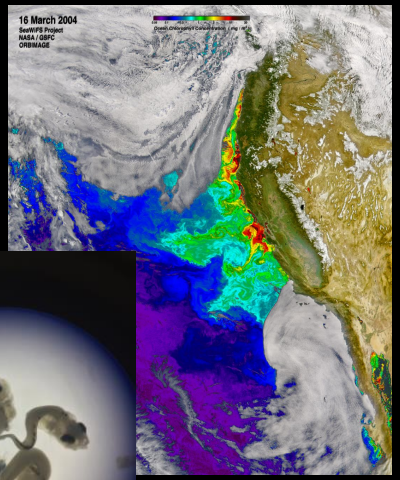
Dispersal strategies of larval fishes in the central California Current: Implications for recruitment resilience under climate change



Helen Killeen[1,2], Steven Morgan[2], David Gold[3], & John Largier[2]

[1]California Department of Fish & Wildlife;

[2]Coastal Marine Sciences Institute, University of California, Davis;

[2]Department of Earth and Planetary Sciences, Univ. of Calif., Davis

PICES Annual Meeting | Yokohama, Japan | November 2025

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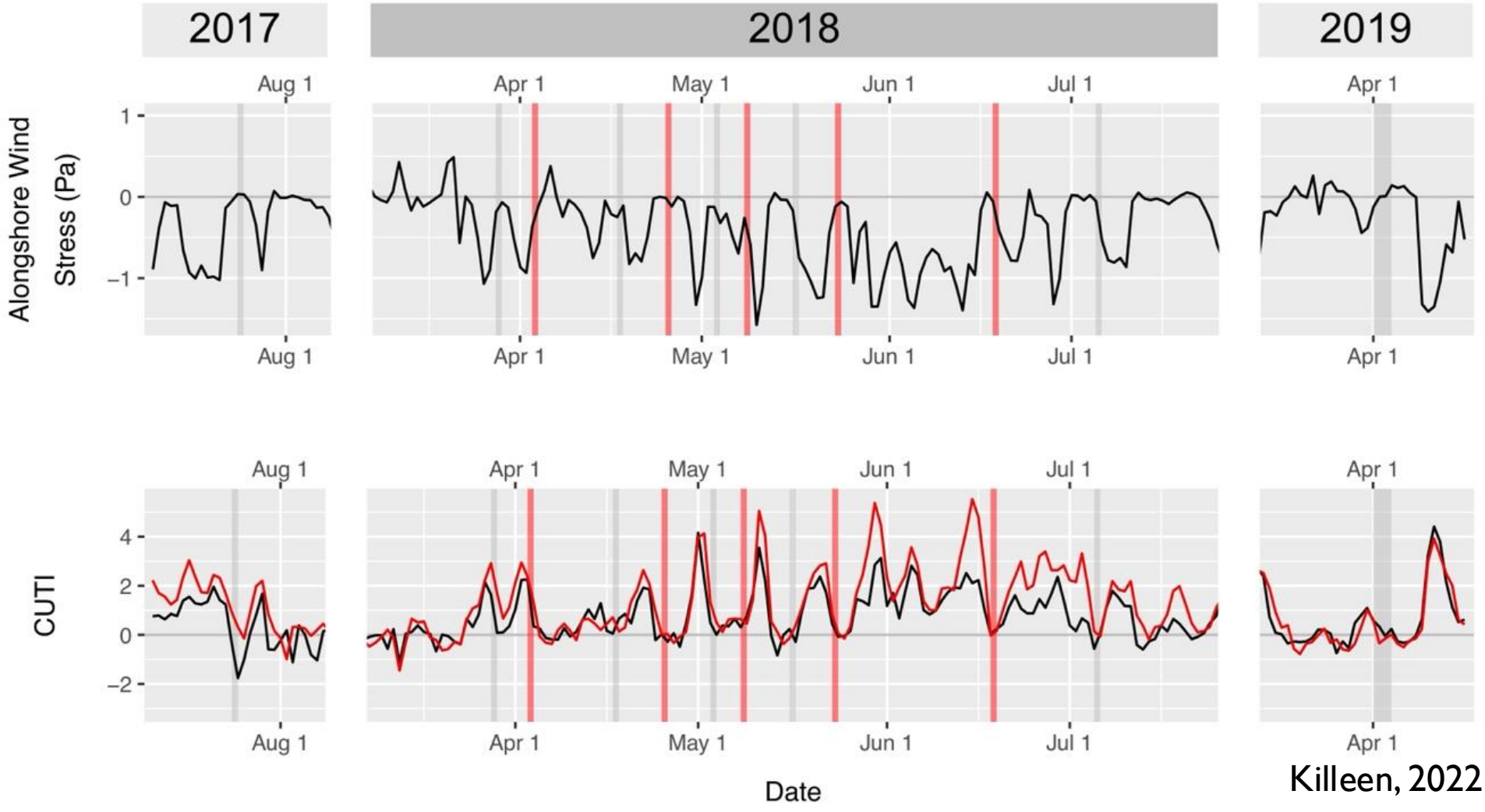
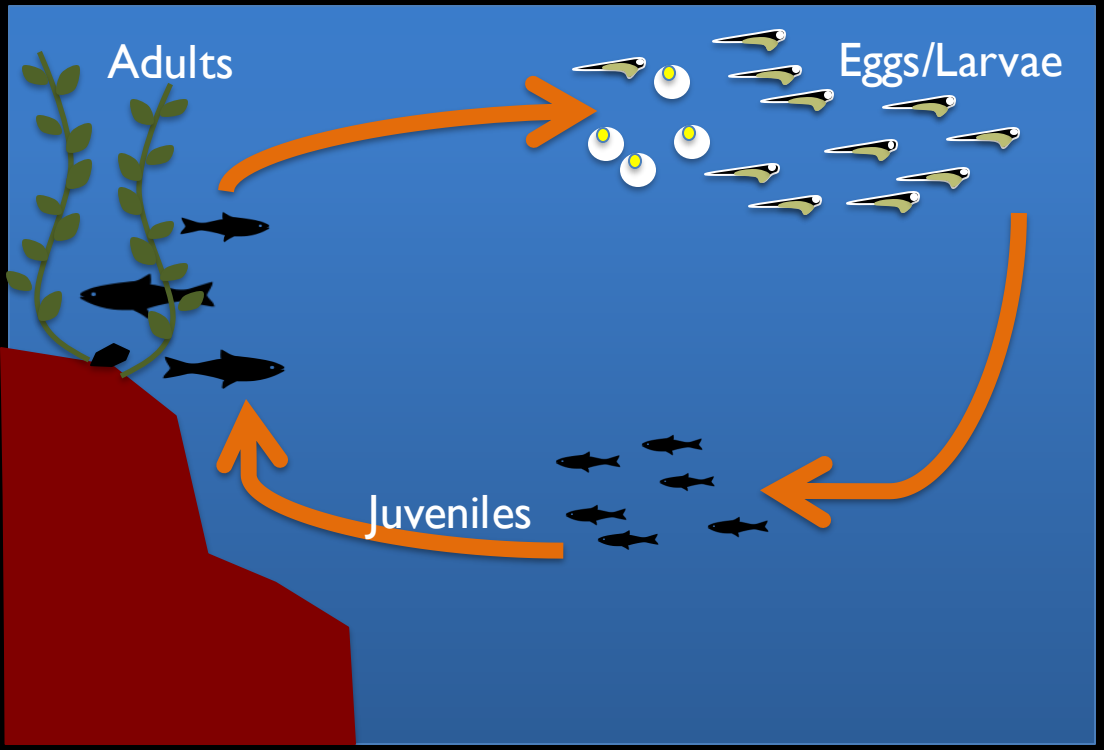
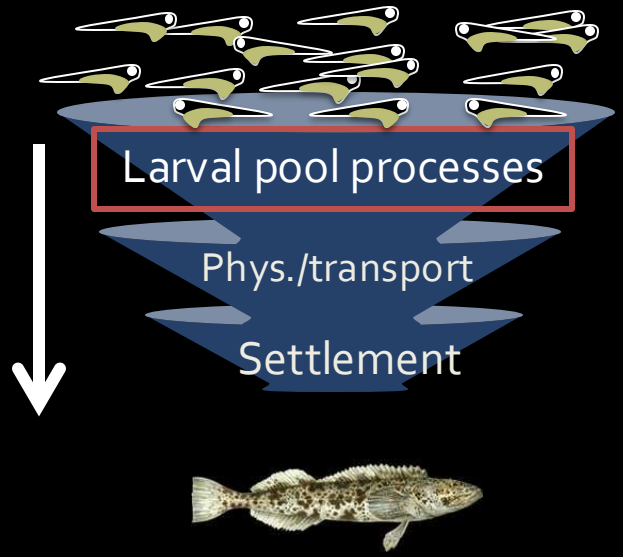
Erick Morales Oyola



