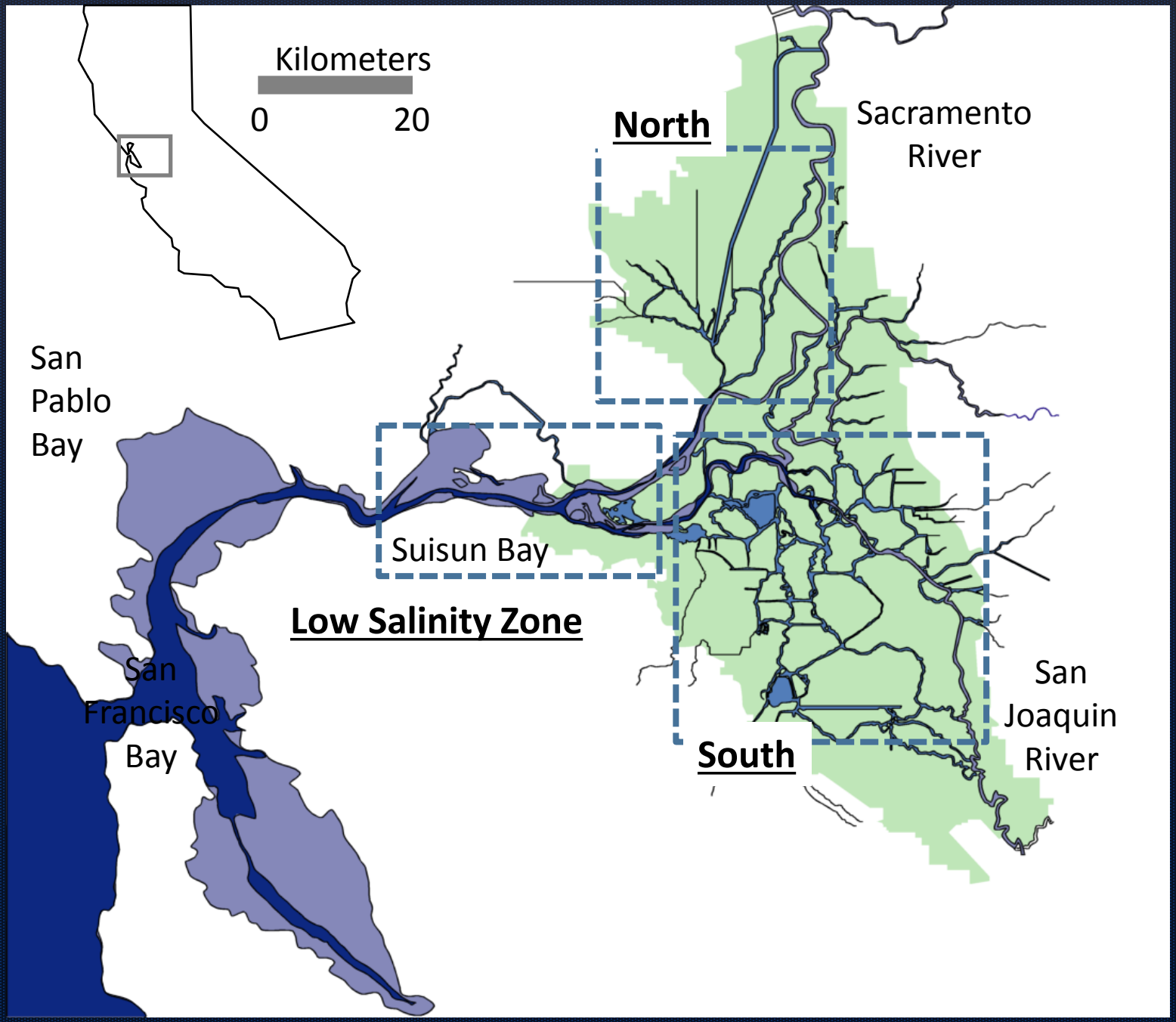
Our working paradigm should be different from other estuaries

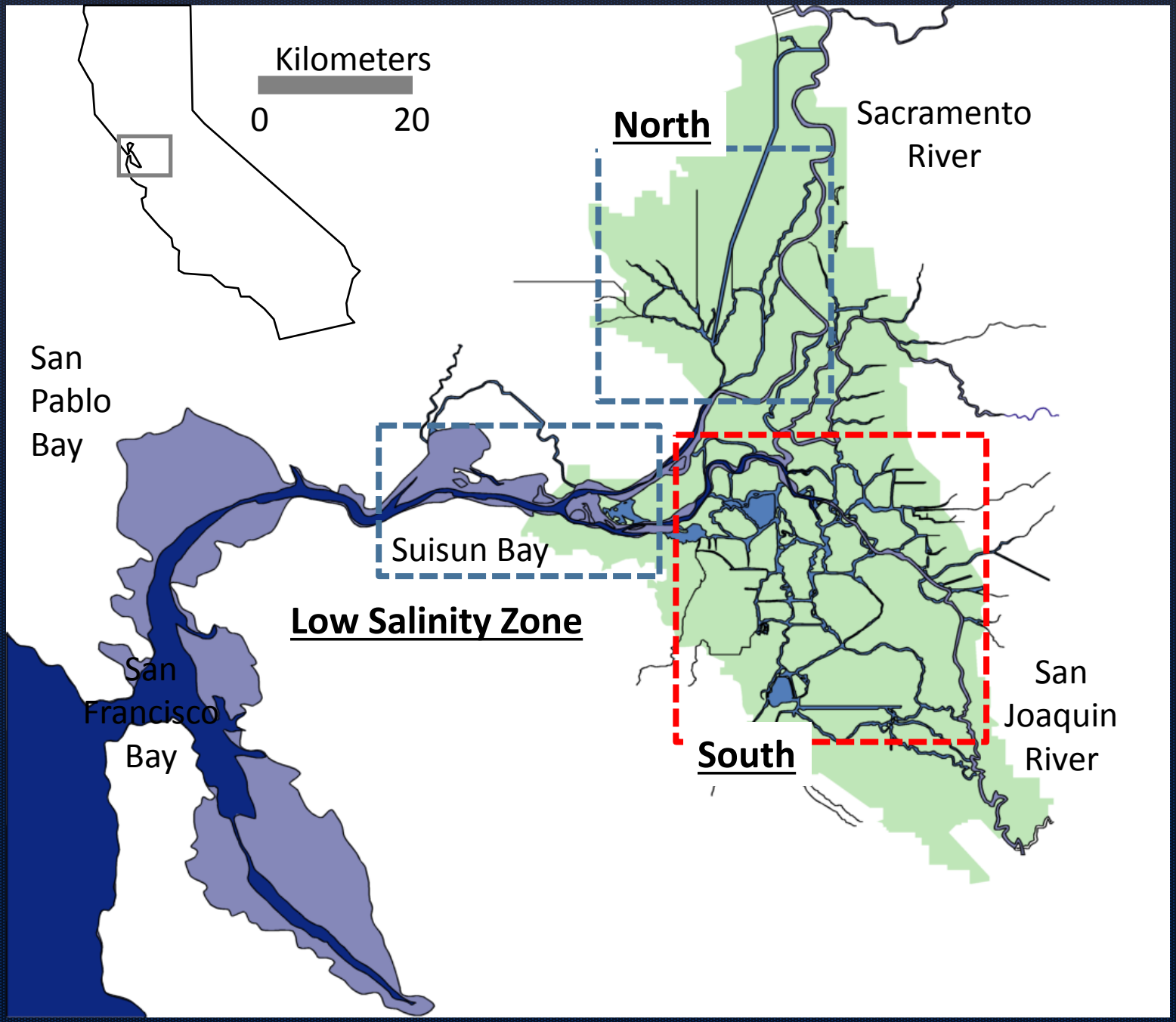
Our canvas is a little different….

~ 90% marshes have been diked drained in SF Estuary

Most invaded estuary in the world
~ 30 common non-native fish species in the Delta

# of publications on fish use of shallow water habitats prior to CALFED?


Kilometers
0
20
North
Sacramento River
San Pablo Bay
Suisun Bay
Low Salinity Zone
San Francisco Bay
South
San Joaquin River


Kilometers
0
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North
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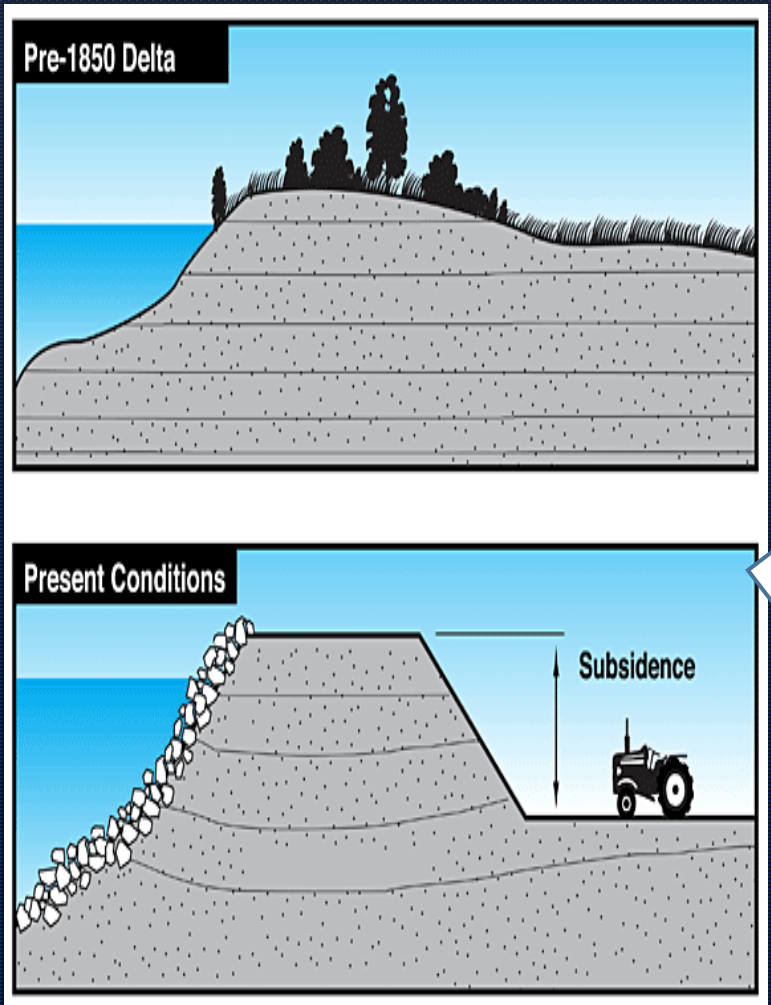
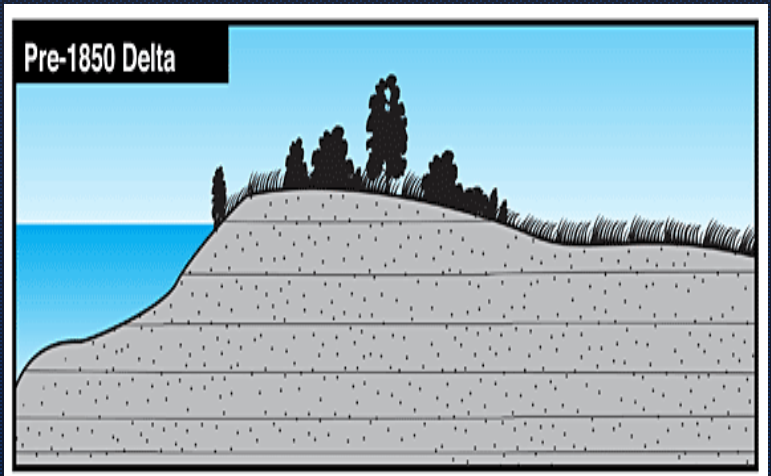
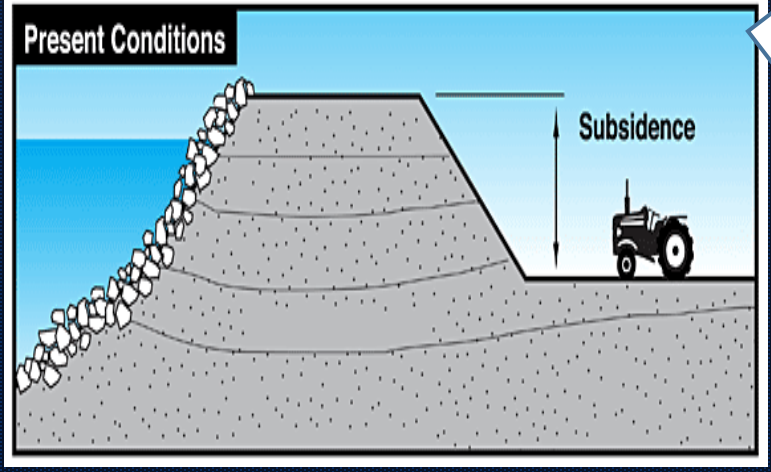
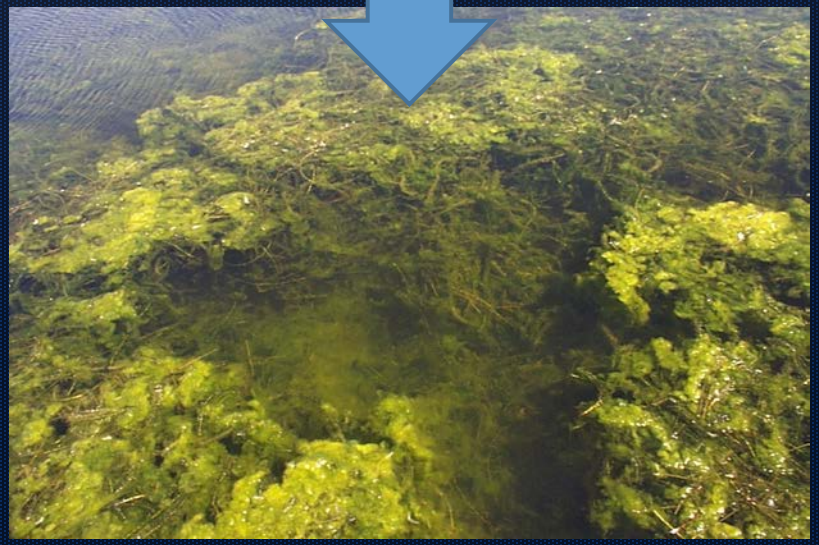
Subsided marshes in the south Delta have become overrun by SAV



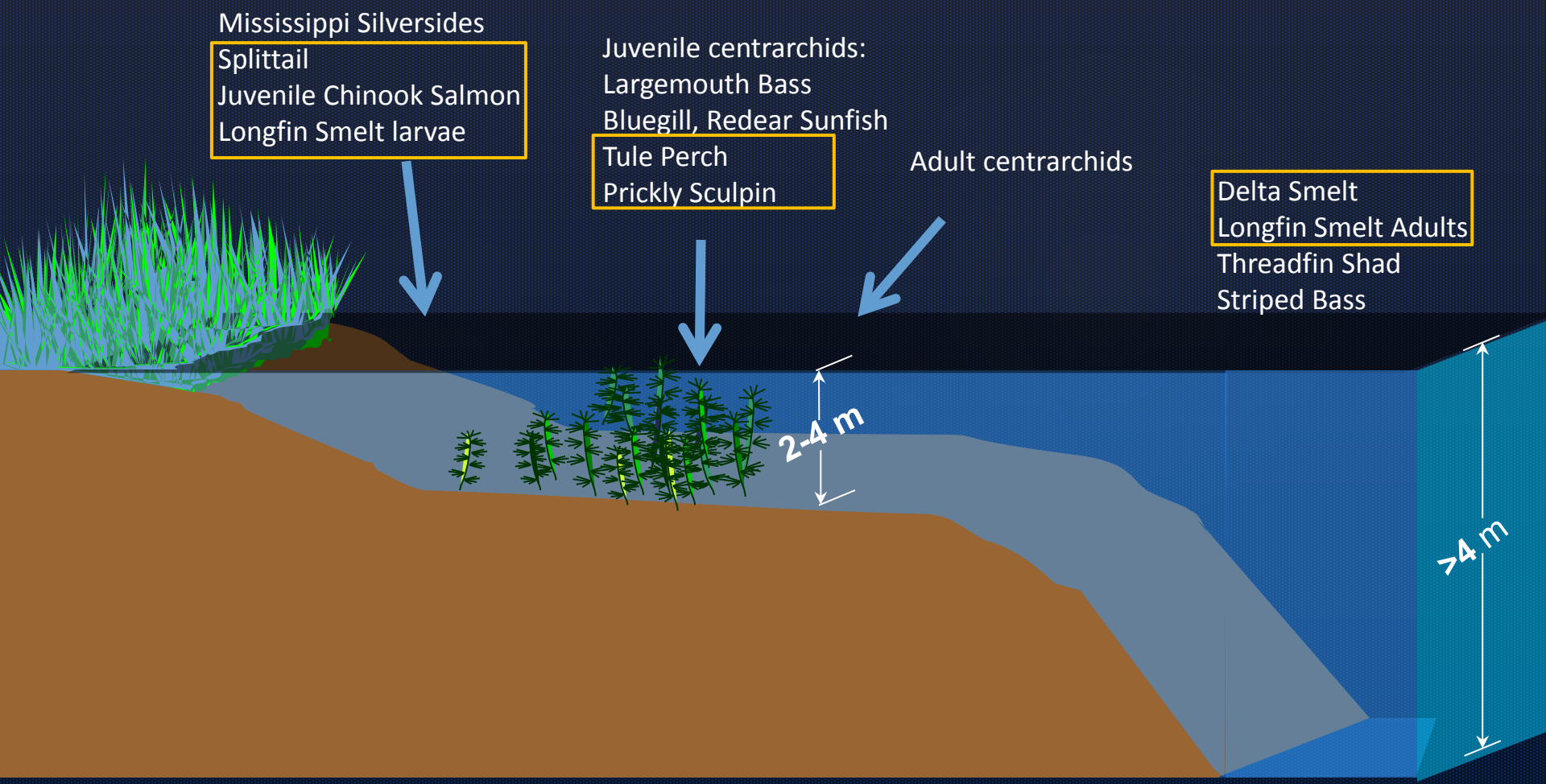
Subsided marshes in the south Delta have become overrun by SAV







