is clear and the effect is greater when the largest amount of sound reflected by the fish is in the broadside aspect rather than the head/tail aspect. The difference between the polar diagrams might possibly be an effect of the fish size and orientation. Henderson et al.\textsuperscript{16} reported that fish orientation defined as the pitch, yaw and roll angles of the fish with respect to the acoustic transducer, is a major influence on the TS. The effect of a change of fish orientation of a few degrees may be sufficient to introduce a large change in the TS. The former studies reported that the yaw angle of fish\textsuperscript{17} and roll angle of fish\textsuperscript{18} have a significant influence on the fish TS.

Further, Foote\textsuperscript{19} reported that the highest TS should be obtained when the major scattering component of fish is perpendicular to the sound. The fish TS changes significantly with yaw angle and the effect is greater when the largest amount of sound reflection by the fish is from the broadside aspect rather than from the head or tail aspect of the fish.\textsuperscript{15} In contrast, when a fish faces the transducer, the TS is low and varies only slightly (Fig. 4, pitch angle of 90\textdegree). These results clarified that a change of the roll angle of the fish has less influence on the TS values. These findings are the same as those of Benoit-Bird et al.,\textsuperscript{20} who reported that the variation of the TS of all snapper species was

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{polar_diagram.png}
\caption{Polar diagram of fish directivity in the yaw angle for fish (FL=14.1 cm, 15.1 cm, and 15.5 cm). 0\textdegree, 90\textdegree, 180\textdegree, and 270\textdegree denote right side, tail, left side, and head aspects of fish, respectively. The numbers 0\textdegree, 30\textdegree, 60\textdegree, and 90\textdegree represent the pitch angles of the fish.}
\end{figure}