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Telemetry Study on Juvenile Yellowfin tuna *Thunnus albacares* Around a Payao in the Philippines

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【Research Articles】

Telemetry Study on Juvenile Yellowfin Tuna *Thunnus albacares* Around a Payao in the Philippines

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Abstract

Three juvenile yellowfin tuna (22-26cm FL) and two rainbow runners (27 and 30cm FL) were monitored around a payao (FAD: Fish Aggregating Device) in Panay Gulf, the Philippines. A receiver was attached to the anchor line of the payao and ultrasonic transmitters were implanted into the abdominal cavities of the fish. All the fish stayed around the payao for over 60 hours and there was no difference in the hourly detection rate during daytime and nighttime. Juvenile yellowfin tuna were swimming in significantly deeper waters, maximum 105m, than rainbow runners of the same size. The similarities between the observed behaviors of payao-associated juvenile yellowfin tuna and FAD-associated adults are very striking. Juvenile yellowfin tuna swam within a limited shallow range during nighttime and dived to deeper waters during daytime then moved away from the payao at midnight. One juvenile yellowfin tuna was recaptured two days after release by hand line in the same payao and two juvenile yellowfin tuna were recaptured 12 days after release by ring net in another payao over 3km away. These recaptures indicate that the fish were active enough to feed and swim, and also show the feasibility of undertaking telemetry studies on juvenile yellowfin tuna.

1. Introduction

Fish Aggregating Devices (FADs), including payaos, play an important role in global tuna fisheries[1),2)]. In the Philippines, payaos were first introduced in the 1970s primarily to target tuna and fishing pressure with the use of them remains high (Babaran, unpubl. data, 2006)[3),4)]. Aside from adult tuna, small pelagic species including juvenile tuna that aggregate near the payaos are also captured[5)]. However, little is known about the behavior of such small fish and the efficiency of a payao has not been evaluated quantitatively.

Telemetry is a powerful tool that allows continuous and simultaneous monitoring of fish behavior. Most telemetry studies on tuna behavior around FADs involve adult fish using ultrasonic transmitters and data loggers[6)～20)]. With some exceptions, these studies have already revealed relatively consistent patterns in the swimming behavior of adult tuna near FADs. For instance, during the daytime adult tuna swim in deeper waters with characteristic deep dives and move to shallower depths within the mixed layer at night[8),12)～14),20)], apparently to follow the diel migration patterns of prey organisms in the Sound Scattering Layer (SSL). Others swim away from FADs at dusk for feeding excursions and return to the same FAD or swim to another FAD during the daytime[12),14),19),21)]. Others remain associated with the FAD over a period of several days after tagging. And still others return to the FADs periodically, as if they have a memory of the positions of the FADs[18)]. Data loggers, which also allow the storage of physiological and environmental data, have been implanted in young bluefin tuna. Past studies have revealed that their prey environment and temperature influence their swimming patterns partic-

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ularly in the vertical direction[22)~26)]. However, despite recent advances in telemetry, no information is available on the swimming behavior of juveniles of large tuna species that normally associate with payaos. Moreover, no experiments had been conducted with juvenile tuna until now, due to lack of access to the fishing grounds near the Philippines from where these tuna species start to migrate when they reach about 30 cm in length[27)].

In this study, we present the results of a telemetry experiment on several juvenile yellowfin tuna *Thunnus albacares* conducted around a payao in the Philippines. Our main objective was to determine the feasibility of undertaking these experiments, which are necessary before proceeding to embark on more comprehensive studies in the future. We also wanted to obtain initial information about the patterns in the swimming behavior of juvenile yellowfin tuna. To determine the characteristic swimming behavior of juvenile yellowfin tuna, the behavior was compared with that of another pelagic species of the same size, rainbow runners *Elagatis bipinnulatus* that was monitored simultaneously. Rainbow runners are a common pelagic species around payaos and as they are fast swimming predators similar to yellowfin tuna, they are a good comparative fish. Finally, we related the swimming patterns of juvenile yellowfin tuna with known observations of adult yellowfin tuna.

