Effects of seasonal variation in oceanography on invertebrate larval assemblages in the upwelling system of northern Monterey Bay, California, USA

Erin V. Satterthwaite[1]

Steven Morgan[1], John Ryan[2], Julio Harvey[2], Robert Vrijenhoek[2]

[1]Bodega Marine Laboratory, University of California, Davis

[2]Monterey Bay Aquarium Research Institute (MBARI)

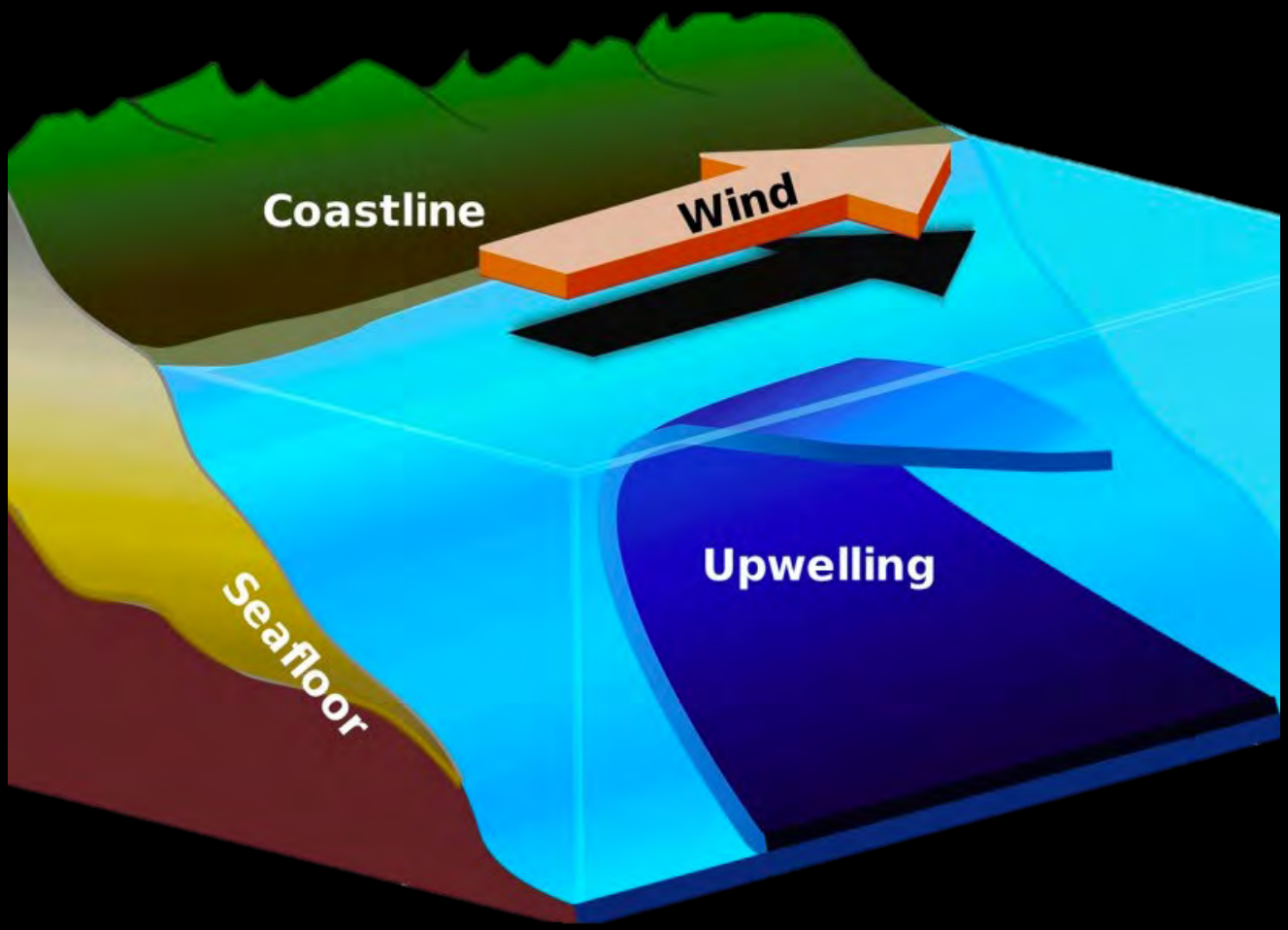
Essential to **understand sources** of **variability** in **larval transport**

Variability in circulation affects larval transport

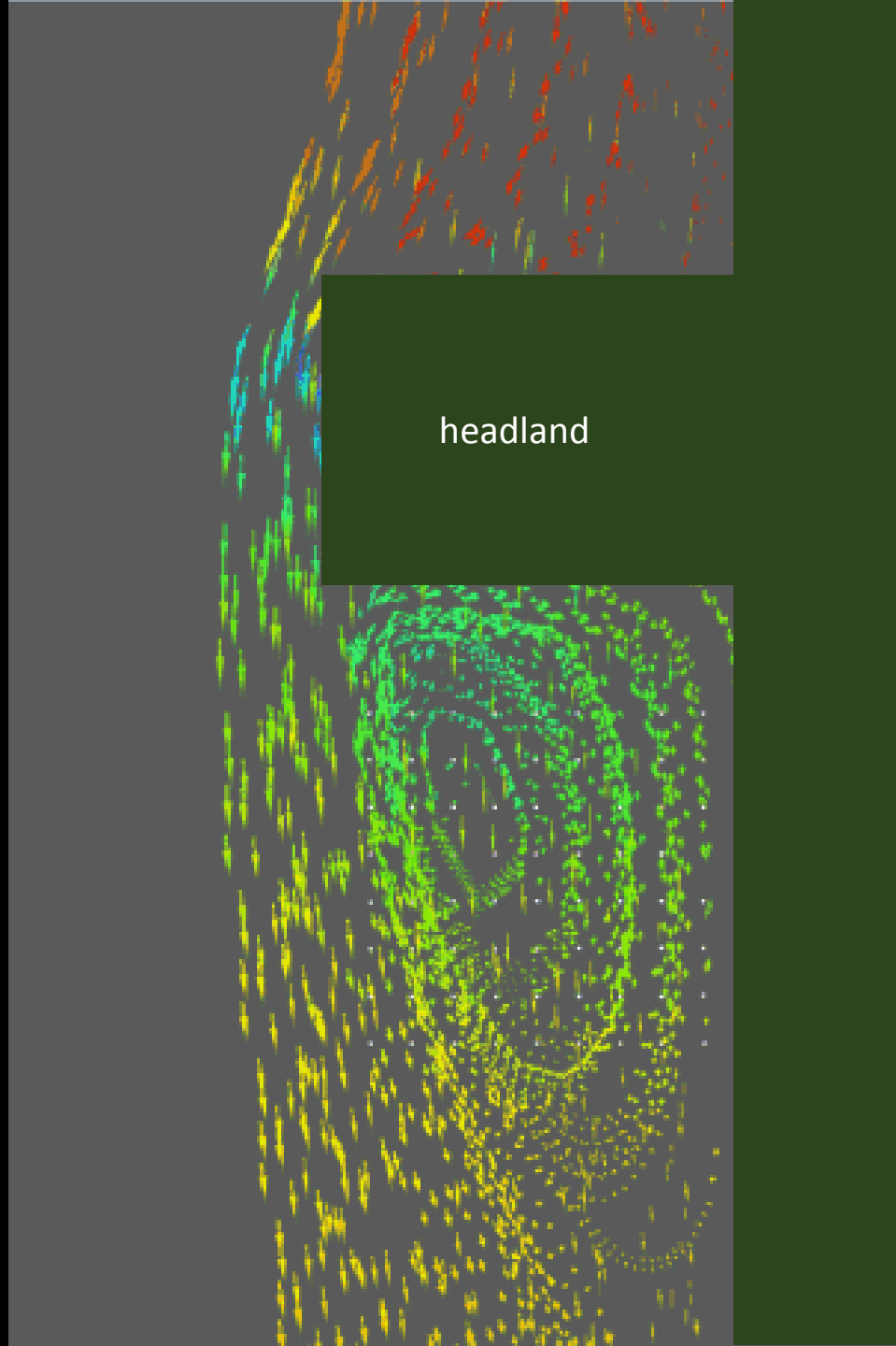
Wind-driven coastal upwelling important source of variation in circulation

Wind-driven coastal upwelling important source of variation in circulation

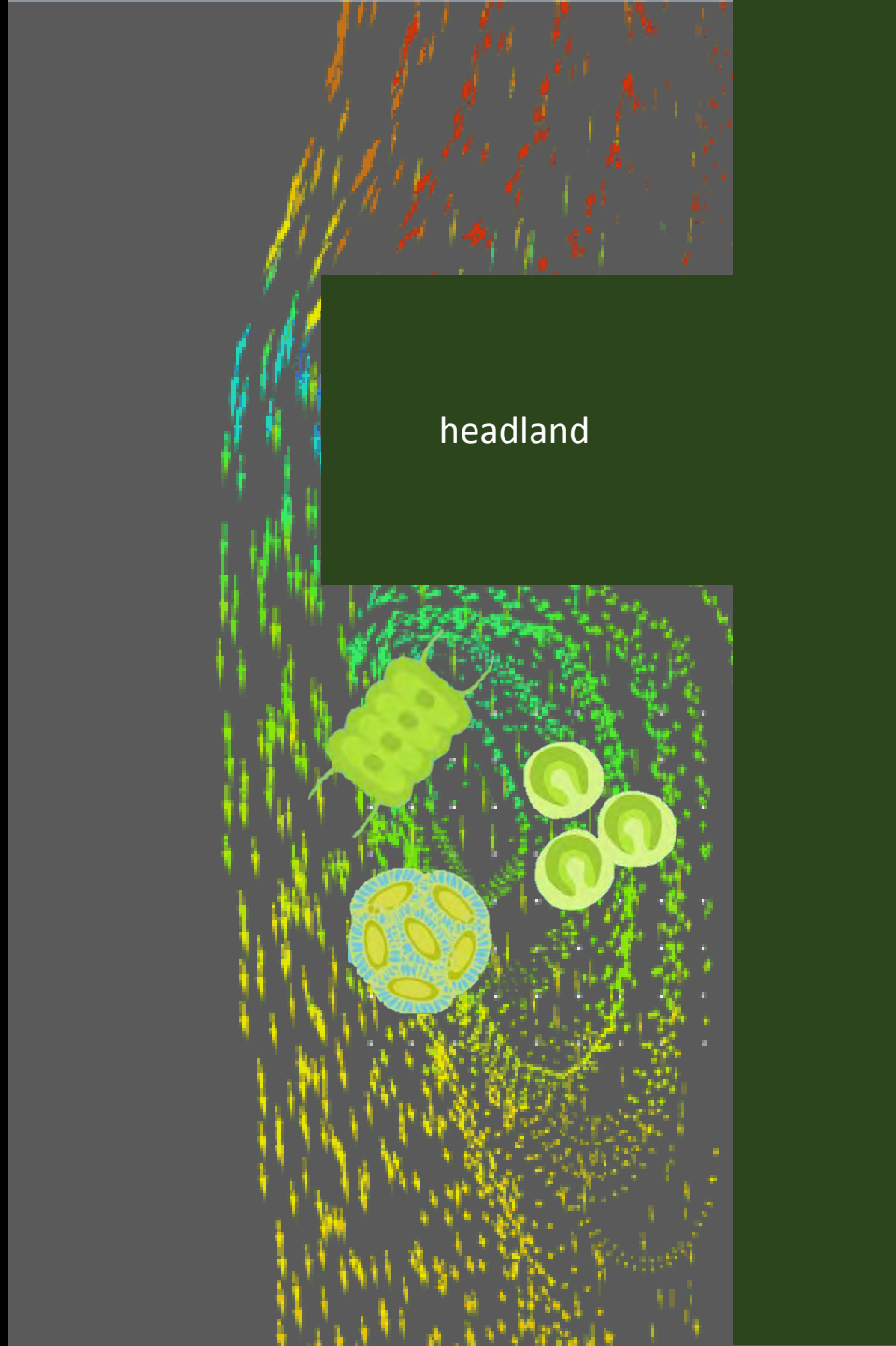
Wind-driven coastal upwelling important source of **variation** in **circulation**



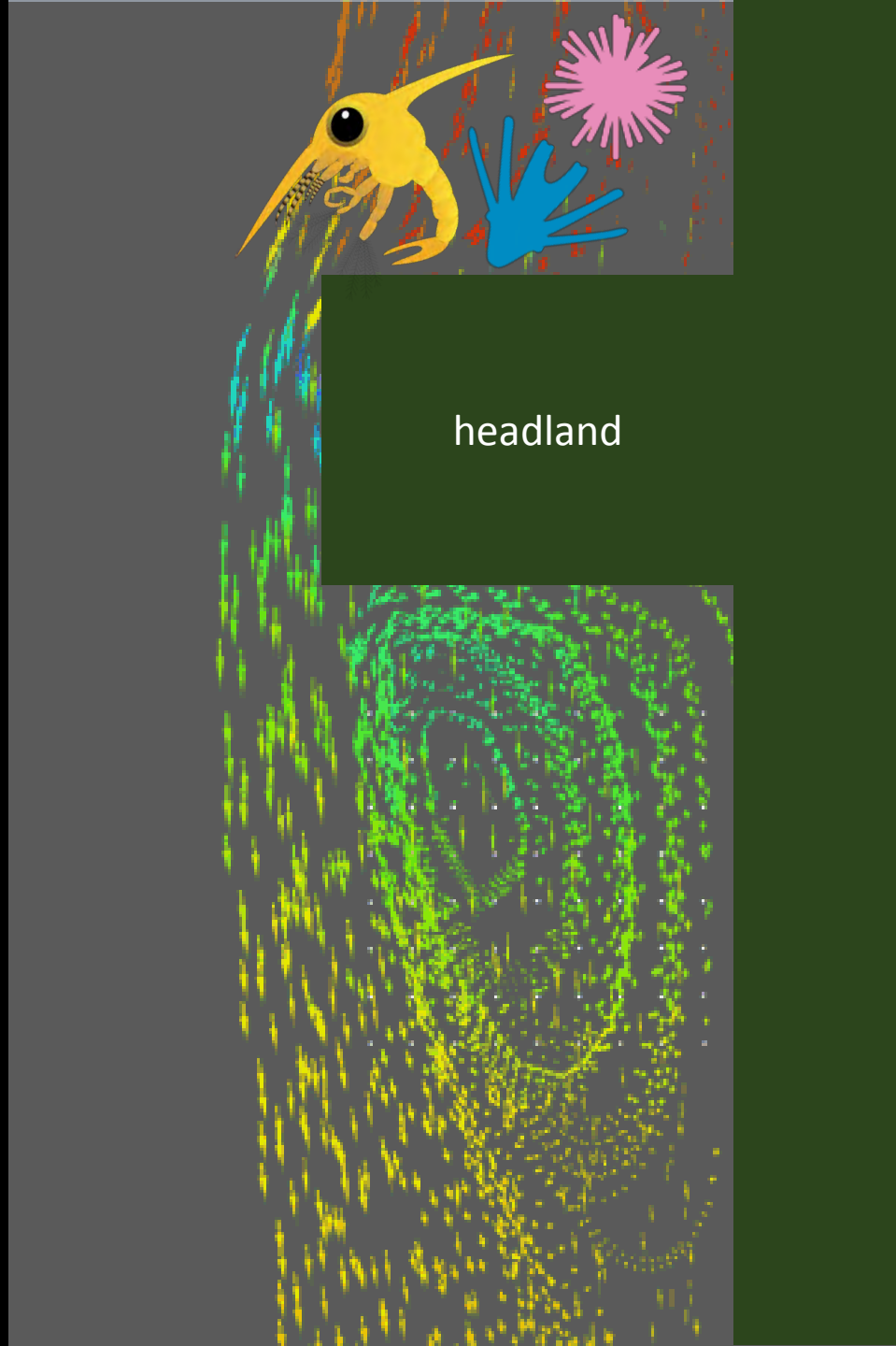
Wind-forcing & coastal geometry influence nearshore circulation patterns



