

Results of UW-WDFW Ballast Water Zooplankton Sampling 2001-2014

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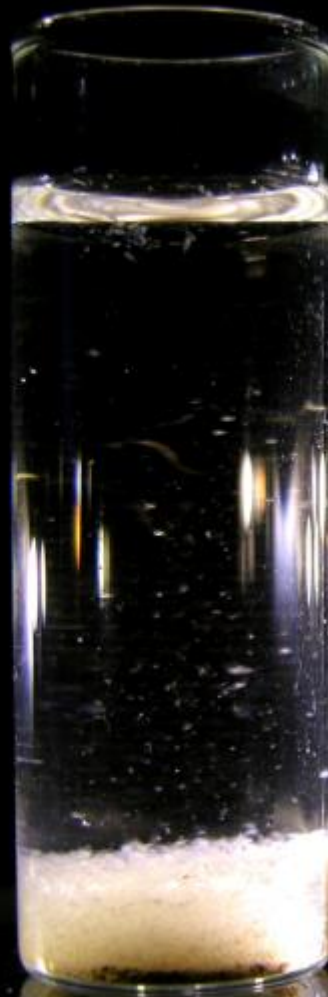
Results from a study funded by the EPA Puget Sound Marine
and Nearshore Grant Program

Ballast Water Exchange

- Almost all ballast discharged into Puget Sound comes from trans-Pacific (Japan, Korea China) or west coast (California, Central and South America) sources
- All ships entering Washington waters are required to conduct ballast water exchange
- 200 nautical miles offshore for trans-Pacific voyages
- 50 nautical miles offshore for coastal voyages
- Exemptions for safety of ship (weather) or ballast from “common waters”
- Most voyages report conducting an exchange (empty-refill of flow-through)

IKAN ACAPULCO #1 SWB-S

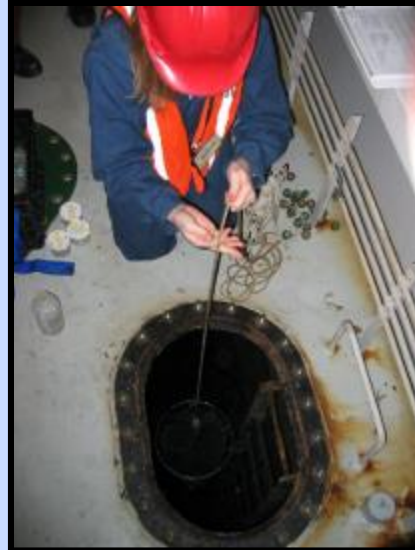
1/22/09 Before Exchange



1/26/09 After Exchange



Sampling Ship's Ballast in Puget Sound



Summary of Sampling

- UW started sampling May 2001; WDFW took over June 2004; samples analyzed through June 2014
- Standard 73 μm mesh plankton net was used—vertical hauls
- We analyzed samples from 816 tanks from ships entering Puget Sound
- Taxa were classified as coastal or oceanic
- When possible, coastal taxa were further classified as to whether or not they were non-indigenous in Puget Sound

Oceanic/Unknown

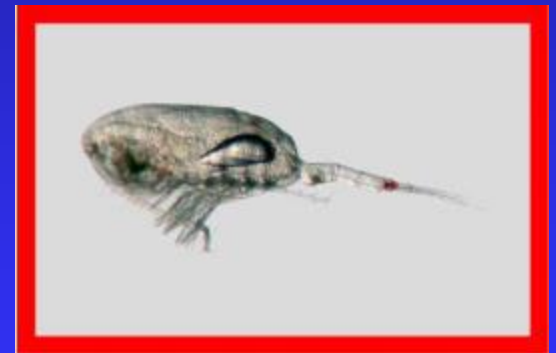
Organisms characteristic open ocean habitats, plus those that can occur in both coastal and oceanic waters. Consist mostly of holoplanktonic copepods.



Calanus



Tortanus



Pseudocalanus

Coastal

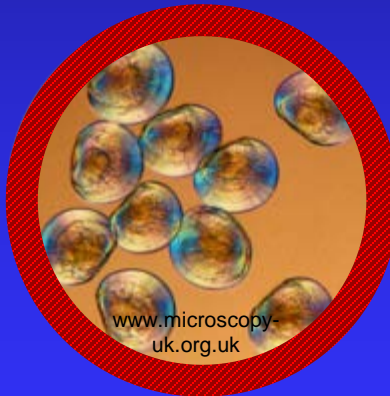
Organisms characteristic of bays and other nearshore habitats are assumed to be non-indigenous when the ballast source is not local. Consists mostly of larval meroplankton that usually cannot be identified to species.



Neomysis



Barnacle
nauplii



Bivalve
larvae



Crab zoea

Non-indigenous (NIS)

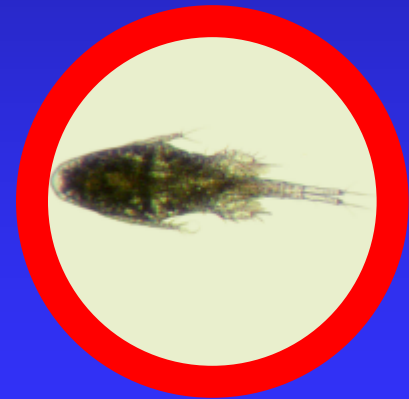
Organisms that are known to be non-indigenous to the west coast of the Pacific Northwest. These can include holoplankton and meroplankton