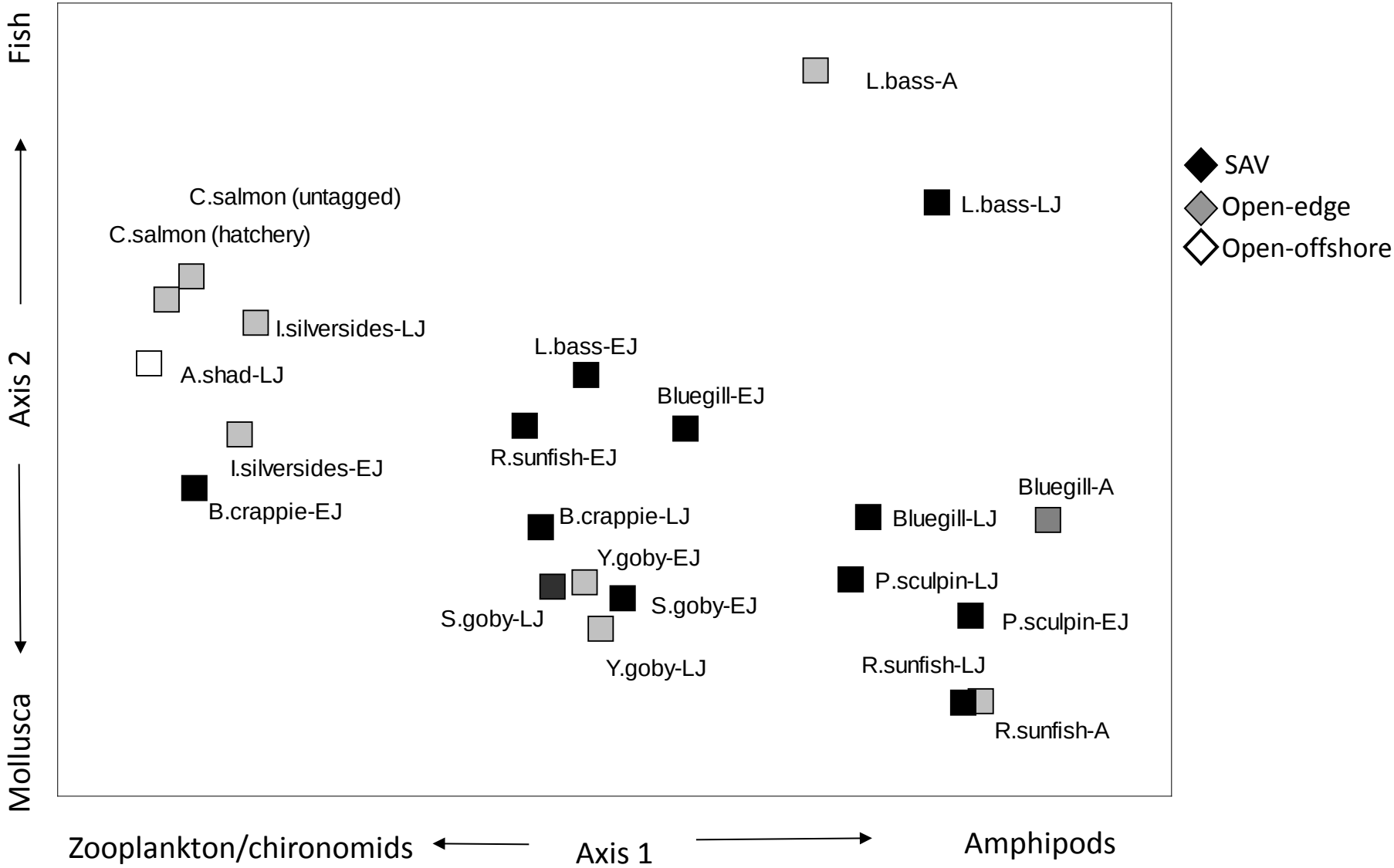
Fish communities tightly linked to habitats



Brown 2003, Brown and May 2006, Brown and Michnuik 2007
Dean 2005
Grimaldo et al. 2004, 2012, 2013
Gewant and Bollens 2005
Feyrer and Healy 2004
Feyrer et al. 2002

Howe et al. 2014
McLain and Castillo 2010
Nobriga et al. 2005, Nobriga et al. 2006
Toft et al. 2003
Sommer et al. 2011
Visitainer 2006

Fish generally consumed prey from their rearing habitats

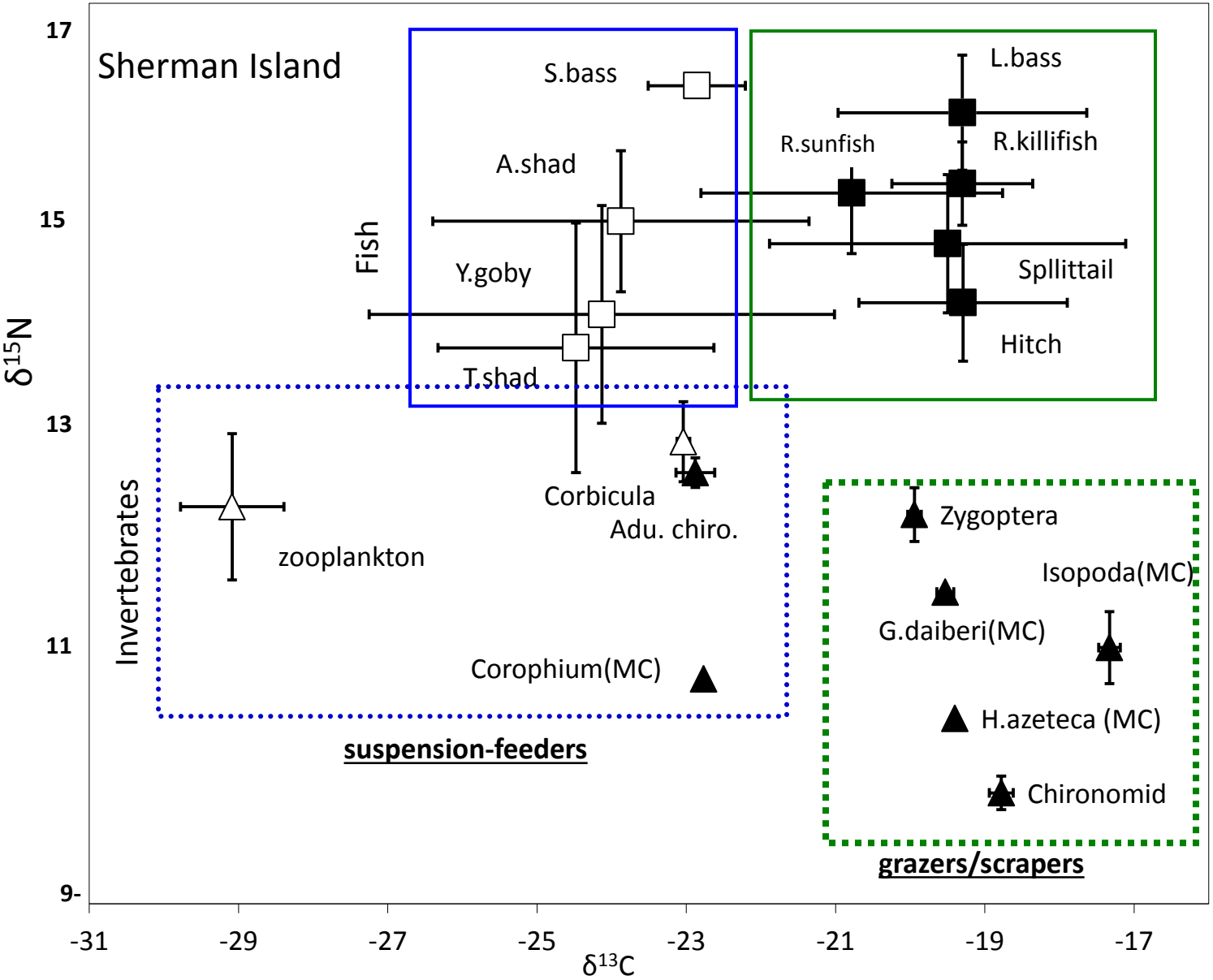


Early juvenile (EJ) = 20-49 mm FL	Late juvenile (LJ)=50-99 mm FL	Adult (A) = >100 mm Fl

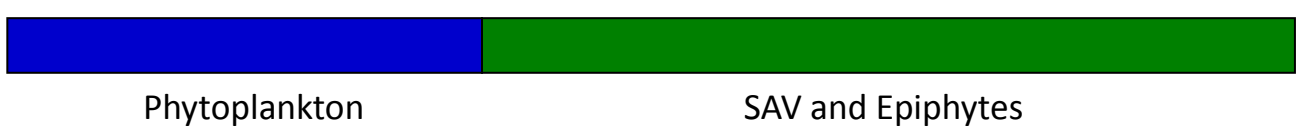
Modified from Grimaldo et al. 2009. Marine and Coastal Fisheries

See Toft et al. 2003, Estuaries for FAV differences

Habitats shaped food web subsidies to fishes



Ho:δ^{13}C=Among fishes
ANOVA (GLM)
P< 0.001, reject



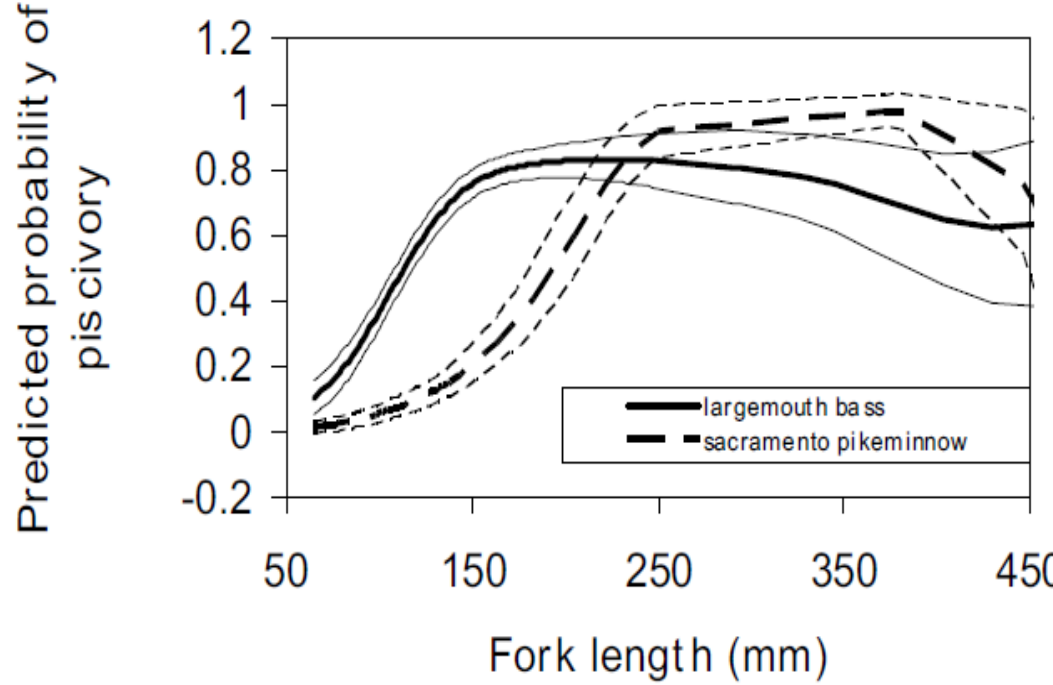
Modified from Grimaldo et al. 2009.

Non-native predators consume native fishes in relation to their abundance

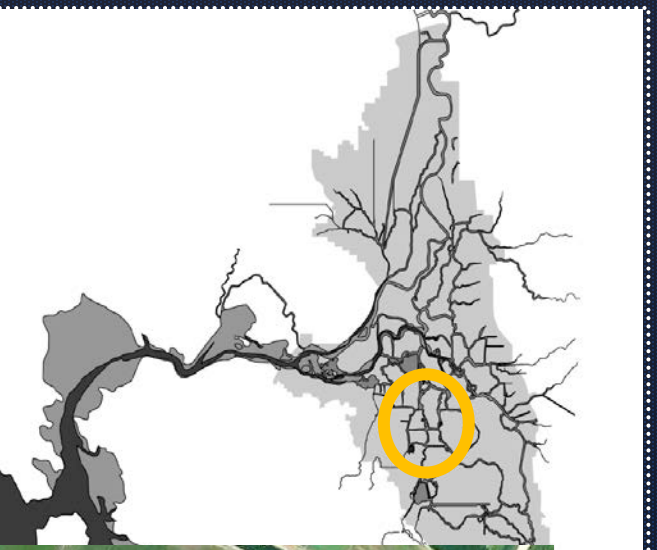
Predator Species	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Largemouth bass	ChiSal[a] InlSil PriScu[a]	PriScu[a] TulPer[a]	Lepomi PriScu[a] TulPer[a] WesMo YelGob	ChiSal[a] InlSil LarBas PriScu[a] RaiKil Splitt[a] StrBas YelGob	InlSil LarBas Lepomi PriScu[a] SacPik[a] ThrSha Triden YelGob	GolShi InlSil LarBas Lepomi RaiKil ThrSha Triden YelGob	InlSil LarBas Lepomi Triden YelGob	BigLog InlSil YelGob
Sacramento pikeminnow	InlSil	PriScu[a] Triden YelGob	BigLog PriScu[a] TulPer[a]	InlSil StrBas ThrSha YelGob	InlSil StrBas Triden	YelGob	InlSil YelGob	AmeSha InlSil YelGob
Striped bass	ChiSal[a]	PriScu[a] Splitt[a]	StaFlo[a] Triden TulPer[a] YelGob					

