2025 Report of PICES/ICES Joint Working Group on Best Practices for Using Deep Learning in Processing Plankton Images (WG54)

The first business meeting of Working Group 54 (WG 54) on Best Practices for Using Deep Learning in Processing Plankton Images was held virtually on October 20 and 27, 2025, with 12 members in attendance. This meeting served as the kickoff to discuss approaches for achieving WG54's Terms of Reference (ToRs). Attendance was affected by an ongoing government shutdown, which limited the ability of several members, particularly those employed by government agencies, to participate. The meeting agenda is provided in *Endnote 2*.

AGENDA ITEM 1
Welcome and Introductions

1) Updates on Memberships
   - Dr. Gulce Kurtay has relocated to Germany; accordingly, her membership will be listed under ICES rather than PICES/USA.
   - Dr. Jeff Ellen has requested to participate in WG 54 under his affiliation with Scripps Institution of Oceanography rather than NIWC.
   - Dr. Thomas Kelly has departed the University of Alaska, and his continued involvement with WG 54 remains unclear.

2) Introductions (affiliations and research focus) and related projects
   - Parallel efforts are underway within ICES Zooplankton WG (WGZE)
   - The EU AQUA project

AGENDA ITEM 2
Background and Motivation

- Rationale for establishing WG54
- Expected outcomes and deliverables

AGENDA ITEM 3
Scope and Objectives of WG 54

For the scope and objectives of WG 54, we discussed defining core themes that include dataset standards, annotation protocols, model benchmarking, interoperability, and open data sharing, as well as identifying both short- and long-term objectives (Tor 1-3). Recognizing that the primary

focus of the field is not the development of new deep-learning algorithms but rather their effective application, WG 54 will emphasize the feasibility of identifying solutions that enable models to be applied across different imaging platforms. This effort will be supported through coordinated data curation and testing, with particular attention to evaluating multi-modal modelling approaches.

AGENDA ITEM 4
Work plan and Timeline

WG 54 will focus on establishing foundational deliverables, including an inventory of existing plankton image datasets across participating institutions and imaging platforms, and the development of a preliminary framework for model comparison and benchmarking. These activities will support clearly defined milestones leading up to the PICES and ICES annual meetings, where progress will be reviewed and priorities for subsequent phases refined. Intersessional work will be conducted through targeted tasks and the formation of focused subgroups, as appropriate, to advance specific objectives such as data standardization, annotation practices, and cross-platform model evaluation (*Endnote 3*).

AGENDA ITEM 5
Upcoming events

- 2025 PICES annual meeting in Yokohama
- 2026 AGU/ASLO/TSO Ocean Science meeting in Glasgow

WG54 Endnote 1

WG 54 participation list

***** co-chair, ** early career scientist

Members	Country	2025 October meeting
Hongsheng Bi*	USA	☑
Akash Sastri	Canada	☑
Paul Covert*, **	Canada	☑
Robert Campbell	USA	☒
Satoshi Kitajima	Japan	☑
Dhugal Lindsay	Japan	☑
Kazutaka Takahashi	Japan	☑
Jeff Ellen	USA	☒
Fang Zhang	China	☑
Haiyong Zheng	China	☒
Julie Keister	USA	☒
Xuemin Cheng*	China	☒
David Kimmel*	USA	☒
Mark Benfield	USA	☑
Gulce Kurtay**	Germany	☑
Thomas Kelly**	USA	☒
Piotr Margonski	Poland	☒
Sophie Pitois*	UK	☑
James Scott	UK	☒
Klas Ove Möller	Germany	☒
Ankita Ravi Vaswani**	Germany	☒
Elaine Fileman	UK	☒
Jung-II Kin	Korea	☒
Gi-Seop Lee	Korea	☒
Hyunjin Yoon	Korea	☒
Jennifer Fisher	US	☒
Jeanette Gann	US	☒
Kelia Axler	US	☒
Zesen Zhang	China	☑
Mitsuko Hidaka	Japan	☑

WG 54 Endnote 2

WG 54 meeting agenda

1. **Welcome and Introductions**
   1) Updates on Memberships
   2) Introductions (affiliations and research focus) and related projects
   3) Overview of WG 54 goals within the PICES/ICES framework

2. **Background and Motivation**

3. **Scope and Objectives of WG 54**
   1) Defining core themes: dataset standards, annotation protocols, model benchmarking, interoperability, and open data sharing
   2) Identifying short- and long-term objectives

4. **Work Plan and Timeline**
   1) Deliverables for Year 1 (e.g., data inventory, model comparison framework)
   2) Milestones leading to the PICES/ICES annual meetings
   3) Discussion of intersessional work and subgroup formation

5. **Upcoming events**

6. **Member Contributions and Next Steps**
   1) Shared google folder
   2) Draft outline
   3) Planning the next virtual meeting and assigning action items

WG54 Endnote 3

PICES/ICES Joint Working Group on Best Practices for Using Deep Learning in Processing Plankton Images (WG54)

1. Scope

This review paper aims to synthesize current knowledge and best practices in applying deep learning (DL) to plankton image processing. It will examine common DL models, key challenges in plankton image analysis, and the potential of multimodal learning to improve cross-platform applications. The paper will serve as a reference for researchers, data scientists, and ecologists working at the intersection of marine biology and artificial intelligence, and will complement the objectives of the PICES/ICES WG 54.

2. Outline

Part I: Introduction: Common Deep Learning Models in Plankton Image Processing (brief introduction)

- Overview of deep learning evolution in marine imaging and its relevance to plankton studies.
- Common architectures (e.g., CNN (ResNet, EfficientNet, SparseNet, DenseNet), GAN, Transformer-based models) used in plankton image processing.
- Comparison of traditional, end-to-end (mask-R-CNN, YOLO), hybrid approach, and ensemble DL approaches.
- Strengths and limitations of these architectures in terms of accuracy, scalability, interpretability, and transferability.
- Role of data augmentation, pretraining, and transfer learning for limited plankton datasets.
- Discussion on computational challenges, model reproducibility, and metadata dependence.

Part II: Main Challenges in Image Processing (focusing on the generality of the model)

- To what taxonomic level should DL models classify? (species, genus, functional group)
- Balancing generalization versus specificity in model training across datasets.
- How can diversity metrics be derived from model outputs?
- Addressing biases in annotations and class imbalance.
- Reproducibility considerations in automated plankton classification.
- Integration of environmental metadata and contextual information.
- Cross-validation and benchmarking: towards a multimodal modelling approach.

Part III: Toward Multimodal and Cross-Platform Models

- Introduction to multimodal learning: combining image, environmental, and metadata inputs.
- Advantages of multimodal and domain adaptation models for harmonizing data from different instruments.
- Case studies demonstrating model transfer between selected systems (likely separate zooplankton and phytoplankton).
- Technical requirements for model interoperability and metadata standardization.
- Future perspectives: foundation models and large-scale annotation sharing.