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Effects of ulvoid (*Ulva* spp.) accumulation on the structure and function of eelgrass (*Zostera marina* L.) bed

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Abstract

The objective of this study is to clarify the effect of ulvoid (*Ulva* spp.) accumulation on the structure and function of an eelgrass bed by the coast of Iwakuni, Seto Inland Sea, Japan. We monitored eelgrass shoot density and volume of ulvoid accumulation in the study site and evaluated effects of the accumulated ulvoid canopy on the percent survival, seedling density, growth rates, photosynthetic photon flux density (PPFD) and carbon contents of eelgrass. Eelgrass shoot density decreased by the accumulation of ulvoid. Also, seedling density decreased by the increase in the ulvoid volumes. Shoot density, seedling density and leaf elongation were negatively correlated with ulvoid volume. Carbon contents in eelgrass decreased by the accumulation of ulvoid (canopy height: 25 cm). These results suggest that accumulation of ulvoid bloom has significant negative impacts on the structure and function of eelgrass bed, i.e. decreases in vegetative shoot density, seedling density, shoot height and growth rate.

Keywords: *Zostera marina*; Ulvoid accumulation; Shoot density; Seedling; Carbon content

1. Introduction

Seagrass habitat has decreased worldwide (Short and Wyllie-Echeverria, 1996) due to coastal development and/or eutrophication in coastal waters in the 20th century. Eutrophication results in excessive growth of phyto-plankton in water and epiphyte on eelgrass leaves. The increased phytoplankton and epiphyte cause deterioration of eelgrass bed by blocking the light needed for photosynthesis Duarte, 1991; Williams and Rucklshaus, 1993; Kendrick et al., 2002; Greve and Krausen-Jensen, 2005). Recently, ulvoid (*Ulva* spp.) blooms called as "Green Tides" have occurred in eutrophic coastal waters around Japan. *Ulva* spp. are composed of attaching and floating types in Hiroshima Bay, the Seto Inland Sea. Floating ulvoid often shows an extraordinary increase in abundance in estuary and the inner part of the bay Uchimura et al., 2004). Ulvoid is reported to have replaced eelgrass in the Seto Inland Sea, Mikawa Bay and Tokyo Bay (Ohno, 1999).

We have monitored eelgrass density and distribution in the restored habitat by the coast of Iwakuni in western Hiroshima Bay. In this place, floating *Ulva* grows and accumulates, and covers the sea bottom, often with a 20–30 cm thickness. Ulvoid blooms often occur from autumn to winter. Eelgrass density and distribution shows the maximum in spring and the minimum in winter. Extraordinary increase in ulvoid abundance may be a cause of eelgrass die-out in winter. The objective of this study is to clarify the effect of ulvoid accumulation on the structure and function of an eelgrass bed by the coast of Iwakuni.

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2. Methods

2.1. Study sites

The study site is located on the coast of Iwakuni, the Seto Inland Sea, Japan (Fig. 1). There is a dredged area of about 2 ha with the depth range from D.L. −1.0 to −3.0 m. We constructed an eelgrass habitat of 600 m^2 in the dredged area with elevations (D.L. −0.5 to −1.0 m) suitable for eelgrass in June 2000. A test area (15 m × 35 m) was established in the constructed habitat. The area was divided into 10 (7 m × 7.5 m) sections. Transplantation (1 shoot m^{-2}) and seeding (500 seeds m^{-2}) were carried out in 4 sections in August and November 2000, respectively. Two sections were unvegetated without any transplantation and seeding. A natural habitat where eelgrass bed disappeared after the typhoon attack in September 1999 was selected as a control site. Ten control sections were established in the same way as test sections in the constructed habitat. Monitoring quadrate (2 m × 2 m) was placed in each section.

2.2. Monitoring of eelgrass and ulvoid

We monitored shoots density, shoots length of eelgrass and ulvoid volume at approximately 2-month intervals after the transplantation and seeding. Ulvoid volumes were obtained by multiplying percent coverage by canopy height.