Nearshore circulation affects **plankton**



Nearshore circulation affects **plankton**

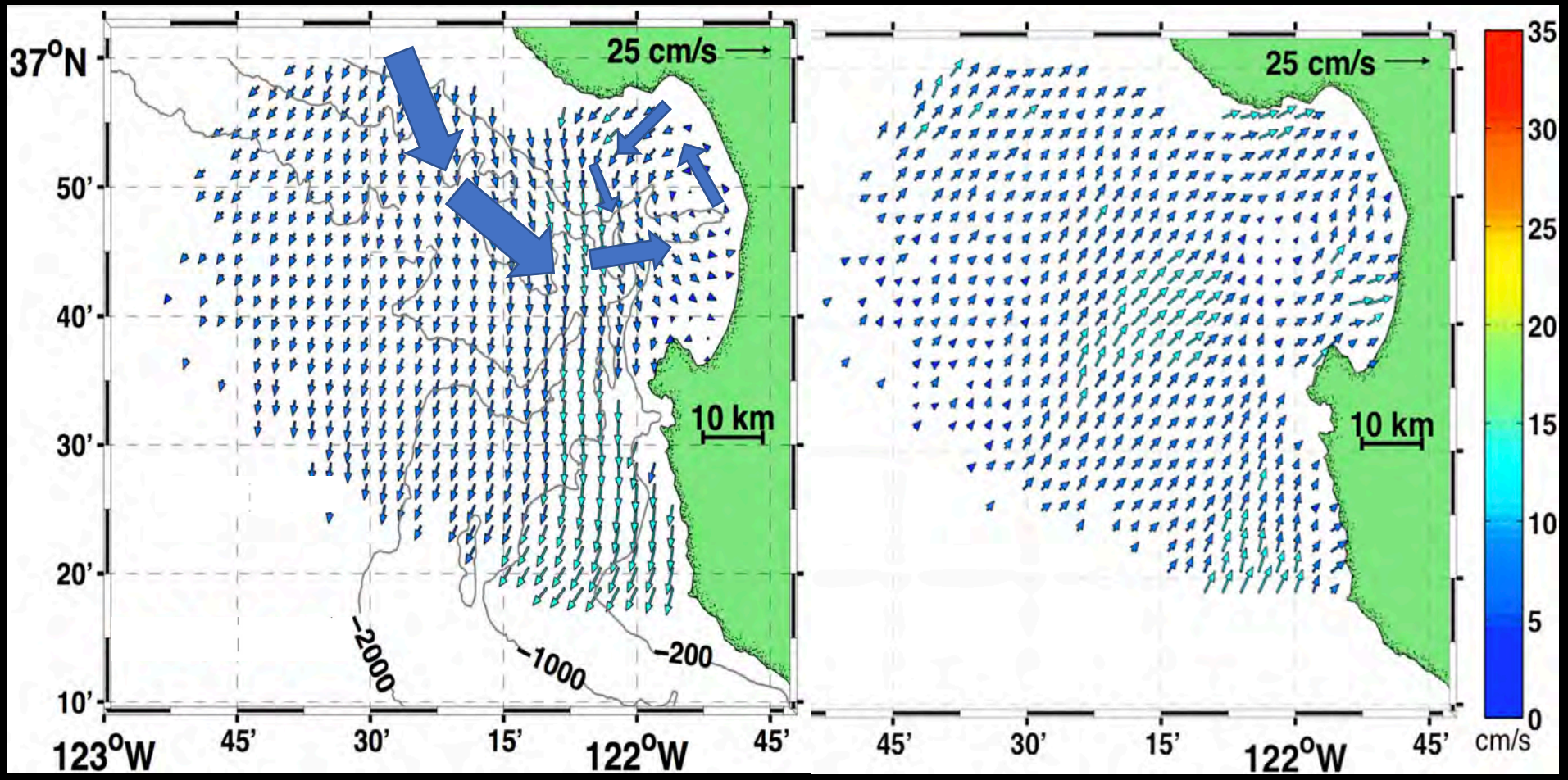


Monterey Bay is an ideal study location

Variable circulation in Monterey Bay

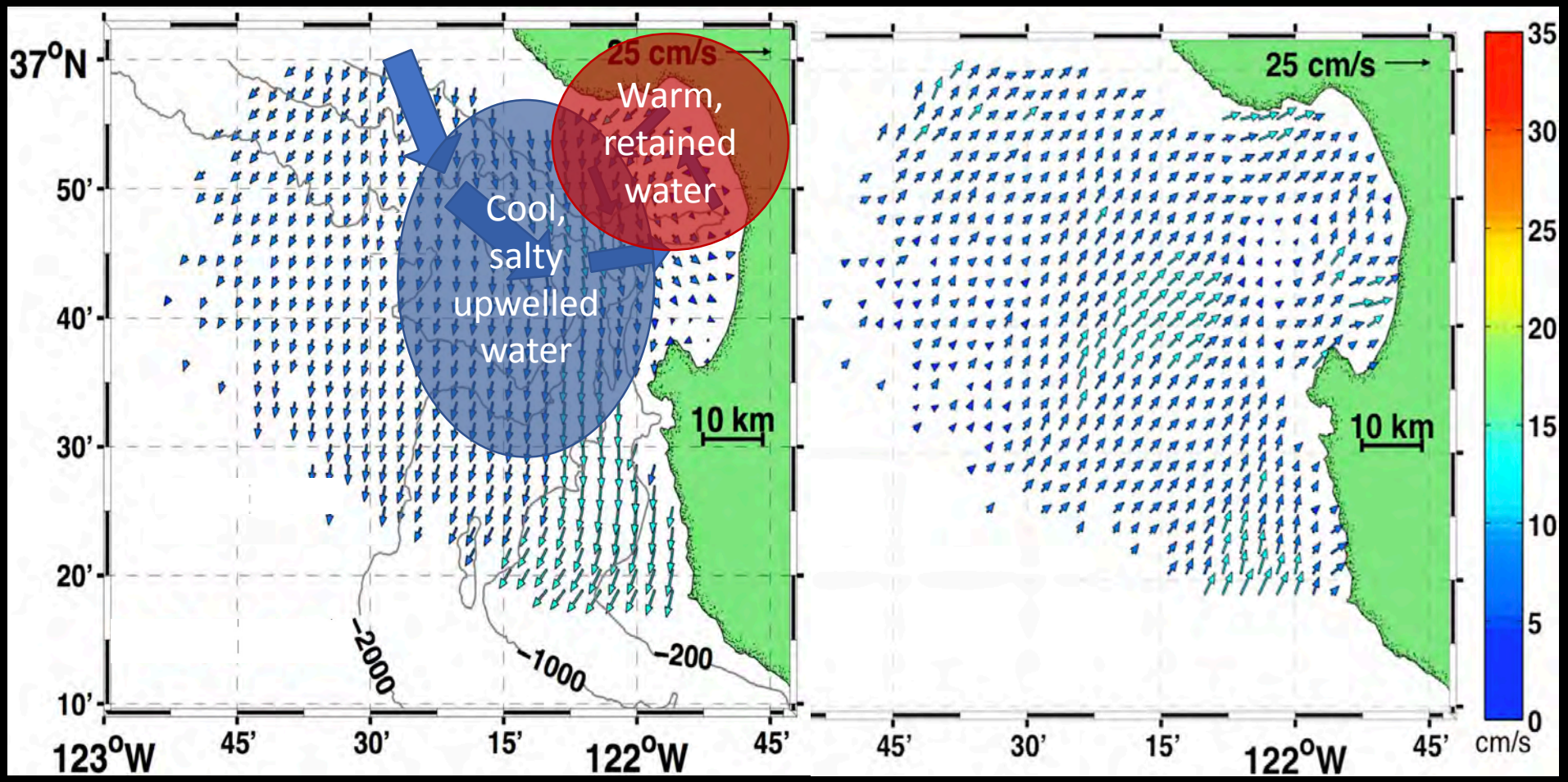
Upwelling

Relaxation



adapted from Paduan et al. 2018

Variable circulation in Monterey Bay

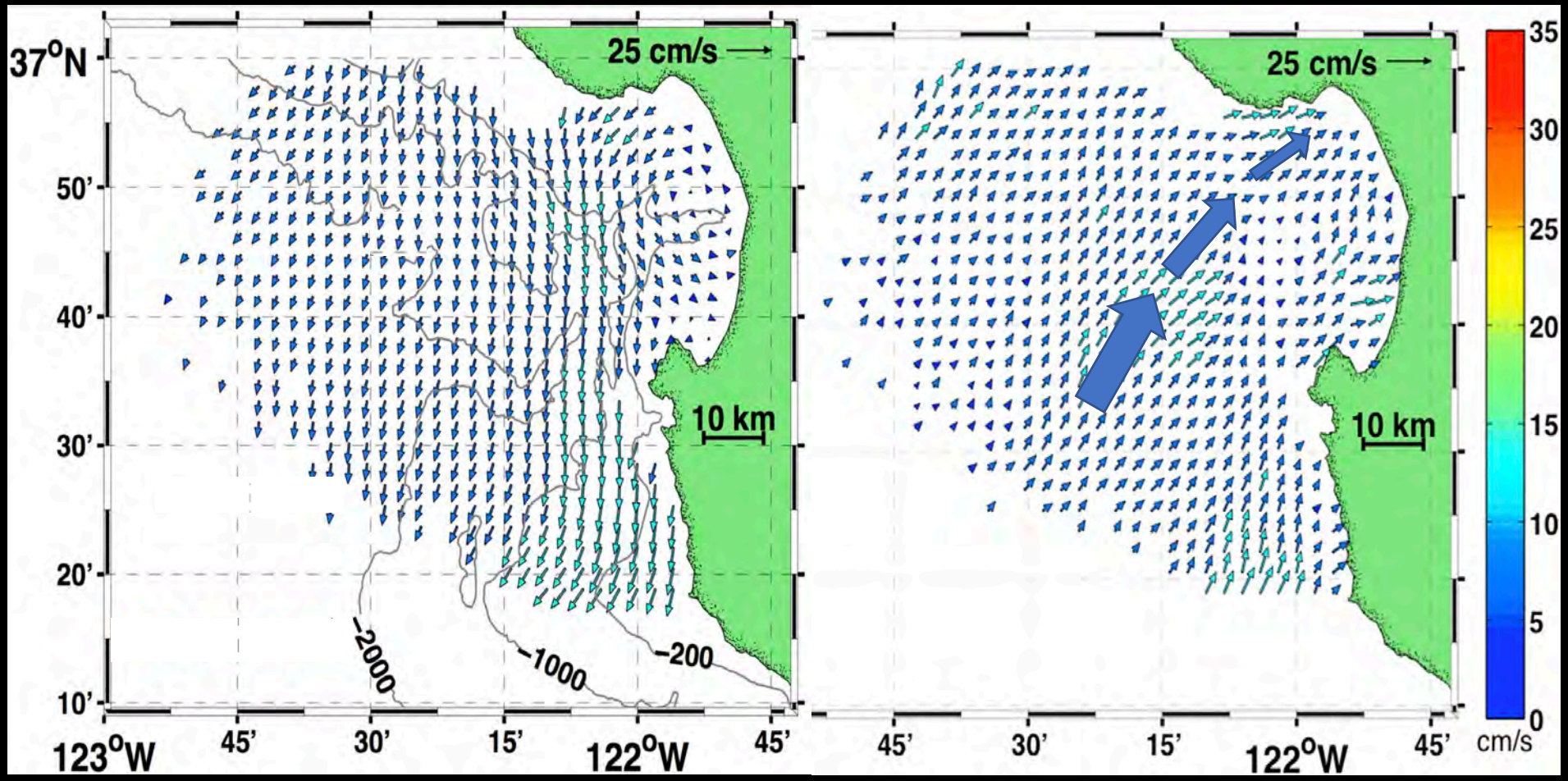


adapted from Paduan et al. 2018

Variable circulation in Monterey Bay

Upwelling

Relaxation



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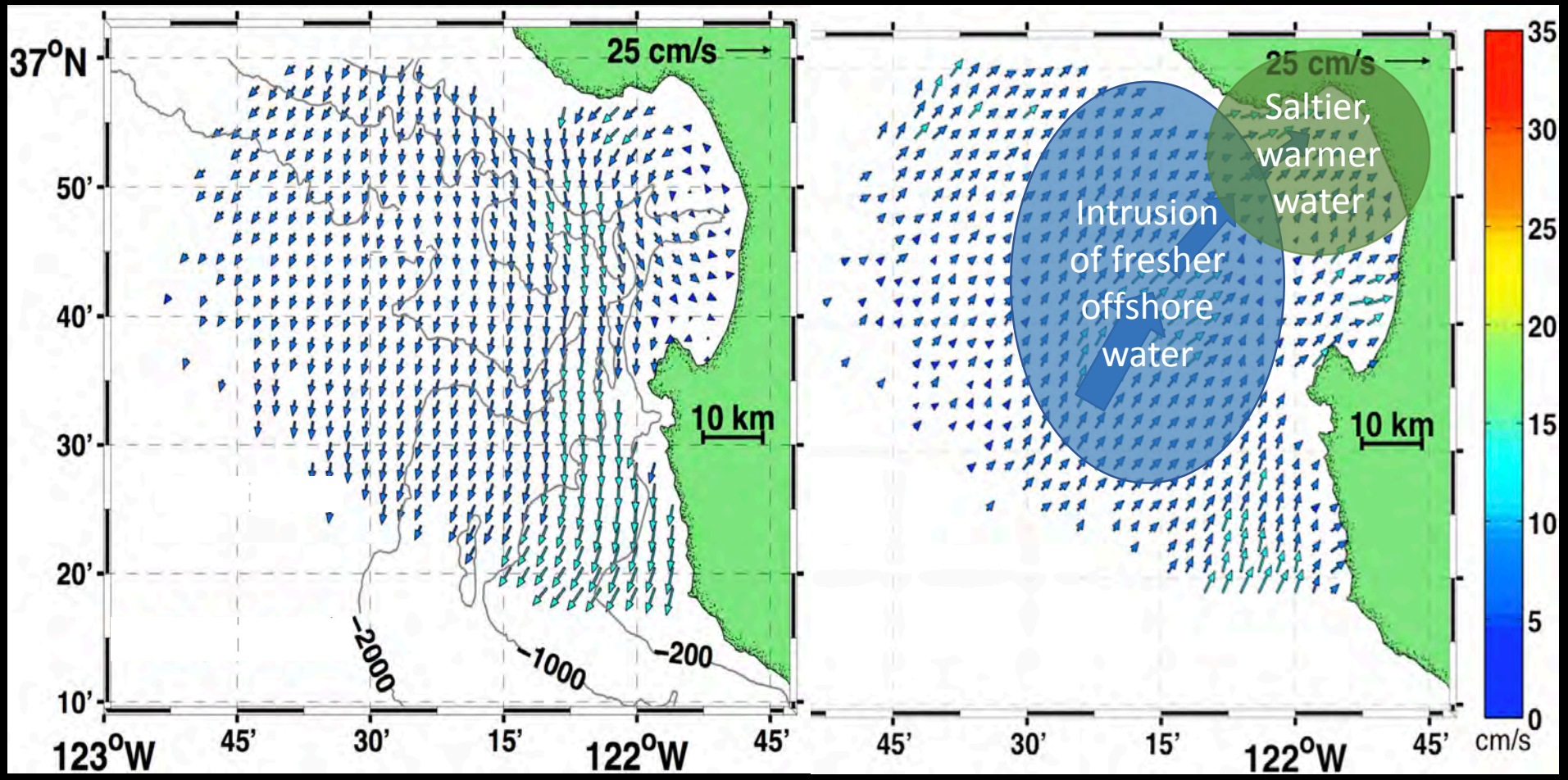
Variable circulation in Monterey Bay

Upwelling

Relaxation



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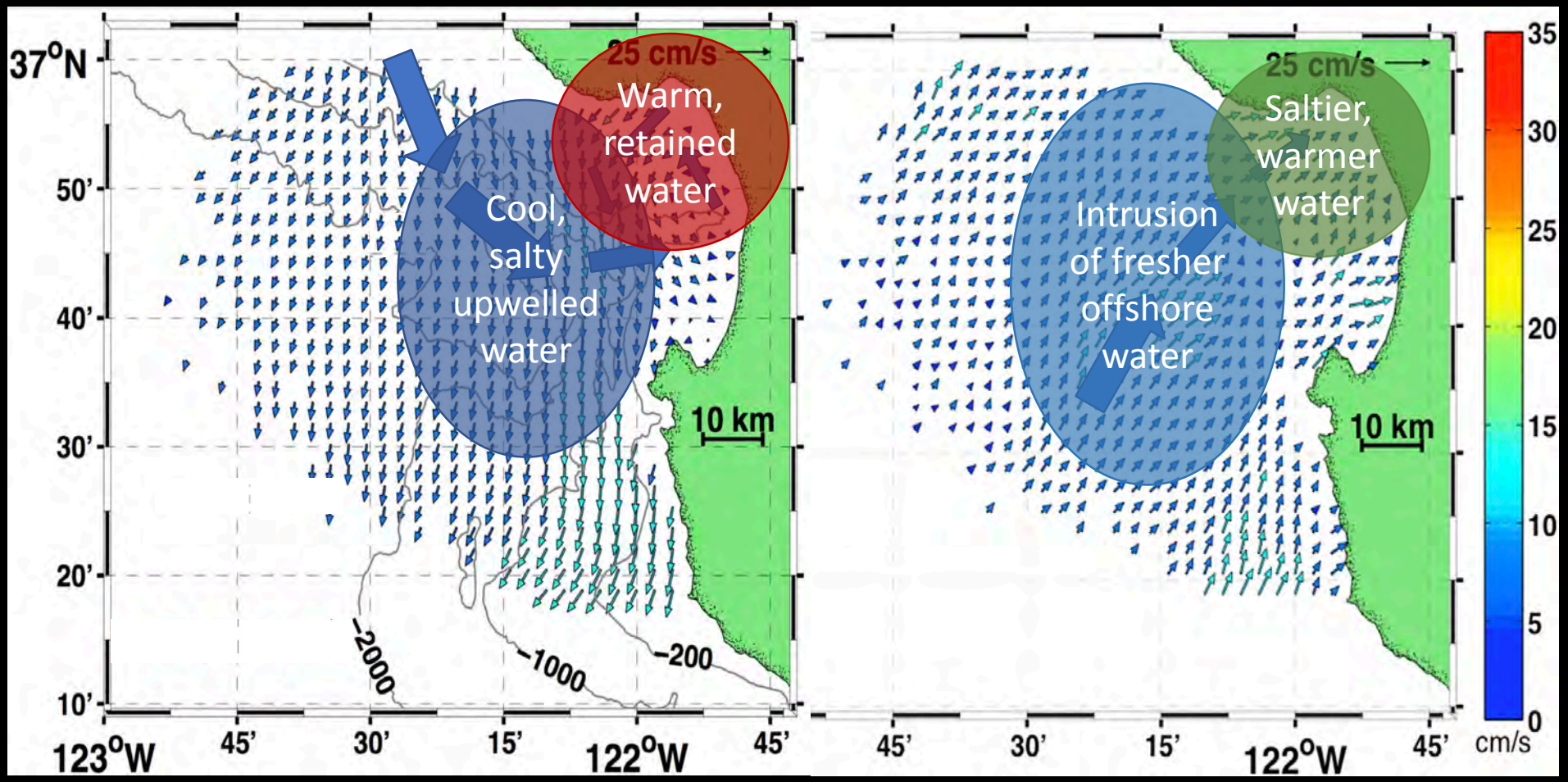
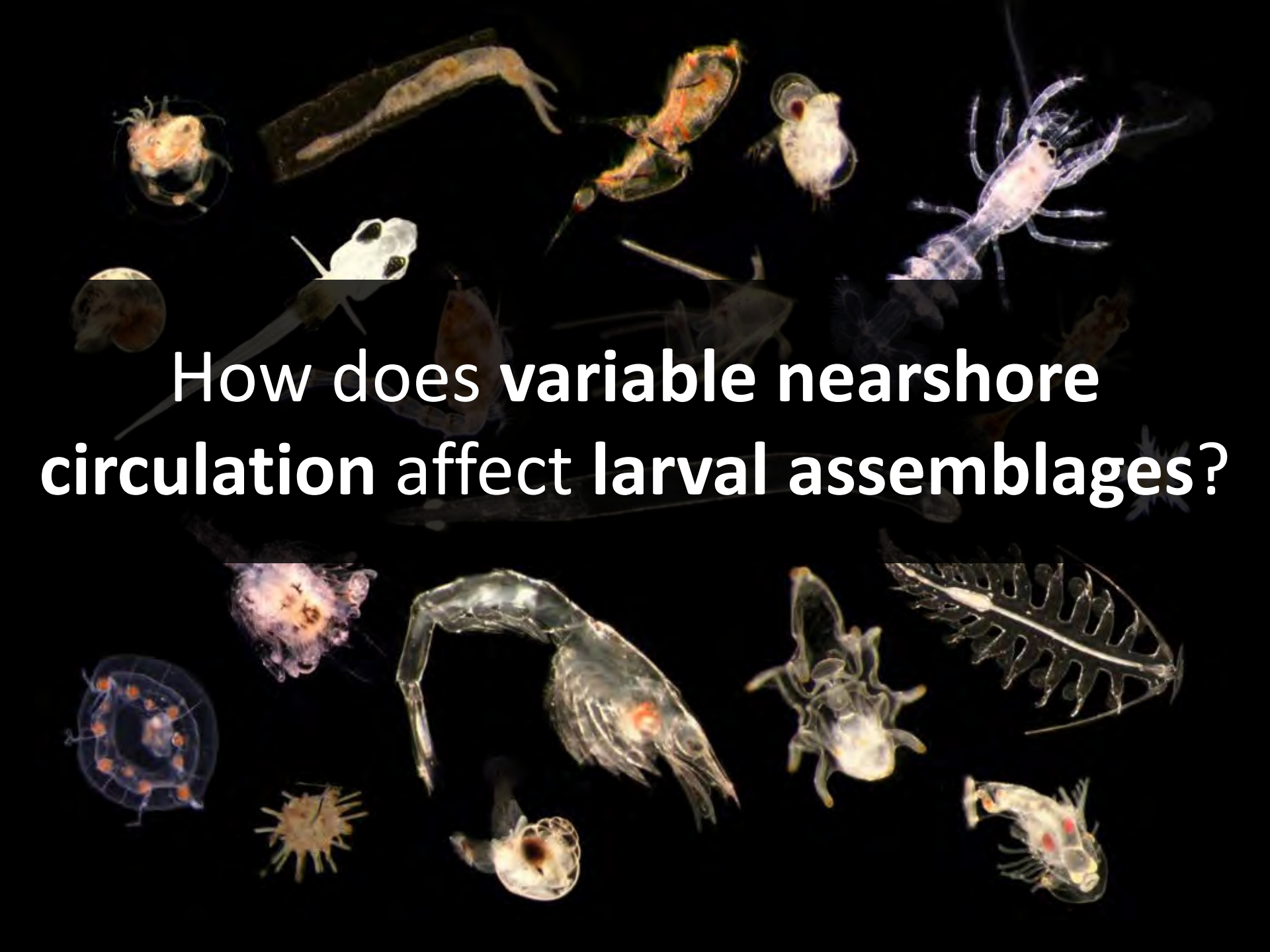
Variable circulation in Monterey Bay

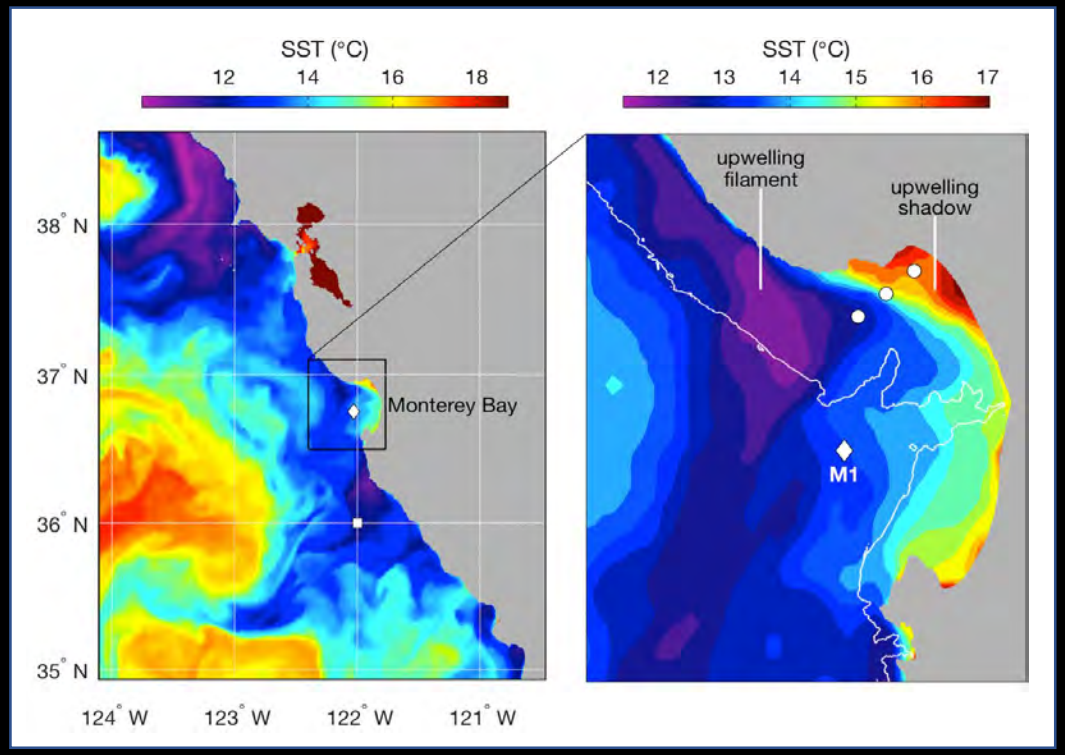


adapted from Paduan et al. 2018

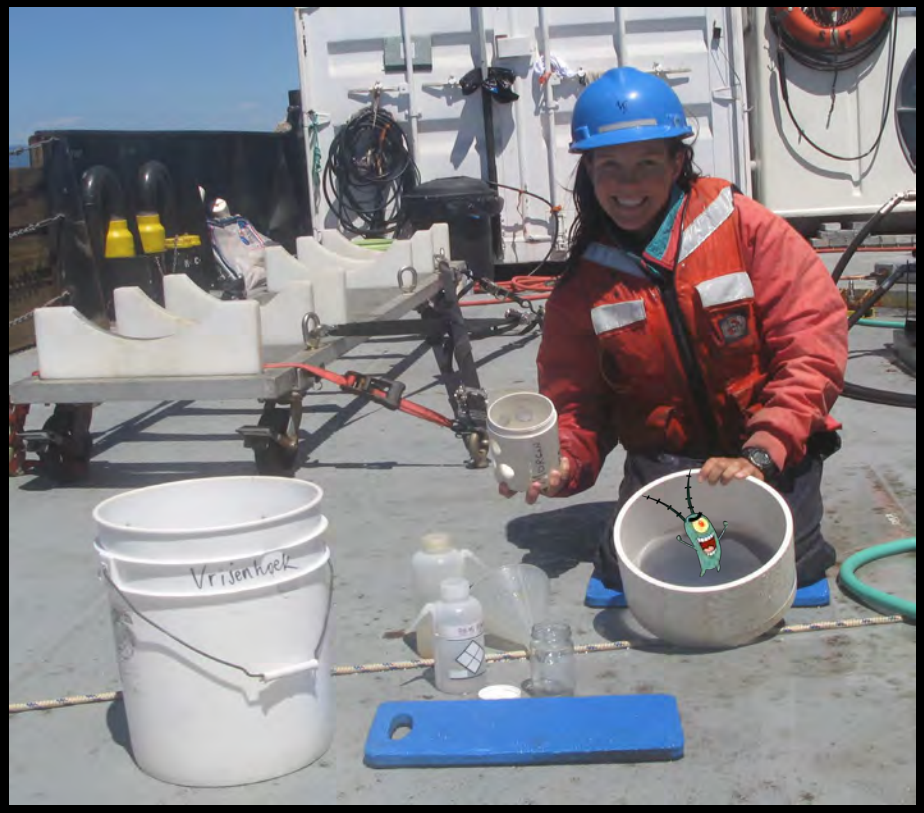

How does **variable nearshore circulation** affect **larval assemblages**?

