What if we can predict phytoplankton blooms two months in advance?

Hakase Hayashida

May 13, 2025


[Ocean Color Image Gallery]

国立研究開発法人海洋研究開発機構
JAMSTEC
JAPAN AGENCY FOR MARINE-EARTH SCIENCE AND TECHNOLOGY

Outline of this talk (30 mins)

- Ocean prediction
- Ocean biogeochemistry and ecosystems
- Ocean health prediction
- Discussion

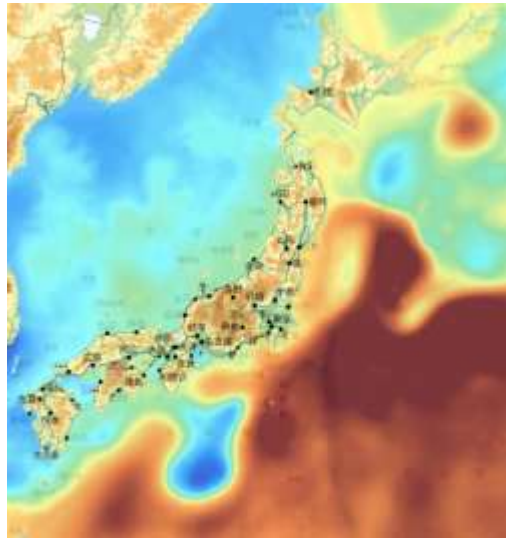
An operational ocean prediction system

Data assimilation

Prediction

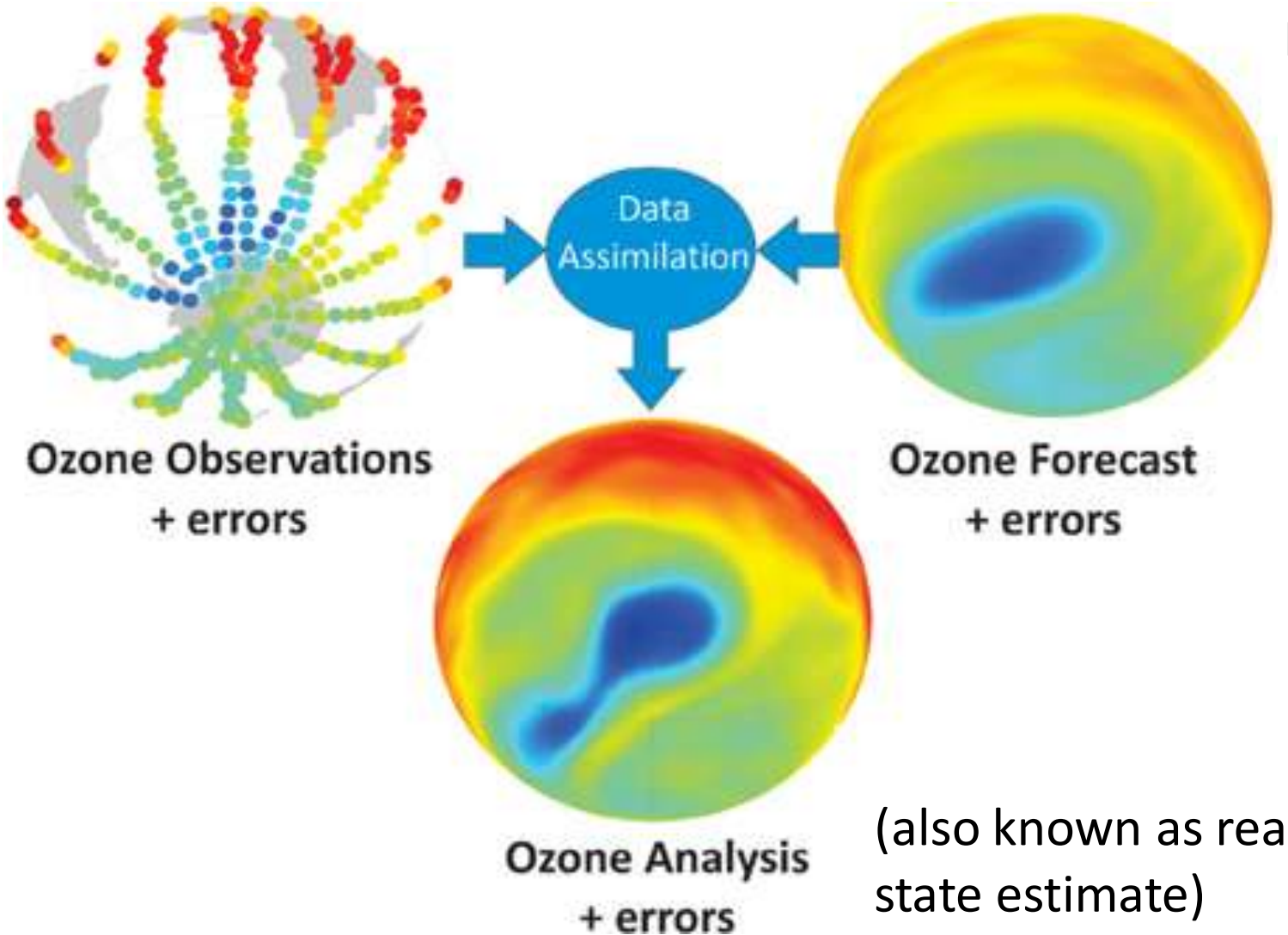
$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}-fv=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\nu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2}\right)$$

Visualization



Application

Data assimilation



[Lahoz & Schneider, 2014]

(also known as reanalysis, or state estimate)

