New method that combines dead reckoning and acoustic telemetry to measure fine scale movement of tuna associated with FADs

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Abstract

Mitigating small tuna by-catch in FADs fishery is an urgent task for sustainable fishery. In developing practical method for mitigating by-catch, the knowledge on the reaction of fish to the fishing gear (FAD, net) is necessary. New “Hybrid fish tracking method”, which is a combination of dead reckoning and acoustic telemetry, was introduced and tested in the FAD fishing site. Out of ten occasions that we tagged tunas with package of data logger and pinger, 4 fishes were successfully recaptured. As the results showed fine scale trajectory of tunas, the new method is considered to be good tool for understanding tuna behavior around FAD and net.

Introduction

The Fish Aggregating Devices (FADs) attract fish including small Bigeye tunas. This nature results in by-catch of small bigeye tuna in purse seine fishery and causes negative impacts to its stock status. Effective method to mitigate the small tuna by-catch is necessary.

To mitigate small tuna by-catch, potential solutions may be changing the conventional method of setting net or letting small fish escape through large mesh of the net. In developing such method, however, there is an obstacle that is the lack of knowledge on the interaction of fish and fishing gear (FAD, net). By obtaining knowledge such as how fish move around a FAD or react to fishing net, we could develop practical ways to mitigate by-catch of small tunas. In this study, we introduced new “Hybrid fish tracking method” that combines dead reckoning and acoustic telemetry to measure fine scale movement of tuna associated with FADs

Materials & Methods

(1) Hybrid fish tracking method

Hybrid fish tracking method is a new way to measure fine scale movement of fish under water by combining dead reckoning and acoustic telemetry.

Dead reckoning is a method to estimate position of fish by calculating the distance and direction that travelled from previously known position. The data loggers such as acceleration logger are used to measure fish speed, acceleration, direction, depth and so on. By calculating those data, the position of a fish is estimated from the previous position (one second before). Three-dimensional trajectory of a fish will be obtained by successive position estimate by such calculations. This procedure, however, can accumulate errors over time and results in large error in position, even if error in single step is very small.

The accumulated error can be corrected by combining position estimates with acoustic telemetry. The position of a fish attached with acoustic pinger can be estimated by calculating difference of the timing a pinger signal reaches to multiple receivers with known position.

(2) Field experiments

A tuna purse seiner Taikei-maru No.1 was used for the study. Field experiments took place in Oct. to Nov. 2016 in eastern Indian Ocean. Sample fishes were captured by lure fishing near FAD and was attached with logger package and then released. The tagging was done day before the set or just before the set. The logger package includes Vemco acoustic pinger (V13 or V16) and Little Leonardo data logger (PD3GT or 3M-PD3GT). When PD3GT, which lacks direction sensor, was used Star Oddi direction sensor (DST-magnetic) was also added.

The acoustic signals from the pinger was received with 3 or 4 acoustic receivers (Vemco VR2W). The receivers were deployed to make triangle or rectangle formations. In recording before the set receivers were suspended from the work boats. In recording during the set 2 receivers were suspended by ropes that were tied to cork line of the net and another 2 receivers were suspended from the boats. When the experiment continued overnight, a VR2W receiver was attached to the FAD to collect data of presence / absence of the fish. All the receivers were set with GPS logger to record the position where pinger signals were received. When a pinger signal reached to 3 or more receivers, the pinger position was calculated from the GPS position of the receivers. The estimated pinger position was used for correcting dead-reckon-estimated trajectory.

The tagged tunas were recaptured from the catch and the data was collected from the loggers.

Results

In 13 trials, we managed to tag 10 tunas. Of the ten, 4 fish were recaptured and its logger data were successfully collected.

An example of fish trajectory that was recorded overnight is shown below (Bigeye tuna; FL62cm). Figure 1 shows the horizontal movement of the fish. Blue line is the trajectory estimated from dead reckoning. Small circles show the positions estimated from

simultaneous pinger reception. Red line is the corrected trajectory based on the pinger-estimated positions. The trajectory between pinger-estimated positions were linearly interpolated from dead reckon data. Figure 2 shows the horizontal trajectory of the same fish overlaid to FAD position. Figure 3 shows the three-dimensional trajectory of the same fish.

