MAY 28
2024

Leveraging open science, synthesis, and collaboration to advance fisheries and food web knowledge in the estuary

Denise Colombano, PhD
Delta Stewardship Council

State of the Estuary 2024

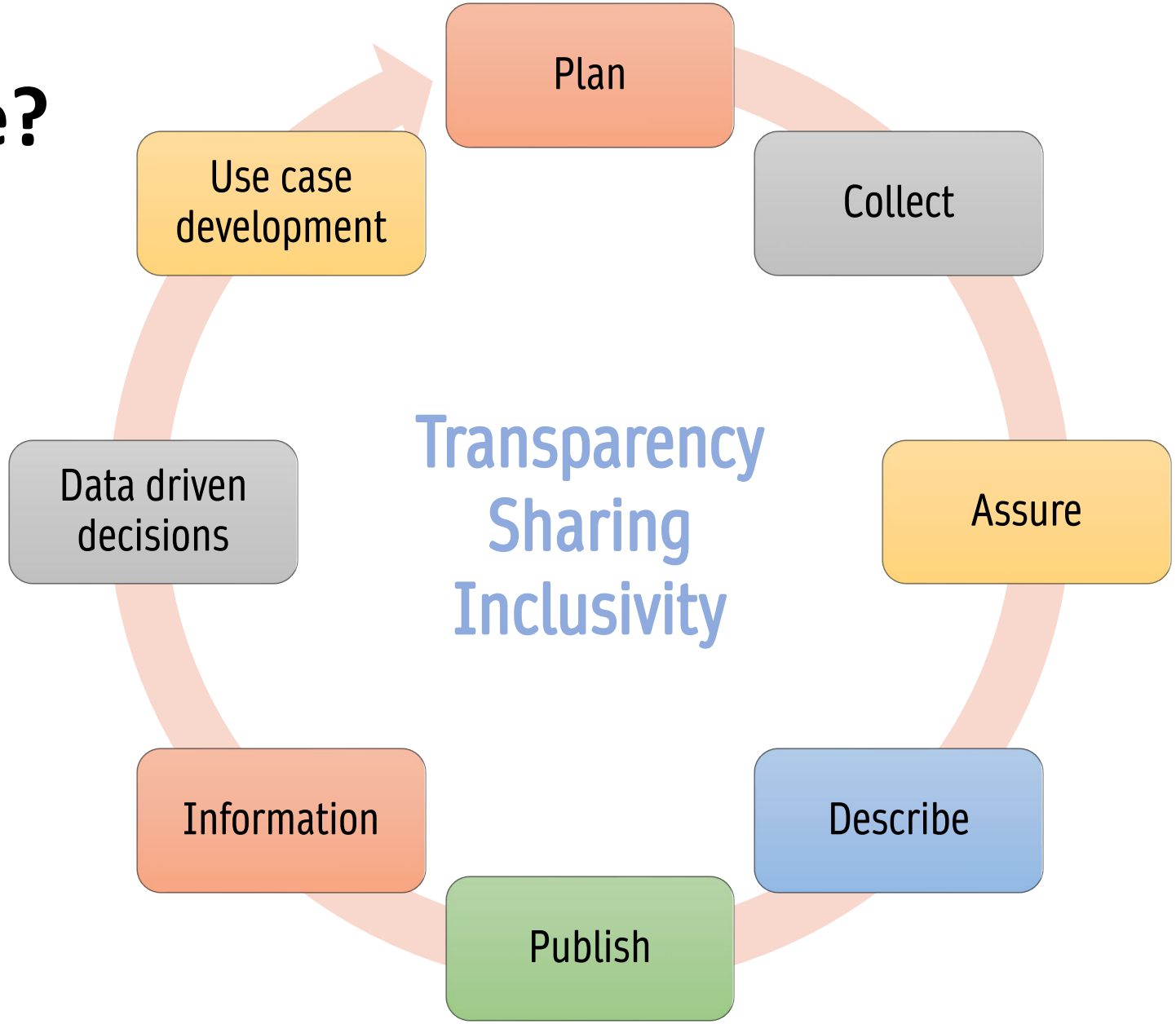
Delta Science Program
DELTA STEWARDSHIP COUNCIL

“Our capacity to efficiently provide timely information to meet modern societal challenges will depend on a global “greening” of ecology – that is, data should not only be generated and analyzed, but must also be available to be re-used and recycled.”

- Hampton et al. 2013, “Big data and the future of ecology”

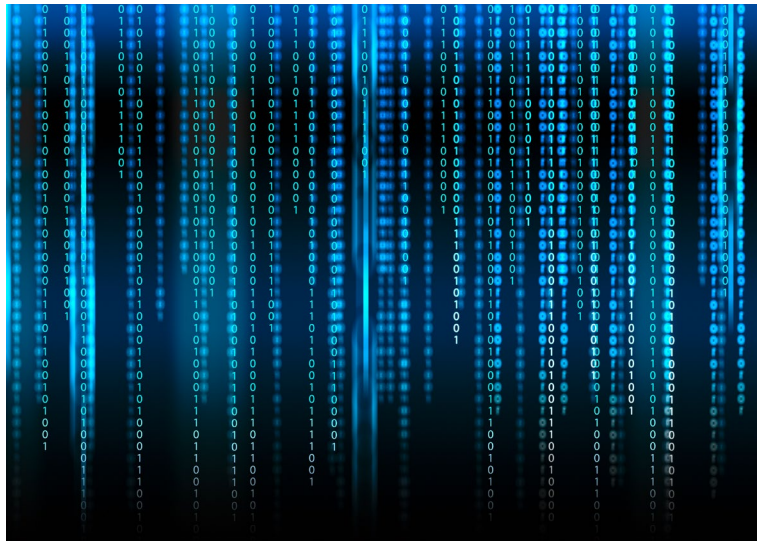
What is open science?

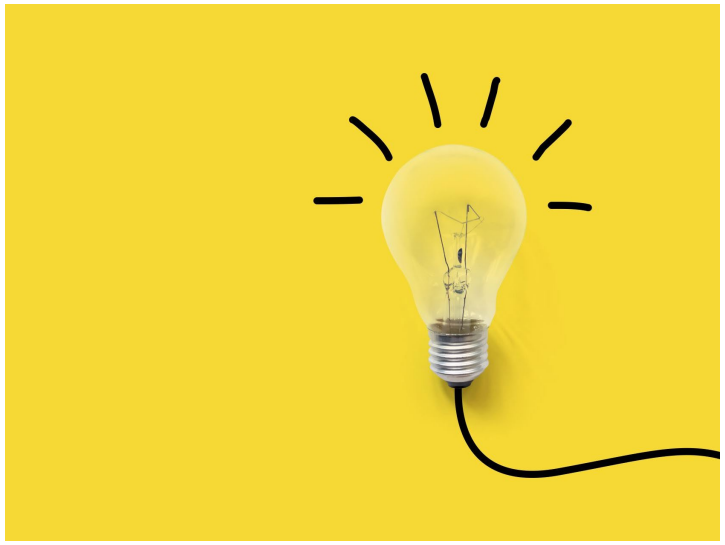
- Open scholarship at each stage of research lifecycle
- AB 1755: Open and Transparent Water Data Act



https://water.ca.gov/ab1755

What is synthesis?

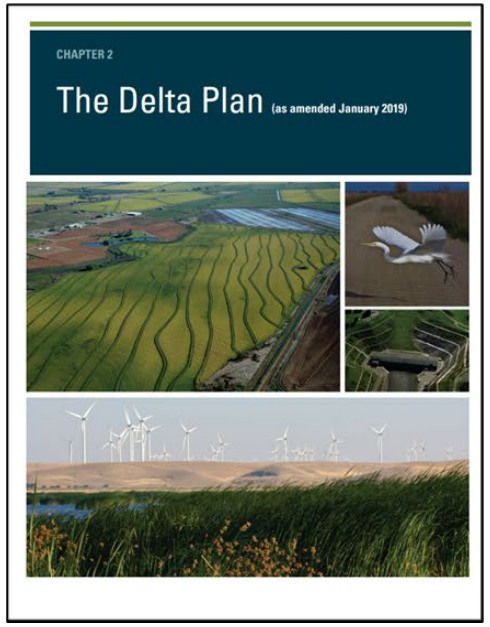


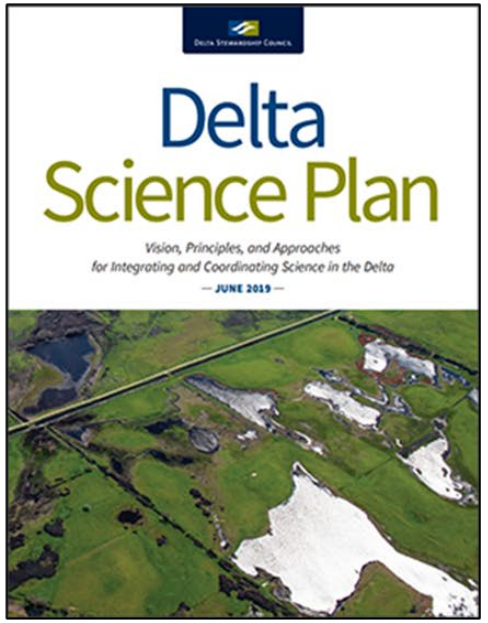


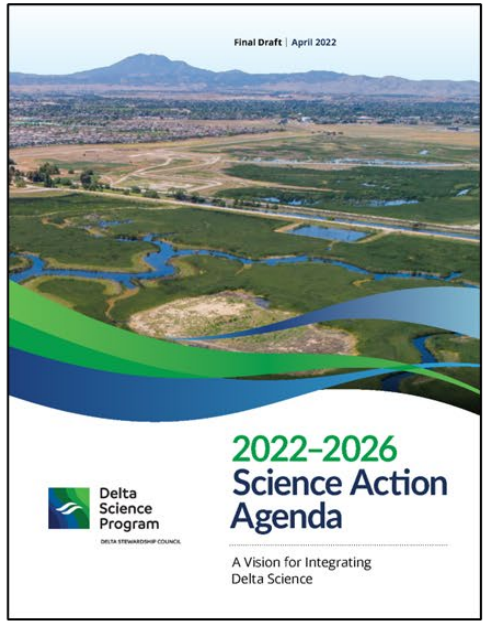
The process of combining disparate sources of information/data to see the bigger picture and gain new insights