Oithona davisae



Pseudodiaptomus forbesi



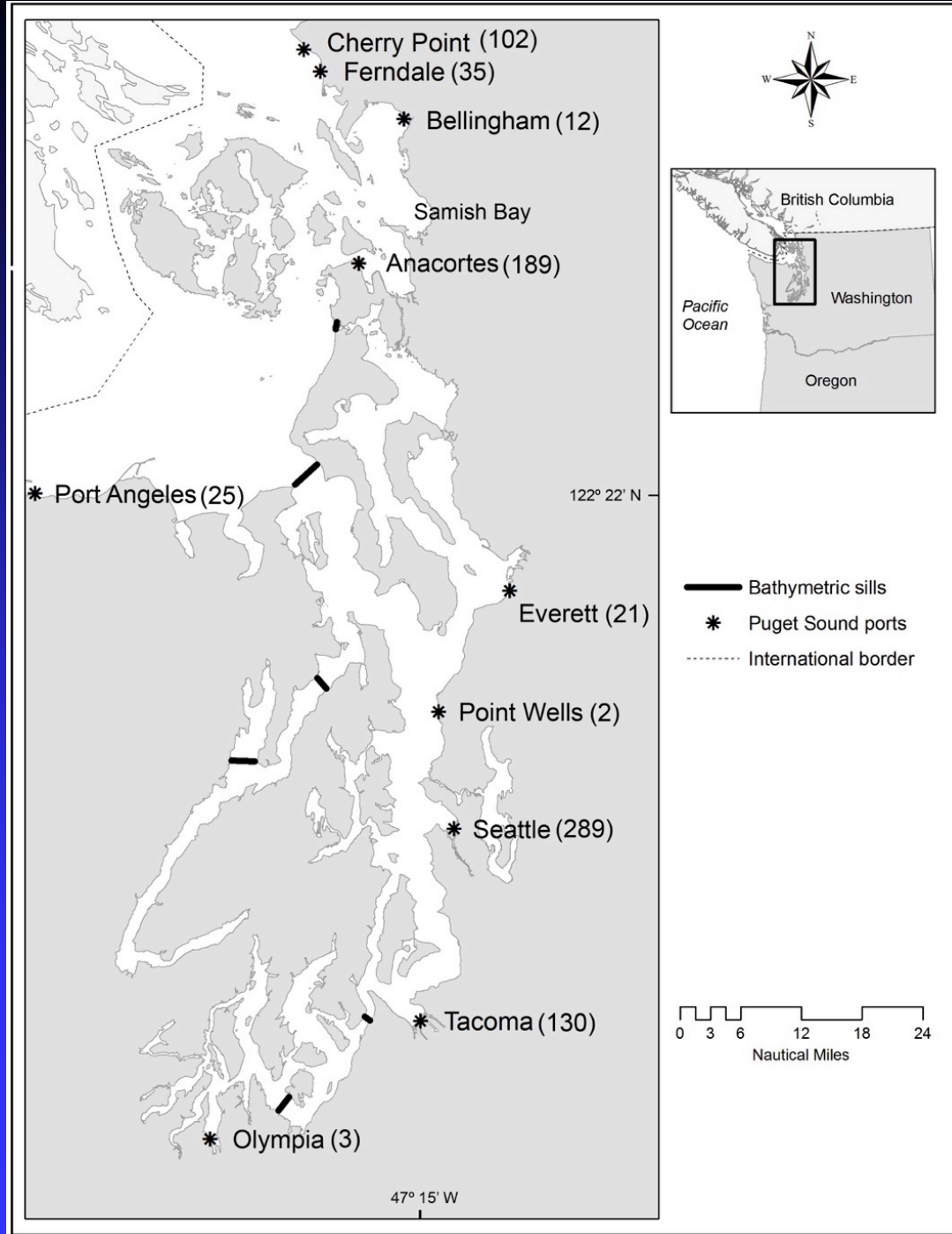
Limnoithona tetraspina

Main Report Elements

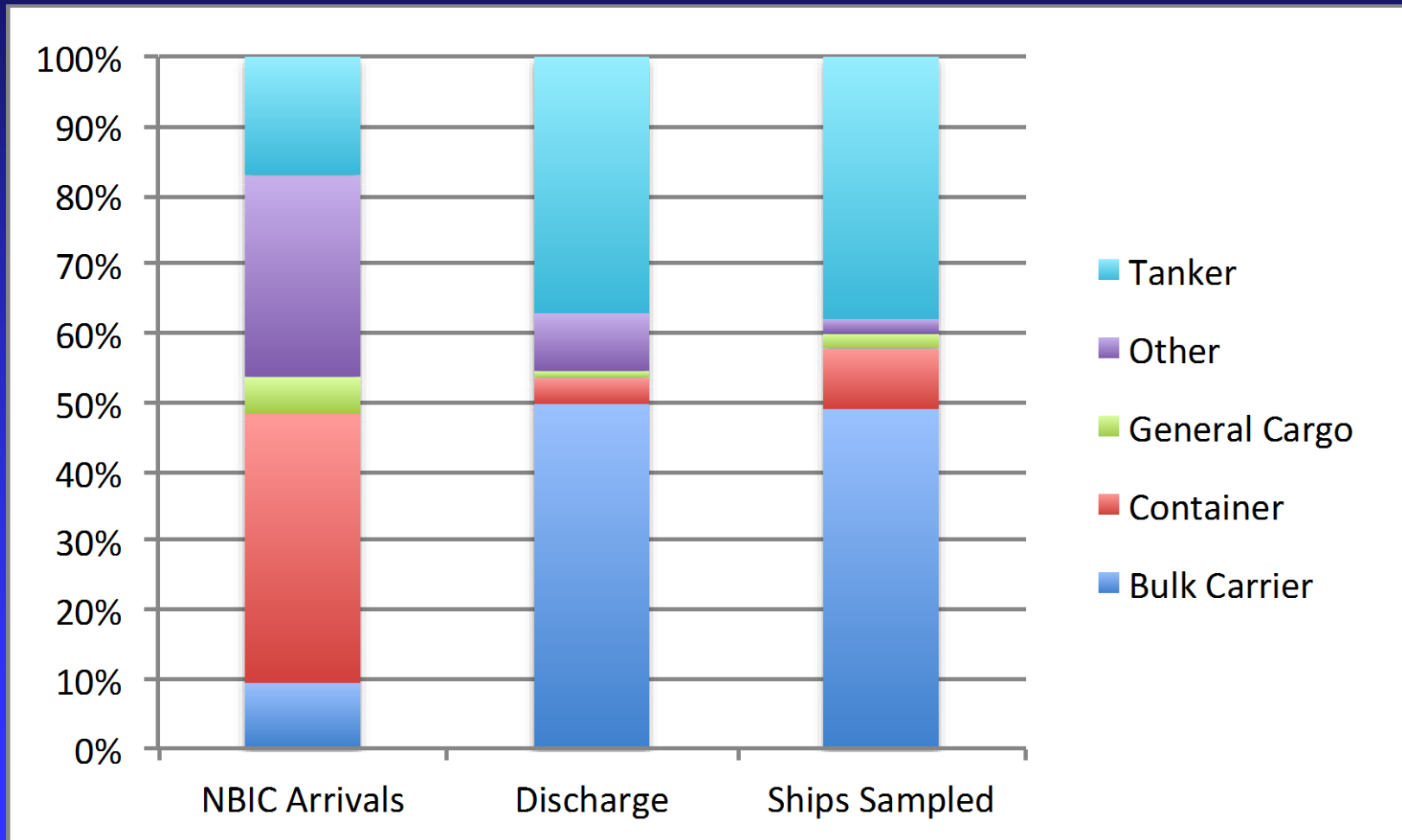
- Ballast Water Age
- BWE Effectiveness
 - By vessel type
 - By ballast origin
 - Over time
- Non-indigenous zooplankton species in Puget Sound
- BWE exchange zooplankton data as a management tool (Allen Pleus)

Sampling Locations and Vessel Types

Ballast sampling 2001-2014—Sampling sites, number of ships sampled, and location of Puget Sound sills