2.3. Effect of ulvoid accumulation on eelgrass

We investigated effects of ulvoid accumulation on eelgrass using 300 L outdoor tanks with or without ulvoid. We put three test trays (20 cm diameter × 10 cm deep) in each tank with running seawater. Each tray was filled with tidal flat sand and planted with five eelgrasses (30 cm height). We established tanks with 0 cm, 13 cm and 25 cm ulvoid canopy height and maintained the height the experiment. Eelgrass survival rate and leaf elongation rate were determined for three treatments between October and December 2003. Elongation rate was determined by marking leaf using a felt pen.

To determine effects of ulvoid accumulation on seedling generation rate, five pots (10 cm diameter × 10 cm deep) planted with twenty seeds were put in tanks with 0 cm, 13 cm and 25 cm ulvoid canopy height in December 2004. Seedling in each pot was counted at approximately 2-week intervals between December 2004 and January 2005.

The effects of shading by accumulated ulvoid on carbon contents in eelgrass were estimated by using outdoor tanks with ulvoid (0 cm and 25 cm canopy height). Carbon content of leaves (center of No. 3 leaf: No. 1 is the youngest and innermost leaf), rhizomes (from 2 to 3 node) and roots were determined using a CHN analyzer (Yanako CHN Corder MT-5). The shading of solar irradiation by ulvoid was estimated by the decrease in photosynthetic photon flux density (PPFD) using an underwater 2π cosine-corrected sensor (Sanyosokki Co.: MPQ-V) placed at the bottom of the cylinder.

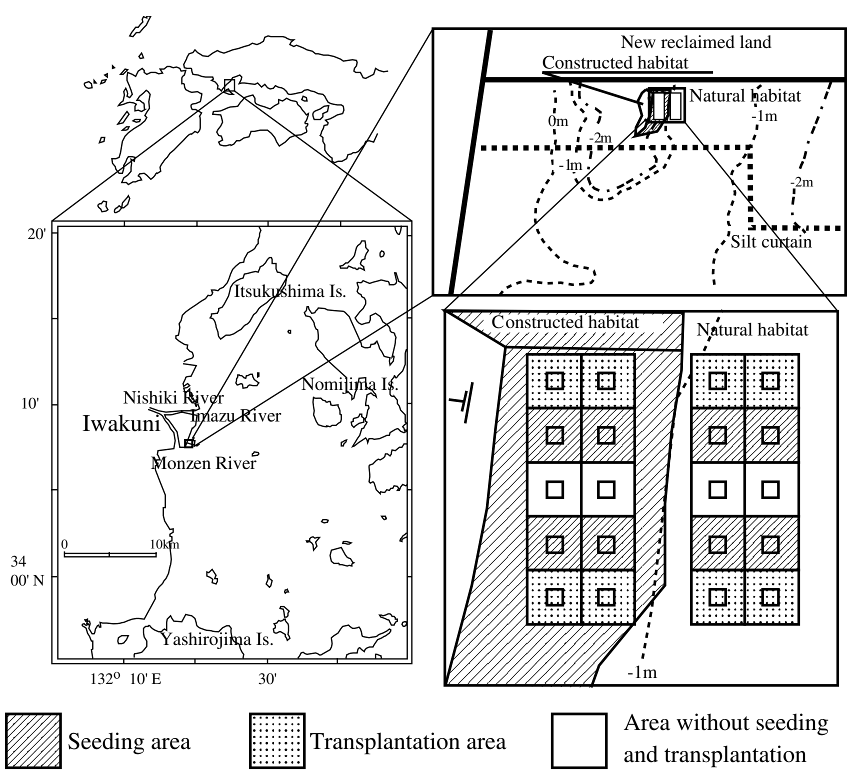

Fig. 1. Map of study sites on the coast of Iwakuni, Yamaguchi Prefecture. Small squares indicate 2 m × 2 m quardrates.