Japan Coastal Ocean Predictability Experiment

Prediction duration and resolution

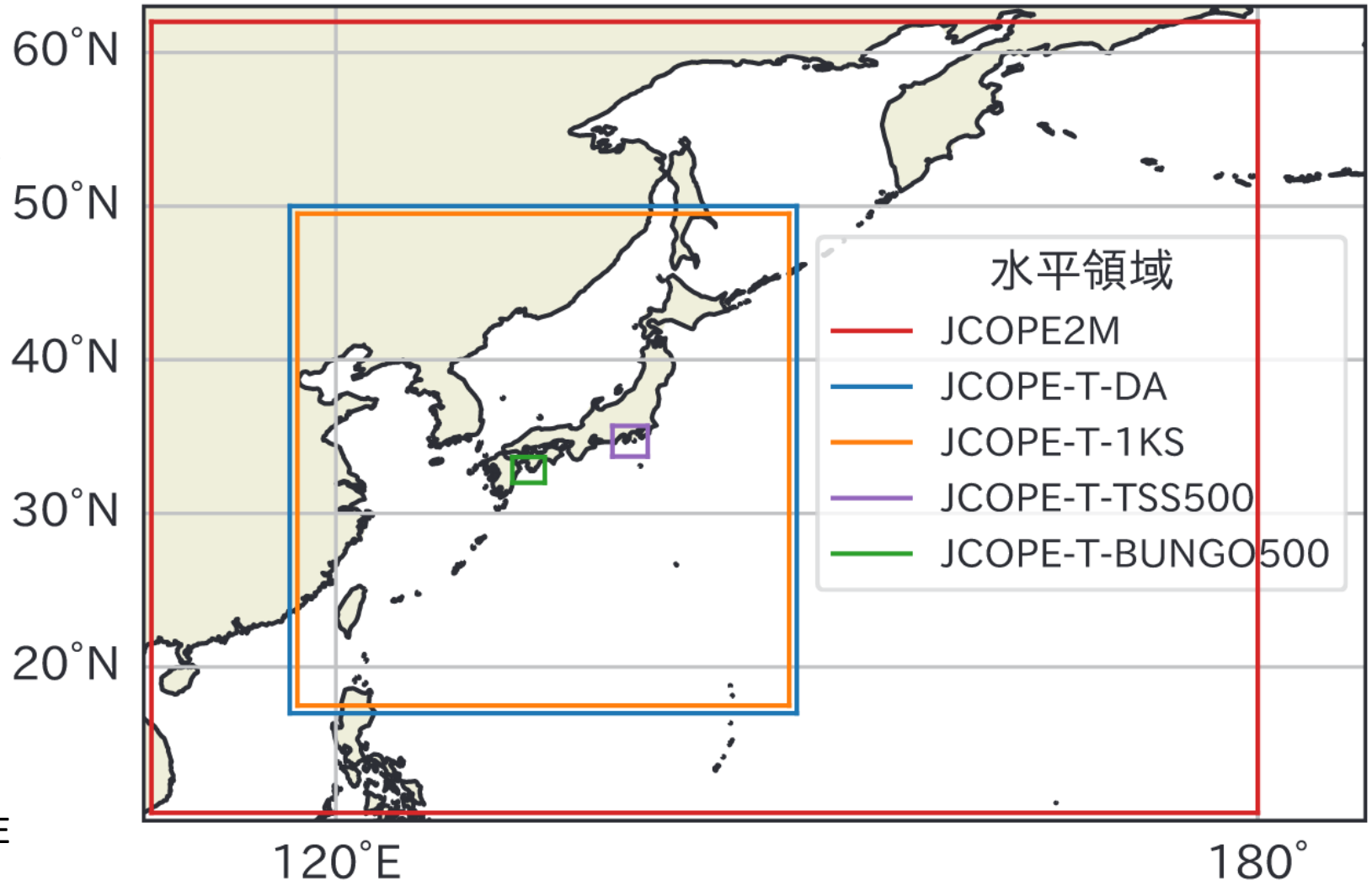
60 days at 9 km

20 days at 3 km

10 days at 1 km

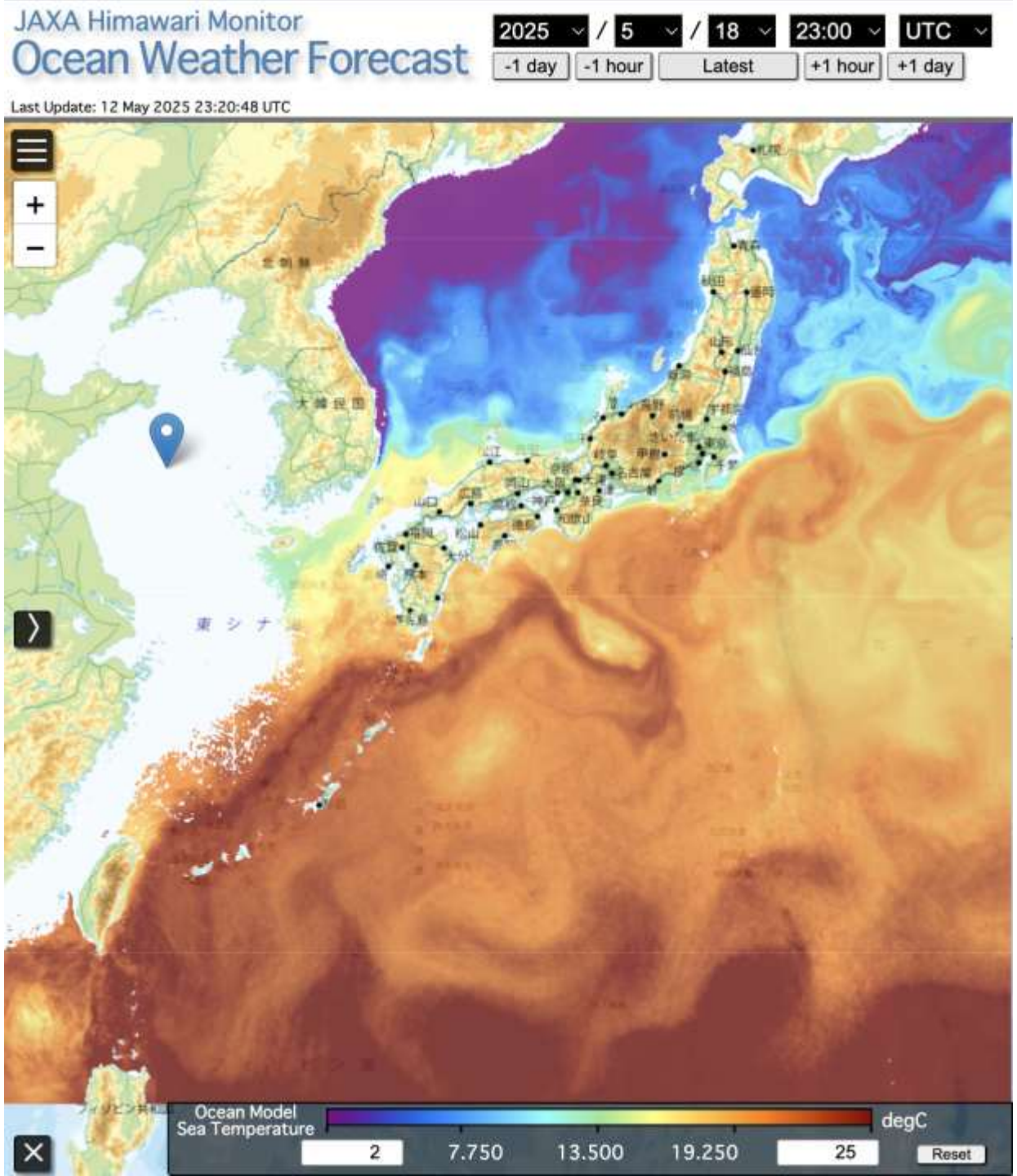
5 days at 200 m

← More info on JCOPE



