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Biological environmental characteristics in habitats of an abalone *Haliotis diversicolor* in the eastern coast of Jeju-do, Korea

Joon-Taek Yoo[1], Young-Min Choi[1], Moon-Ho Yang[2], Yang-Jae Im[3], Joon-Chul Ko[4] and Dae-Soo Chang[1]

[1]Fisheries Resources Research Division, NFRDI, Busan 619-192 Korea, [2]Jeju Fisheries Research Institute, NFRDI, Jeju-do 690-192, Korea, [3]West Sea Fisheries Research Institute, NFRDI, Incheon 400-420, Korea, [4]South Sea Fisheries Research Institute, NFRDI, Jeollanam-do 556-823

ABSTRACT

This study describes biological environmental characteristics in natural habitats of *Haliotis diversicolor* in the coastal area of Sungsanpo located in the eastern coast of Jeju-do, Korea. The field survey was monthly conducted from May 2006 to February 2007. *H. diversicolor*, sea urchin, turban shell and marine algae were collected by two divers using SCUBA. The species composition of demersal fishes were seasonally investigated by fish traps in 2007. During the study period, more than 67% of *H. diversicolor* and sea urchin were found in the depth shallower than 5 m, and more than 64% of turban shell were found in the depth deeper than 3 m. The dominant algal species in May were generally *Undaria pinnatifida*, *Ecklonia cava*, *Sargassum*. spp. and coralline algae. Most of demersal fishes collected by the fish traps were wrasses which have been reported as a major predator of young abalone.

Key words: Jeju, *Haliotis diversicolor*, natural habitat, biological environmental characteristics

INTRODUCTION

Haliotis diversicolor is a relatively small abalone species (maximum shell length 10 cm) that is distributed in southern Korea, southern Japan, Taiwan, and southern China (Geiger, 1999; Lee *et al*., 2002). Locally in southern Korea, *H. diversicolor* is mainly found in the coastal waters of Jeju-do (Kim and Chung, 1985). The catch of *H. diversicolor* which is a commercially important shell species for woman divers in Jeju-do rapidly decreased since the late 1990s (Ko *et al*., 2008), hence it was an important task to establish a recovery plan of the abalone stock.

According to Kawamura (2007), recovery of abalone stock is heavily dependent on an increase in natural recruitment with high density of juvenile abalone. Further, a number of studies have been made on environmental factors affecting natural recruitment of abalone (Kawamura, *et al*., 2002; Roberts *et al*., 1999; Tomascik and Holmes, 2003). It is therefore important to examine environmental characteristics in natural habitats of *H. diversicolor* for understanding its natural recruitment. However, in Korea, there has been very little information on environmental factors in natural habitats of abalone because most viewpoint of studies on abalone has been focused on rearing and releasing of abalone.

The aim of this study is firstly to describe biological environmental characteristics in natural habitat of *H. diversicolor* and to discuss on biological factors responsible for its natural recruitment.

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Corresponding author: Young-Min Choi
Tel: +82 (51) 720-2290 e-mail: ymchoi@nfrdi.go.kr
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MATERIALS AND METHODS

The field survey was monthly conducted in the coastal area of Sungsanpo located in the eastern coast of Jeju-do, Korea, during May-October 2006, December 2006 and February 2007 (Fig. 1). The study

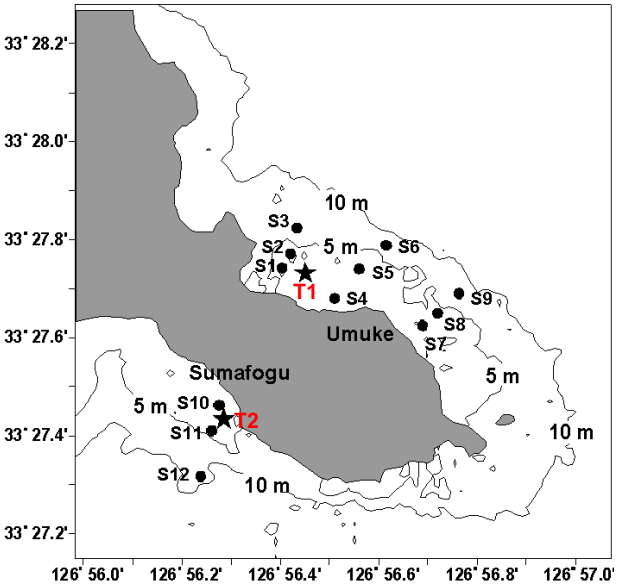

Fig. 1 Map of the study area. Black circles (S1-S12) and stars (TI and T2) are stations of scuba survey and fishing survey by fish trap, respectively. Stations 1, 4, 7 and 10 are located in the 0-3 m depth interval, stations 2, 5, 8 and 11 are located in the 3-5 m depth interval and stations 3, 6, 9 and 12 are located in the 5-10 m depth interval. Sumafogu and Umuke are local names in the study area.

area has been known as a major fishing ground of *H. diversicolor* in the coastal waters of Jeju-do.