Killeen, 2022

Larval dispersal is a primary contributor to population connectivity





Based on figure from Piñeda, 2000

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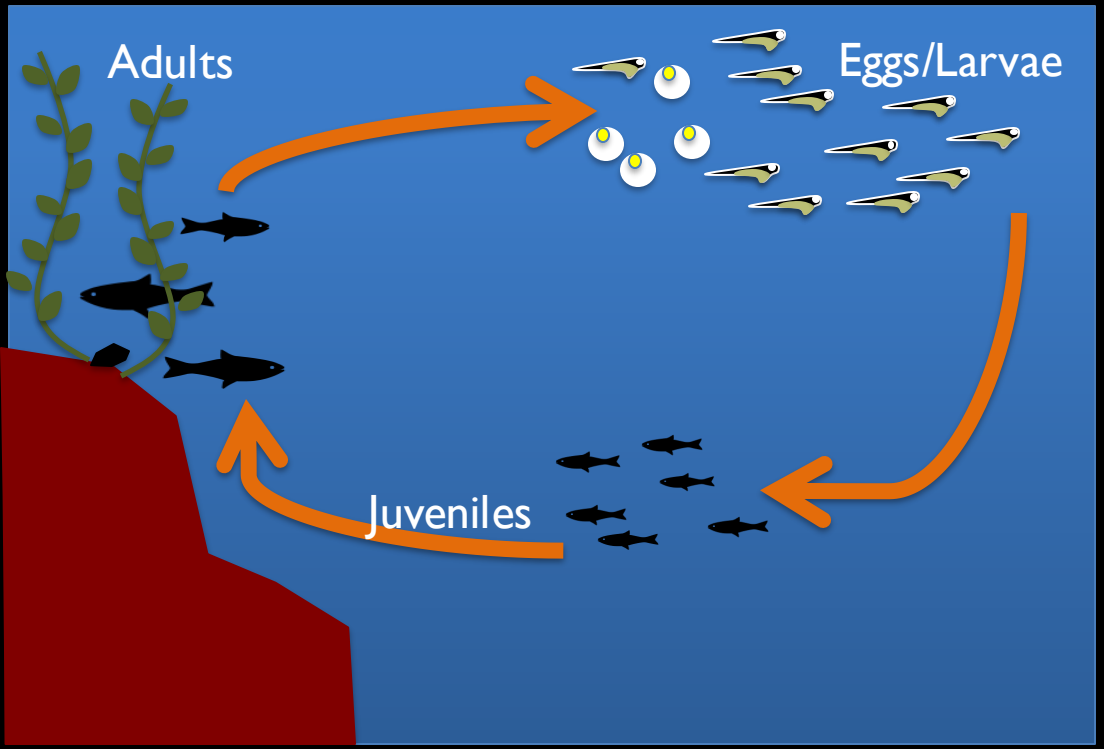
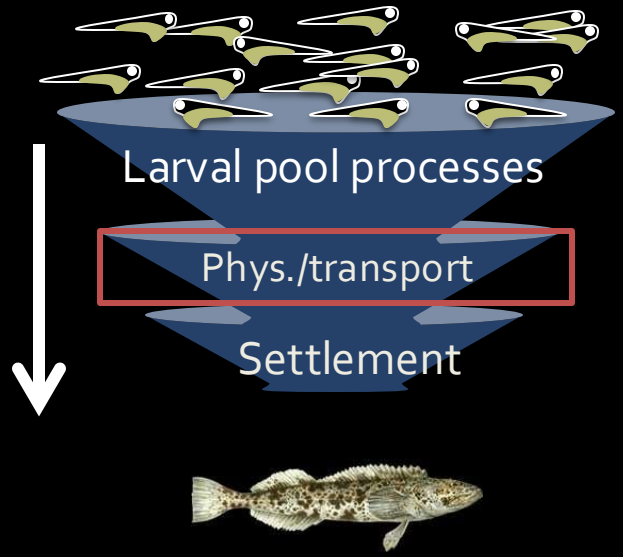
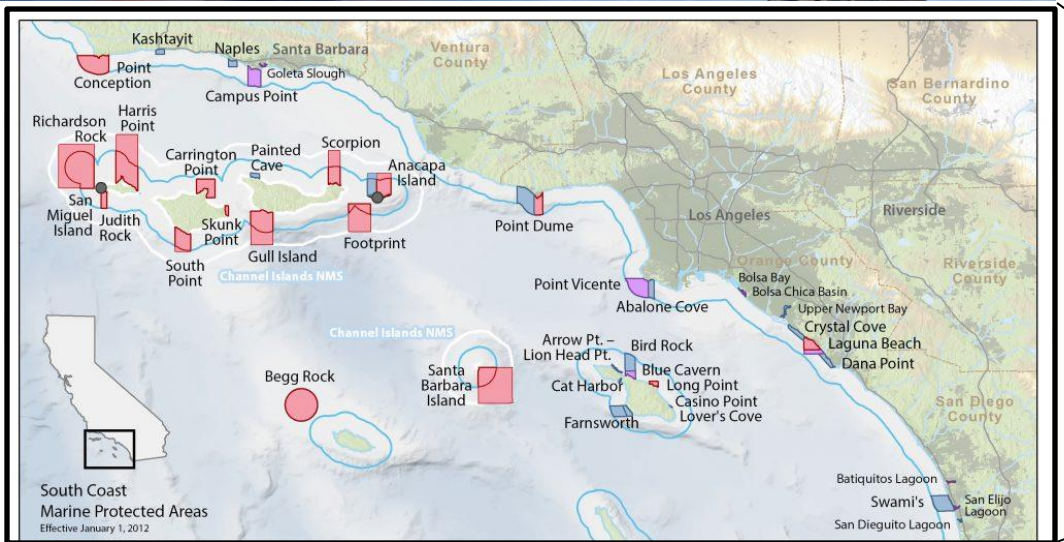


