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Hidden underlying mechanisms for changes in mesozooplankton communities: Transport and eddy driven changes

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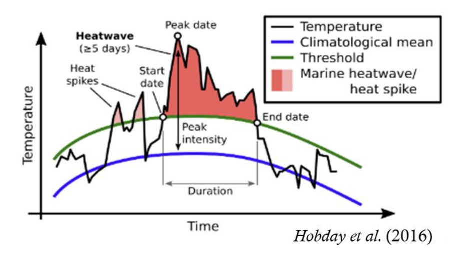
Abstract

Mesozooplankton communities have been used extensively as reliable climate change indicators, mainly because of their rapid growth and sensitivity to environmental changes. This study explored the modifications in the taxonomic composition of the mesozooplankton community and the associated physical changes of transport-driven, eddy-driven, and marine heatwaves in the summers of the last 14 years (2009–2022) within the mixed layer of the Ulleung Basin in the East/Japan Sea, where surface waters have rapidly warmed in recent decades. A slight increase was observed in the abundance of mesozooplankton from 2009 (3,709 inds.m^{-3}) to 2022 (4,231 inds.m^{-3}), with two notable peaks in 2015 (11,377 inds.m^{-3}) and 2020 (11,184 inds.m^{-3}), which was mainly attributed to the prevalence of *Noctiluca scintillans*. The first peak in 2015 showed thaliaceans to be the next dominant taxa, in which the southward direction of meandering in East Korea Warm Current (EKWC), presence of the Ulleung warm eddy, lower volume of the Western Channel (V-west) of the Korea Strait, and marine heatwaves (MHWs) did not occur. In contrast to the first peak, the second peak in 2020 showed *Pyrocystis pseudonoctiluca* to be the next dominant species, which may have been transported and advected by the strong V-west and eastward direction of the EKWC and the occurrence of MHWs that allowed the persistence of the subtropical species *P. pseudonoctiluca*. Overall, the significant increases in the second dominant mesozooplankton taxa appeared to be affected by physical changes, including transport or eddy-driven changes, along with the occurrence of strong V-west, the direction of the EKWC, and the occurrence of MHWs, which may synergistically influence the increase in the second dominant taxa during summer. This study highlights the complex interplay between notable variations in mesozooplankton communities and environmental factors, highlighting the potential consequences of different physical changes (transport-driven and eddy-driven) in this regional ocean.

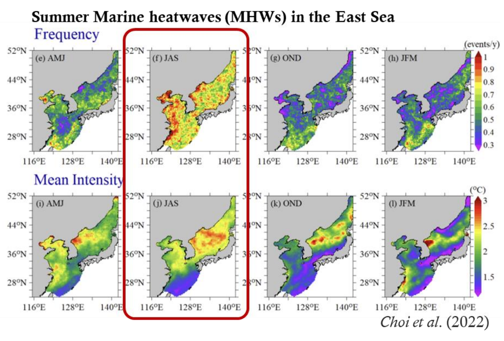
Introduction

- Mesozooplankton communities are useful indicators of climate change because they have short life cycle, respond rapidly to changing temperature and rely on ocean currents for dispersal and distribution
- Mesozooplankton communities change in response to physical forcing, complex current characteristics, food availability, predation pressure, and probability of ecosystem shifts caused by climate change
- With increasing global warming, occurrence of marine heatwaves(MHWs) (prolonged extreme climate phenomena) has increased more frequently in summer in the East/Japan Sea
- **Objectives:**
  1) describe long-term variability of mesozooplankton abundance and taxonomic composition from 2009–2022 during summers in Ulleung Basin
  2) explore the links between physical-biological relationships and specific environmental features



Hobday et al. (2016)

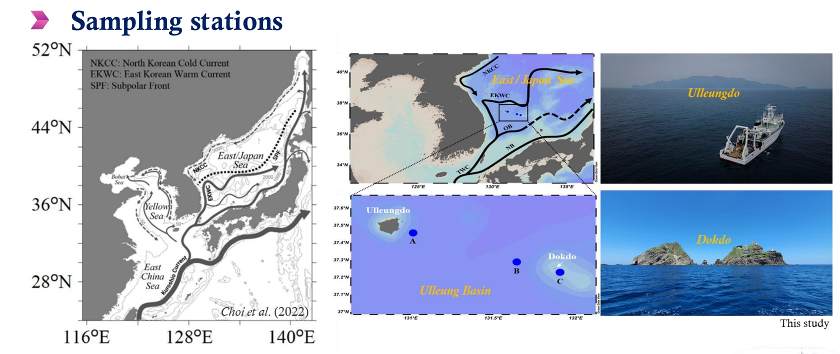
Summer Marine heatwaves (MHWs) in the East Sea