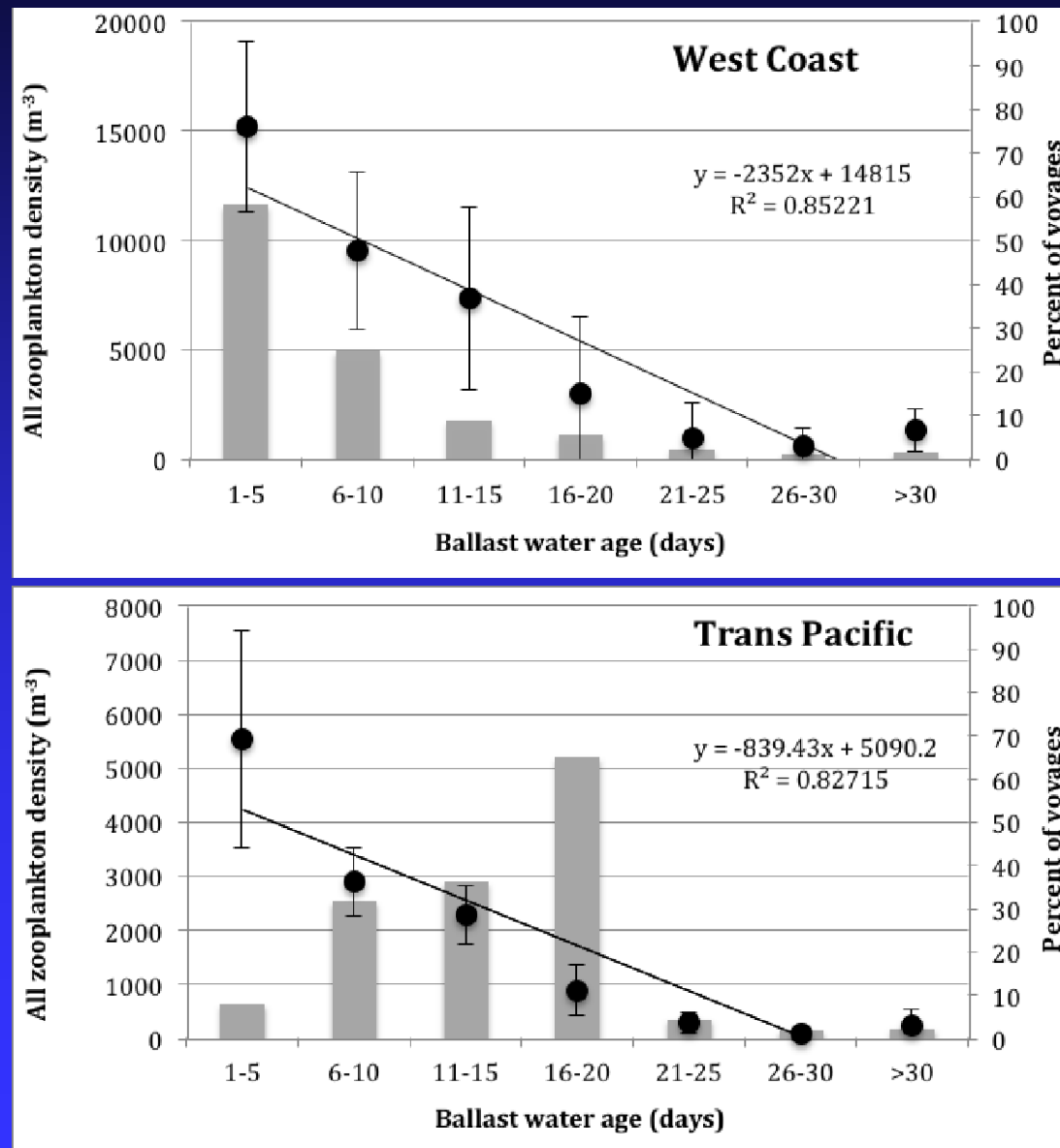


Percent composition of major ship types arriving in Puget Sound 2004-2014 (NBIC data) compared to tanks sampled (816) during the same time period



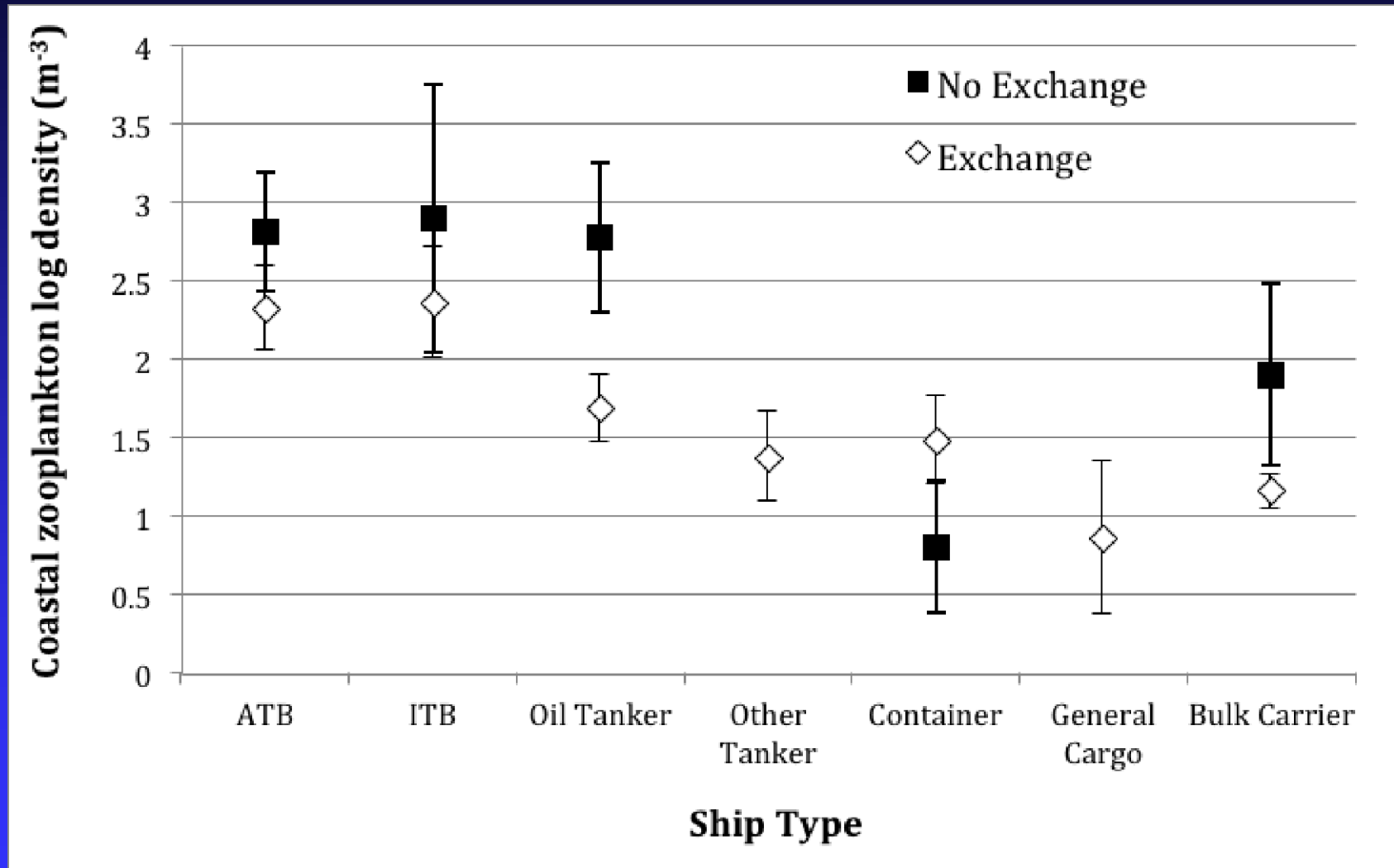
Ballast Water Age

Ballast water age: Mean densities of total zooplankton for trans Pacific and west coast trips