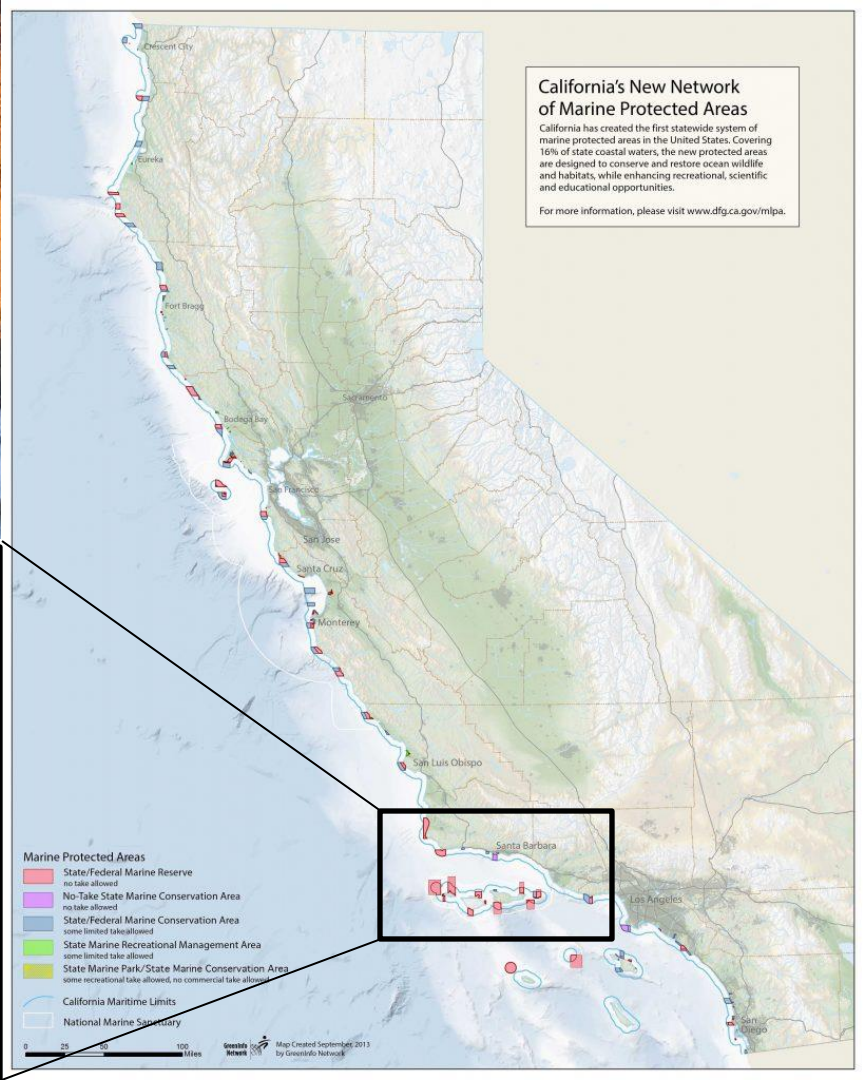


Based on figure from Piñeda, 2000

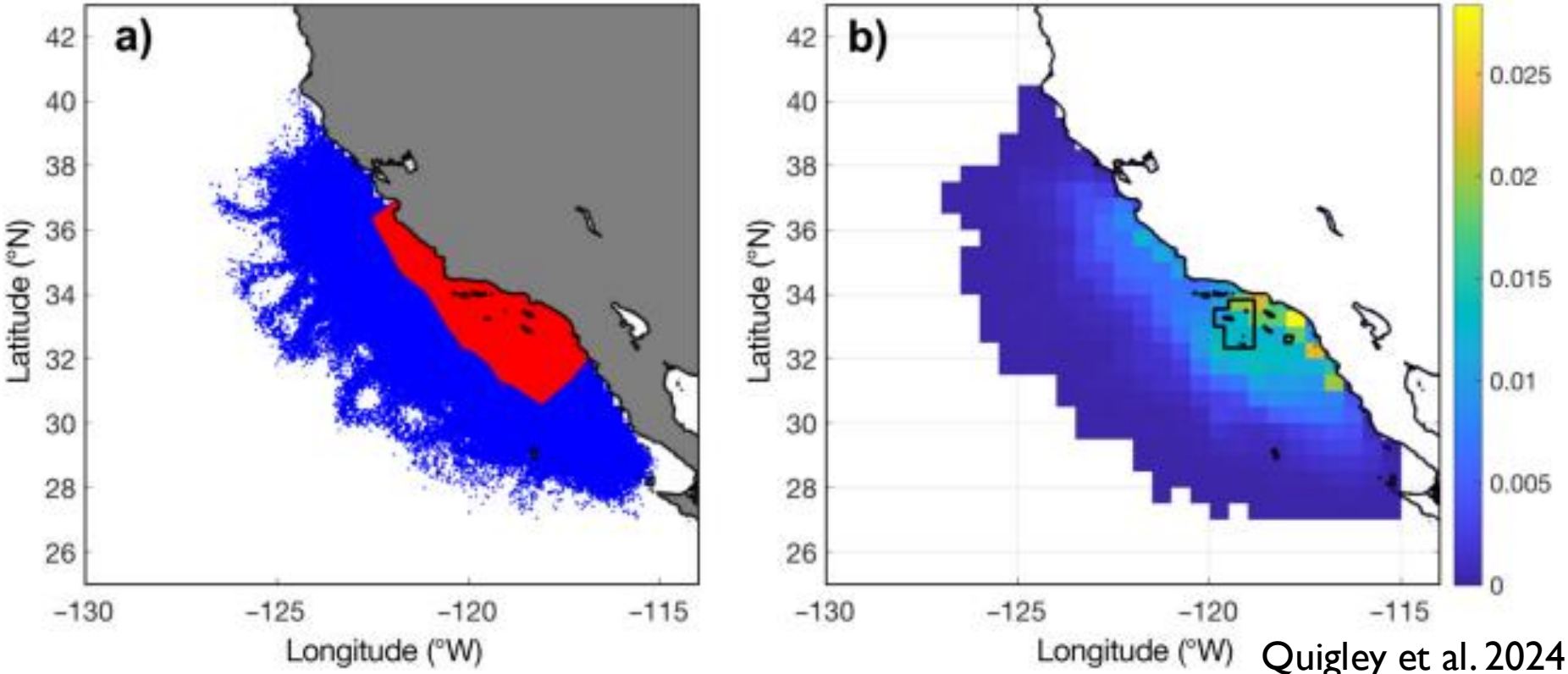

Artwork by Zoe Farmer


IUCN


Kashtayit
Naples
Santa Barbara
Point Conception
Goleta Slough
Campus Point
Ventura County
Los Angeles County
San Bernardino County
Richardson Rock
Harris Point
Carrington Point
Painted Cave
Scorpion
Anacapa Island
San Miguel Island
Judith Rock
Skunk Point
Gull Island
Footprint
South Point
Channel Islands NMS
Point Dume
Los Angeles
Riverside
Orange County
Riverside County
Point Vicente
Abalone Cove
Bolsa Bay
Bolsa Chica Basin
Upper Newport Bay
Crystal Cove
Laguna Beach
Dana Point
Channel Islands NMS
Arrow Pt. – Lion Head Pt.
Bird Rock
Blue Cavern
Long Point
Casino Point
Lover's Cove
Cat Harbor
Farnsworth
Begg Rock
Santa Barbara Island
San Diego County
Batiquitos Lagoon
Swami's
San Elijo Lagoon
San Dieguito Lagoon
South Coast
Marine Protected Areas
Effective January 1, 2012