2. Materials and methods

The experiments were conducted around a payao named “Liwanag” (10°32′N, 122°16′E) deployed approximately 10km off the coast of Miagao in Panay Island, Philippines (**Fig.1**). In Panay Gulf, several payaos were installed in the same network at a few kilometers distance but the actual numbers and positions were not clarified. The depth of the water was approximately 500m.

A set receiver (VR2-DEL, Vemco Ltd., Canada)

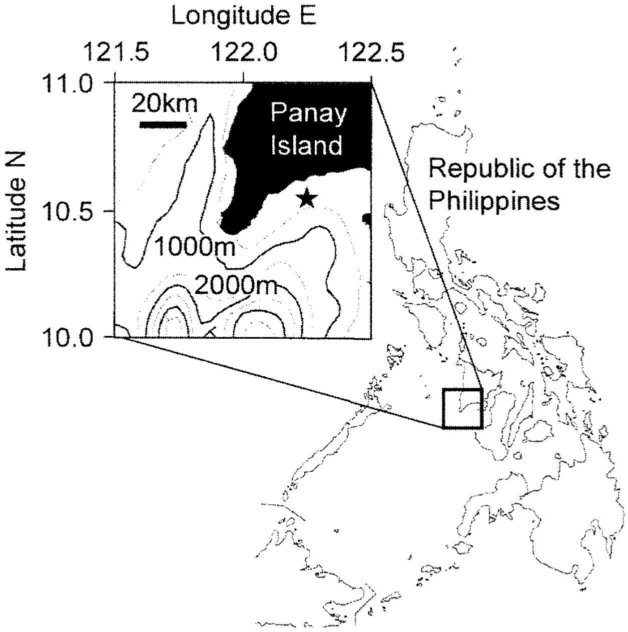

Fig.1 Map of Panay Gulf, the Philippines showing the location of the experimental payao “Liwanag” (black star). Bold lines are isobaths per 1,000m.

was installed on the anchor line of the payao at a depth of approximately 20m by scuba diving on 13 August, 2005. The receiver, which weighed 170g in water, was 73mm in diameter and 308mm long. The receiver decodes the ID numbers and swimming depths of the fish implanted with transmitters within the detection zone and records the numbers and time stamp in a flash memory. A preliminary study was conducted to determine the detection zone of the receiver around the payao. A transmitter was submerged and moved around the payao by boat and the position of the boat was recorded by GPS. Later, the records of the receiver were downloaded and the detection distance was determined by comparing the detected time and the boat position simultaneously.

A professional fisherman captured experimental fish around the payao by hand line. Three yellowfin tuna (YT1-3, 22-26cm FL) and two rainbow runners (RR1 and 2, 27 and 30cm FL) were captured from 13 to 15 August, 2005. The details of each fish are given in

Table 1 Details of tagged fish.

Fish ID		Fork Length (cm)	Release	End of record	Duration (hour)	Transmitter
Yellowfin tuna	YT1	22	14：15 13 – Aug. 2005	14：21 13 – Aug. 2005	0	V7
	YT2	22	14：18 13 – Aug. 2005	23：39 17 – Aug. 2005	129	V7
	YT3	26	12：45 15 – Aug. 2005	16：12 19 – Aug. 2005	99	V9
Rainbow runner	RR1	30	10：54 14 – Aug. 2005	00：00 17 – Aug. 2005	61	V9
	RR2	27	09：20 16 – Aug. 2005	16：11 19 – Aug. 2005	79	V9