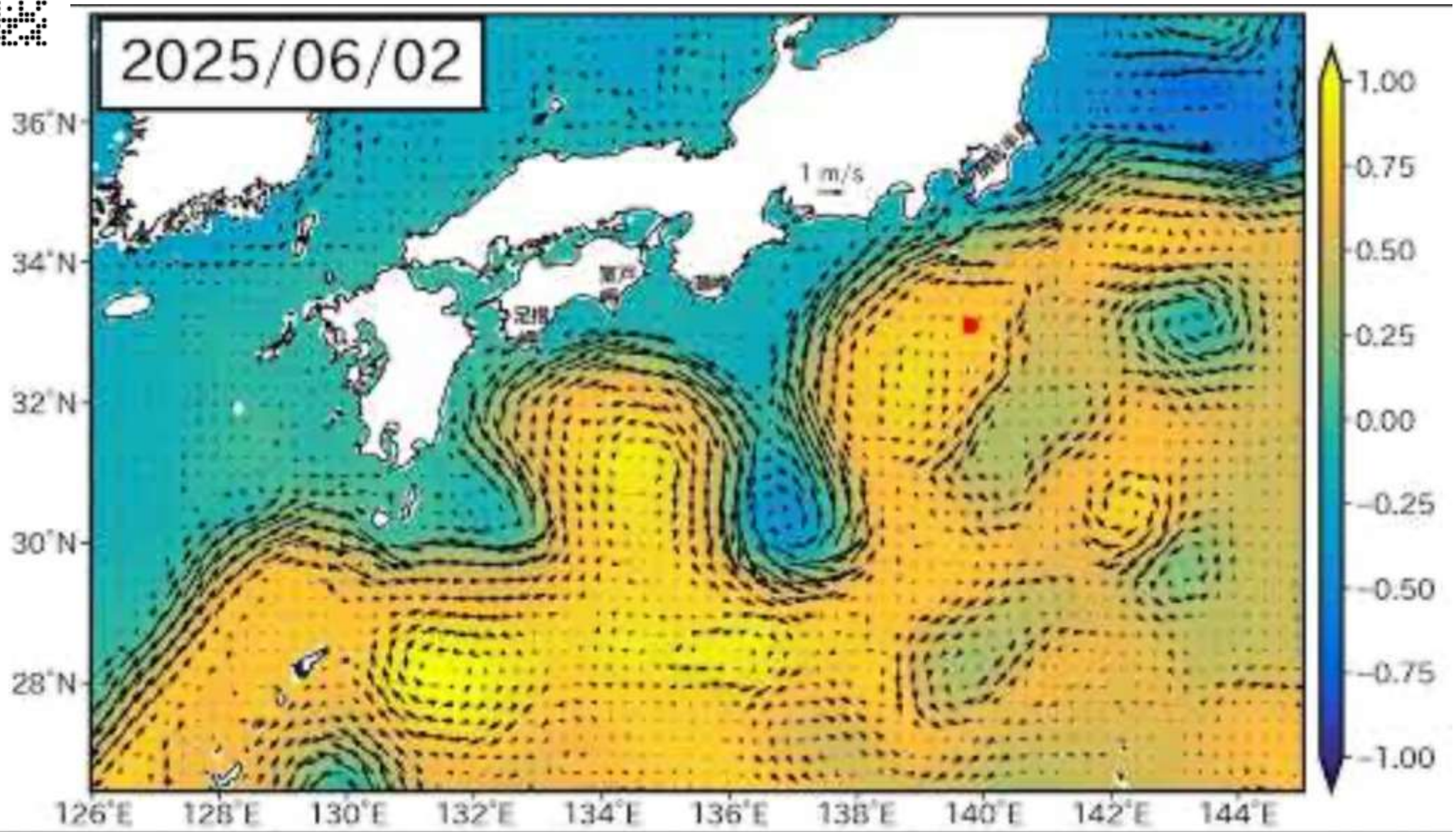
Visualization

See our seven-day forecast!

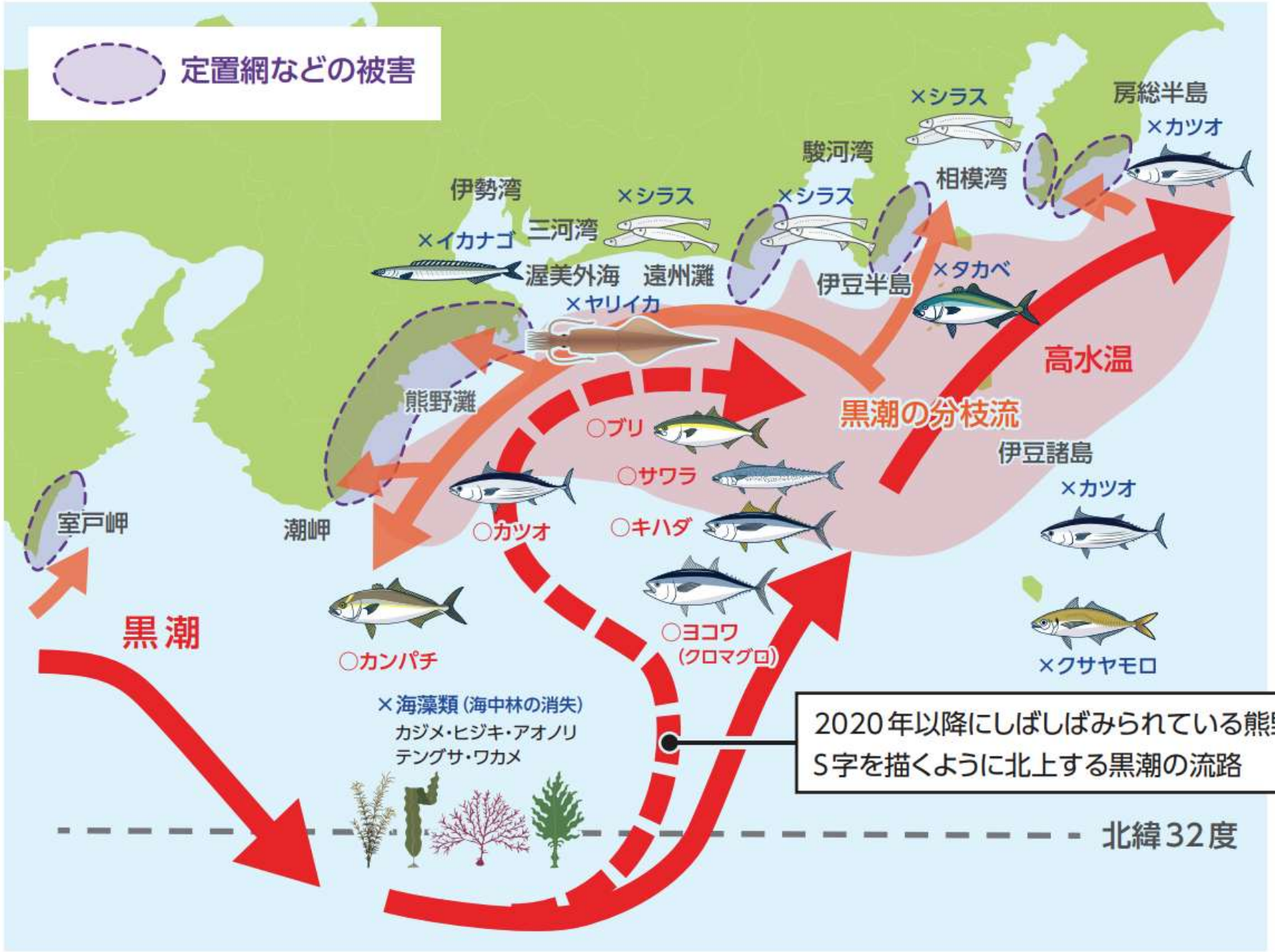


Two-month Kuroshio prediction south of Japan

Subscribe to our YouTube Channel ☺



Why bother to predict ocean currents?



