

Distribution and recent reduction of *Gelidium* beds in Toyama Bay, Japan

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Abstract

The distribution and recent reduction of *Gelidium* beds, i.e. mat-like beds dominated by the agarophyte *G. elegans* Kützinger in Toyama Bay (Sea of Japan), in which 95% of the coastline is protected artificially, are reported. *Gelidium* beds were common in shallow waters (usually <10 m deep); most of the large beds (>1 ha) were restricted to the inner coasts of the bay. In calm and eutrophic areas, however, *G. elegans* was heavily colonized by epiphytes. In the last decade, two beds were buried *in situ* and beds in their vicinity were damaged by the stagnation of coastal water and/or sedimentation by silts which accompanied land reclamation. At the other two beds monitored since 1988, *Gelidium* declined a few times but most prominently in 1998, when episodic long summer rain was recorded. This is the first report, not only on the current status of *Gelidium* beds other than for the central Pacific Coast of Honshu in Japan, but also concerning reduction of the beds caused by both anthropogenic and natural events.

Introduction

Gelidium beds have been one of the most important seaweed beds in Japan because *Gelidium* (and species of related genera) have been the major materials for commercial extraction of agar (Akatsuka, 1986). Recently, however, less attention has been paid to *Gelidium* beds than before because domestic agar yields have declined drastically. The major reason for the reduction is the lower price of dried agarophytes, resulting from an increase in imports from other parts of the world and the decrease in the use of agar among a variety of polysaccharides (Fujita, 2004). Although data in the Nature Conservation Bureau (1994) showed that decrease of *Gelidium* beds was the most serious among eight types of domestic seaweed beds, little is known about the current status of *Gelidium* beds other than for the central Pacific (e.g. Yanase et al., 1982, Tokyo Metropolitan Fisheries Experiment Station, 1996).

Among prefectures of Honshu Island facing the Sea of Japan, Toyama Prefecture has ranked first, providing 89% of the annual *Gelidium* yield for more than a decade because the yields in 11 other prefectures have declined more rapidly (Fujita, 2004). In this prefecture, *Gelidium* has been cropped in Toyama Bay by hand or harvested using a stick with iron claws or triangular rakes called 'Manga' dropped from boats. These *Gelidium* fisheries have been summer jobs for diver-fishermen and labourers working for set-net fisheries (Fujita, 1994). Furthermore, *Gelidium* beds have been re-evaluated as nurseries for fish and shellfish, particularly for horned turban, a commercial gastropod *Turbo cornutus* (Fujita et al., 1990; Fujita & Kamono, 1998). However, *Gelidium* yield has also decreased along the prefectural coast (Fujita & Shozen, 1999, and revised in Figure 1) and little has been known about *Gelidium* beds up to now. In the present paper, we describe the distribution, current status and recent reduction of *Gelidium* beds in Toyama Bay.

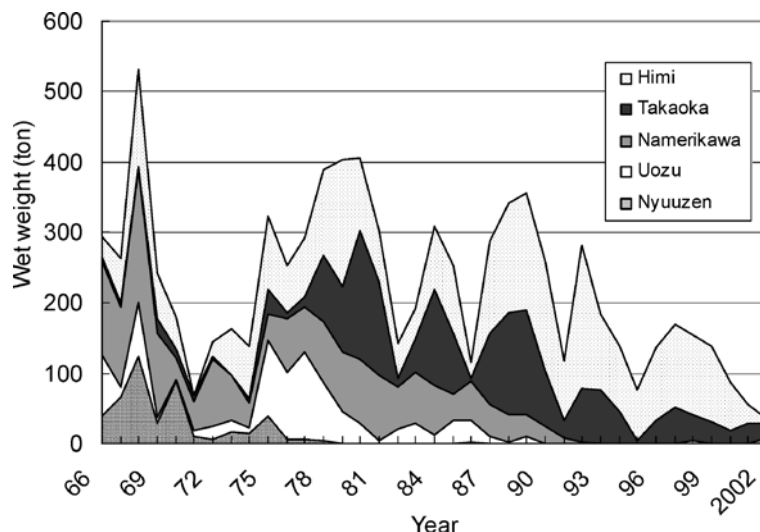


Figure 1. Yearly changes in the *Gelidium* yields (raw) by towns in Toyama Bay between 1966 and 2002 (revised from Fujita & Shozen (1999)).