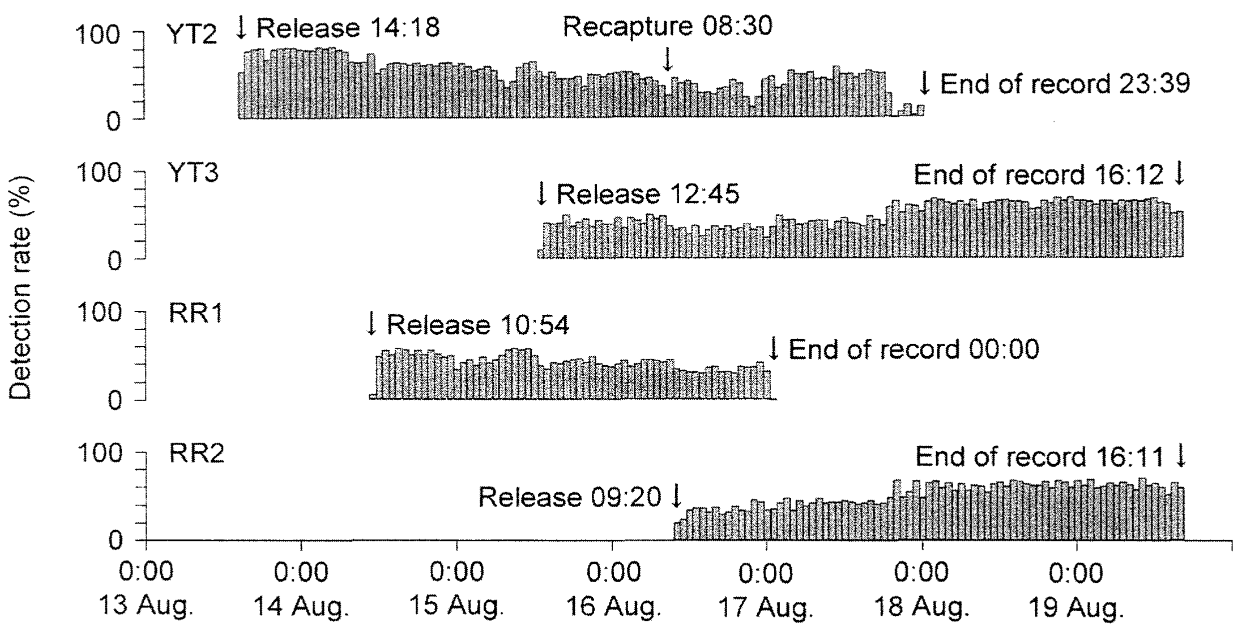

Fig.2 Time series data of the hourly detection rates of YT2, YT3, RR1 and RR2 tagged near payao on August 13-16, 2005 in Panay Gulf, the Philippines. There was no difference in the hourly detection rate during the daytime and nighttime.

Table 1. The fish were implanted with coded ultrasonic transmitters (V9P-2H-S256 or V7-2L-R256, Vemco Ltd., Canada). The V9P transmitter, which has a pressure sensor, weighed 2.9g in water, was 9mm in diameter, and 46mm long. The transmitter emitted a train of eight pings at a power output of 147 dB every 20±10s for identification and depth measurement[28]. The V7 transmitter, which does not have a pressure sensor, weighed 0.9g in water, was 7mm in diameter, and 20mm long. This transmitter emitted a train of six pings at a power output of 136 dB every 10±5s only for identification. Tag implantation was conducted according to the procedure on adult yellowfin tuna described by Ohta and Kakuma[18]. The surgical operations were performed just after catching the fish aboard a 10-m outrigger fishing boat and took only about 1min for each fish. The fish were laid on their backs on a makeshift operating table. An incision of approximately 15mm was made in the abdomen of the fish to allow the transmitter to be inserted. The wound was sutured with one stitch. Ordinary dart tags were then punched next to the second dorsal fin. The fish were released immediately after the operation.

The receiver was retrieved at 16 : 12 on 19 August, 2005 and the stored data were downloaded. To facilitate the retrieval of fish, notices of monetary rewards for recaptured fish were distributed in nearby fishing communities and fish markets.

