Mixed layer depth & chlorophyll *a*

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1. Hypotheses for phytoplankton bloom

☑ Critical Depth Hypothesis (CDH; Sverdrup, 1953)
- Bloom initiation occurs in spring
- Caused by increase in light availability above the threshold, mainly through mixed layer shoaling

☑ Disturbance-Recovery Hypothesis (DRH; Behrenfeld and Boss. 2014)
- Bloom initiates in winter when mixed layer is deep;
- Caused by decrease in grazing pressure through decreasing prey/predator encounter rates
- Analyses based on areal **biomass [m^{-2}]** instead of **concentration [m^{-3}]** in the North Atlantic

Question
- Mixed layer and phytoplankton in the NW Pacific?
- Bloom mechanism: CDH, DRH or others?

2. Profiling float observations in the Kuroshio-Oyashio Extension region (KOER)

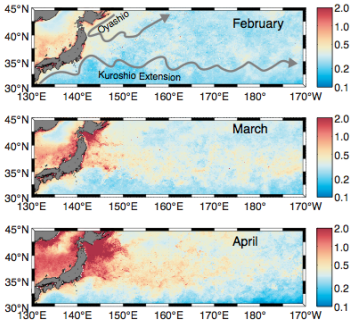


Fig. 1. Monthly sea surface chl *a* [mg m^{-3}] in the KOER

- Profiling float "NINJA"
- Measuring P, T, S, Chl, and Turbidity
- Profiling 5–500 m every 5 days, otherwise parking at 40 m
- Analyze vertically integrated and averaged chl and turb

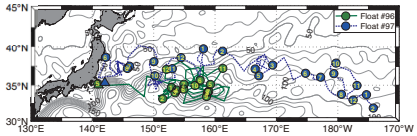


Fig. 2. Float positions at a 5-day interval

3. Fluctuations from winter to spring

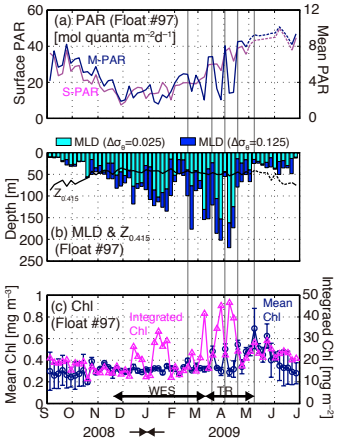


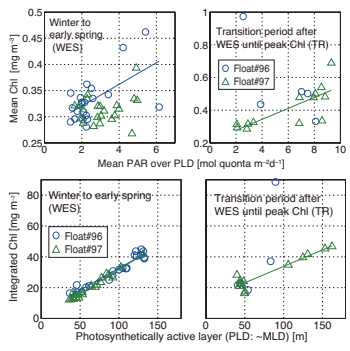
Fig. 3.
(a) light intensity
(b) Mixed layer depth (MLD) and $Z_{0.415}$ (depth of irradiance limit)
(c) mean and integrated chlorophyll *a* within PLD (either MLD or $Z_{0.415}$, whichever is deeper).

WES: Winter to early spring period
TR: Transition period after WES until the spring bloom

4. Correlation analysis

Fig. 4.
Relationships between mean PAR and mean chl *a* (upper), and PLD and integrated chl *a* (lower), for periods of WES (left) and TR (right).

- Similar results for turbidity (particle backscatter)



5. Phytoplankton responses to MLD fluctuations

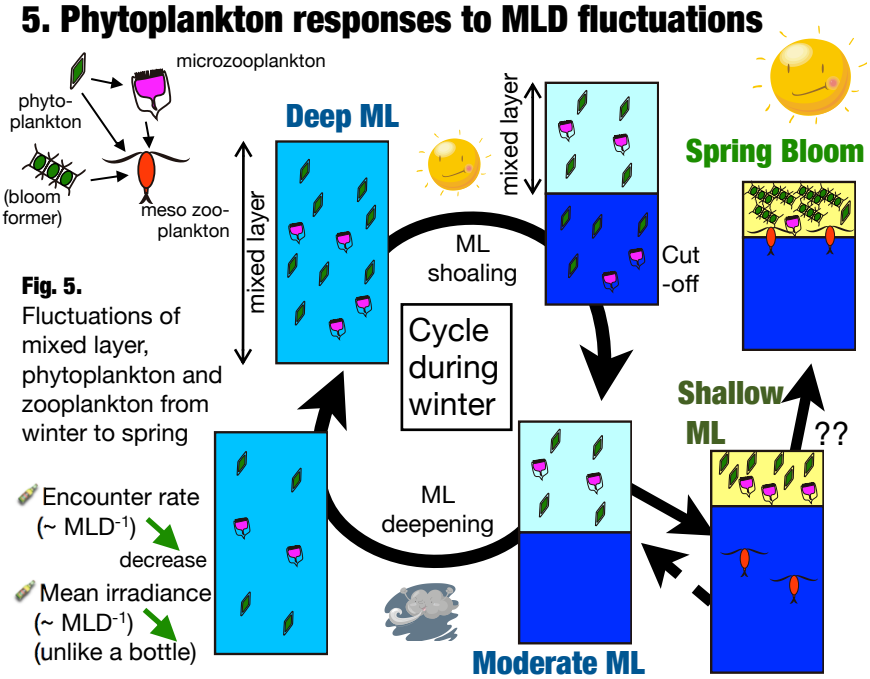


Fig. 5.
Fluctuations of mixed layer, phytoplankton and zooplankton from winter to spring

- Encounter rate (~ MLD^{-1}) ↘ decrease
- Mean irradiance (~ MLD^{-1}) ↘ (unlike a bottle)

6. CDH or DRH?

- Phytoplankton biomass increased in winter when MLD was deep. (**consistent with DRH**)
- Deepening of MLD would decrease irradiance similarly to encounter rates, which likely compensate each other. (**opposed to DRH**)
- Positive responses of mean chlorophyll *a* to MLD shoaling events were observed (**consistent with CDH**)

Both production-driven (e.g., CDH) and loss-driven (e.g., DRH) processes are responsible for phytoplankton bloom in the Kuroshio-Oyasio Extension region

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