Choi et al. (2022)

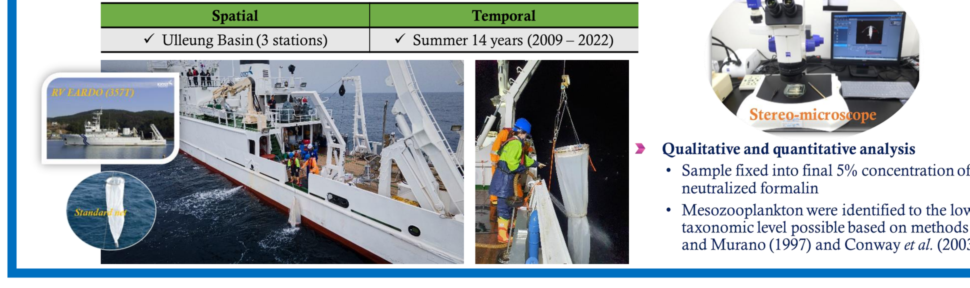
Materials and Methods

Sampling stations

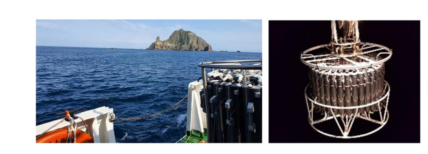


Choi et al. (2022)
This study

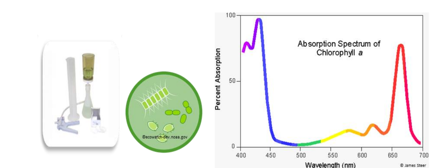
Spatial	Temporal
✓ Ulleung Basin (3 stations)	✓ Summer 14 years (2009 – 2022)



Qualitative and quantitative analysis
- Sample fixed into final 5% concentration of borax-neutralized formalin
- Mesozooplankton were identified to the lowest taxonomic level possible based on methods of Chihara and Murano (1997) and Conway *et al.* (2003)

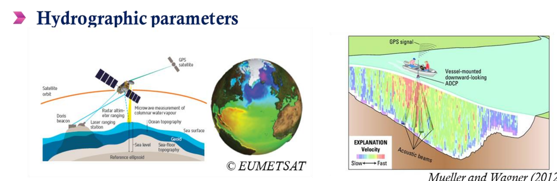


Vertical profiles of temperature, salinity, oxygen, fluoresceance
- CTD (SBE 911, SEABIRD)
- Downcast or upcast CTD data



Total chlorophyll-*a* concentrations
- Filtered using GF/F glass fiber filters
- Extracted using acetone solution (90%)
- Fluorometer (10-AU, Turner designs)