3. Results

The maximum detection distance of the receiver was approximately 700 and 500m in radius for V9P and V7 transmitters, respectively. **Fig.2** shows the time series data of the hourly detection rate of all fish, except for YT1, the data of that was too short for analysis. YT2 was monitored for 129 hours until the middle of the night on 17 August, 2005. YT3 was monitored for 99 hours until the end of the experiment. RR1 was monitored for 61 hours until midnight on 17 August, 2005. RR2 was monitored for 79 hours until the end of the experiment. All the fish were monitored continuously without interruption over one hour until the end of each record. There was no difference in the hourly detection rate during daytime (from sunrise at 6 : 41 to sunset at 19 : 10) and nighttime (Mann-Whitney Test, $p>0.05$).

Fig.3 shows the time series data of the swimming depths of YT3, RR1, and RR2. YT3 dived occasionally over 50m and clearly swam deeper than the RRs. The swimming depth distributions of the three individuals were different (Kruskal Wallis Test, $p<0.001$) (**Fig.4**). YT3 was swimming in significantly deeper waters (16.1±10.4m, mean and SD) than both RR1 (6.8±4.8m) and RR2 (7.7±3.5m) (Welch's t-test, $p<0.001$). The maximum swimming depth of YT3 was 105 m at 18 : 59 on 15 August, 2005.

YT3 showed a diurnal vertical swimming pattern

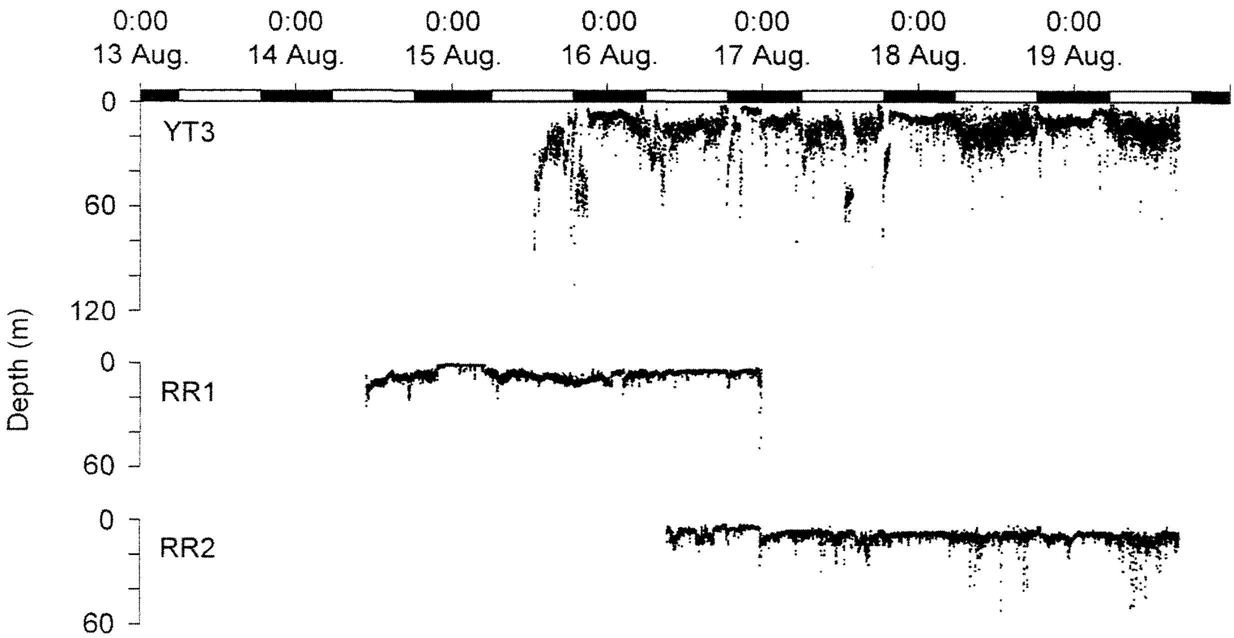

Fig.3 Time series data of the swimming depths of YT3, RR1 and RR2. YT3 swam within a limited shallow range during nighttime (indicated by a horizontal black bar) and dived to deeper waters during daytime (white bar).