Haliotis diversicolor is often divided into the two subspecies: *Haliotis diversicolor* diversicolor and *Haliotis diversicolor* aquatilis. However, genetic and morphological differences between the two subspecies are ambiguous (Onitsuka, 2006), and Geiger (1999) classified *H. diversicolor* diversicolor and *H. diversicolor* aquatilis as *H. diversicolor*. This study followed the definition presented by Geiger (1999).

A team of two divers using SCUBA surveyed twelve sampling stations in the study area (Fig. 1). Samples were collected using quadrats of 2 m × 2 m dimension, which laid at depth intervals of 0-3 m, 3-5 m and 5-10 m. *H. diversicolor*, sea urchin (*Echinoidea*) and turban shell (*Batillus cornutus*) were monthly collected and counted by the divers in the sampling stations. Marine algae were also collected by the divers on May 2006 and their relative coverage was estimated inside the quadrats. In order to look at dominant algal species in natural habitat of

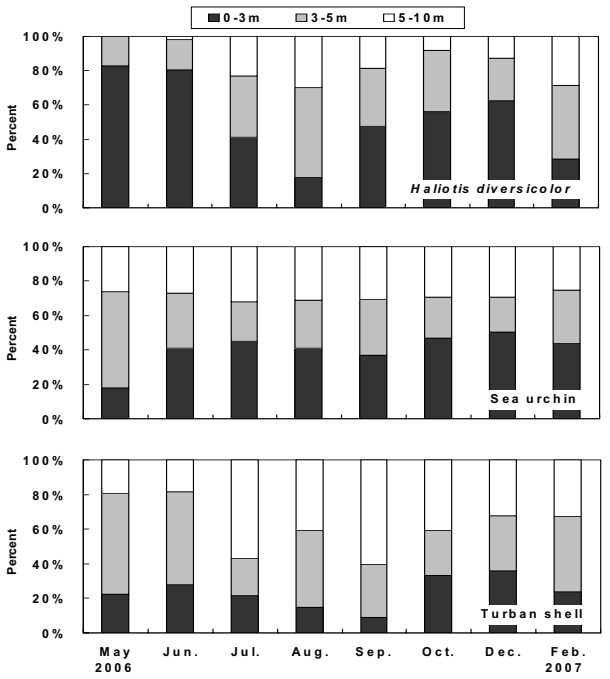

Fig. 2. Proportions of *Haliotis diversicolor*, sea urchin and turban shell collected at each depth interval.

H. diversicolor, algal species greater than 20% coverage at each sampling station is only represented in this study.

On the other hand, Shepherd and Daume (1996) reported that wrasses were a major predator on juvenile abalone in a crustose coralline habitat in West Island, South Australia. Hence, in this study, demersal fishes were seasonally investigated by fish traps in 2007. The dimension of a fish trap is 32 cm × 60 cm, and a cluster of fish traps consists of five fish traps. The cluster setted on bottom in the vicinity of 5 m depth was hauled after two days in two sampling stations (Fig 1).

RESULTS

H. diversicolor collected in the study area from May to June was mostly found in the depth shallower than 3 m, and than the species was mainly distributed in the depth shallower than 5 m (Fig. 2). During the study period, more than 67% of *H. diversicolor* and sea urchin collected in the study area were found in the depth shallower than 5 m, and more than 64% of turban shell were found in the depth deeper than 3 m