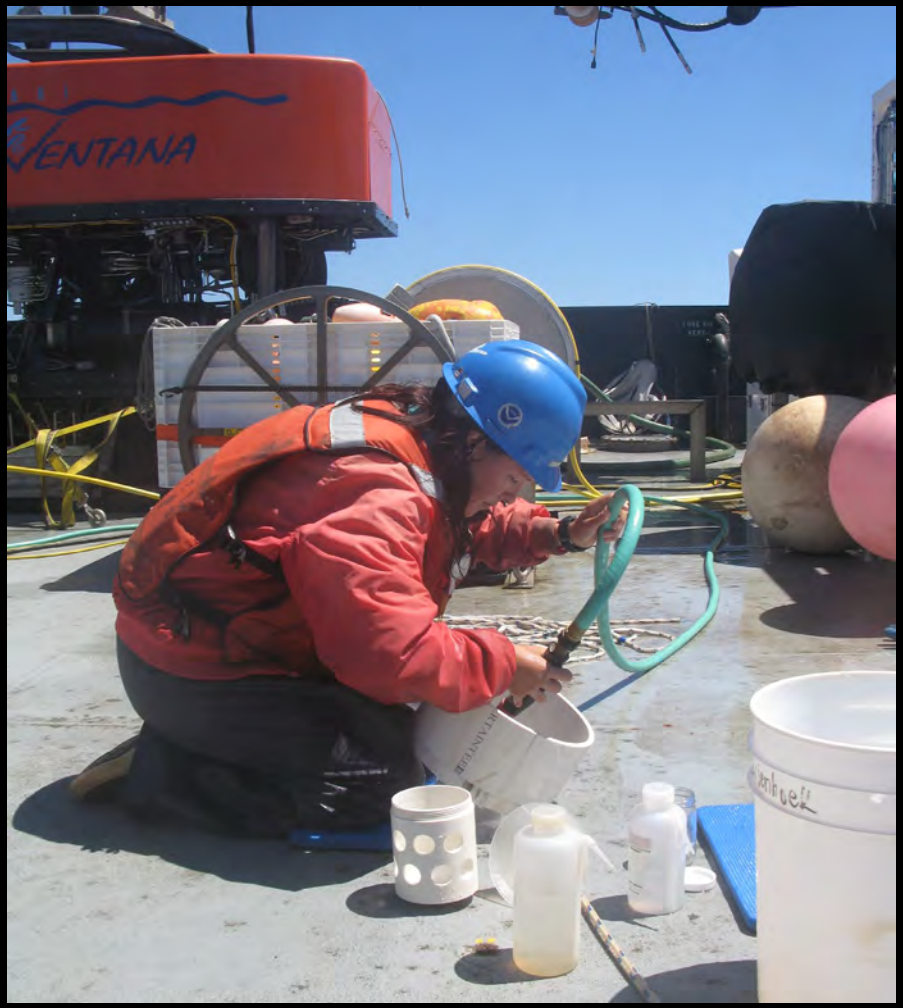
Sampled in Monterey Bay during late summer and early fall

- Monterey Bay
- August & October 2013
- 3 stations
  - Inner Bay
  - Mid Bay
  - Outer Bay
- 3 depths
- Buoy & Satellite data

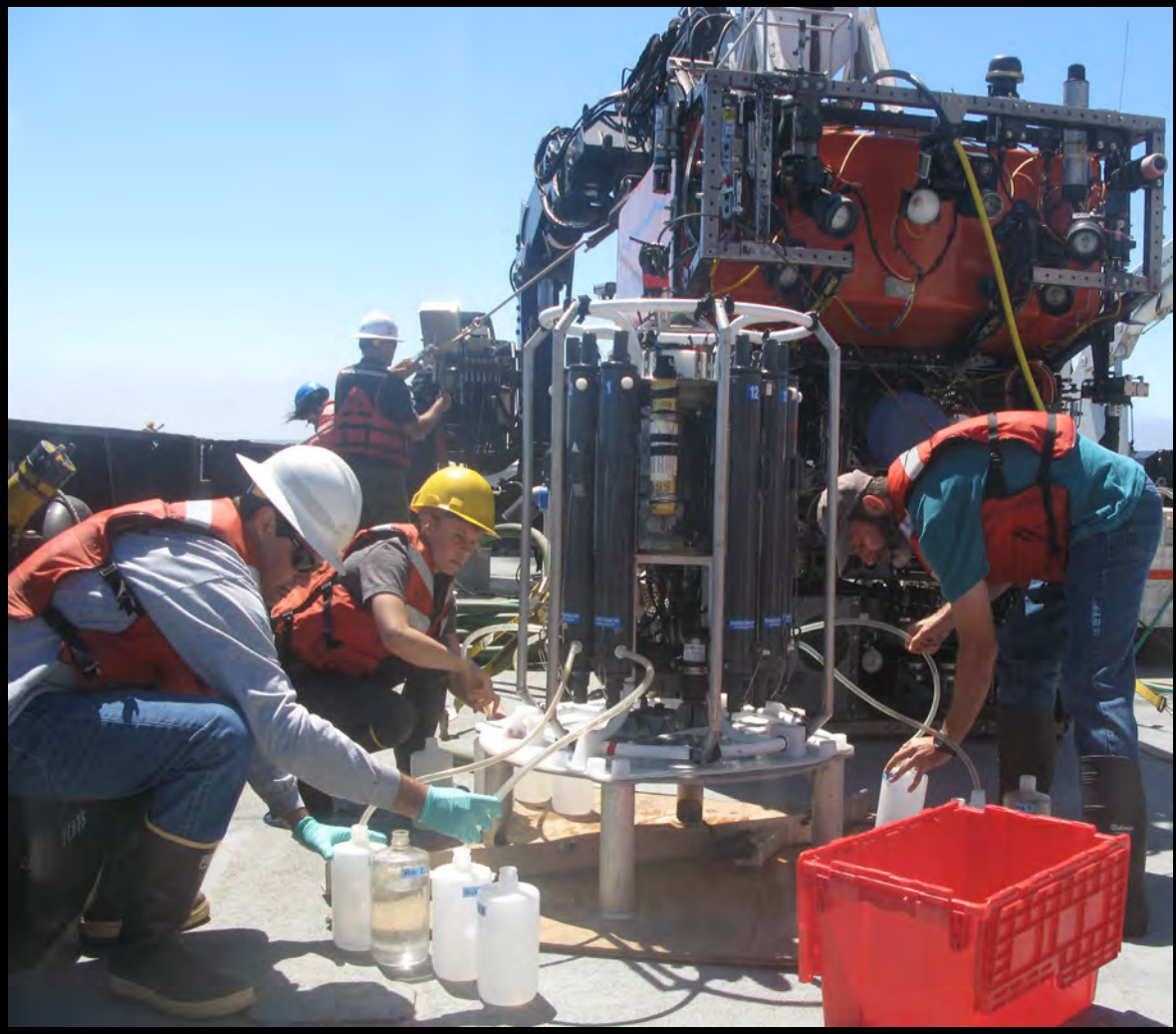


Larvae collected with a **plankton pump**




VENTANA

Physical data collected with CTD attached near the plankton pump

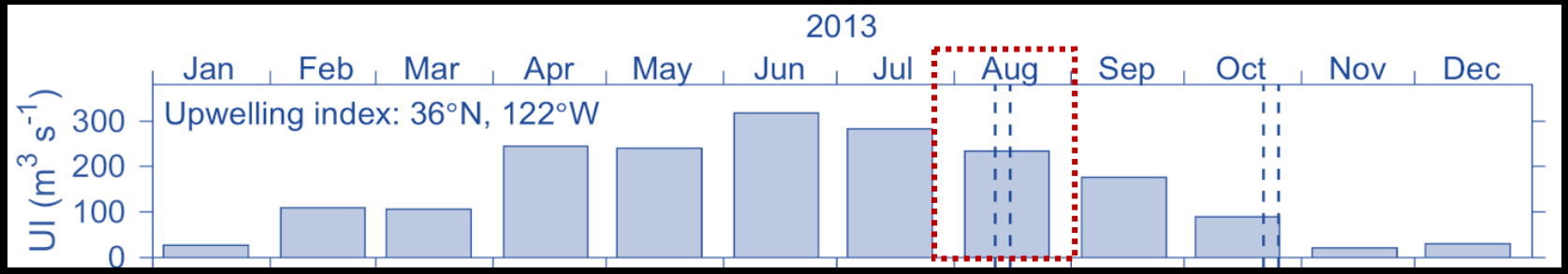


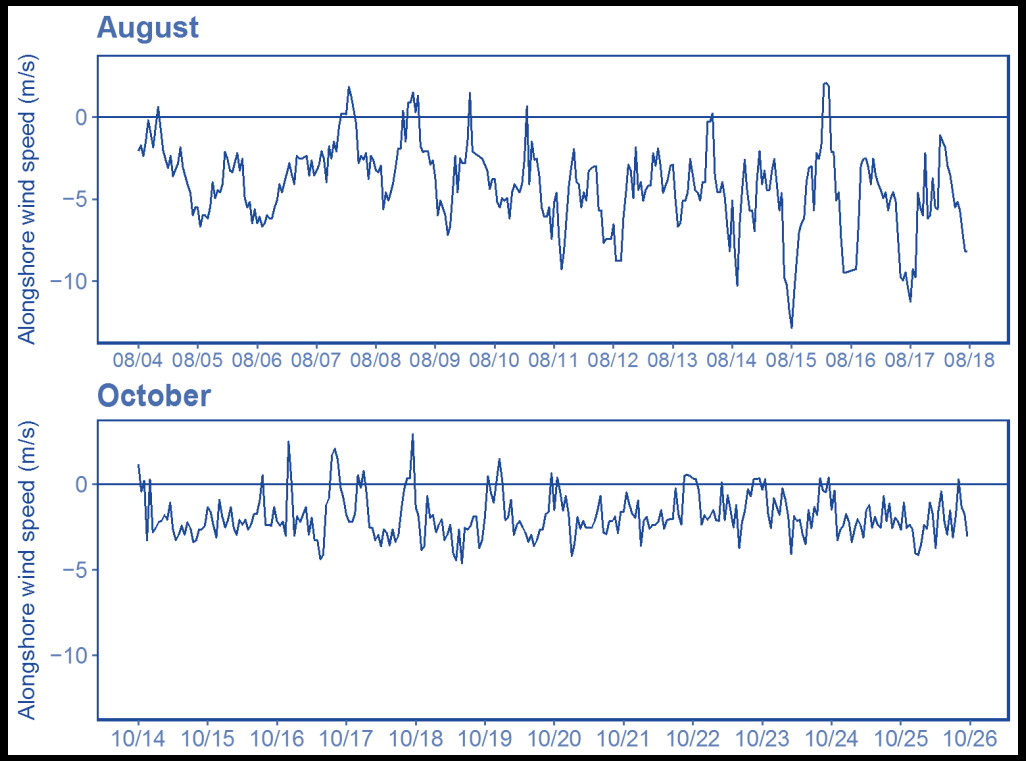
Physical data collected with CTD in autonomous underwater vehicle (AUV)


MAX GROSS: 9500 KG

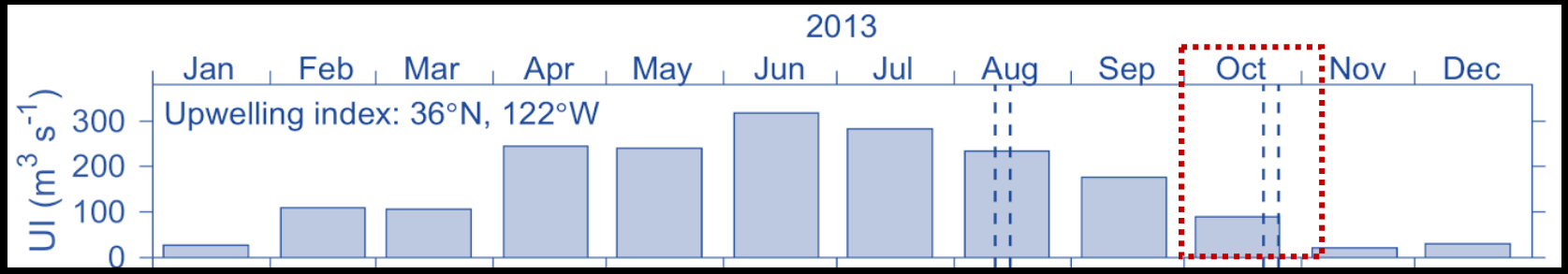
Oceanographic conditions varied seasonally.

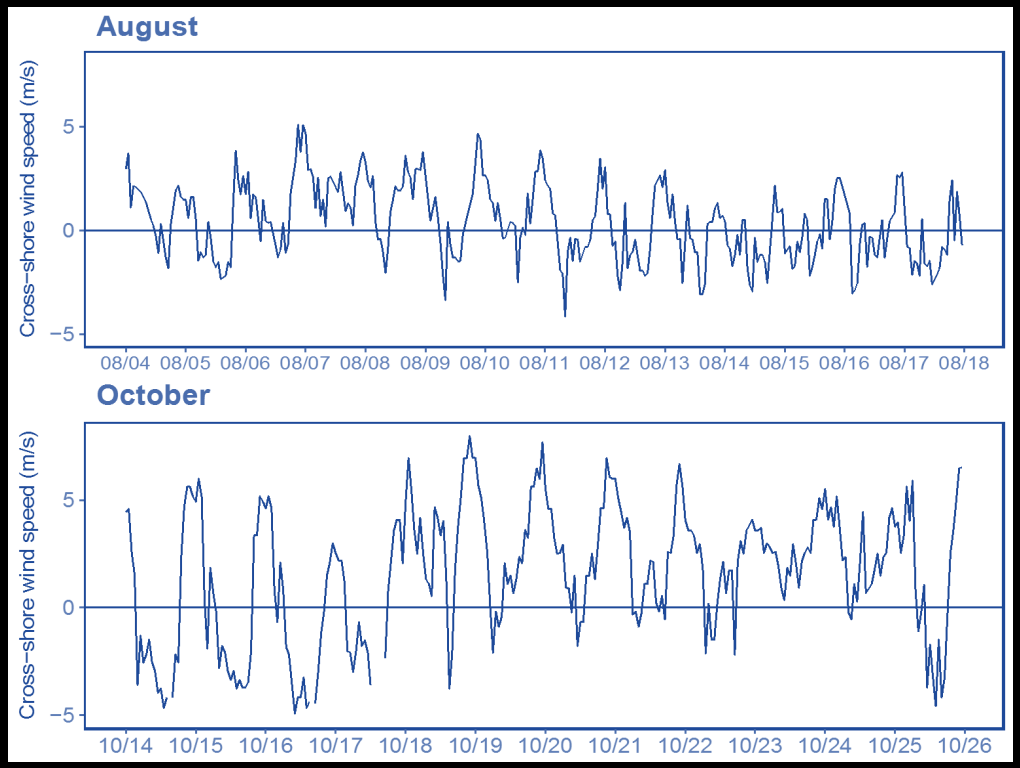
Upwelling-favorable conditions in August



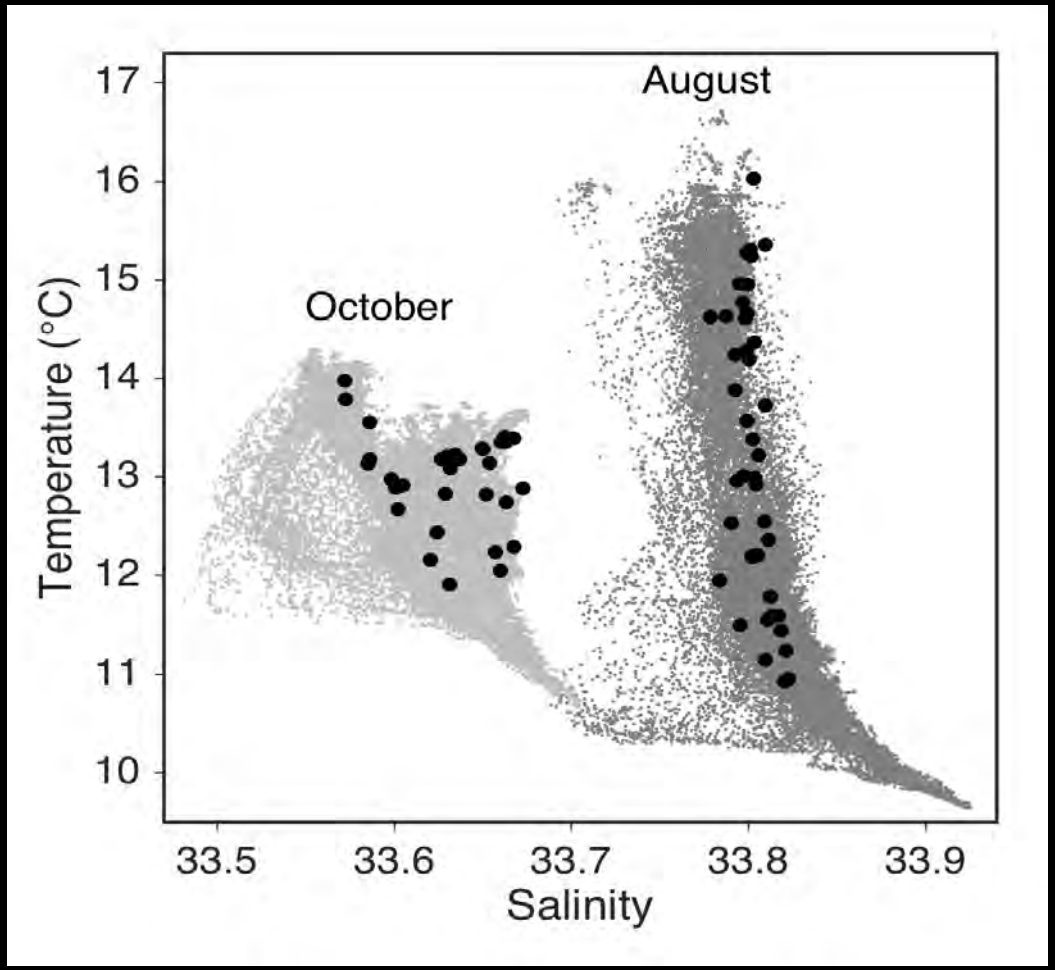


Relaxation conditions in October





Water type differed between August and October



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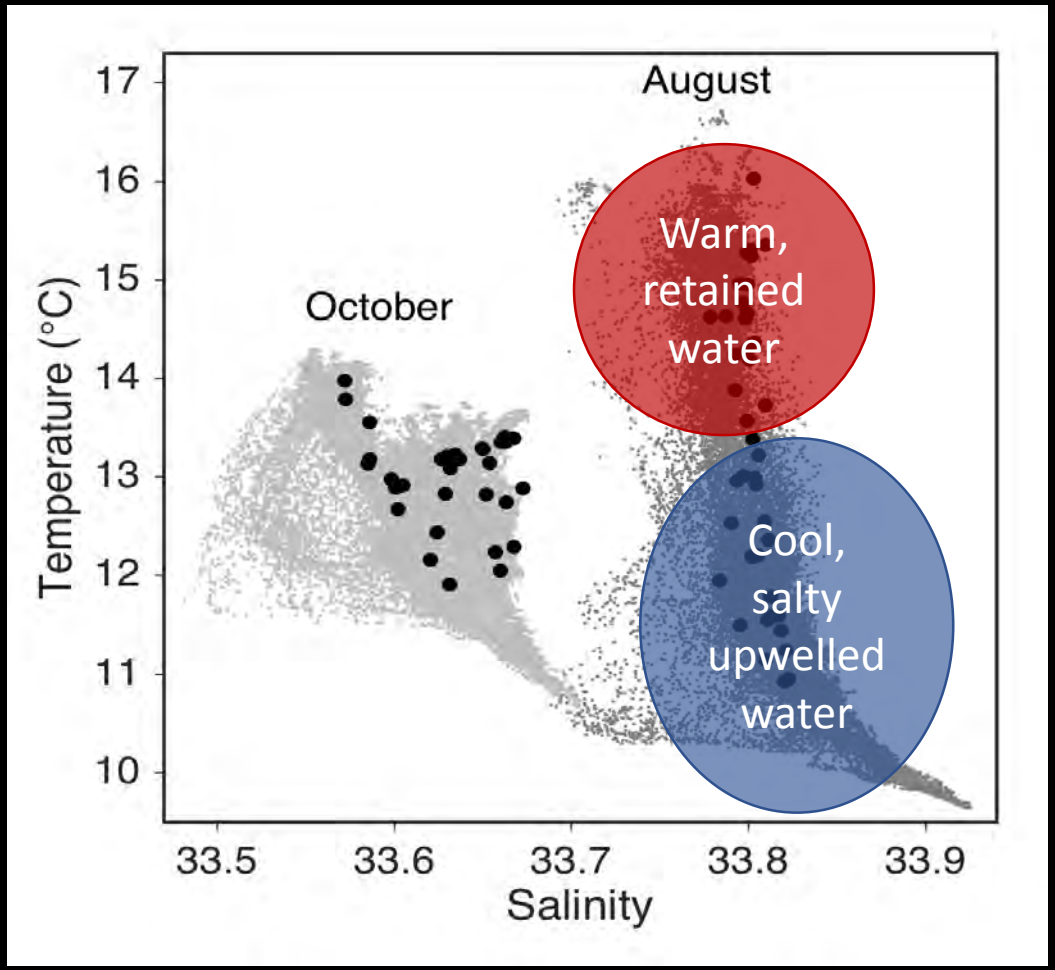