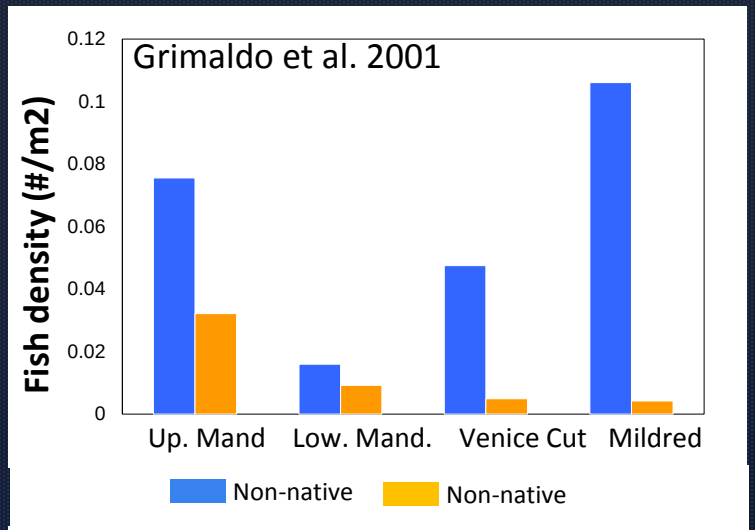
[a]Native species

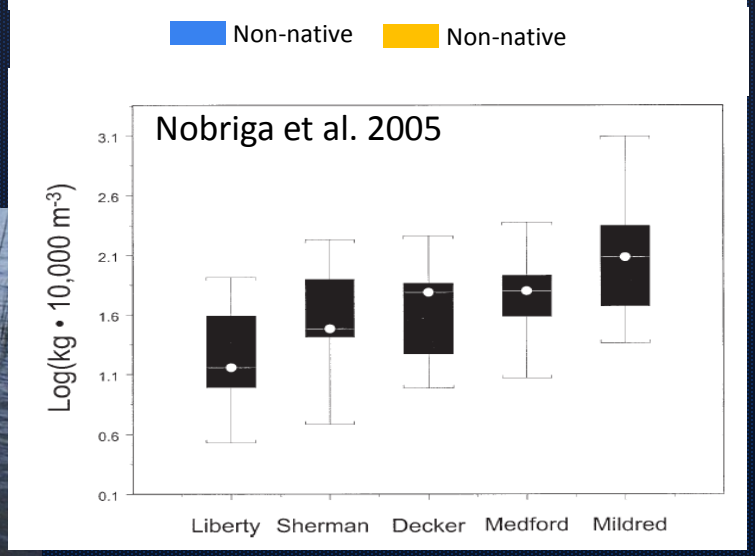
Nobriga and Feyrer 2007. SFEWS



Sub-tidal marshes without SAV function differently than those with SAV



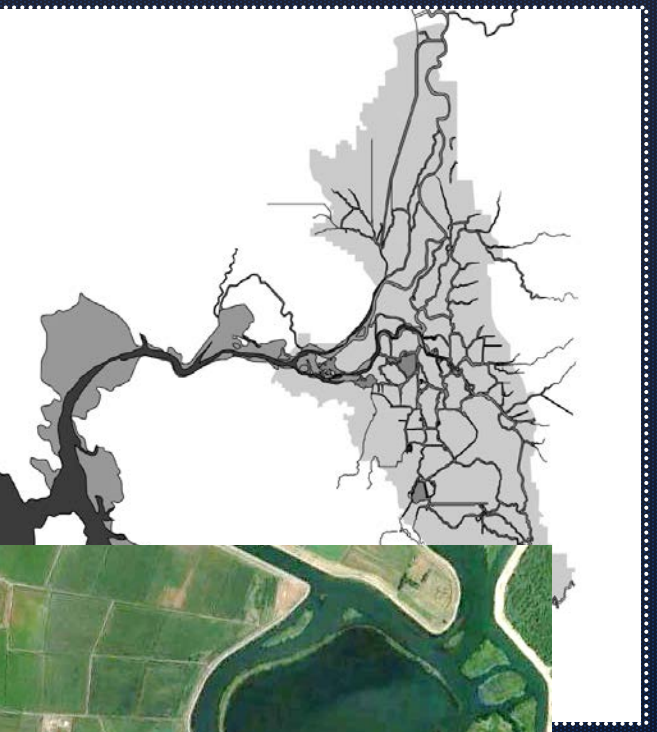




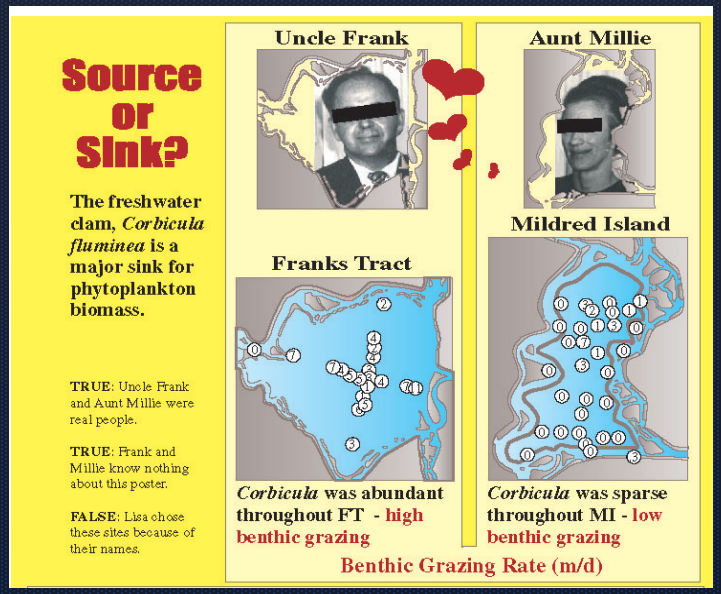
Lot's of pelagic fish!

4-6 m deep, SAV limited to edge

Production can be good in deep sub-tidal habitats without clams



4-6 m deep, SAV limited to edge



Lucas et al. 2002, Poster presentation

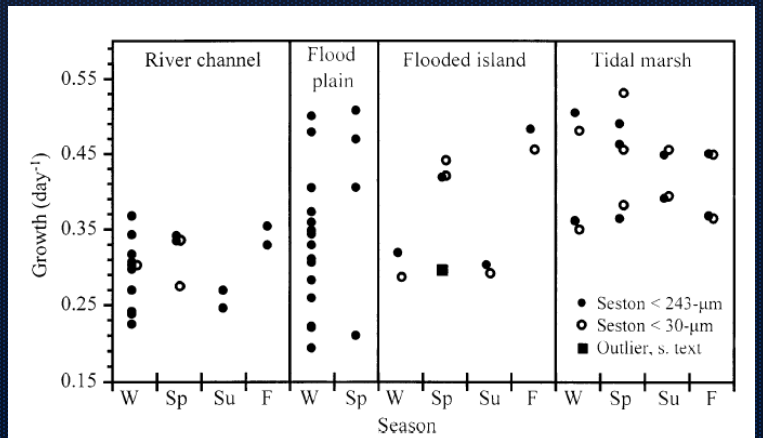


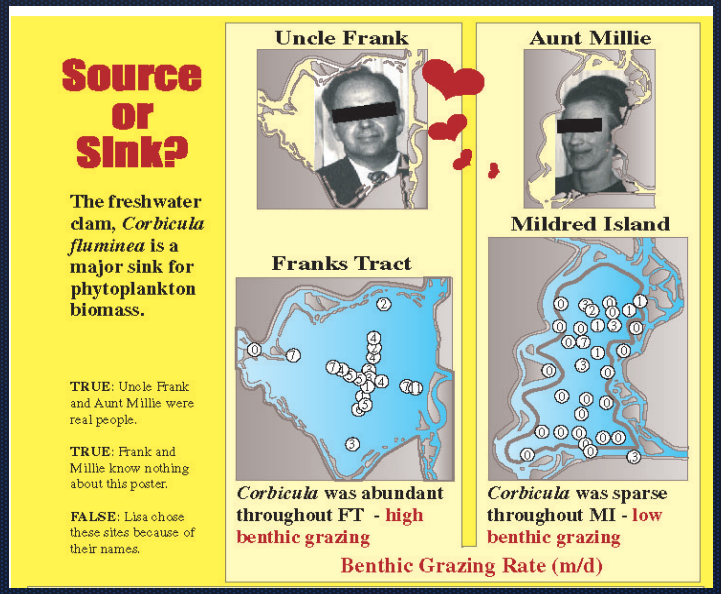
Fig. 2. Seasonal and habitat-related variation in *Daphnia* growth rates under standardized experimental conditions. W, winter; Sp, spring; Su, summer; and F, fall.

Mueller-Solger et al. 2002. L&O

Location, Location, Location

What if?

4-6 m deep, SAV limited to edge



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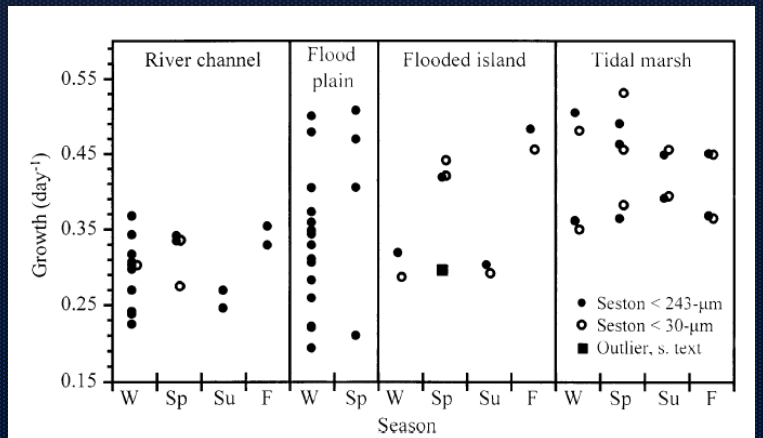

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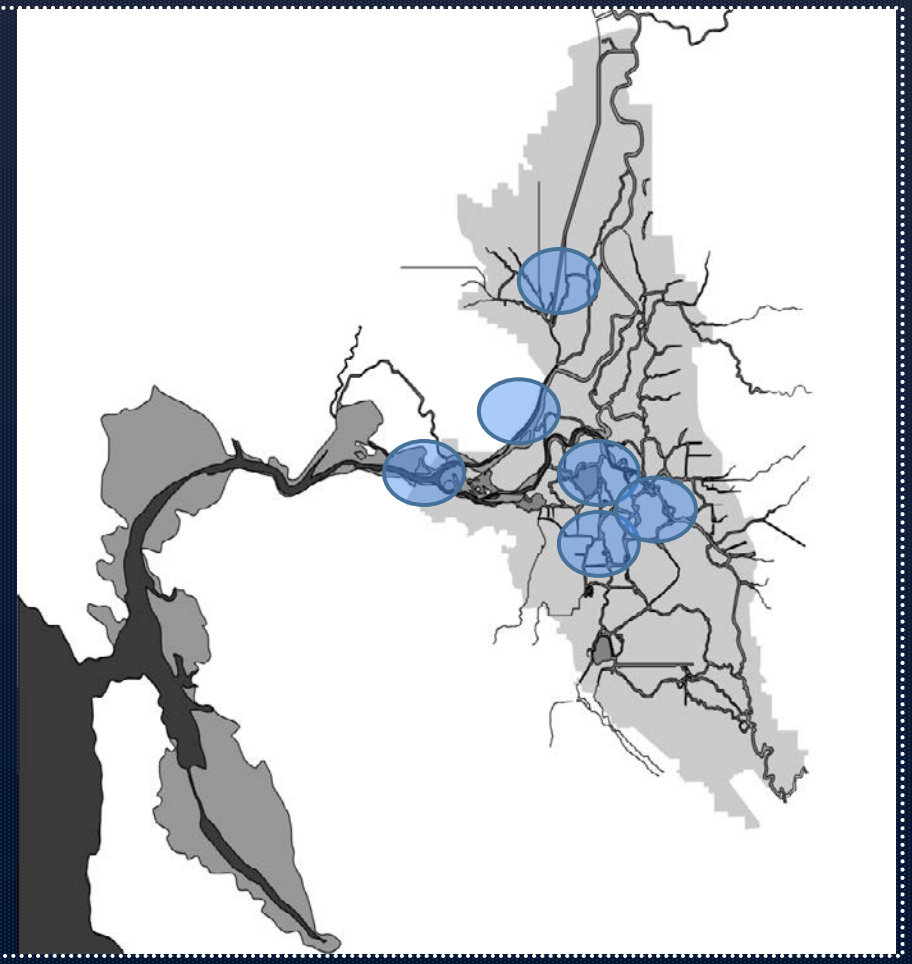
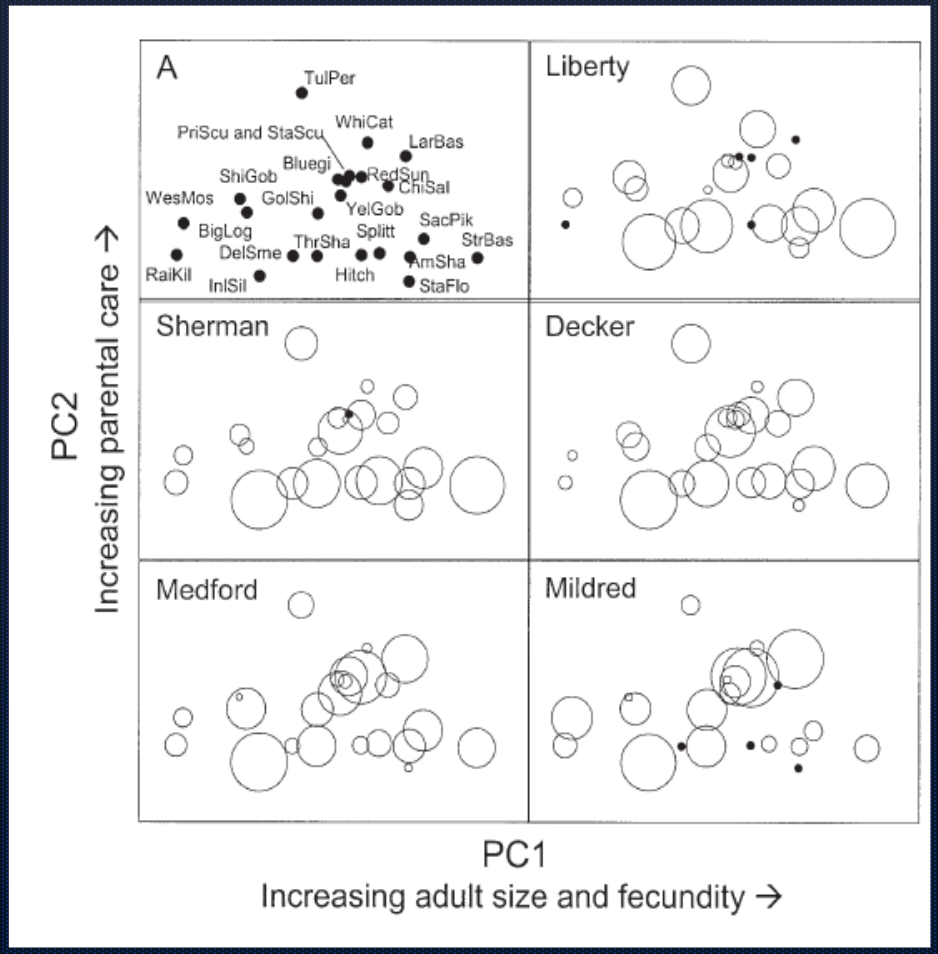
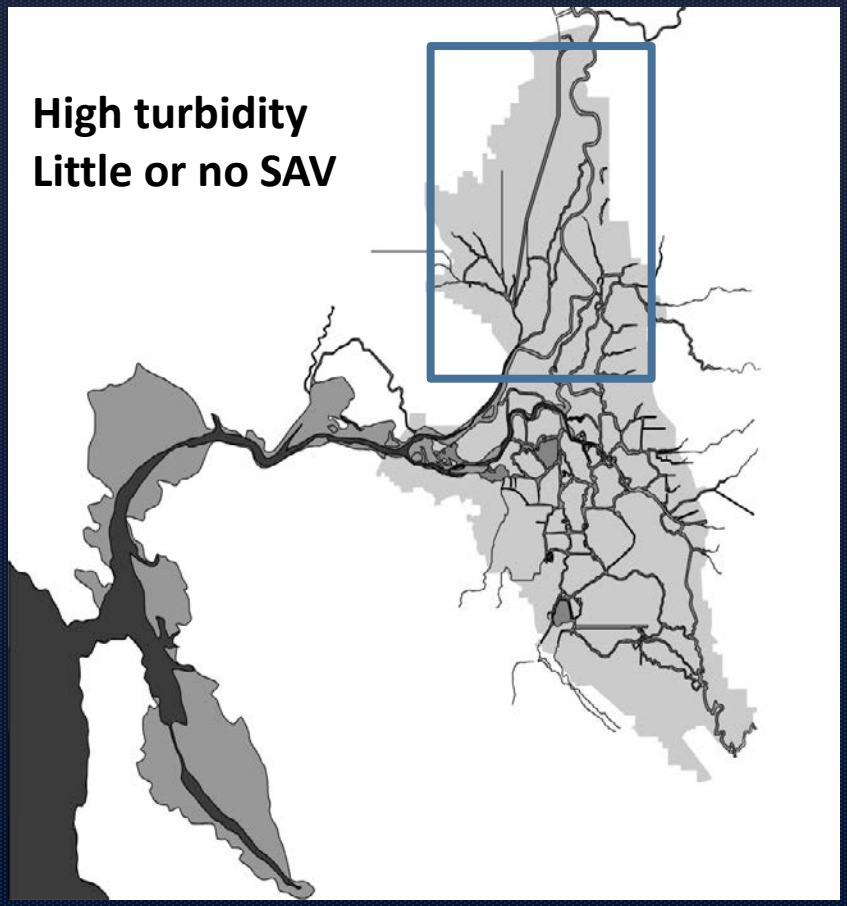
Fish communities vary by region

