BIOTELEMETRY STUDY ON MARINE LIVES USING CODED ULTRASONIC TRANSMITTER

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ABSTRACT

We employed coded ultrasonic transmitters (V8SC-6L, Vemco Ltd., Canada) in order to track many fishes simultaneously. We were able to track up to 256 different fishes using the transmitters on the same frequency. In this study, we used one VR28 tracking system (Vemco Ltd., Canada) and two VR1 tracking systems (Vemco Ltd., Canada) together to track black rockfishes that inhabited the seawall of the Kansai International Airport. Many tagged black rockfishes were identified at the same place respectively for a long time using the transmitters. These results show that the combination of the VR28 receiver system and the VR1 receiver system is a powerful tool to provide us the useful data including position of the tagged fish and the time of fish attendance in certain areas.

***Keywords**: biotelemetry, black rockfish, coded ultrasonic transmitters, VR28 system, VR1 system*

INTRODUCTION

The Kansai international airport (KIX) that opened in 1994 is the only marine airport in the world. The KIX off the Sensyu district, southern part of the Osaka bay was made as an international airport to represent Japan next to the Narita airport (Fig.1). The sea around the KIX was about 18m deep and the seafloor was extremely soft. To minimize the environmental influence, almost the seawall (8.7 km) of the KIX, which was 11.2 km in circumference, was made in a gently sloping rubble mound seawall. Now a day, many kinds of seaweed grew thick and many marine lives inhabited around the KIX. Moreover, the sea around the KIX became a spawning ground and nursery for marine lives.

Many black rockfishes *Sebastes inermis* inhabit around the KIX. The black rockfish is a common species in Japan. It ranges along the coast from the southern Hokkaido to Kyushu and is often found at the rocks and *Zostera* areas (Harada 1962). The black rockfish is used in both commercial and sport fisheries. From a study of allele frequencies, the black rockfish didn't seem to move on a large scale (Numachi 1971). Though the black rockfish grows slowly with comparison of other rockfish species in Japan, the life span is relatively long, at least 5 ages (Hatanaka & Iizuka 1962; Mio 1960; Yokogawa et al. 1992; Yokogawa & Iguchi. 1992).

Biotelemetry systems using radio and ultrasonic transmitters and receivers had been employed since the 1960's. Their performance has improved since micro-electronics technologies were developed rapidly during these years. We employed coded ultrasonic transmitters (V8SC-6L, Vemco Ltd., Canada) in order to track many fish simultaneously. Up to 256 different fishes were tracked using the coded ultrasonic transmitters on the same frequency. Although black rockfishes usually did not form a large school, in most case the adult black rockfishes were aggregating, 10 to 20 at a place, in rock crevices and holes or were lurking underneath the boulders as smaller

groups or individually (Harada 1962). The coded ultrasonic transmitters are the most suitable to track the black rockfish which inhabit the same place at the same time. The objectives of this study were to clarify movements of the black rockfishes using the coded ultrasonic transmitters and to evaluate the new biotelemetry using the coded ultrasonic transmitters.

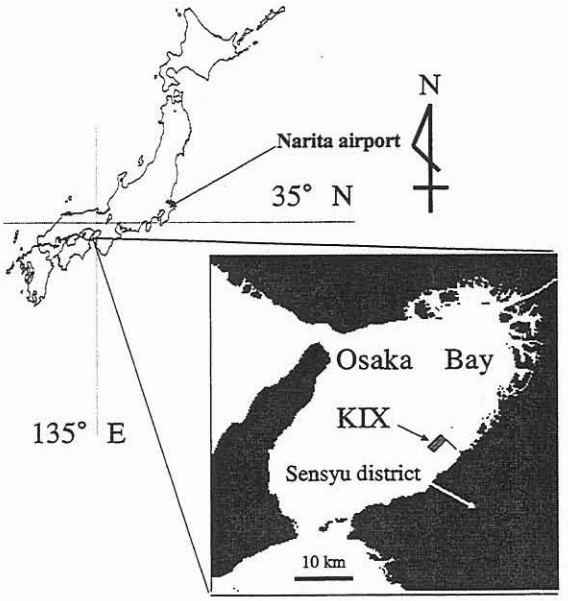

Figure 1. Map of Kansai international airport (KIX). The KIX is located in the Osaka Bay, 5km off the Sensyu district, southern part of Osaka Prefecture.