Materials and methods

Toyama Bay (largely from $36^{\circ}50'N$ to $37^{\circ}N$ and $137^{\circ}E$ to $137^{\circ}40'E$) is located on the central Sea of Japan coast of Honshu Island, Japan. The prefectural coastline of the bay is ca. 100 km long and shared by nine towns. The inner coasts of the bay, particularly the coast of Himi and east coast from Namerikawa to Uozu, are highly sheltered by the Noto Peninsula and Ikujibana Cape (Figure 2). The notable characteristics of the coast are the small tidal range (<0.5 m), eutrophication and low salinity (15 to 30 PSU in surface seawater) caused by inflow of many rivers as well as a high rate (95%) of artificial protection (Nature Conservation Bureau, 1998). Hard substrata comprise cobbles and rocks in the inner and outer coasts of the bay, respectively. The detailed environments have been described elsewhere (Fujita & Shozen, 1999, 2002 and papers cited in these reports).

The current status of *Gelidium* beds was surveyed by SCUBA diving during the Comprehensive Environmental Survey of Fishery Grounds in Toyama Bay made in 2001 and some additional visits. Distributions of seaweed beds were determined by taking aerographs (1/5000 in scale) of the whole prefectural coast. Areas of *Gelidium* and other seaweed beds were estimated using a planimeter after their outlines were traced on the contoured map. Here we described the detailed information on *Gelidium* beds that was not given in the report (Fujita & Shozen, 2002). The status of beds in the past was known from previous papers cited in

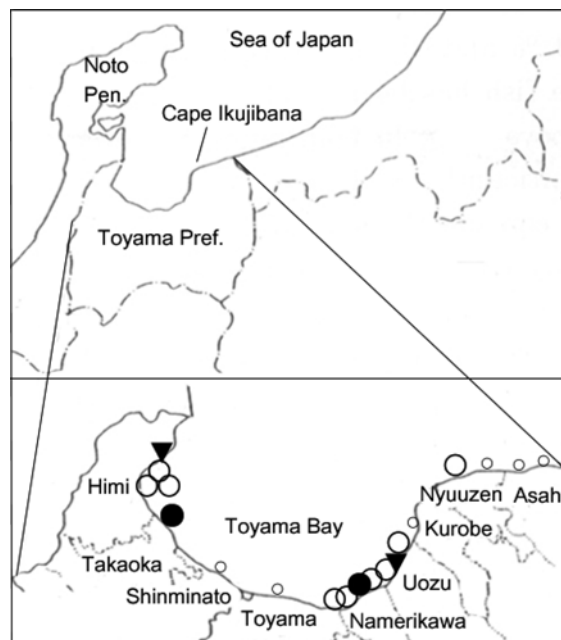


Figure 2. Map showing the location of Toyama Bay and the occurrence of *Gelidium* beds. Large (O) and small (o) open circles indicate large (>1 ha) and smaller *Gelidium elegans*-dominated red-mat like beds, respectively. Solid circles (●) = monitored *Gelidium* beds; Triangles (▼) = *Gelidium* beds declined after 1990.

Fujita and Shozen (1999, 2002) and unpublished photographic data.

Long-term monitoring began in 1988 at two *Gelidium* beds off Namerikawa ($36^{\circ}46'N$ $137^{\circ}21'E$) and Takaoka ($36^{\circ}48'N$ $137^{\circ}3'E$) on the east and west sides