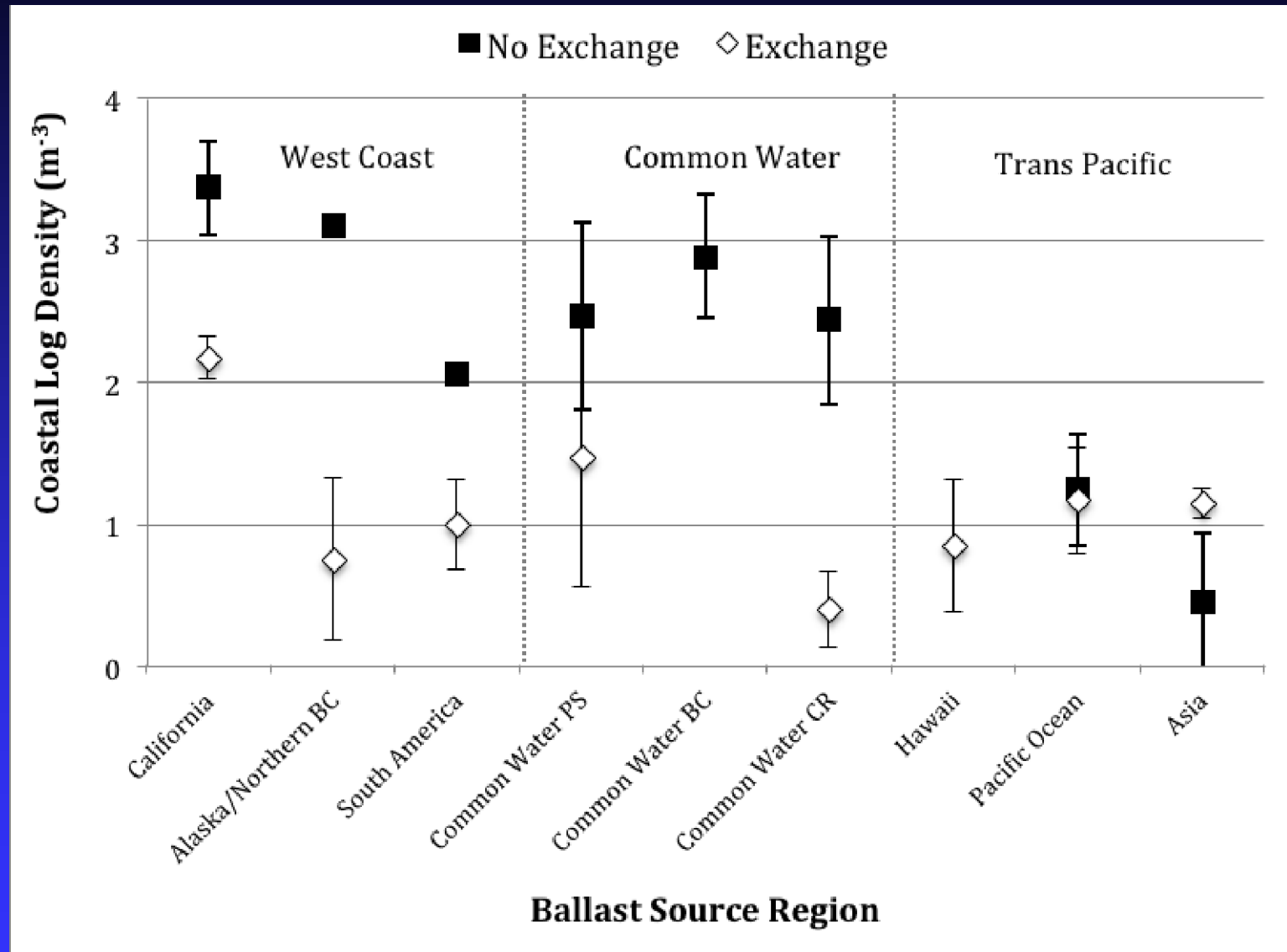
Ballast Water Exchange

BWE by vessel type—all coastal plankton



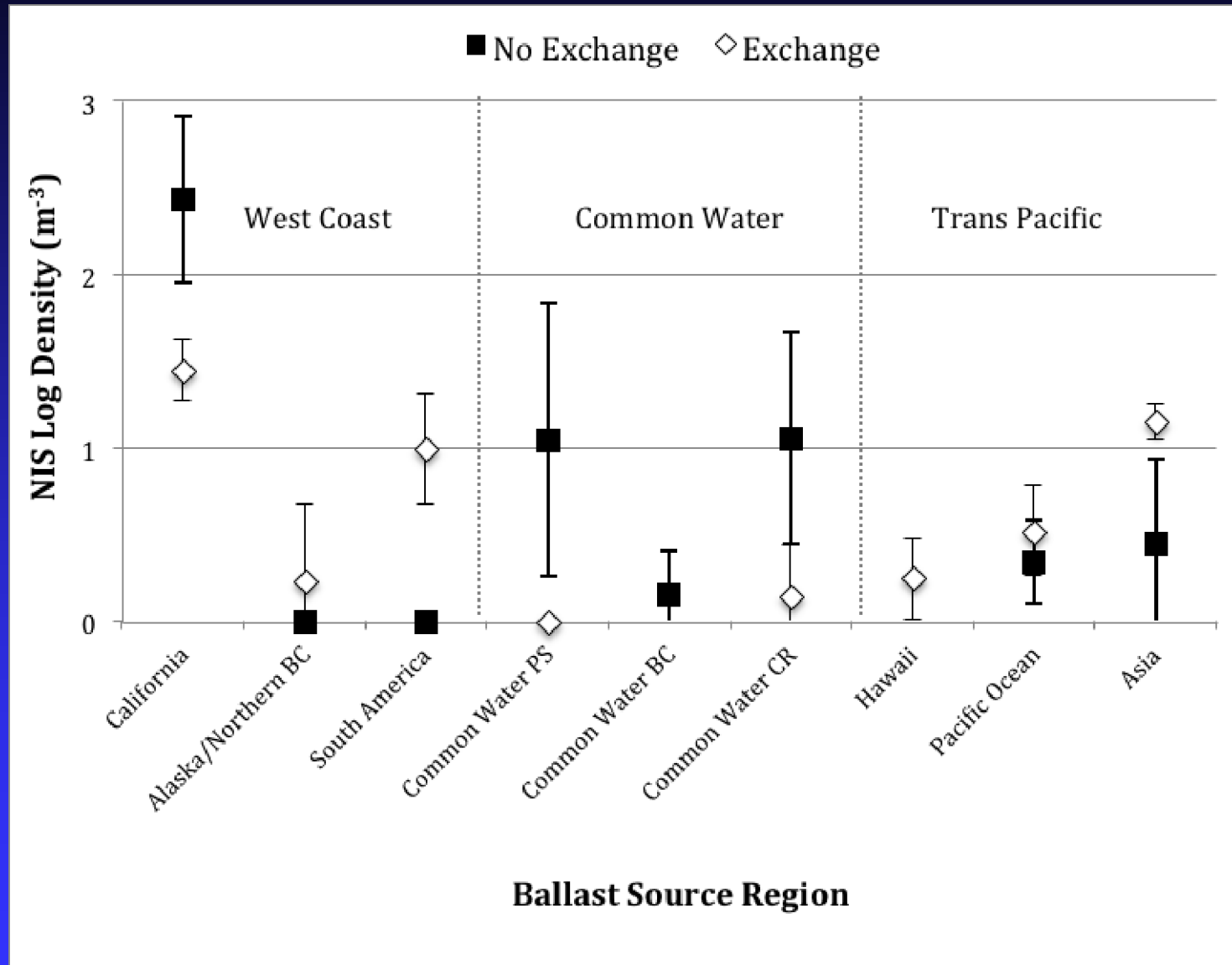
Average densities of all coastal zooplankton from exchanged and un-exchanged tanks by vessel type; error bars are 95% confidence intervals