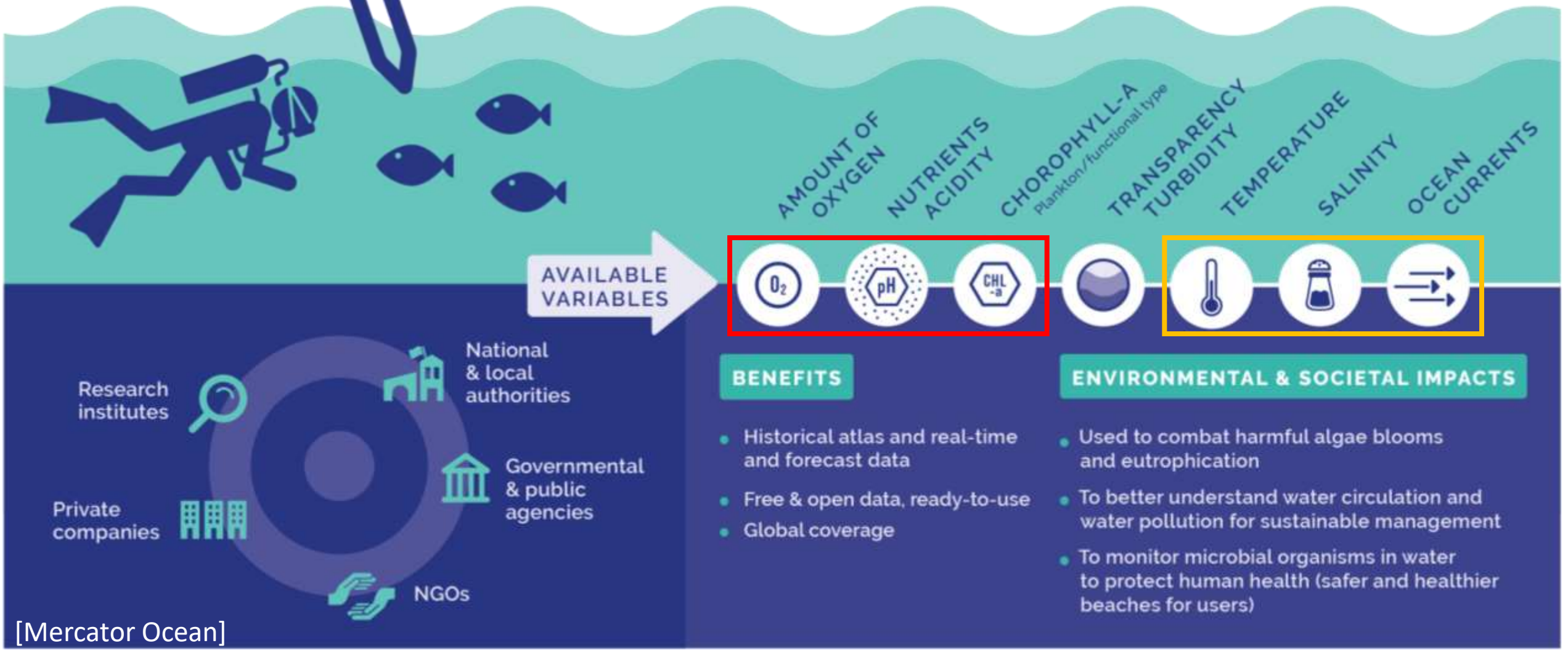
[FRA NEWS vol. 73 2023.1]

Reported impacts of the Kuroshio large meander on fisheries and aquaculture

Are marine ecosystems affected by temperatures and currents only?

OCEAN HEALTH

Ocean health is determined not only by temperature and currents, but also by biogeochemical and ecological variables such as oxygen, pH (acidity), nutrients, and plankton biomass.



[Mercator Ocean]