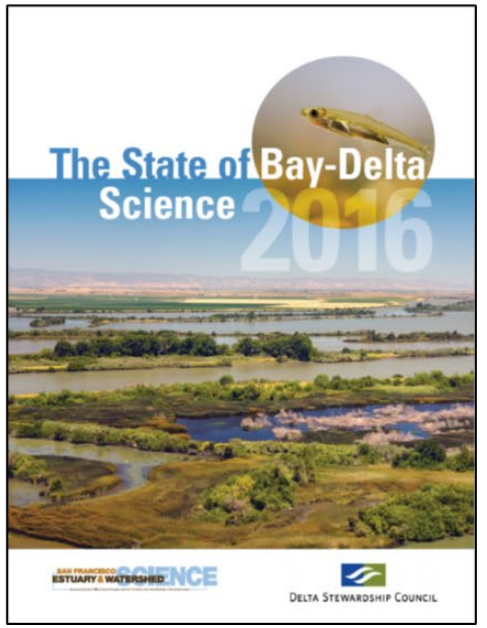
Synthesis at the Delta Science Program

- Perform analysis and synthesis of scientific information to report on status and trends of key issues
- Update the scientific state of knowledge; identify science needs and data gaps; guide adaptive management









Where can I find open data products?

DELTA SCIENCE TRACKER

R Shiny applications for the Sacramento San Joaquin Delta

Delta Science Program
DELTA STEWARDSHIP COUNCIL

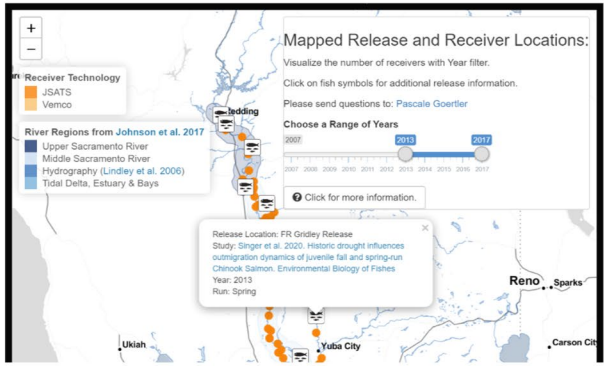
Hosting a shiny app on our site

sted in hosting a shiny app on our account, please read over the policy, fill out the questionnaire, and submit it to shiny@deltacouncil

Hosted applications (8)

ıkton synthesis app

Salmon release and telemetry receiver locations



Delta-Stewardship-Council

Overview | Repositories 17 | Projects 1 | Packages | People

Delta Stewardship Council

3 followers · California · https://deltacouncil.ca.gov/

Popular repositories

deltafish — Public
R · 11 · 1

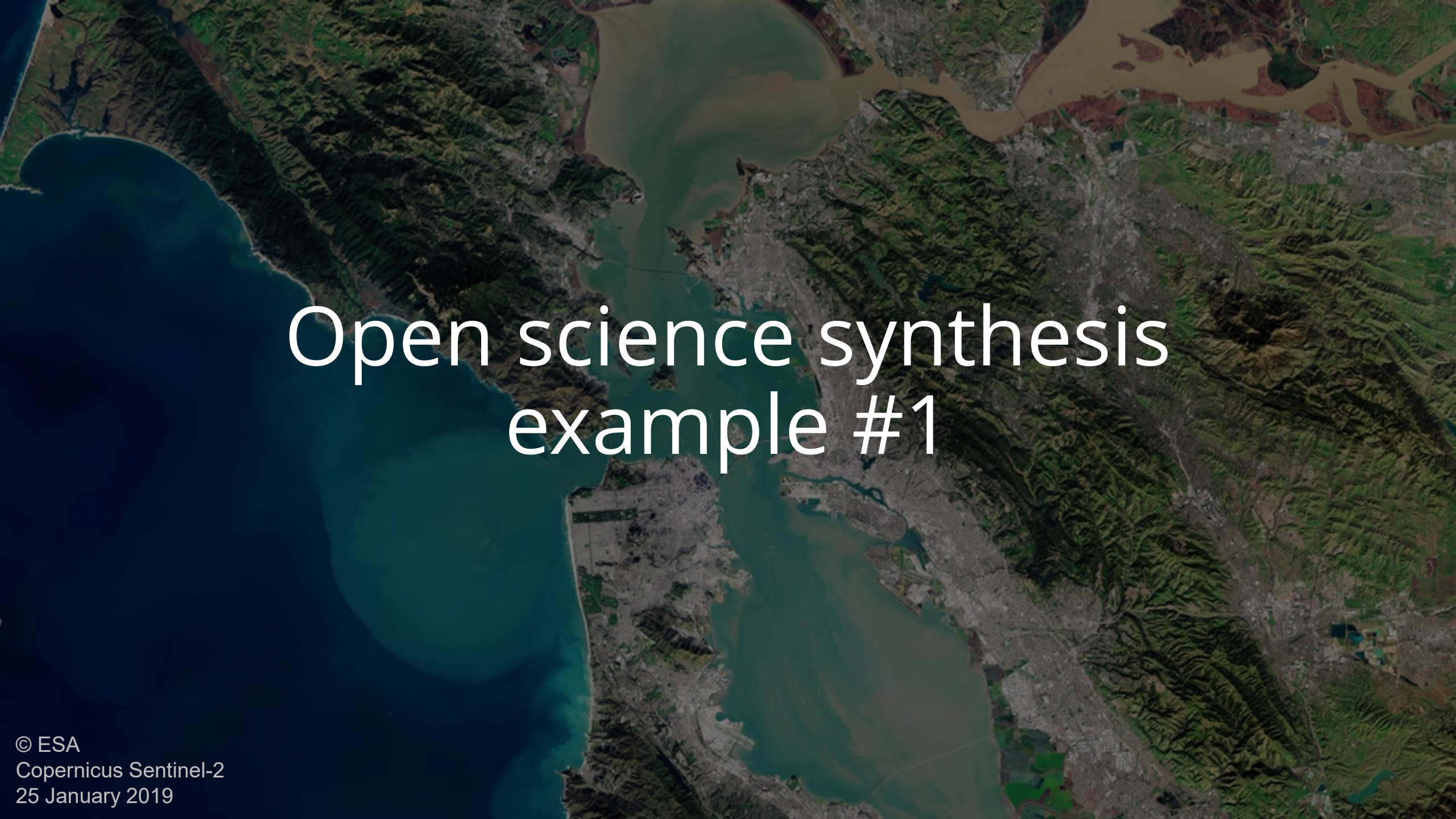
swg-21-foodwebs — Public
Foodwebs working group from the 2021 DSP-NCEAS synthesis working group
R · 8 · 4

swg-21-data — Public
This partnership between the Delta Science Program and National Center for Ecological Analysis and Synthesis will provide high-quality training in data science and statistics and an opportunity for...
4 · 1

swg-23-infrastructure — Public
2023 synthesis working group infrastructure project
R · 3

swg-23-sovi — Public
Data integration for the 2023 synthesis working group (swg) on existing