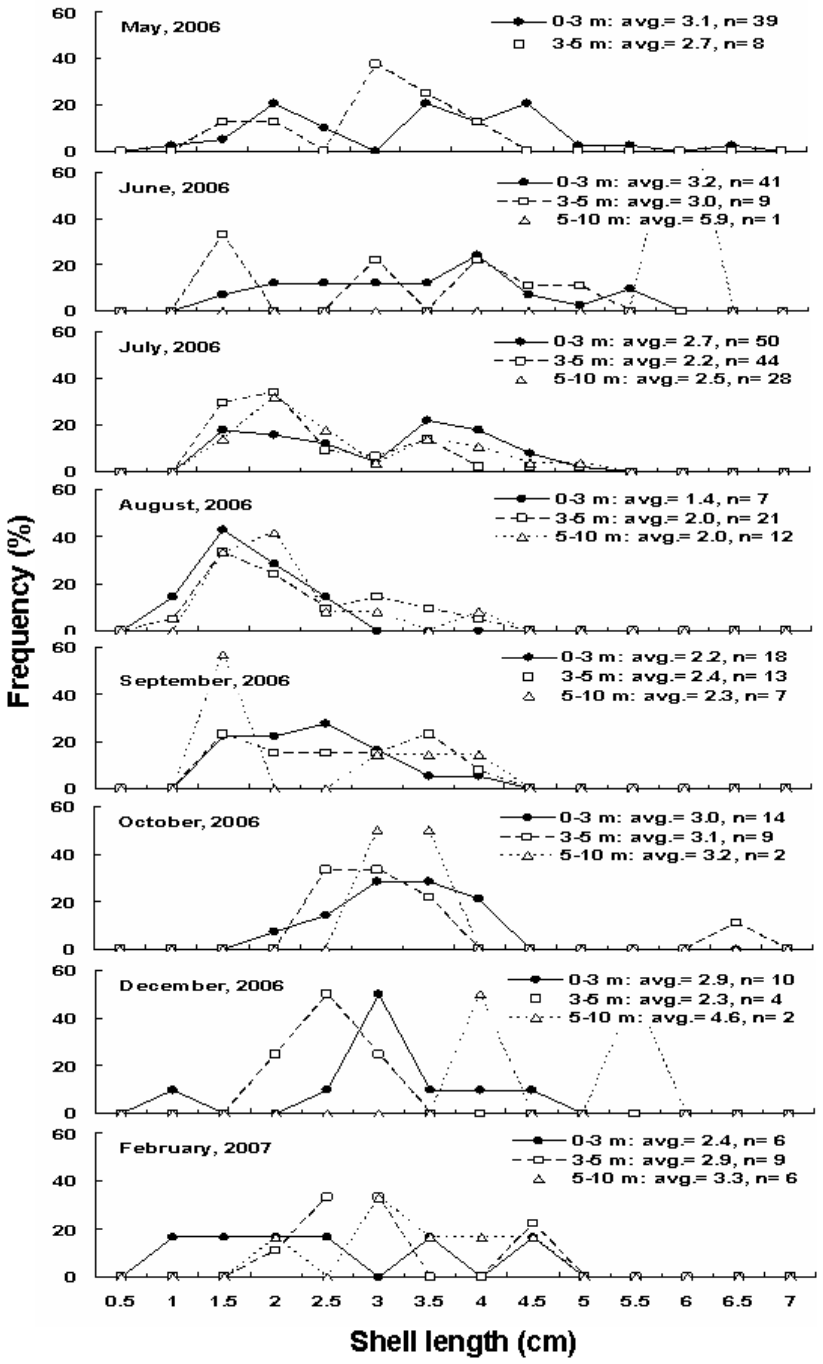

Fig. 3. Length-frequency distribution of *Haliotis diversicolor* collected at each depth interval.

(Fig. 2). Figure 3 shows length-frequency distribution of *H. diversicolor* collected at each depth interval. Different of size of *H. diversicolor* in depth was not significantly observed, and *H. diversicolor* collected in summer was smaller than in other season.

Table 1 shows geological characteristics and dominant algal species at each sampling station. The dominant algal species in the study area were generally *Undaria pinnatifida*, *Ecklonia cava*, *Sargassum*. spp., coralline algae. In particular,

Table 1. Geological characteristics and dominant algal species at each sampling station on May 2006.

Station	Geological characteristic	Dominant algal species
1	rock	• *Undaria pinnatifida*, *Ecklonia cava*, *Grateloupia turuturu* (90%)
2	rock	• *Ecklonia cava* (75%)
3	rock, sand	• *Undaria pinnatifida*, *Ecklonia cava*, Sargassum. spp (90%)
4	rock	• *Ecklonia cava*, *Sargassum*. spp (70 %)
5	rock	• coralline algae (80 %)
6	rock	• *Ecklonia cava* (75 %)
7	rock, sand	• *Ecklonia cava*, *Sargassum*. spp (95 %)
8	rock, gravel, sand	• *Ecklonia cava*, *Sargassum*. spp (85 %)
9	rock, sand	• *Ecklonia cava*, *Sargassum*. spp (45%) • coralline algae (55 %)
10	rock	• coralline algae (80 %)
11	rock, sand	• *Undaria pinnatifida*, *Ecklonia cava*, *Sargassum*. spp (65%) • coralline algae (30 %)
12	rock, sand	• coralline algae (60 %)

(%) : relative coverage

Table 2. Species composition of demersal fishes in the coast of Umuke (T1) and Sumafogu (T2) in 2007. The fish traps setted on bottom in the coast of Sumafogu in December were lost.