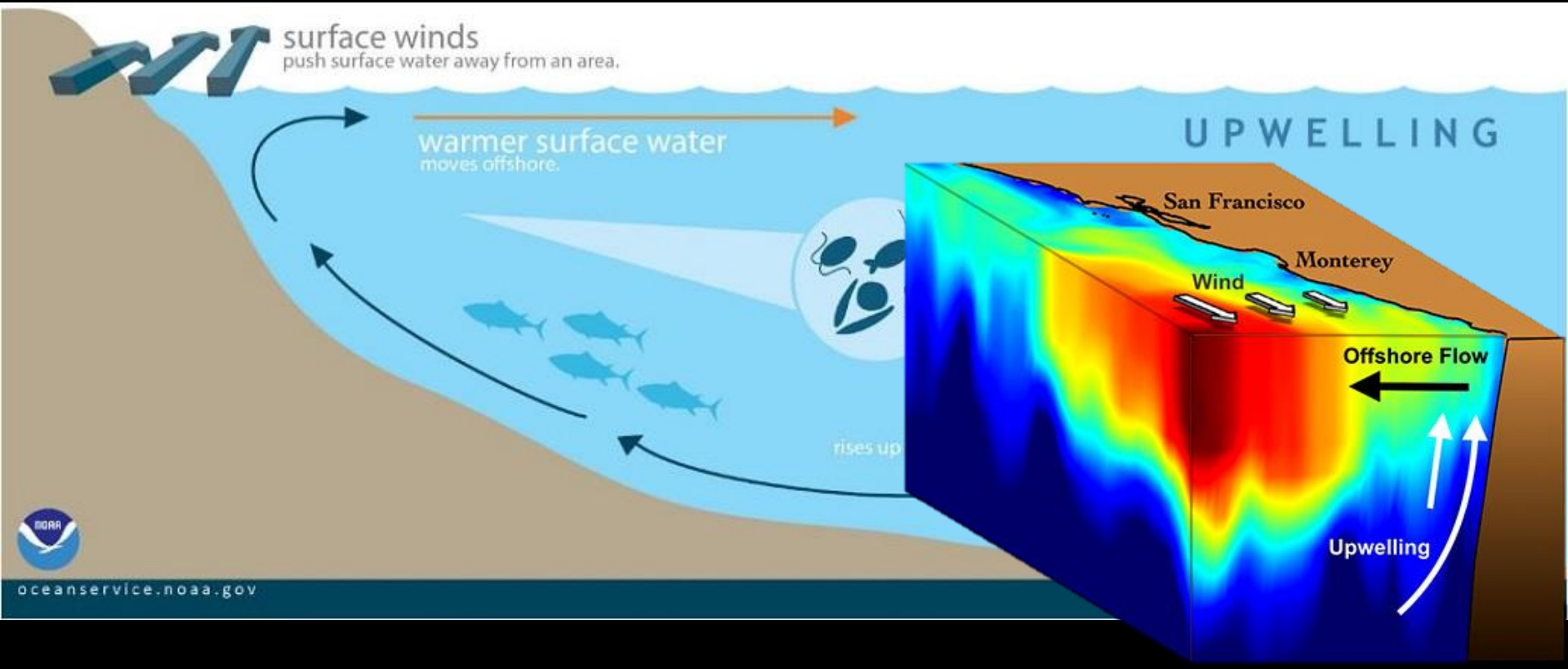

California's New Network
of Marine Protected Areas
California has created the first statewide system of marine protected areas in the United States. Covering 16% of state coastal waters, the new protected areas are designed to conserve and restore ocean wildlife and habitats, while enhancing recreational, scientific and educational opportunities.
For more information, please visit www.dfg.ca.gov/mlpa.
Crescent City
Eureka
Fort Bragg
Sacramento
Bodega Bay
San Francisco
San Jose
Santa Cruz
Monterey
San Luis Obispo
Santa Barbara
Los Angeles
San Diego
Marine Protected Areas
State/Federal Marine Reserve
no take allowed
No-Take State Marine Conservation Area
no take allowed
State/Federal Marine Conservation Area
some limited take allowed
State Marine Recreational Management Area
some limited take allowed
State Marine Park/State Marine Conservation Area
some recreational take allowed, no commercial take allowed
California Maritime Limits
National Marine Sanctuary
0 25 50 100 Miles
Map Created September 2013
by GreenInfo Network

Dispersal is often estimated using advection diffusion models with depth integrated flow fields

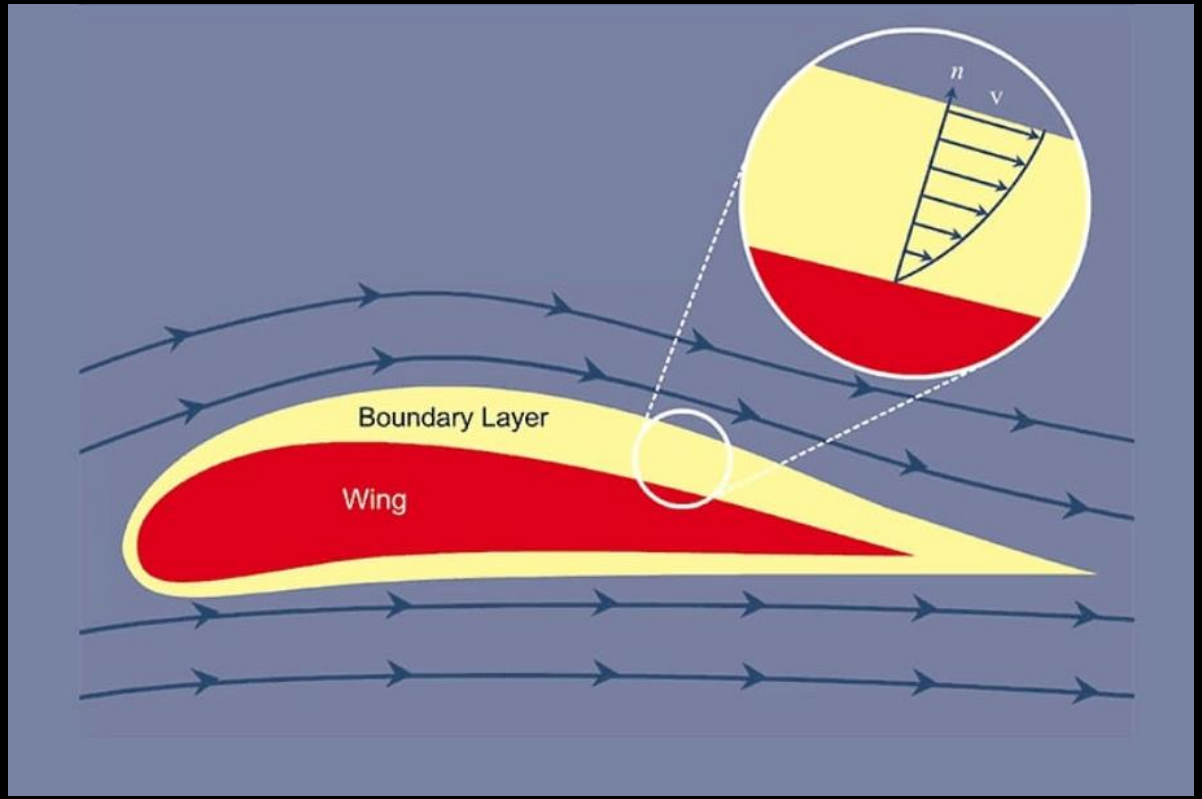


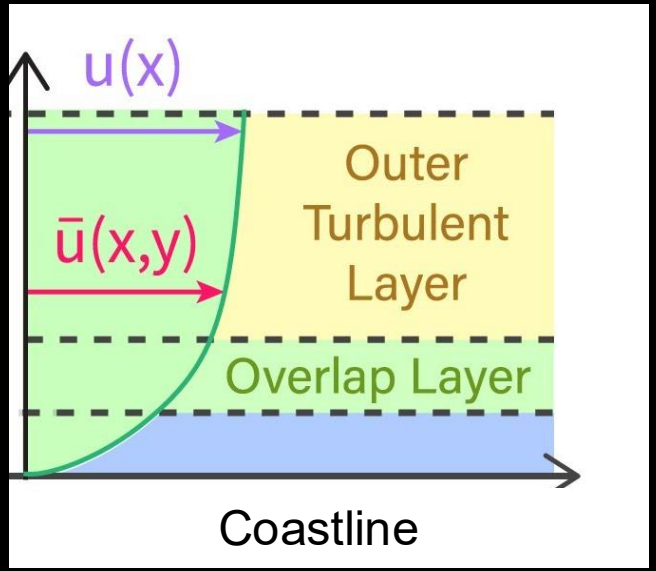
Quigley et al. 2024

Upwelling creates layered, opposing cross-shore currents with net offshore, equatorward flow at the surface



A nearshore (~6 km) coastal boundary layer creates reduced alongshore and cross-shore flow