BWE by source region—all coastal plankton



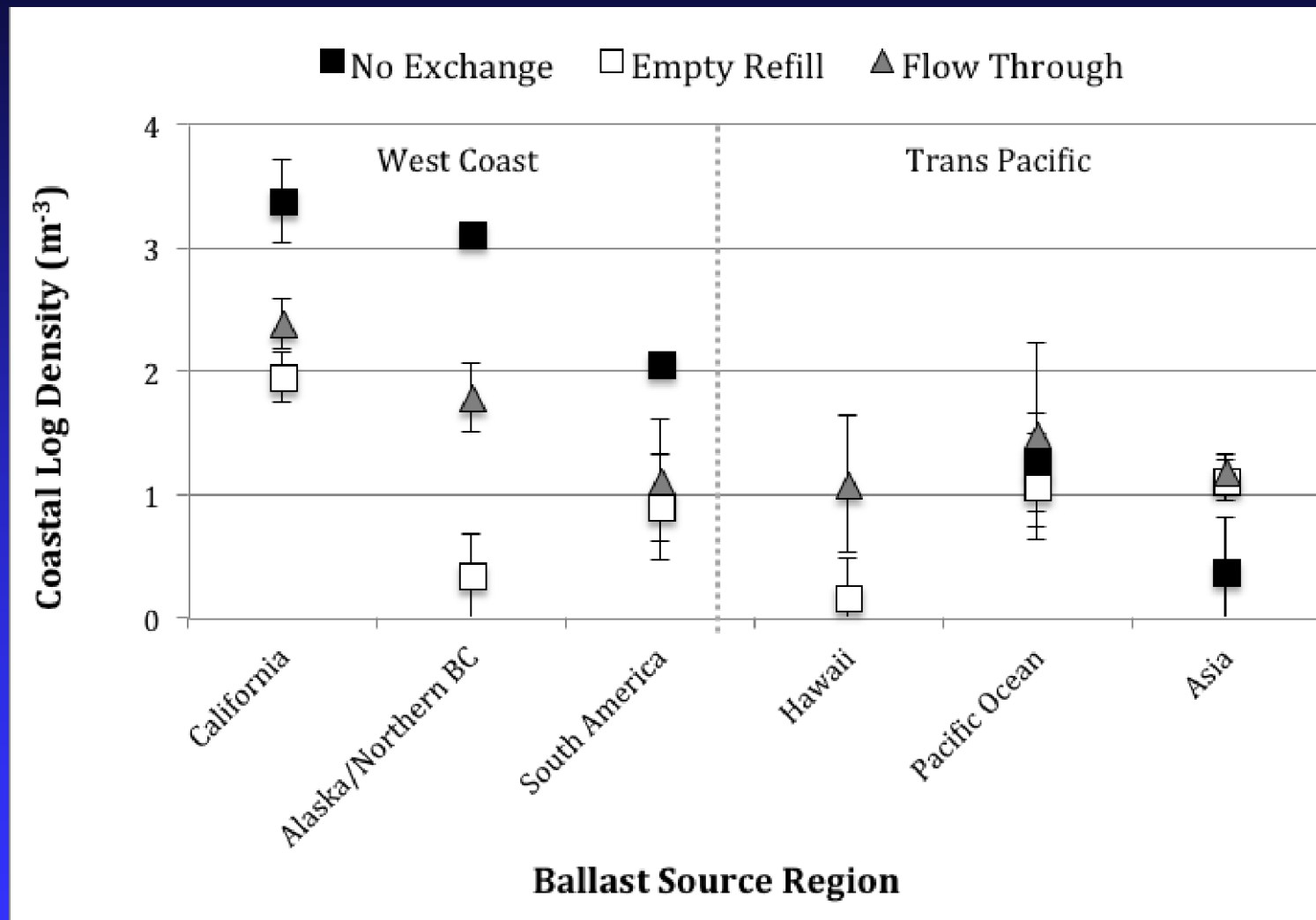
Average densities of all coastal zooplankton from exchanged and un-exchanged tanks by source region; error bars are 95% confidence intervals

BWE by source region—NIS only plankton



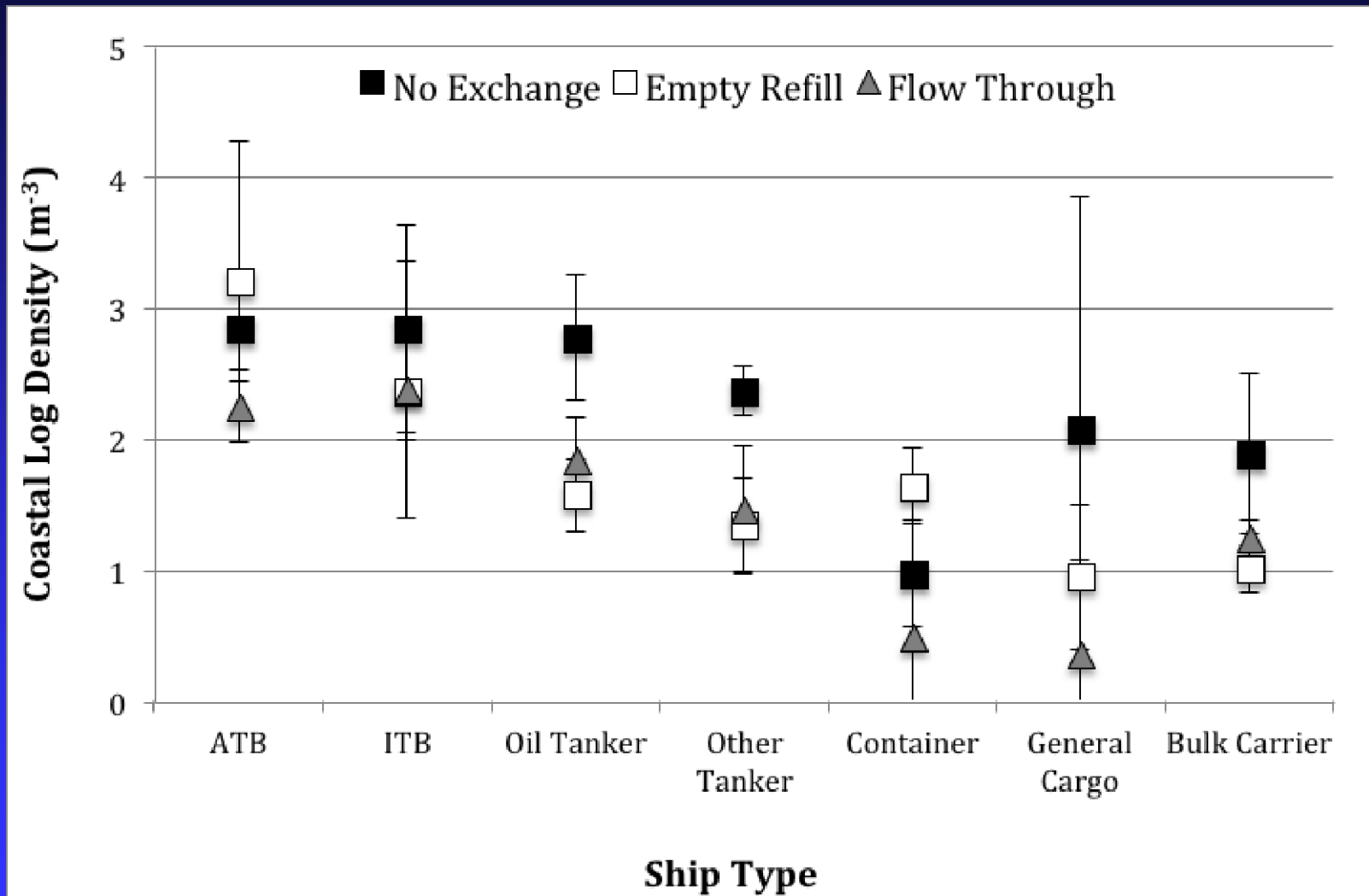
Average densities of NIS zooplankton from exchanged and un-exchanged tanks by source region; error bars are 95% confidence intervals

BWE by exchange method and source region— all coastal plankton



Average densities of all coastal zooplankton between the two ballast water exchange methods by source region.

