Detection Range and Horizontal Accuracy of a Fine-Scale Positioning Telemetry System at Kaeng Krachan Reservoir, Thailand

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ABSTRACT

We examined the detection range and the accuracy of fine-scale positioning using Vemco Positioning System (VPS) for understanding the habitat use of Mekong giant catfish at Kaeng Krachan reservoir, Thailand. The appropriate distance between receivers and sound pressure of transmitters for the VPS was determined from the detection range test. We deployed 24 receivers at 500 m distance for the VPS positioning. The positioning accuracy was estimated using the stationary transmitters at fixed locations in the VPS array. The positions of the stationary transmitters were measured accurately (< 15 m). These results suggest that the VPS positioning can be useful for investigating fine-scale habitat use of Mekong giant catfish.

KEYWORDS: biotelemetry, VPS, positioning accuracy, Kaeng Krachan reservoir

INTRODUCTION

Acoustic telemetry with transmitters and receivers has been a powerful tool in the study of fish ecology and movement behavior in the field (Cooke et al., 2004, Topping et al., 2006, Farrugia et al., 2011). Acoustic receivers detect individuals tagged with transmitters within detection range. Data show that tagged individuals were present or absent within the detection range. Conventional acoustic telemetry with a horizontal positioning accuracy of approximately 200-500 m enables us to roughly estimate the home range of target fish (Topping et al., 2006). Recently, a new fine-scale positioning system using acoustic telemetry, the Vemco Positioning System (VPS), has been developed (Andrews et al. 2011, Espinoza et al. 2011). This system uses at least three hydrophones and hyperbolic positioning based on measuring time difference of arrival of transmitted signals. To synchronize internal clocks of all receivers in this system, transmitters at fixed location – called a sync-tag – are used. In this positioning system, fish tagged with acoustic transmitters are located with about 1.5 m in horizontal accuracy (Andrews et al., 2011).

The Mekong giant catfish (*Pangasianodon gigas*) is an endemic species in the Mekong River basin, and one of the largest freshwater fish in the world (Hogan, 2004). This species is commercially and culturally important for local people in Thailand. However, the population of wild Mekong giant catfish has been drastically decreasing and it is listed in the CITES Appendix I and IUCN Red List of threatened species as a Critically Endangered Species (Akagi et al., 1996, Hogan, 2004). In Thailand, artificial insemination of Mekong giant catfish has been developed since 1981, and many hatchery-reared juveniles have been released into domestic reservoirs for species management. We used conventional telemetry and roughly estimated the home ranges of Mekong giant catfish with a positioning accuracy of 500 m after their release (Mitamura, 2005). However, the accuracy of conventional telemetry was not sufficient to learn about the detailed home range of the catfish. Recently, we have tried to make more accurate estimates of home ranges using fine-scale positioning acoustic telemetry at Kaeng Krachan reservoir, Thailand.

Prior to release of tagged fish, we verified whether the fine-scale positioning system was useful in a reservoir in Thailand. First, we examined the detection range of receivers for transmitters in our study area to decide the appropriate distance between receivers in the positioning system. Secondly, we deployed receivers for the positioning system according to detection range tests and measured actual positioning accuracy using transmitters at fixed locations. In this paper, we report the results of these detection range and horizontal positioning accuracy tests.

MATERIALS AND METHODS

The Vemco Positioning System (VPS) was used for fine-scale positioning. VPS uses hyperbolic positioning to calculate transmitter positions based on a time difference of arrival algorithm among at least three receivers (Espinoza et al. 2011, Fig. 1). Internal clocks of receivers can be synchronized by detecting the same signals of sync tags collocated with receivers. The positioning accuracy of VPS is supposed to be approximately 1.5 m, considering the temporal resolution of receivers (VR2W, Vemco, Canada). Field experiments were conducted at Kaeng Krachan reservoir, Petchaburi province, Thailand (N12.9°, E99.6°). At this reservoir, hatchery-reared juvenile Mekong giant catfish have been released for approximately 20 years (Mitamura et al. 2012).