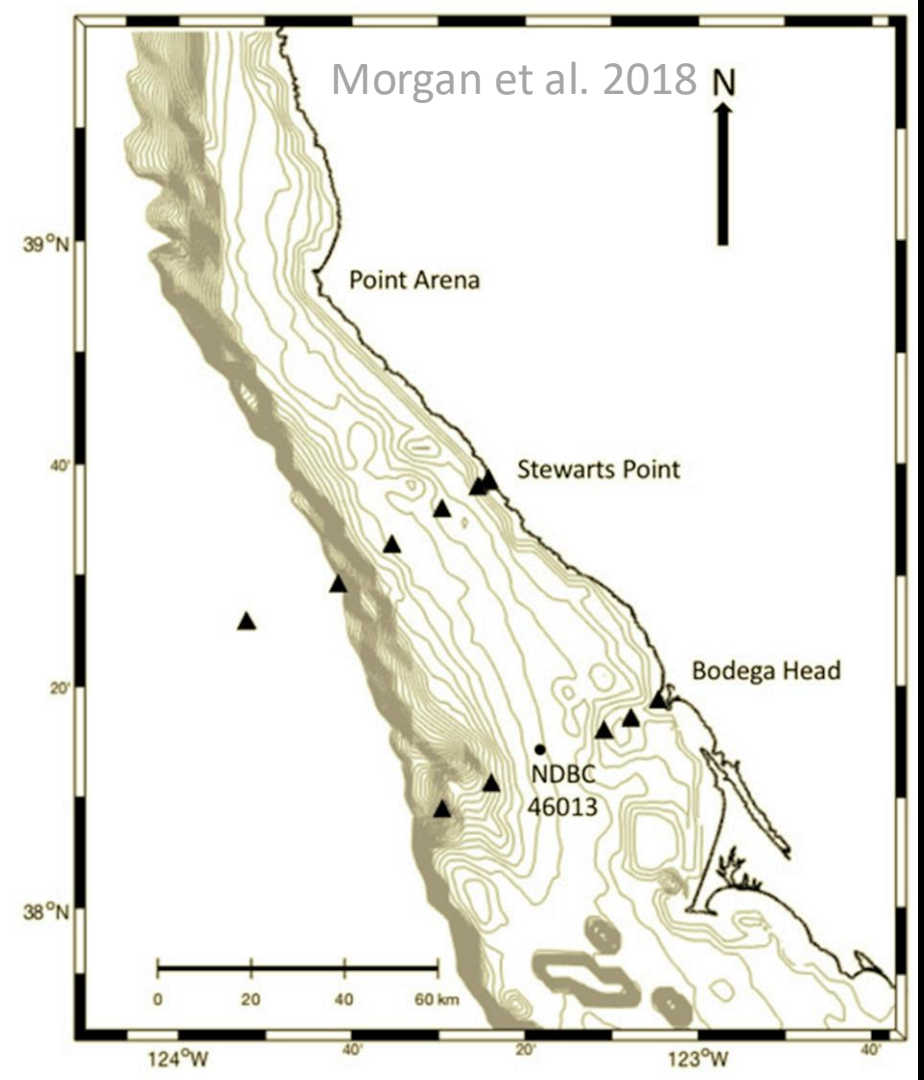
Invertebrate larvae are known to exploit flow structures in upwelling systems to control transport

Do fish larvae exhibit such behaviors?

Where do larval fishes occur?

Do nearshore larval fish exhibit depth preferences?

If so, what does this mean for management and conservation?



Methods

- 9 cross shelf cruises
- 2 transects

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- 2 transects
- 5 stations, 4 depths
- Mar-July 2018

Depths sampled:

- Neuston (top 0.5 m)
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- Bottom (to 100 m)


Photo: Bodega Marine Lab

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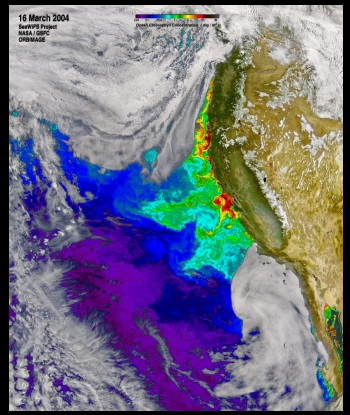
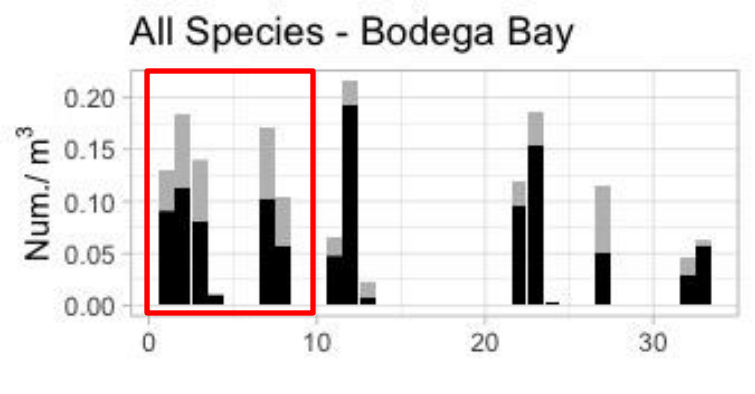


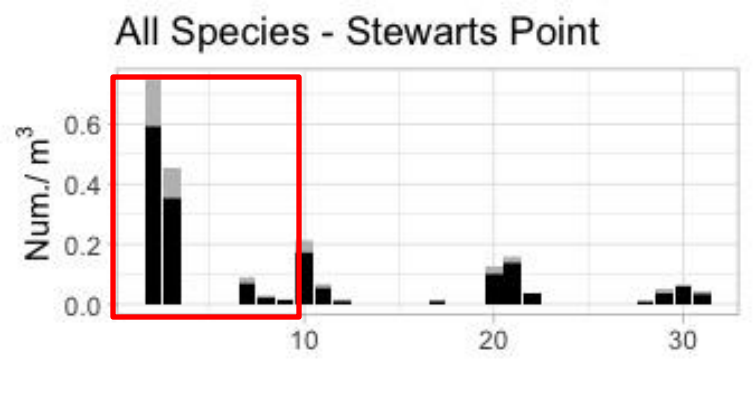


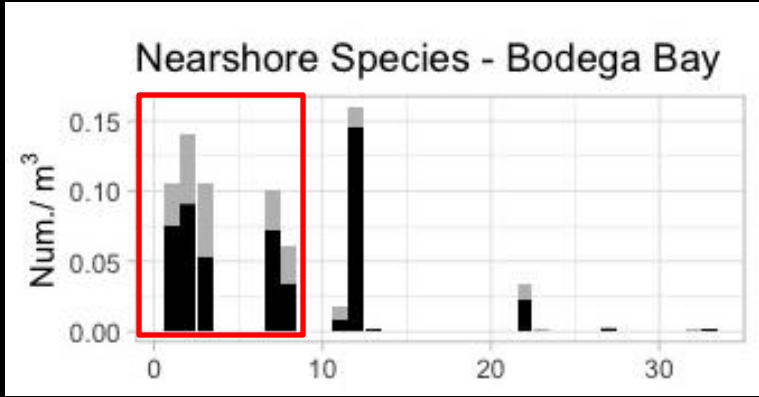
Nearshore	Mid-Shelf	Offshore
Lingcod Ophiodon elongatus	**Pacific sanddab** Citharichthys sordidus	**Pacific Hake** Merluccius productus
California halibut Paralichthys californicus	**Dwarf wrymouth** Cryptacanthodes aleutensis	**Dover sole** Microstomus pacificus
English sole Parophrys vetulus	**Petrale sole** Eopsetta jordani	**Pacific sardine** Sardinops sagax
Monkeyface prickleback Cebidichthys violaceous	**Slipskin snailfish** Liparis fucensis	**Arrowtooth flounder** Atheresthes stomias
Scalyhead sculpin Artedius harringtoni	**Pygmy poacher** Odontopyxis trispinosa	**Slender blacksmelt** Bathylagus ochotensis

