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Species and year class compositions of demersal fishes in Onagawa Bay after the huge disturbance in 2011

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Abstract — To assess the population status of coastal fishery resources, demersal fish composition caught by gillnet and year-class compositions were examined in Onagawa Bay, Miyagi Prefecture, after the Great East Japan Earthquake in 2011. The two most dominant fishes were greenlings and brown hakeling. The catch per unit effort (CPUE) of total fishes fluctuated seasonally, without ever reaching a seriously low level. There were few black rockfish and marbled sole recruits of the year-class after 2011. The year-class compositions of many species displayed similar changes, with the majority of fish caught in 2012 belonging to year-classes that reproduced before 2011. Although the proportion of year-classes before 2011 decreased as the year progressed, CPUEs were not at a low level. The data suggests that there are no serious problems with the current population status; however, future trends in recruitment need to be assessed.

Key words: Gill net, CPUE, Otolith

Introduction

A magnitude 9.0 earthquake struck off the Sanriku coast, Japan, on March 11, 2011. The earthquake generated a tsunami that caused serious damage to the fishing industry, primarily in the seven prefectures from Hokkaido to Chiba along the northeastern Pacific coast of Japan. Several studies have reported the impacts of the earthquake and subsequent tsunami on the coastal fish community in the Tohoku area (Goto et al. submitted for publication, Shirakihara et al. submitted for publication). These studies indicated that no direct effects of the 2011 tsunami were apparent on the surf zone fish community, although some changes occurred in the pelagic fish composition due to oceanographic fluctuation. Scientific information regarding the abundance, composition, and recruitment of fishes needs to be provided to rebuild the coastal fisheries after the serious damage experienced. We monitored the demersal fish composition and examined their successive recruitment in Onagawa Bay, Miyagi Prefecture, to assess the population status and maintain the coastal fisheries.

Materials and Methods

The survey area of Onagawa Bay is located at the northern base of the Oshika Peninsula, Miyagi Prefecture (Fig. 1). The continuous monitoring of demersal fish composition was conducted using a gill net in the inner bay area, from April 2012 to December 2014, once a month or every few months. Three nets (50 m each, with an inner mesh of 7.0 cm and outer mesh of 22.7 cm) were set on the sandy mud bottom at a water depth of around 30 m, from 16:00 till 09:00. Supple-

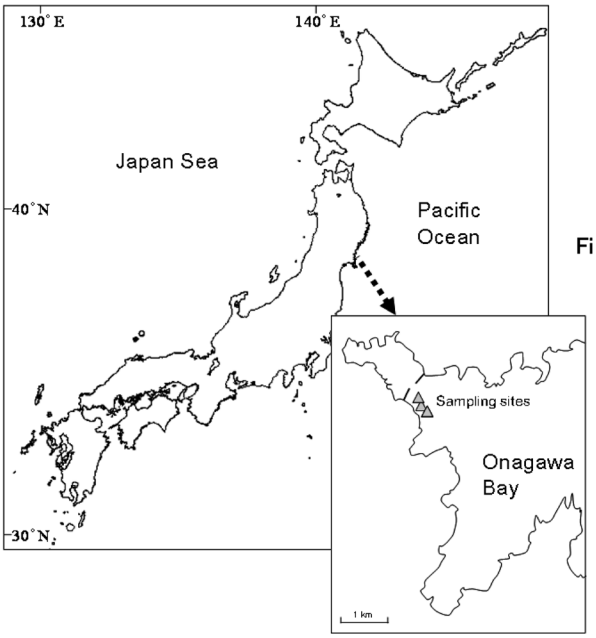

Fig. 1. Survey site in Onagawa Bay.

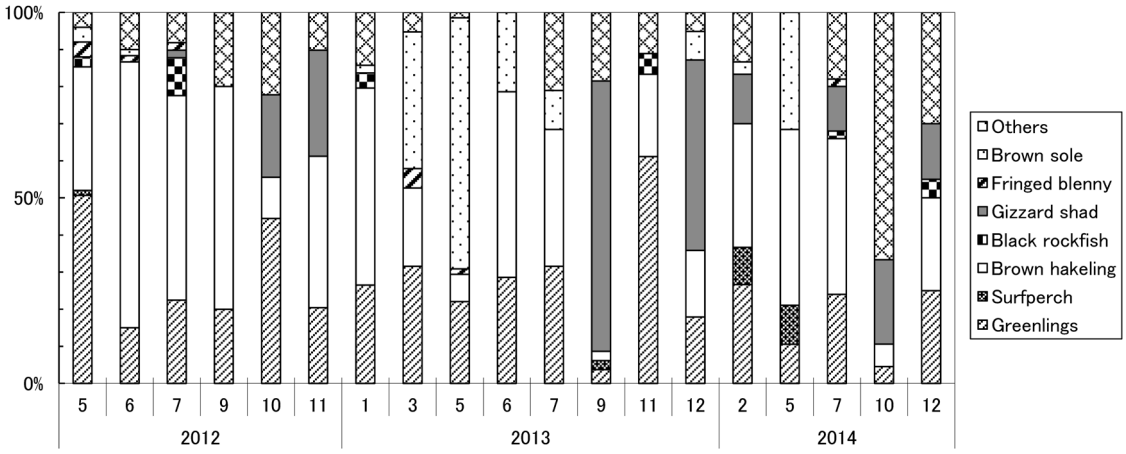

Fig. 2. Seasonal change in fish composition caught by gillnet in Onagawa Bay.

