DIVE INTO AI: Emerging Ocean Opportunities

WHAT WE HEARD

Building Bridges

November 2024

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LAND ACKNOWLEDGEMENT

The workshop series began with acknowledging and respecting the First Nations, Metis, and Inuit peoples on whose traditional territories the Canadian Integrated Ocean Observing System's (CIOOS) work is conducted across Canada.

We strive for respectful relationships with all Indigenous peoples as we search for collective healing, true reconciliation, and honouring these beautiful lands and seas together.

The virtual session hosts from CIOOS Atlantic were located in Kjipuktuk, otherwise known as Halifax, the traditional and unceded territory of the Mi'kmaq.

INTRODUCTION

The Canadian Integrated Ocean Observing System (CIOOS) is a national online platform that supports coastal and ocean stewardship, economic innovation, and marine safety and navigation by providing access to high-quality coastal and ocean information data.

> "CIOOS engages locally, connects regionally, and coordinates nationally to elevate Canada's ocean monitoring to the global stage. These partnerships generate information and facilitate place-based solutions to advance our understanding of the ocean."

Artificial intelligence (AI) is a transformative technology with global impact and enormous potential to improve efficiency and effectiveness in ocean science. In 2024, CIOOS received funding from Canada's Ocean Supercluster for Building Bridges, a project-based approach to accelerate the adoption of AI in the ocean sector. This project has revealed that while some organizations work extensively with AI, many others are just beginning to explore its potential.

The 'Dive into AI: Emerging Ocean Opportunities' workshop series, which took place over three sessions in November 2024, was designed to be a starting point for broader collaboration and capacity-building between beginner and experienced AI practitioners. It set the stage for advancing AI adoption, fostering connections, and building a sustainable foundation for AI integration into ocean science practices. Each session increased in complexity, beginning with an introduction to Artificial Intelligence (AI) and concluding with detailed case studies showcasing practical applications in ocean science.

Session 1: Introduction to Ocean AI and Building Bridges
Session 2: Preparing for AI in Ocean Science
Session 3: AI Case Study Discussions

INTRODUCTION TO OCEAN AI

Session 1

This workshop session highlighted the importance of collaboration, demystification, accessibility, and regional focus in advancing ocean observation and AI adoption. AI offers the potential for transformative innovation in the ocean sector. However, meaningful AI requires a strong framework built on strategic, technical, and ethical considerations.

> "Most of AI analysis is cleaning the data and having a normalized workflow and pipeline that can get you to standardized data sets".
>
> - Chris Whidden, Dalhousie University.

Data preprocessing, cleaning, and management are fundamental prerequisites for effective AI applications, as gaps, biases, and inconsistencies can significantly impact model performance. Jay Kumar emphasized the importance of addressing the entire AI pipeline, from data acquisition to AI model deployment. Each step in this workflow presents opportunities for AI to streamline processes and cater to diverse user needs. This ensures that AI solutions are robust, adaptable, and integrated seamlessly into existing workflows.

AI's ability to revolutionize industries is underscored by its practical applications. All initiatives are grounded in real-world applications. By integrating diverse data sources and leveraging AI solutions, organizations can automate processing tasks, improve evidence-based decision-making, and address operational inefficiencies. Start small, learn from prototypes through iterative processes, and scale up as solutions prove effective. Additionally, focus on aligning AI initiatives with sustainable practices, such as minimizing waste and

contributing to long-term ocean health and economic growth. This acknowledges the dynamic nature of both AI technology and the ocean environment.

Chris Whidden framed success in AI adoption as a collaborative effort requiring input from diverse fields, including ocean science, data management, machine learning, and policy. Partnerships are essential for bridging gaps in shared knowledge and accessible resources to support the advancement of AI applications.

Further, ethics must be considered in AI design and implementation. AI tools, training, and resources should be accessible to organizations of all sizes. This reflects a commitment to democratizing AI and ensuring equitable participation across sectors. Transparency, fairness, and accountability are critical for ensuring AI systems align with broader governance and maintain societal values.

PREPARING FOR AI IN OCEAN SCIENCE

Session 2

This workshop session highlighted the steps required to implement AI and its responsible uses through ethics and governance.

> "Canada is also a global leader in AI. We have some of the best AI researchers in the world, and it's one of the reasons why I think ocean AI should be Canada's real drive and push on the AI opportunities. Really collaborating with our AI expertise and bringing that in with our ocean expertise is a significant opportunity for all of us."
>
> - Jennifer LaPlante, Ocean Supercluster

AI adoption in ocean science is advancing rapidly, driven by Canada's leadership in innovation and the growing need for data-driven solutions in marine industries. Jennifer LaPlante shared examples of AI applied in optimizing transportation, supporting environmental monitoring in the Arctic, enhancing renewable energy applications, and improving fisheries and aquaculture management, and many other use cases. However, successful implementation is fundamentally tied to the availability and accessibility of high-quality data.

Data scarcity, proprietary restrictions, and underutilization present significant barriers, requiring new approaches to incentivize data sharing and collaboration. Reliable AI models are highly dependent on well-structured training data. Yet, challenges remain in defining objectives, addressing biases, and ensuring adaptability across different environments.

The balance between customization and efficiency requires organizations to assess whether to build or buy AI solutions based on long-term needs, operational cost, and control over intellectual property. Sustainability is an important factor, as AI's energy consumption and environmental impact should be mitigated by choosing

efficient models and computing practices. Continuous evaluation and adaptability are necessary, as AI models must be regularly updated to reflect changing environmental conditions and ensure ongoing accuracy.