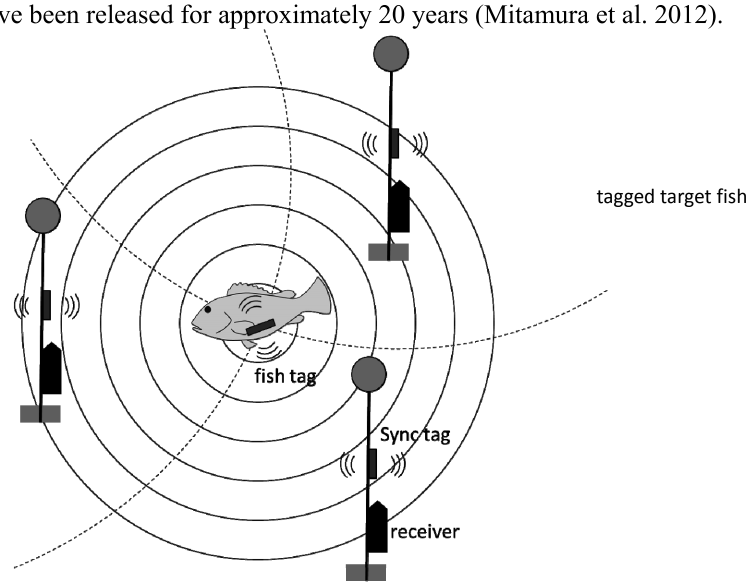

Fig. 1. The fine-scale positioning used in this study. Hyperbolic positioning based on measuring time difference of arrival of acoustic signals is used to calculate the locations of tagged target fish. Transmitters are collocated on each receiver in order to synchronize the internal clock of receivers.

First, detection ranges of acoustic receivers for time synchronizing transmitter (sync tag, V16-6H, 16 mm in diameter, 98 mm in length and 34 g in air, Vemco, Canada), and for fish tagging transmitters (Fish-tag1, V13-1L, and Fish-tag2, V13-1H, 13mm in diameter, 44 mm in length and 12.3 g in air, Vemco, Canada) were examined in February 2012. The sound pressures of the sync tag, Fish-tag1 and Fish-tag2 were 160db, 147 dB and 153 dB, respectively. Sync tag and fish tags transmitted acoustic signals by random delay interval ranging from 20 to 40 s, and signals were collocated with ten acoustic receivers (VR2W, Vemco, Canada) moored at the reservoir (Fig. 2). Ten acoustic receivers were deployed in places 0 m and 400-1200 m distance at approximately 100 m intervals from the transmitters. Signals were recorded for 15 hours, and then data were downloaded using a laptop PC. Detection rates of Fish-tag1, Fish-tag2 and sync tag were calculated for each interval distance.

Secondly, horizontal positioning accuracy of VPS was examined at the reservoir from July to September 2012. Twenty-four acoustic receivers were deployed and distance between receivers was set to overlap with the detection range (Fig. 3) based on the detection range test mentioned above. Sync tags were collocated with all the receivers to synchronize the clocks of the receivers. Four stationary transmitters (V16-6L, 153 dB) were placed at four different fixed locations in the VPS array. Both sync tags and stationary transmitters transmitted acoustic signals by random delay interval ranging from 500 to 700 s. The locations of the receivers and the stationary transmitters were measured using GPS (Fig. 3). Signals were recorded for 2 months. The data of all receivers was sent to the vendor for calculation of the recording time of acoustic signals, longitude, latitude and Horizontal Positioning Error (HPE), which is a relative measure of the potential error of the calculated position (Espinoza et al. 2011).

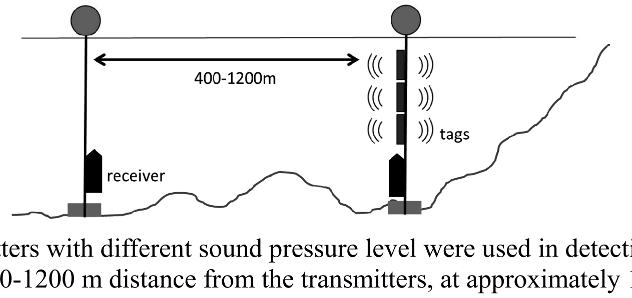

Fig. 2. Three transmitters with different sound pressure level were used in detection range tests. Ten acoustic receivers were set at 400-1200 m distance from the transmitters, at approximately 100 m intervals and the detection rates at each distance were calculated.

