



COLLEGE OF ENGINEERING  
AND COMPUTER SCIENCE  
FLORIDA ATLANTIC UNIVERSITY

Announces the Ph.D. Dissertation Defense of

## Ranjoy Barua

for the degree of Doctor of Philosophy (Ph.D.)

### “Applications of Digital Holographic Imaging Towards Characterization of Marine Plankton Distributions and Biophysical Interactions”

November 4, 2022, 1.00 p.m.  
HBOI, Room # LE 247  
5600 US 1 North  
Fort Pierce, FL 34946  
Webex Meeting Number: 2621 721 3163  
Password: PvHrMfmp794

DEPARTMENT:

Ocean and Mechanical Engineering

ADVISOR:

Aditya R. Nayak, Ph.D.

PH.D. SUPERVISORY COMMITTEE:

Aditya R. Nayak, Ph.D., Chair

Michael S. Twardowski, Ph.D.

Oscar M. Curet, Ph.D.

Bing Ouyang, Ph.D.

ABSTRACT OF DISSERTATION

Applications of Digital Holographic Imaging Towards Characterization of Marine Plankton Distributions and Biophysical Interactions

Characterization of the distribution and biophysical interactions of oceanic planktonic organisms is crucial to address fundamental science questions associated with climate change, marine ecology, pollution, and ocean optics. Thus, development of instrumentation techniques for monitoring plankton at high spatial and temporal resolutions is important. This dissertation deals with the advancements made in applying digital holography – a 3-D non-intrusive, freestream imaging technique – to address three different applications associated with marine plankton monitoring and ecology. In the first project, an autonomous inline digital holographic microscope was successfully deployed for rapid *in situ* detection of the harmful dinoflagellate, *Karenia brevis* in the coastal Gulf of Mexico. Monitoring *K. brevis* abundance and distribution are crucial for early warning systems and implementing preventative measures to limit potential damage. The holographic system was successfully paired with a convolutional neural network for automated data processing to ensure rapid and accurate *K. brevis* detection. In the second project, field experiments with an *in situ* holographic imaging system and observations on a thin layer (vertically limited aggregation) of a mixotrophic planktonic ciliate in the Atlantic Ocean's Delaware shelf are reported. Ciliate abundances were up to 6 times higher than documented in prior literature, and the ciliate layer was highly correlated with the location and intensity of the subsurface chlorophyll a maximum. This study highlighted the potential for substantial underestimation of an important group of organisms to the planktonic biomass as well as the importance of pairing *in situ* imaging systems with standard sensors in marine ecosystem studies. In the third project, holographic microscopy was used to characterize the growth and orientation of colonial diatoms under laminar and turbulent flow regimes in a temperature and light controlled environment in the lab. For all species and replicates, mean colony lengths were higher in laminar flow, indicating turbulence limited colony size. Clear preferential orientation in the mean flow direction was observed under laminar flow conditions, albeit with differences based on mean aspect ratios of different species. Together, these three studies encompass important observations, demonstrating the value of digital holography towards diverse laboratory and field-oriented applications in marine ecology and plankton monitoring.

## BIOGRAPHICAL SKETCH

Born in Chattogram, Bangladesh

B.Sc. in Mechanical Engineering, Rajshahi University of Engineering and Technology, Rajshahi, Bangladesh, 2011

M.Sc. in Mechanical Engineering, University of Massachusetts Dartmouth, North Dartmouth, MA, USA, 2018

Ph.D. in Mechanical Engineering, Florida Atlantic University, Boca Raton, Florida, 2022

## CONCERNING PERIOD OF PREPARATION

### & QUALIFYING EXAMINATION

**Time in Preparation: Year** – Fall 2018- Fall 2022

**Qualifying Examination Passed: Spring 2019**

### Published Papers:

Barua R., D. K. Sanborn, L. Nyman, M. McFarland, T. Moore, J. Hong, M. Garrett, and A. R. Nayak. "In situ digital holographic microscopy for rapid detection and monitoring of the harmful dinoflagellate, *Karenia brevis*." *Harmful Algae*. (Under revision).