(**Fig.5**). YT3 frequently stayed in a relatively shallow and narrow layer between 5 and 15m during nighttime. In the daytime, the fish swam in a deeper and wider layer between 10 and 25m (**Fig.6**). YT3 was swimming in significantly deeper waters (19.5 ± 10.6m) during the daytime compared to at nighttime (12.5 ± 8.9m) (Welch's *t*-test, $p<0.001$).

While fishing for more fish to tag, we recaptured YT2 two days after release at 8 : 30 on 16 August, 2005. This allowed us to examine the wound, and the fish was re-released immediately. Although the wound was not completely healed, it was fastened by the stitch tightly. Twelve days after release, a ring net operating in another payao over 3km away from the tagging site re-recaptured YT2 with YT1 on 25 August, 2005. The transmitter of YT2 remained but that of YT1 was missing. The fisherman reported that the wounds were healed. The external tags reminded him of the monetary rewards for recaptured fish.

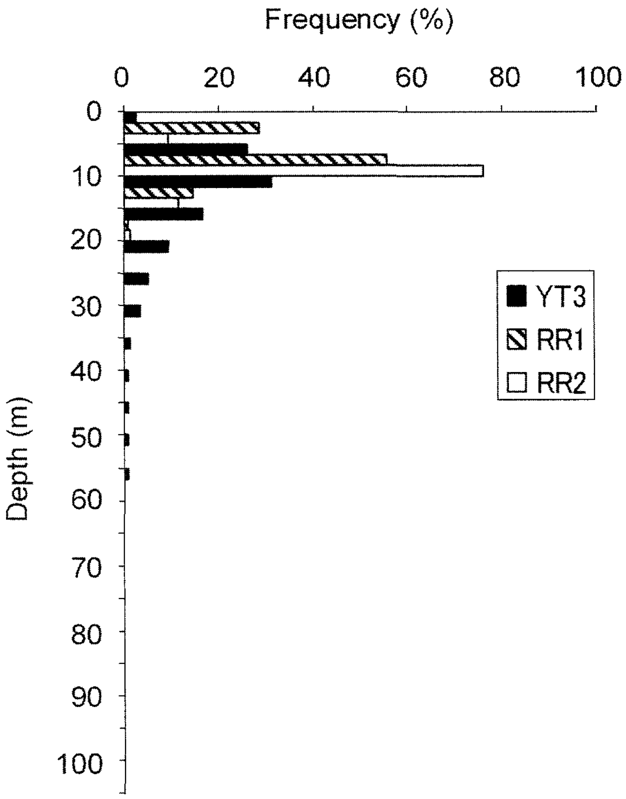

Fig.4 Overall depth distribution of YT3 (solid), RR1 (hatched), and RR2 (open) near payao. YT3 was swimming in significantly deeper waters than both RR1 and RR2.

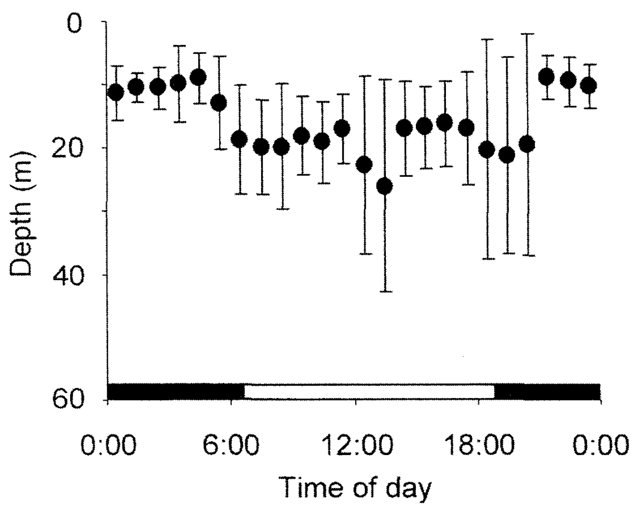

Fig.5 Diurnal vertical swimming pattern of YT3. A solid circle indicates the hourly mean of swimming depth and a vertical bar indicates SD.