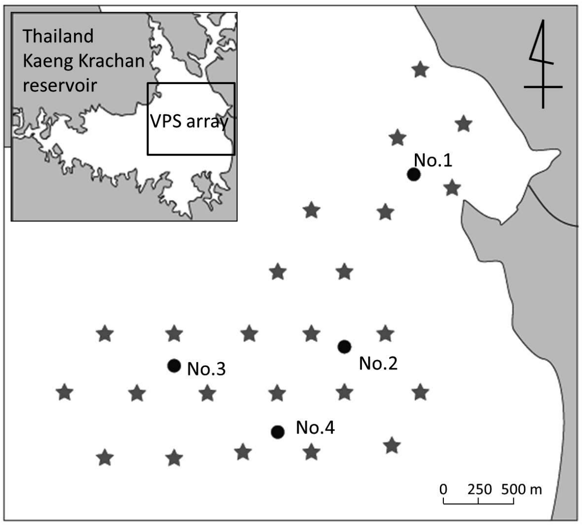

Fig. 3. Positions of all receivers and stationary transmitters in Kaeng Krachan reservoir. Black dots indicate the positions of the stationary transmitters (No.1-4) and stars indicate the positions of the receivers.

RESULTS AND DISCUSSION

The appropriate distance between the receivers was determined from the results of the detection range test. The signals of sync-tag were detected efficiently by the receiver located at 700 m distance (> 85 %). However, the detection rate decreased dramatically around 800 m distance (Fig. 4). On the other hand, when the distance from the transmitter was shorter than 500 m, the detection rates were lower. Therefore, the optimal detection range of the VR2W for sync tag in Kaeng Krachan reservoir was considered to be a range from 500 to 700 m. The detection range of VR2W for Fish-tag1 was different from Fish-tag2. The signals of the latter were detected adequately at 500 m distance (77 %) in contrast to those of the former (22 %). Based on these results, Fish-tag2 was better than Fish-tag1 for our study. We then decided to set the receivers in the VPS array at 500 m distance in the study site, so that both sync tag and Fish-tag2 would be detected simultaneously by at least three receivers.

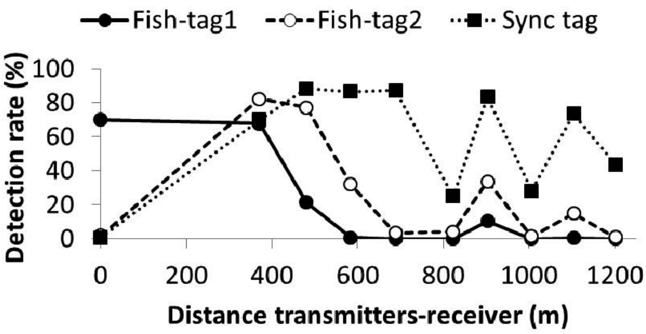

Fig. 4. Relationship between the detection rate of transmitters and the distance from the receivers (VR2Ws).

Fine-scale positioning of stationary transmitters was achieved in this study site. Although four of 24 receivers could not be retrieved, the locations of the stationary transmitters were finely calculated using data from 20 receivers. The precision of positioning within the array was ensured by the results of 4 different locations (Table1, Fig. 5). Average of distance between VPS and GPS positioning was under 10 m (total average = 8.16±10.68 m). Most numbers of localization of No. 2-4 were in a range of 0-5 m (Fig. 6).

Table 1. Fine-scale positioning the stationary transmitters.

No. of stationary transmitter*	The number of detection	Distance from GPS positioning (m)	
		Average	Standard deviation
1	1339	14.94	10.85
2	359	6.81	8.24
3	1536	3.70	2.63
4	1134	6.62	13.62
total	4368	8.16	10.68

*See Fig.1.