swg-21-connectivity — Public
connectivity synthesis subgroup



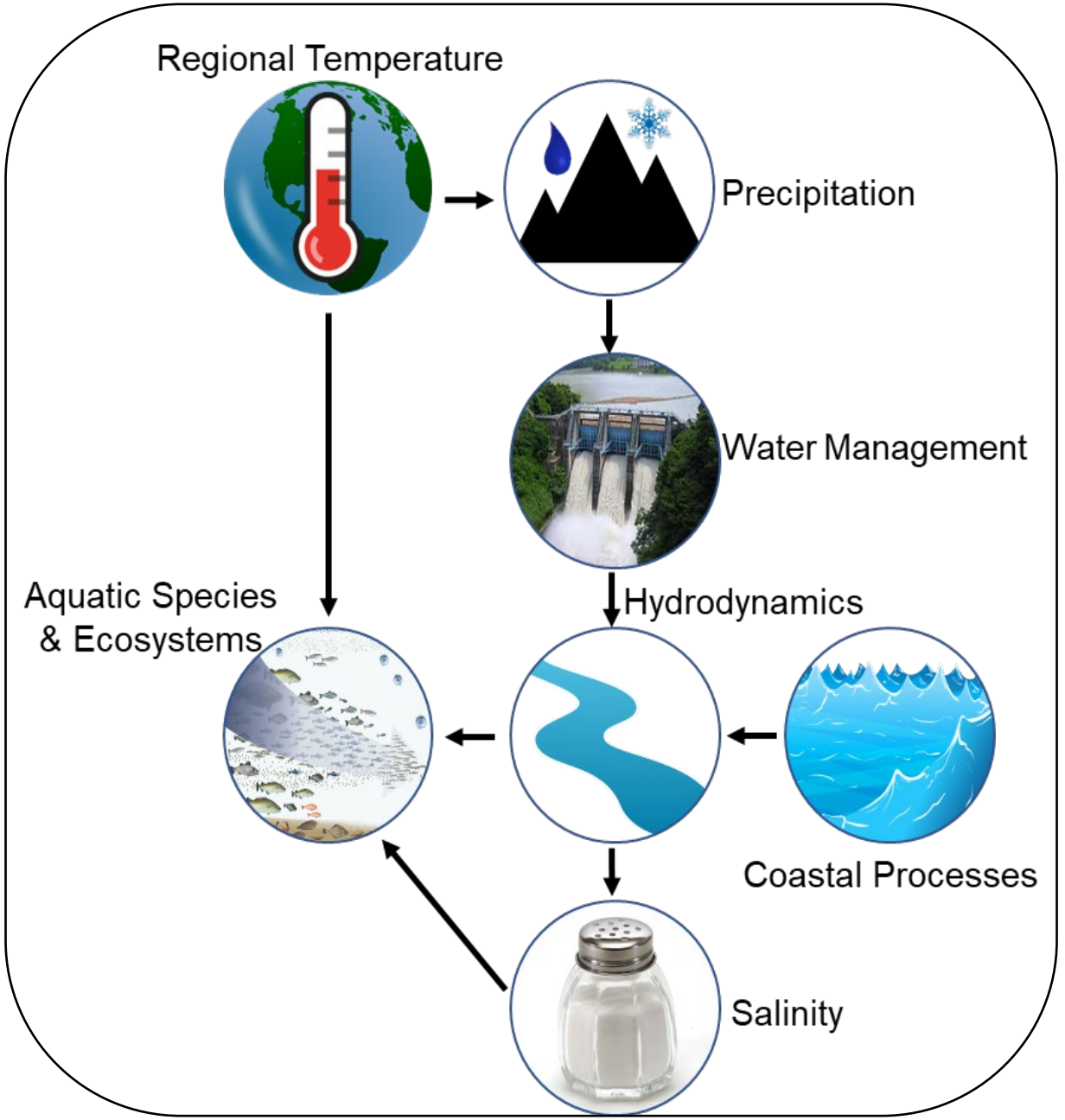
Open science synthesis example #1

Delta Science Program synthesis working group

2021-2022

Drivers of the estuary food supply

Critical knowledge gap identified by Delta Independent Science Board



Hot off the press…

ARTICLE

ECOLOGY
ECOLOGICAL SOCIETY OF AMERICA

Evaluating top-down, bottom-up, and environmental drivers of pelagic food web dynamics along an estuarine gradient

Tanya L. Rogers[1] | Samuel M. Bashevkin[2] | Christina E. Burdi[3] | Denise D. Colombano[4] | Peter N. Dudley[1,5] | Brian Mahardja[6] | Lara Mitchell[7] | Sarah Perry[8] | Parsa Saffarinia[9]

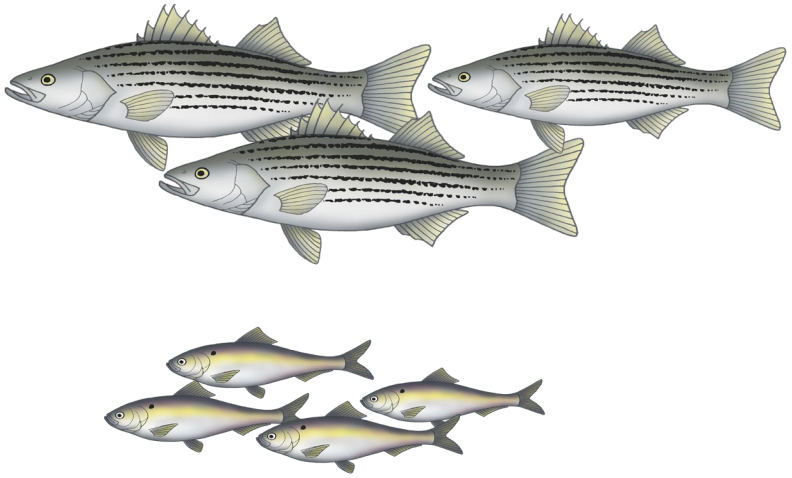
https://doi.org/10.1002/ecy.4274

What is top-down control?

Predator

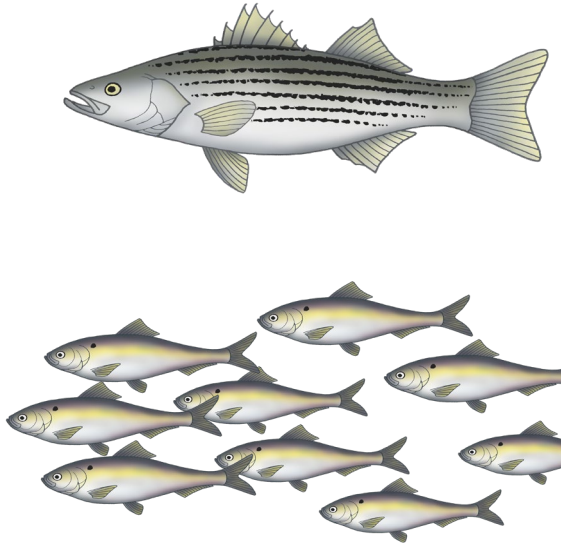
Prey

Many predators



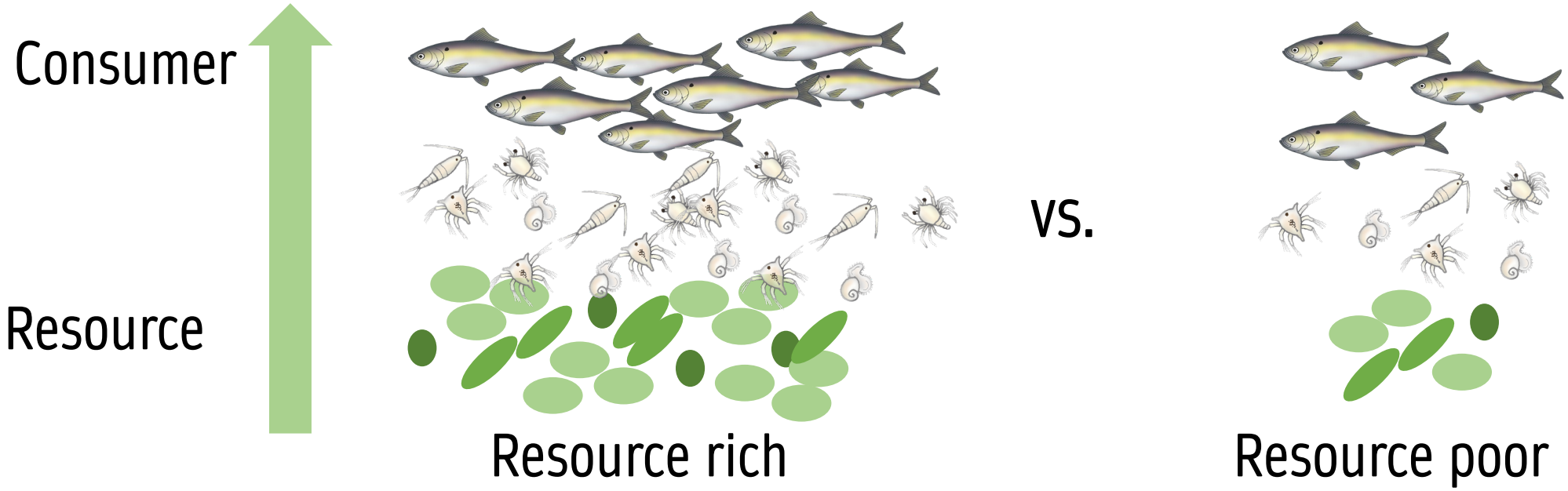
vs.

Few predators



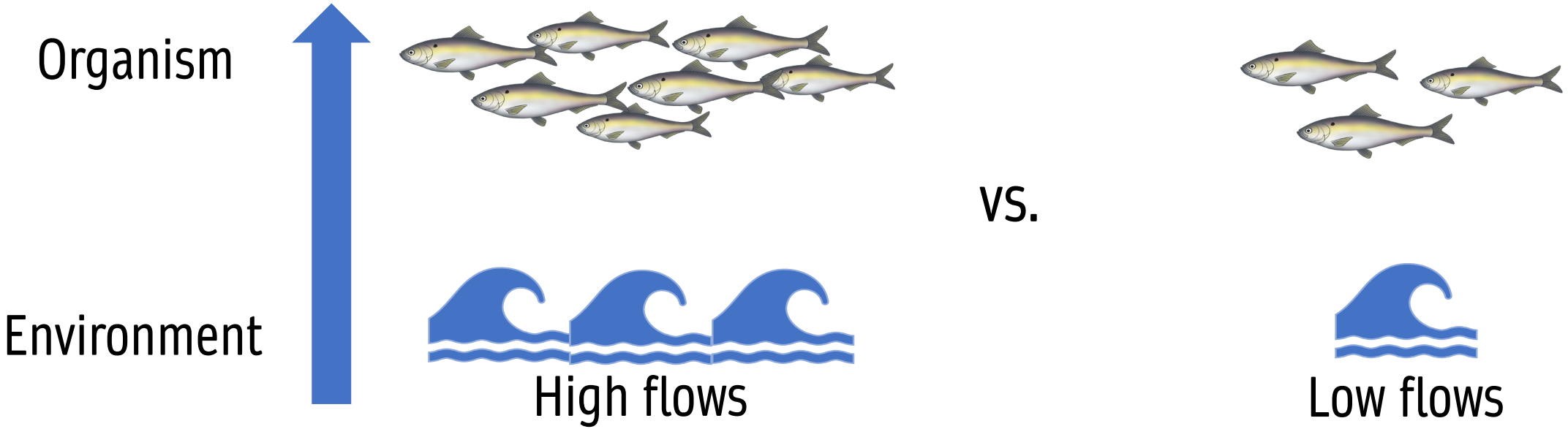
The number of predators controls the number of prey through direct consumption

What is bottom-up control?