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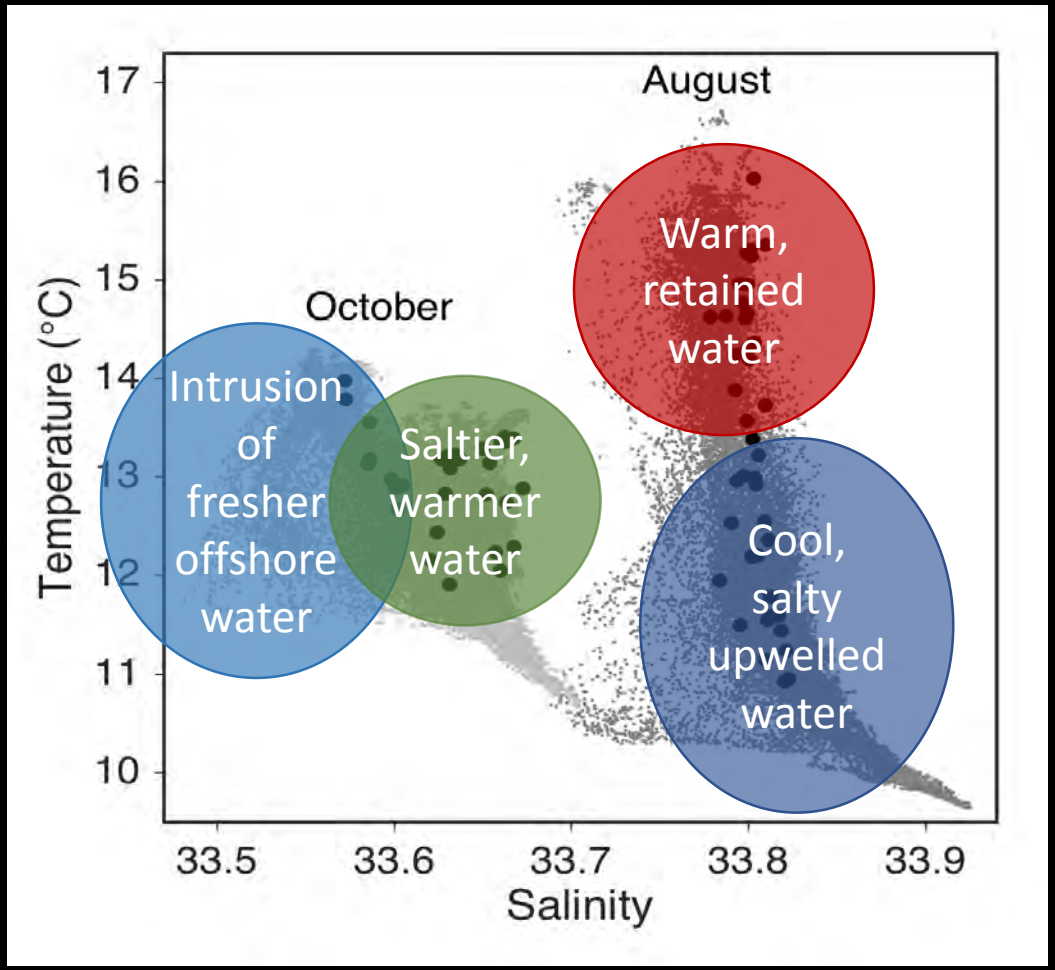
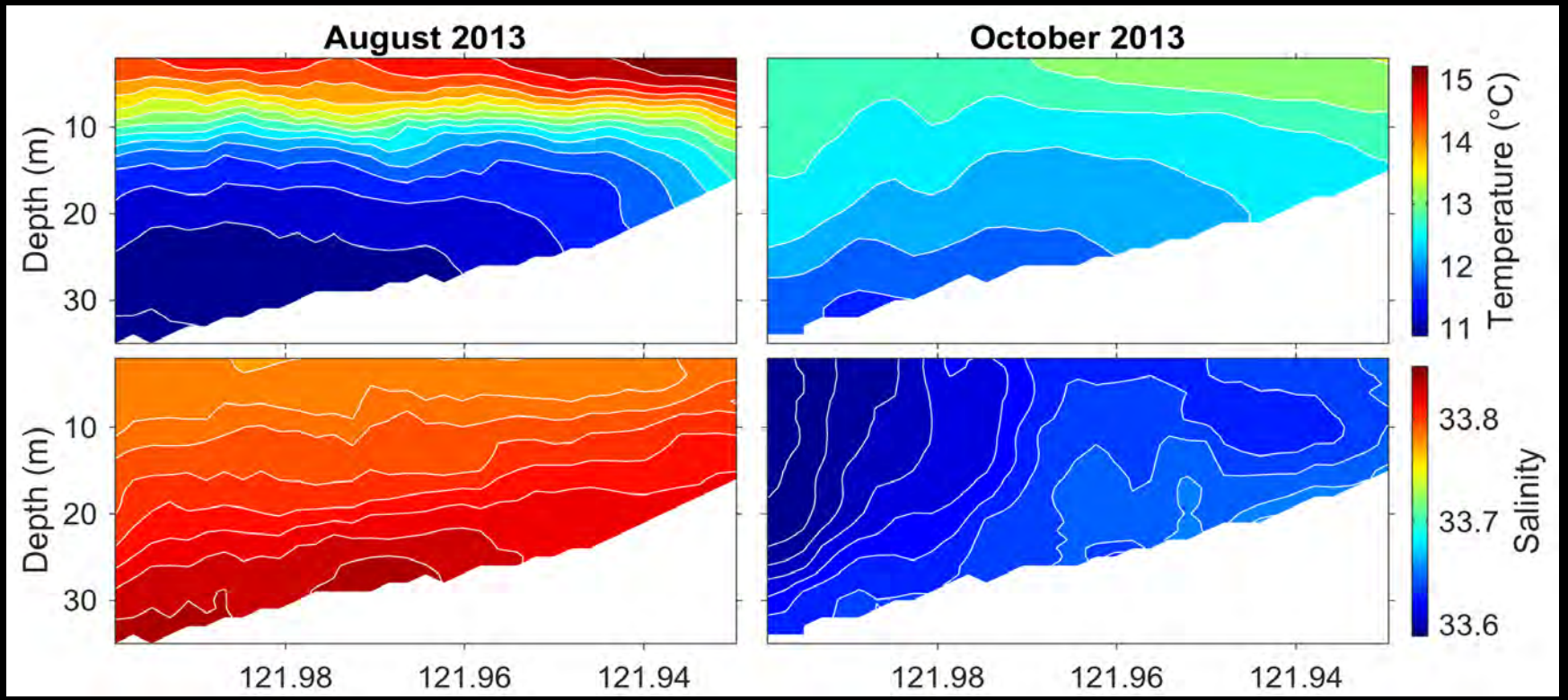


Vertical stratification differed between months



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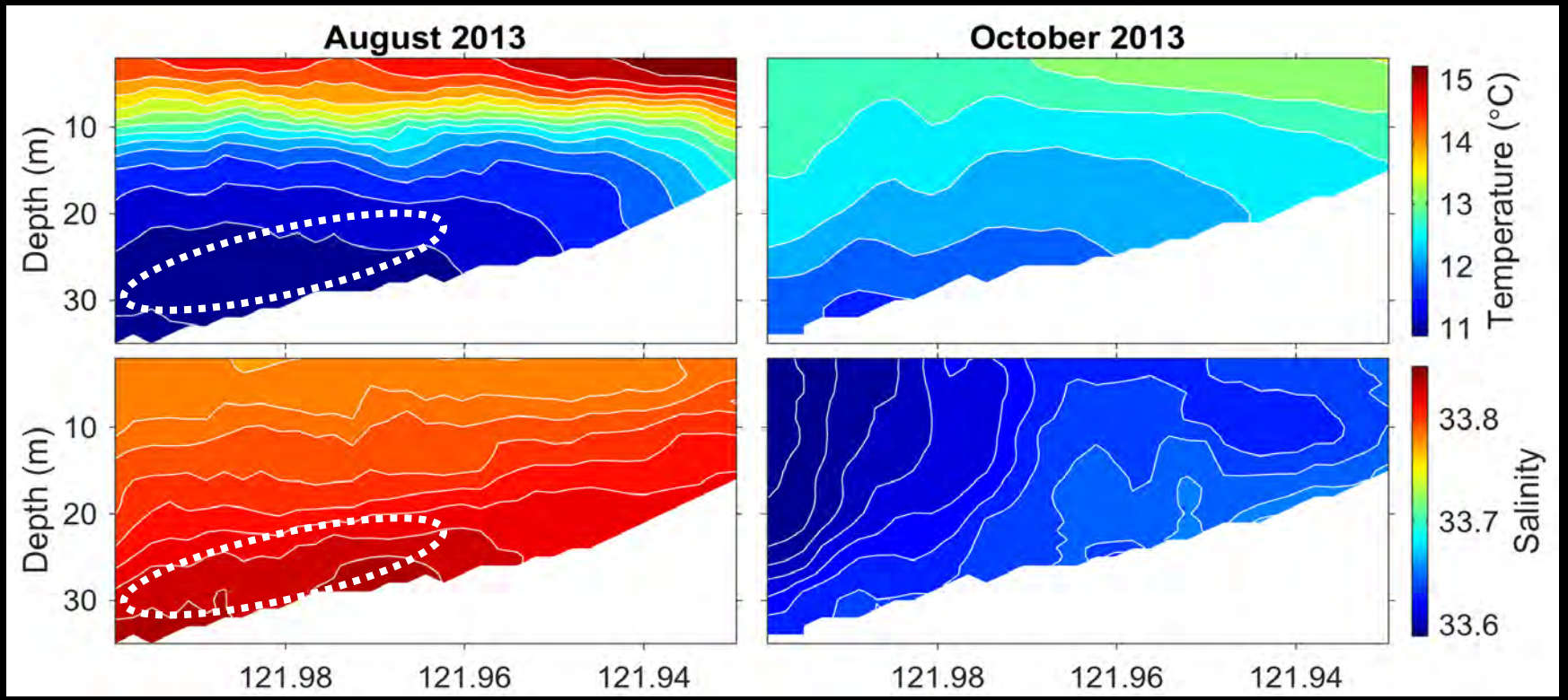

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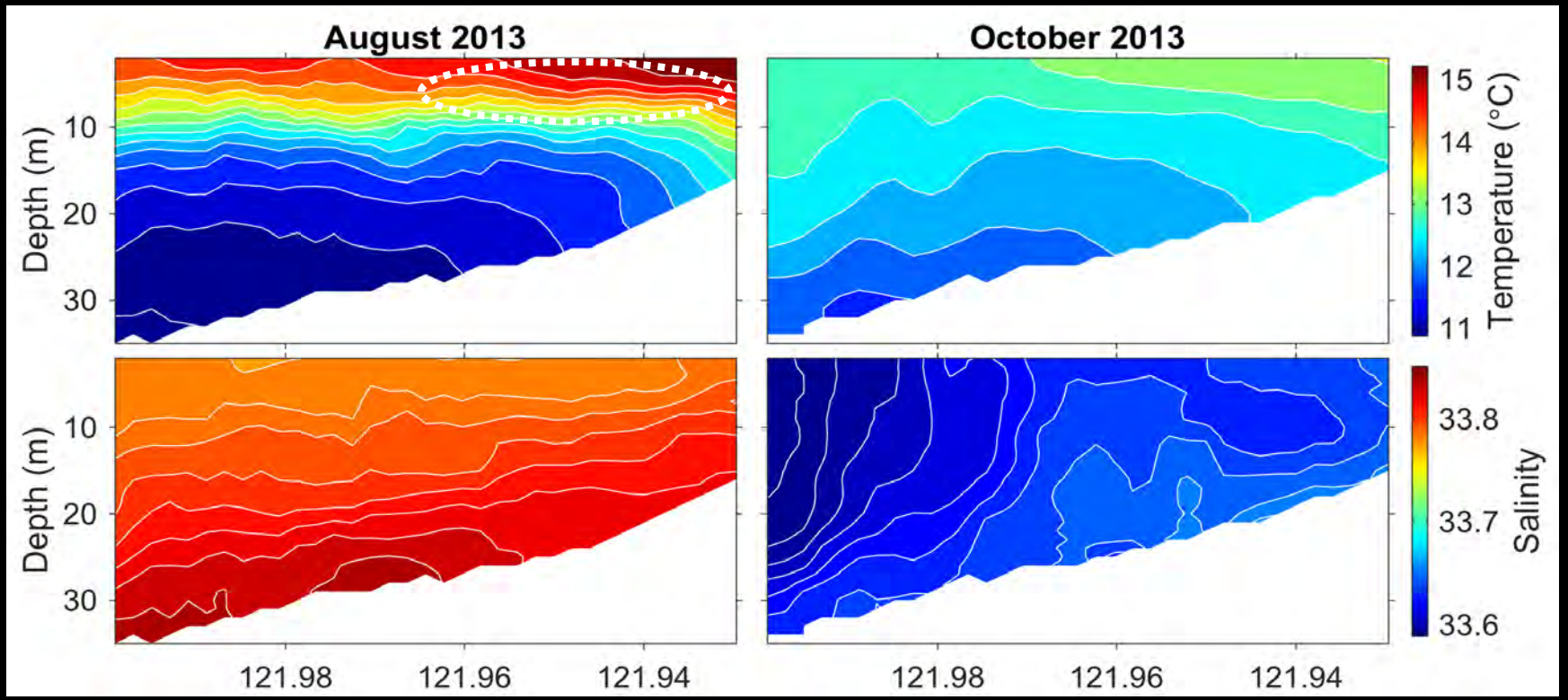

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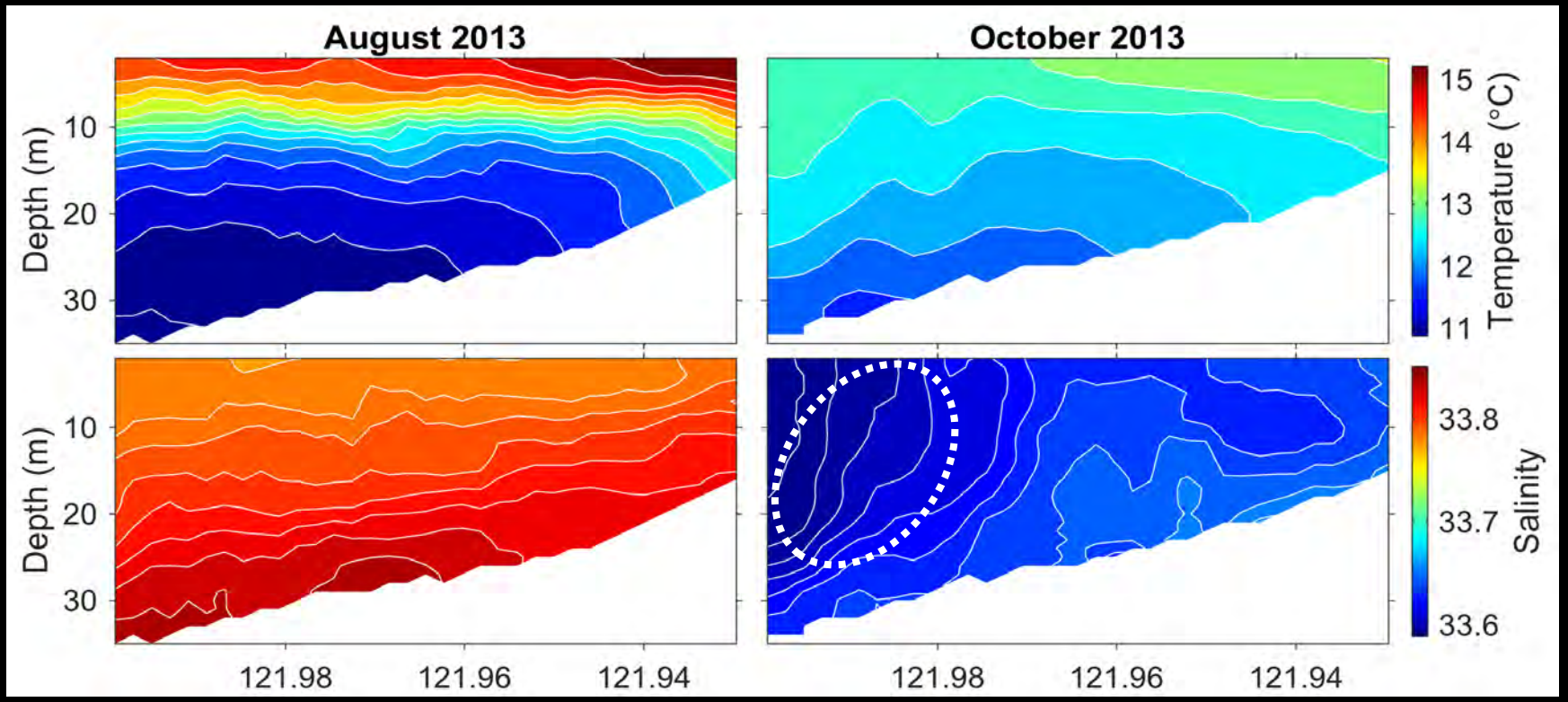