English name	April		August		December	
	No. of ind.	Catch (g)	No. of ind.	Catch (g)	No. of ind.	Catch (g)
Coast of Umuke (T1)						
Bambooleaf wrasse	13	631.3	1	110.0	27	1459.2
Multicolorfin rainbowfish			4	386.8		
Cocktail wrasse					1	65.7
Marbled rockfish	3	156.7	4	570.9	2	1343.4
Spotbelly rockfish	1	179.0				
Firefish	1	102.8				
Striped catfish	1	63.7				
Flatfish			1	241.9		
Common conger					1	162.0
Coast of Sumafogu (T2)						
Bambooleaf wrasse	9	424.4				
Multicolorfin rainbowfish			4	377.4		
Cocktail wrasse			1	44.1		
Marbled rockfish	2	373.7	2	414.9		
Brown-lined puffer			1	92.3		
Convict grouper			1	1232.7		
Common Conger			1	501.6		

coralline algae were more dominant in the coast of Sumafogu (station 1-9) than in the coast of Umuke (Station 10-12).

On the other hand, most of demersal fishes caught by fish traps in the coasts of Umuke and Sumafogu were wrasses (Bambooleaf wrasse, Multicolorfin rainbowfish and Cocktail wrasse) (Table 2).

DISCUSSION

In japanese coastal water, despite a large amount of juvenile abalone has been cultured and released since 1970s, natural recruitment remains low (Kawamura, 2007). Accordingly, it is important to accumulate sufficient information on environmental characteristics in habitats of abalone for more understanding its natural recruitment, although the information is very little in Korea. This study therefore described biological environmental characteristics in habitats of *H. diversicolor*.

According to Kim and Chung (1985), *H. diversicolor* was mainly distributed in the vicinity of tidal zone, and this study also confirmed that a main distribution area of *H. diversicolor* is the depth shallower than 5 m. This study cannot provide adequate answer to why size of *H. diversicolor* during July-September, a spawning period of the species (Lee and Lee, 1982), tends to become smaller, and a detailed field survey on spatial distribution of *H. diversicolor* is more necessary in future.

As a result, the main distribution areas of *H. diversicolor* and sea urchin were almost the same (Fig. 2). Although Andrew *et al*. (1998) reported enhancement of abalone recruitment by urchin removal in New South Wales, Tomascik and Holmes (2003) showed that pinto abalone abundance in British Columbia is positively correlated with urchin abundance. It is very difficult to know whether *H. diversicolor* could be related to sea urchin in field. Roberts *et al*.(1999) suggested two possible interactive mechanisms: (1) reduction of mortality caused by urchin grazing of post-larvae or competition for microscopic algal food; (2) increased shelter/food availability due to changes in the algal community following urchin clearance.

Wrasses and crabs are the major predators of young abalone (Shepherd and Daume, 1996), and this study also showed that wrasses dominated in the habitats of *H. diversicolor* (Table 2). However, studies on actual predation rates are lacking, so the relative importance of predation is unknown (Roberts *et al*., 1999).

On the other hand, because Park *et al*. (1994) and Oak *et al*. (2004) reported that the largest number of algal species in the vicinity of tidal zone along the coast of Jeju-do was found during the spring, the survey of marine algae in this study conducted in May. Macroalgae were more dominant in the coast of Umuke than in the coast of Sumafogu. Although postlarval abalone settle largely on crustose coralline algae in natural habitats (Kawamura *et al*., 1998), increase of coverage of coralline algae could result in a worse food environment for juvenile and adult abalone because macroalgae are main source for their food (Cornwall *et al*., 2009; Takami and Kawamura, 2003).

Further, the density of *H. diversicolor* is possibly affected by the fishing pressure of woman divers. A recent study on the management policy of *H. diversicolor* fisheries suggested that the current level of fishing mortality (F) must be decreased below the F level in the mid 2000s (Ko *et al*., 2008). The reduction of density of adult abalone by high fishing effort could limit fertilization success and subsequent recruitment (Kawamura *et al*., 2002). To development an appropriate plan to prevent recruitment overfishing in fisheries management of *H. diversicolor* is also an our major task in future.

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