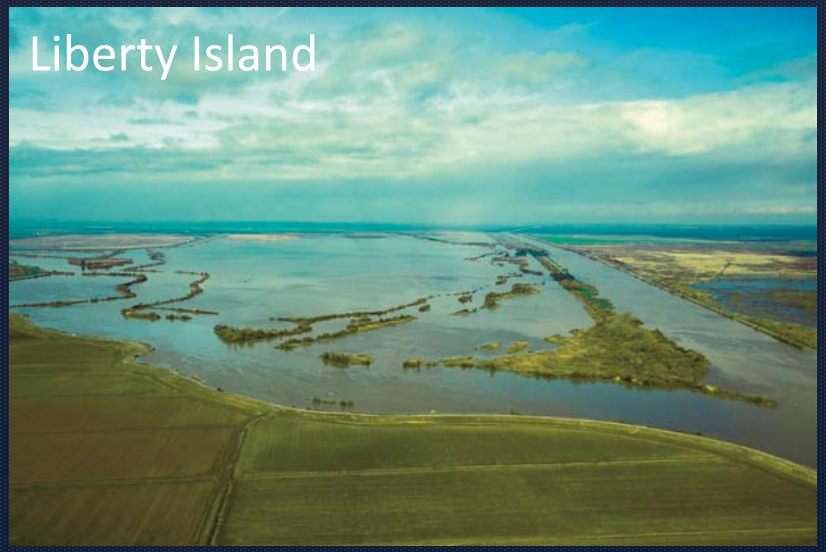




Nobriga et al. 2005

Sub-tidal Habitats in the North Delta Support Native Fish in Decent Densities





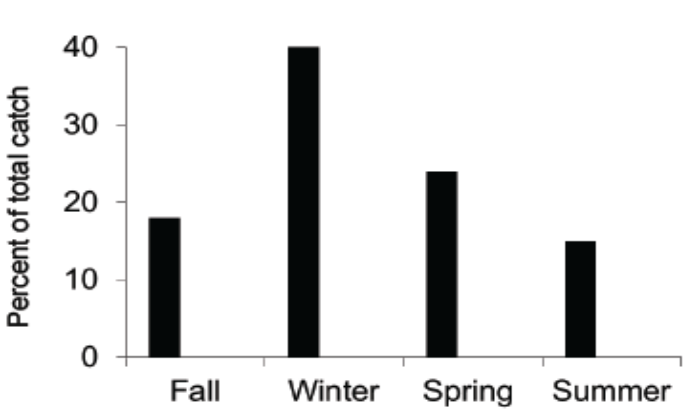
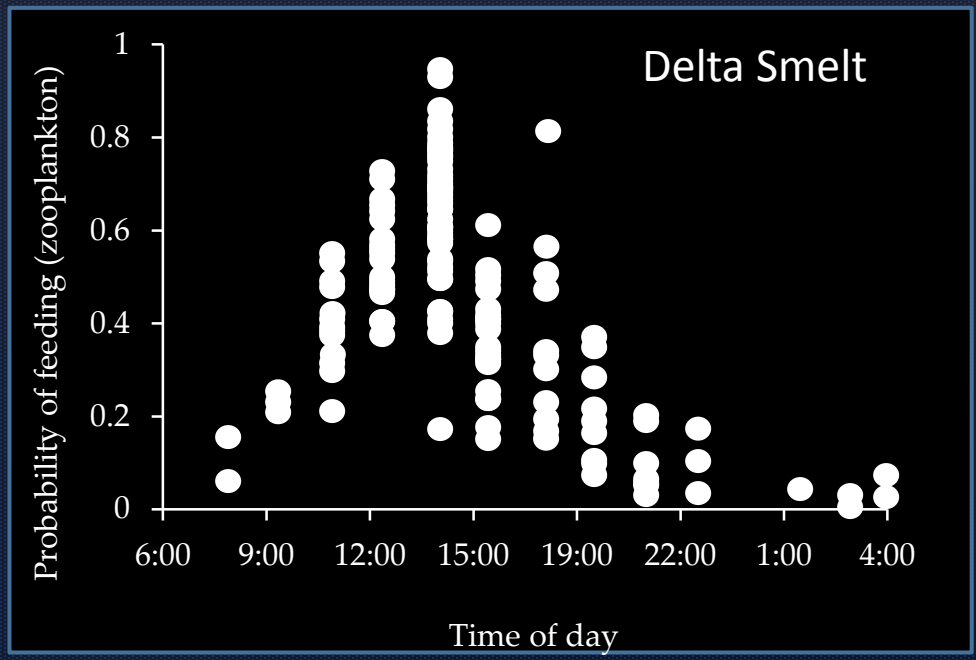


Figure 5 Distribution of catch of delta smelt across seasons in Liberty Island based on USFWS beach seine data from August 2002 through October 2004 (n = 93 fish)

Sommer and Mejia 2013. SFEWS

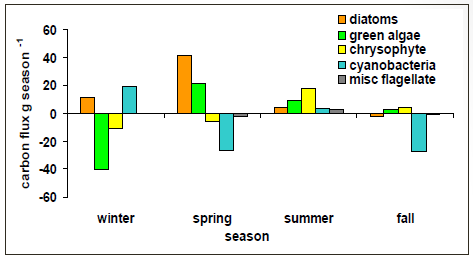
North Delta Sub-Tidal Marshes Can Be a Source of Food to Consumers



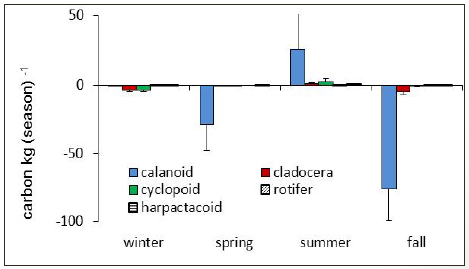
Grimaldo et al. in press SFEWS

Plankton flux

phytoplankton



zooplankton



Source: Peggy Lehman, 2012 CABA workshop
See Lehman et al. 2009, Aquatic Ecology

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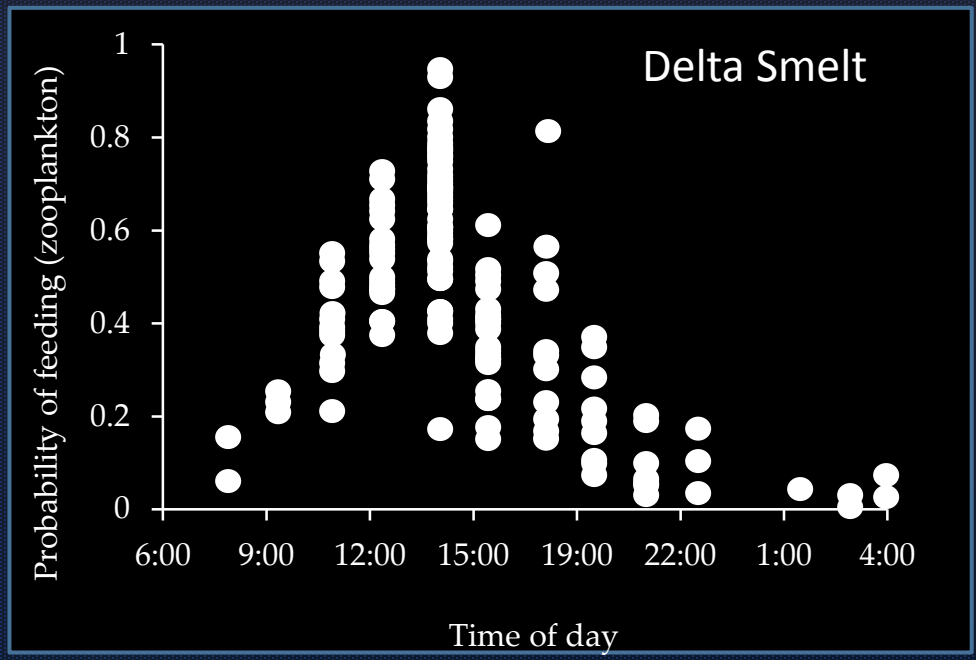

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Plankton flux

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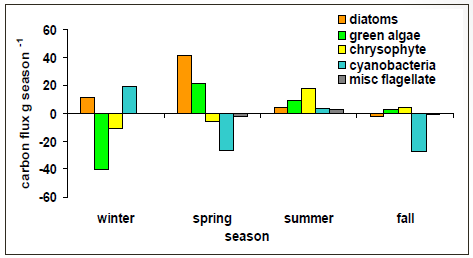
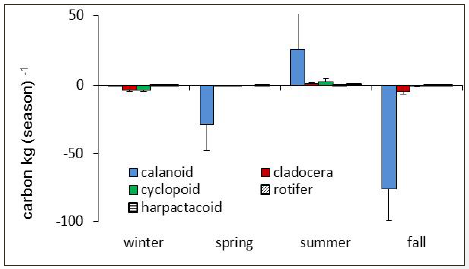


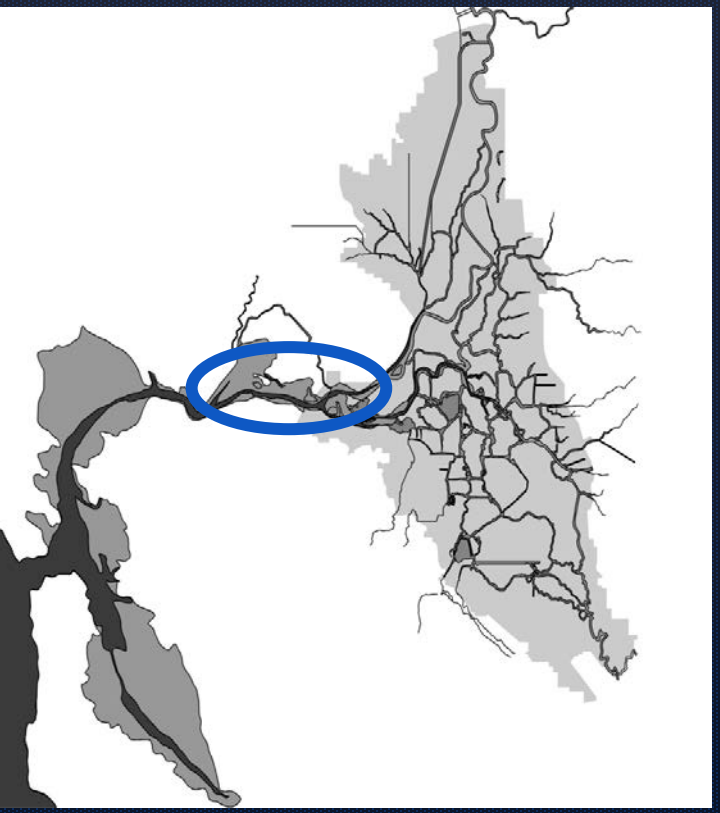
zooplankton



Source: Peggy Lehman, 2012 CABA workshop
See Lehman et al. 2009, Aquatic Ecology

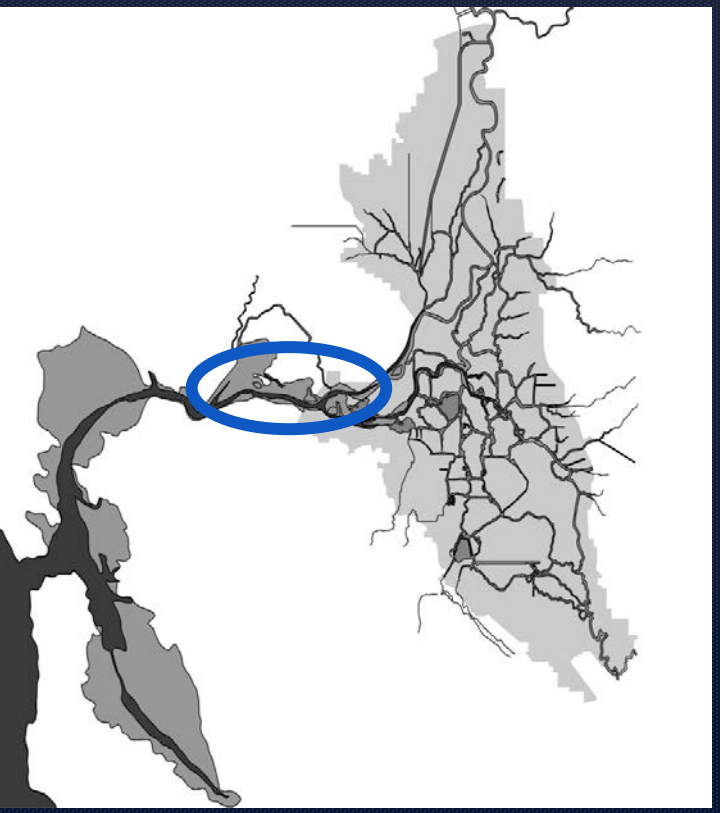
Future work should focus on regional processes not just dynamics within Liberty Island

The forgotten landscape…..where actual tidal marshes exist



Low Salinity Zone
-Native SAV, little invasive SAV
-Turbid environment

Food web crashed, became a dead zone for pelagic production



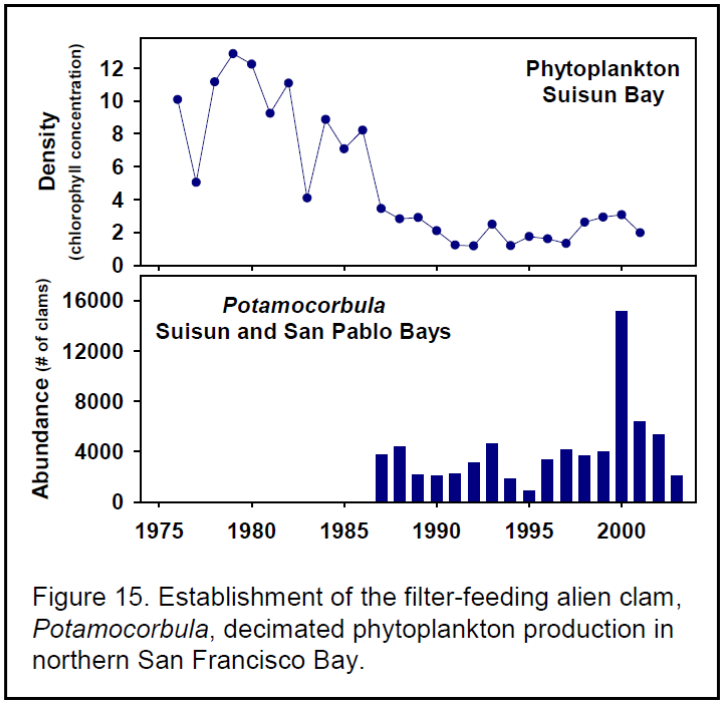
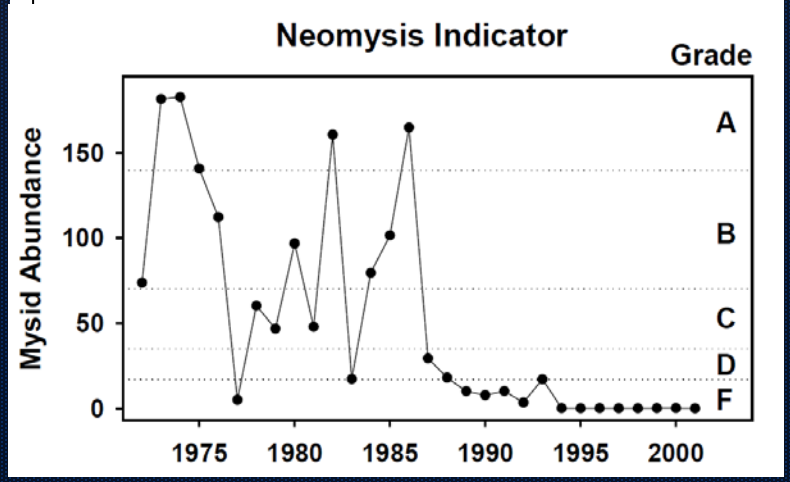
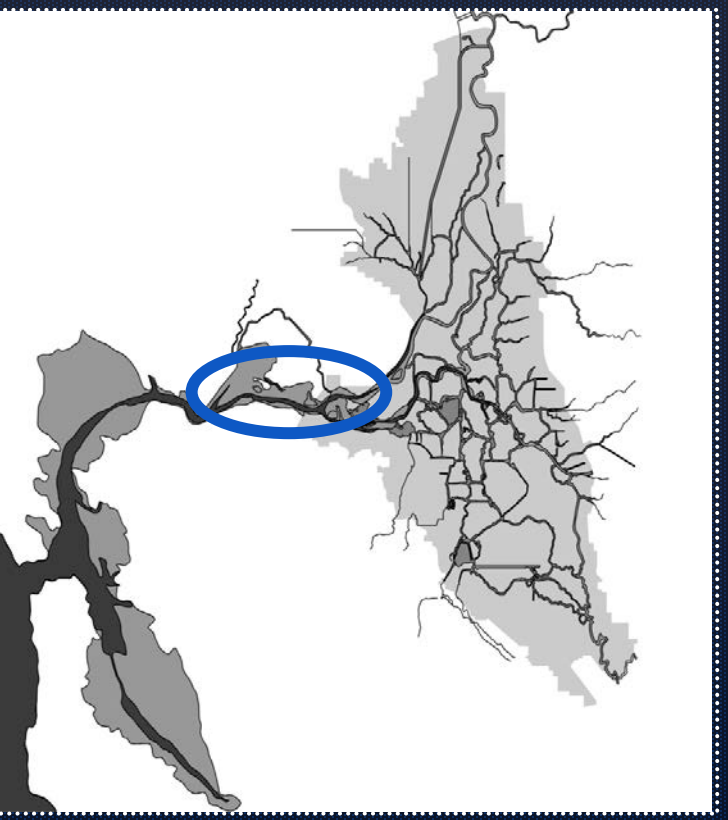


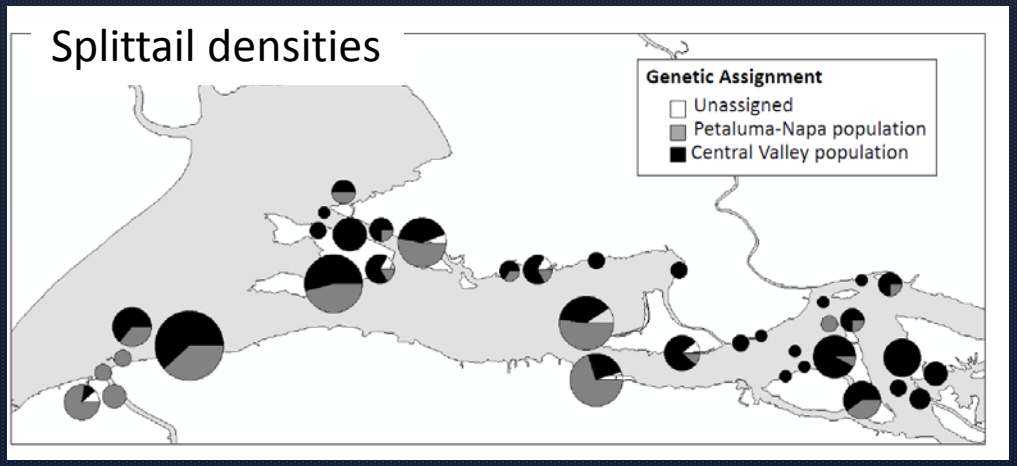
Figure 15. Establishment of the filter-feeding alien clam, *Potamocorbula*, decimated phytoplankton production in northern San Francisco Bay.