While AI offers immense potential, its effectiveness ultimately depends on how it is designed, governed, and integrated within broader scientific and operational frameworks. Governance and oversight are critical, as AI must be deployed with transparency, human control, and security safeguards to avoid unintended consequences. Legal and regulatory compliance must be proactively integrated into AI to prevent risks and ensure alignment with evolving policies.

Ethical considerations must be prioritized, including safeguarding sensitive information and ensuring that human oversight remains central to AI-driven decision-making. Transparency and explainability are critical in ensuring that AI systems function in a way that users can understand, interpret, and trust, particularly when dealing with probabilistic models and decision-making processes.

A collaborative approach, supported by learning initiatives and community-building efforts, is necessary to bridge gaps in knowledge and implementation. AI models depend on high- quality, diverse datasets to generate reliable insights; yet, data sharing and accessibility barriers must be addressed to unlock their full potential. A multidisciplinary approach is key, bringing together experts from different fields to oversee AI's integration and ethical deployment within ocean science and industry.

To best maneuver an unfamiliar world with AI, new skills must be learned to leverage its strengths and not be

blind-sided by its complexities. Training and education are fundamental to ensuring that individuals across disciplines can understand AI and its limitations, and integrate it into their work. AI literacy enables diverse stakeholders to engage with AI confidently, ensuring that its adoption is both effective and equitable. A key outcome of Building Bridges is the development of an AI learning ecosystem for the ocean sector, including education resources that are accessible, useful, and relevant to diverse backgrounds.

AI CASE STUDY DISCUSSIONS

Session 3

This workshop session highlighted the growing role of AI in ocean-related research and operational processes with concrete examples, emphasizing its ability to address longstanding challenges in data management, anomaly detection, and environmental monitoring.

> "Self-supervised learning is a very exciting branch of machine learning that is able to learn information from a large unlabeled dataset by creating supervised tasks from the data itself."
>
> - Spencer Bialek, Ocean Networks Canada

Across multiple projects, AI-driven solutions demonstrated their capacity to enhance efficiency, reduce manual workloads, and improve the accuracy of data analysis. A key theme that emerged was the necessity of AI for processing large volumes of complex and dynamic ocean data that would otherwise be impractical to manage manually. From hydrophone anomaly detection to vessel fuel optimization, these advancements reflect a shift toward AI-assisted decision-making and automation in marine research and industry.

A notable insight was the use of self-supervised learning methods, particularly in cases where labeled data is scarce. In hydrophone anomaly detection, this approach allowed models to recognize data irregularities even without predefined labels, addressing a major limitation of traditional supervised learning. Similarly, AI-powered quality control for tide observations leveraged historical datasets to train models capable of identifying and correcting erroneous data, illustrating the

adaptability of machine learning in improving the reliability of environmental monitoring.

Another recurring theme was the alignment of AI applications with broader principles of data accessibility and usability. The integration of AI in metadata extraction and standardization ensured that ocean data remained findable, accessible, interoperable, and reusable (FAIR), making it more useful for future applications. This highlights AI's dual role in both streamlining data processing and enhancing the long-term value of marine datasets.

Furthermore, projects exploring AI-driven habitat mapping underscored the importance of scalable monitoring methods, with machine learning models proving to be a powerful tool for expanding ecological research beyond traditional fieldwork constraints.

Discussions pointed to the importance of explainability and transparency in AI adoption. Particularly in regulatory and legal contexts, ensuring human oversight and maintaining interpretability of AI-driven decisions. This was evident in NOAA's approach to AI-driven quality control, where efforts were made to balance automation with expert validation to uphold data integrity and institutional trust. The practical challenges of AI implementation, such as adapting models to rare or evolving environmental events, also emerged as critical considerations for ensuring long-term effectiveness.

AI is becoming an important tool for optimizing operations, improving environmental monitoring, and facilitating data-driven decision-making. While technical advancements continue to evolve, the integration of AI is reshaping how ocean data is collected, analyzed, and utilized, allowing for more efficient and adaptive approaches to ocean research and conservation.

CONCLUSION

Workshop discussions highlighted AI's growing role in ocean science and industry, emphasizing its ability to process vast datasets, automate complex analyses for novel big data insights, and improve decision-making. AI is streamlining tasks in environmental monitoring, vessel optimization, ecosystem mapping, and beyond; yet its success depends on high-quality, well-structured data and intentional management.

> The need for better data-sharing, standardization, and interoperability emerged as a critical consideration, reinforcing that AI is only as effective as the data it relies on.

Advanced ML techniques, such as self-supervised learning, are addressing key challenges like anomaly detection and quality control, allowing AI models to generalize beyond predefined datasets. However, ensuring transparency, accuracy, and adaptability remains essential, as AI systems must function reliably in dynamic real-world conditions. Ethical concerns, including the need for human oversight and explainability, are particularly important in regulatory contexts, where AI-driven insights must be both interpretable and accountable.

As AI moves from research to operational use, balancing automation with expert validation is crucial to maintaining trust and reliability. The discussions underscored that AI's potential will only be fully realized through responsible governance, interdisciplinary collaboration, and ongoing refinement, ensuring that its integration into ocean science aligns with both technological and ethical priorities.

ABOUT
BUILDING BRIDGES

The Dive Into AI Workshops, hosted by CIOOS, are part of the Building Bridges project, announced in June 2024 and funded by Canada's Ocean Supercluster.

CANADA'S OCEAN SUPERCLUSTER

The Building Bridges project focuses on equipping organizations in the ocean sector with the tools and knowledge needed to implement AI solutions effectively. Building Bridges plans to lower AI adoption barriers through addressing multiple components of AI development.

Contact us at info@cioos.ca if you have any questions about Building Bridges or the Workshop sessions.

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