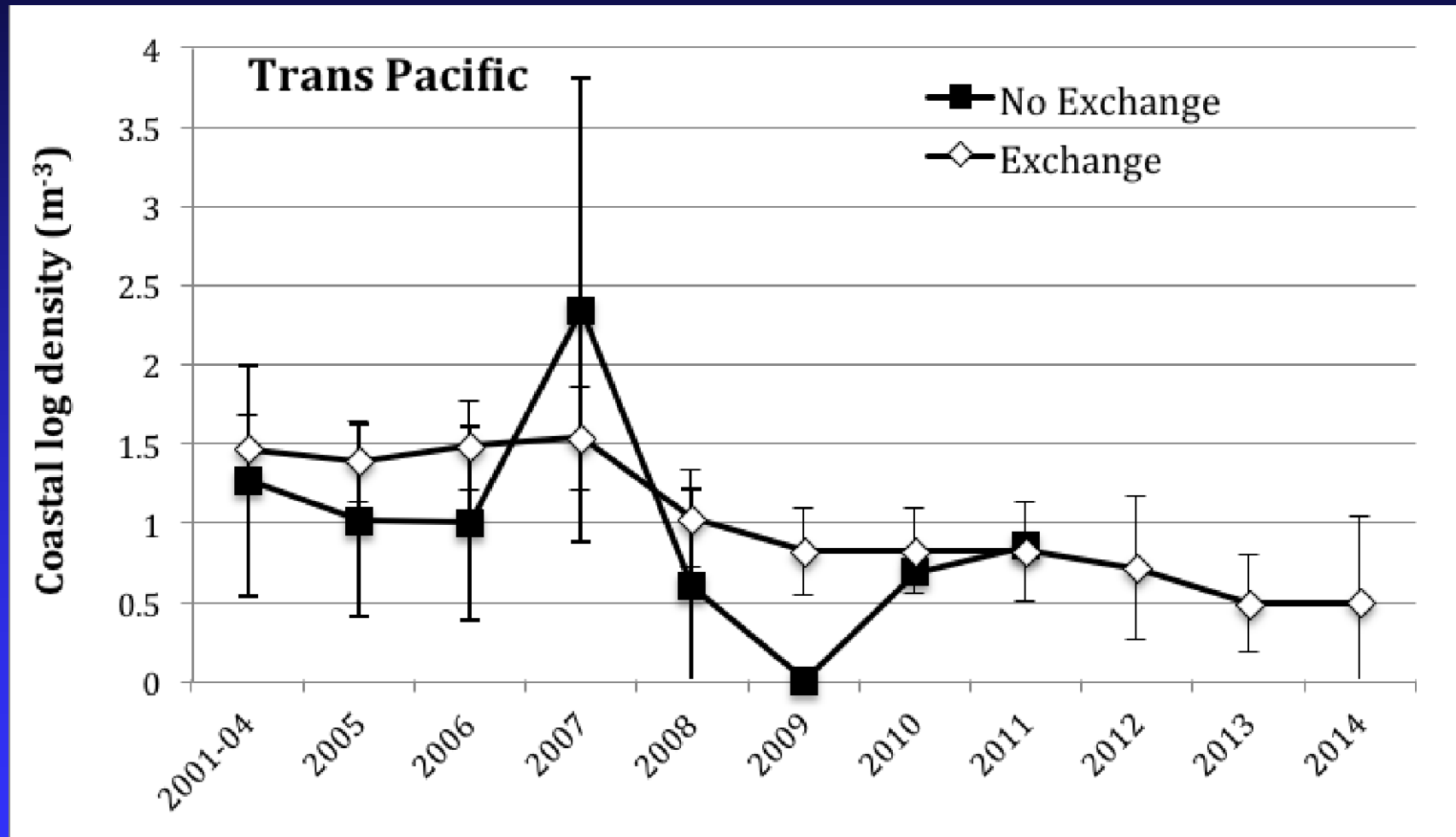
BWE by exchange method and vessel type—all coastal plankton



Average densities of all coastal zooplankton between the two ballast water exchange methods by vessel type.