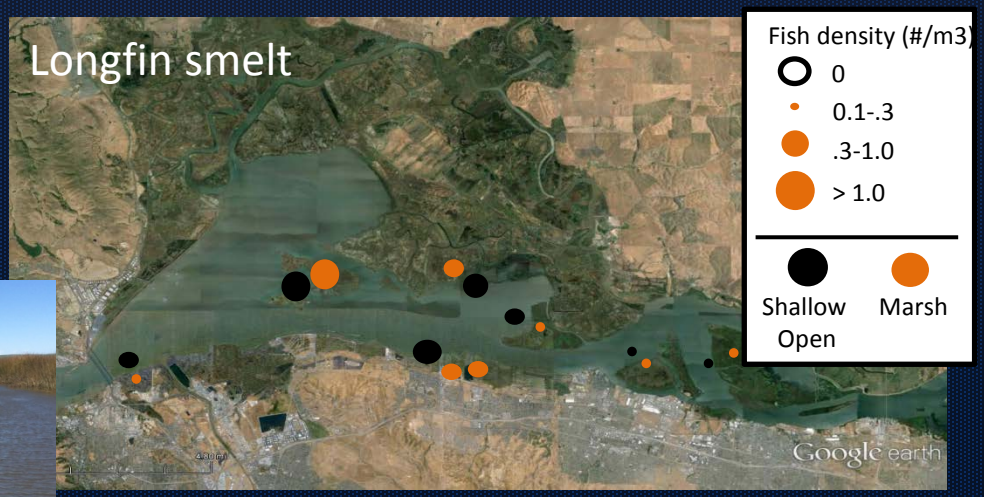
Bay Institute 2004

Initial Fish Studies Show Promise: Tidal marshes support high densities of native fish

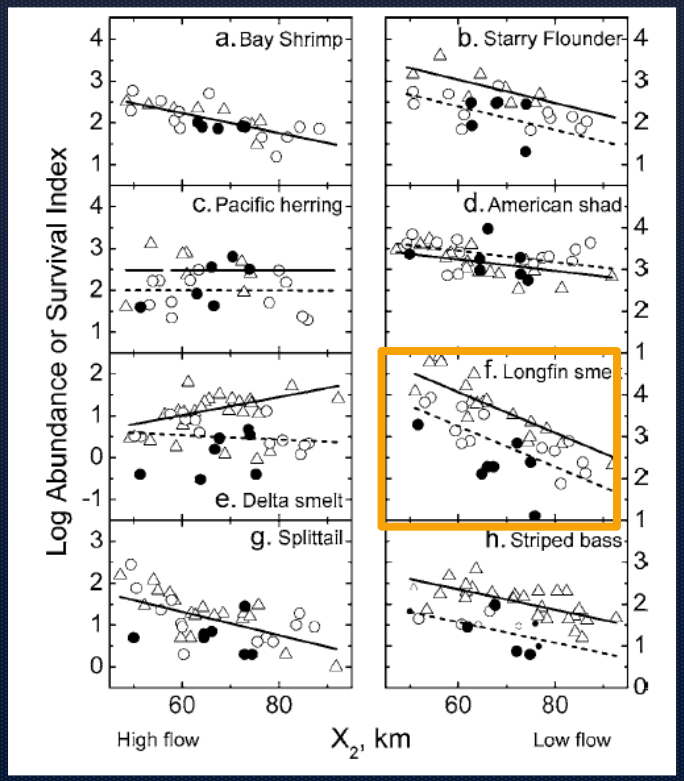




Feyrer et al. in press

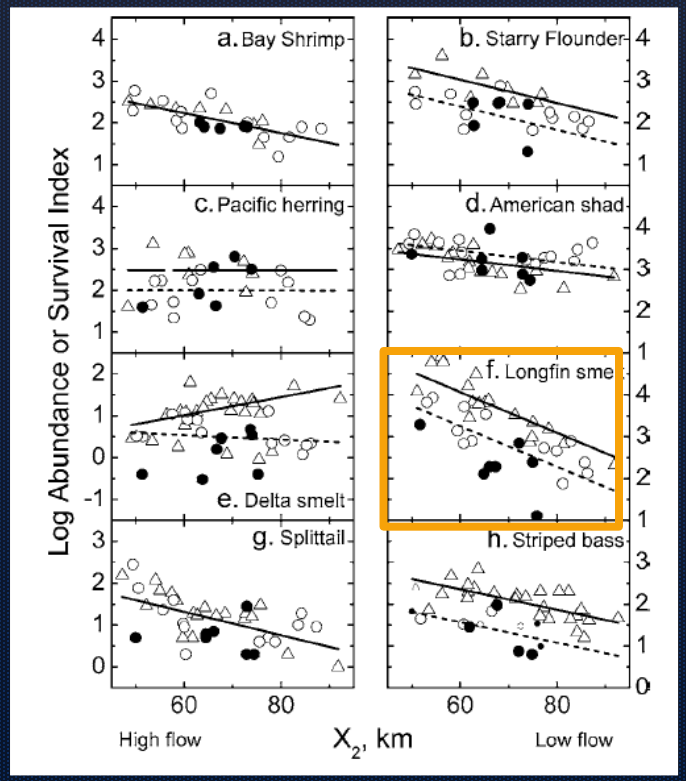


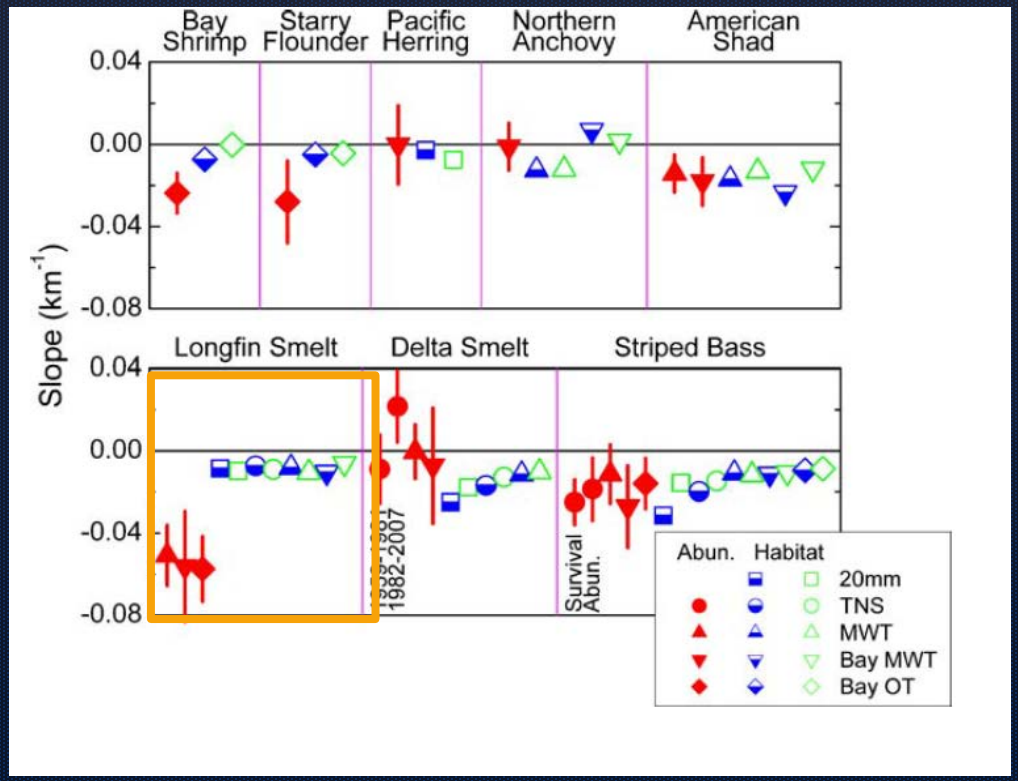
Focus has centered on flow-abundance relationships



Kimmerer et al. 2009

What are the potential mechanisms underlying abundance-flow relationship for longfin smelt?





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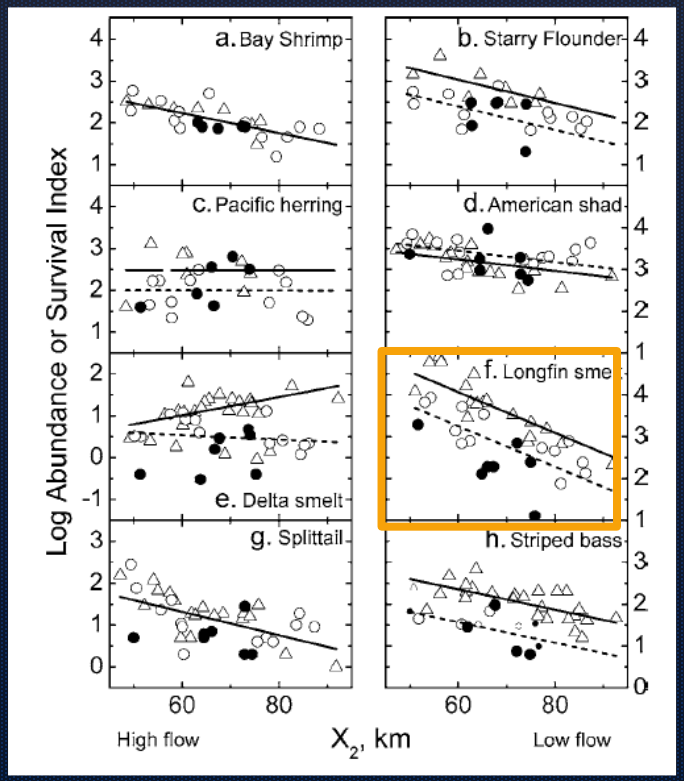
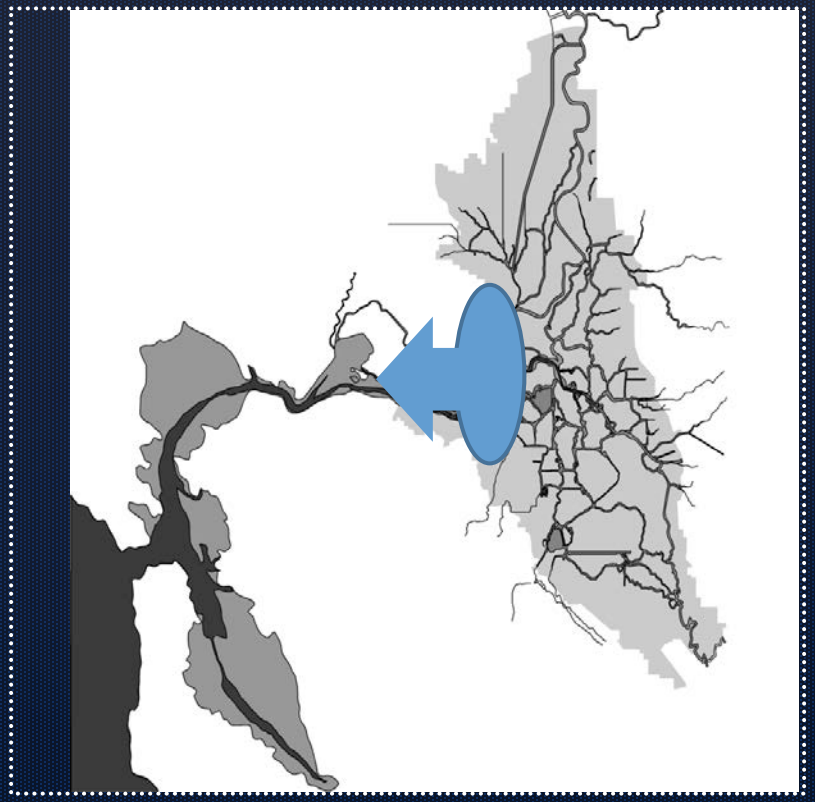
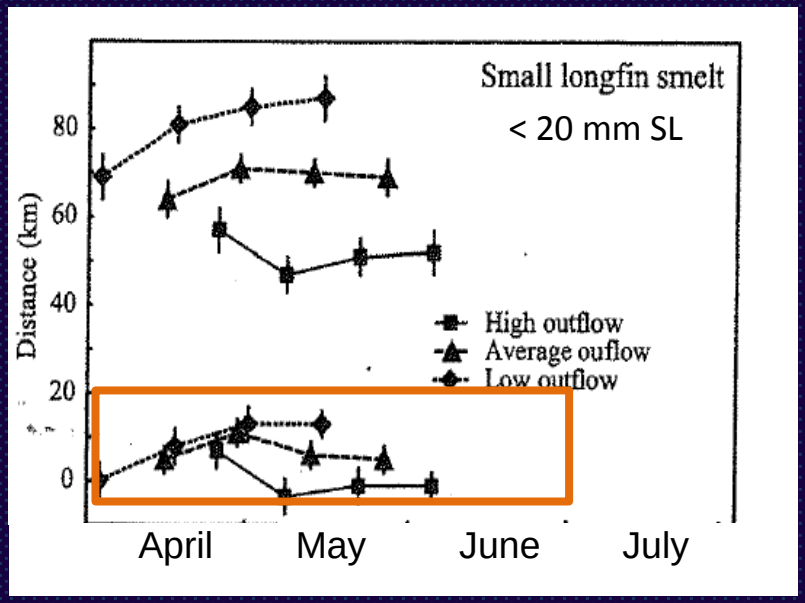


Kimmerer et al. 2009

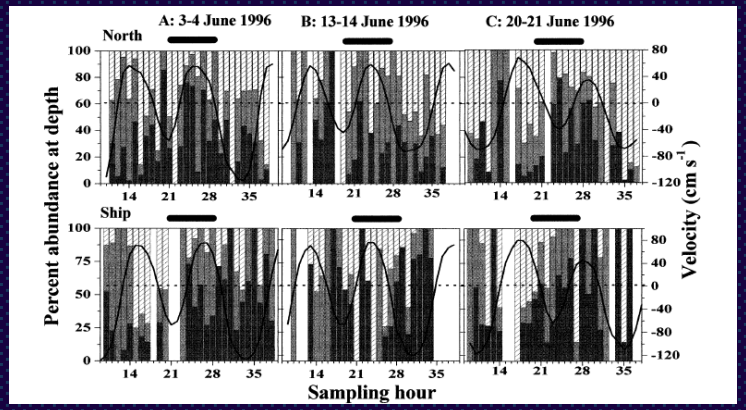


Hypothesis: Advection and transport

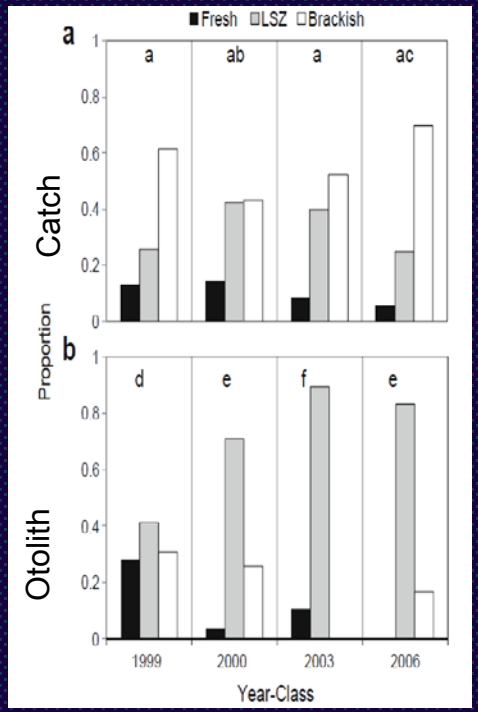
What do we know about longfin smelt in the LSZ?



