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Telemetry monitoring of fine scale movement: behavior of black rockfish in a small home range

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ABSTRACT

Several fish species show a strong homing ability and distinct site fidelity to their original habitats and spawning sites. While some pelagic fishes exhibit long-distance migration in an ocean, some site-specific fishes show homing and site fidelity behaviors within a small home range (e.g. < 1 km²). Fine-scale monitoring (accuracy: meters) of movements contributes to the understanding of homing and site fidelity behaviors particularly for the site-specific fishes. We have studied the homing and site fidelity behaviors of the black rockfish which is a typical site-specific fish. In 2004, we tried to monitor fine-scale movements of the rockfish using a positioning telemetry system and introduce the results in this paper.

KEYWORDS: *Sebastes inermis*, *Sebastes cheni*, positioning system, homing, acoustic telemetry

INTRODUCTION

How fish can easily find their original habitat and natal home, under water, remains an unsolved riddle of animal behavior. Salmonids return to their natal river to spawn (Hasler et al. 1983, Dittman & Quinn 1996). Homing of Atlantic cod to spawning grounds is also well known (Green & Wroblewski 2000, Lawson & Rose 2000, Robichaud & Rose 2001). These fish species show long-distance homing migration in an ocean. In contrast to these fishes, other fish species show homing and/or site fidelity within their small home range. For example, it has been revealed since 1970's that many rockfishes of the genus *Sebastes* exhibit homing ability and a strong fidelity to their habitats if displaced (Carlson & Haight 1972, Matthews 1990, Love et al. 2002).

Homing and site fidelity behaviors have been studied with tag-recapture, scuba observation, acoustic observation (e.g. fishfinder), and acoustic telemetry with a vessel and/or a fixed monitoring receiver (accuracy: hundreds meters). However, using these methods, it is difficult to continuously monitor fine-scale movement of several fish at a time. Fine-scale positioning is a step to understand animal behaviour. Continuous fine-scale monitoring of fish movements have a high possibility of uncovering an unsolved riddle of the homing and site fidelity behaviors underwater, on which many researchers have been engaged in working. A few acoustic positioning telemetry systems (e.g. VRAP system, Vemco), which simultaneously allow accurate

horizontal positioning (accuracy: meters) of targets within a small area, have been developed (Hawkins et al. 1974, Ralston & Horn 1986, Klimley et al. 2001), and contribute to the understanding of fish homing and site fidelity behaviors.

We have studied on homing and site fidelity behaviours of the black rockfish Shiro-Mebaru *Sebastes cheni*. Our species was described as *S. inermis* in our previous papers (Mitamura et al. 2002, 2005, 2009). However, recently, the species was separated into 3 different species (Kai and Nakabo 2008), and now our species is *S. cheni*. Our studies demonstrated that the black rockfish returned to their habitats after being displaced about 1–4 km, within some days (Mitamura et al. 2002). They primarily use olfaction to return to their home habitats from outside of their small home ranges (Mitamura et al. 2005). However, in these studies, fine-scale movements (accuracy: meters) were not monitored because conventional acoustic telemetry was used with a research vessel and/or a fixed monitoring receiver. Fine-scale monitoring would contribute to the understanding of the homing and site fidelity behaviors of fish particularly within a small home range. In our next step, we tried to monitor fine-scale movement of the black rockfish using a positioning telemetry system. In this paper, we introduce fine-scale movements of the black rockfish (see the detail in Mitamura et al. 2009).

MATERIALS AND METHODS

Study site

The study was conducted in Maizuru Bay, Japan, where the maximum sea-bottom depth is 13-15 m (Figs. 1, 2). The sea-bottom consists primarily of mud, but there are three small specific rocky areas.

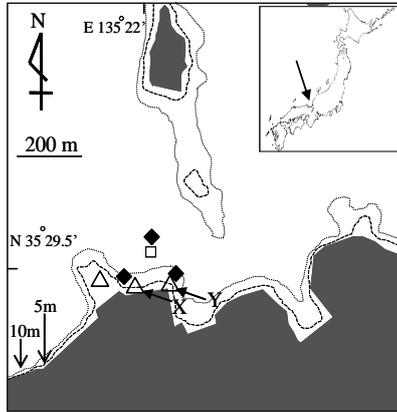


Fig. 1 Map of the study site, Maizuru Bay, Kyoto, Japan. Dashed lines along the coast indicate depth contours. The map marks VRAP buoy locations (◆), rocky areas (△), the release site (□), and captured sites (X and Y)

