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Target strength of Bigeye, Yellowfin and Skipjack measured by split beam echo sounder in a cage

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Introduction

Catch of juvenile Bigeye and Yellowfin by purse-seine FADs operations is considered to be harmful for the stock. Practical methods to reduce the proportion of juvenile tuna catch are needed.

One of the potential solutions for the problem is acoustic estimation of size and species of the fish gathering around FADs. Provided that the composition of schools can be predicted, it would be possible to avoid operation when juvenile Bigeye dominates.

Target Strength (TS) is basic information for fisheries acoustics. For a given species, TS is considered to be a function of size. TS also varies among species. For example, TS of fish with swim bladder is much higher than that of fish without swim bladder because swim bladder is much stronger scatterer than fish body itself. It is expected that Tuna has much higher TS than Skipjack because Tuna has swim bladder and Skipjack doesn't.

Hara (2001) studied the relation between body size and swim bladder size and showed that Bigeye has bigger swim bladder than same sized Yellowfin (following equations).

Yellowfin: Lsb = 0.194 x L

Bigeye: Lsb = 0.319 x L

where Lsb is length of swim bladder, L is fork length.

Taking these information into account, we assumed that TS of three species is in order: Bigeye > Yellowfin > Skipjack.

And we conducted TS measurement using caged fish both to verify the assumption and obtain basic information on the acoustic properties of these target species.

Materials and method

<Cage>

Two cages, the experiment cage and the stock cage, were installed in an inlet at Kakeroma Island. The experiment cage, 5m diameter and 20m deep, was used for acoustic measurement. It has iron frame on the surface and bottom. Net of the cage was made with strong Vectran string with 75mm mesh size.The stock cage was used to stock fish and kept them alive until the time of experiment. The structure was similar but it only has 5m deep. The transducer was set on the upper center of experiment cage.

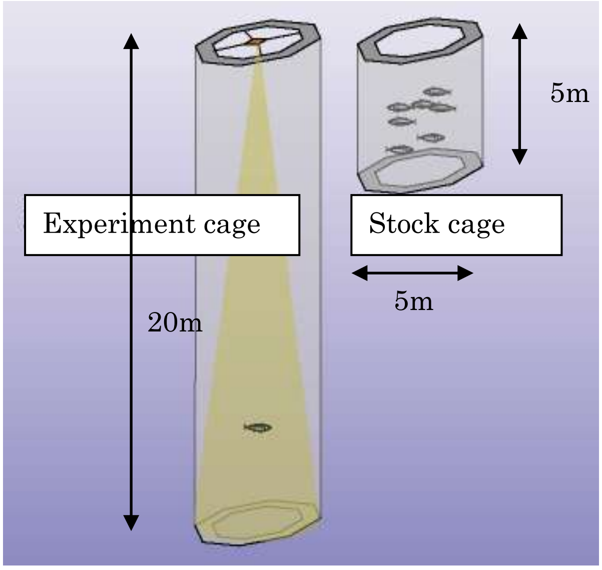

Fig.1 Dimension of two cages used for the experiment

<Sample fish>

Sample fish were caught by a local fishing boat with pole and line method. Caught fish were stocked in the reserve tank in the boat and brought to the experimental sight alive. All fish were moved from the boat to the stock cage several hours after catch. They were kept untouched for about one day to get them accustomed to the new environment.

<TS measurement>

Kaijo KFC5000 quantitative echo sounder system was used for the measurement. The system has 38 kHz split beam transducer. Ping rate was 200ms and pulse duration is 0.6ms. The echo sounder was calibrated with standard sphere method before the measurement.

Only one fish at a time was submit to the acoustic beam for TS measurement. Each fish were measured 30 to 60 minutes per individual. Sample fish was removed from the cage and its fork length was measured.

Acoustic data was analyzed using software SonarData EchoView. The echo trace, which is a series of single echo from one target, was detected by the software. The maximum TS value in a echo-trace was picked and averaged over individual fish.

Results

After settled in the experiment cage, fish swimmed around drawing horizontal circle. Vertically the three swimming patterns were observed, (A) smooth, level move with little vertical move, (B)small "up and down" like sinusoidal curve, (C)acute ascent and acute descent.

Out of 26 Skipjack, 44 Yellowfin and 14 Bigeye that were measured, 11,42 and 14 were used for the analysis after bad data were eliminated.

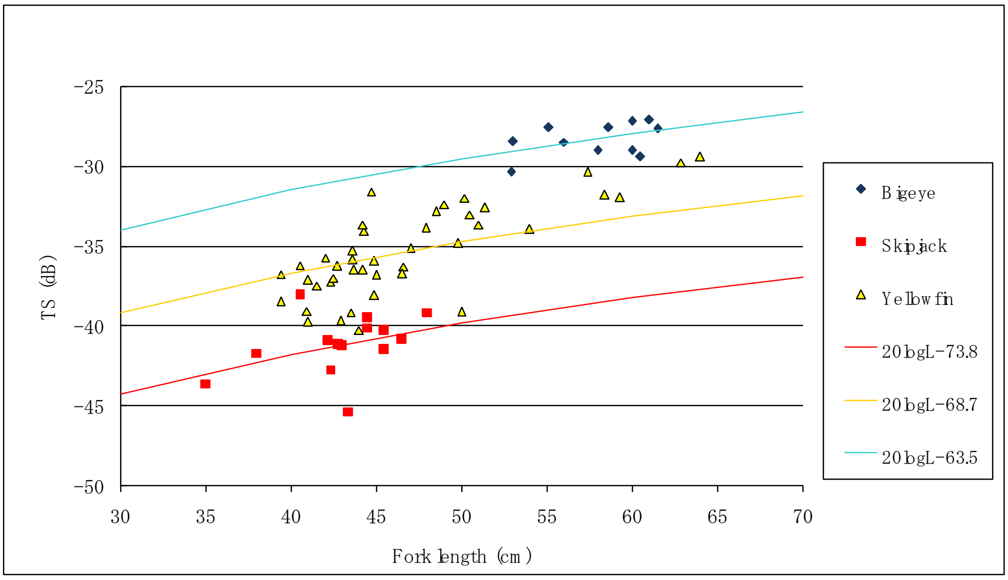

Fig2 Mean Target Strength of measured fish (maximum values from each echo trace was used for the analysis, preliminary result, not to be cited)