1. Where do larval fishes occur?

1. Highest larval fish densities are on the inner shelf



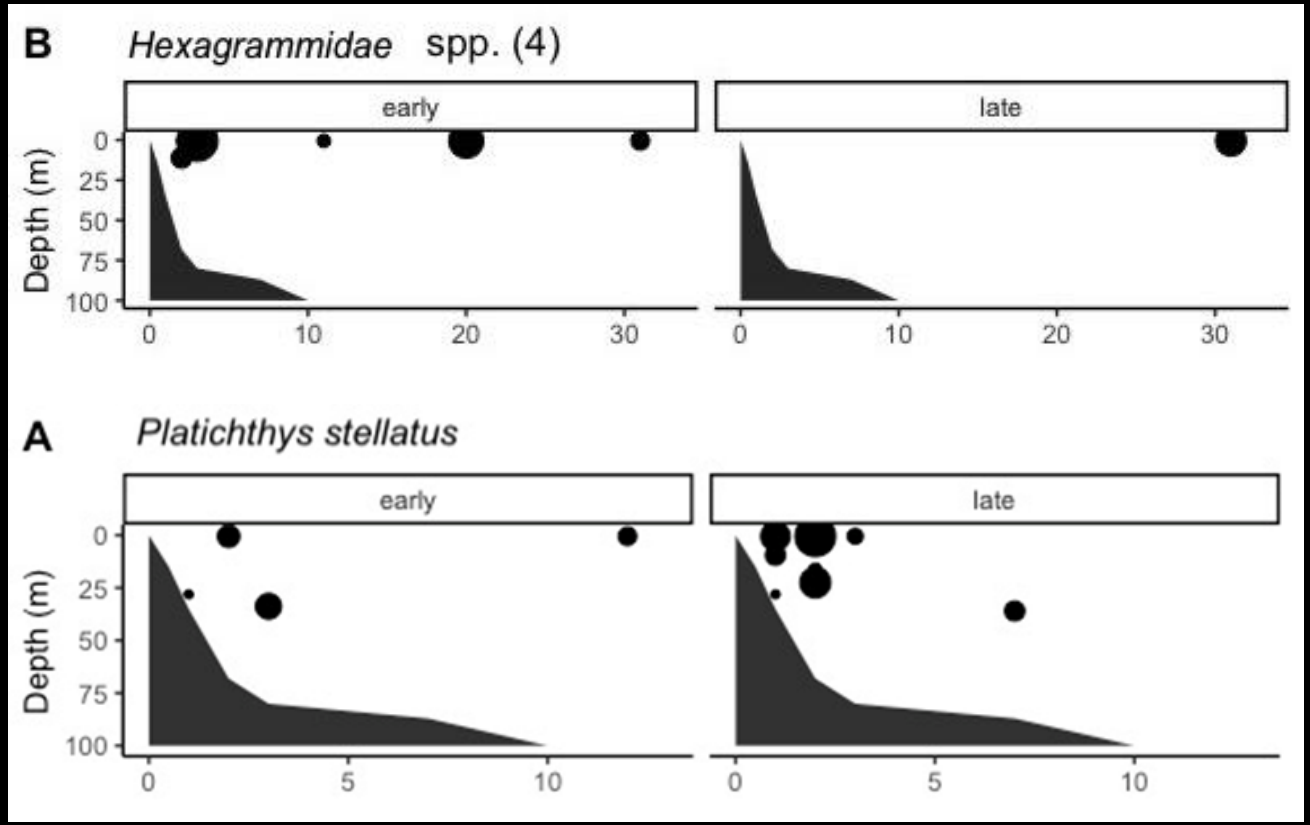




Killeen, 2022

2. Do nearshore larval fish exhibit depth preferences?

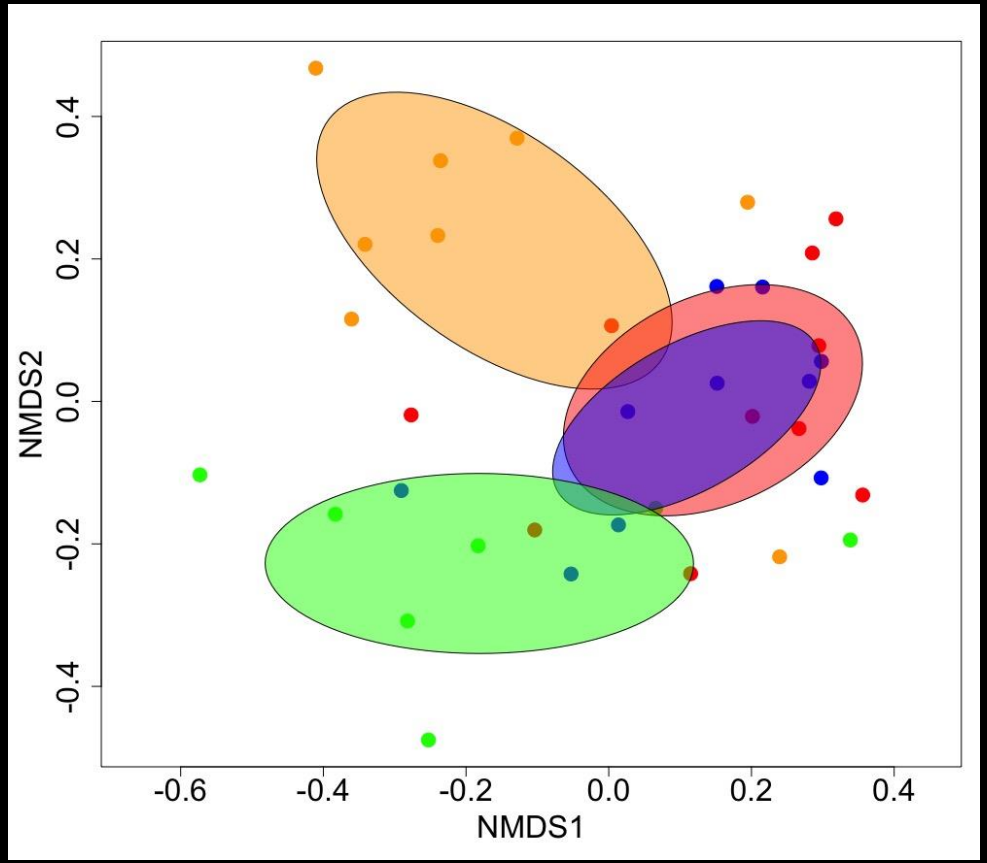
Some species show consistent preferences



Killeen, 2022

2. Nearshore larval fish communities vary strongly by depth

ANOSIM
$R^2 = 0.38$
$p = 0.01$



Sampling depth
- Neuston
- Top
- Middle
- Bottom

Killeen, 2022

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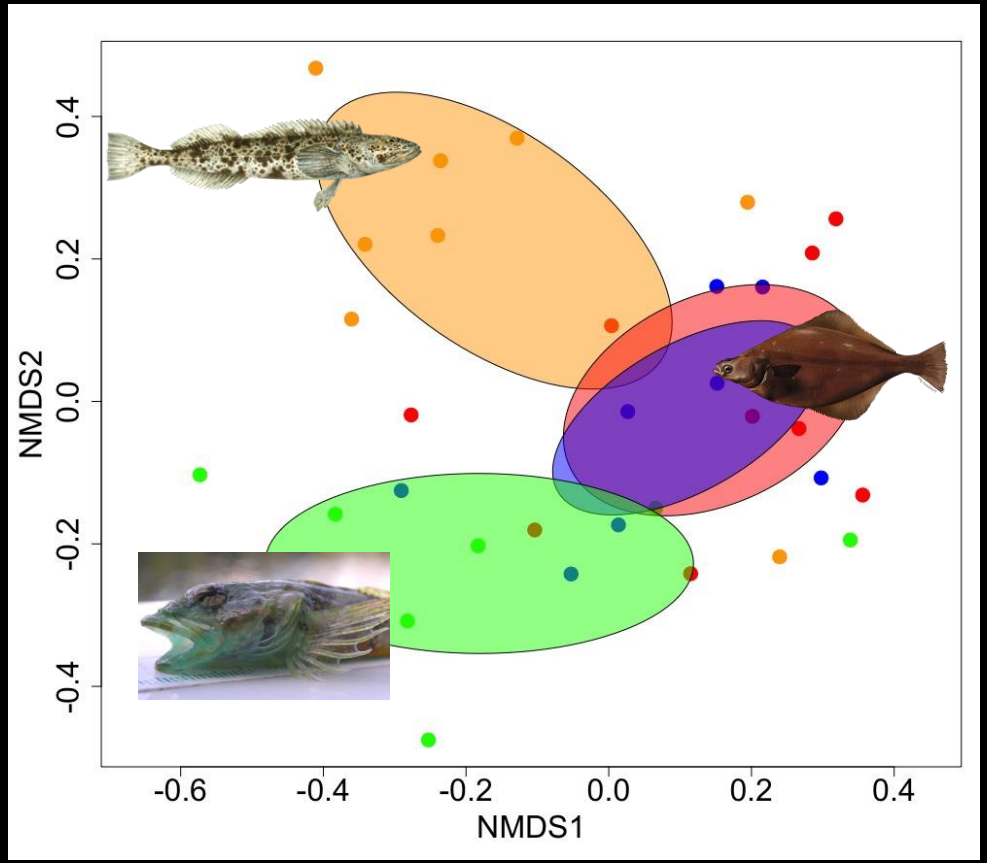