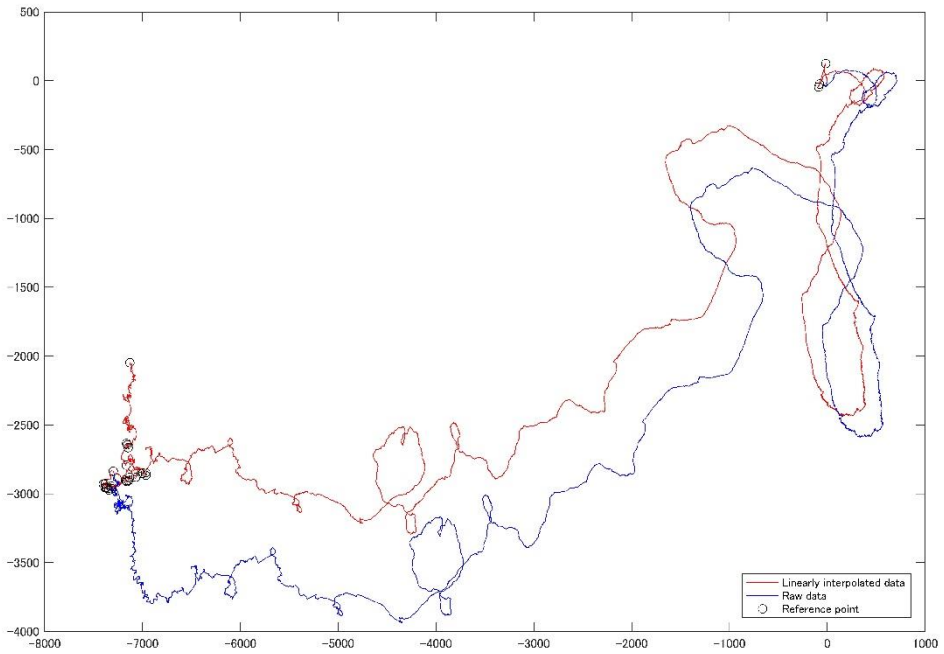

Fig.1 Estimated trajectory of 62cm Bigeye tuna (red line)