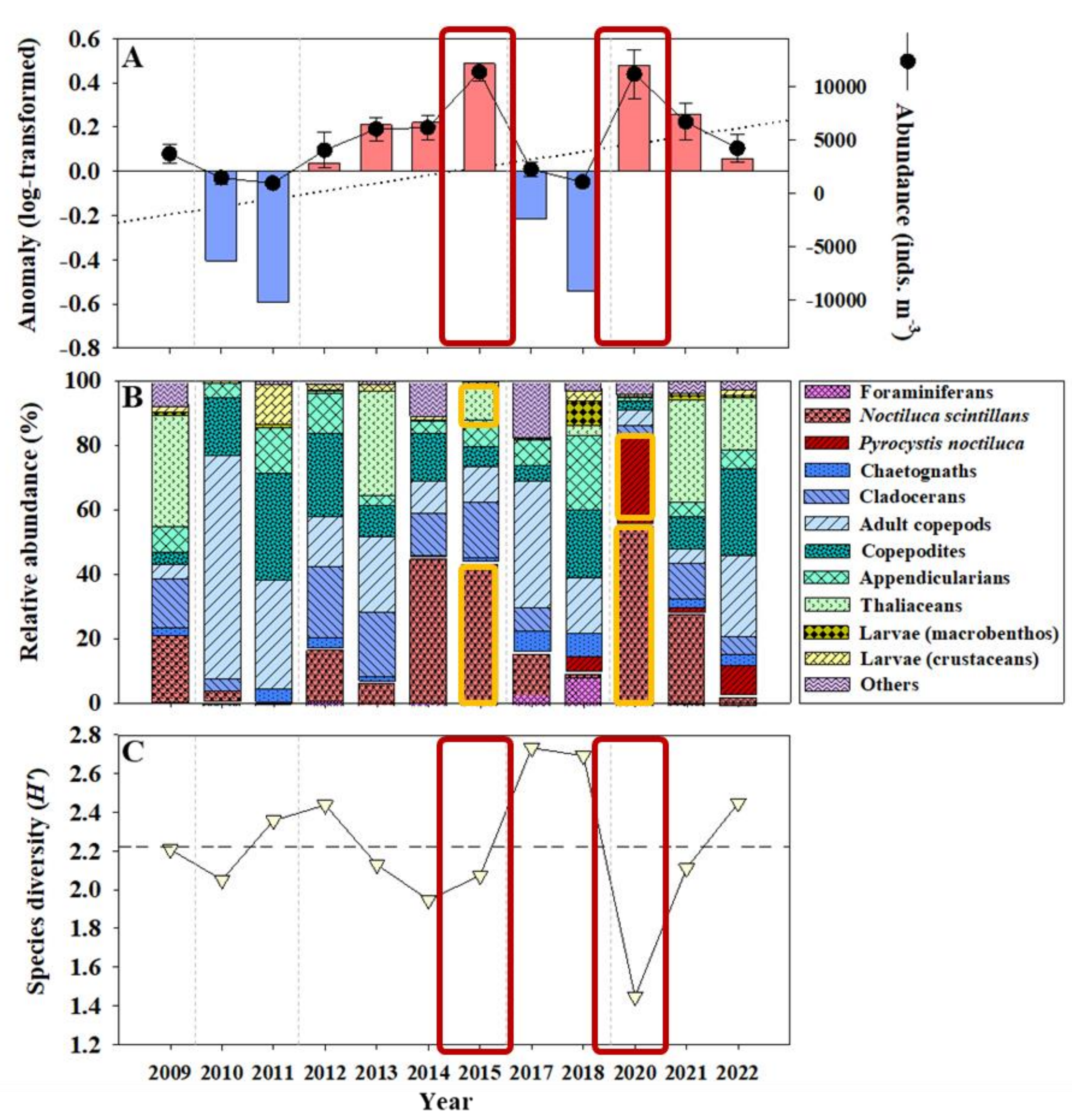
Hydrographic parameters


© EUMETSAT
Mueller and Wagner (2012)

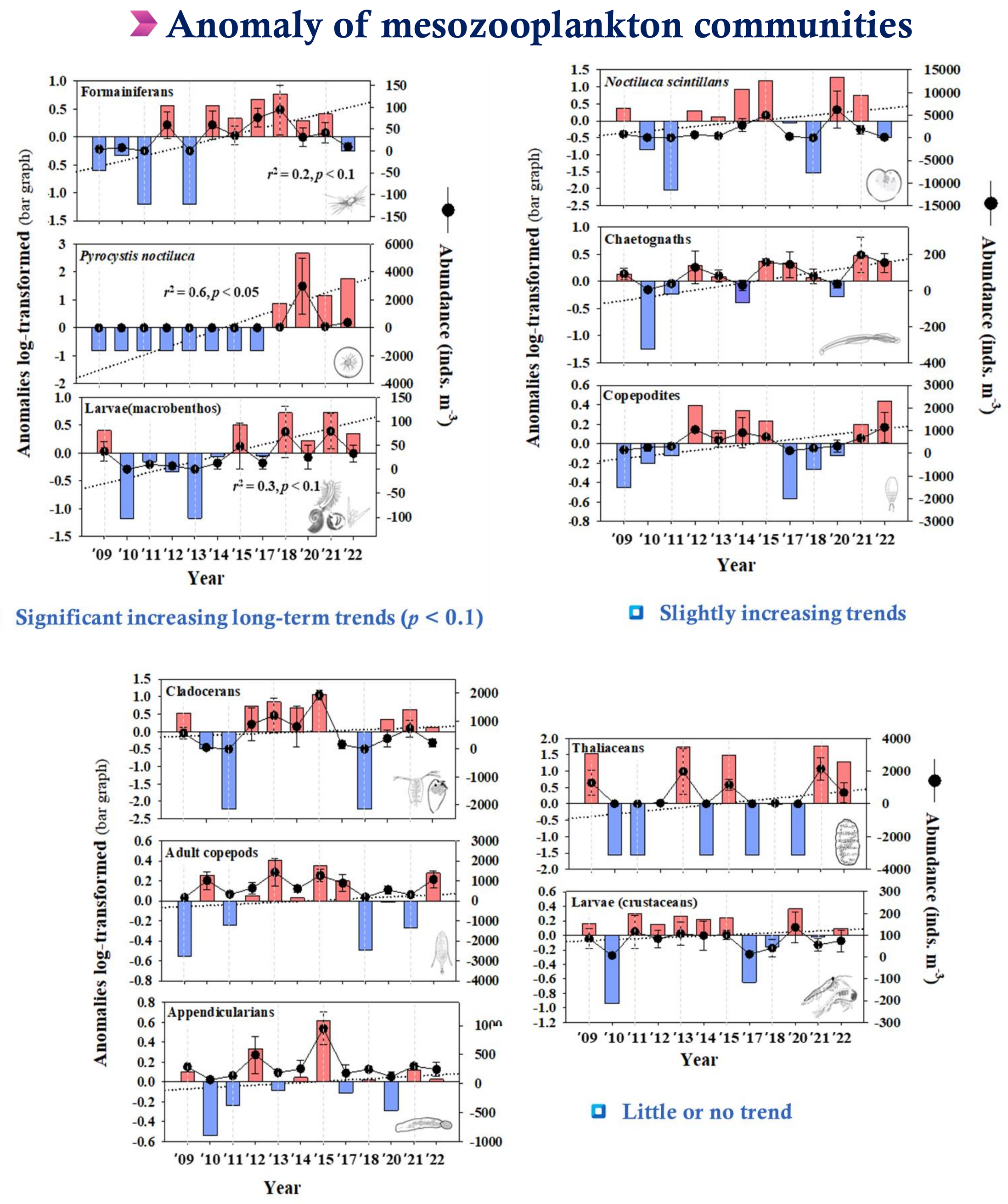
- Satellite data (Operational Sea Surface Temperature and Sea Ice Analysis)
- Vertical profiles of currents (Acoustic Doppler Current Profiler, TRDI)