Ocean biogeochemistry

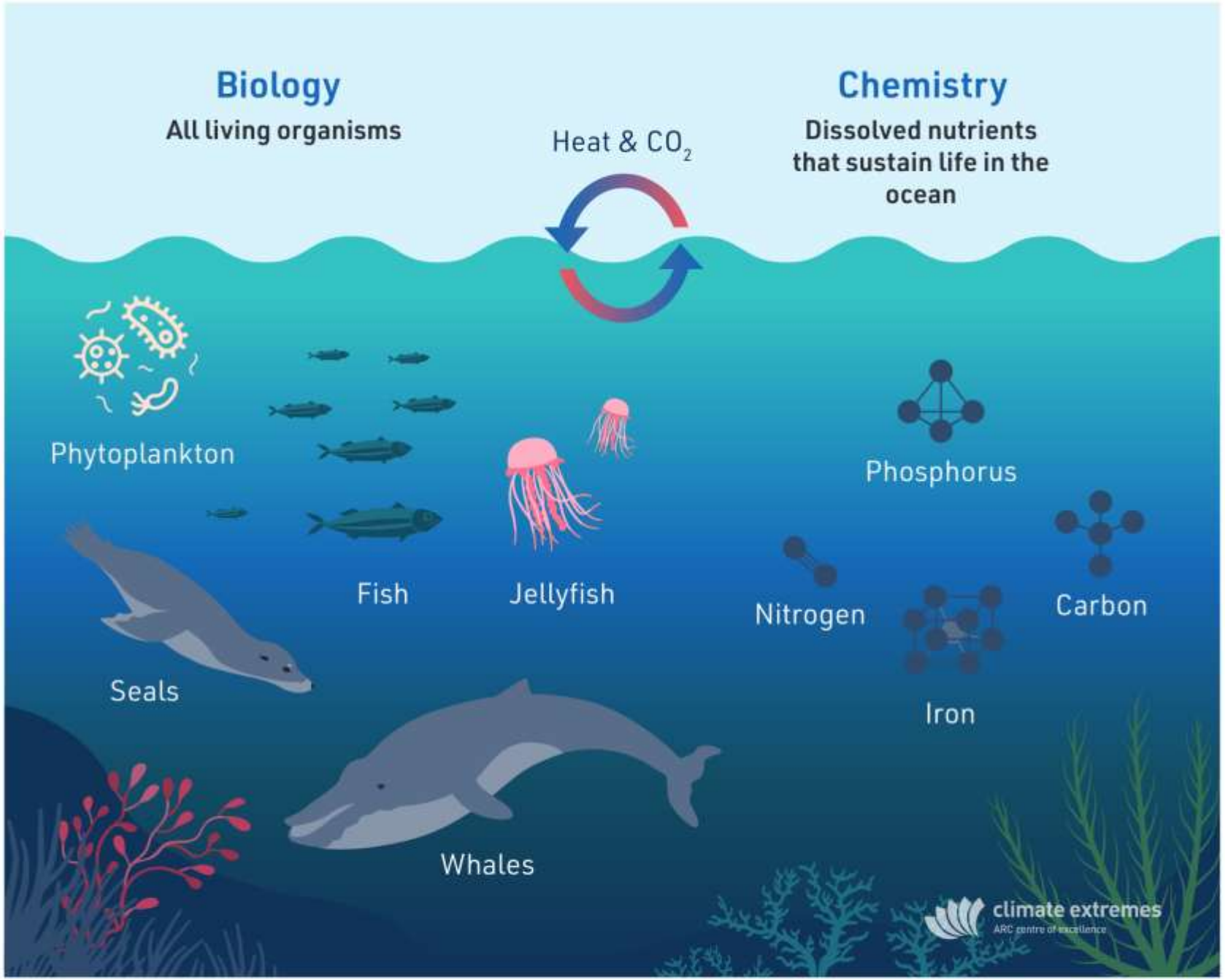
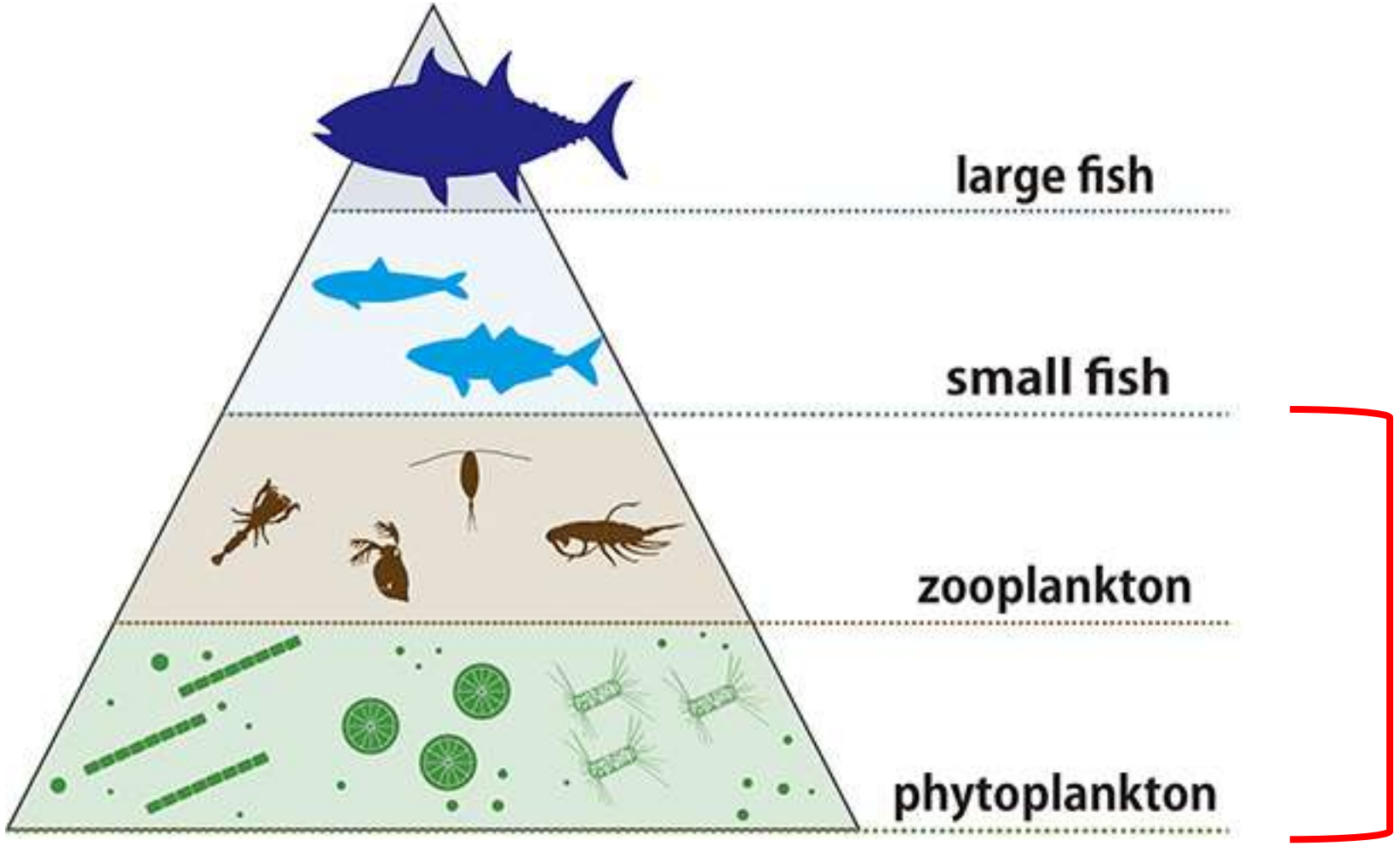


Figure 1: The elements of ocean biogeochemistry.

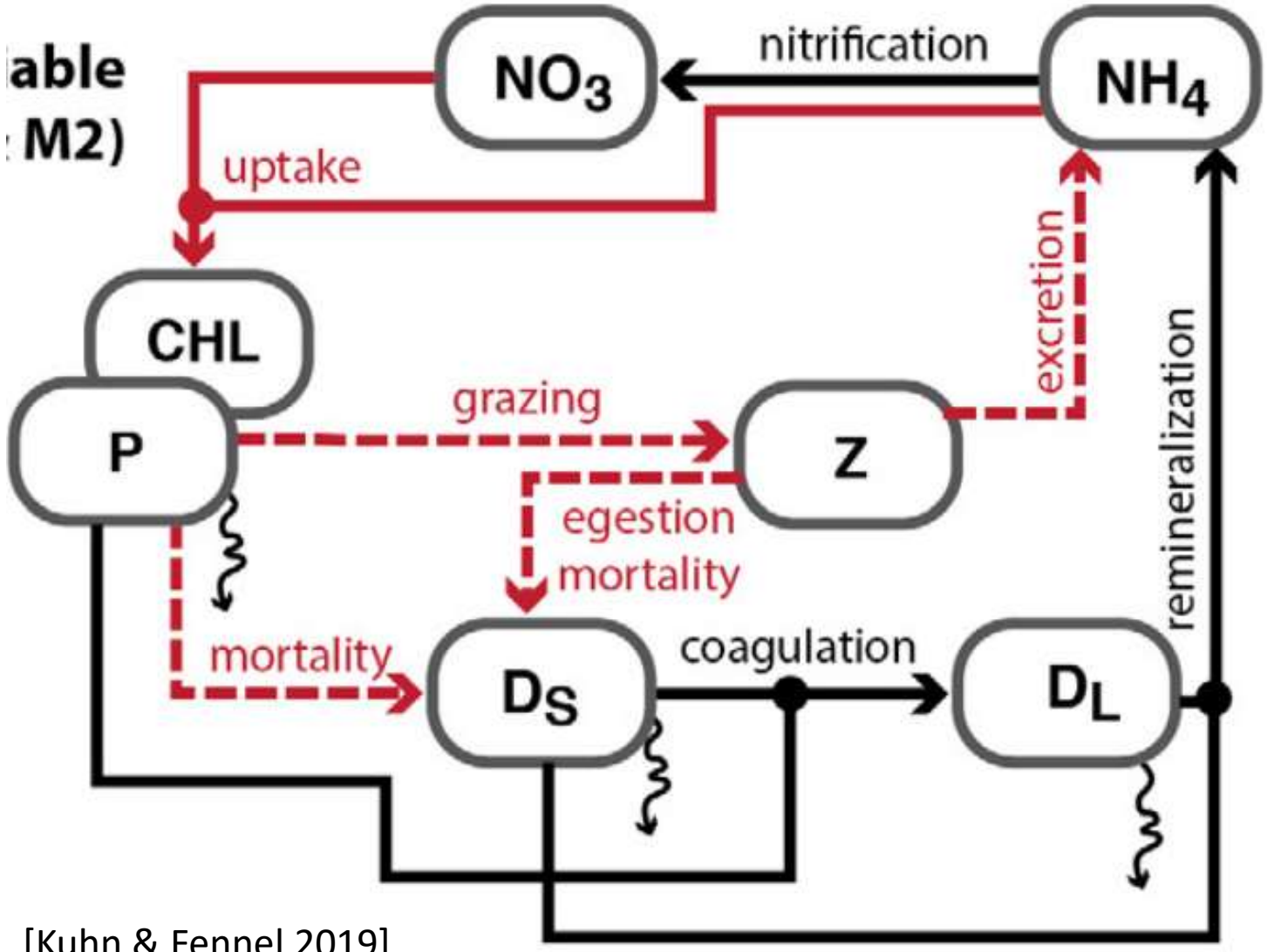
[Strutton and Patel, CLEX Briefing Notes]