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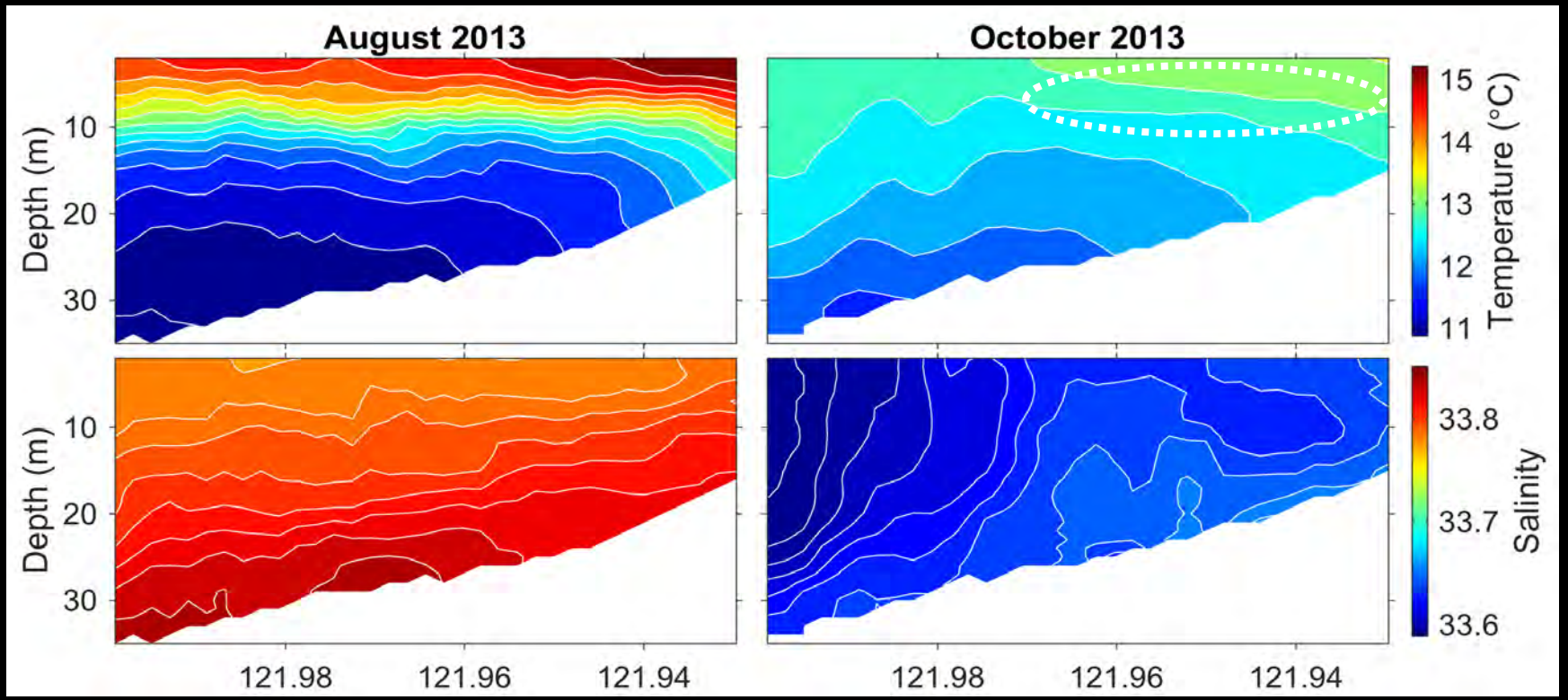


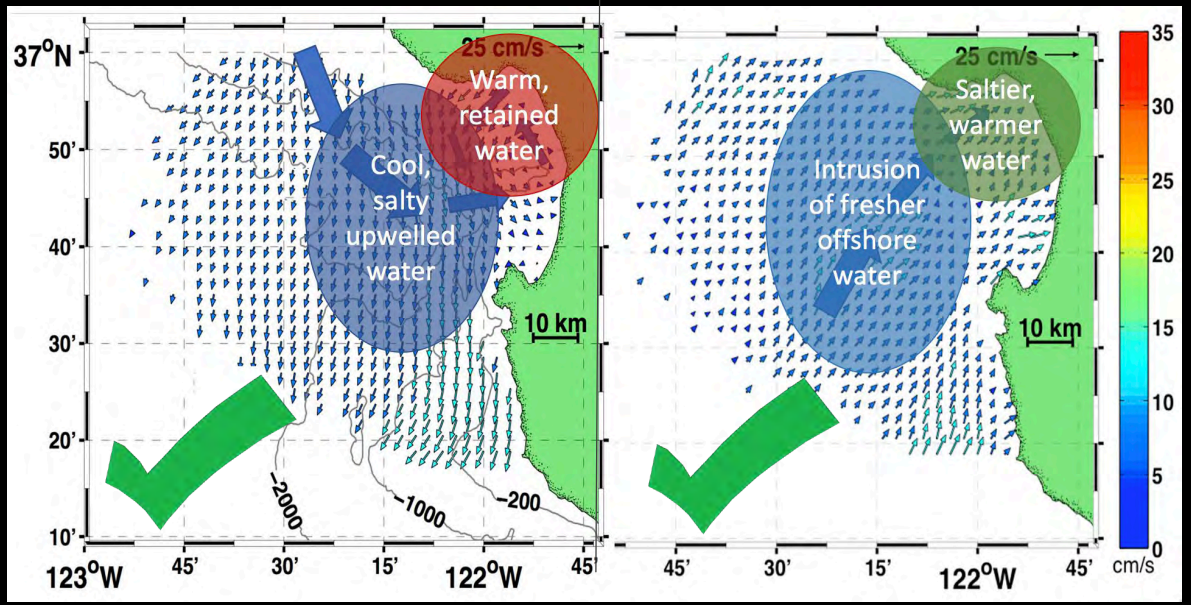
Nearshore hydrodynamics differed

August: Upwelling

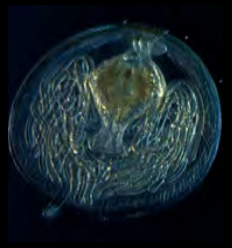
- **Upwelling-favorable** winds
- **Cold, salty deep upwelled water**
- **Warmest retained water inshore**

October: Relaxation

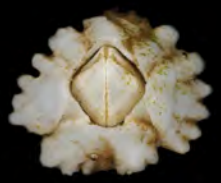
- **Intrusion** of **fresh, offshore water**
- Strong **northward, onshore flow**
- **Warm water inshore**



Cast of characters

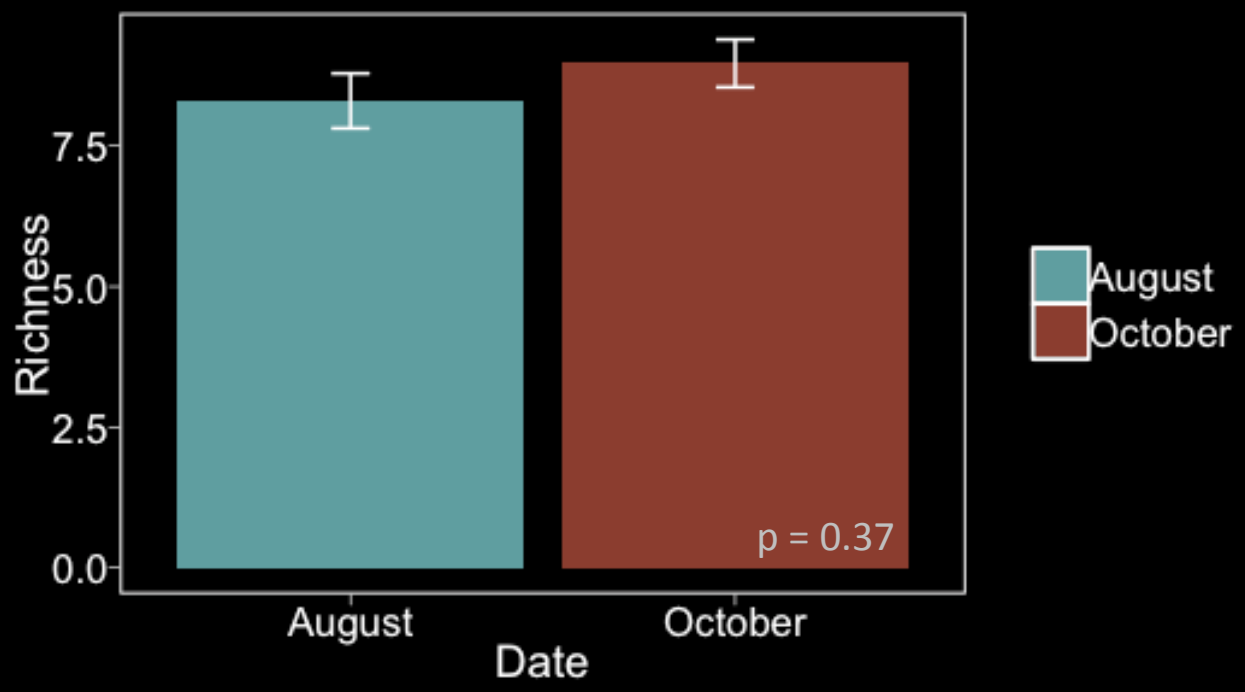


Brachiopods
Brittle stars

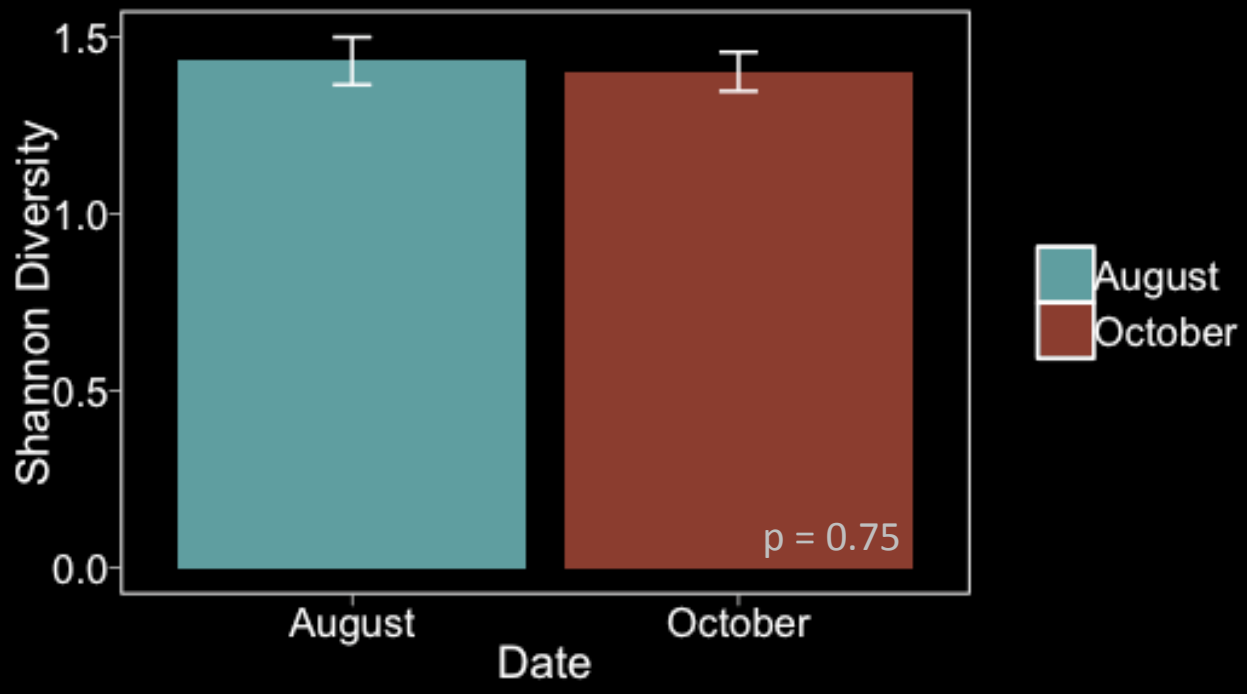


Barnacles
Crabs
Urchins
Mole crabs
Snails
Clams
Bryozoans
Mud shrimp

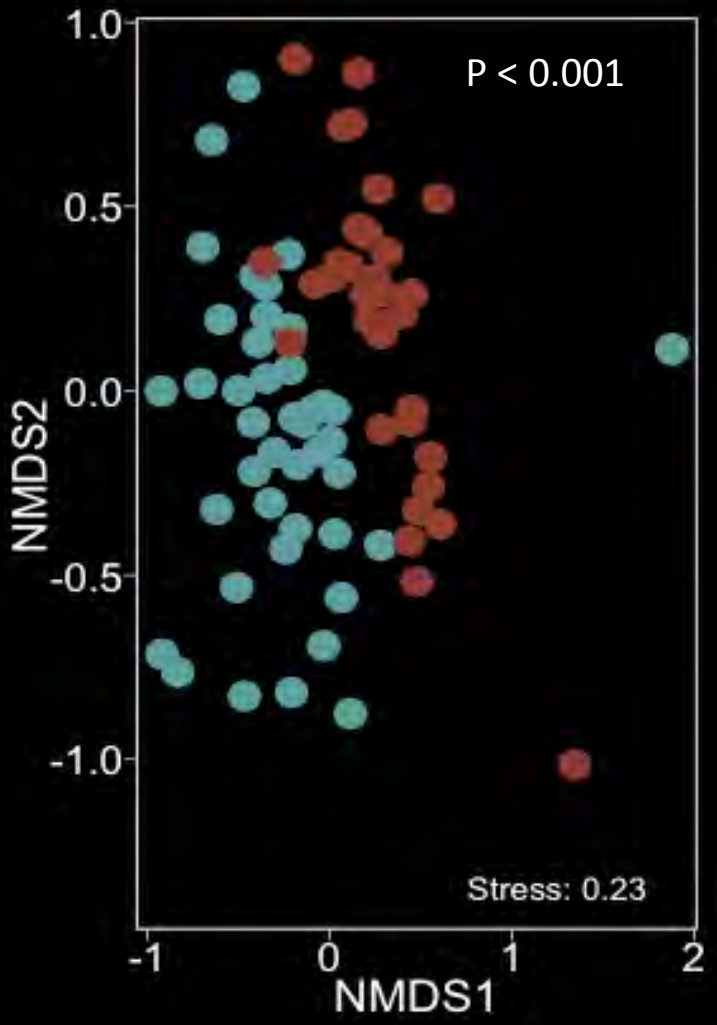
Species richness was similar between months

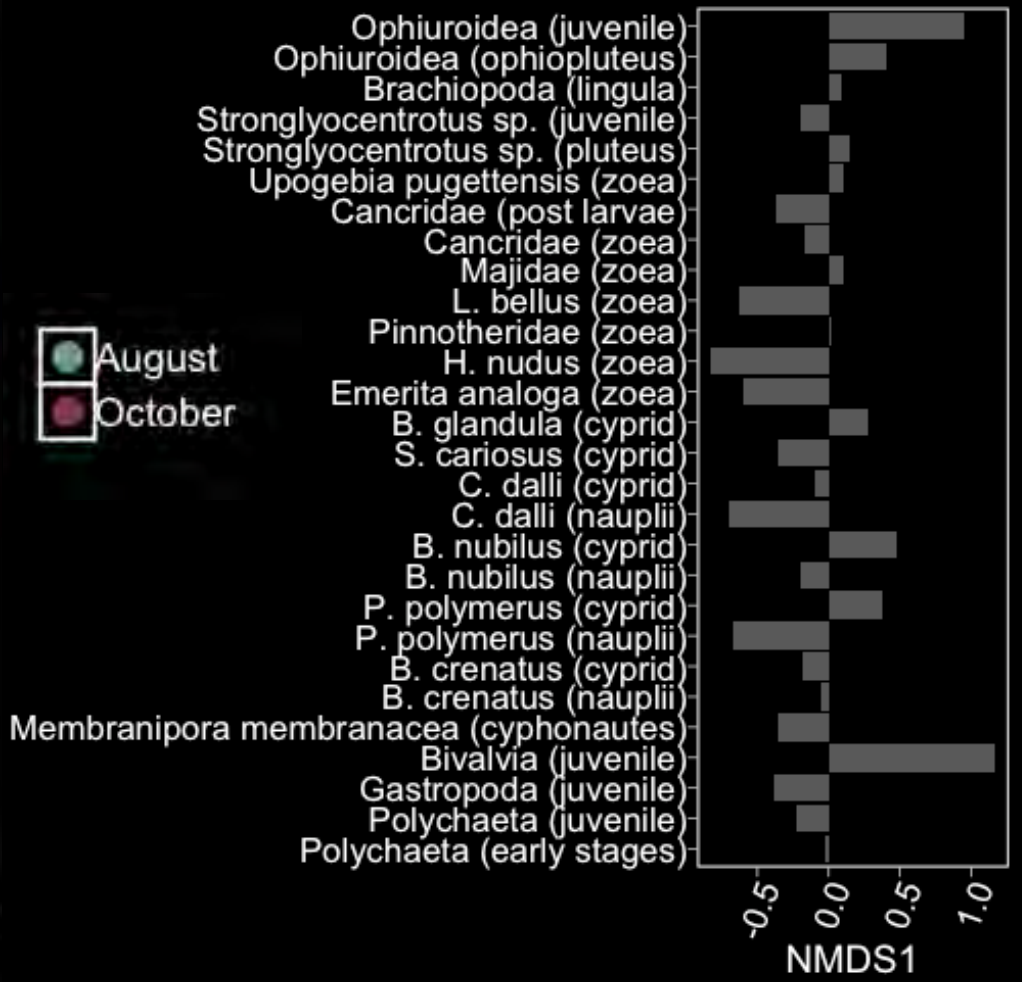


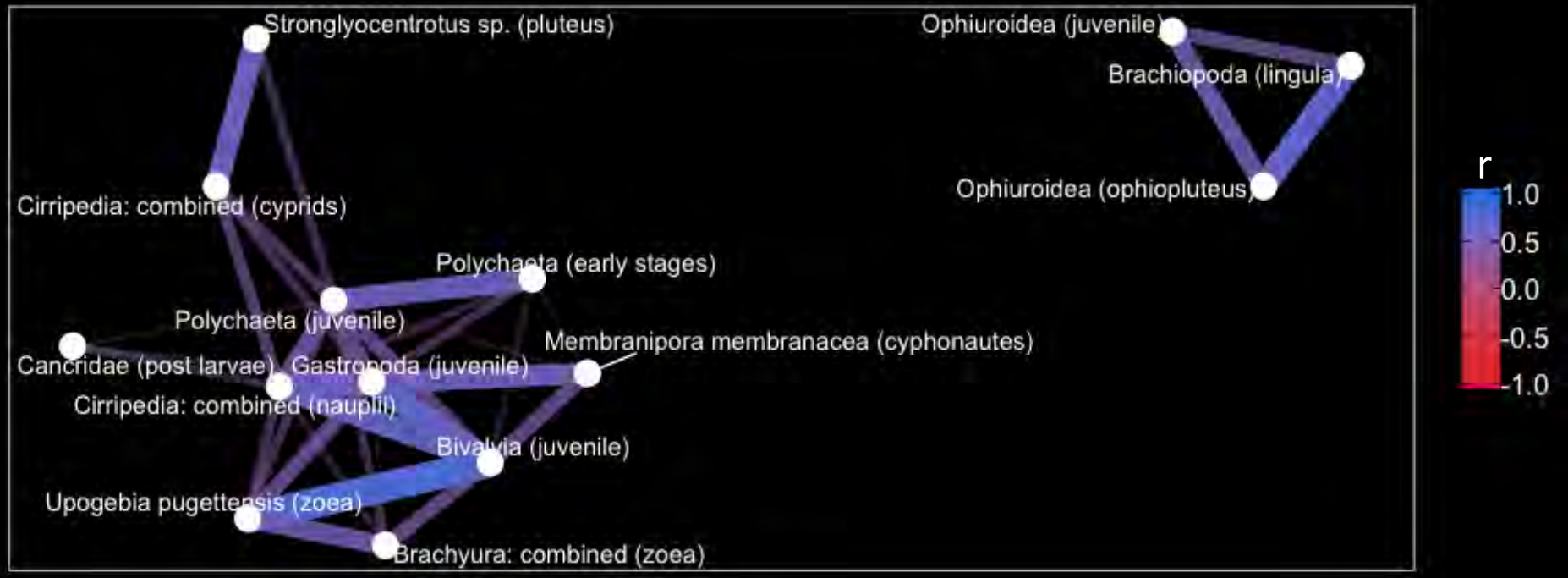
Diversity was **similar** between months



