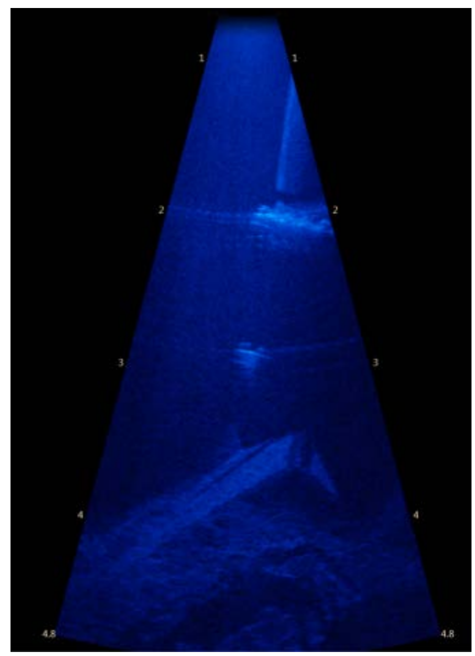
Acoustic Camera Particle Image Velocimetry (PIV)

Dredging Operations Environmental Research (DOER) Program

U.S. ARMY CORPS OF ENGINEERS BUILDING STRONG®

Problem

USACE dredging projects that use hopper dredges (both contractor and District-owned) are increasingly being challenged with regulatory agency concerns about entrainment of fish and other species (e.g., sea turtles). Some regulatory agencies are considering limiting or eliminating hopper dredging in certain areas because of the paucity of knowledge regarding entrainment risk to special status species. Coastal USACE Districts work with regulatory agencies to determine hopper monitoring techniques, entrainment risk, and entrainment risk reduction, but a major challenge confronting them is that there are limited published data on the flow field around hopper dragheads. The significant challenged posed by quantifying the flow field around dragheads is the high turbidity of the water. Indeed, quantifying a flow field in low-visibility underwater environments is a significant gap in flow measurement capability. Acoustic-based instruments (e.g., ADV, ADCP) perform admirably in turbid environments, but only yield point or profile velocity measurements, rather than a two-dimensional velocity field. Particle-image-velocimetry (PIV) is an accepted method of acquiring two-dimensional velocity flow fields in lab settings, but has seen limited field use due to the inability to quantify the flow in turbid environments.



Study Description

The objective of our study is to develop the capability to acquire two-dimensional velocity fields in highly turbid flows such as near dredging operations or in navigation channels using 3D acoustic cameras. This will facilitate coordination between USACE and regulatory agencies in providing science-based solutions gleaned from quantification of draghead flow fields. We performed PIV on a relatively simple laboratory flow (e.g., flow behind circular cylinder at low Reynolds number) using the images from an acoustic camera while making simultaneous optical camera-based PIV and ADV transect measurements. This will allow us to assess the efficacy of the acoustic-camera-based PIV system in a controlled manner. The ultimate goal of this work is to scale up the system to be deployed in the field to quantify the flow around a real draghead.

Products

Our project has resulted in an ERDC special report discussing appropriate background information to understand how acoustic cameras may be used in PIV analysis, as well as a conference paper and presentation detailing the use of acoustic cameras to track the settling velocity of inertial particles. In FY18 we will submit a journal article that details the results of our comparison experiment. These findings will also be presented at the 2019 Ocean Sciences Meeting in New Orleans, LA, and the general technique will be summarized in an ERDC Tech Note. We anticipate follow-up projects to scale up this system to quantify the flow around a real draghead and other turbid flow environments and ultimately to make it available to USACE and the wider scientific community as a new technique to acquire two-dimensional velocity field information in turbid environments.

Summary

This project investigates the use of a 3D acoustic camera to acquire two-dimensional velocity vector fields from PIV analysis. We performed an experiment to quantify the two-dimensional velocity field of a simple laboratory flow using PIV with both 3D acoustic camera images and standard optical camera images, along with ADV transect measurements, to determine whether the acoustic camera PIV results are accurate. The success of this project will lead to an entirely new technique to measure flow velocities in turbid environments in the field, one that yields substantially more information than the technologies currently available (i.e., two-dimensional velocity vector fields) and allows velocity gradient based hydrodynamic signals to be directly estimated.

Balancing operational and environmental initiatives and meeting complex challenges of dredging and dredged material placement in support of the navigation mission.

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