mental collections using 12 pods were also operated to catch conger eel *conger myriaster*. We counted fish caught by the net and estimated the catch per unit effort (CPUE).

To obtain the year class compositions of demersal fishes after the earthquake, individual ages were determined by otolith observation. Six species of important fisheries resources in Onagawa Bay were examined: Greenlings *Hexagrammos otakii*, brown hakeling *Physiculus maximowiczi*, black rockfish *Sebastes schlegeli* and brown sole *Pleuronectes herzensteini*, which were major fishes caught in our gillnet surveys, marbled sole *Pseudopleuronectes yokohamae*, which was one of the major fish before the earthquake, and conger eel, which predominantly inhabits the survey area. Samples of conger eel were supplemented from catches of pod collectors, because the fish was rarely caught by the gillnet. Sagittal otoliths were removed from each fish, cleaned, dried, and stored under natural conditions until further observation. Otoliths were then mounted, embedded in polyester resin, and then cut into ≈ 0.3 mm transverse sections using a diamond saw (Leica sp1600, Leica Microsystems GmbH, Wetzlar, Germany). Sections were mounted on glass slides and their surfaces were ground to sequentially finer grades using carborundum paper #800–#2000. Sections were examined using a binocular microscope under transmitted light. The magnification was either 40× or 100×.

Results

The two dominant fishes were greenlings and brown hakeling (Fig. 2). These fishes dominated the species composition in almost all surveys throughout the period of 2012 to 2014. Their dominancy was reduced in autumn because of increases in many migratory pelagic fishes (e.g., gizzard shad) every year. In 2013 and 2014, brown sole dominated in spring.

The CPUE fluctuated over a range of 3 to 27 (Fig. 3).

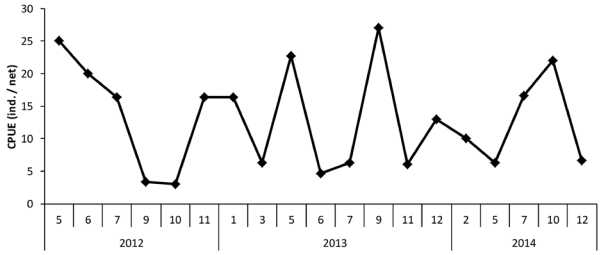

Fig. 3. Seasonal change in CPUE (number of fish caught by a net) in Onagawa Bay.

There was a tendency for the CPUE to rise when the shad and the brown sole occurred seasonally.

Year-class compositions of major species were estimated by otolith age determination (Fig. 4). No black rock fish were caught in 2014 and no marbled sole were caught in 2013–2014. The year-class compositions of black rockfish and brown sole were relatively stable throughout this survey period, with the dominancy of the 2010 and 2011 year-classes remaining unchanged. Greenling, brown hakeling, and conger eel, displayed similar changes, i.e., the majority of fish caught in 2012 had reproduced before 2011. The proportion of the total fishes in year-classes from before 2011 decreased as the year progressed. The 2011 and 2012 year-classes that hatched after 2011 dominated the catch in 2014.

Discussion

The composition of fish species caught by the gill net was dominated by resident demersal fishes that were found throughout the year in the study area, although soles and pelagic fishes also occurred in spring and autumn, respectively. The species list did not differ from that recorded before the large tsunami in 2011 (Katayama et al. 2016). The CPUE varied widely, but was not remarkably lower or higher than

