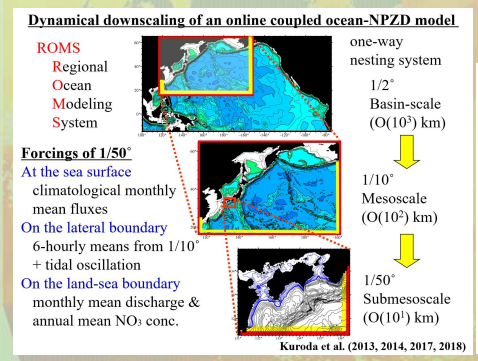
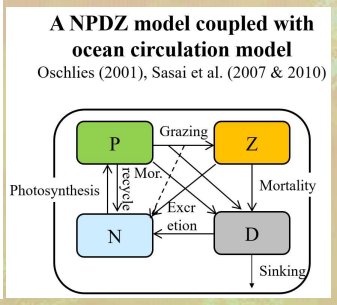
Numerical experiments using a coupled physical–biochemical ocean model to study the Kuroshio-induced nutrient supply on the shelf and slope region south of Japan: Case study of Tosa Bay facing the Kuroshio

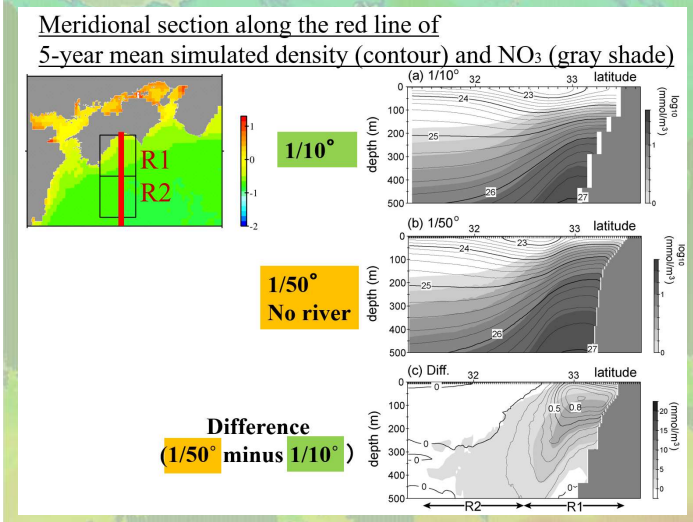
Hiroshi Kuroda, Akinori Takasuka, Yuichi Hirota, Taketoshi Kodama, Tadafumi Ichikawa, Daisuke Takahashi, Kazuhiro Aoki and Takashi Setou
(Fisheries Research and Education Agency)

Introduction: We developed a triply nested 1/50° ocean model coupled with a lower trophic level ecosystem model and conducted numerical experiments to identify the major processes that supply nutrients on the shelf and slope region north of the Kuroshio. Tosa Bay facing the Kuroshio, was selected for our experiment. Our focus is roles of submesoscale variations with *O(10km)* and *O(1day)*.

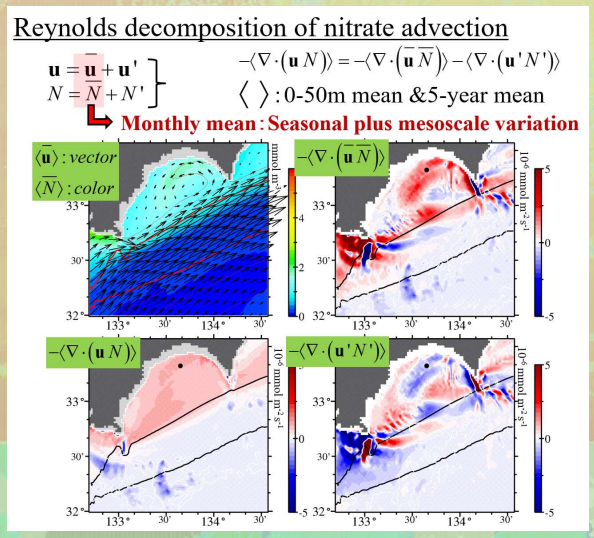




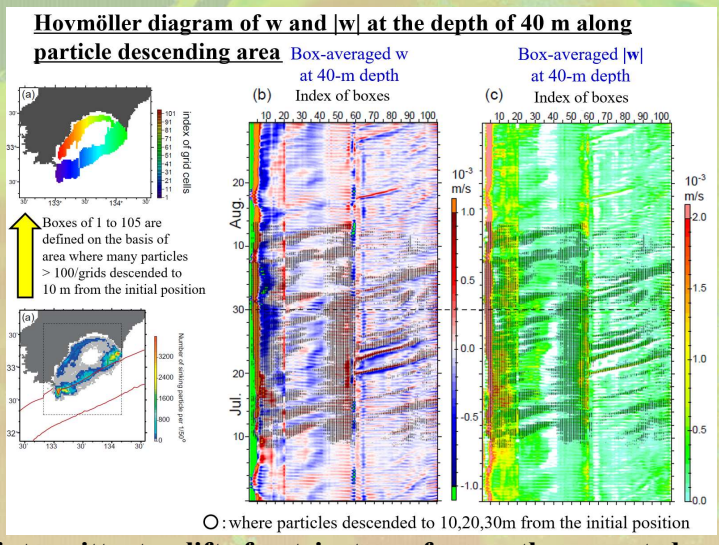
Result 1: Comparisons of numerical simulations using different grid sizes revealed that a grid size of no larger than 1/50° was essential to reproduce a time-independent density structure related to the Kuroshio jet that uplifted nitrate from subsurface waters into the euphotic zone north of the Kuroshio front.



Result 2: Advection of nitrate is a major source of nitrate north of the Kuroshio front. Eddy advection of nitrate for depths of 0-50 m based on Reynolds decomposition, attributable primarily to submesoscale variations, had both positive and negative values within Tosa Bay, the indication being that eddy advection functioned regionally to supply or remove nitrate.



Result 3: Lagrangian particle-tracking experiments (backward in time) were performed to examine the major pathways of the nitrate used for primary production in Tosa Bay during the summer, when subsurface maxima of primary production typically appeared. The experiments revealed that when the Kuroshio took a stable nearshore path, nitrate was frequently uplifted around the Kuroshio front and horizontally transported along the front and into the bay via the counterclockwise circulation within the bay.



Conclusions:

1) Importance of submesoscale modeling to simulate the Kuroshio-induced nutrient supply in terms of time-independent structure of density and nutrient.
2) Eulerian viewpoints: Reynolds decomposition
Roles of time-dependent submesoscale variations via eddy advection of nutrient are spatially different, i.e., supply of nitrate or removal of nitrate.
3) Lagrangian viewpoint: Particle tracking
In summer when the Kuroshio takes a nearshore path, an intermittent uplift of nutrient was frequently generated near the Kuroshio fronts, horizontally transported into the bay and used for photosynthesis in the subsurface.

Reference: Kuroda et al. (2018): Numerical experiments based on a coupled physical-biochemical ocean model to study the Kuroshio-induced nutrient supply on the shelf-slope region off the southwestern coast of Japan. Journal of Marine Systems, 179, 38-54.