Experimental investigation of the large scale flow structures around a trawl

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The analysis of hydrodynamics of various types of fishing net structures, and especially of a trawl, has been of great interest for scientists for a long time. Such investigation has an impact not only on commercial fishing operations including the fishing vessel energy efficiency but also on biological and socio-economical environment.

Due to the flexibility of the net, there is a complex interaction between flow, geometry (solidity) and shape of the net. In fact, the analysis of the hydrodynamic flow around (and also in) fishing net structures is extremely related to the strong influence of hydrodynamic fields on the shape of trawl elements, acting forces, fish behaviour and on catchability of fishing gears.

Despite its practical engineering application, there is almost no reported study on the analysis of hydrodynamic flow around a fishing net structure, however a lot of results related to the Vortex Induced Vibration of a cylindrical or spherical structure can be exploited. To the author knowledge, we present one of the first studies aiming at investigating the instantaneous hydrodynamic flow around a porous structure.

For such analysis, two kinds of net structure are considered: a) a rigid cod-end and b) a moving bottom trawl. Flow field measurements behind both porous structures are then conducted using Time Resolved PIV method. This method is based on an image acquisition rate allowing the time resolved sampling of the vortex shedding phenomenon. Experimental measurements are performed in the IFREMER wave-current circulation flume tank.

Based on these measurements, the main flow characteristics around fishing net structure are investigated.

First, the analysis of the movement of the trawl is investigated from the second flow configuration. Note that in this case, the trawl is free to move in the three directions. Indeed, the bottom trawl is induced to vibrate by its own wake. Note that to our knowledge, there are no papers which address the analysis of the instability of the shear layer separating a body having 3 degrees of freedom. This is possible in our work because of the net deformation of the trawl. We then determine the transverse movement of the trawl subjected to flow instabilities. Even if the moving bottom trawl is subjected to move in the three directions, we show that the transverse movement of the trawl can be related to the vortex shedding flow instability deduced from a fixed porous structure.

Second, a comparative analysis of the mean flow field and the turbulent kinetic energy obtained in both flow configurations are examined. Noticeable differences are then observed due to the movement of the bottom trawl in the second flow configuration.

Third, we investigate the large scale flow structures present in the flow developing around both porous net structures. For such purpose, Proper Orthogonal Decomposition is implemented to extract the large scale flow structures of each flow configuration. POD is then used to detect the instantaneous energetic flow structures. It is also demonstrated the effectiveness of the POD procedure to extract the frequency associated with these flow structures. POD is shown to be robust to act as a filter for the frequency analysis.

Then, the vortex shedding phenomenon is studied. It is demonstrated that the vortex shedding phenomenon obtained behind a rigid cod-end has some similarities with the one behind a cylinder with a Strouhal number approaching 0.2. We also investigate the typical frequencies associated with the flow behind a moving bottom trawl. Furthermore, similar analyses are performed using instantaneous velocity fields projected onto the first POD modes. It is then confirmed that the POD is effective as a filter for the frequency analysis. More precisely, a specific analysis of the first temporal POD coefficient shows that these coefficients exhibit the typical frequency of the vortex shedding phenomenon.

Finally, these experiments form one of the first studies in which i) the main flow characteristics around fishing net structure are investigated and ii) the analysis of the instability of the shear layer separating a body having 3 degrees of freedom is performed. Also it is shown the effectiveness of POD to act as a filter for the frequency analysis of the turbulent flow behind a moving bottom trawl. This new experimental database can be also used to validate numerical results as well as numerical model.