The availability of food resources controls the number of consumers that can eat and survive

What is environmental control?



Prevailing environmental conditions directly control the number of organisms based on physiology or behavior

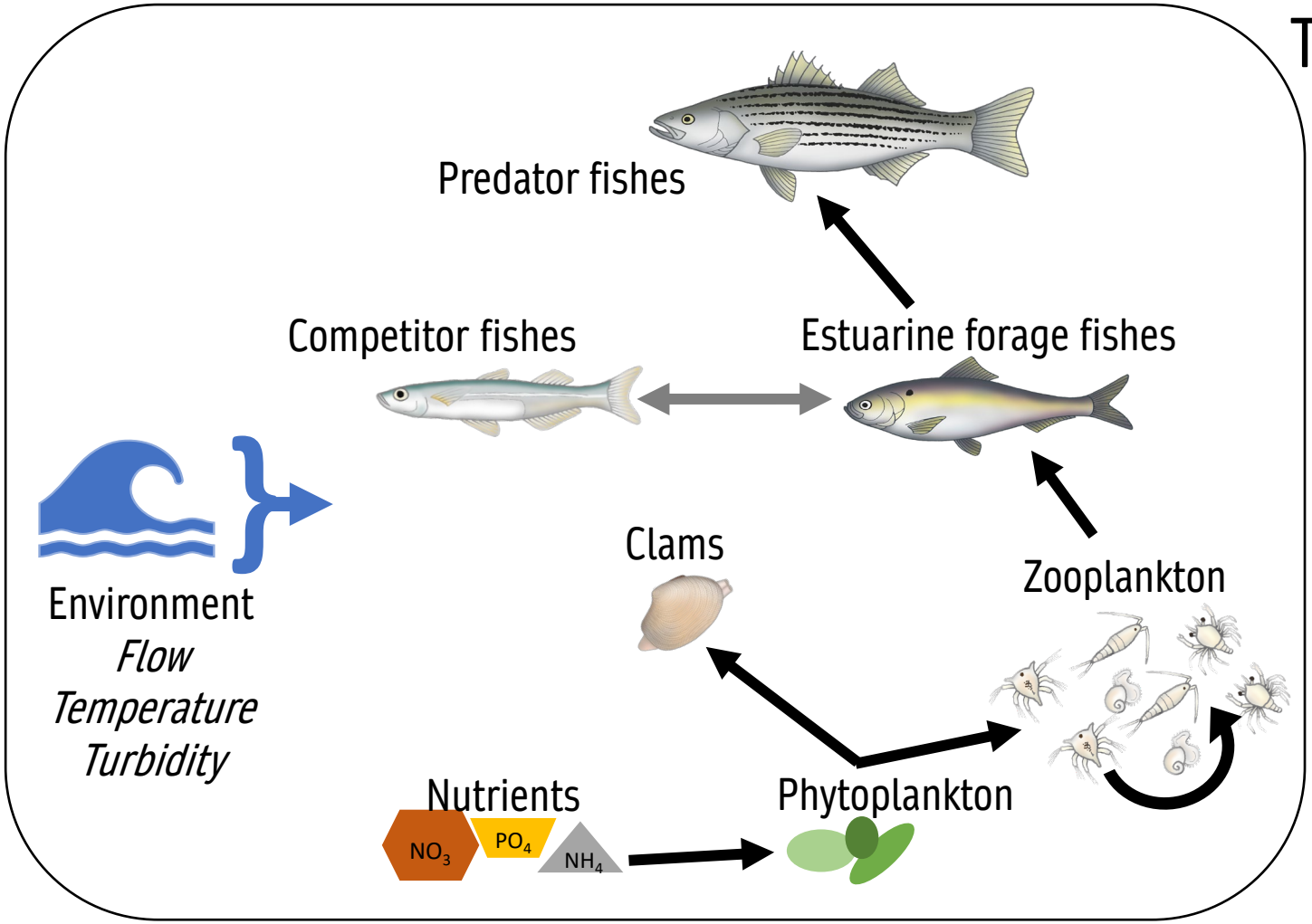
Food web conceptual model

Modeled relationships:

Environment

Direct interaction

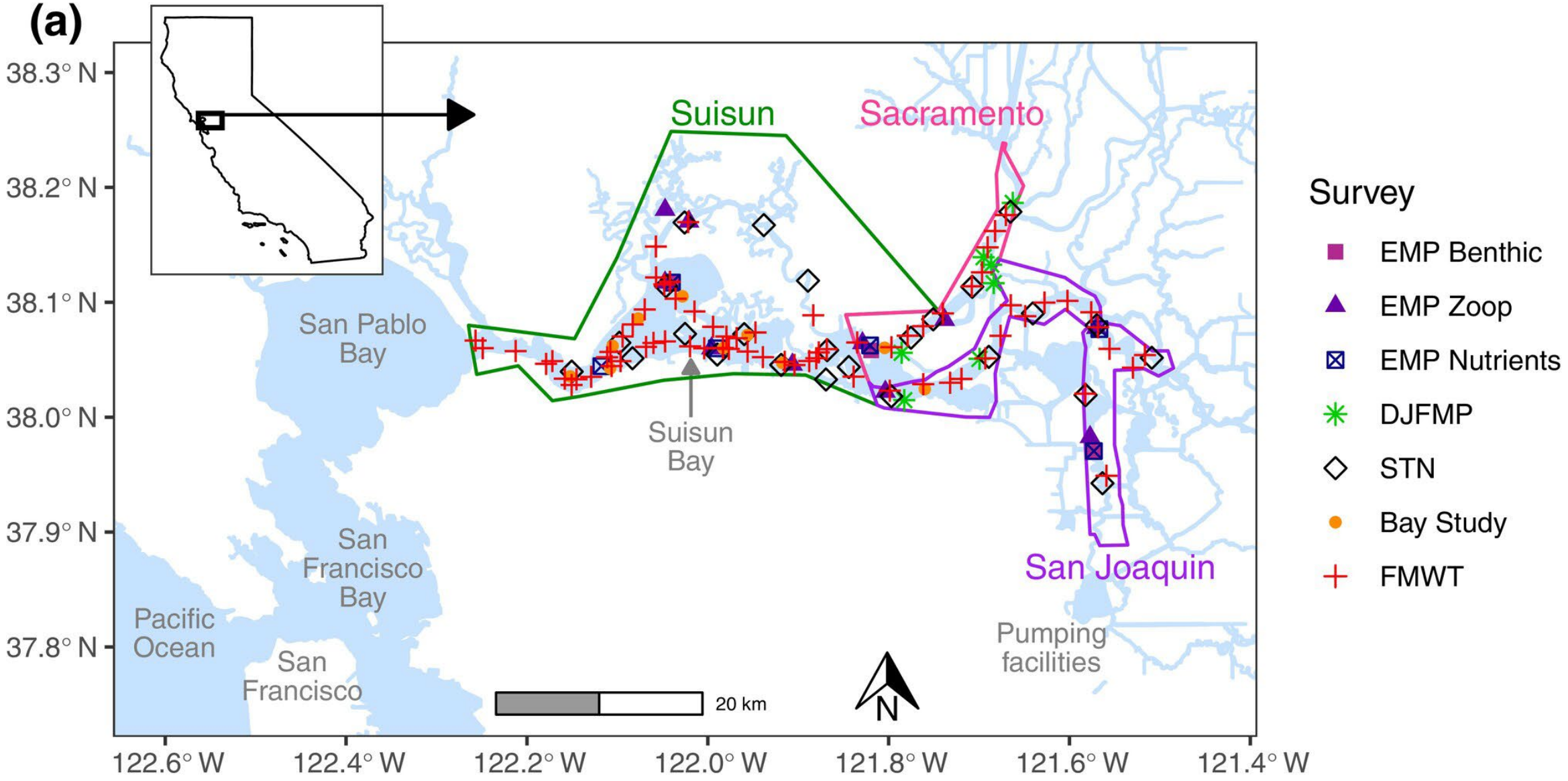
Other interaction



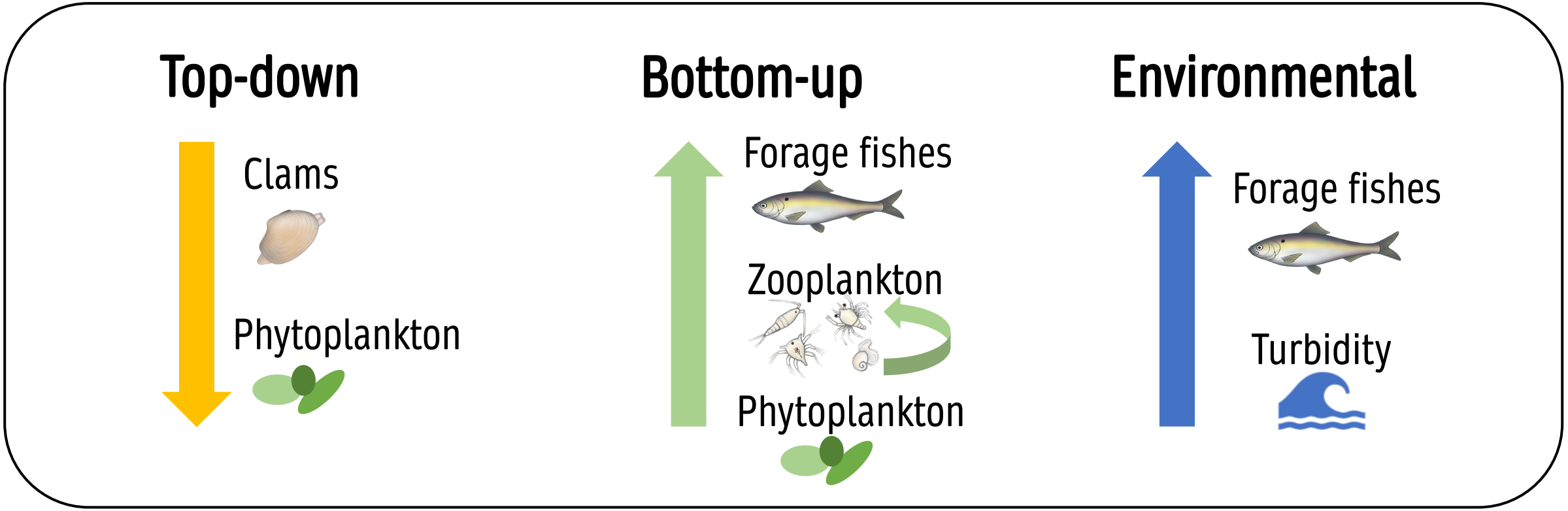
Synthesis in action:
8 different datasets 1980-2020

TABLE 1 Variables and data sources.