Results and Discussion

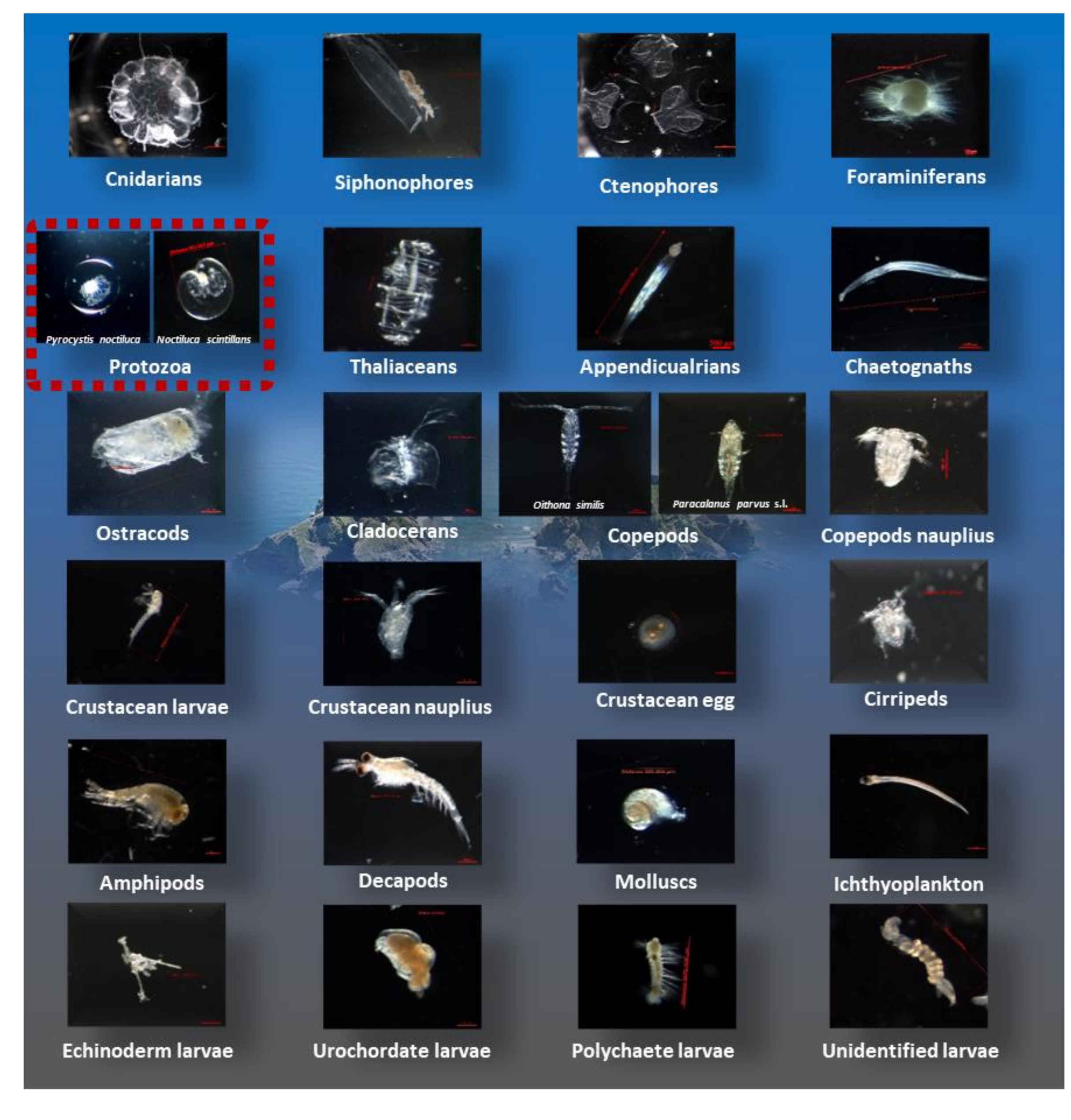
Mesozooplankton community and numerically dominant taxa