Larval assemblage differed between months






Stronglyocentrotus sp. (pluteus)
Ophiuroidea (juvenile)
Brachiopoda (lingula)
Cirripedia: combined (cyprids)
Ophiuroidea (ophiopluteus)
Polychaeta (early stages)
Polychaeta (juvenile)
Membranipora membranacea (cyphonautes)
Cancridae (post larvae)
Gastropoda (juvenile)
Cirripedia: combined (nauplii)
Bivalvia (juvenile)
Upogebia pugettensis (zoea)
Brachyura: combined (zoea)
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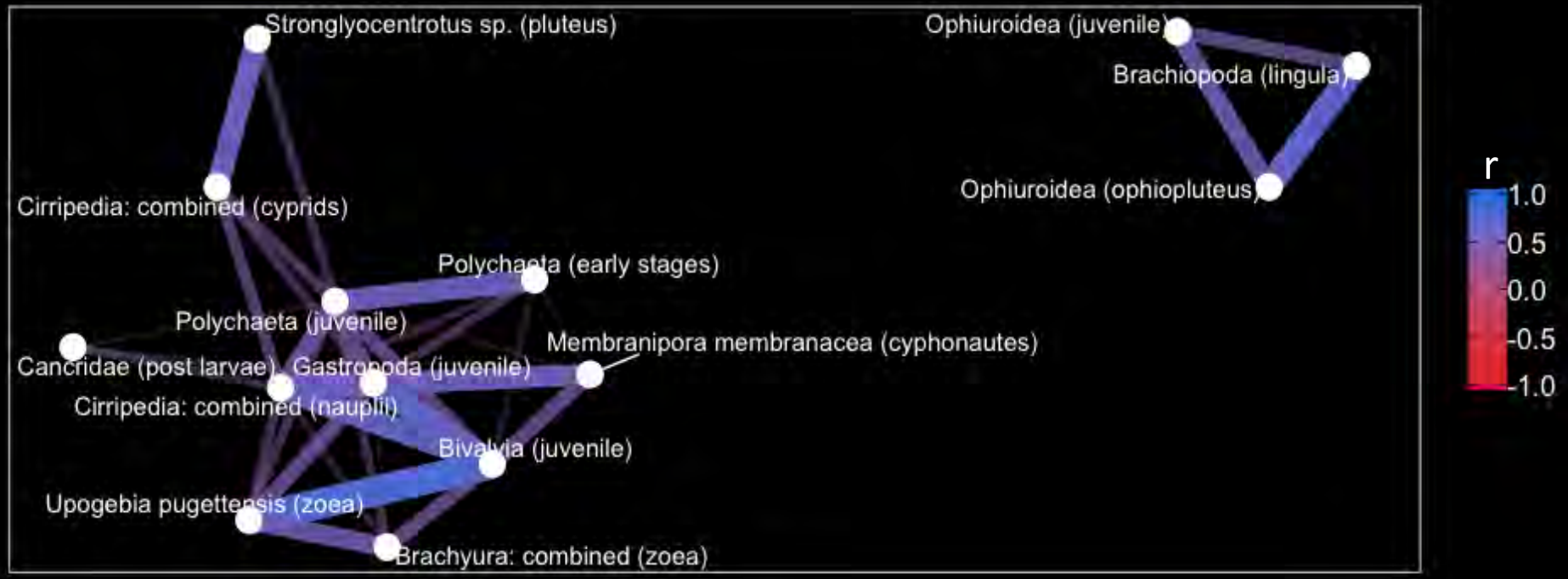
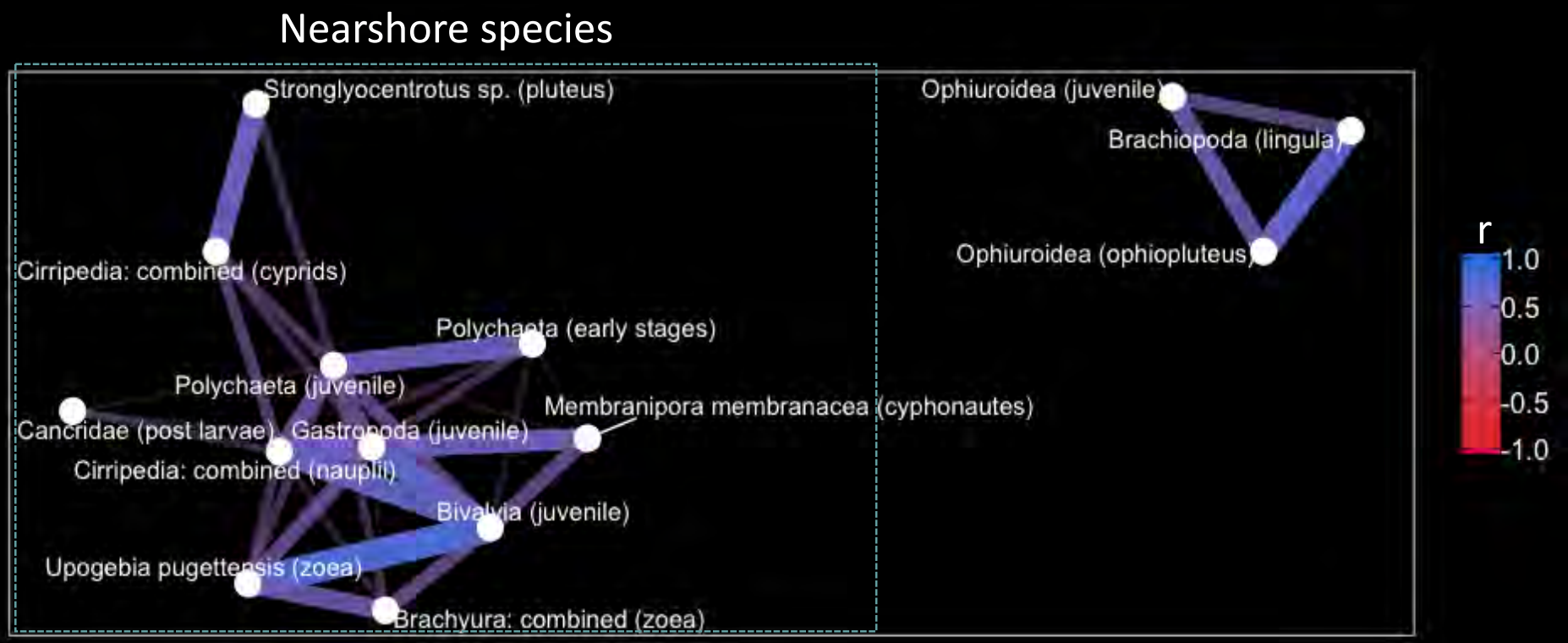
1.0
0.5
0.0
-0.5
-1.0

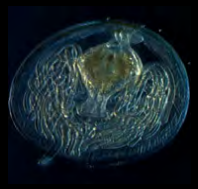
Species correlate by adult habitat distribution



Larvae of nearshore species are correlated to each other



Brachiopods
Brittle stars




Nearshore species

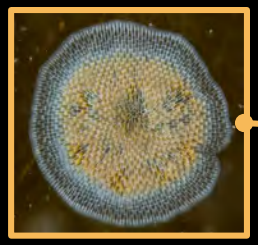


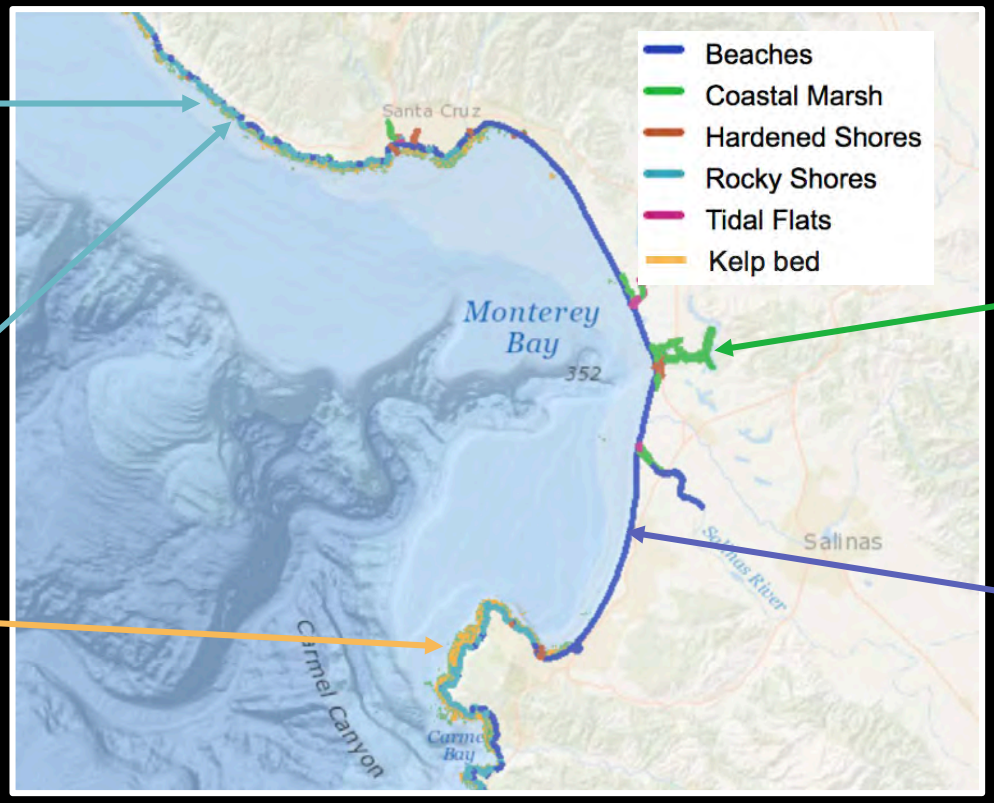





Barnacles
Crabs
Urchins
Mole crabs
Snails
Clams
Bryozoans
Mud shrimp

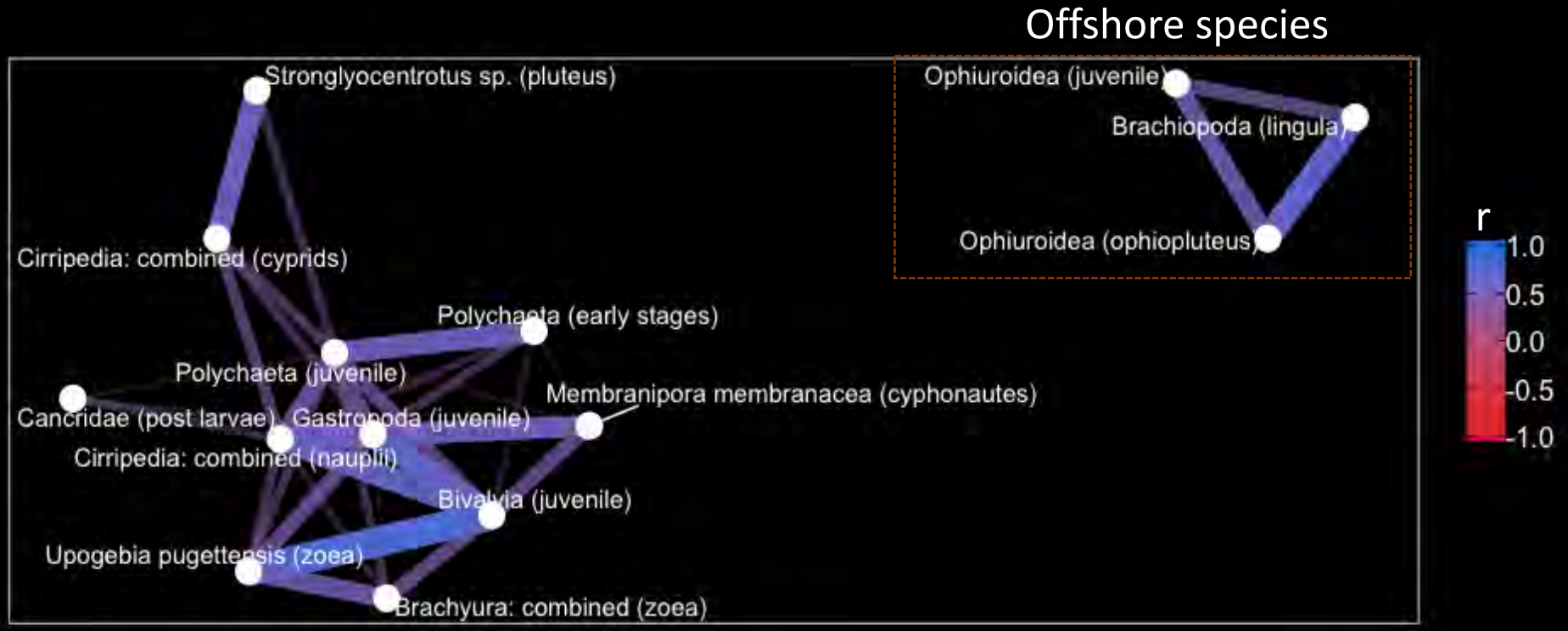
Nearshore species are restricted to the **intertidal** and **coastal** zone





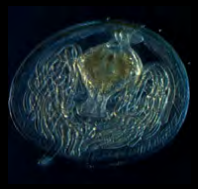
Marine Bios 2018

Larvae of offshore species are correlated to each other



Offshore species

Brachiopods
Brittle stars





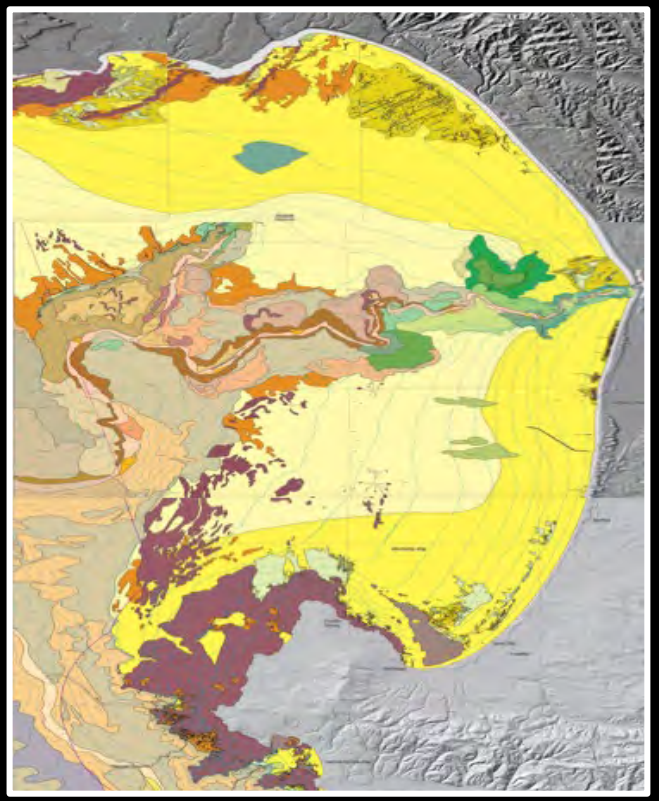






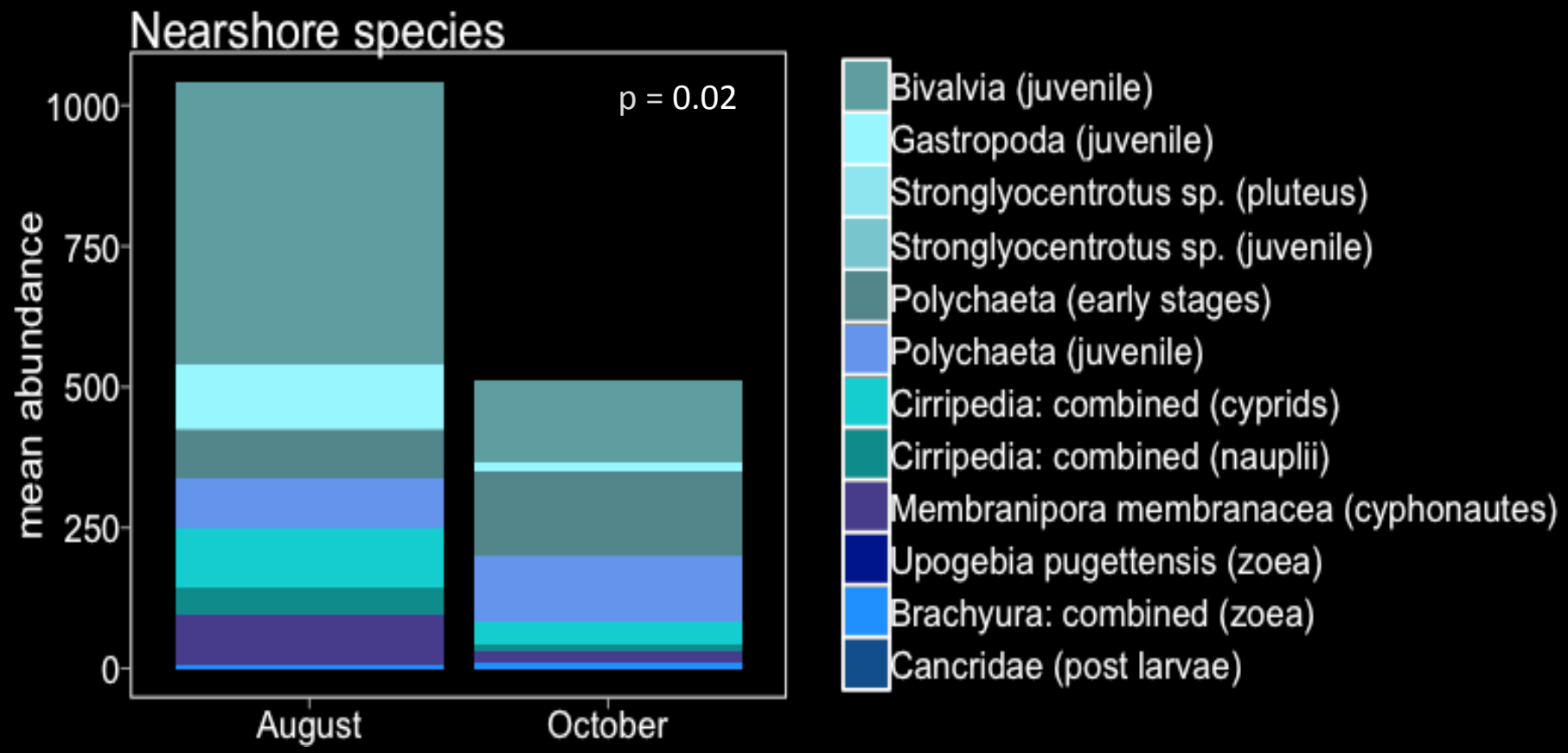
Barnacles
Crabs
Urchins
Mole crabs
Snails
Clams
Bryozoans
Mud shrimp

Offshore species are common in the **deep sea**

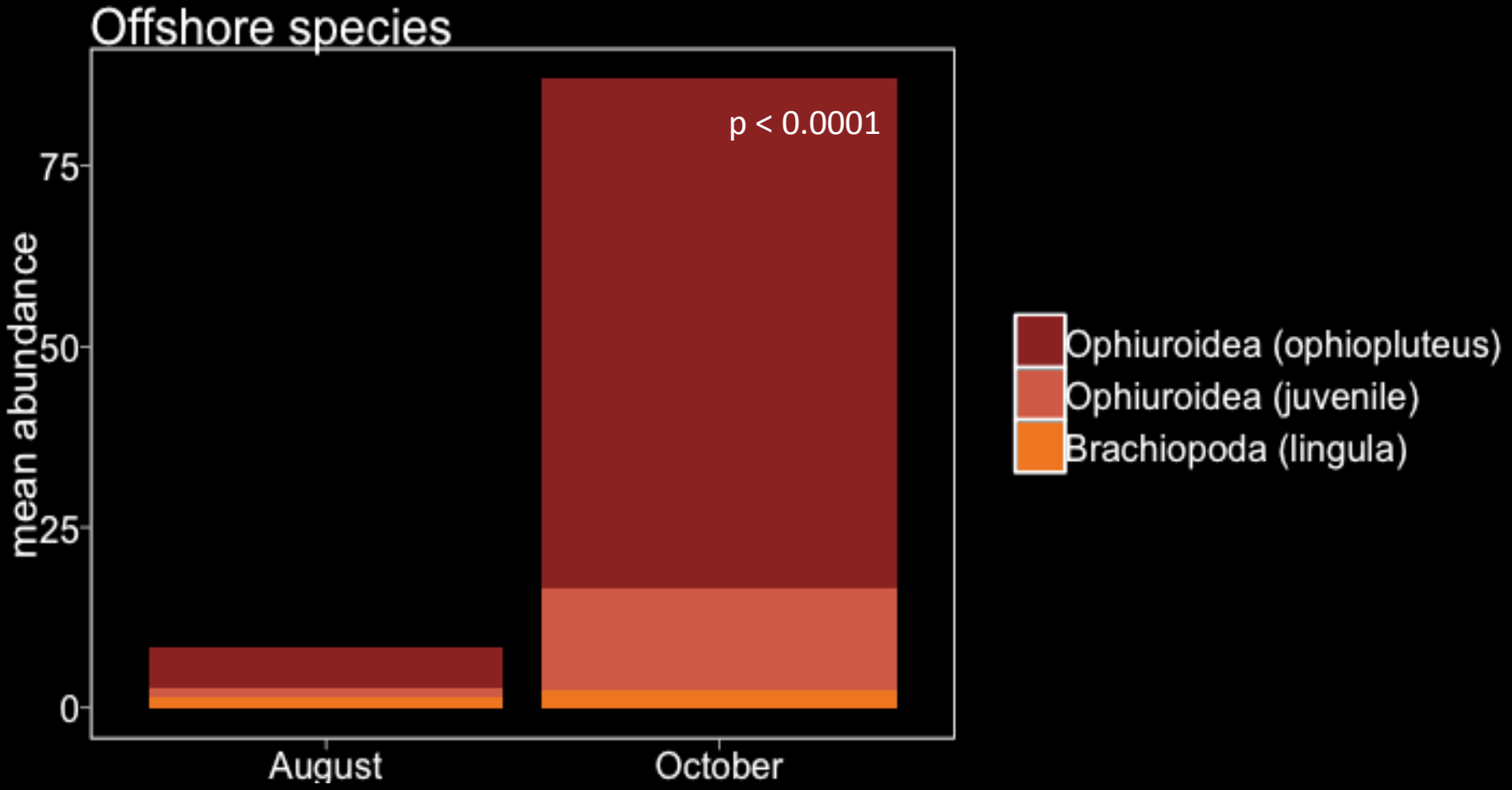


USGS

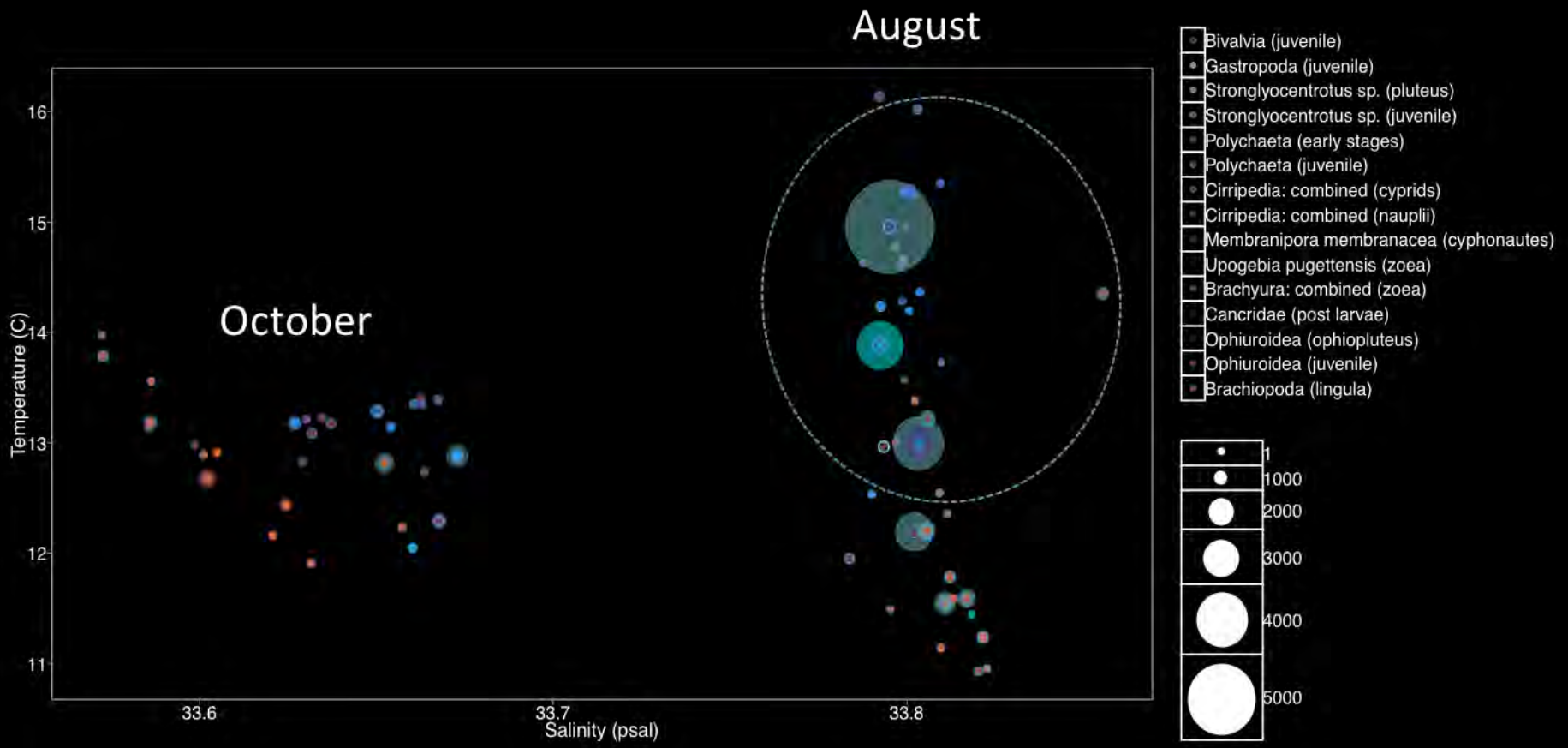
Larvae of nearshore species more abundant in August