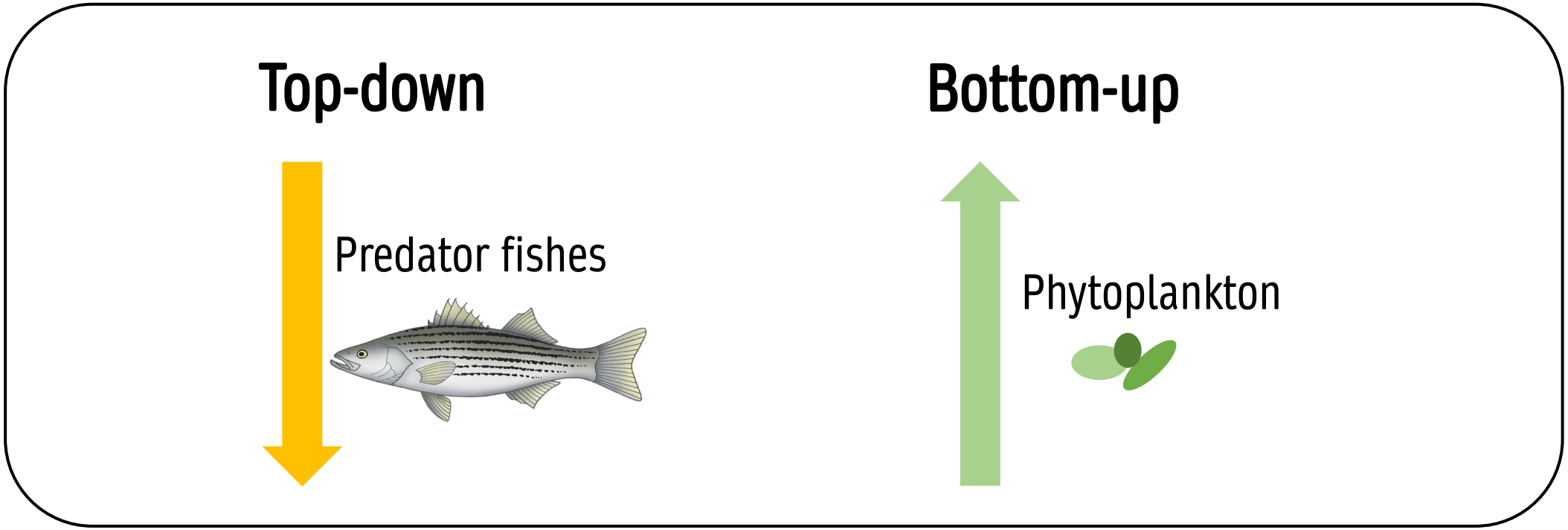
Variables	Data source	Citation
Zooplankton (cladocerans, herbivorous copepods, mysids, predatory copepods, rotifers)	Environmental Monitoring Program (EMP Zooplankton)	Barros (2021)
Benthic invertebrates (clams, amphipods)	Environmental Monitoring Program (EMP Benthic)	Wells and Interagency Ecological Program (2021)
Fish (estuarine fishes, marine fishes, age 1+ striped bass)	San Francisco Bay Study Midwater Trawl (BSMT)	https://wildlife.ca.gov/Conservation/Delta/Bay-Study
Fish (estuarine fishes)	Fall Midwater Trawl Survey (FMWT)	https://wildlife.ca.gov/Conservation/Delta/Fall-Midwater-Trawl
	Summer Townet Survey (STN)	https://wildlife.ca.gov/Conservation/Delta/Townet-Survey
Fish (Mississippi Silverside, centrarchid species)	Delta Juvenile Fish Monitoring Program (DJFMP)	Interagency Ecological Program, McKenzie, et al. (2021)
Chlorophyll-*a*, Temperature, Secchi depth, Nutrients	Environmental Monitoring Program (EMP Water Quality)	Interagency Ecological Program, Martinez, et al. (2021)
Flow	Dayflow, California Department of Water Resources	https://data.cnra.ca.gov/dataset/dayflow


(a)
38.3° N
38.2° N
38.1° N
38.0° N
37.9° N
37.8° N
122.6° W
122.4° W
122.2° W
122.0° W
121.8° W
121.6° W
121.4° W
Suisun
Sacramento
San Joaquin
San Pablo Bay
Suisun Bay
San Francisco Bay
Pacific Ocean
San Francisco
Pumping facilities
20 km
N
Survey
EMP Benthic
EMP Zoop
EMP Nutrients
DJFMP
STN
Bay Study
FMWT

Key finding #1:
All three drivers were important in the models (net effects had similar magnitudes)