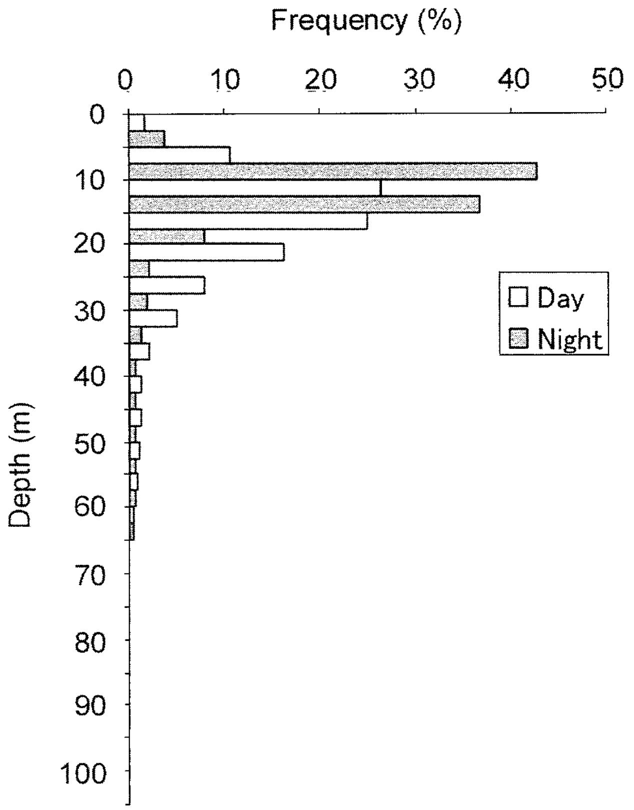

Fig.6 Day (open) and night (solid) depth distribution of YT3. The fish was swimming in significantly deeper waters during daytime.

4. Discussion

YT1 was monitored only briefly after release. When the fish was recaptured, the transmitter was missing; it had probably dropped out due to inexperience in tagging in the first experimental fish. All the other fish, including rainbow runners, were monitored for more than 60 hours after their release and showed vertical and or horizontal movement. The recapture of YT2 two days after release indicates that the fish was not only alive but also active enough to show its feeding behavior. This fact also suggests that the trauma of the operation was not serious. In addition, the re-recapture of YT2 and the recapture of YT1 indicate that the fish were active enough to swim to another payao over 3km away. These results suggest that it is possible to conduct telemetry experiments involving juvenile yellowfin tuna in the Philippines even with the cramped conditions of a small boat.

Although the number of experimental animals was limited, the similarities between the observed swimming behaviors of payao-associated juvenile yellowfin tuna and FAD-associated adults of various tuna species are very striking[7),8),12)~14),16),18),21)]. YT3 swam within a limited shallow range during nighttime and dived to deeper waters during daytime. Ohta and Kakuma[18)] reported that adult yellowfin tuna showed a similar diurnal vertical swimming pattern and dived to depths over 200m. Dagorn *et al.*[22)] reported that adult yellowfin tuna stayed at depths over 1,000m. Although the maximum swimming depth of juvenile yellowfin tuna was not as deep as that of the adults, YT3 was swimming in significantly deeper waters than RRs of the same size. Nevertheless, the horizontal associate pattern of juvenile yellowfin tuna was similar to that of rainbow runners as mention below, the vertical distribution of juvenile yellowfin tuna was different from that of rainbow runners.

The observed vertical movements during daytime were probably feeding excursions for small prey. In an echo survey near payaos also in Panay Gulf, Yamanaka and Babaran (unpubl. data, 2003) observed separate clusters of small prey (5 to 10cm BL) during daytime at depths between 20 and 30m within a range of about 600m from the payao raft. This depth range coincides with the swimming depth of YT3 during daytime. As all the experimental fish were captured by hand line and YT2 showed feeding behavior just two days after release around the payao, the presence of these prey organisms was an important factor in maintaining the aggregation of juvenile yellowfin tuna near these floating structures.

