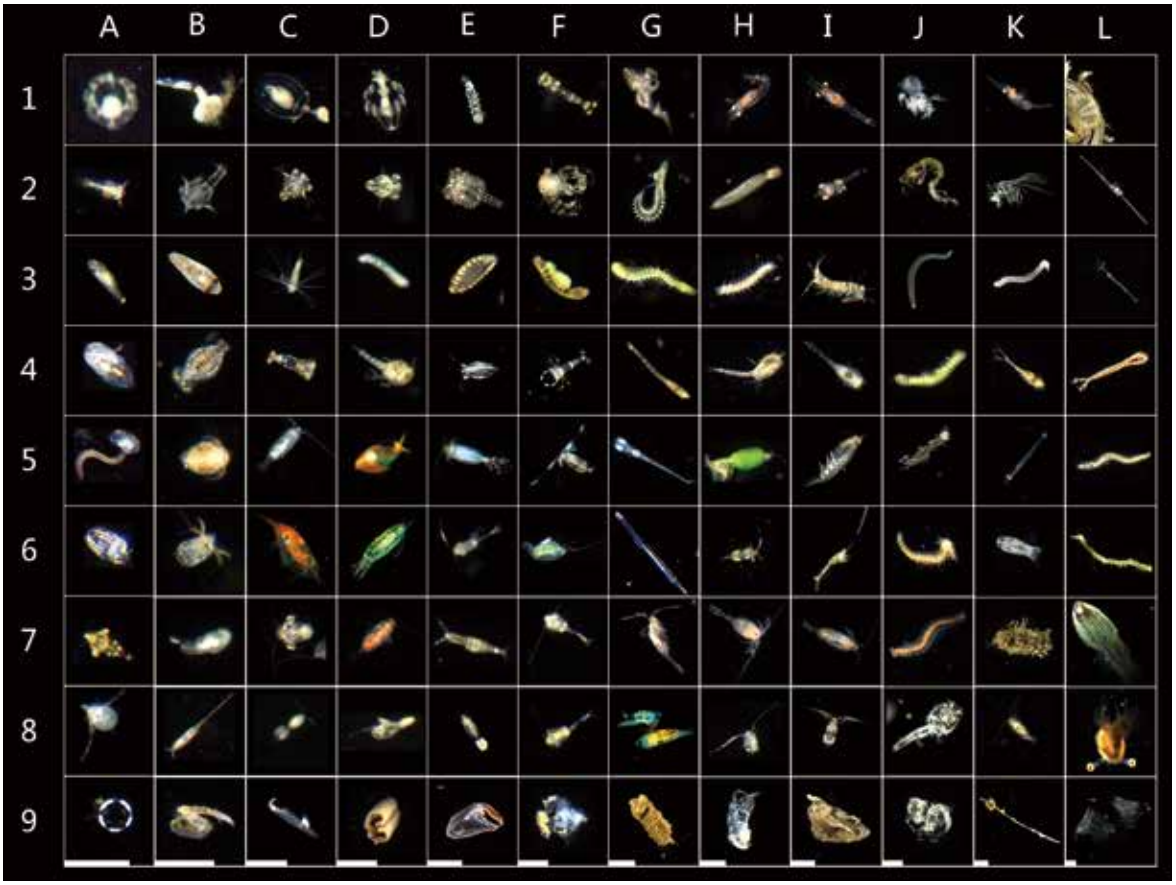
Buoy-borne Underwater Dark Field Imaging System Improves Marine Plankton Monitoring Capability

Mesoplankton refers to plankton with a body size between 200–20,000 μm. Since mesoplankton are the key components of coastal ecosystems, their abundance and composition can promptly reflect environmental changes in local seawater.

A research team, led by Dr. LI Jianping from the Shenzhen Institute of Advanced Technology (SIAT) of the Chinese Academy of Sciences, has developed a buoy-borne underwater dark field imaging system that can expand the geographical and temporal marine plankton monitoring capabilities of a surface buoy network.

The study was published in *IEEE Journal of Oceanic Engineering* on Oct. 20.

The new imager in the trial system features a new strobe LED illuminator with a 360° inward convergent laminar lighting design. Such optical design not only facilitates high-quality underwater darkfield color photography of marine plankton, but also reduces light leakage to the local underwater environment and thereby minimizes the distortion of their distribution caused by phototaxis-induced aggregation of zooplankton.



Examples of mesoplankton and nonplankton particle ROIs captured by the underwater imager during coastal raft tests. (Image by LI Jianping's team)

In addition, the installation of different lenses enables the imager to support switchable magnifications for imaging a size range of 200 μm–40 mm. The imager is equipped with an embedded computer to perform online object detection preprocessing after image acquisition to reduce data storage and transmission loads.

The system can detect individual plankton and suspended particles from raw images. It can then transmit the cropped region of interest (ROI) vignettes instantly to a remote server, where they are further identified and quantified by cloud computing-based deep learning algorithms to obtain monitoring information for end users' remote retrieval.

Through raft and buoy trials, 46,804 plankton and suspended particle images have been annotated through a human-machine mutually assisted effort. The result is a data set with 90 categories.

For eight months, the imager system was integrated into the surface buoy and deployed in Daya Bay in the northern South China Sea. Thanks to its high-frequency and long-time continuous sampling capability, it transmitted a total of 1,545,187 region-of-interest images back to the server.

It also observed plankton diel vertical migration phenomena with a higher temporal resolution and, for the first time, an unprecedented outbreak of *Creseis acicula* in the waters near the southwest coast of Daya Bay.

"This is the first successful trial of deploying a submersible imager under a moored surface buoy for long-term, continuous, high-frequency and *in situ* monitoring of marine plankton in coastal waters," said Dr. LI. "The popularization of such a paradigm, especially with a networked deployment, will reduce the cost, enlarge the spatial coverage, increase the sampling frequency, and extend the deployment time of the marine plankton monitoring programs."

Examples of plankton ROIs were collected by the underwater imager during the buoy trial. (Image by LI Jianping's team)

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Reference

J. Li, T. Chen, Z. Yang, L. Chen, P. Liu, Y. Zhang, . . . X. Sun, (2021) Development of a buoy-borne underwater imaging system for *in situ* mesoplankton monitoring of coastal waters. *IEEE Journal of Oceanic Engineering*, 1. doi: 10.1109/JOE.2021.3106122.