Key finding #2:
Data quality or quantity issues

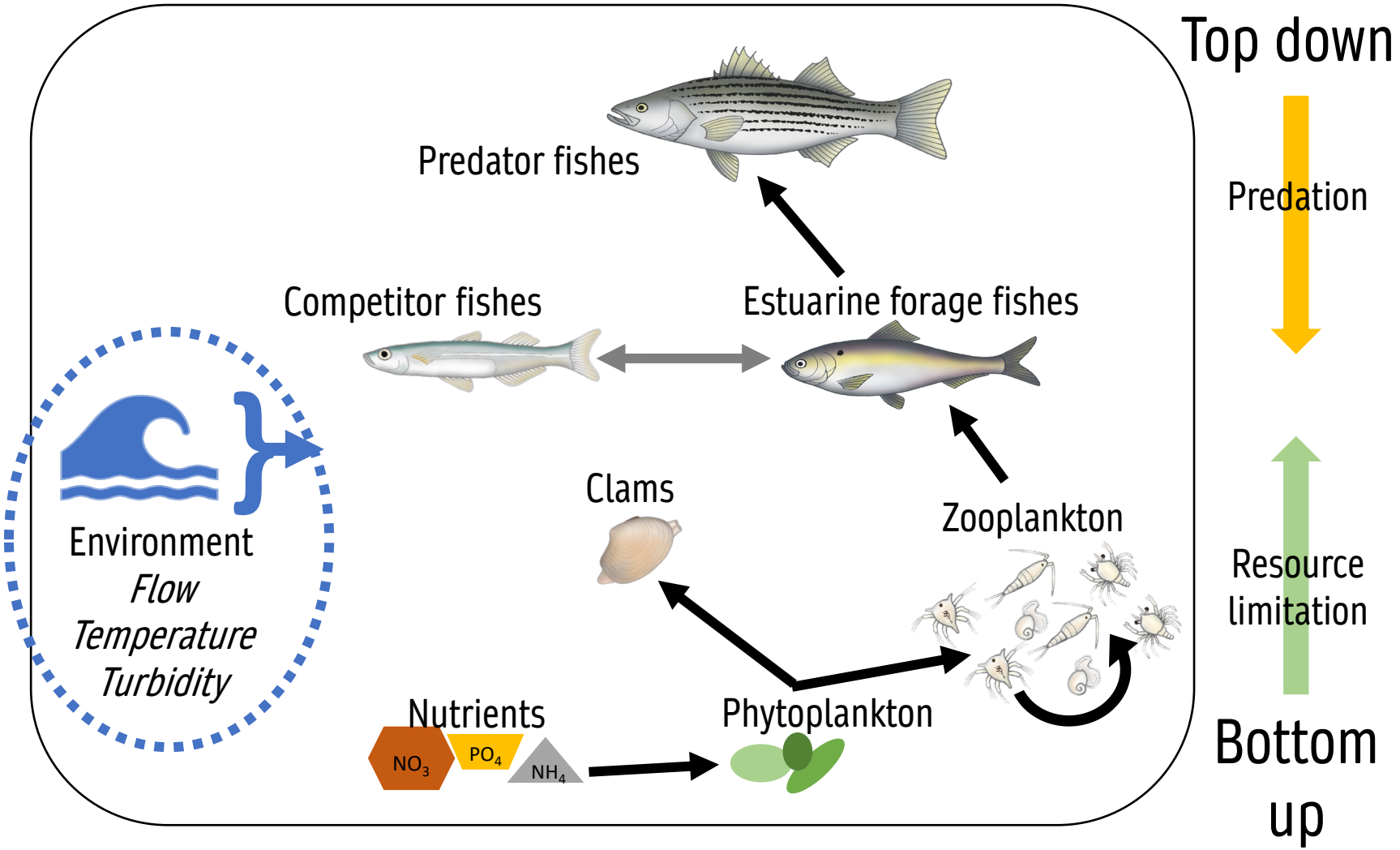


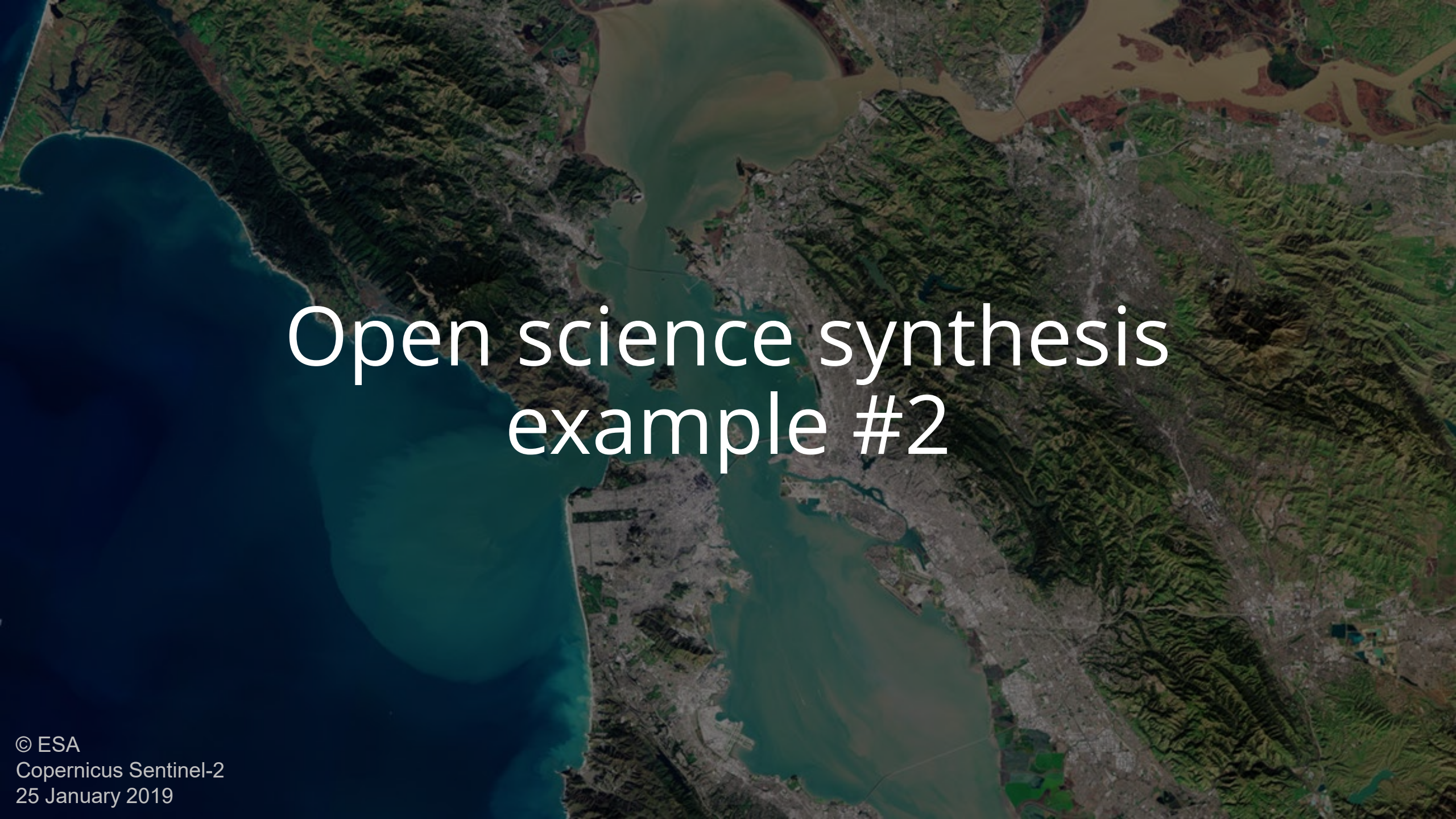
Not enough data to determine effects of large fishes

Low resolution data; need to identify species

Key takeaways for research and management

- Synthesis revealed new insights not previously known
- Model support for ecosystem-based management solutions





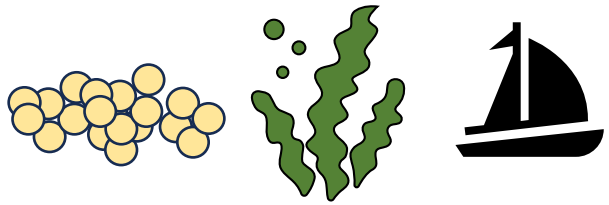
Open science synthesis example #2

Pacific herring life cycle

Move into estuary, spawn

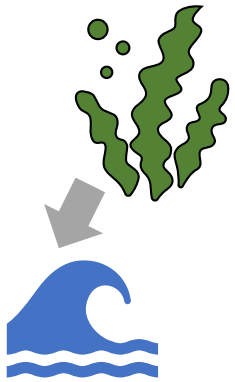
Adults

Eggs



Hatch, drift

Planktonic larvae



Rear in estuary

Young of the year

Move out to ocean

Sub-adults

Recruit

Sac-roe

UmamiMart.com

Whole fish

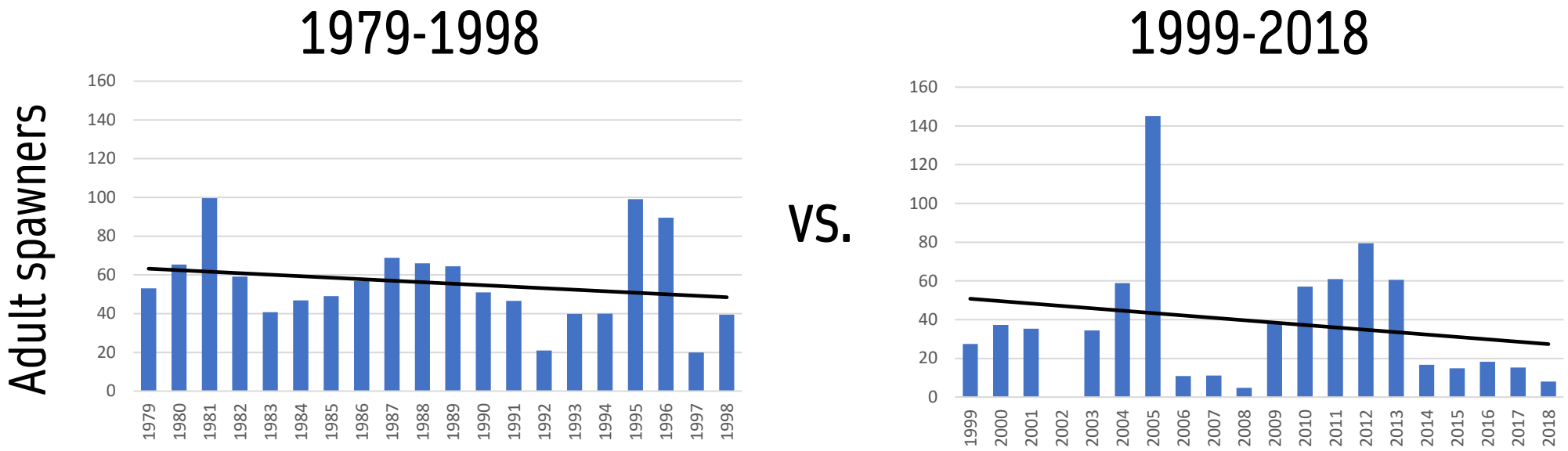
TheFrisc.com

Eggs on kelp

adfg.alaska.gov

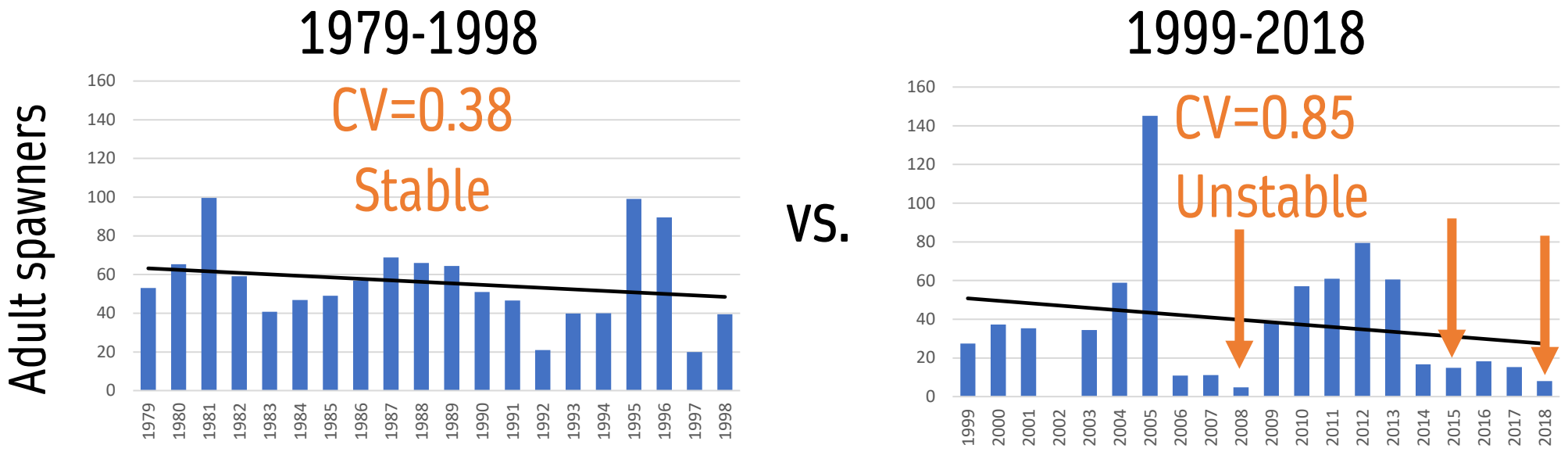
- Support commercial, recreational, and subsistence fisheries
- San Francisco Bay = largest spawning aggregation in the state

What is population stability?