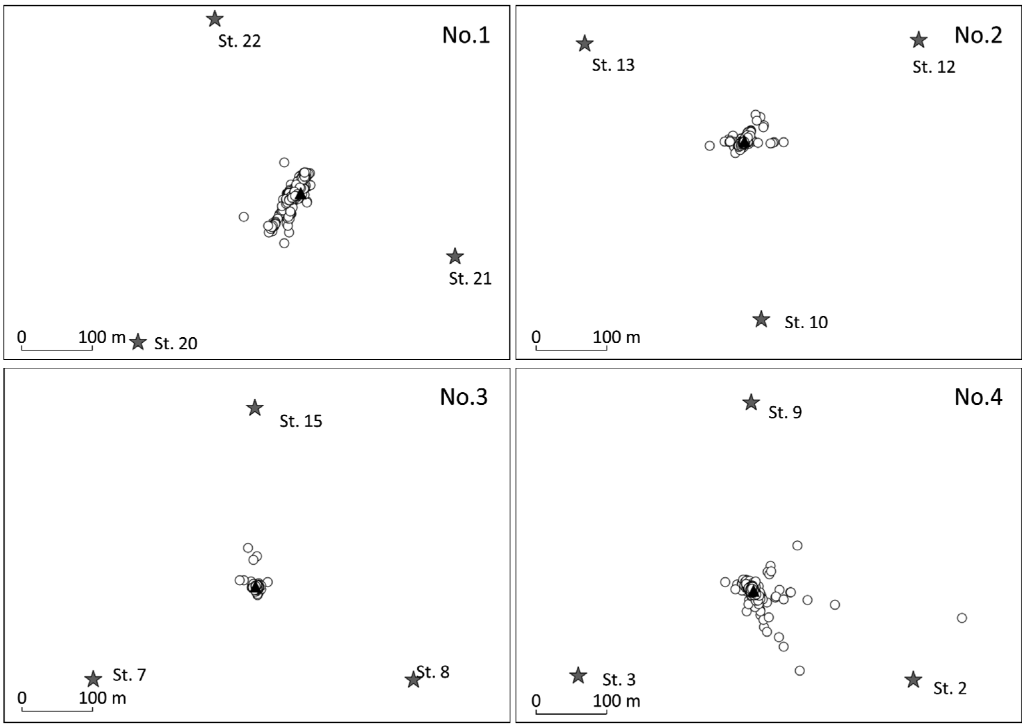

Fig. 5. Results of the accuracy test using four stationary transmitters. (Solid triangles, gray stars and open circles indicate the deployed position of the transmitters, the calculated positions and the locations of the receivers, respectively.)

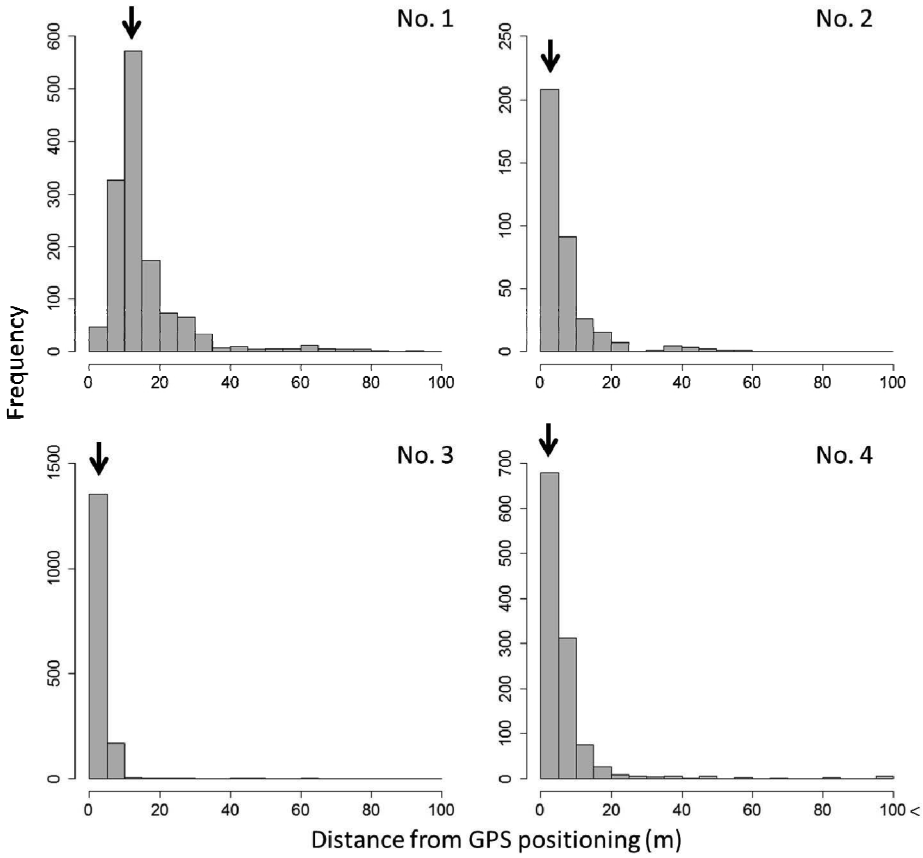

Fig. 6. Distance between VPS results of fixed transmitters and GPS positioning. Arrows indicate the highest number of localizations.

In this study, positioning accuracy was more adequate compared with the conventional method (VR2W). The suitable distance (500 m) between receivers achieved not only detailed positioning but also monitoring a wide range area at Kaeng Krachan reservoir. Since Mekong giant catfish use a small home range (< $1km^2$), VPS positioning with high accuracy shown in this study will be useful ascertaining a more accurate home range. Collecting information about environmental conditions (e.g. dissolved oxygen, temperature) and topography, as well as the fine-scale movement patterns, will help us to understand the catfish habitat use in the reservoir.

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