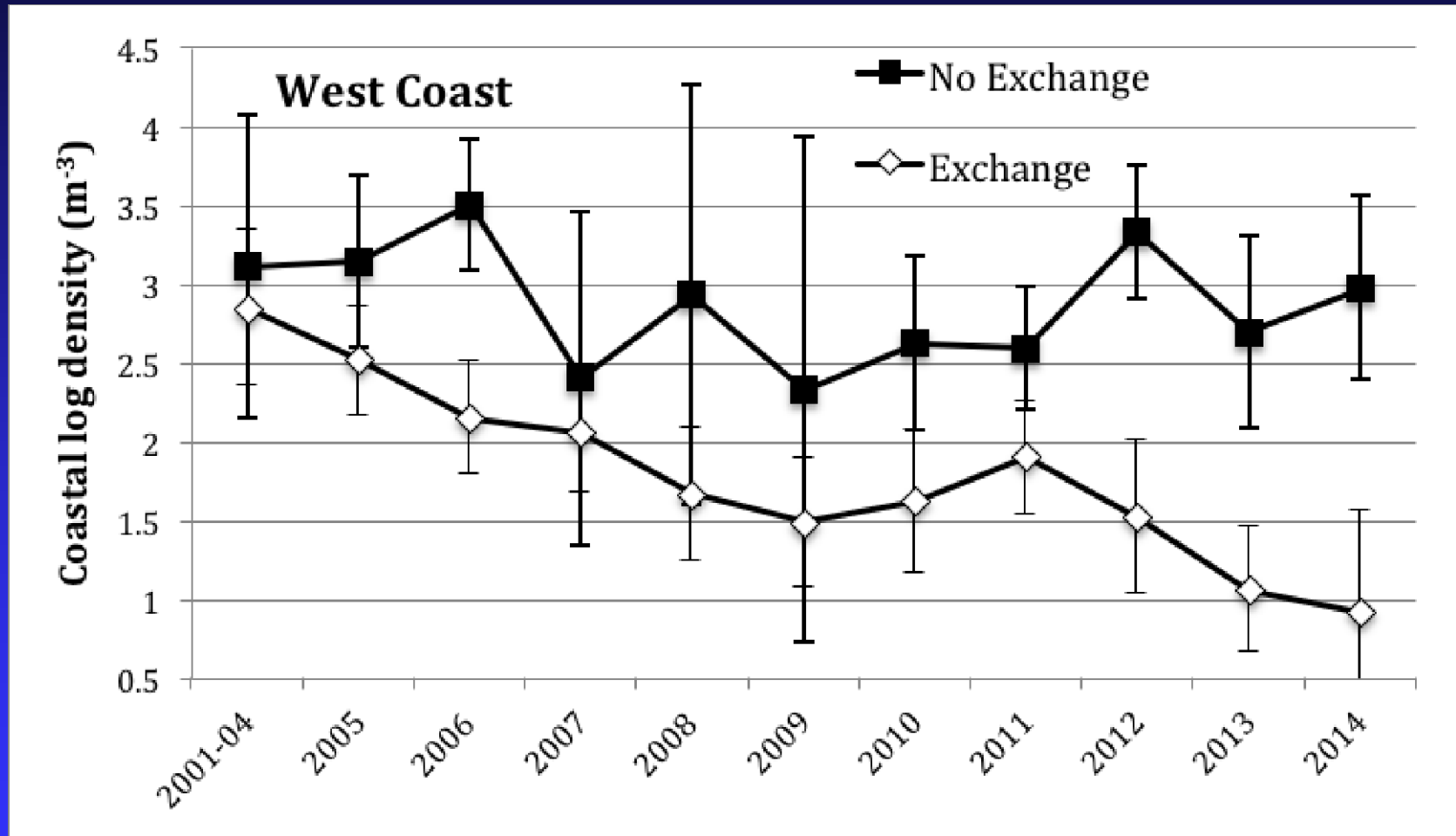
BWE Effectiveness Over Time

Coastal plankton densities by year for Trans-Pacific trips



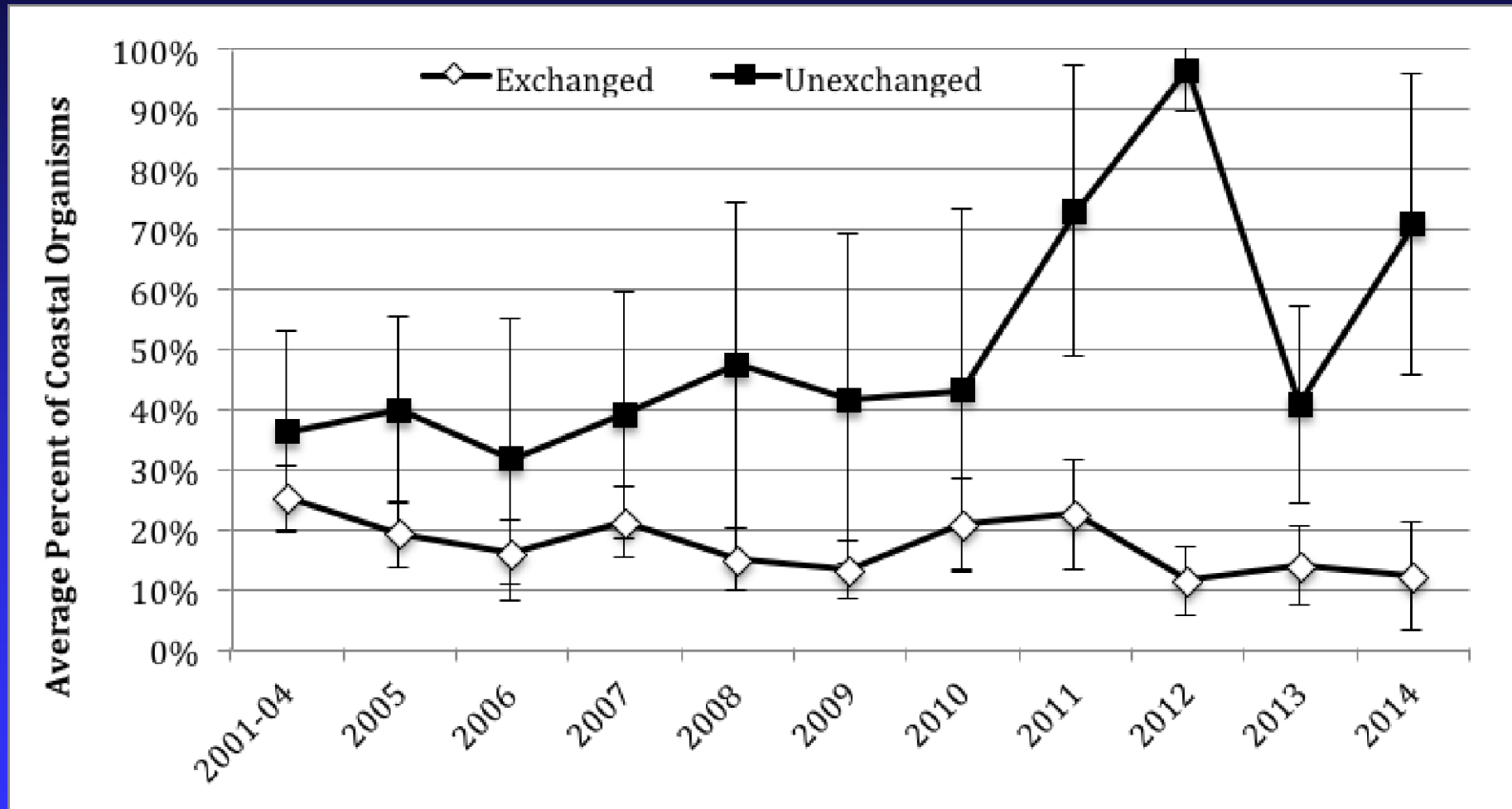
Average log 10 transformed densities of coastal zooplankton in ballast tanks by year for Trans-Pacific and California sources for vessels that conducted BWE.