The relationship between the mean TS and fork length for Bigeye, Yellowfin and Skipjack is shown in Figure 2. TS of all three species shows positive correlation with the size. Logarithmic regression curves for each species are also shown in the figure X. Formulas show that, for same size of fish, TS of Bigeye tuna is 5.1dB higher than that of Yellowfin, and TS of Yellowfin is 5.2dB higher than that of Skipjack.

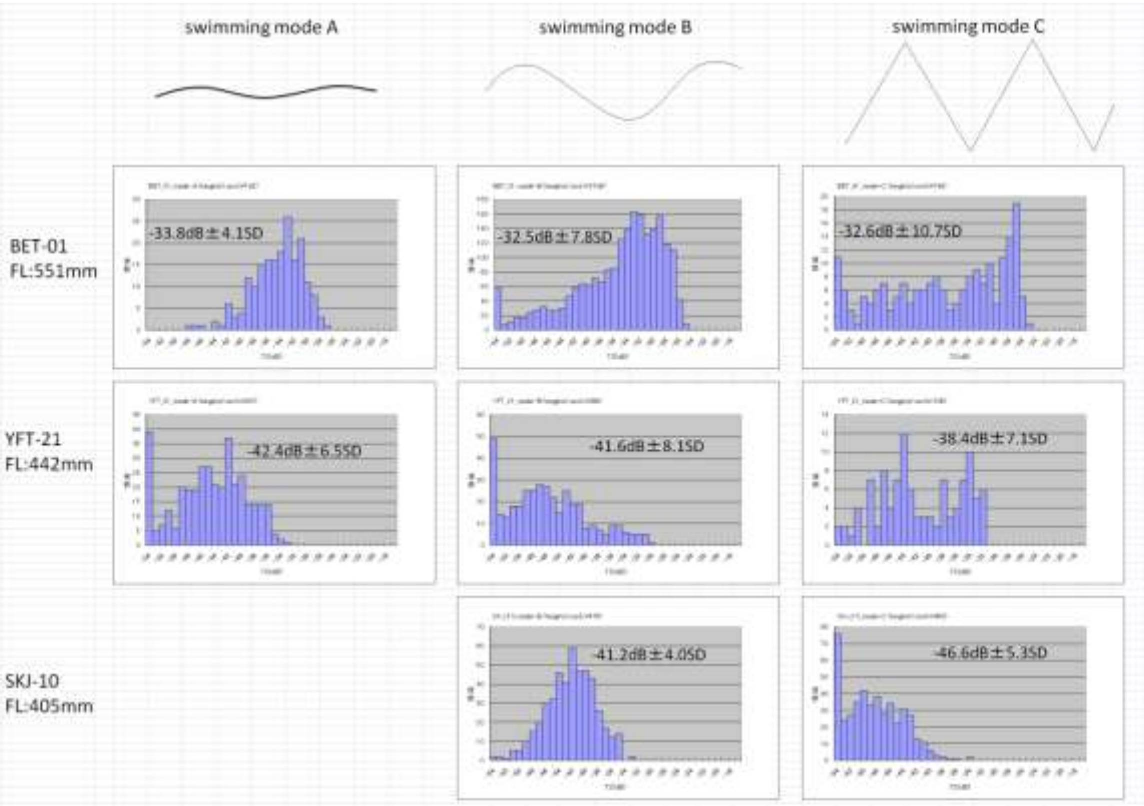

Fig.3 Change of TS distribution from different swimming mode of same individual

Fig.3 shows the change of TS distribution from different swimming mode of same individual. Swimming mode A is smooth, level move with little vertical move, swimming mode B is small "up and down" like sinusoidal curve, Swimming mode C is acute ascent and acute descent.
For Bigeye and Yellowfin, TS distribution from swimming mode-A was a unimodal and showed relatively small variance (SD). When fish moves up and down (swimming mode B & C) TS distribution showed higher variance and sometimes bi- or multimodal. For Skipjack, swimming mode A wasn't observed. TS from swimming mode B and C showed unimodal distribution. Average TS for mode-B was higher than that of mode-C.

Discussion

The result supports our first presumption that TS is stronger in order: Bigeye > Yellowfin > Skipjack.
High variance of TS was observed when fish is moving up and down especially for smimbladdered fish like Bigeye and Yellowfin. This can be explained by "back-scattering pattern". Acoustic scatter from a fish has a spatial distribution of back scattering sound energy which called back-scattering pattern. So, observed TS of a single fish is composite function of back-scattering pattern and its tilt angle distribution. Thus, swimming pattern of a fish has big influence on TS distribution of the fish.
In order to achieve the goal of acoustic estimation of fish species and size, we need to reduce the variance. So we need to further the analysis of these data to get the relationship between tilt angle and TS for each species.