

2022 Report of Working Group 48 on *Towards Best Practices Using Imaging Systems for Monitoring Plankton*

The fourth and fifth business meetings of Working Group (WG 48) on *Towards Best Practices Using Imaging Systems for Monitoring Plankton* was held virtually on March 9, and September 8, 2022, prior to PICES-2022 (Busan, Korea). There were 12 and 11 members who attended the March 9 and September 8 meetings, respectively (*WG 48 Endnote 1*). Dr. Hongsheng Bi (USA) chaired the meetings. The annual meeting was used to present recent developments, and to discuss next steps WG 48 ToRs. The agenda for the meetings are presented *WG 48 Endnotes 2 and 3*.

AGENDA ITEM 2

Update on memberships

- Dr. Alexis Fischer (USA) stepped down from the Working Group.
- Dr. Dhugal J. Lindsay (JAMSTEC) and Prof. Kazutaka Takahashi (University of Tokyo) are new members, representing Japan.
- WG 48 requests the appointment of Ms. Sabrina Groves, early career scientist (Ph.D student) from University of Maryland to join the Working Group to increase early career and female scientist participation.

AGENDA ITEM 3

Next steps

Update on:

- a review paper on underwater imaging systems for plankton monitoring for submission to *ICES Journal of Marine Science* or *Marine Ecology Progress Series*
 - Finished the introduction section.
 - Completed a new background study using frequency plankton data from PlanktonScope. The hourly time-series data will be used to illustrate the advantage of underwater imaging systems.
 - Drs. Robert Cowen and Moritz Schmid from Oregon State University will join the review paper. Dr. Cowen is the inventor of *in-situ* ichthyoplankton plankton imaging systems.
- a review paper on deep learning in marine biology for submission to *ICES Journal of Marine Science* or *Marine Ecology Progress Series*
 - Developed a draft outline.
- “*Deep learning in marine science*” topic for submission to *Frontiers in Marine Science*
WG members, Drs. Haiyong Zheng, Xuemin Cheng, Mark Benfield and Dr. Bi developed a research topic entitled “*Deep learning in marine science*” for submission to a special issue in *Frontiers in Marine Science* (*WG 48 Endnote 4*). This topic intends to draw on applications of deep learning systems in different aspects of marine science, which could facilitate the preparation of our review manuscript on deep learning in marine biology. To date, we have received 15 manuscript submissions. The deadline for manuscript submission is January 27, 2023.

AGENDA ITEM 4

Meetings and meeting proposal

- WG 48 members Bi, Cheng, Keister, Kimmel, and Cheng convened a session (OT03) on “*Towards best practices for using imaging systems for plankton monitoring*” in theme session Ocean Technologies and Observatories at the AGU/ASLO/TOS Ocean Sciences Meeting in February 24–March 4, 2022, Honolulu, USA.
- WG 48 members Bi, Keister, Kimmel and Sastri convened a topic session on “*Application and best practice of imaging technologies for plankton and ecosystem monitoring*” at the 2022 PICES Annual Meeting.
- WG 48 members Bi, Kimmel, Zheng, Kimmel proposed a topic session on Applications of deep learning systems in marine science” for PICES-2023 (*WG 48 Endnote 5*).

WG 48 Endnote 1

WG 48 participation list

Members	Country	March 9 attendance	September 8 attendance
Hongsheng Bi (Co-Chair)	USA	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Xuemin Cheng (Co-Chair)	USA	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
David Kimmel	USA	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Julie Keister	USA	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Robert Campbell	USA	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Mark Benfield	USA	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Akash Sastri (BIO)	Canada	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Paul Covert	Canada	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Haiyong Zheng	China	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Haifeng Gu	China	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Satoshi Kitjima	Japan	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Lindsay Dhugal	Japan	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Kazutaka Takahashi	Japan	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Wongyu Park	Korea	<input type="checkbox"/>	<input type="checkbox"/>
Pitor Margoński	ICES <i>ex officio</i> member	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Klas Ove Moeller	Observer	<input type="checkbox"/>	<input type="checkbox"/>
Sabrina Groves	Student, Observer	<input type="checkbox"/>	<input checked="" type="checkbox"/>