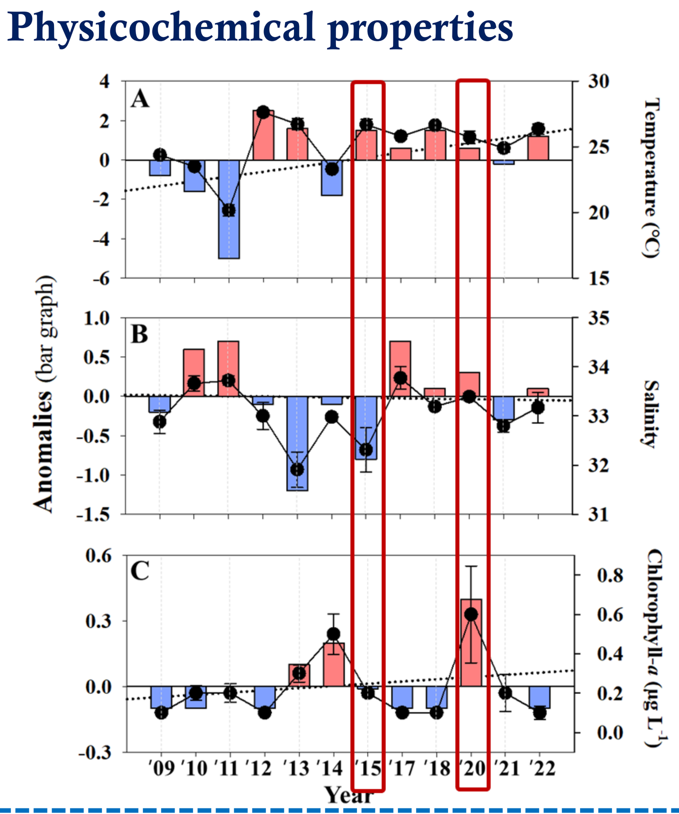
Anomaly of mesozooplankton communities



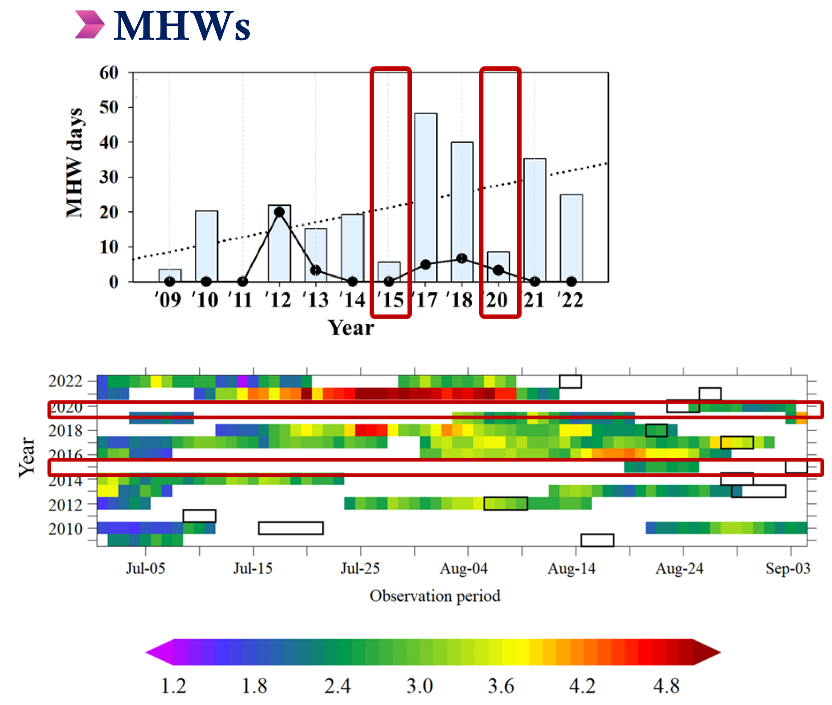
- Significant increasing long-term trends ($p < 0.1$)
- Slightly increasing trends
- Little or no trend