MATERIALS AND METHODS

Study site, sample fish, attachment of coded ultrasonic transmitters and fish release treatment

The Osaka Prefecture government prohibits all fishing activity from the point of view of environmental protection as well as airport security within 390 m along the north, west, and south sides and within 490 m along the east side of the airport island. The sample rockfishes were fished at the 3 points (A, B and C) of the eastern seawall of the airport island under the special permission by the Osaka Prefecture government from September to November 2000 (Fig. 2). They were mature because the sexual maturity is first attained at 2 age and more than about 150 mm of the total length. Tab.1 shows the summary of the sample rockfishes. They were reared for some days in preserve fish tanks of the Tajiri fishery cooperative before the implantation of the coded transmitters. The Tajiri fishery cooperative is the nearest fishery cooperative to the KIX at the southern foot of the liaison bridge (Fig. 2).

We used ultrasonic coded transmitters (V8SC-6L, Vemco Ltd., Canada) that was 8.5 mm in diameter, 25 mm long, and weighed 2.2 g in water and transmitted complex codes of up to six pulses. Up to 256 different codes were identified on the same frequency (Voegeli et al. 1998).

The transmitters were implanted surgically into the abdomen of the fish. The surgical treatment was performed under anesthesia using 0.1% 2-Phenoxyethanol. The implant operation took about 5 minutes. The fish was placed between some sponge rubbers in a bath of supplying the fresh bubbling seawater during the operation. An incision of about 10 mm in length was made in the abdomen of the fish and the

transmitter was inserted. The wound of surgery was closed with an operating needle and suture. An antibiotic was applied. The fish was held for about four days in fish tanks after the surgical treatment.

Four release experiments were conducted on 18 September, 6, 22, and 25 November, 2000. Each fish was released at about 15-m water depth at two release points (R1 and R2). R1 was located at the northern end of the KIX, where the seawall is not gently sloping rubble. The other point (R2) was located at the opposite side in the shallows of the KIX. Thirteen fish in R1 on 18 September, 3 fish in R1 and R2 respectively on 6 November, 2 fish in R1 and R2 respectively on 22 November and 2 fish in R1 on 25 November were released (Tab. 1). The distance from the point of initial capture at A, B, and C to the release point (R1) was about 1 km, 2.5 km and 3.5 km respectively. A distance from the release point R2 to the points of initial capture (A and B) was about 4.5 km. We tracked the fish continuously for 25 hours after release on 18-19 September and for about 8 hours on 6, 22 and 25 November. Tracking for about 8 hours was attempted intermittently every two or three days following continuous initial tracking until 15 December 2000. We tracked the sample fish around the KIX Island and along the opposite side in the shallows of the KIX.