Sampling depth
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- Top
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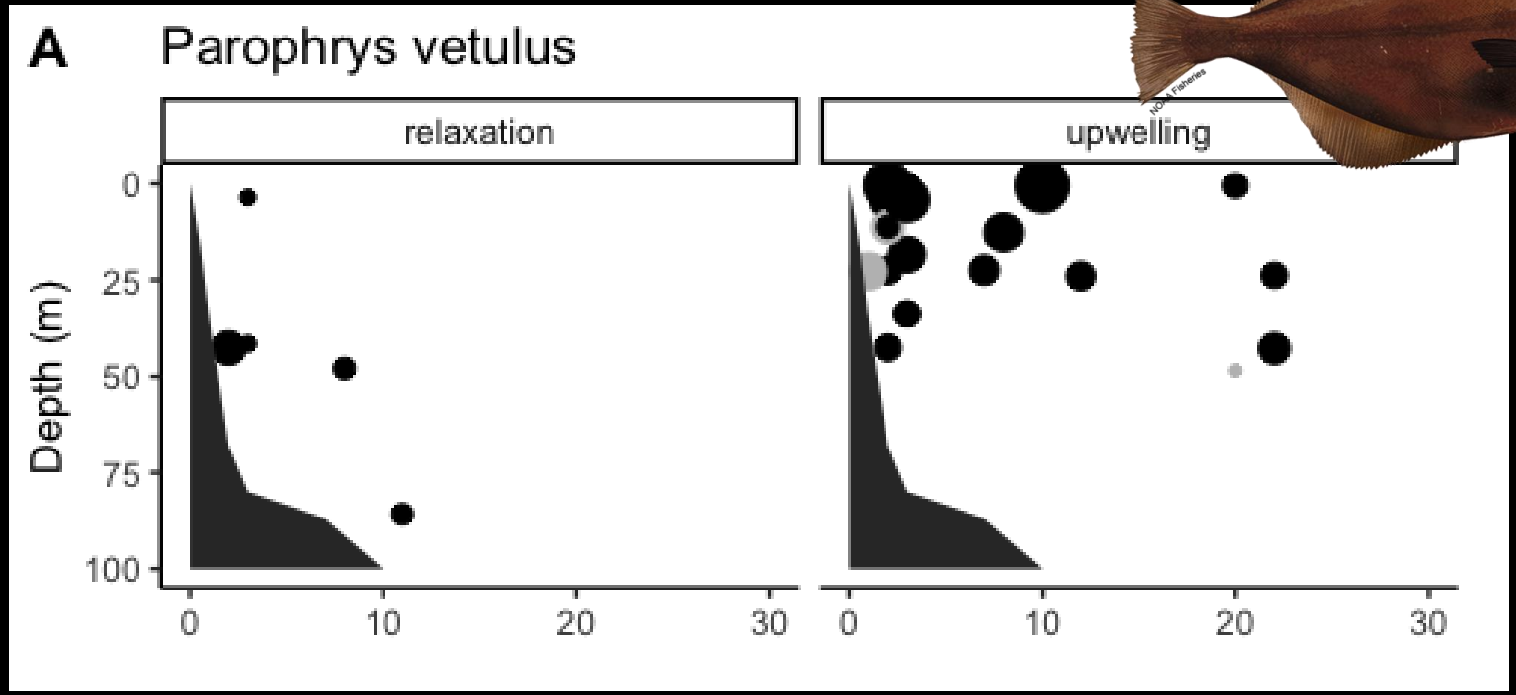
- Bottom