Marine food chain (pyramid)



https://www.animalia-life.club/qa/pictures/marine-phytoplankton-food-chain.html

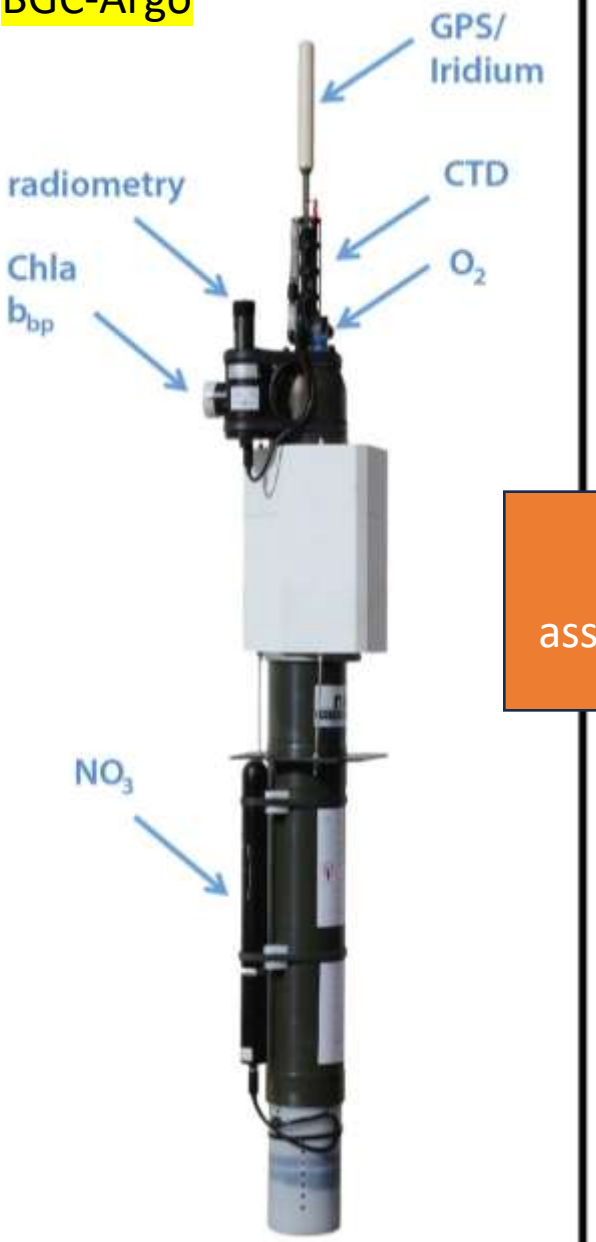
Nutrients-Phytoplankton-Zooplankton-Detritus model



[Kuhn & Fennel 2019]