Adult spawners declining and becoming more variable

What is population stability?



Record lows prompted commercial fishery closures

What guides fishery closure decisions as of 2019?

ELSEVIER

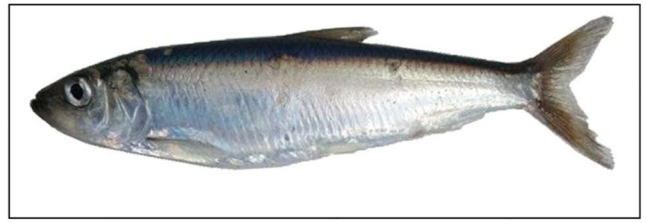
Fisheries Research

Volume 205, September 2018, Pages 141-148

Forecasting herring biomass using environmental and population parameters

William J. Sydeman, Marisol García-Reyes, Amber I. Szoboszlai, Sarah Ann Thompson, Julie A. Thayer

California Pacific Herring Fishery Management Plan



Pacific Herring, *Clupea pallasii*.

October, 2019

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

- Forecasting model for adult spawners
- Below threshold? CDFW proactively closes the fishery for the season

Forecasting model:
Adult spawners entering the estuary

Adults entering the estuary to spawn in wintertime (biomass)

=

Adults entering the estuary to spawn in wintertime (biomass)
One year prior

+

Ocean temperatures during the summer and fall prior to spawning season

+

Juveniles rearing in the estuary three years prior (abundance)

Forecasting model:
Adult spawners entering the estuary

=

+

Ocean temperatures during the summer and fall prior to spawning season

+

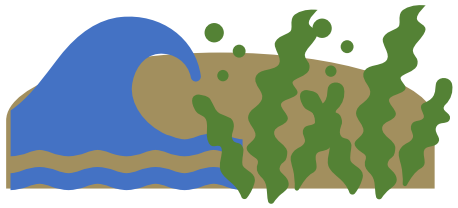
Adults entering the estuary to spawn in wintertime (biomass)

Adults entering the estuary to spawn in wintertime (biomass)
One year prior

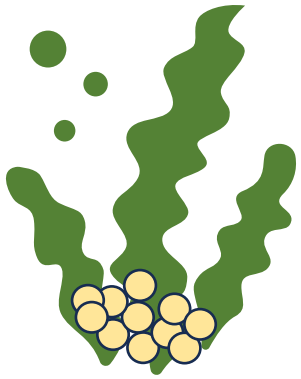
Juveniles rearing in the estuary three years prior (abundance)

What factors threaten population stability?

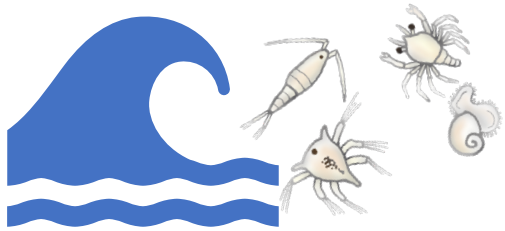
Rearing habitat loss



Spawning habitat loss



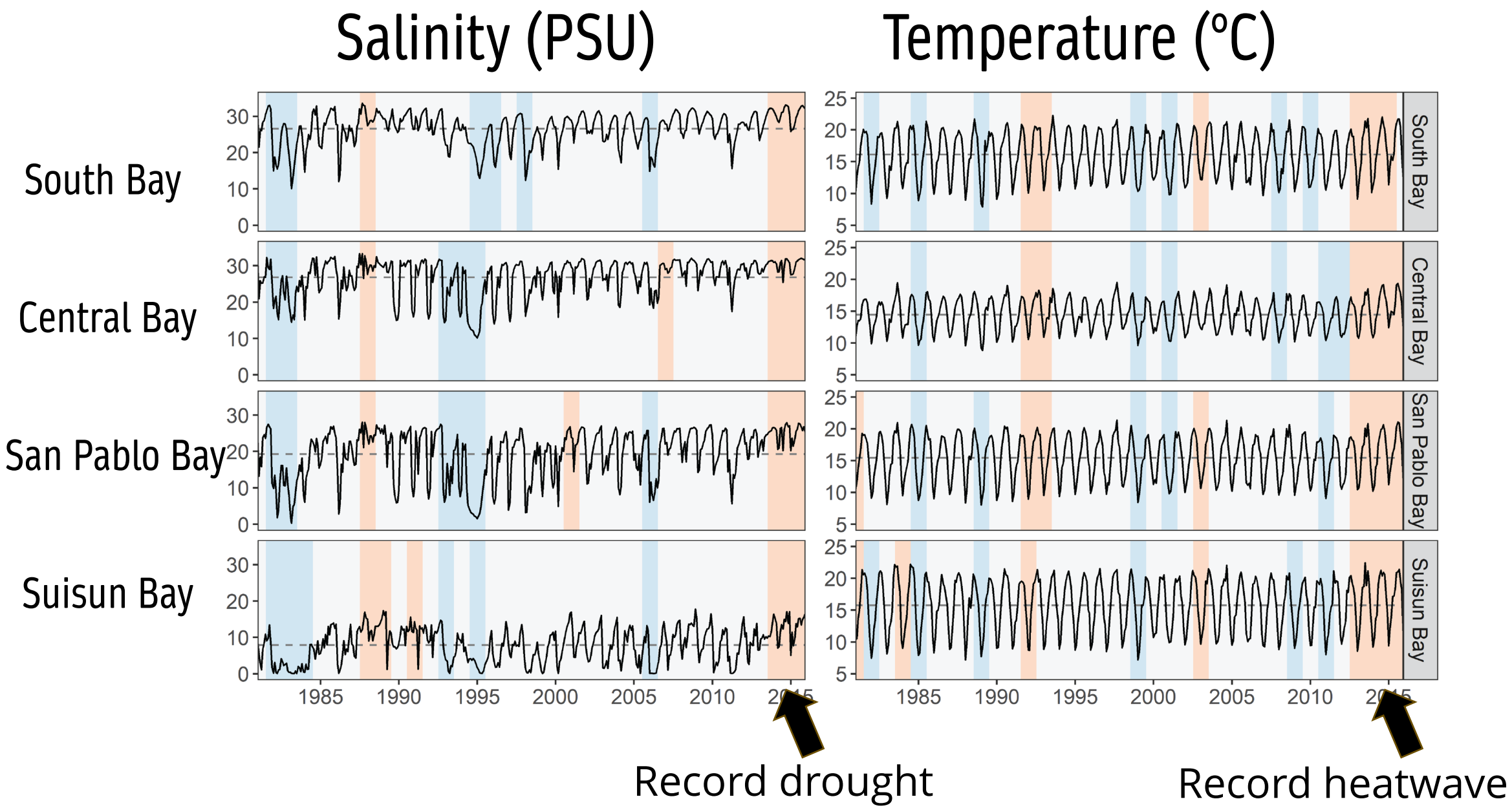
Upwelling frequency & duration



Marine heatwaves

Flood vs. drought

Low adult numbers


Salinity (PSU)
Temperature (°C)
South Bay
Central Bay
San Pablo Bay
Suisun Bay
30
20
10
0
25
15
5
1985
1990
1995
2000
2005
2010
Record drought
Record heatwave

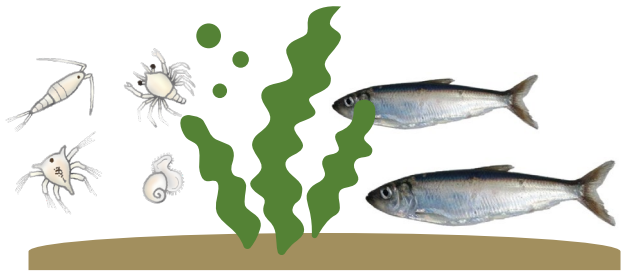
Conceptual model:
Juveniles rearing in the estuary

Juveniles rearing in the estuary in springtime (abundance)

=

Adults entering the estuary to spawn during the prior winter (biomass)

+



Competition for resources (density dependence)

+

Temperatures in the estuary

+

Salinities in the estuary

Synthesis in action:
2 different datasets 1981-2015

TABLE 1 Summary of long-term biological and environmental monitoring datasets used in candidate multivariate autoregressive state-space models.