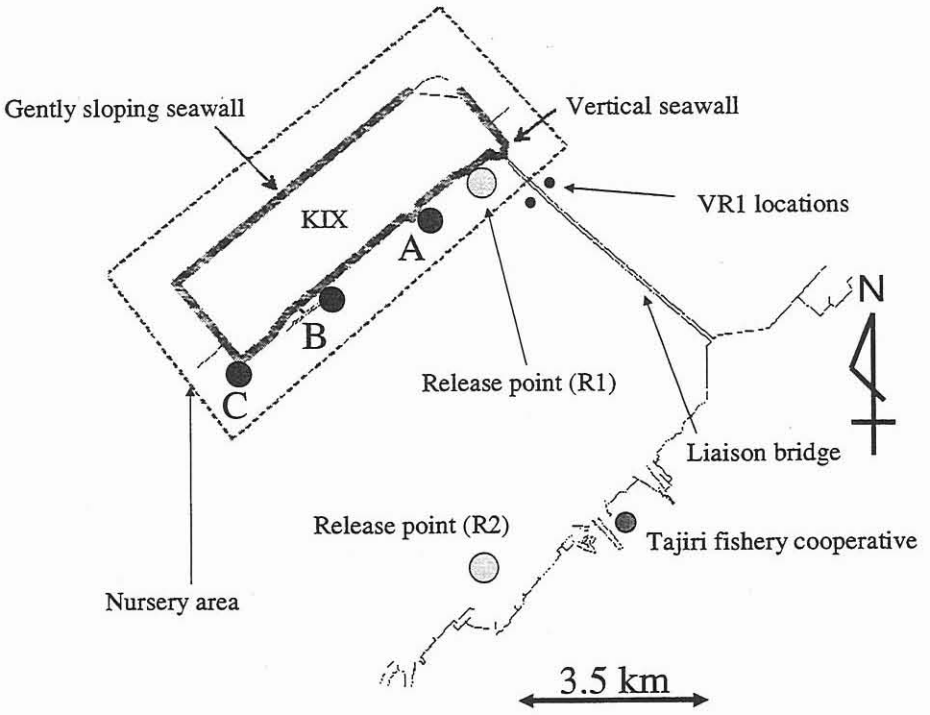

Figure 2. The study area and two release points, R1 and R2. The marks of A, B and C indicated the fishing points where the sample rockfish were caught. The two VR1 systems were set up at the no.4 girder of the liaison bridge.

Tracking system

We used one VR28 system and two VR1 systems (Vemco Ltd., Canada) to track the tagged fish. The VR28 tracking system consisted of a four channel ultrasonic receiver, connected to a four element hydrophone array. This system was installed in the research vessel. The quad hydrophone array provided 360 degrees of monitoring coverage so that the bearing to a transmitter could be determined without having to rotate a directional

hydrophone. The VR28 system receiver was connected to a computer through an RS232 serial port. We supplied computer controlled all VR28 receiver function, including frequency, gain, and echo rejection blanking interval. Beside the ID number of the coded transmitters, the position of the ship decided by GPS (Garmin Co., USA) was saved to the computer. Garmin GPS receivers are accurate to within 15 m on average. We managed to operate the research vessel along the east seawall of the KIX, and we decided that the position where the signals from tagged fishes were detected by all the four channels was the position of the tagged fish.

The VR1 system was the submersible, single channel receiver that recorded the ID number and time stamp from 256 coded ultrasonic transmitters as the tagged fish traveled within receiver range, 300-500 m of the receiver. The dimension was 60 mm in diameter with 205 mm length. The lithium battery lasted for six months. The data were downloaded quickly and easily in the field without opening the case by using a magnetic probe and PC interface. We installed two VR1 systems in this study at the no. 4 girder of the liaison bridge (Fig. 2).

RESULTS

Movement of the black rockfish

Throughout the experiments, the tagged fish released at the point R1 moved to the northeast or the southwest along the east seawall of the KIX or stayed around the release point just after the release. Two VR1 systems at the liaison bridge recorded few attendances of the tagged fish. All of the tagged fish moved along the east seawall to the southwestern direction after 4-5 hours release. Fourteen of the twenty fish caught at the three points, A, B, and C on the gently sloping seawall and released at R1, were identified at their original habitat, i.e., from A to A; 100% (3 of 3 individuals), from B to B; 57% (4 of 7 individuals), from C to C; 70% (7 of 10 individuals). Twelve tagged fish migrated to their habitat within 4 days and two fishes migrated to their habitat after 7 days. Six fish released at R1 did not return to the sites where they were captured originally. The fish that migrated to their original sites did not move out from these habitats during our investigation. The six fishes that did not home stayed around the release point R1 or moved back and forth on the east seawall. All of them never passed their original site. The bottom topography by the echo sounder suggested that the points A, B, and C featured rough rubble bottoms. The tagged fish migrating to their home were often found at these featured bottoms. Consequently, the tagged fish stopped at the featured bottom area and went to next one after another during migration and then they homed.

Five tagged fish released at R2 moved to the northeast or the southwest after the release. Three (ID: 98, 172 and 175) of the five fish migrated to their habitat within 2-11days. The fish (ID: 174) was recaptured by a fisherman at the place between the release point and its habitat. One fish released at R2 was only tracked for 1 day and did not return to original site of capture. The VR1 systems recorded no data of the five fish that were released at R2. These fish might have moved directly to their home site while not passing near the VR1 receiver. After all, the rate of homing migration in all experiments were as follows, from A to A; 100% (3 of 3 individuals), from B to B; 60% (6 of 10 individuals), from C to C; 67% (8 of 12 individuals) (Tab. 1).