Fish and tagging

Three black rockfish were collected in fish traps around X and Y rocky areas (Fig. 1). The body lengths of the fish were 19, 17 and 17 cm. They were considered to be mature. An ultrasonic coded transmitter with depth sensor (V9P-6L, depth resolution ± 0.22 m, 38 mm in length, 9 mm in diameter, 2.2 g in water, Vemco, Halifax, NS, Canada) was used for a single fish, and two transmitters without depth sensor (V7-4L, 20.5 mm in length, 7 mm in diameter, 0.8 g in water, Vemco) were used for two other fish due to their small body size. The transmitters were surgically implanted into the peritoneal cavity of fish under anaesthesia that was induced using 0.1% 2-phenoxyethanol on 13 June 2004. The wound was closed using an operating needle and sutures, and the antibiotics oxytetracycline hydrochloride and polymixin B sulphate were applied. A previous experiment demonstrated that implantation had no discernible effect on survival or growth.

Three tagged fish were released in a muddy area 80-120 m away from the capture points on 14 and 15 June 2004. One transmitter provided the swimming depth data of a single fish. However, in this paper, vertical movement is not focused and introduced (see the result of the vertical movement in Mitamura et al. 2009).

Monitoring system

For simultaneously monitoring of fish fine-scale movement, the radio-linked acoustic positioning system (VRAP, Vemco) was used. Three buoys of the VRAP system were placed in a triangular configuration, approximately 100 m apart, surrounding the rocky areas from 14 to 18 June 2004 (Fig. 1). The buoys record the signals of transmitters and relay data to a land-based station linked to a personal computer by radio signals. Then, the computer determines the transmitter position based on the differences in recorded time of the signals. Thus, this system accurately provides the horizontal positions (accuracy: 1-2 m) of the transmitters. The system can also record depth of a transmitter with a depth sensor.

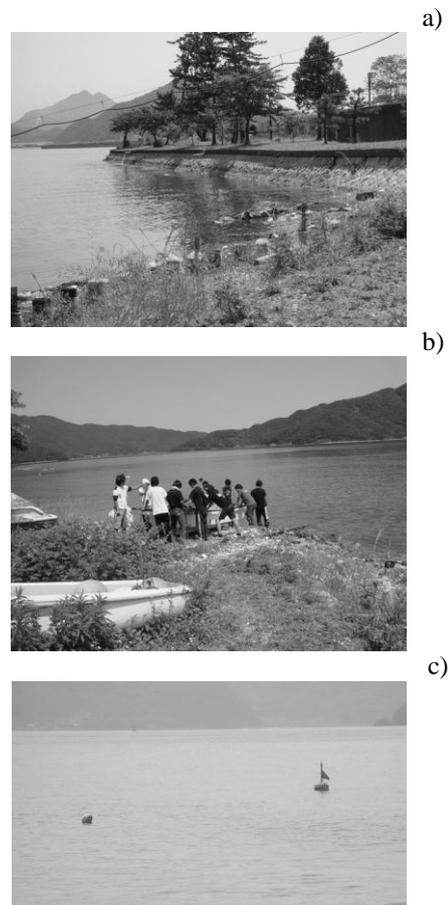


Fig. 2 Photos of the study site, Maizuru Bay, Kyoto, Japan (a, b) and a VRAP buoy (right) at the study site (c)

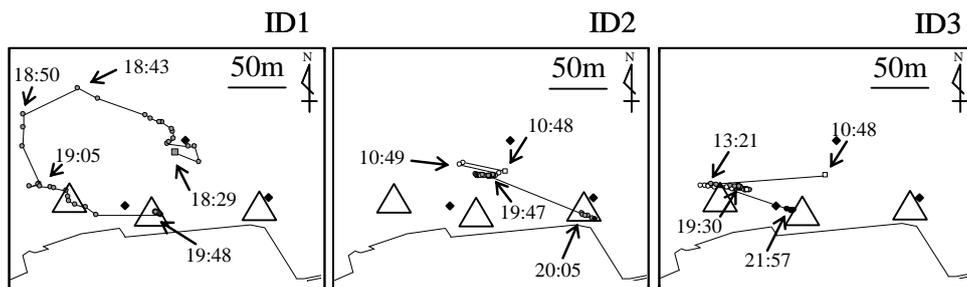


Fig. 3 Homing paths. a location (○) represents the time of day: white, grey and black colors show daylight (09:00-17:00 hours), dusk (17:00-22:00 hours) and night (22:00-04:00 hours), respectively. One fish (ID 1) released during dusk, and two fish (IDs 2, 3) released during daylight.