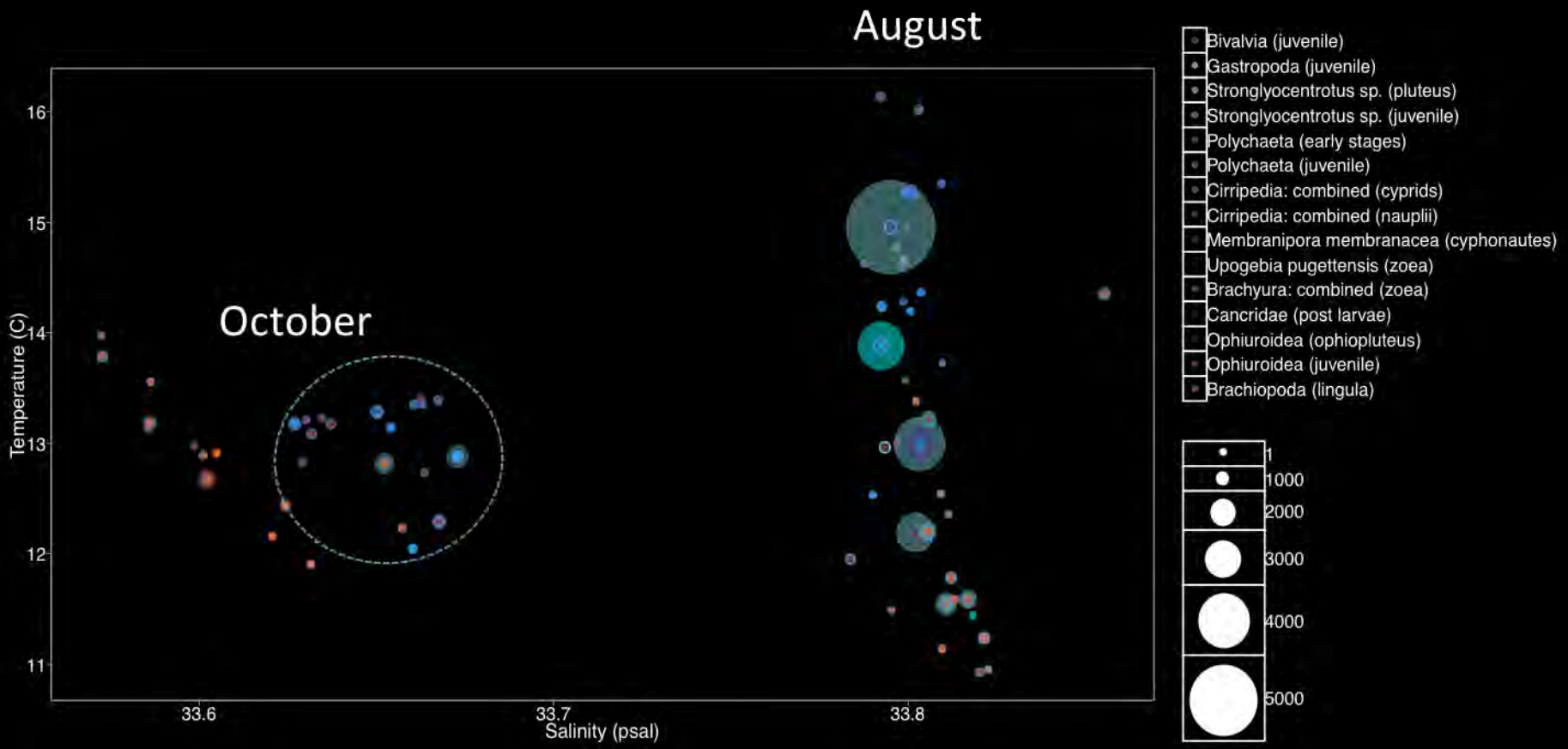
Larvae of offshore species more abundant in October



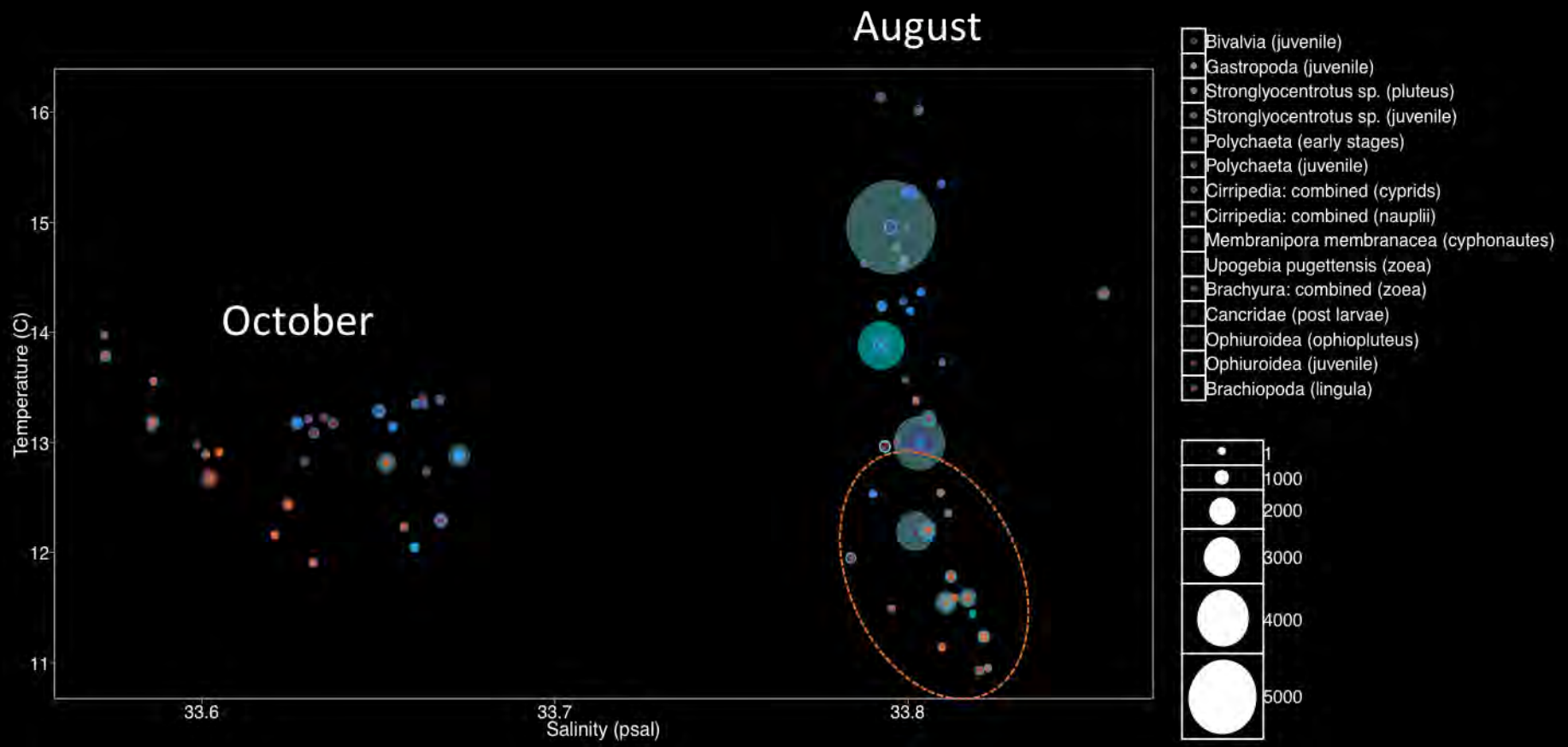
Larvae of nearshore species in warmer, retained water in August



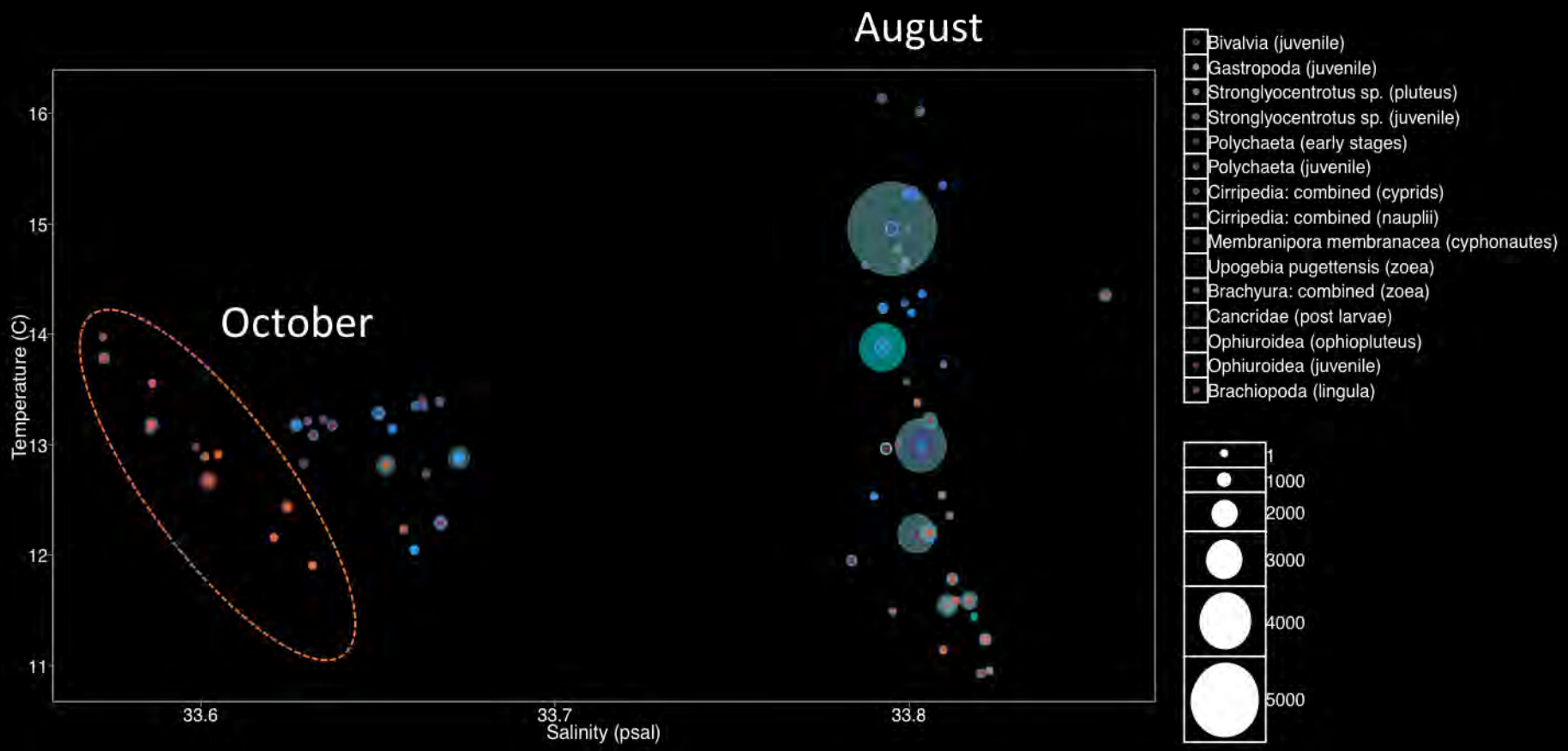
Larvae of nearshore species in inshore, saltier water in October



Larvae of offshore species in cold, upwelled water in August



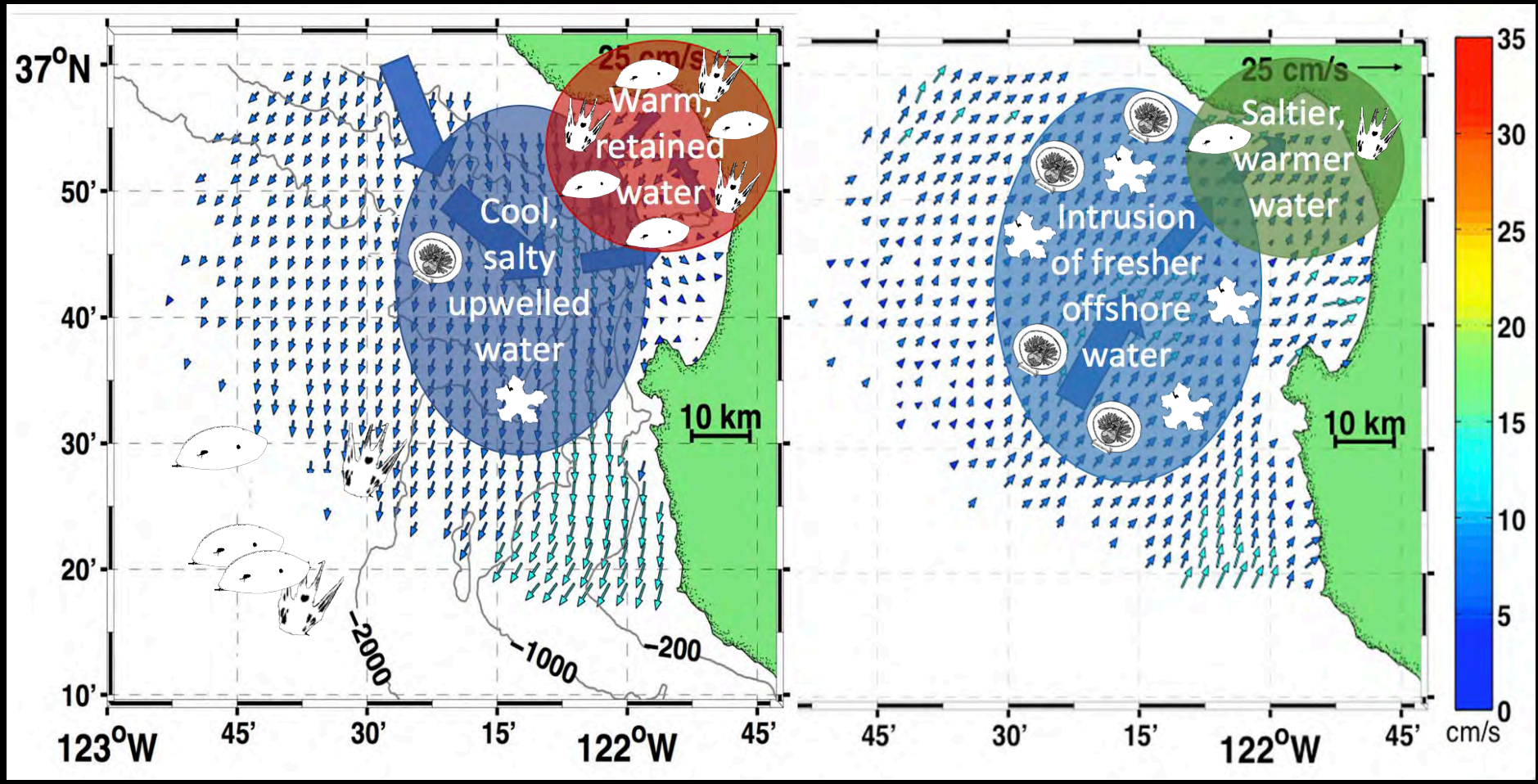
Larvae of offshore species in lowest salinity water in October



Seasonal variation influenced larval assemblage

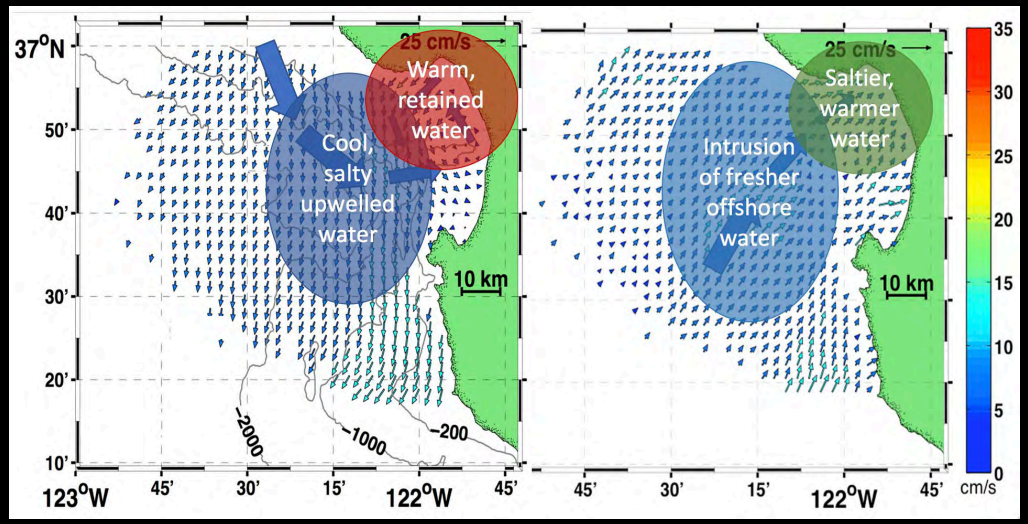
Upwelling (August)

Relaxation (October)



Adult habitat distribution & changing oceanographic conditions influence larval distributions