Table 1. Summary of total lengths, date tracking began, recovery duration, homing duration, captured point, release point and site of final destination of the sample fish.

ID	Total length (mm)	Date tracking began	Recovery duration (days)	Homing duration*1 (days)	Captured point*2	Release point*3	Site of final destination*4
64	238	18-Sep-00	2	N	B	R1	Other
73	207	18-Sep-00	53	1	B	R1	B
74	215	18-Sep-00	8	N	B	R1	A
75	220	18-Sep-00	2	N	B	R1	Other
76	218	18-Sep-00	8	1	B	R1	B
108	190	18-Sep-00	2	1	A	R1	A
109	237	18-Sep-00	2	1	A	R1	A
110	212	18-Sep-00	43	7	A	R1	A
111	208	18-Sep-00	67	N	C	R1	Other
112	206	18-Sep-00	8	7	C	R1	C
113	203	18-Sep-00	32	1	C	R1	C
114	206	18-Sep-00	53	1	C	R1	C
115	208	18-Sep-00	73	1	C	R1	C
171	235	6-Nov-00	40	2	B	R1	B
172	222	6-Nov-00	4	4	B	R2	B
174	223	6-Nov-00	2	Recaptured	B	R2	-
175	237	6-Nov-00	40	11	C	R2	C
176	215	6-Nov-00	40	4	C	R1	C
177	213	6-Nov-00	35	N	C	R1	A
57	215	22-Nov-00	24	2	B	R1	B
98	223	22-Nov-00	24	2	B	R2	B
180	205	22-Nov-00	1	N	C	R2	Other
181	210	22-Nov-00	24	4	C	R1	C
99	230	25-Nov-00	10	1	C	R1	C
185	200	25-Nov-00	2	N	C	R1	A

*1 N means no homing. Homing duration means the days it took to return to point of capture. Recaptured means that the sample fish (ID: 174) was recaptured by a fisherman at the place between the captured point and the release point.
*2 Captured point A, B and C in Fig.2
*3 Release point R1 and R2 in Fig.2
*4 Site of final destination means the place of the fish at the end of the experiment. The fish that homed did not move out from their original sites for our investigation. A, B and C were captured points in Fig.2. Other means the point that is different from A, B and C.

New biotelemetry technology

After homing, seventeen black rockfishes did not move out from their habitat respectively. Namely, 3 fish stayed at the A point after homing, 6 fish at the B point and 8 fish at the C point. We could identify many tagged fish at the same place respectively using coded ultrasonic transmitters on the same frequency instead of chasing the tagged fish continuously on board.

Throughout the investigation from on 18 September 2000 to on 15 December 2000, all the tagged fish were identified although the identification rates reduced (Fig. 3).

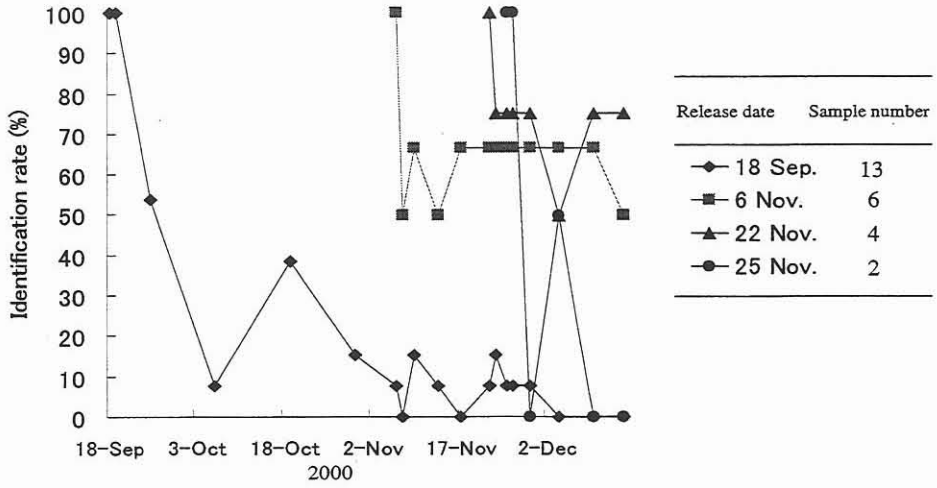

Figure 3. Relationship between the identification rates of the rockfishes released with coded ultrasonic transmitters and elapsed days.