Physicochemical properties

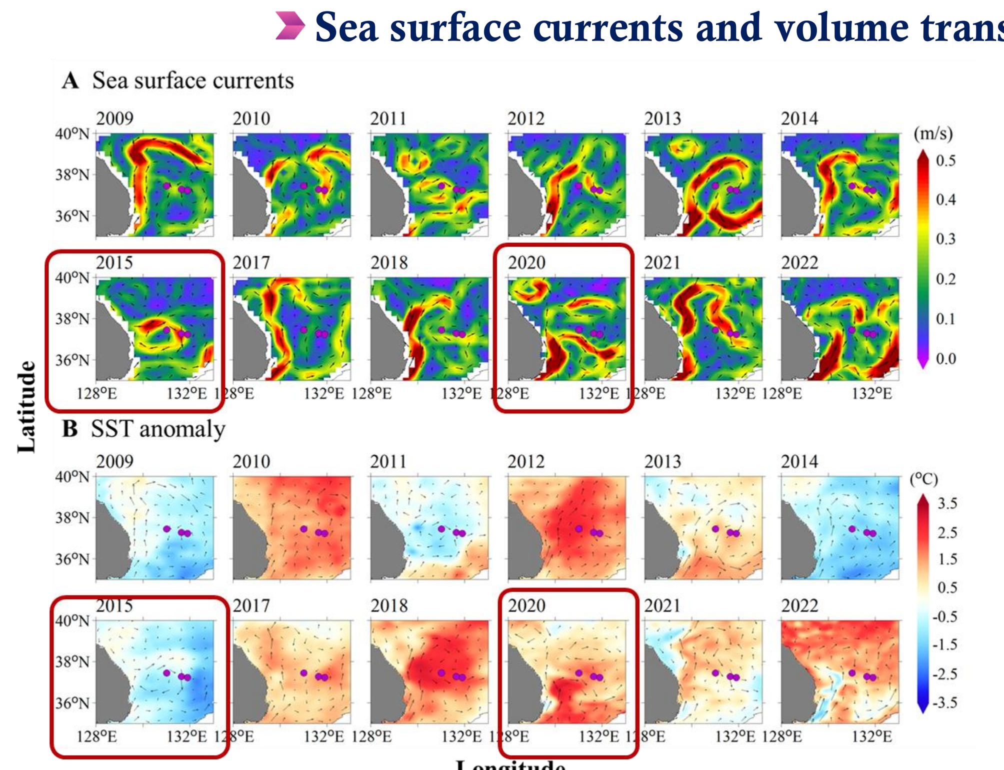


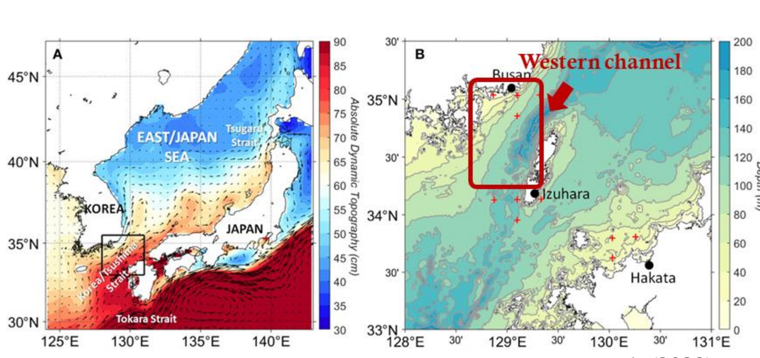
MHWs



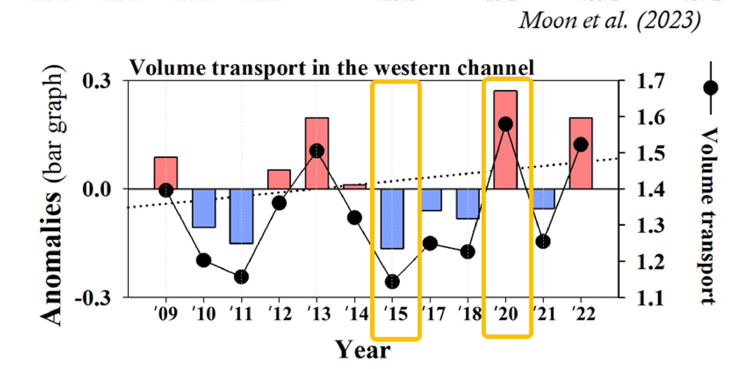
*Occurrence and the intensity of the MHWs, the rectangular black-lined box represents the in situ period