Coastal plankton densities by year for West Coast trips



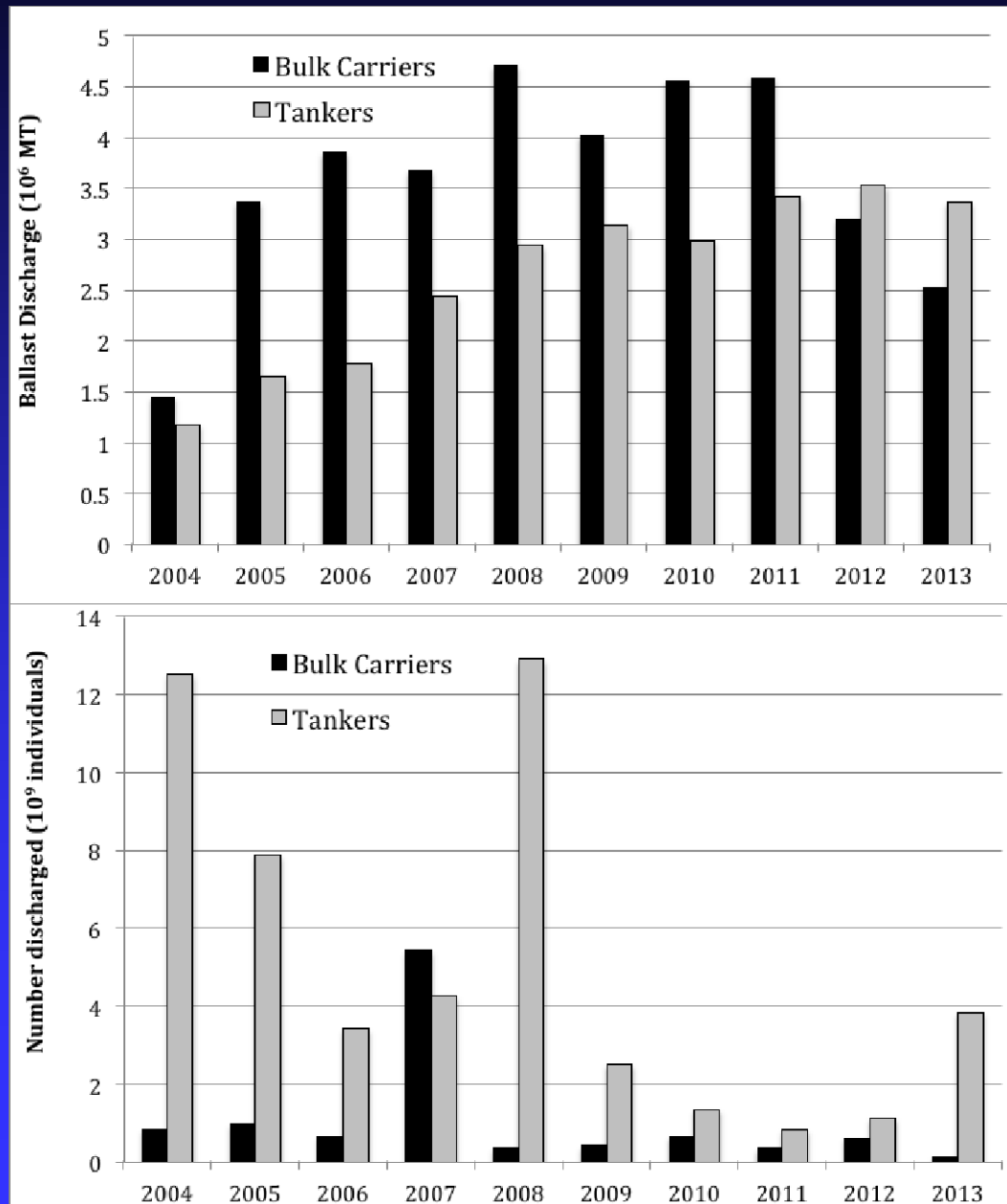
Average log 10 transformed densities of coastal zooplankton in ballast tanks by year for Trans-Pacific and California sources for vessels that conducted BWE.

Percent composition represented by coastal plankton by year: exchange vs. no exchange



Percent composition represented by coastal zooplankton in exchanged and un-exchanged ballast by year

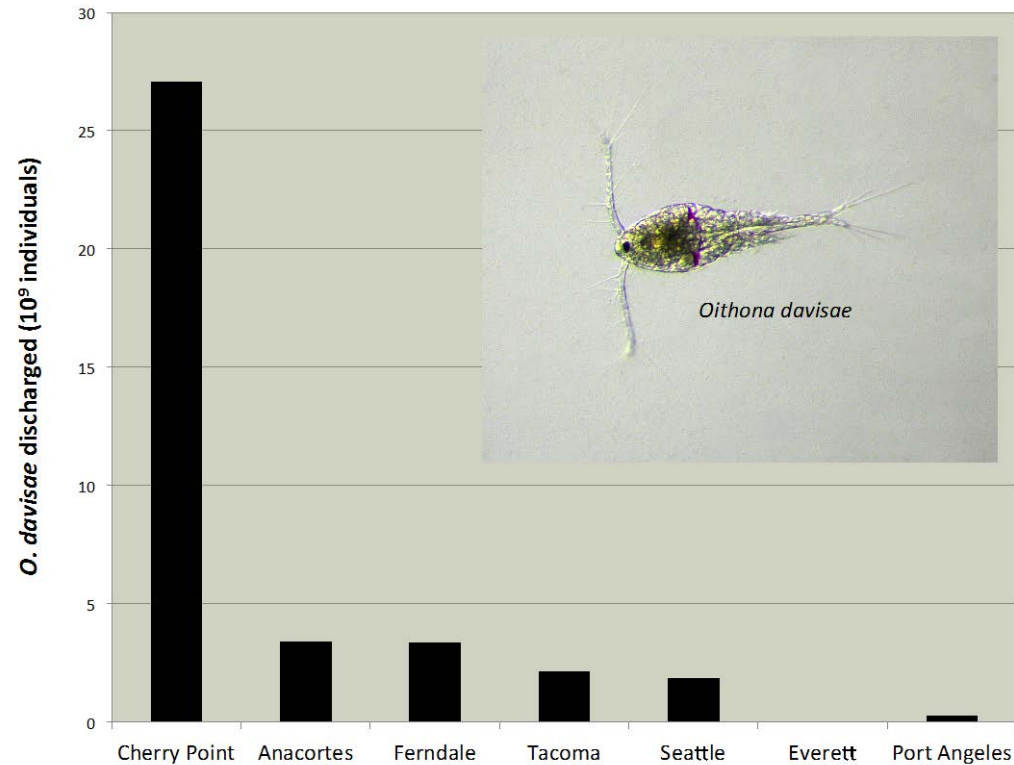
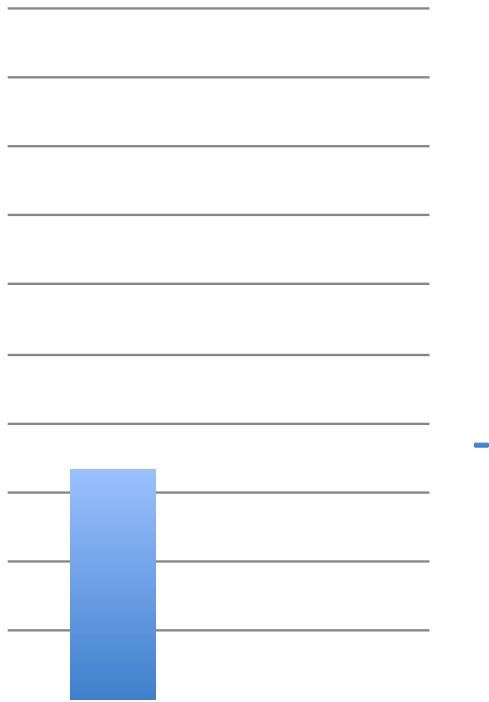
Yearly ballast discharged (NBIC data—top) and estimated total coastal organisms discharged into Puget Sound (bottom) for two main ship types.



Non-indigenous zooplankton species in Puget Sound

Percent composition of copepod species at Samish Bay, Washington, September 2004 and 2012.

Estimated total *Oithona davisae* numbers discharged into main port areas of Puget Sound 2004-2014 based on data from NBIC and WDFW-UW ballast plankton sampling.



Take-home Messages

- Ballast ages of greater than 30 days would have been most likely to meet the USCG standards for less than 10 organisms in the ≥ 50 micrometer size class.
- Although bulk carriers discharged more water into Puget Sound, total abundance of higher risk zooplankton discharged was greater from tankers (ATBs, ITBs, oil tankers).
- Densities and discharges of coastal and known non-indigenous zooplankton in ballast water of ships on West Coast routes originating in California exceeded those from other West Coast and Trans-Pacific routes.
- Significant reductions were observed in densities of high risk organisms in ballast, especially after 2008, but this does not necessarily indicate introduction risks have been reduced similarly because we don't know how much reduction in numbers is needed to make a difference.

Ballast Water as a Management Tool

Allen Pleus