Sanborn D., A. Base, L. Garavelli, R. Barua, J. Hong and A.R. Nayak, "Digital holography for real-time non-invasive monitoring of larval fish at power plant intakes", *Canadian Journal of Fisheries and Aquatic Sciences*. (Under revision).

Greer A. T., J. C. Lehrter, B. M. Binder, A. R. Nayak, R. Barua, A.E. Rice, J. Cohen, M. McFarland, A. Hagemeyer, N.D. Stockley, K.M. Boswell, I. Shulman, S. deRada, and B. Penta, 2020. "High-resolution sampling of a broad marine life size spectrum in relation to shelf biophysical characteristics." *Frontiers in Marine Science*, 7, 542701.

Barua R., M. McFarland, J. M. Sullivan, A. R. Nayak, 2022. "Orientation dynamics of elongate colonial diatoms in circular couette flow." *Virtual Ocean Sciences Meeting 2022*.

Nayak A. R., L. Nyman, R. Barua, M. McFarland, A. Greer, J. Lehrter, B. Penta. May 22-27, 2022. "Observations on a thin layer of the mixotrophic planktonic ciliate, *Laboea strobila*, using in situ digital holography." *Microscale Ocean Biophysics 6.0*, Port de Soler, Mallorca, Spain.

Nayak A. R., T. Moore, R. Barua, M. McFarland, May 15-20, 2022. "Characterizing spatial distributions of cyanobacteria blooms in freshwater lakes using in situ digital holography." *2022 Joint Aquatic Sciences Meeting*, Grand Rapids, Michigan USA.

Barua R., L. Nyman, M. McFarland, T. Moore, M. Garrett, A.R. Nayak, Apr 25-29, 2022. "An in situ holographic imaging system for monitoring the red tide dinoflagellate, *Karenia brevis*." *2022 Gulf of Mexico Conference*, Baton Rouge, Louisiana, USA.

Base A., L. Nyman, L. Garavelli, R. Barua, A.R. Nayak, Feb 28 – Mar 4, 2022. "A digital holographic imaging system for in situ monitoring of endangered and sensitive fish larvae in cooling water intake structures.", *2022 Virtual Ocean Sciences Meeting*.

Nayak A. R., L. Nyman, R. Barua, M. McFarland, A. Greer, J. Lehrter, B. Penta, Feb 28 – Mar 4, 2022. "Characterizing a subsurface ciliate thin layer in the coastal Atlantic Ocean using in situ digital holographic microscopy.", *2022 Virtual Ocean Sciences Meeting*.

Nyman L., R. Barua, M. McFarland, T. Moore, M. Garrett, A.R. Nayak. Jun 22- 27, 2021. "An in situ holographic imaging system for characterizing distributions of *Karenia brevis*", *Virtual ASLO Aquatic Sciences Meeting*.

Nayak A. R., L. Nyman, B. Guo, J. Hong, R. Barua, M. McFarland, A. Greer, B. Penta. Jun 22- 27, 2021. "High resolution observations on the formation and evolution of a subsurface ciliate layer in the coastal Atlantic Ocean", *2021 Virtual ASLO Aquatic Sciences Meeting*.

Barua R., M. McFarland, J. M. Sullivan, J. Rines, M. Omand, A. R. Nayak, 2021. "Effect of fluid shear on the orientation and light limited growth rate of colonial diatoms." *Virtual ASLO Aquatic Science Meeting 2021*.

Barua, R., A. Base, L. Nyman, S. Goughan, B. Guo, M. McFarland, T. Moore, L. Garavelli, J. Hong, M. Garrett, A. R. Nayak, 2021. "Applications of digital holographic microscopy towards aquatic particle and plankton monitoring." *IEEE International Workshop on Metrology for the Sea*. (Invited)

Barua R., M. McFarland, J. M. Sullivan, J. Rines, M. Omand, A. R. Nayak, 2020. "Characterizing light limited growth and orientation of elongate colonial diatoms under laminar and turbulent Couette flow regimes." *Ocean Sciences Meeting 2020*, San Diego, California, USA.