Sea surface currents and volume transport in the Western Channel



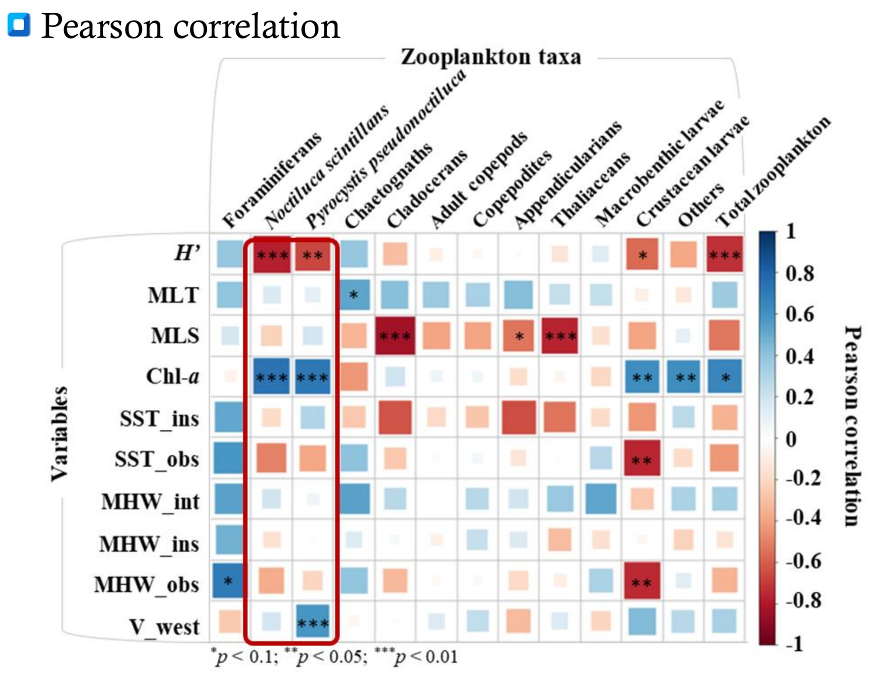


Moon et al. (2023)



