

Why do *Ecklonia cava* ssp. *kurome* remain in deep waters in Isoyake area off Eastern Kyushu, Japan?

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E. cava ssp. *kurome*
Distribution: Temperate
Family: Laminariaceae

Background

Seaweed beds such as kelp and *Sargassum* are important to many marine organisms, especially abalones and lobsters. However, the disappearance of seaweed beds (known as **Isoyake** in Japan) are occurring in temperate zones in the world due to **rising sea water temperatures** and **overbrowsing of herbivorous fish** (Fisheries Agency 2022). Progress of Isoyake is not spatially uniform, and little is known the conditions of the remaining seaweed beds.

Purpose : Predict the progress of isoyake area and select suitable sites for restoration of seaweed beds.
⇒ Clarify the survival conditions of *Ecklonia cava* ssp. *kurome* (Kurome) in the coastal waters of Nagoya, Oita Prefecture, where Kurome has declined significantly over the past 5 years.

Method

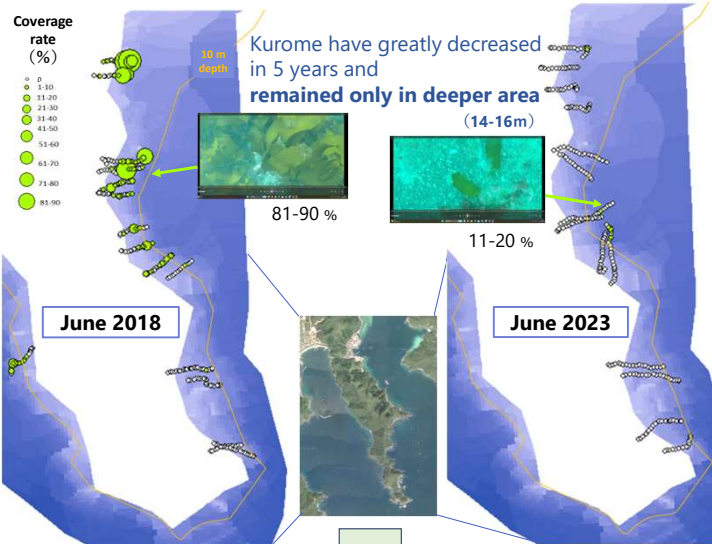
Survey of remaining Kurome beds

- Coverage survey of Kurome (Jun. 2018 & Jun. 2023, GoPro HERO4)
Using video camera while diving along several lines, video recordings of the sea bottom was taken and then extracted Kurome coverage rate was estimated based on screenshots every 30 seconds.
- Substrate and Kurome survey (Oct. 2022)
A 170 m line was set up from shore to offshore, and while swimming, the substrate type was recorded every 1 m and the density of Kurome every 5 m.

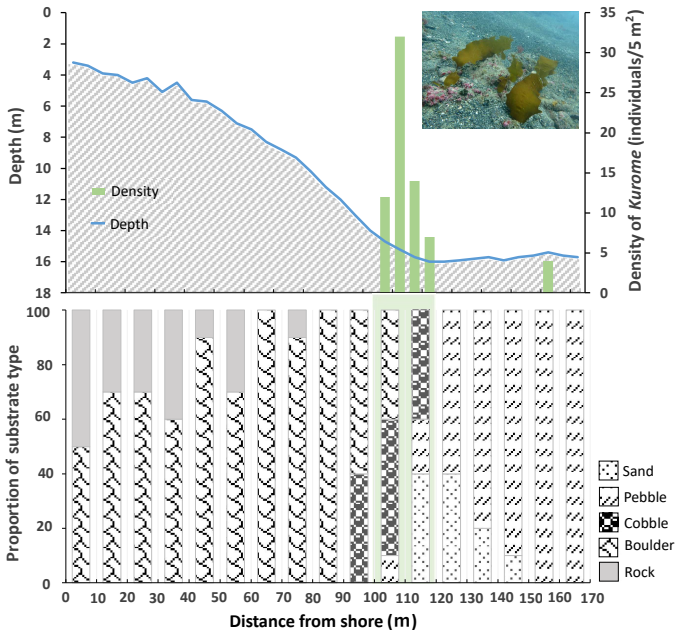
Environmental Characteristics Survey

- **Water Temperature** (Sep. 2022-Sep. 2023, SonTek CastAway-CTD)
- **Underwater Photosynthetically Active Radiation (PAR)** (Oct. & Dec. 2022, JFE Advantech, DEFI2-L; Jun. 2023, Li-Cor, LI-192SA & LI-1400)
- **Herbivorous fish** (Dec. 2022)
GPS-tracked under water visual census: count the number of Japanese parrotfish *Calotomus japonicus* (dominant herbivorous fish) in a 5 m wide area.