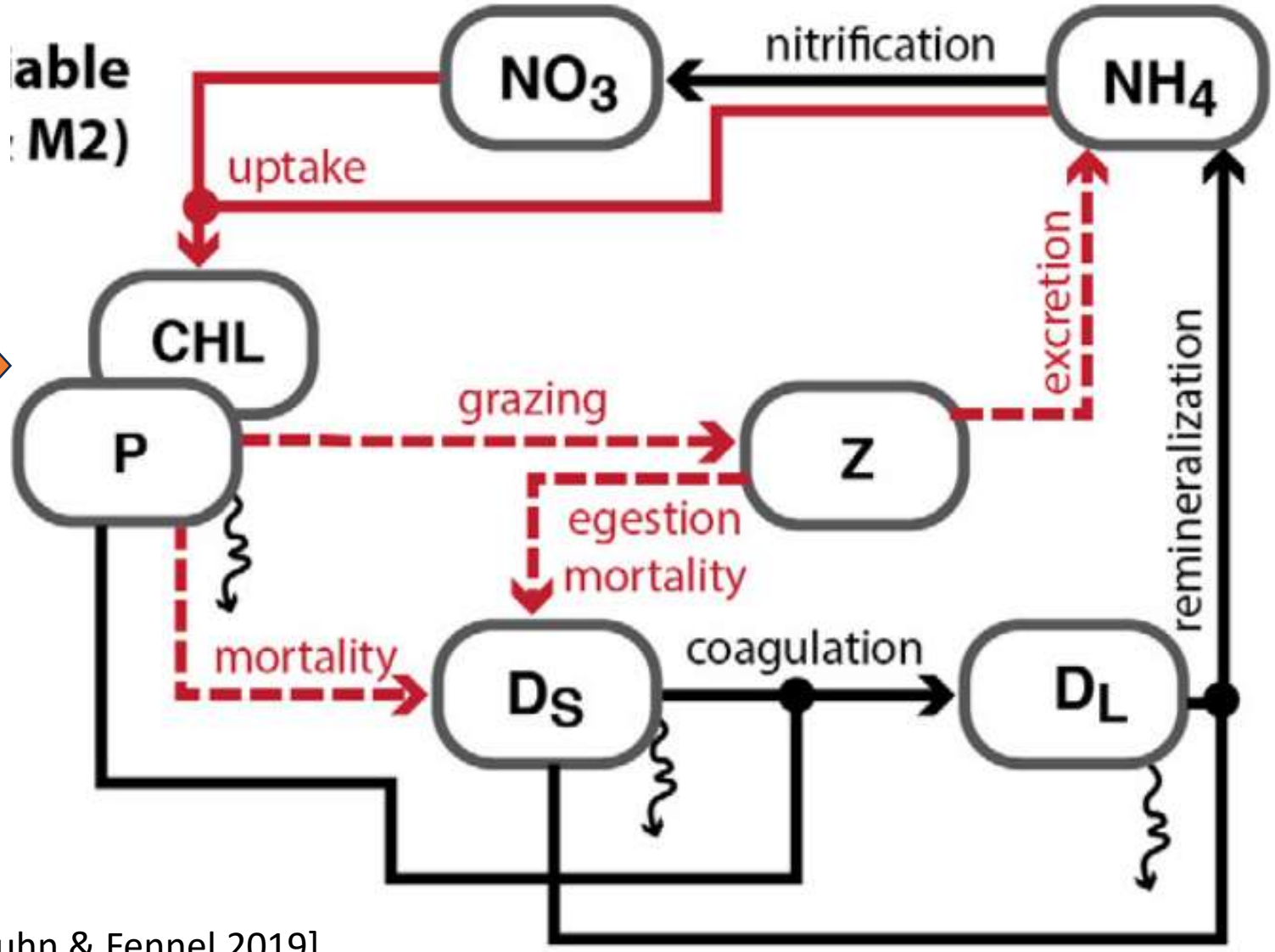
Data assimilation of BGC-Argo

BGC-Argo



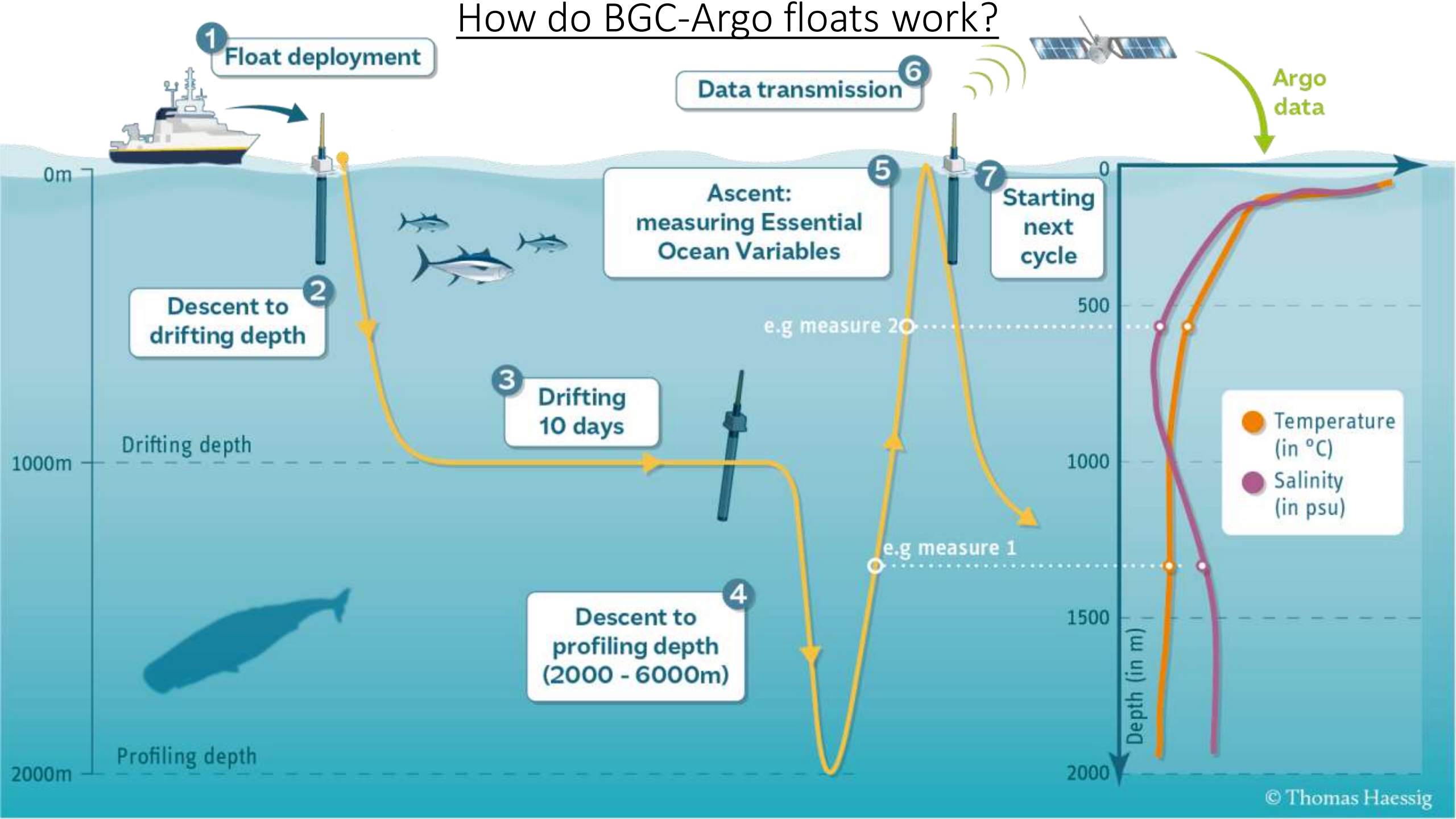
[Roemmich et al. 2019]