Relationship between mesozooplankton community and environmental factors

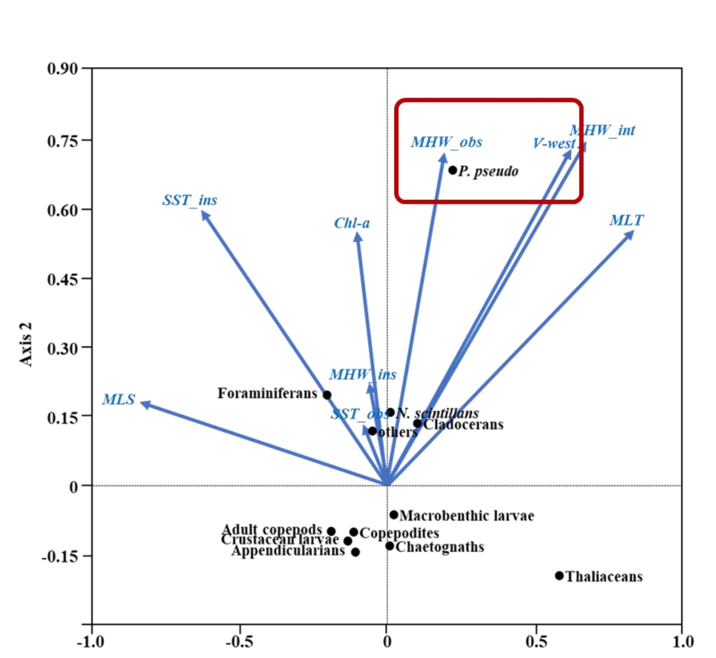
- Pearson correlation



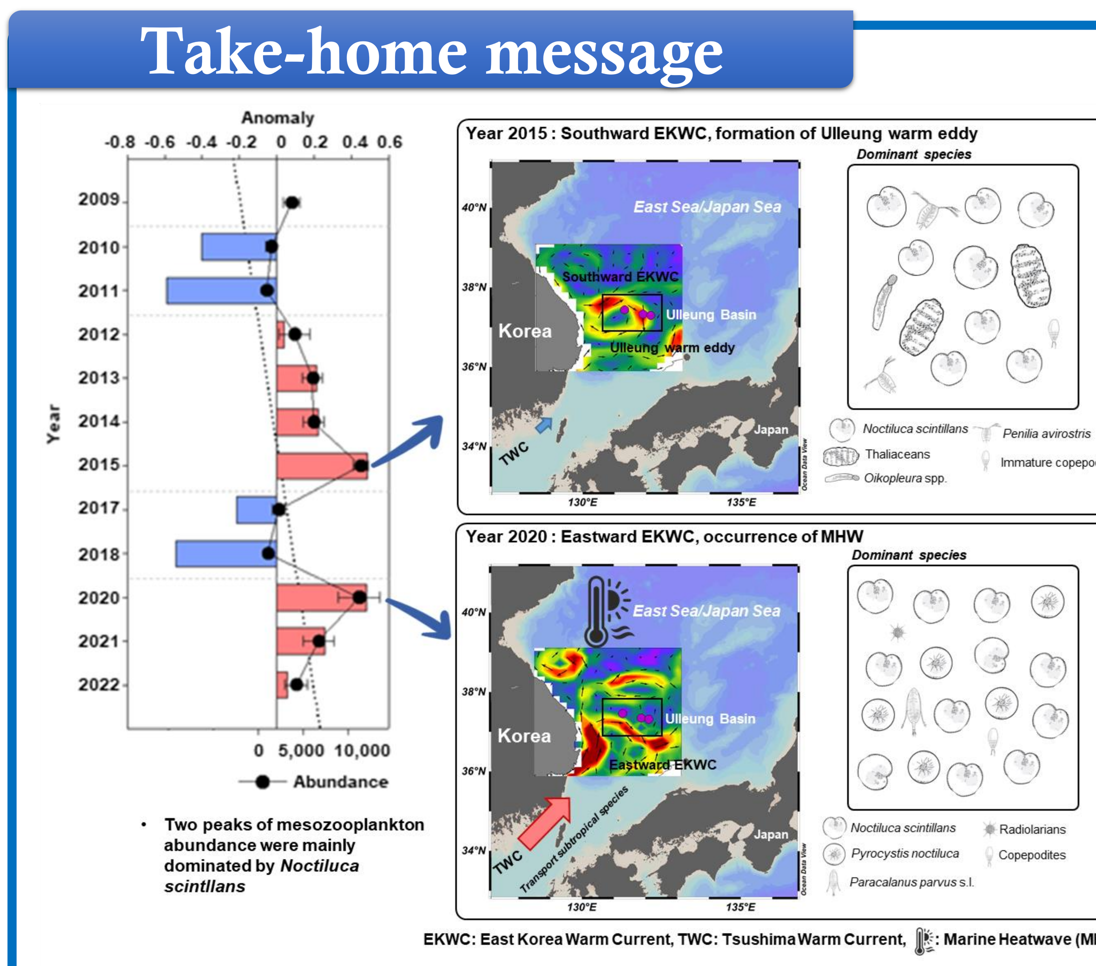
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Species diversity (*H'*), and the environmental variables, including surface mixed layer temperature (SMLT), surface mixed layer salinity (SMLS), surface chlorophyll-*a* (chl-*a*) concentrations, sea surface temperature anomaly from satellite data during the in situ (SST_ins) and observation periods (SST_obs), marine heatwave intensity(MHW_int), duration of MHW during the in situ (MHW_ins) and observation periods (MHW_obs), and the volume of the Western Channel (V-west)

- Canonical Correlation Analysis



Take-home message



- Two peaks of mesozooplankton abundance were mainly dominated by *Noctiluca scintillans* blooms
- Thaliaceans were the next dominant taxa in 2015, influenced by Ulleung warm eddy
- *Pyrocystis pseudonoctiluca* was first observed in 2018, became the next dominant taxa in 2020.
- *P. pseudonoctiluca* was driven by strong volume of the Western Channel and marine heatwave in 2020
- Notable mesozooplankton abundance peaks were from subtropical non-copepod species

Kim, M., Choi, W., Jang, C. J., & Kang, J. H. (2024). Hidden underlying mechanisms for changes in mesozooplankton communities: Transport and eddy driven changes. *Science of The Total Environment*, *946*, 174336.