+



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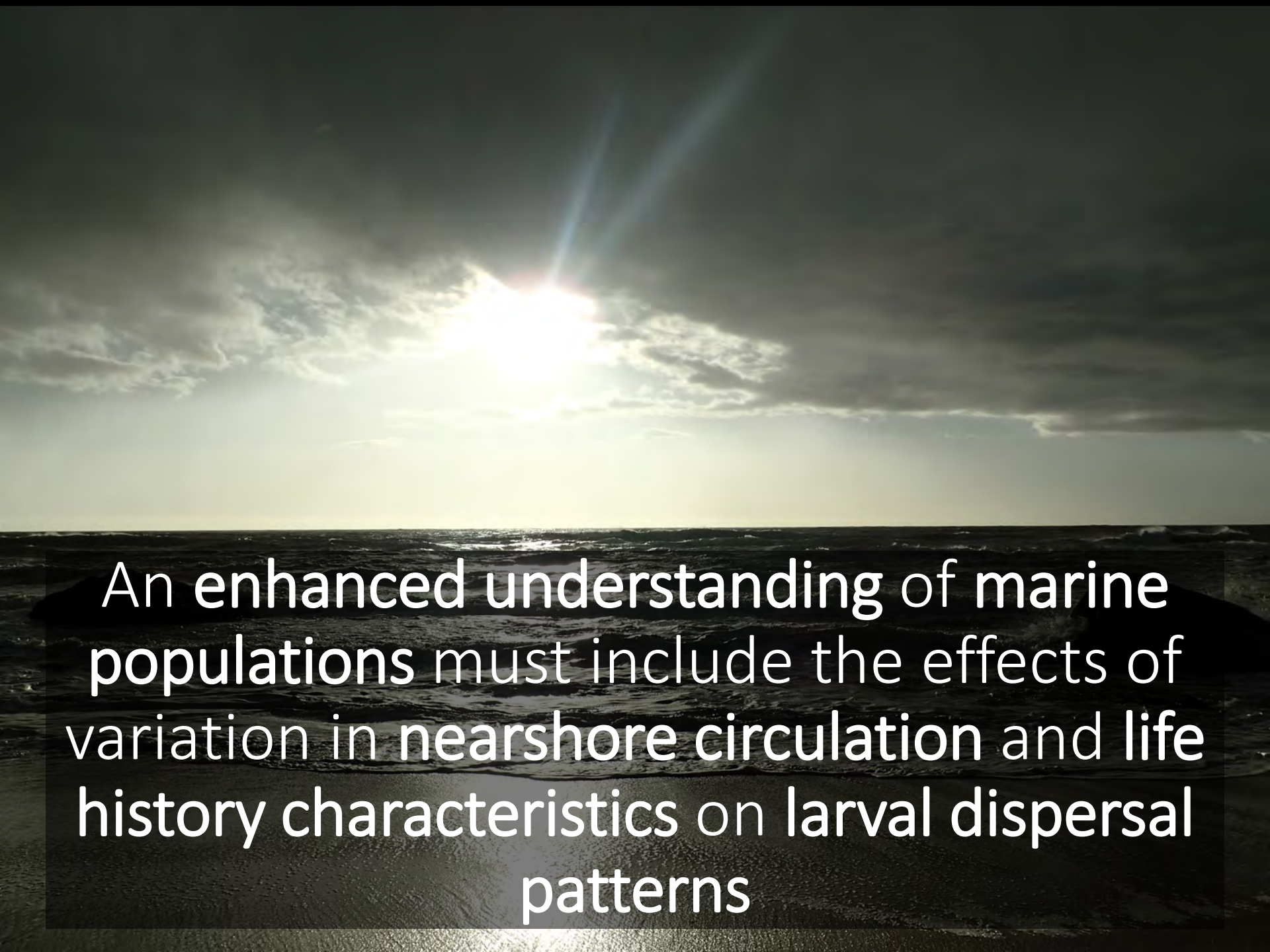
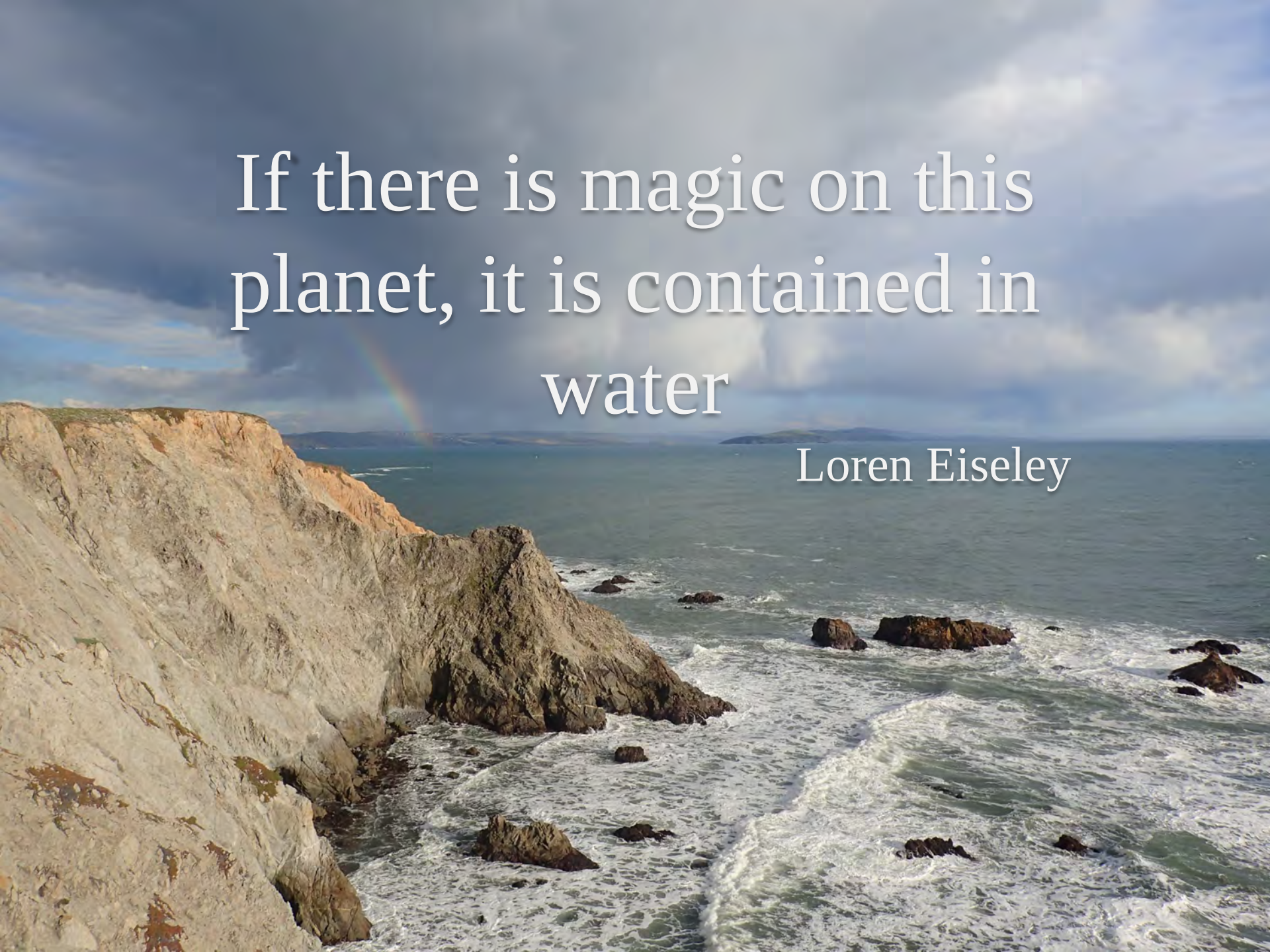
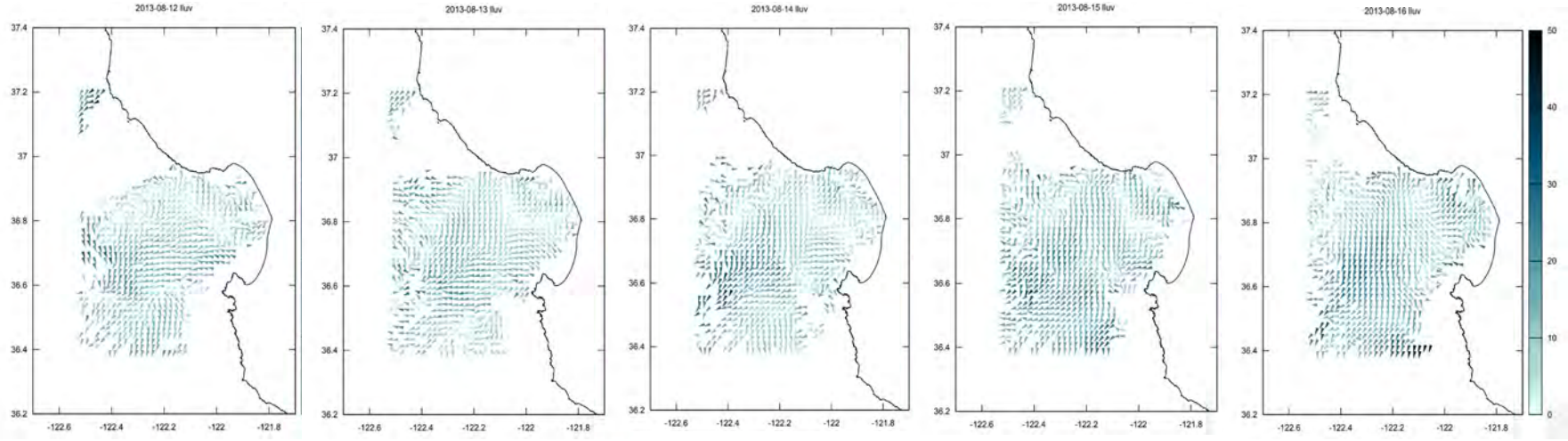
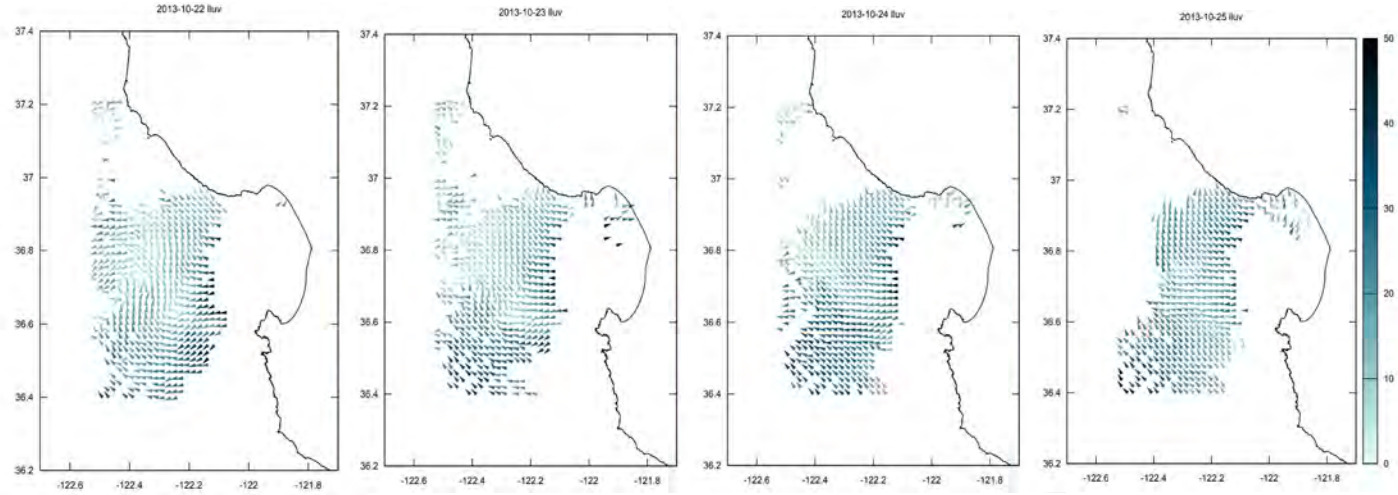

An enhanced understanding of marine populations must include the effects of variation in nearshore circulation and life history characteristics on larval dispersal patterns

Thank you!


If there is magic on this planet, it is contained in water
Loren Eiseley


2013-08-12 Iluv
2013-08-13 Iluv
2013-08-14 Iluv
2013-08-15 Iluv
2013-08-16 Iluv
37.4
37.2
37
36.8
36.6
36.4
36.2
-122.6
-122.4
-122.2
-122
-121.8
50
40
30
20
10
0


2013-10-22 Iluv
2013-10-23 Iluv
2013-10-24 Iluv
2013-10-25 Iluv
37.4
37.2
37
36.8
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36.4
36.2
-122.6
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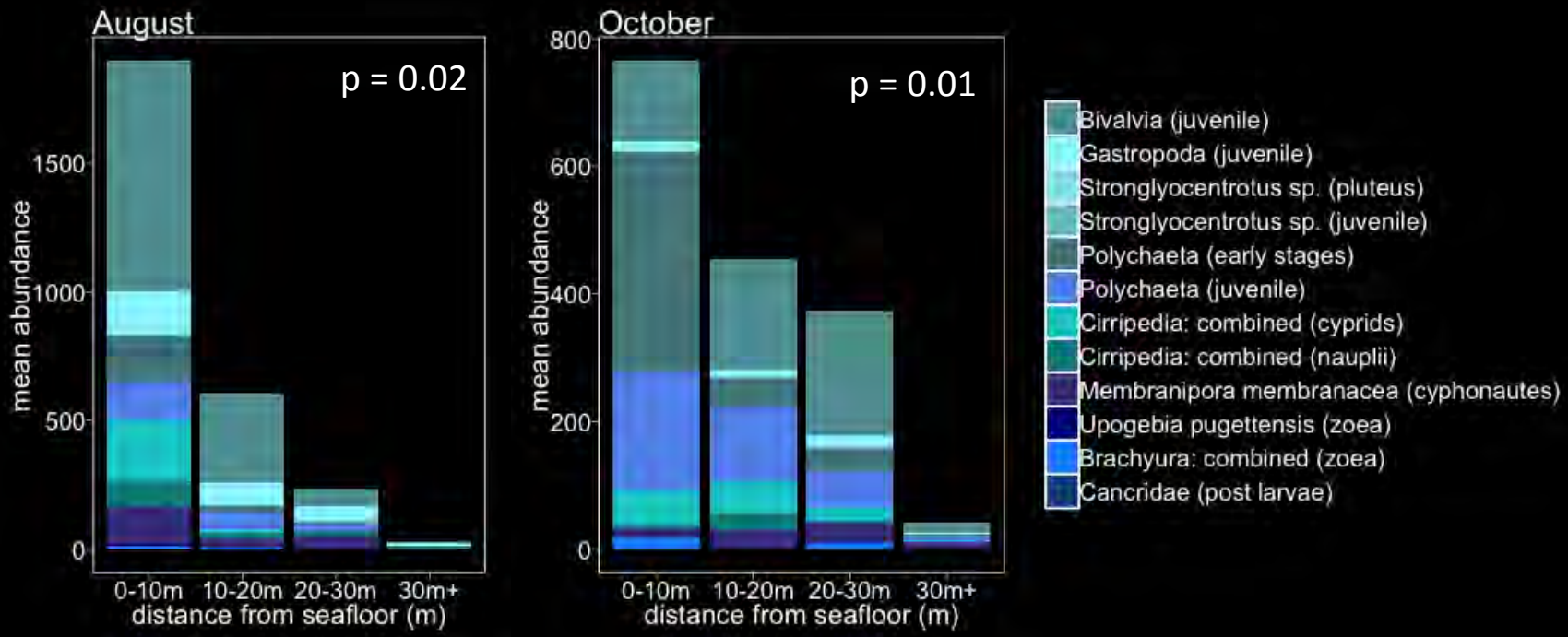
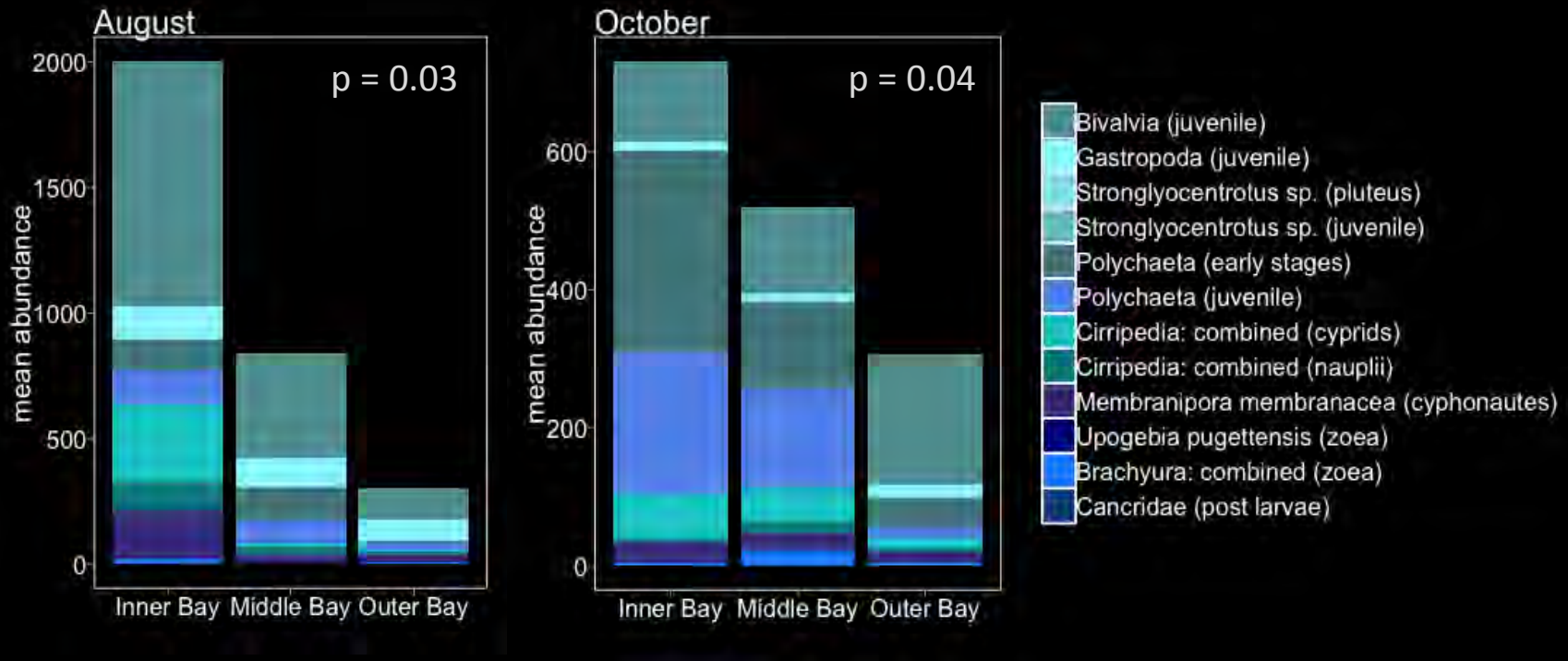
-122.2
-122
-121.8
50
40
30
20
10
0

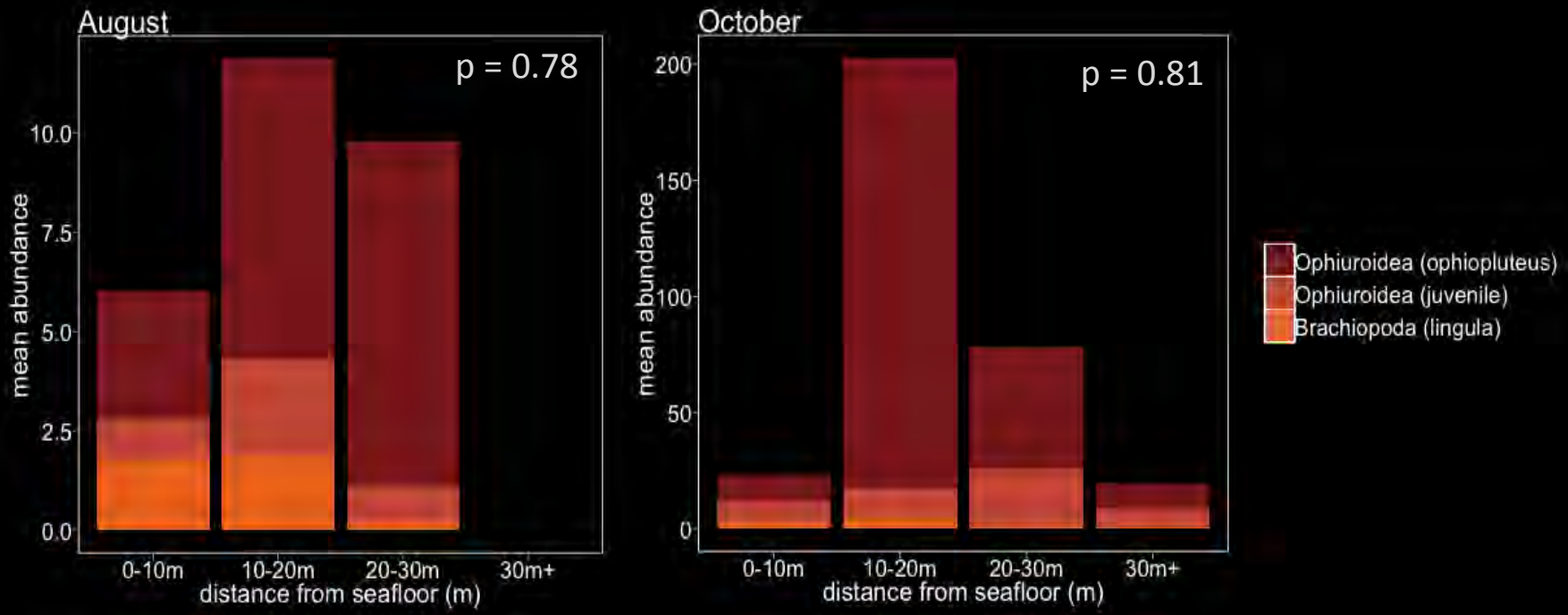
Nearshore species stayed near the bottom



Nearshore species more abundant in the **inner bay** in both months



Offshore species distributed throughout the **water column**



Offshore species more abundant in the **outer bay** in both months