# Variation of sound field surrounding target in TR (Time Reversal) sound field using ICA (Independent Component Analysis) processing results

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# 1. Introduction

Passive target detection is considered to underwater targets separate (TGT) from reverberation in shallow water. Possible method is included time reversal (TR) processing and independent component analysis (ICA) processing and so on. Tsurugaya et al. are investigating the separation of TGT positions by combining ICA processing and TR processing <sup>1-4</sup>. TR sound field is obtained by TR processing the signals separated by ICA processing. Although TR sound field obtained from TR processing has information of the separated signals, it is difficult to extract specific features from it. Furthermore, TGT position is extracted from TR difference sound field by using a search TGT (S-TGT). S-TGT is inserted into the sound field where TGT exists. Then, TR difference sound field by S-TGT and TGT is obtained. The S-TGT is moved to obtain the TR difference sound field. The position of S-TGT that is matched TR difference sound field obtained by TGT only is the position of TGT.

Therefore, we are examined the change in TR difference sound field near TGT position.

For ICA processing, the rica function for extraction by reconstruction ICA in MATLAB is used, and the calculation for sound propagation is used FOR3D<sup>5</sup>. Using sound source depth is 15m, and the display is shown the first separated wave by ICA processing.

# 2. TR difference sound field

In order to confirm the signals separated by ICA processing, we are used a TR sound field obtained by performing TR processing on the separated signals. However, the TGT position information cannot be clearly captured by TR processing of the separated signals alone. Therefore, as shown in Figure 1, we are used the TR difference



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sound field, which is the difference between TR sound field with TGT exists and TR sound field without TGT. Bottom depth is 100m.

# 3. Search-target

Search-TGT is introduced to obtain the presence and location of the target. The concept of Search-TGT (S-TGT) is shown in Fig. 2. The position of S-TGT is moved. TR difference sound field at the position of S-TGT is obtained, and the pattern is compared with TR difference sound field where only TGT is existed. When the position is matched, TR difference sound field also is matched. The depth and distance of S-TGT where both patterns is matched are the distance and depth of TGT.



Fig. 2 Concept of Search-TGT

# 4. Search for TGT

#### 4.1 Search in depth direction

When searching depth in the depth direction,



Fig. 3 Comparison of TR difference sound field for S-TGT depth

Left figure is single TGT, right one is S-TGT+TGT each depth is a); 5m, b); 15m, c);40m

TR difference sound field of a single TGT and S-TGT+ TGT is shown in Fig. 3. In a), depth of S-TGT is 5m, in b), is 15m, and in c), is 40m. The left of each figure is single TGT for each depth. and the right of each figure S-TGT+ is TGT. The left

and right patterns do not match in a) and c), but in b), the left and right pattern is matched. In other words, the depth of S-TGT is matched TGT depth, and as a result, the left right pattern is matched.

#### 4.2 Search in range direction

TR difference sound field of the single TGT and S-TGT +TGT when searching in the range



Fig. 4 Comparison of TR difference sound field for S-TGT distance Left figure is single TGT, right one is S-TGT+TGT each distance is a); 3km, b); 4km, c); 5km

direction is shown Fig. 4. TGT depth is 15m. In a) S-TGT distance is 3km, in b) is 4km, and in c) is 5km. The left side of each figure is the case of single TGT, the right side is the case of S-TGT+TGT. The patterns on the left and do not match in a) and c), but in b) patterns the is matched. In other wards, the distance of S-TGT is TGT distance when pattern is matched.

# 5. Change in TR difference sound field surrounding TGT

TR difference sound field at the position of S-TGT is shown in Fig. 5. The horizontal axis is the



STGTR4200m STGTR4000 STGT STGTR4000 STGT STGTR4000 STGTR4000 STG

TR difference sound field for the position of TGT



horizontal axis ; distance from sound source (m) vertical axis ; depth from surface (m)

distance of S-TGT from the sound source, and the vertical axis is the depth of S-TGT. The figure shown here is shown the state in which the scattering the scattering due to S-TGT and TGT is superimposed. TGT is at a distance of 4km and a depth of 45m. For confirmation, TR difference sound field TR difference sound field by TGT is shown in the upper-left of the figure. Although not shown here, TR difference sound field was obtained at intervals of 500m in the distance direction and 1m in the depth direction.

The position matched TR difference sound field of S-TGT and TR difference sound field of TGT shown in upper-left is when the position of S-TGT is at a distance of 4000m and the depth of 45m. In other words, the position of S-TGT when both TR difference sound fields match is the position of TGT. It can also be clearly separated from the surrounding TR difference sound field.

### 6. Summary

We were investigated a method to determine the location of the TGT using TR difference sound field. Using the S-TGT, we are compared the patterns of TR difference sound field obtained from S-TGT and TR difference sound field obtained from the true TGT. The depth and distance of the S-TGT in the matching pattern is became the true TGT location. Furthermore, we are investigated the change in TR difference sound field of S-TGT+TGT near TGT. The patterns of TR difference sound field of TGT and its surroundings are different. But, when the position of S-TGT and TGT is matched, the patterns of both TR difference sound fields are also matched. Therefore, the position obtained by S-TGT is the location (a distance and a depth) of TGT.

#### References

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