All the fish were detected without interruption and the hourly detection rate did not show any diel differences. This indicates that these fish were swimming within the detection radius of the receiver most of the time. Ohta and Kakuma[18)] revealed that adult yellowfin tuna also exhibited a similar pattern of association with anchored FADs. They reported five patterns, A was characterized by a higher detection rate during nighttime than daytime, B was characterized by a higher detection rate during daytime than nighttime, C was characterized by a few hours absence occurring around sunset, D was characterized by several hours absence beginning around noon and individuals that showed no clear pattern were allocated to E. Although the small fish in this study were allocated to pattern E, it is possible that the observations of juvenile yellowfin tuna in this study may just be one of several association patterns.

YT2 remained around the payao for 129 hours after tagging, but the record ended in the middle of the night on 17 August, 2005. Departure from the tagging site at nighttime has been reported in adult yellowfin tuna[13]. YT2 probably moved away from the payao in the horizontal plane due to the limited range of its vertical plane, namely the detection distance of the receiver almost reached the bottom and the maximum swimming depth of YT3 was 105m. The reported recapture of both YT1 and YT2 provides direct evidence to support this horizontal movement. YT1 and YT2 were captured and released at almost the same time then recaptured at the same time in another payao over 3km away. Unfortunately we did not know the hour of departure of YT1 due to lack of the transmitter, these fish might be swimming together in the same school.

Although YT1 and YT2 demonstrated horizontal movement and their capacities to escape from the influence of the single payao, it seems possible for juvenile yellowfin tuna to reside over a longer period near the floating structures. The results of this study indicate that a single payao unit seems capable of restraining the movements or even altering the migration route of juvenile yellowfin tuna. Moreover, since payaos are usually deployed as a network, another payao may easily attract individuals as YT1 and YT2 were moved to another payao and then recaptured. Aprieto[27] reported that yellowfin tuna begin to migrate from Philippine waters at about 30cm, and this indicates that escape from the space affected by a floating structure may be part of their natural behavioral repertoire until they finally migrate out. Several units within a payao network therefore can act collectively as an ecological trap, which is suspected to be possible in drifting FADs[29]. However, available supporting evidence now indicates that both drifting FADs and payaos have a similar effect by altering the feeding behaviors of associated fish. More comprehensive studies are required to confirm whether payaos really have a negative effect on associated fish populations.

The recapture of YT1 and YT2 showed that fishing pressure around the payaos was very high. It is clear that a network of payaos can render these immature fish vulnerable to fishing by ring nets and hand lines. On the other hand, this provides an opportunity to clarify the behavior of juvenile yellowfin tuna in greater detail by using data loggers because the probability of retrieving implanted tags seems high. Moreover, by installing additional receivers in a network of payaos, it would be possible to record how juvenile yellowfin tuna use the habitat and environment provided by the network in a region where information is inadequate for the management of Philippine tuna, which are part of the Pacific stocks.

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フィリピンパヤオ周辺におけるキハダ幼魚のテレメトリー

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和文要旨

フィリピンのパヤオ（浮魚礁）周辺で，キハダ幼魚の腹腔内に超音波発信機を挿入して放流し，パヤオのアンカーラインに装着した受信機で行動をモニタリングした。キハダ幼魚はパヤオ周辺にとどまり，同時にモニタリングした同サイズのツムブリに比べ，明らかに深い層を遊泳した。夜間は比較的浅く狭い層を遊泳し，昼間は深く広い層を遊泳する日周性や，深夜にパヤオから離れるなど，これまでに報告されているキハダ成魚とよく似た行動を示した。再捕結果から摂餌や移動が確認され，キハダ幼魚のテレメトリーが可能であることが示された。

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