Data assimilation

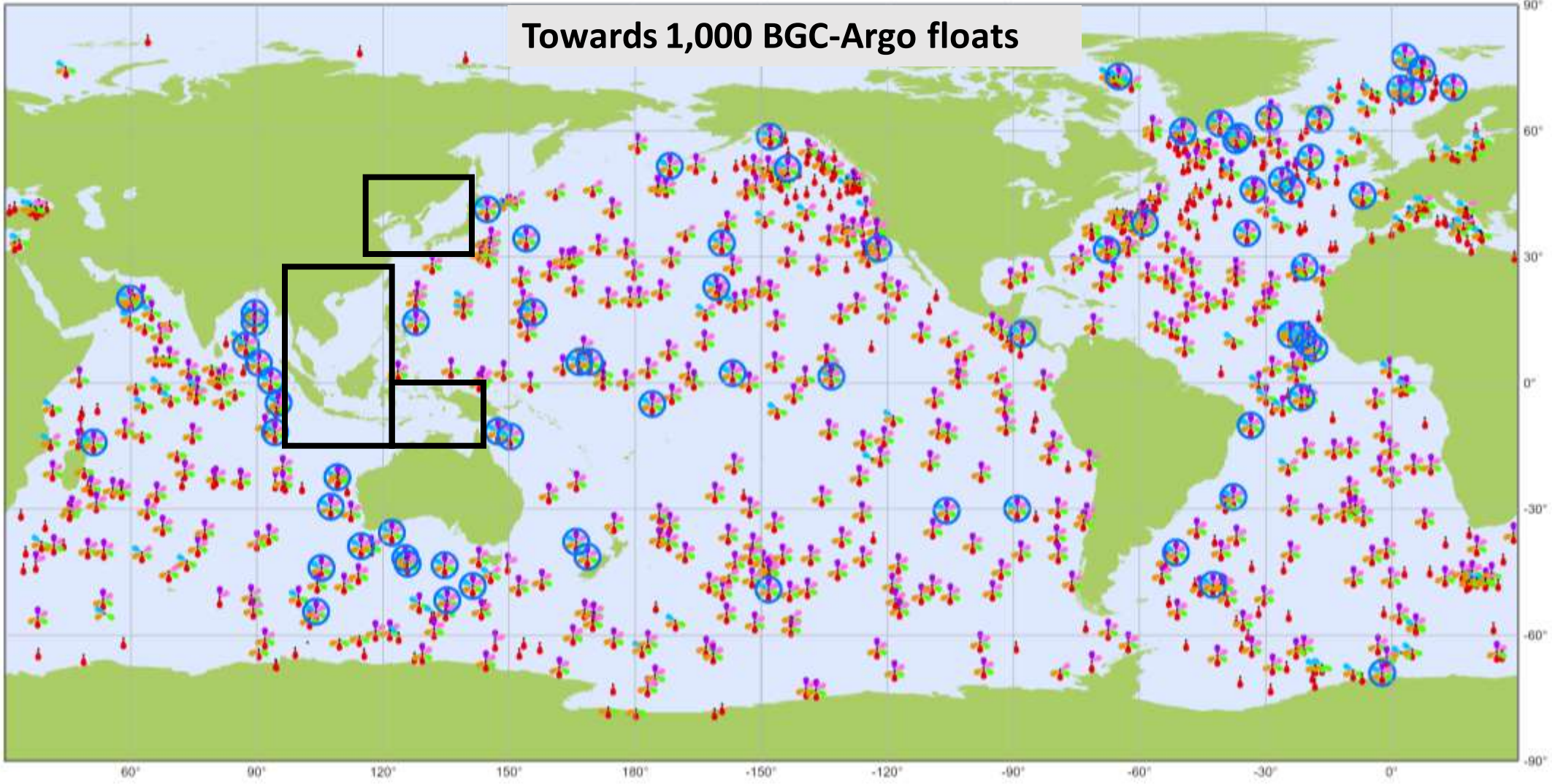


[Kuhn & Fennel 2019]

How do BGC-Argo floats work?



Towards 1,000 BGC-Argo floats



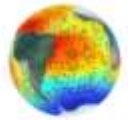
Biogeochemical Argo

Sensor Types

Latest location of operational floats (data distributed within the last 30 days)

- Operational Floats (775)
- Suspended particles (539)
- Downwelling irradiance (156)
- pH (447)
- Nitrate (440)
- Chlorophyll a (539)
- Oxygen (768)
- Full BGC Floats (74)

April 2025

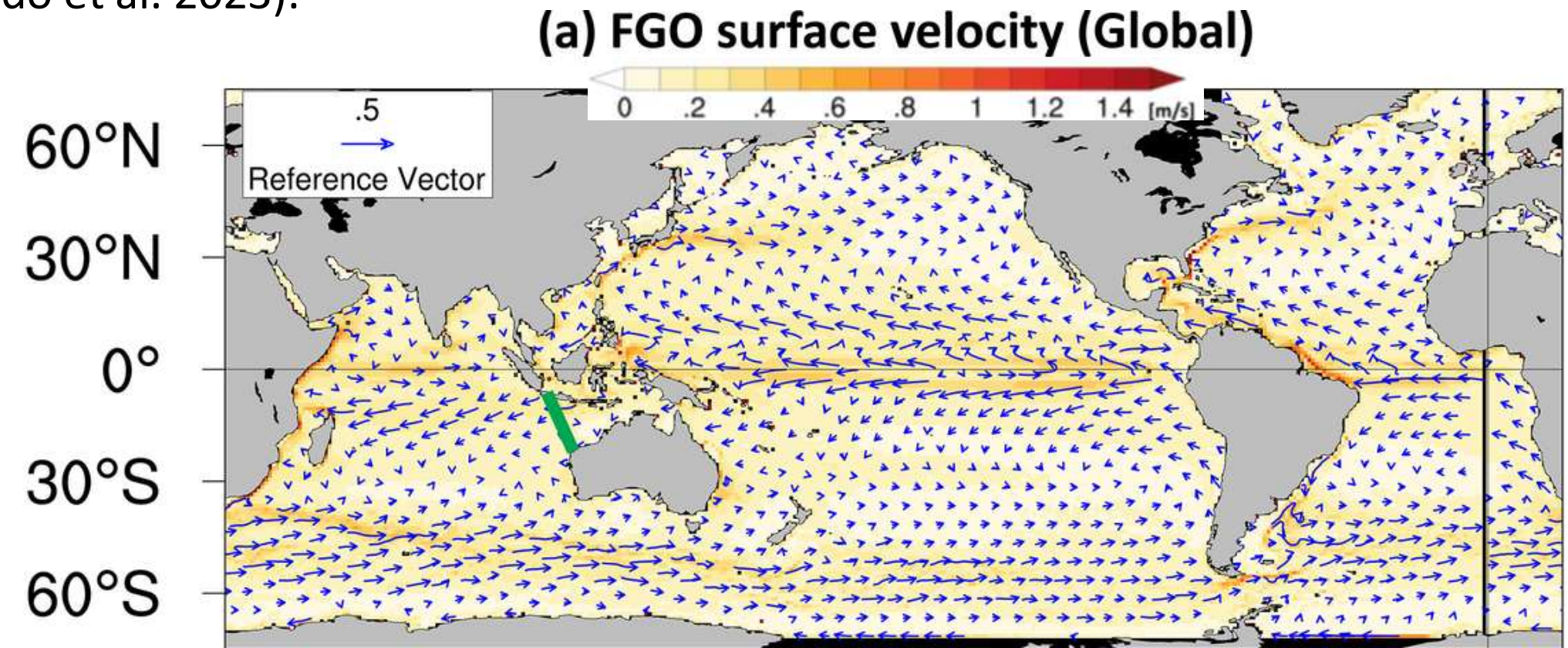


Generated by ocean-ops.org, 2025-01-03
Projection: Plate Carree (-150.0000)

JCOPE-FGO – beyond the northwest Pacific

- Reanalysis data available since 1993.
- Skillful Multiyear Prediction of the Kuroshio and Gulf Stream Jets and Eddy Activity (Kido et al. 2023).

Download the reanalysis data ☺



Conclusions

- Operational ocean prediction systems such as JCOPE have assisted marine industry such as navigations and fisheries in the northwest Pacific since 2001, by providing two-month prediction of temperature and currents.
- However, it is important to note that ocean ecosystem health is not only affected by physical processes, but also on biogeochemical processes.
- We are exploring data assimilation of BGC-Argo observations for two-month prediction of phytoplankton blooms and other ocean ecosystem health variables.

Discussion (Questions)

- How could ocean ecosystem health prediction be useful?
- Which variables would be helpful?
- At what temporal and spatial scales?
- How would you like the prediction information to be provided?
  (e.g., YouTube, images, interactive maps)

hakaseh@jamstec.go.jp

[https://1000logos.net/thank-you-

Abstract

In this seminar, I will introduce a short-range ocean prediction system known as the Japan Coastal Ocean Predictability Experiment (JCOPE) and its ongoing development to incorporate marine biogeochemistry. JCOPE has been providing routine two-month ocean weather forecasts around Japan since 2001. It does so by combining a numerical ocean model with satellite and autonomous float observations to generate a realistic present condition of the ocean and simulating possible future conditions that are driven by atmospheric weather forecasts. Both the best state estimate of the past (reanalysis) and the prediction of ocean temperature, salinity, current, and sea surface height can be made freely available for non-profit and scientific research purposes. Currently, we are exploring the possibility of incorporating ocean biogeochemistry into JCOPE, which is expected to enhance its capability by providing information relevant to ocean ecosystem health, such as nutrient concentrations, phytoplankton biomass, dissolved oxygen levels, and pH. While this development is still in its infancy, let's discuss its potential application for scientific research and sustainability initiatives. We note that JCOPE has a configuration that is beyond the northwest Pacific, and therefore, may also be of great interest to students and early career researchers in Asia and Oceania.