WG 48 Endnote 2

WG 48 meeting agenda

20:00 – 2100 EST, Wednesday, March 9, 2022

1. Opening remarks (Bi)
2. Update on membership changes
3. Discussion of next steps (All)
 - Draft review on underwater imaging systems for plankton studies
 - Potential special topic of deep learning for marine science (Zheng)
4. Final comments (Co-Chair)
5. Adjourn

WG 48 Endnote 3**WG 48 September 8 meeting agenda**

20:00 – 2100 EST, Thursday, September 8, 2022

1. Opening remarks (Bi)
2. Report a new background study using high frequency plankton data from imaging system. The hourly time-series plankton data will be part of the review paper of underwater imaging systems.
3. Updates on the review paper on the underwater imaging systems for marine plankton monitoring.
4. Discussion of next steps (All)
 - Discuss the outline for the review of deep learning in marine biology.
 - Develop a workshop proposal for the PICES 2023 annual meeting (Bi et al. Endnote 5).
5. Meetings and meeting proposal
6. Adjourn

WG 48 Endnote 4**Proposal for special topic in *Frontiers in Marine Science***

Deep learning (DL), mainly composed of deep and complex neural networks such as recurrent networks and convolutional networks, is an emerging research branch in the field of artificial intelligence and machine learning. The DL revolution continues to have a far-reaching impact on all scientific disciplines and every corner of our lives. With continuing technological advances, marine science is entering into the big data era with the exponential growth of information. DL is an effective means of harnessing the power of big data. Combined with unprecedented data from cameras, acoustic recorders, satellite remote sensing, and large model outputs, DL enables scientists to solve complex problems in biology, ecosystems, climate, energy, as well as physical and chemical interactions. Although DL has made great strides, it is still only beginning to emerge in many fields of marine science, especially towards representative applications and best practices for the automatic analysis of marine organisms and marine environments.

Currently, DL in marine science mainly leverages cutting-edge techniques to analyze data collected by in-situ optical or acoustic imaging sensors for underwater applications, such as plankton classification and coral reef detection. This research topic aims to expand the applications of marine science to cover all aspects of detection, classification, segmentation, localization, and density estimation of marine objects, organisms, and phenomena.

Topics of interest include, but are not limited to:

- Best practices for the application of deep learning in marine/underwater object detection/classification of marine organisms (plankton, fish, and coral reef, etc.) and marine environments (trash and debris, etc.).
- Deep learning for optical/acoustic image enhancement in ocean observation/exploration (marine organism, seafloor, etc.).
- Deep learning for detection, classification, localization, and density estimation of marine organisms (fish and marine mammals) with underwater optical/acoustic data acquisition technology.
- Deep learning for detection, classification, and segmentation of objects and phenomena in the ocean from the data of remote sensing and drone surveys.
- Research on new datasets for underwater/marine optical/acoustic data analysis.

WG 48 Endnote 5

**Workshop proposal for Topic Session on
“Applications of deep learning systems in marine science” at PICES-2023**

Co-convenors: Hongsheng Bi (USA), Haiyong Zheng (China), Julie Keister (USA), David Kimmel (USA)

Duration: 1 day

Marine science is entering the big data era where deep learning will have an increasingly far-reaching impact. The combination of deep learning and unprecedented amounts of data generated from different instruments and modeling platforms will enable scientists to address complex issues in biology, ecosystem science, climate, as well as physical and chemical interactions. Although deep learning has made great strides, it is still only beginning to emerge in many fields of marine science, especially towards representative applications and best practices.

The cutting-edge techniques of deep learning in marine science mainly utilize Convolutional Neural Networks and Transformers for applications in underwater vision, such as plankton classification and coral reef detection. These techniques leverage the data collected by in situ optical or acoustic imaging sensors. Our session seeks contributions that provide examples of applications of deep learning across marine science. Our goal is to share state-of-the-art science that serves to facilitate the convergence of deep learning and marine science and improve our ability to analyze heterogeneous and multi-source oceanographic data.