RESULTS AND DISCUSSION

Our monitoring showed fine-scale homing paths and movement patterns within a small home range. All tagged fish returned to the respective captured sites for a brief time (Fig. 3). The fish released at dusk homed for 79 minutes (Fig. 3). The fish arrived at the original rocky area via another rocky area. In contrast to this fish, the two remaining fish released in the daylight did not move in the muddy or rocky areas before dusk (Fig. 3). They finally homed to their original habitat at dusk. Our results suggest that nocturnal black rockfish show homing during the dark period.

The home ranges of the tagged fish after homing were small, and they were restricted to the environment closely surrounding each captured rocky area (Figs. 4, 5). Average home range was $815 \pm 265 \text{ m}^2$ S.D.. The release sites for all fish were outside of the home ranges. The fish showed horizontal movements within their small home ranges. Other rockfish species show diel horizontal and/or vertical movements (Love et al. 2002,

Jorgensen et al. 2006). For example, while the diurnal blue rockfish stay around particular rocky areas at night, they moved far away from these areas during the daylight (Jorgensen et al. 2006). Our study demonstrated that there was a small core area which each nocturnal rockfish primarily utilized at night within a small home range (Mitamura et al. 2009). The black rockfish might feed on prey in the core area at night.

Our study shows that the acoustic positioning telemetry system allows to better understand the behavior and movement of rockfish. To clarify the homing, site fidelity, and diel movements of the rockfish, further comprehensive research with a larger number of fish and for longer periods should be pursued using the acoustic positioning telemetry system. Fine-scale monitoring has been applied to many other fish species within a restricted area (e.g. cod, perch, salem, shark). These studies provided excellent results of their home range size, habitat utilization, activity, diel movement and so on (Hawkins et al. 1974, Ralston

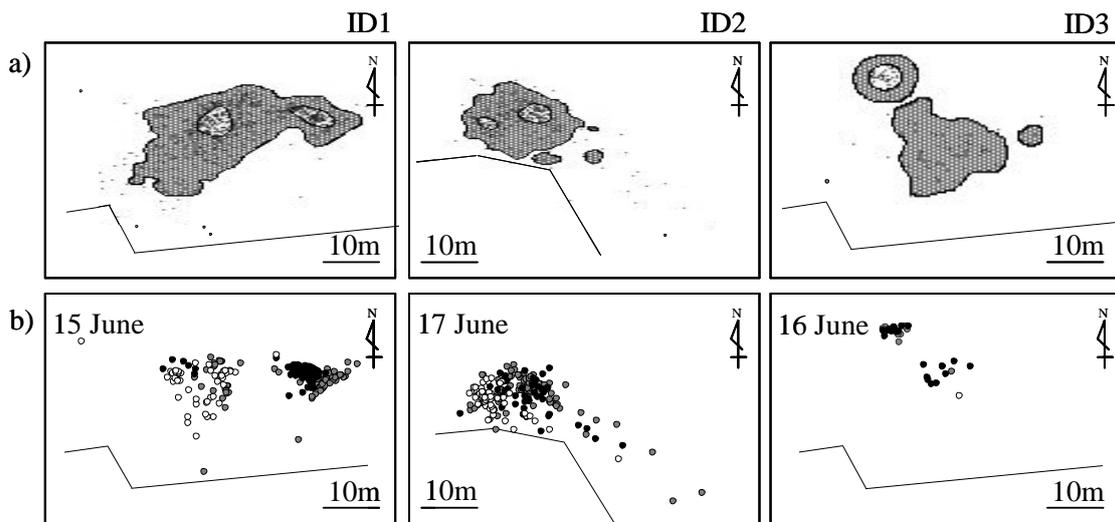


Fig. 4 (a) Outer and inner polygons are home ranges (95 % usage) and core areas (50 % usage), respectively, estimated using the fixed kernel density method. (b) Fish locations recorded in a day. White, grey and black plots represent locations recorded during the daylight (09:00-17:00 hours), dusk and dawn (17:00-22:00 and 04:00-09:00 hours), and night (22:00-04:00 hours), respectively.

& Horn 1986, Klimley et al. 2001, Zamora & Moreno-Amich 2002, Jadot et al. 2006).

The system has a great potential for studying the behavior and movement of fish species with a restricted home range (e.g. $<1 \text{ km}^2$) because the range of the system is limited.



Fig. 5 Photo of a tagged rockfish in front of a rock crevice in its original habitat.

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