Dege and Brown 2004

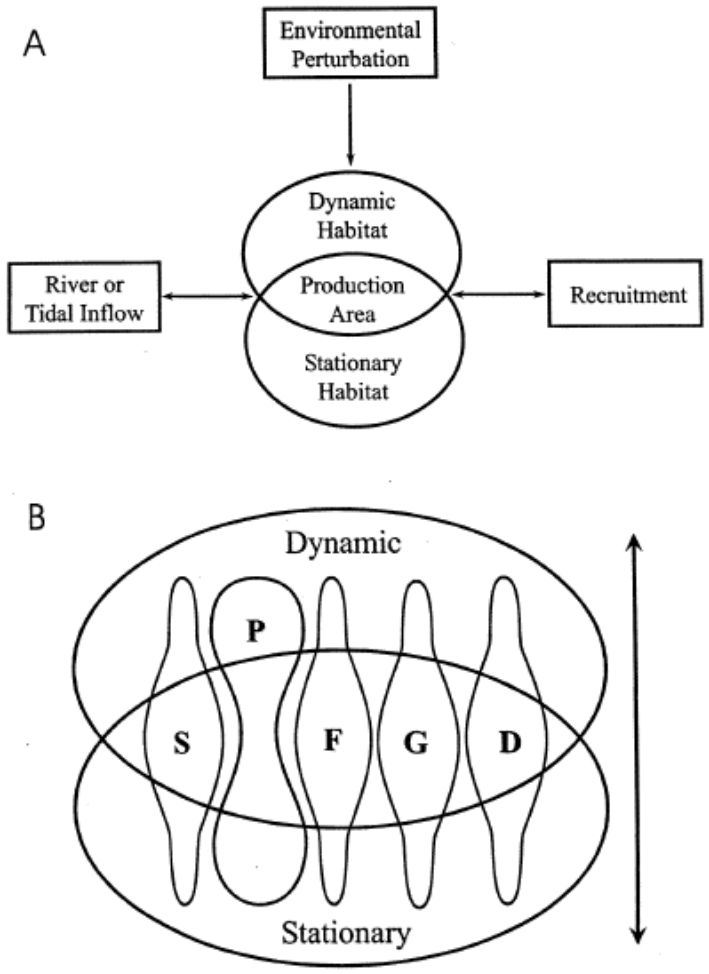


Bennett et al. 2002



Hobbs et al. 2006

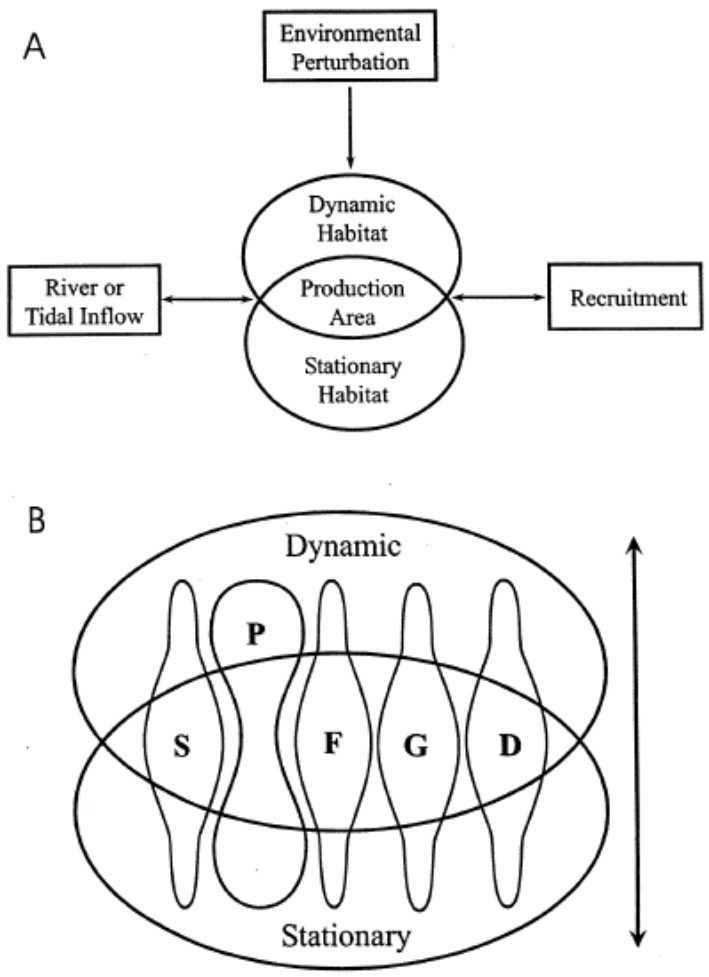
What about stationary habitat?



S = Survival, P = Predator, F = Foraging, G = Growth, D = Density

Peterson 2003

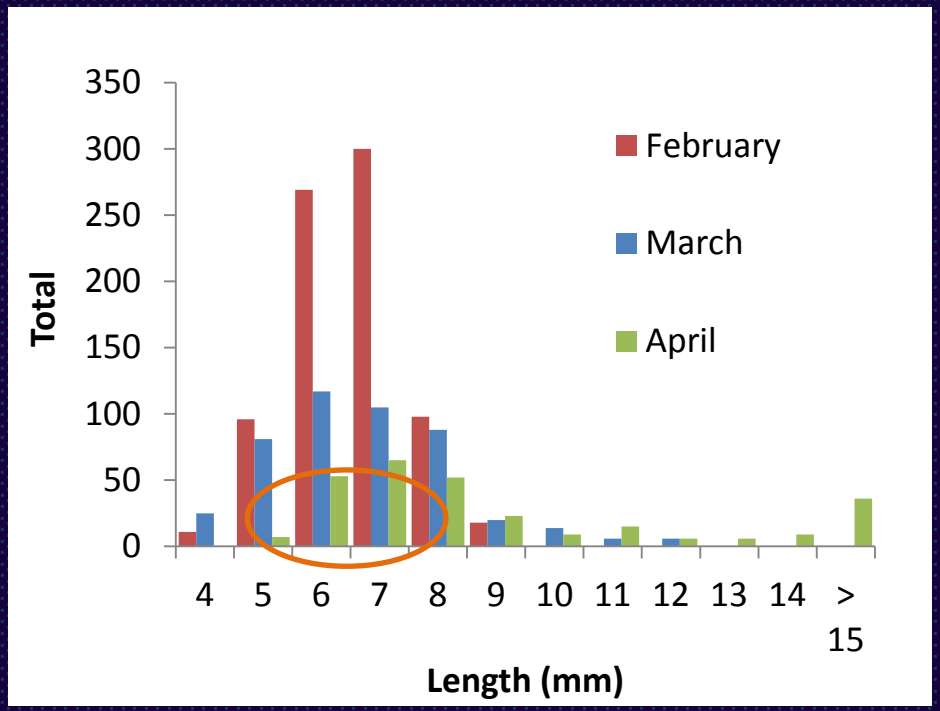
What about stationary habitat?

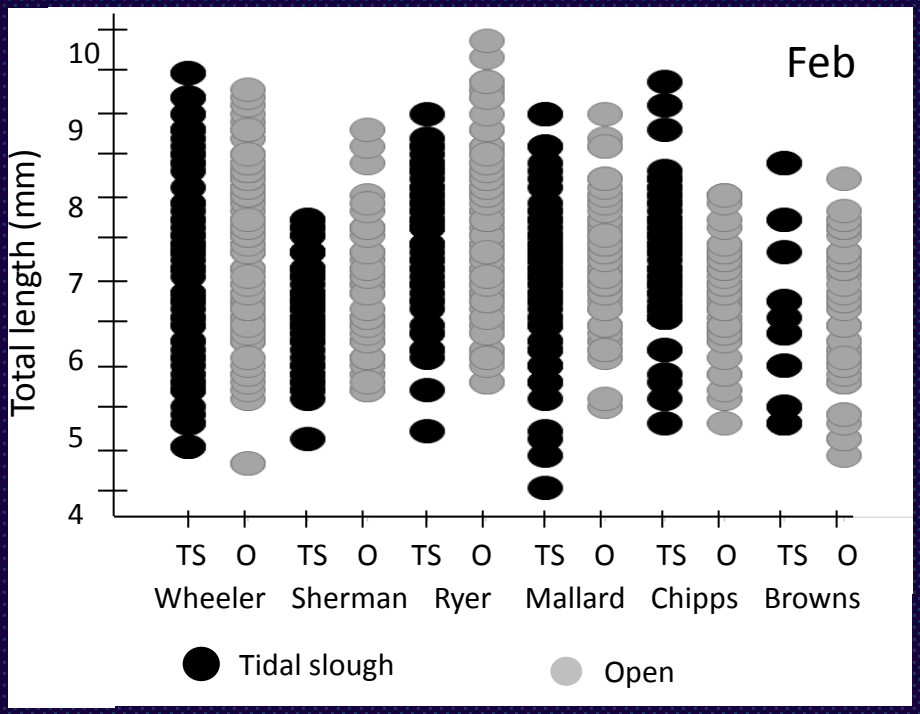


S = Survival, P = Predator, F = Foraging, G = Growth, D = Density

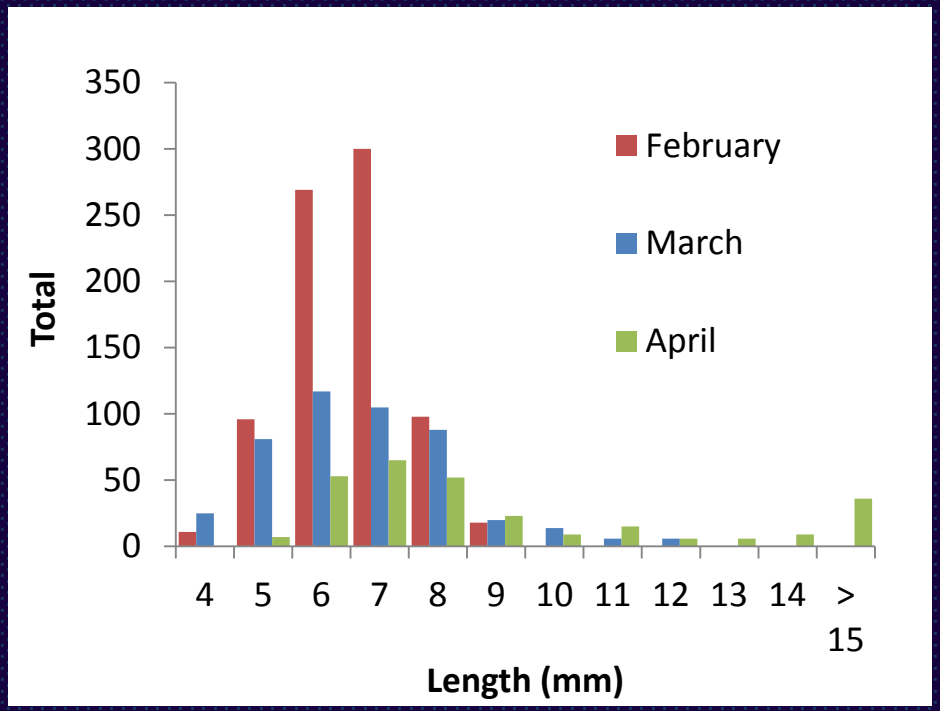
Peterson 2003

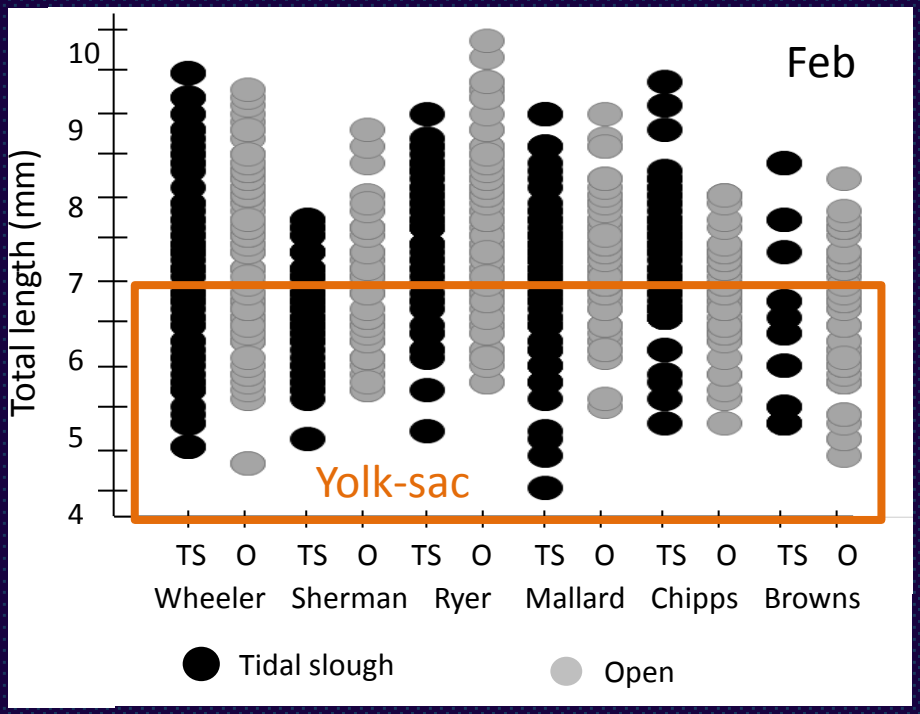
We caught lots of small larvae





Lots of yolk-sac larvae, i.e., newly hatched fish





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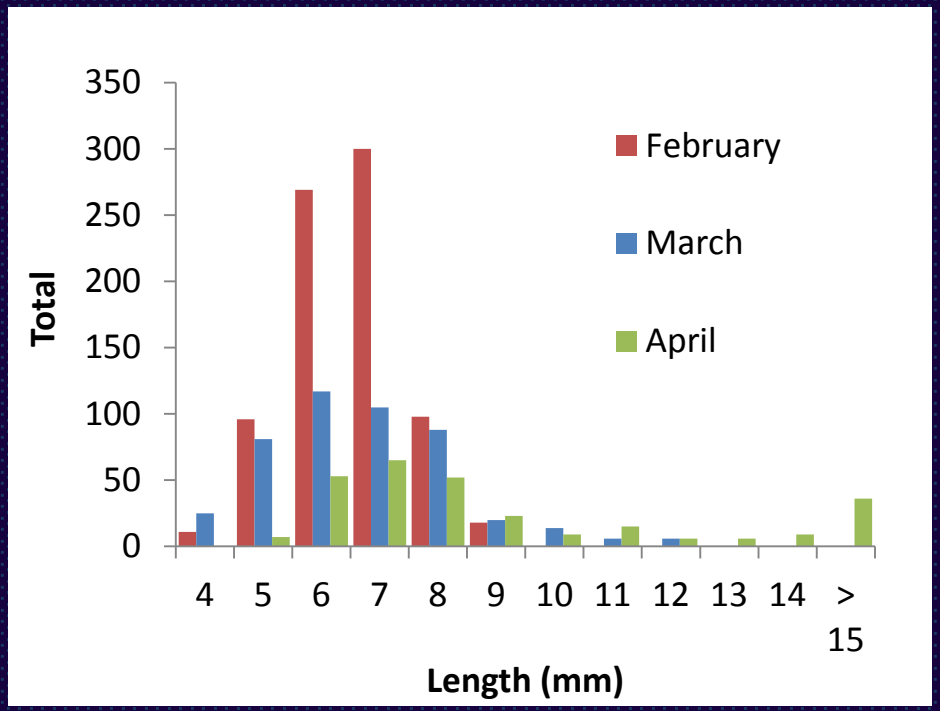
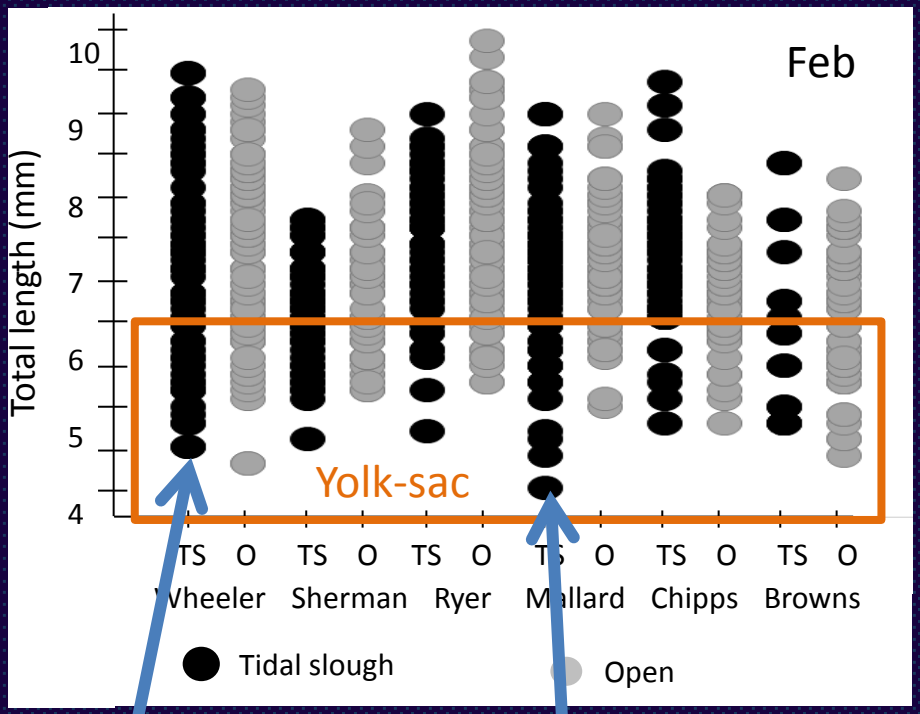
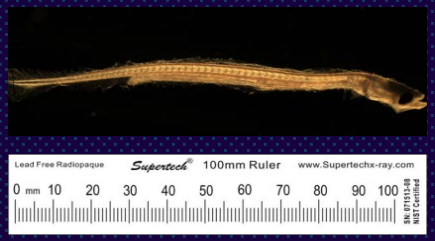