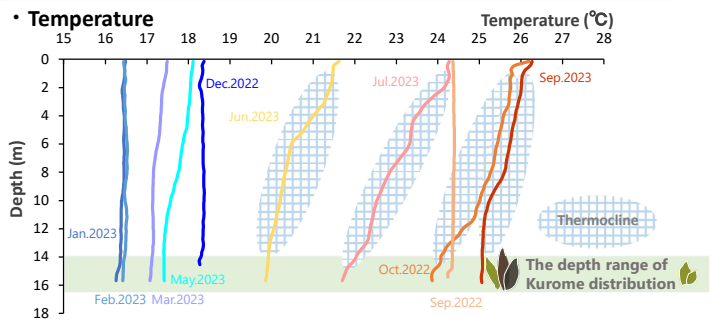
Results Distribution of remaining Kurome



Kurome remain in transition zones from sand to rock

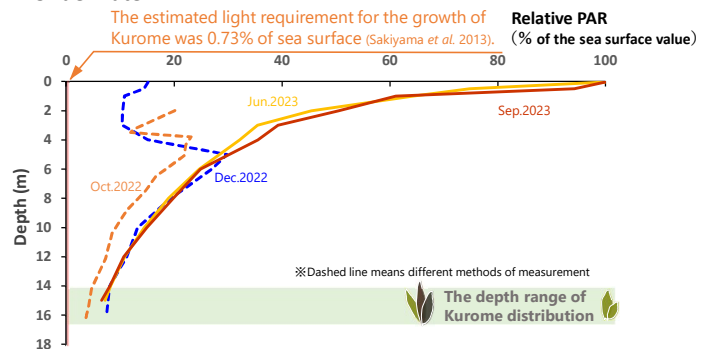


Results Environmental characteristics



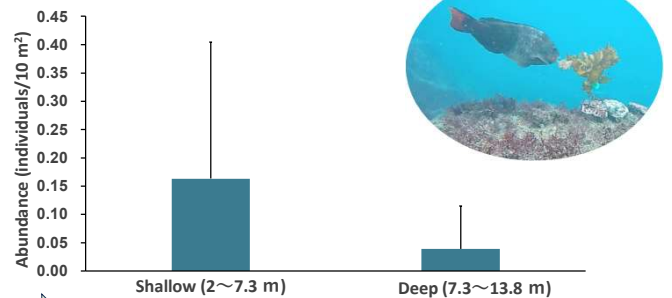
➡ About 2°C lower than sea surface due to the thermocline, during summer to autumn.

Underwater PAR



➡ Underwater PAR at the growing site is higher than the estimated light requirement for the growth.

Abundance of herbivorous fish



➡ Shallow >> Deep (Wilcoxon test, P<0.05, N=22)

Discussion Remaining condition Kurome

- **Temperature** Low water temperatures during summer to autumn ($\leq 22^\circ\text{C}$)
 - ➡ Optimal water temperature for sporophytes is 10-20 °C, upper growth limit is 28 °C (Baba, 2021)
 - Less feeding pressure by herbivorous fish of lower temperature (Noda and Kadota, Unpublished data)
- **Light** Above the minimal light requirement for the growth of Kurome
 - ➡ The study area > Light requirement for the growth (0.73%) (Sakiyama et al. 2013)
- **Herbivorous fish** Significantly lower density in deeper waters
 - ➡ Browsing pressure is lower in the deeper depth zone
 - ➡ Sand uplift and sedimentation can inhibit feeding of herbivorous fish (Akita et al. 2022; Noda et al. Unpublished data)

➡ Low water temperature and low browsing rate resulted in the survival of Kurome.

➡ Deep water (14-16 m) and rocky & sandy bottom probably could be utilized as important sites for seaweed bed restoration.

Acknowledgments

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