Variable	Survey name	Gear type	Spatial extent	Period
Age-0 CPUE (mean)	CDFW SF Bay Study	Midwater trawl	S, C, SP, and SU	April–June
SSB Index	CDFW Herring Team	Egg deposition and spawner surveys	Estuary (S, C, and SP combined)	October–April
Mean salinity (PSU)	CDFW SF Bay Study	Water quality sonde: mean of surface and bottom profiles	S, C, SP, and SU	October–June
Mean temperature (°C)	CDFW SF Bay Study	Water quality sonde: mean of surface and bottom profiles	S, C, SP, and SU	October–June

Abbreviations: Variable: °C, degrees Celsius; CPUE, catch-per-unit-effort; PSU, practical salinity units; SSB, spawning stock biomass. Survey name: CDFW, California Department of Fish and Wildlife; SF Bay, San Francisco Bay. Spatial extent: C, Central Bay; S, South Bay; SP, San Pablo Bay; SU, Suisun Bay

Key findings #1:

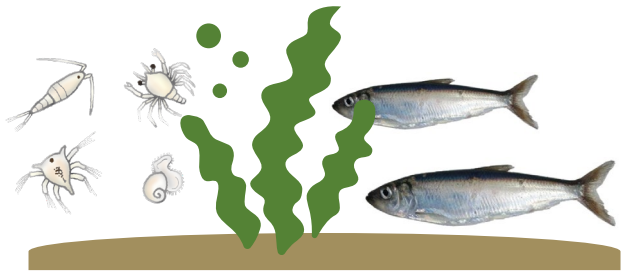
Juveniles rearing in the estuary in springtime (abundance)

=

Adults entering the estuary to spawn during the prior fall (biomass)

X

+



Competition for resources (density dependence)

+

Temperatures in the estuary

+

Salinities in the estuary

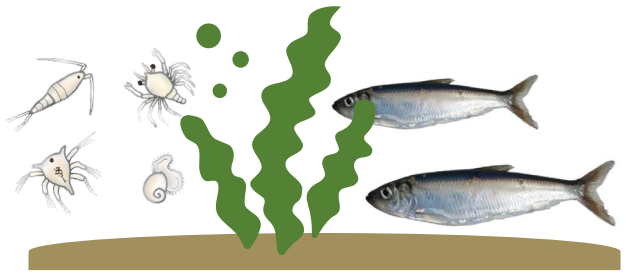
Key findings #1:

Juveniles rearing in the estuary in springtime (abundance)

=

Adults entering the estuary to spawn during the prior fall (biomass)

+



Competition for resources (density dependence)

+

Temperature in the estuary

+

Salinities in the estuary

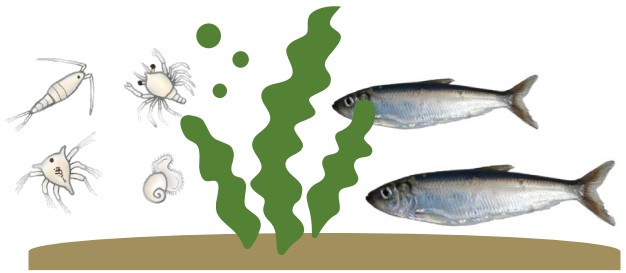
Key findings #1:

Juveniles rearing in the estuary in springtime (abundance)

=

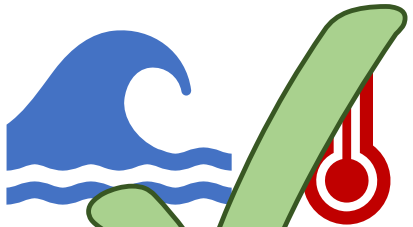
Adults entering the estuary to spawn during the prior fall (biomass)

+



Competition for resources (density dependence)

+



Temperature in the estuary

+

Salinities in the estuary

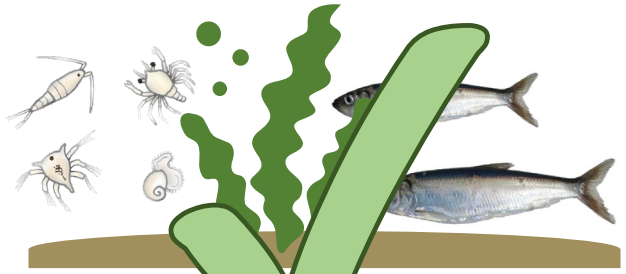
Key findings #1:

Juveniles rearing in the estuary in springtime (abundance)

=

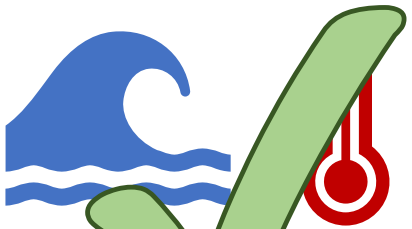
Adults ente[illegible]e estuary to spawn [illegible] prior fall (biomass)

+



Competit[illegible] resources (density dependence)

+



Temperat[illegible]n the estuary

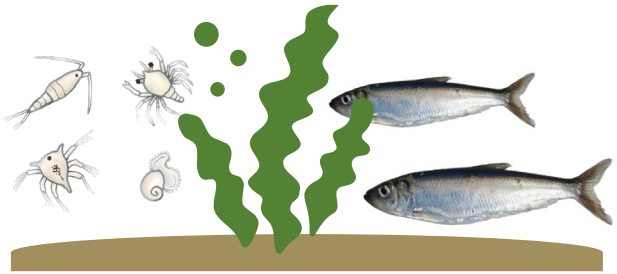
+

Salinitie[illegible]the estuary

Key findings #1:

Cooler water

Saltier water

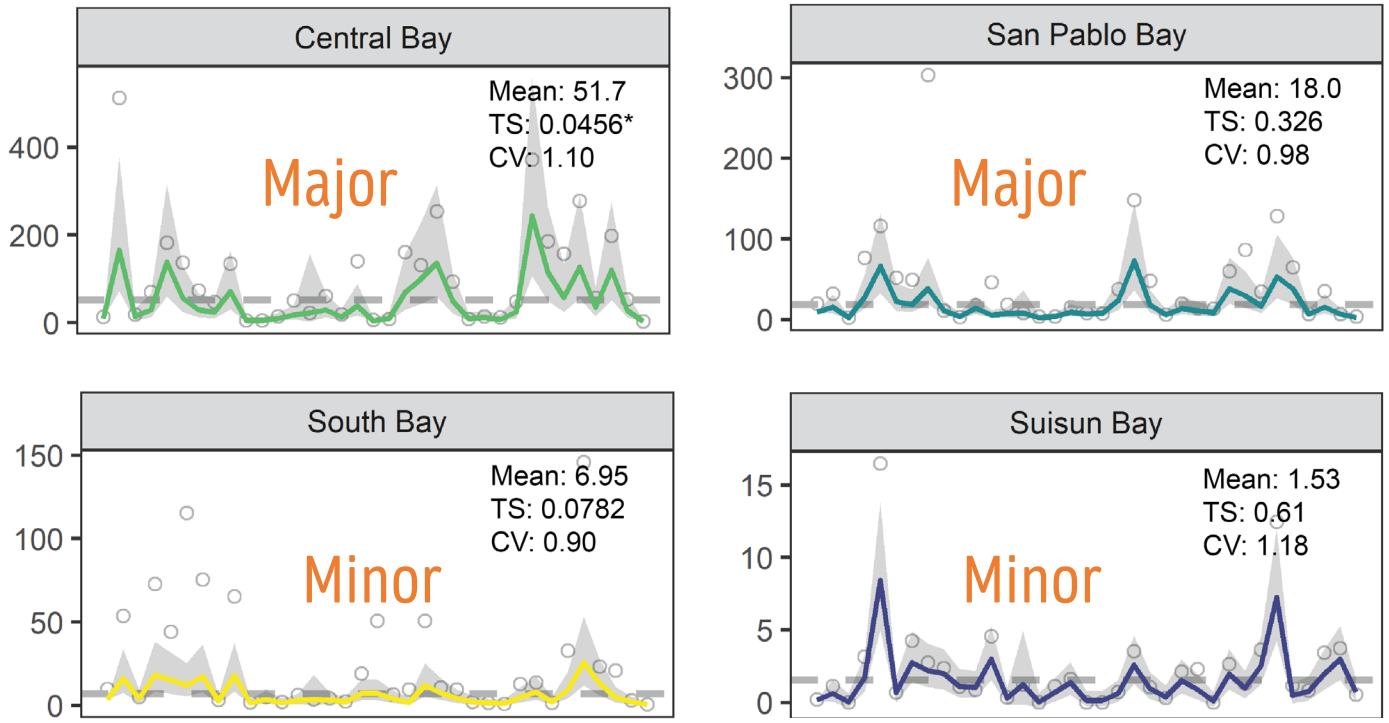


Density dependence

- Juvenile herring generally associated with cool, salty waters
- Strongly density dependent = scarcity of resources (competition for food, cover) limited population growth

Key findings #2:

- Central and San Pablo bays were major contributors to population
- The population was 15% more stable than in individual regions
- Unique regional variation conferred stability



Management implication #1:

Boost juvenile production in the estuary to prevent fishery closures

Ocean temperatures during the summer and fall prior to spawning season

=

+

+

Adults entering the estuary to spawn in wintertime (biomass)

Adults entering the estuary to spawn in wintertime (biomass)
One year prior

Juveniles rearing in the estuary three years prior (abundance)


Management implication #2:
Improve rearing conditions via habitat restoration
(eelgrass meadows, tidal marsh)
© SFEI BEHGU 2015

Management implication #3:

Mitigate marine heatwave effects– topic needs more attention

Adults entering the estuary to spawn in wintertime (biomass)

Ocean temperatures during the summer and fall prior to spawning season

Juveniles rearing in the estuary three years prior (abundance)

Temperatures in the estuary

Warm off the press…

Received: 9 December 2022 | Accepted: 13 December 2022

DOI: 10.1002/ecs2.4440

ECOSPHERE
AN ESA OPEN ACCESS JOURNAL

ARTICLE

Coastal and Marine Ecology

Disentangling abiotic and biotic controls of age-0 Pacific herring population stability across the San Francisco Estuary

Nina Pak[1] | Denise D. Colombano[1] | Thomas Greiner[2] | James A. Hobbs[3,4] | Stephanie M. Carlson[1] | Albert Ruhi[1]

https://doi.org/10.1002/ecs2.4440

Where can I read these papers and access their data products?

Food web study

Herring study

Email me Denise.Colombano@DeltaCouncil.Ca.Gov

“Our ability to produce specific analytical information for local problems that can also address questions at larger spatial scales and over longer time frames depends on our willingness to work collaboratively to collect, preserve, and share our data across projects, locations, and research groups.”

- Hampton et al. 2013, “Big data and the future of ecology”

Thank you

Connect with us

Scan the QR code to subscribe to our email announcements

Deltacouncil.ca.gov

@DeltaCouncil

@deltastewardshipcouncil

Delta Stewardship Council

@deltastewardshipcouncil