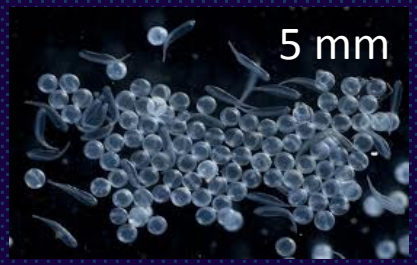


…….Especially in tidal marsh habitats

Do longfin smelt spawn in tidal marsh habitats?

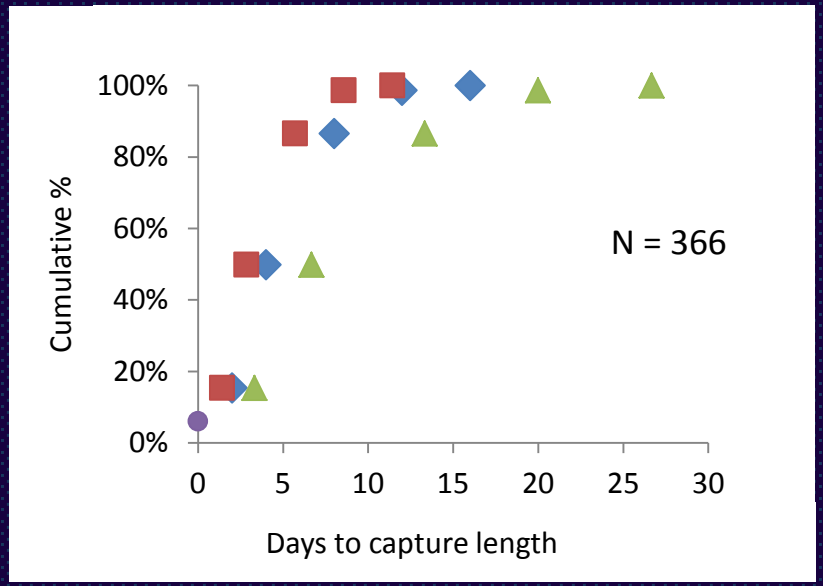


.20 mm/d
.30 mm/d
.40 mm/d

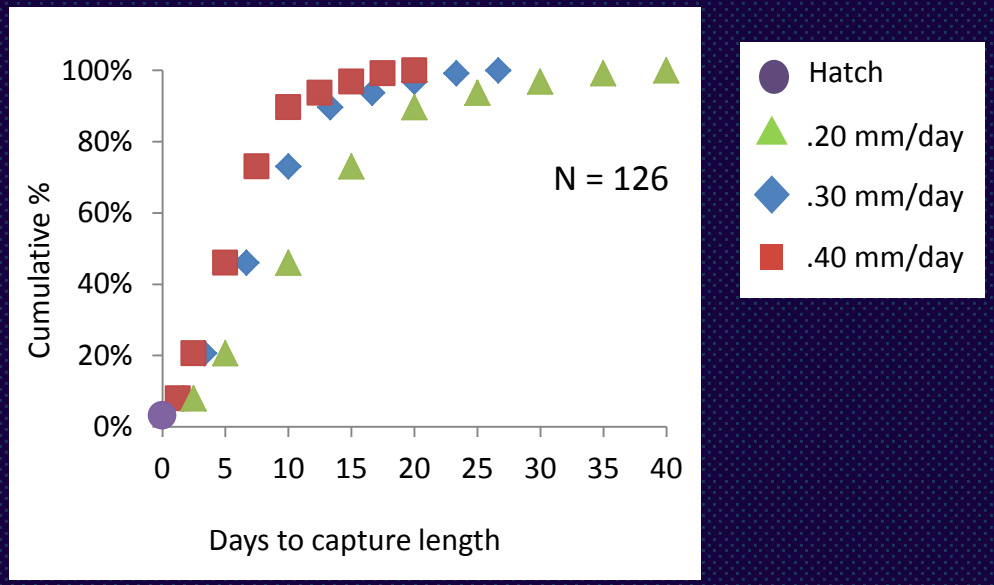


= Days to length

February



March



Do longfin smelt spawn in tidal marsh habitats?

Evidence suggests yes

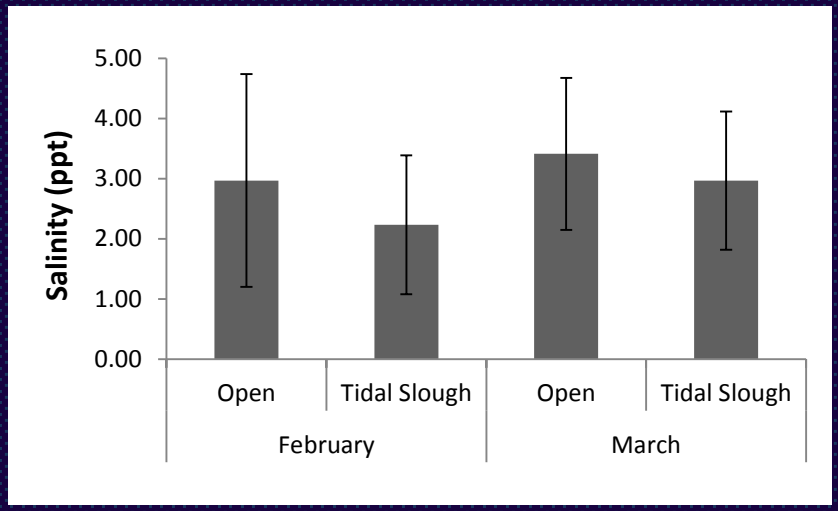
Do longfin smelt spawn in tidal marsh habitats?

Evidence suggests yes

They also spawned in shallow open-water habitats

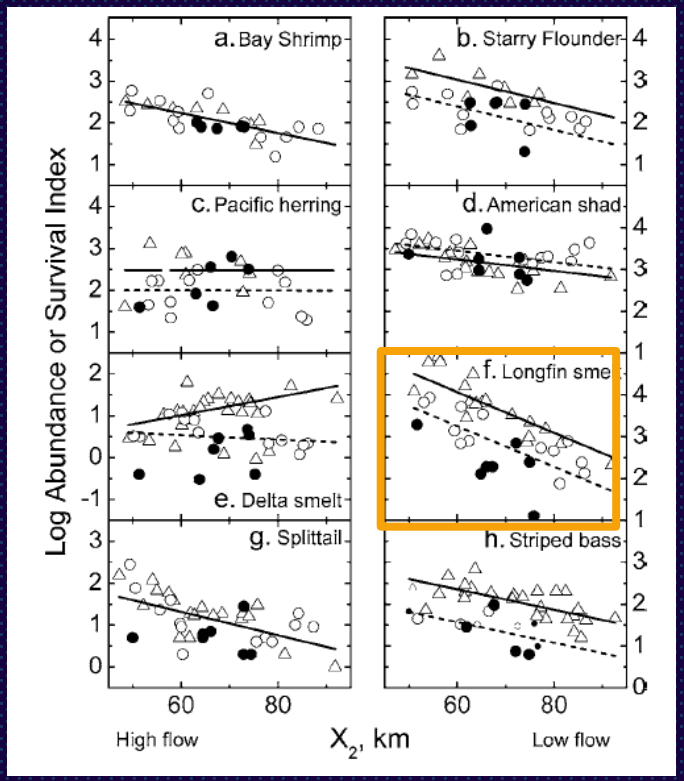
Do longfin smelt spawn in tidal marsh habitats?

Evidence suggests yes



And not in freshwater!

What are the potential mechanisms underlying abundance-flow relationship for longfin smelt?

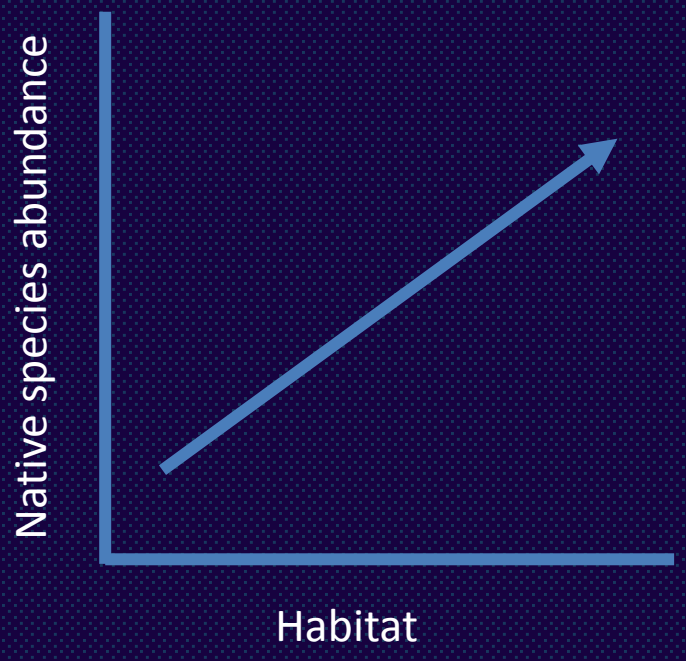


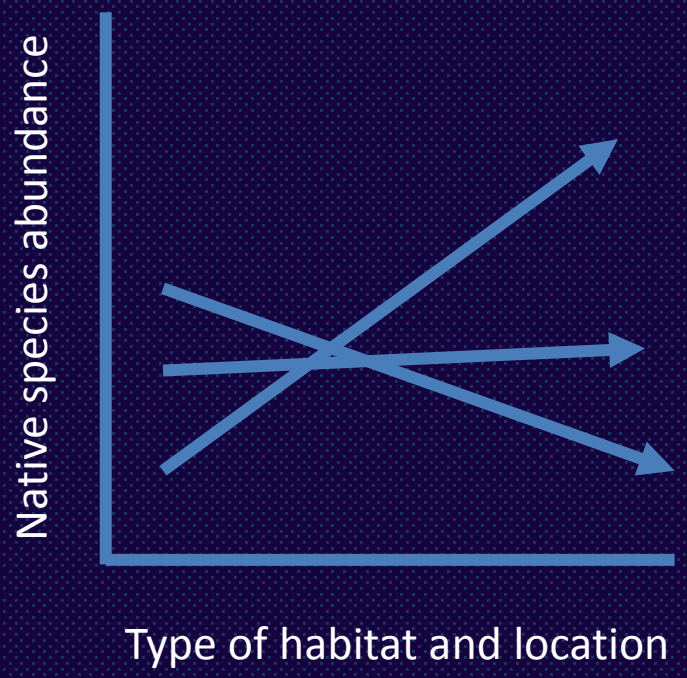
Kimmerer et al. 2009

Availability of spawning and rearing habitat could be one contributing mechanism

Consider restoration in this area of the estuary

Quick recap of what we learned to date:

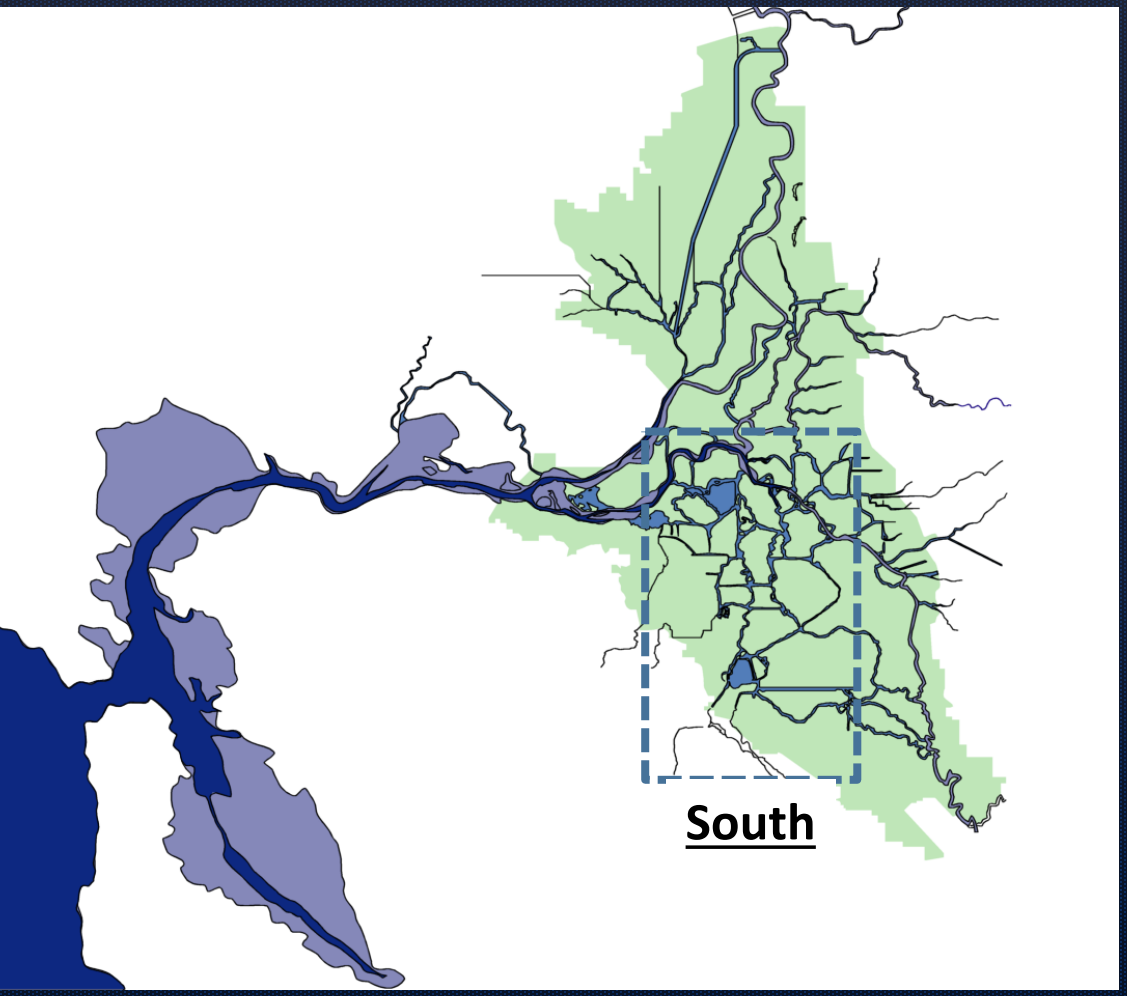




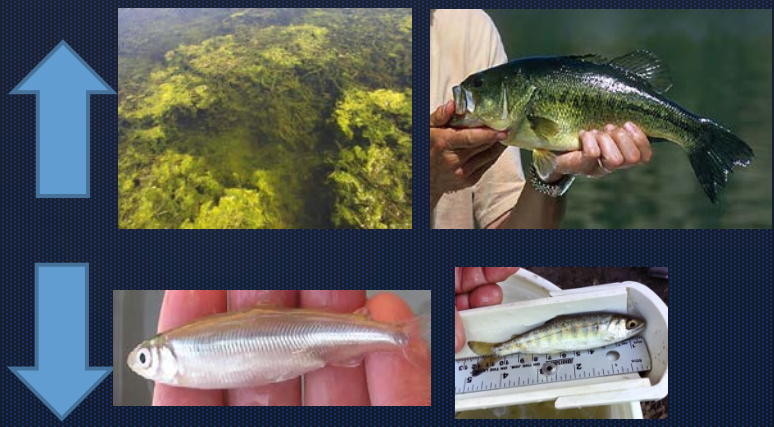
Where should restoration be focused and prioritized to benefit native fish and their habitats?