Killeen, 2022

Some species distributions are linked to upwelling state



Killeen, 2022

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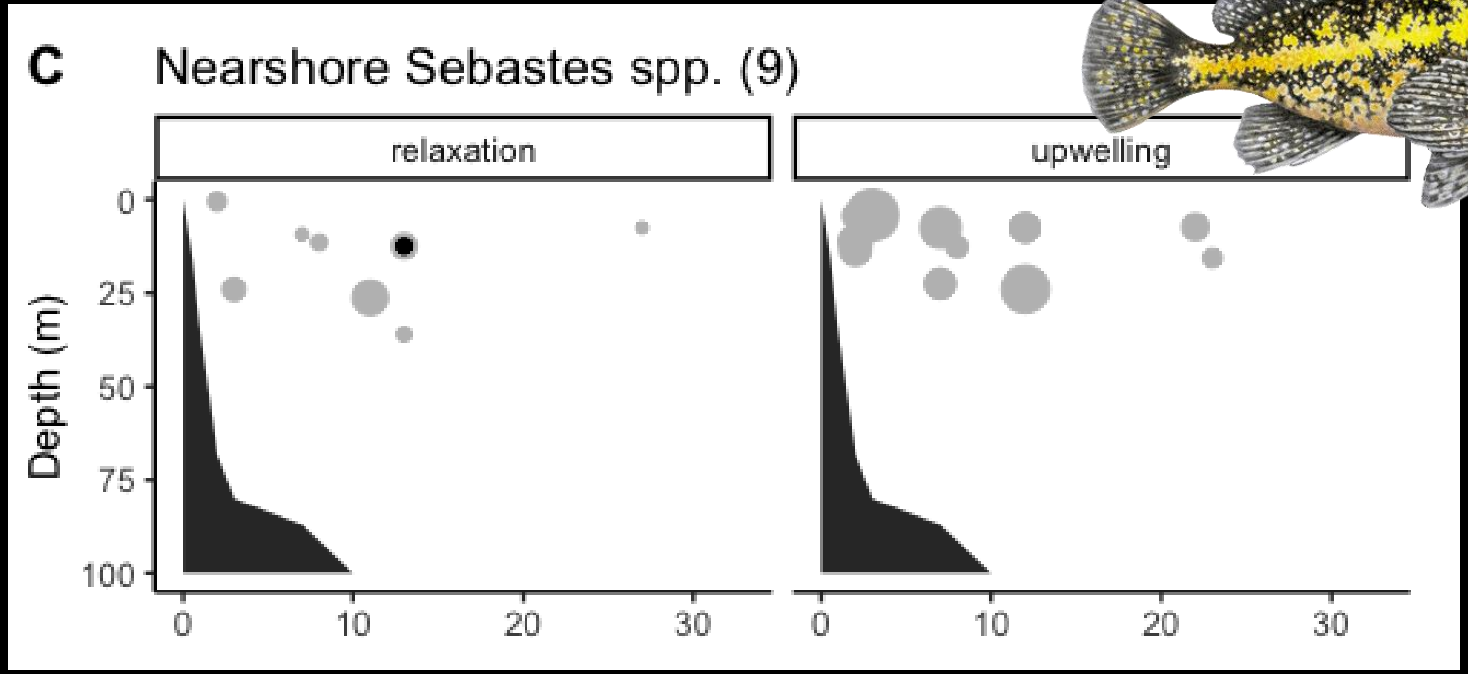
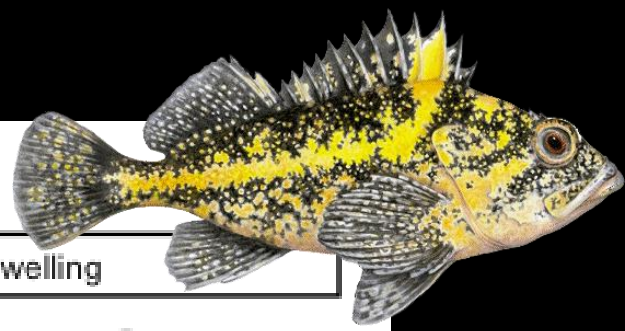
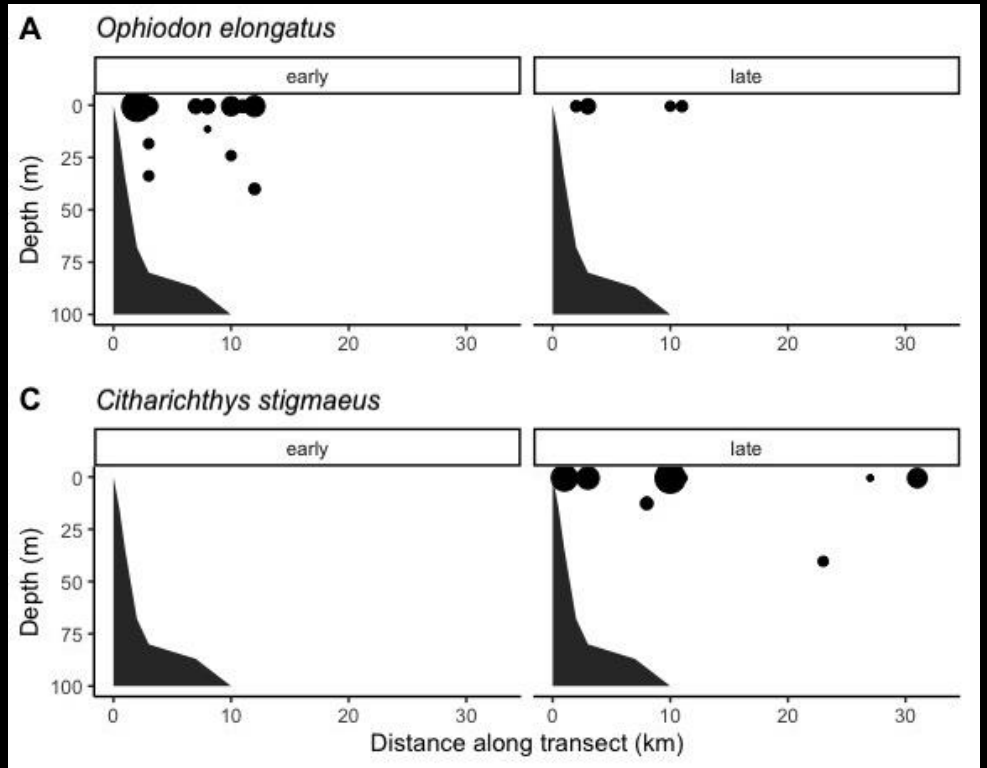




Killeen et al. *in prep*

Some species change distribution throughout development



Killeen, 2022

3. What does this mean for management and conservation?

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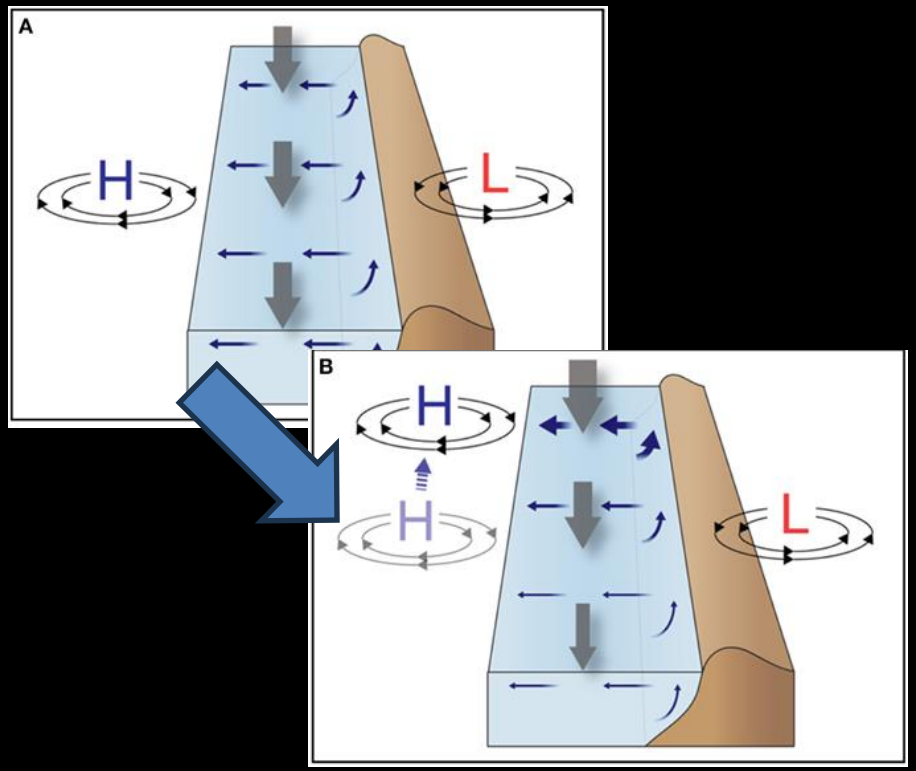
- We need better descriptions of the basic ecology of early life history stages
- Minimize taxonomic generalization
- Numerical dispersal models should include larval behavior
  - Spatial approaches to conservation
  - Biophysical modeling approaches to determine future connectivity

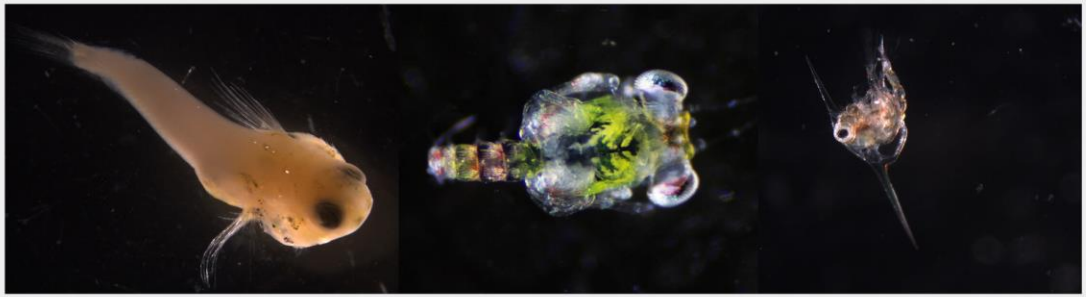
3. What does this mean for management and conservation?

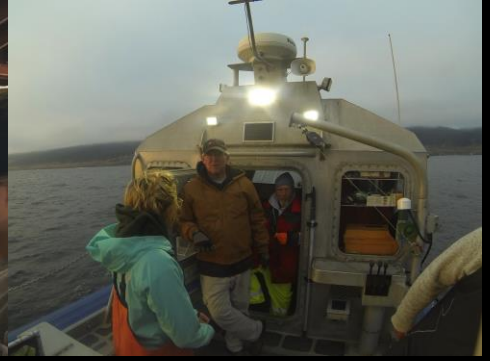
- Changes in oceanographic currents may alter dispersal trajectories, but not in simple ways
- Environmentally- and ontogenetically cued behaviors are potentially sensitive to climate-driven changes, selection pressure
- Local retention of recruits could influence
  - Climate refugia
  - Protected area network effects



García-Reyes et al. 2015

Steven Morgan





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Thanks!

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