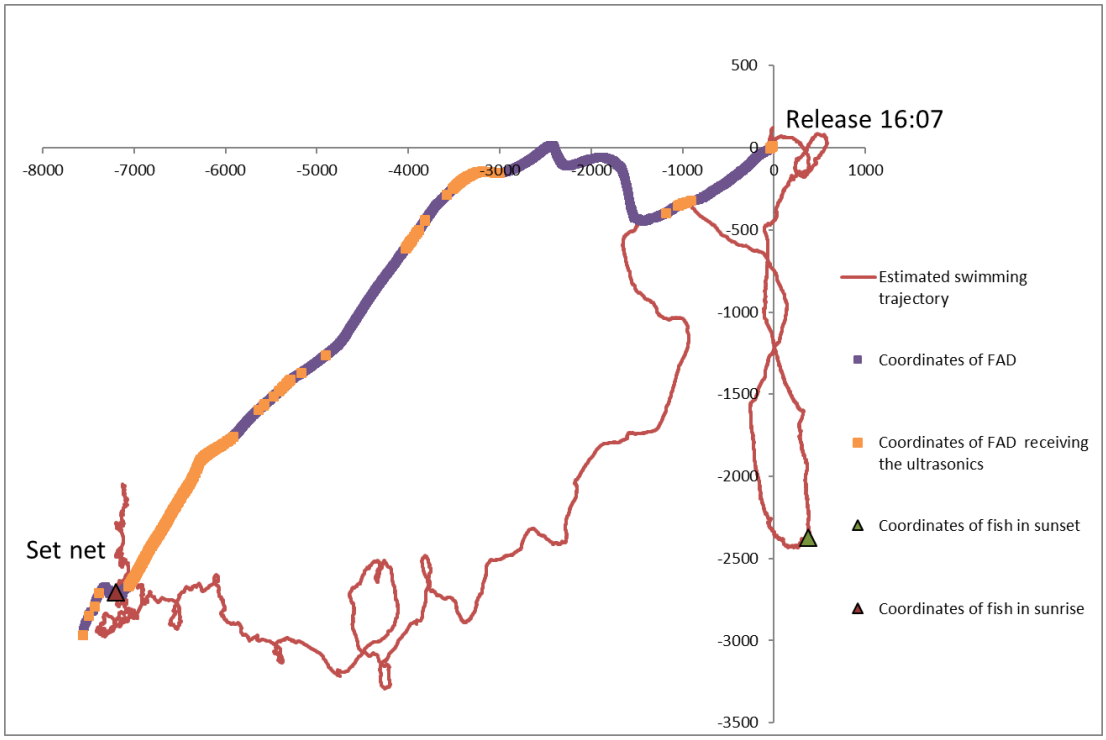

Fig.2 Horizontal trajectory of 62cm Bigeye tuna and FAD

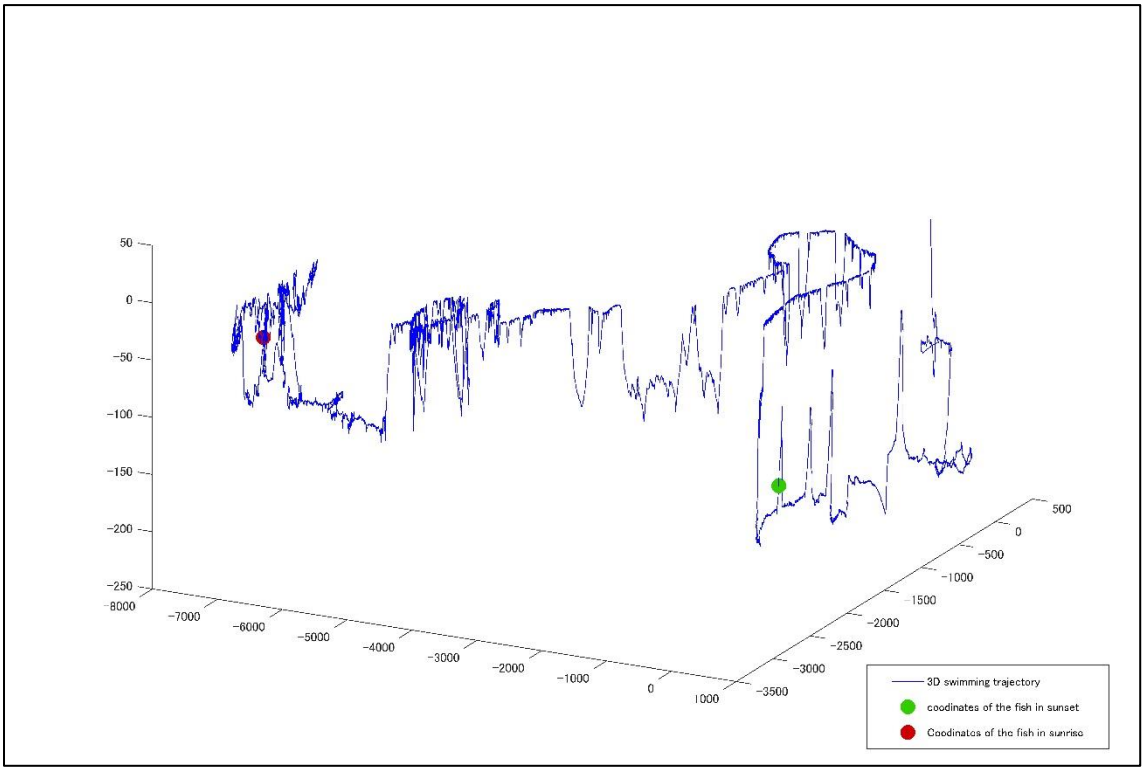

Fig.3 Three-dimensional trajectory of 62cm Bigeye tuna

From these data, the fine scale movement of fish can be analyzed. For example, after being tagged and released the fish dived down to more the 200m depth. During the daytime fish stayed at deep layer most of the time and slowly swam away from the FAD. Just after the sunset it rapidly went up to the surface and seemingly “came back” directly to the FAD. The fish stayed near the surface until around 2:30. During the course of that, the fish went as far as 2,400m from the FAD and finally managed to come back to it again.

Discussion

The new “Hybrid fish tracking method” worked well in the field experiments. The method can be utilized to obtain fine scale movement of target species like we presented here. Such fine scale data is essential in understanding ecology of species that gather around FADs.

We will continue to analyze obtained data set for the better understanding of fish behavior. The next step will be overlaying the 3D trajectory of fish on the simulated 3D net model. That will allow us to understand how a fish react to fishing net and possibly lead to solutions of by-catch problems.