Take Home Message Revisited

To overcome challenges, Manage to your *certainty*



Low Priority



Take Home Message Revisited

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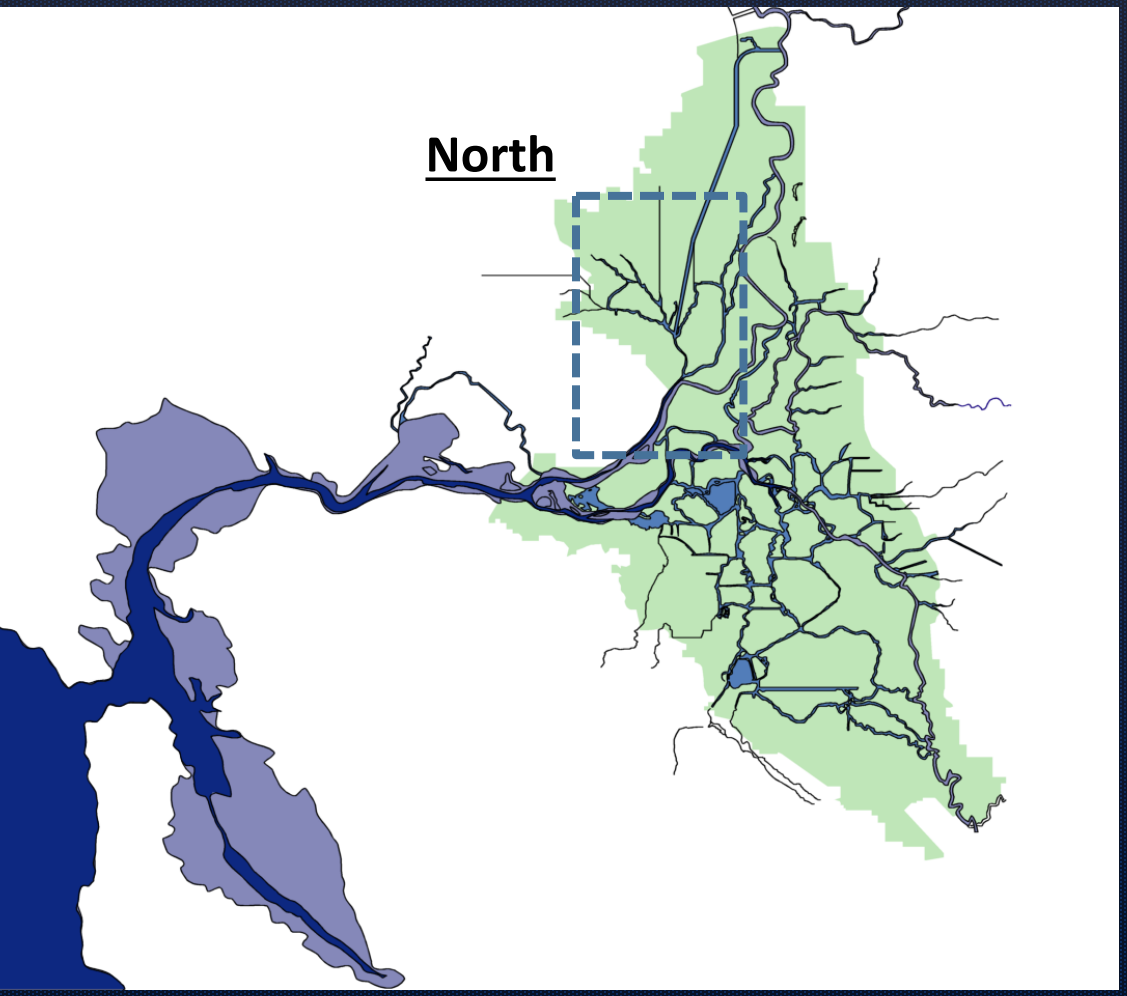
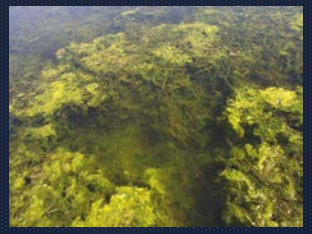
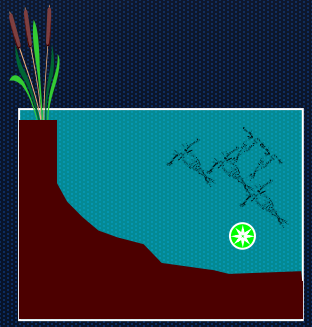




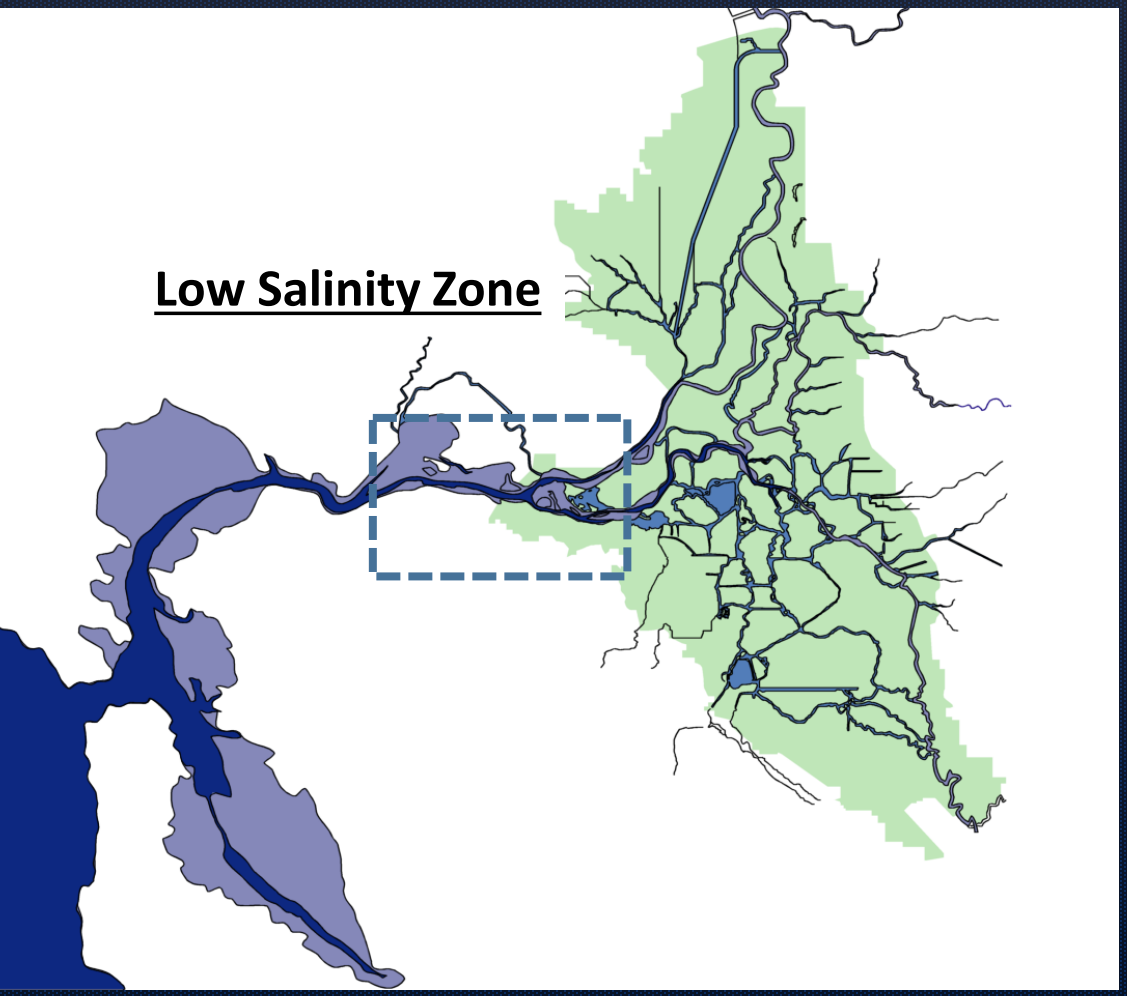


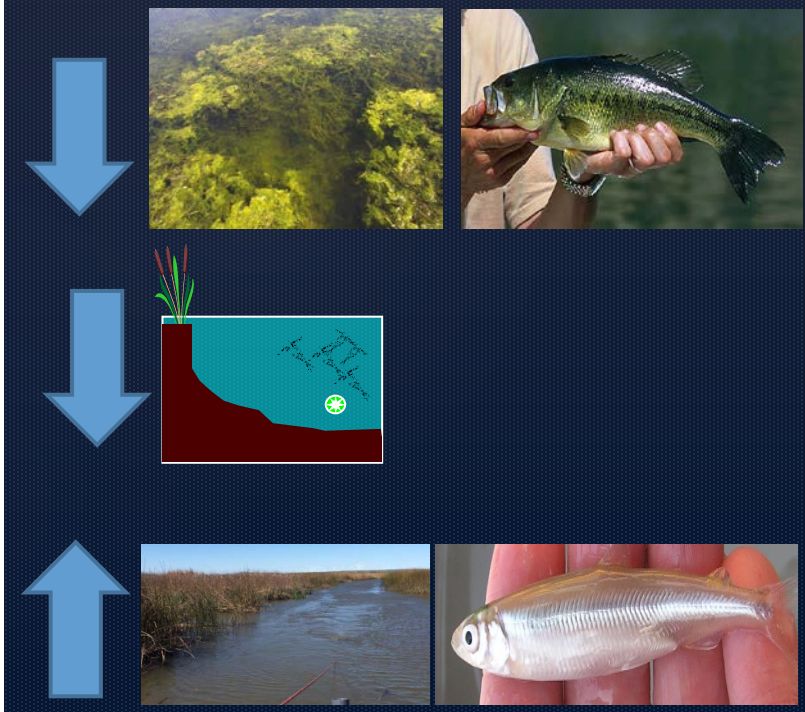
High Priority

-As long as the region stays turbid and free of SAV

Take Home Message Revisited

To overcome challenges, Manage to your *certainty*



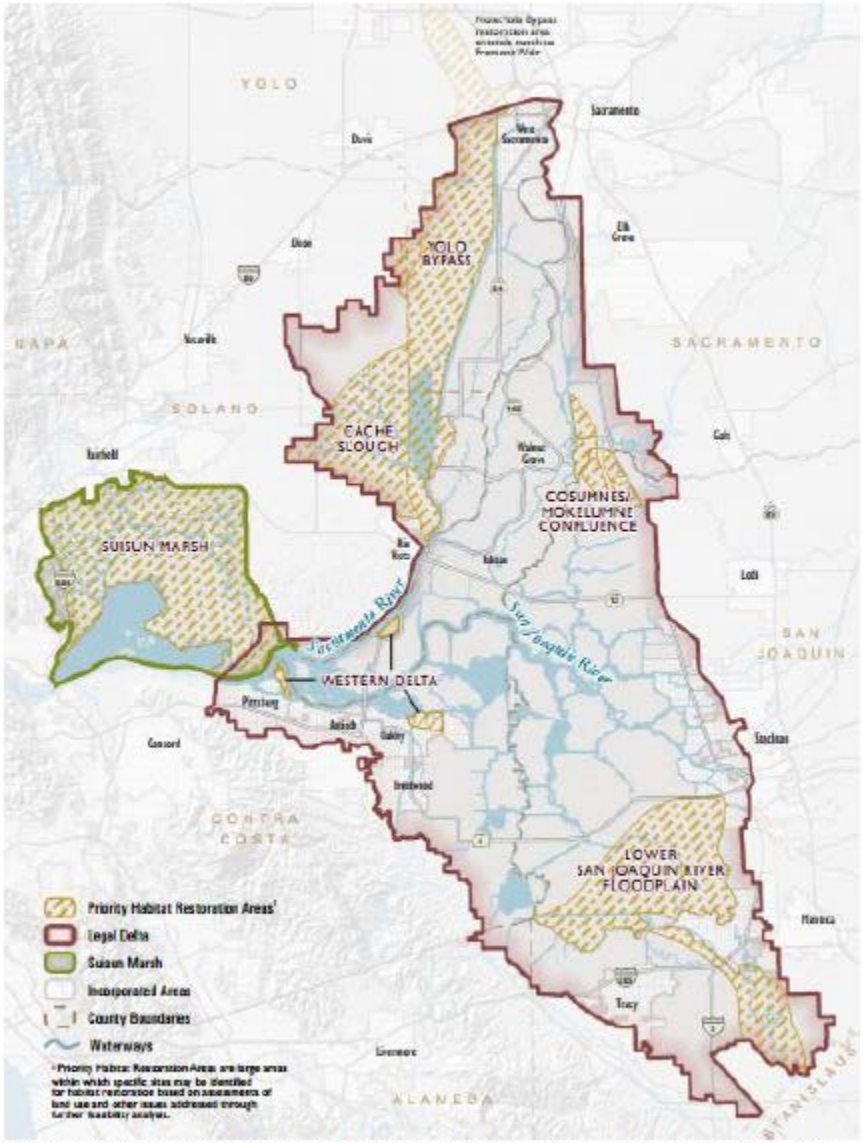


High priority but need to learn more

Message about how habitats functions work for native fishes and where to prioritize restoration areas has been widely acknowledged

Move forward with the blueprint

Figure 1. The Delta Plan's Priority Habitat Restoration Areas



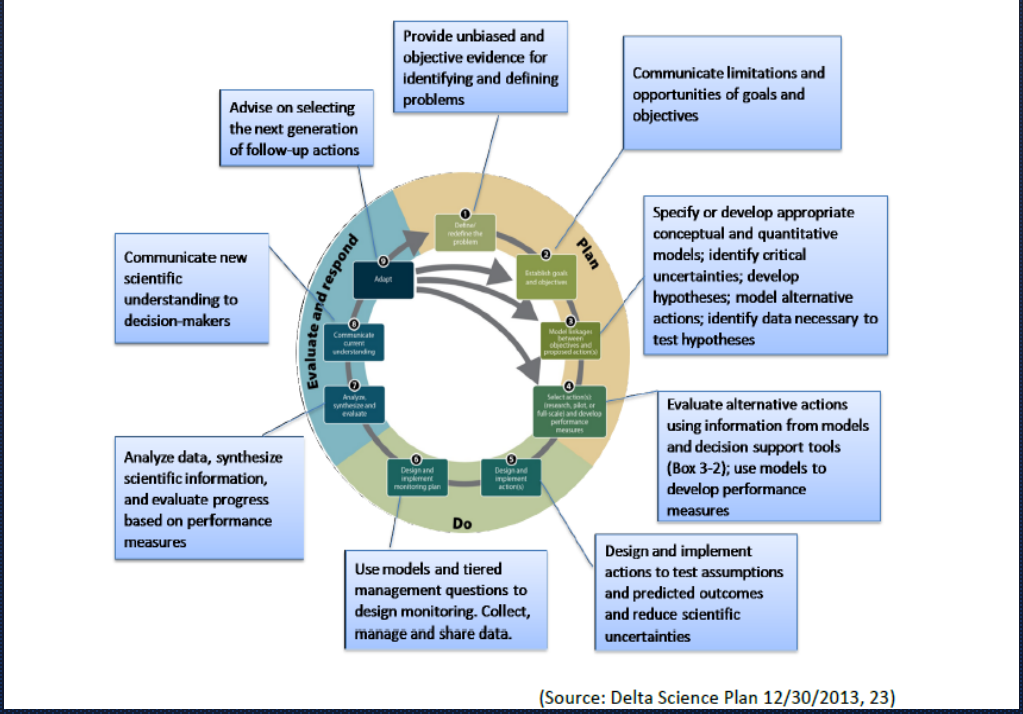
Source: Delta Stewardship Council. 2013. *Delta Plan*, Figure 4-8. Sacramento, CA.

Also see 2012 PPIC report, Where the Wild Things Aren't

Message about how habitats functions work for native fishes and where to prioritize restoration areas has been widely acknowledged.

Move forward with the blueprint

AND, we did all this learning without a rigid prescription to the adaptive management framework



(Source: Delta Science Plan 12/30/2013, 23)