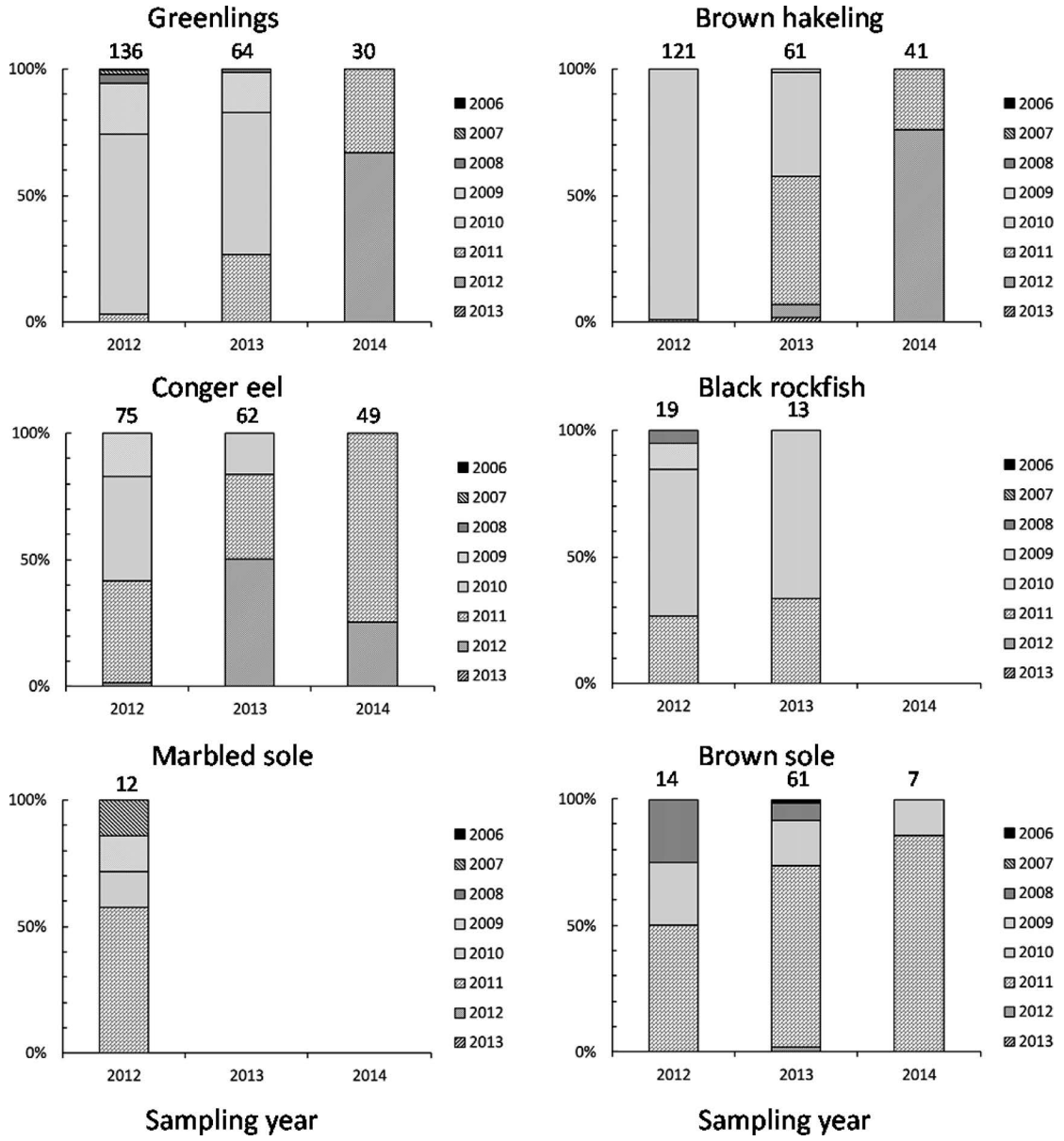

Fig. 4. Year class compositions of greenlings, brown hakeling, conger eel, black rockfish, brown sole, marbled sole collected in Onagawa Bay. Numbers above bars indicate sample sizes.

before the tsunami (Katayama et al. submitted for publication). Although the species composition in summer changed slightly after the tsunami due to decreases in marbled sole and fringed benny, and an increase in gizzard shad, there was no serious long-term effect of the huge disturbance on the fish fauna.

Year-class compositions showed the presence of replacements for greenling, brown hakeling, and conger eel, from year classes surviving the tsunami to new year-classes having recruited successfully. On the other hand, there was an absence of year-classes in 2012 and 2013, and no occurrence in 2013 and/or 2014 for black rockfish and marbled sole. There were few black rockfish and marbled sole recruits in the 2012 year-class. The reasons for the failure of recruitment for these fishes are unknown. There is a need to investigate whether these changes were caused by the environmental changes in Onagawa Bay or by natural population fluctuations.

Only a few reports have been published that document recruitment levels of coastal fishes based on year-class data. Iwasaki et al. (2013) suggested that the abundance of four major demersal fishes has increased due to the cessation of fishing activities by the trawl fisheries off Fukushima Prefecture. The CPUEs of Japanese flounder and Pacific cod doubled compared to levels before the tsunami. There was an increase in biomass for many demersal fishes after the tsunami. However, somatic growth could account for these increases, and new recruits were considered to be present at low levels

(Fukushima Pref., unpubl.). Recent and future recruitment trends should be assessed in order to rebuild the coastal fisheries in the damaged areas.

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