DISCUSSION

Movement of the black rockfish

It is clear that the black rockfishes around the KIX have homing ability in this study. The crack of the rocks existed around the place where we fished the sample fish. The olive rockfish *Sebastes serranoides*, off Santa Barbara, California, rarely moved between shallow water reefs (Love 1980). It was thought that the black rockfish in this study lived in the crack of the rocks of the reef because they did not do large-scale movement after homing. Dodson (1988) reported that fish migration was based on the interaction of experience and instinct. Reese (1989) mentioned that site-specific coral reef fish learn routes and foraging paths by recognizing specific landmarks such as coral heads. Reese hypothesized that site-specific fish, in comparison with mobile, pelagic fish, would be more likely to learn landmarks because they inhabit areas with easily noticeable features. The black rockfishes grow slowly (Hatanaka & Iizuka. 1962), but they live long lives up to 5 years at least (Mio 1960; Numachi 1971,). The black rockfishes that have long lives and don't move far away from their habitat remember the form of the sea bed and environment around their habitat. In this study, the black rockfishes that migrated to their home site were found many times in the rock areas during migration. Also, our study areas had been studied very much to monitor the seawall environment by divers. Resulting from the monitor, many black rockfishes were observed in rock crevices and underneath boulders. In addition, Matthews (1990) reported that because all of the displaced rockfishes were found on or near the reef area on their return route and some stayed for several days, perhaps rockfishes use high relief rock outcrops and rocks and landmarks. Therefore, the black rockfish seemed to use the specific rocks of the sea bed as landmarks or underwater guideposts.

Matthews (1990) reported that copper and quillback rockfish moved to the direction of tidal currents just after the release and perhaps rockfishes used the strong currents to assist in their movements, or used the currents as a directional cue. The black rockfishes released at R1 in this study moved along the seawall that restricted the movement direction of the tagged fishes. Matthews mentioned that current was not flowing in the direction of home site from release site. In our study, the black

rockfishes were displaced from 1000-3500 m, about 2-7 times as 500 m in Matthews' study. But home site and release site were along the seawall in our study. Matthews also reported that most of the copper and quillback rockfishes needed for more than 15 days to return to the captured site. But twelve of the black rockfishes released at R1 returned within 4 days in our study. The seawall was the direction of home site from the release site and there were many specific rocky areas and artificial structures as landmarks in this study site. Therefore the black rockfishes might migrate to their habitat within a few days. Namely, if there would be the more landmarks, man-made structure and currents to the habitat in the study site, the black rockfishes might need to return to their habitat in the less time.

In this study, we found the evidence of the homing behavior of the black rockfish around the KIX Island. However, the simple question, "what is the cue to home?" is left.

New biotelemetry technology

Mellas and Haynes (1985) conducted experiments to determine the effect of three transmitter attachments such as external, surgical and stomach tag on the swimming behavior of rainbow trout and suggested that stomach tagging is the best method of transmitter attachment. Moore et al. (1990) concluded that intraperitoneal implantation had no significant effect on growth, feeding or swimming behavior in juvenile Atlantic salmon. In this study we conducted surgical implantation into abdomen of the fish since our experimental periods were relatively so long that the stomach tag affected feeding. Actually, the results of reservation experiment of the black rockfish with dummy transmitters showed that surgical attachment was adequate. In addition, we caught about 50 fishes carefully and slowly to reduce temperature and pressure stress. We observed no sign of embolism, stress, or mortality from capture at depth. The implantation had no significant effect on swimming behavior in appearance, judging from observation for about four days. All fishes did not die during the holding and surgical procedures at the Tajiri fishery coop.

We could identify many tagged fish at the same place respectively for a long time using coded ultrasonic transmitters. This indicates that the coded ultrasonic transmitter is suitable for a long time tracking of the tagged fish. In addition, the VR1 system recorded the attendance of tagged fish automatically. In a word, the system is suitable for the tracking of the fish which do not move at a large scale without much manpower. The combination of the VR28 receiver system and the VR1 receiver system is a powerful tool to provide us the useful data including position of the tagged fish and the time of fish attendance in certain areas.

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